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A Top-Up Design for PAL to VGA Conversion in Real Time Video Processing System

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Jafar Alzubi ; Sunil Jacob ; Varun G Menon ; Saira Joseph ; P G Vinoj   All Authors

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School of Engineering and Technology,
Kochi, India

Abstract	**Abstract:**

Document Sections

I. Introduction

II. System Overview

III. System Hardware
Software Co-

Abstract:
Real time video processing found its range of applications from defence to consumer electronics for surveillance, video conferencing etc. With the advent of FPGAs, flexible Real-Time Video Processing System (RTVPS) which can meet hard real-time constraints are easily realised with short development time. A hardware software co-design for an FPGA based real time video processing system to convert video in standard PAL 576i format to standard video of VGA / SVGA format with little utilisation of resources is realised and evaluated. Switching between multiple video streams, character/ text overlaying, skin colour detection is also

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I. Introduction

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III. System Hardware
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Design

IV. Implementation
Results

V. Conclusion

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Time Video Processing System (RTVPS) which can meet hard real-time constraints are easily realised with short development time. A hardware software co-design for an FPGA based real time video processing system to convert video in standard PAL 576i format to standard video of VGA / SVGA format with little utilisation of resources is realised and evaluated. Switching between multiple video streams, character/ text overlaying, skin colour detection is also incorporated. The system is also adaptable for rugged applications. VHDL codes for the architecture were synthesized using ALTERA Quartus II and targeted for ALTERA STRATIX I FPGA. The evaluated results show that the resource utilization is low for this design. Since system is also flexible, latest applications can be incorporated in future.

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Distributed Big Data Analytics in the Internet of Signals

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Abstract

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I. Introduction

II. Distributed
System
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Abstract:

Internet of Things (IoT) is a network of ubiquitous devices that are capable of computation and communication over the Internet. These 'things' or devices continuously generate data over the internet and often communicate their data with a central server. Data circulated in this network can be either a control signal or a time dependent signal. The fusion center transforms the collective data from spatially distributed sensing nodes into useful information known as the analytic. This research paper examines the computation of linear and non-linear data analytic in a distributed IoT network. IoT sensors are required to save battery and

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II. Distributed
System
Description

III. Big Data
Analytics

IV. Challenges and
Future Research
Directions

V. Conclusion &
Future Scope

Authors

Figures

References

Citations

Keywords

network can be either a control signal or a time dependent signal. The fusion center transforms the collective data from spatially distributed sensing nodes into useful information known as the analytic. This research paper examines the computation of linear and non-linear data analytic in a distributed IoT network. IoT sensors are required to save battery and bandwidth. Further, the constraints in the computation and communication functionalities are highlighted, and also directions towards solving gaps in the present IoT standards are enlisted.

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Prediction of interaction between inline and cross flow responses of cylinder under vortex induced vibration

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Prediction of interaction between inline and cross flow responses of cylinder under vortex induced vibration.

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ABSTRACT

Extensive research on vortex induced vibration of cylinders has revealed that inline vibration has significant impact on the shedding pattern and also on the amplitude of cross flow vibrations. Interaction between the responses in inline and cross flow directions is still not fully understood. The paper presents a simplified method for understanding the interaction between these two responses using two dimensional computational fluid dynamics (CFD) simulations. This paper addresses two cases where in the cylinder is modeled with a single degree of freedom (SDOF) in CF direction and two degrees of freedom (TDOF) in both CF and IL directions. The trends of variation of hydrodynamic and structural parameters have been analyzed to understand the effect of the second degree of freedom on cylinder response and hydrodynamic force coefficients. The shedding pattern has also been analyzed in the study. A 17 % increase in the value of C_L has been observed in the TDOF case. The results show that the cylinder with SDOF is more prone to lock in vibration. This phenomenon may be related to the shifting of shedding pattern from 2S to 2P when the inline motion is arrested.

NOMENCLATURE

Symbol	Definition (unit)
D	Diameter of the cylinder (m)
V	Current velocity (m/s)
m^*	Mass ratio
f_v	Frequency of vortex shedding (hz)
St	Strouhal number
f_n	Natural frequency of cylinder in water (hz)
f_{nCF}	Natural frequency of cylinder in CF direction (hz)
f_{nIL}	Natural frequency of cylinder in IL direction (hz)
f_{CF}	Frequency of oscillation of cylinder in CF direction (hz)
f_{IL}	Frequency of oscillation of cylinder in IL direction (hz)
f_{oscC_L}	Frequency of oscillation of Lift coefficient (hz)
f_{oscC_D}	Frequency of oscillation of Drag coefficient (hz)
η_b	Ratio of CF and IL direction natural frequencies

1. INTRODUCTION

Vortex induced vibration (VIV) of marine risers has ever been an extensively researched topic. But most of the studies have concentrated on understanding the wake characteristics and estimating hydrodynamic loading and response of either stationary cylinder or cylinder with SDOF [1]. Few results have been reported for study of hydrodynamic response of cylinder with TDOF in both in-line (IL) and cross-flow (CF) directions. ILvibration has significant impact on the shedding pattern and also on the amplitude of CF vibrations [2]. The first of its kind discussions were reported in the case of flow around cylinder with TDOF [3]. They established the effect of reduced velocity (U_r) on the effect of forced and free 2dof response [3]. The effect of IL response on CF response depends on the ratio of natural frequencies in both directions ($\eta_b = \frac{f_{nCF}}{f_{nIL}}$). During lock in, if the natural frequency in the IL direction is twice that in the CF direction, resonance occurs in both directions leading to premature failure of the riser [4]. Also it has been observed that IL response amplitude is a function of U_r and stability parameter, where as the CF response amplitude is a

function of U_r and flow velocity [5]. Wake characteristics, hydrodynamic force coefficients and response vary significantly when both IL and CF vibrations occur simultaneously. Hence there is a need for prediction of response that hold good for the combined IL and CF vibration.

2. PROBLEM DESCRIPTION

In the present paper a riser model with outer diameter 0.076 m has been numerically analyzed using two dimensional (2D) computational fluid dynamics (CFD).Specifications of the riser and the flow condition in listed in Table 1. The incoming flow velocity is fixed as 0.5 m/s to maintain the flow regime uniform at Re = 3.8 x 10^4 which corresponds to the ocean condition encountered by a real marine riser used for petroleum extraction in offshore industries [6]. In this paper an effort has been made to study the effect of IL vibration on the amplitude of CF vibration and also on the wake characteristics.

Table 1 Riser model specifications and flow characteristics

Properties	Values	Units
Diameter (D)	0.076	m
Aspect ratio (L/D)	13.12	-
Flow velocity (V)	0.5	m/s
Reynolds Number of flow (Re)	3.8 x 10^4	-
Mass ratio (m^*)	0.66	-

2.1. MATHEMATICAL MODEL

The riser has been modeled as a 2D cylinder with TDOF in the CF and IL directions. The equations of motion for the riser can be represented as

$$m\ddot{Y} + c\dot{Y} + kY = F_L(t) \tag{1}$$

$$m\ddot{X} + c\dot{X} + kX = F_D(t) \tag{2}$$

where Y is the displacement in CF direction and X is the displacement in the IL direction. The excitation forces are lift force, $F_L(t)$ and drag force $F_D(t)$. The excitation forces are periodic in nature due the alternate shedding of vortices, which causes the riser to oscillate in CF as well as IL directions. The riser is observed to oscillate with frequency equal to frequency of vortex shedding (f_v) in the CF direction and at double the frequency in the IL direction during lock in. Lock in can be defined as the resonance condition during which the vortex shedding frequency lock on to the natural frequency of the riser in the cross flow direction. A simple representation of the mathematical model of riser with TDOF is represented in Figure. 1.

The riser is modeled with zero structural damping in the CF and IL directions. k_x and k_y are stiffness coefficients in the IL and CF directions respectively. In the present study $k_x= k_y$. For such a specific case the natural frequencies in both directions will be same and hence $\eta_b = 1$.
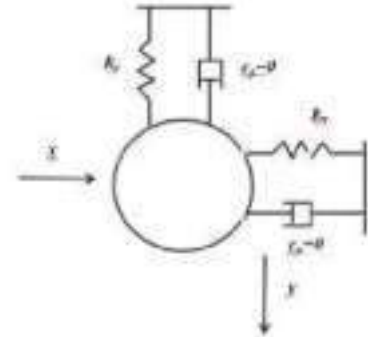

Figure 1 Representation of mathematical model of riser with TDOF.

2.2. FLUID DOMAIN

Figure 2 (a) shows the computational domain for the CFD simulation of VIV of an elastically mounted cylinder with TDOF. The origin of the Cartesian coordinate system is located at the center of the cylinder. The length of the domain is 40D with the cylinder located at 10D away from the inlet boundary. The cross flow width of the domain in 20D with the center of the cylinder at the middle. Detailed views of the mesh around the cylinder along with the computational domain after meshing have been shown in Figure 2 (c) and (b) respectively. There are 307 nodes around the circumference of the cylinder and the minimum element size near the rigid wall boundary has been computed from boundary layer theory to be 0.0001D [7]. The non-dimensional element size represented as $y+$, next to the cylinder surface is found to be less than unity. For cylinder wall a no slip boundary condition has been applied assuming the surface to be smooth. Inlet boundary has been treated has velocity-inlet with inflow velocity, V = 0.5 m/s. Outlet boundary has been treated as pressure outlet, the gradients of fluid velocity are set to zero and the pressure with zero reference pressure. On the two transverse boundaries symmetry boundary condition has been applied. Grid independency study has been carried out for the present grid in the previous work done by the authors [8].
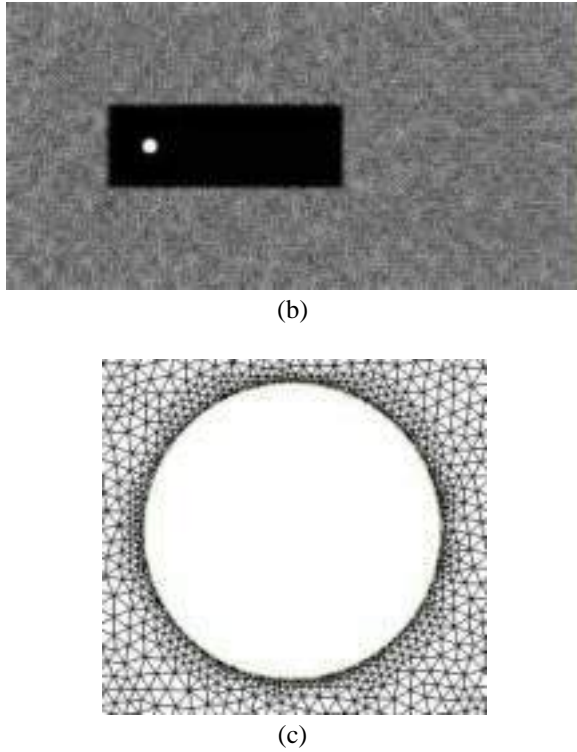

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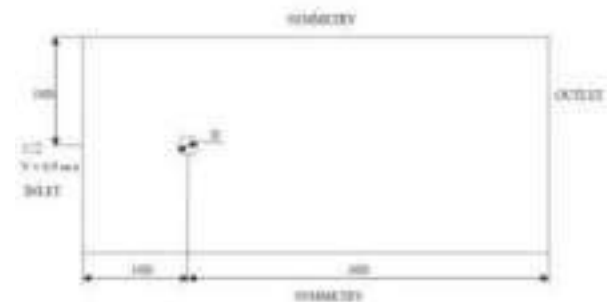
Figure 2 (a) Computational domain (b) computational mesh (c) mesh around the cylinder

2.3. FLOW MODEL

Numerically this problem has been treated as a case of two way fluid structure interactions (2way FSI). Modeling and meshing has been performed in ANSYS ICEM CFD and solving using ANSYS FLUENT. Flow around the cylinder is modeled using the transient, incompressible Navier-Stokes equation based RANS solver with $k - \omega$ SST as the turbulence model. RANS solver does the virtual averaging of velocities over an interval of time and hence for a specific interval the velocity vector appears to be constant in a RANS solver. In the present work an optimized fine grid is used to compensate for this drawback of the solver enabling it to capture the physics of Von-Karman Street eddies.

The governing equations are discretized using finite difference method. Non iterative time advancement (NITA) scheme with fractional time stepping method (FSM) has been chosen for pressure-velocity coupling of the grid. A least squares cell (LSC) based scheme has been used for gradient in spatial discretization and a second order upwind scheme as convective scheme.

2.4. STRUCTURAL MODEL

An elastically mounted cylinder can be mathematically represented by Eq. (1) and (2). These equations of motion are solved using a six degrees of freedom solver (6DOF), an integral part of the main solver by defining the cylinder as an object with TDOF in transverse direction.

A user defined function (UDF) compiled in C programming language has been hooked to the cylinder dynamic boundary conditions. The governing equations for the motion of the center of gravity of the cylinder in the CF and IL directions are solved in the inertial coordinate system. Velocity in the CF and IL directions are obtained by performing integration on Eq. (3) and (4)

$$\ddot{Y} = \frac{1}{m} \sum F_{\mathrm{L}} \qquad (3)$$

$$\ddot{X} = \frac{1}{m} \sum F_{\mathrm{D}} \qquad (4)$$

where $\ddot{X}$ and $\ddot{Y}$, are accelerations in the IL and CF direction respectively, m is the mass of the cylinder and F, resultant fluid force acting on the cylinder in the respective direction. Position of the center of gravity of the cylinder (CG) is updated after solving the equations of motion of a spring mass system represented by Eq. (1) and (2). Mass of the cylinder is given in the UDF as

$$m = m_{\mathrm{b}} + m_{\mathrm{a}} \qquad (5)$$

$$m_{\mathrm{a}} = (1 + C_{\mathrm{A}})m_b \qquad (6)$$

where m_{a} is the added mass and m_{b} is the mass of the cylinder. Added mass coefficient C_{A} for the aspect ratio of the present model is found to be equal to 0.7 [9].

Analysis has been performed assigning the cylinder TDOF with $k_x = k_y$ so that the natural frequencies of the cylinder in both directions remain equal. The results are compared with the case when the cylinder has only SDOF in the CF direction. Amplitudes of CF response are compared with existing results [8] and also the shedding patterns in both cases are analyzed.

3. RESULTS AND DISCUSSIONS

From the numerical analysis of cylinder with TDOF it has been observed that the hydrodynamic force coefficient in the CF direction, C_L shows an increase of 17.4% than that for SDOF case. This result is comparable with the findings of previous research in the field which shows an increase in the lift coefficient value by permitting an extra degree of freedom [10]. RMS value of C_D is almost constant for both cases with a very small decrease of 4% with TDOF case. C_L oscillates about zero with almost equal frequencies for both the cases. But the frequency of oscillation of C_D is lesser by 7.2% for TDOF case. The values of important hydrodynamic and structural parameters of both cases are shown in Table 2.

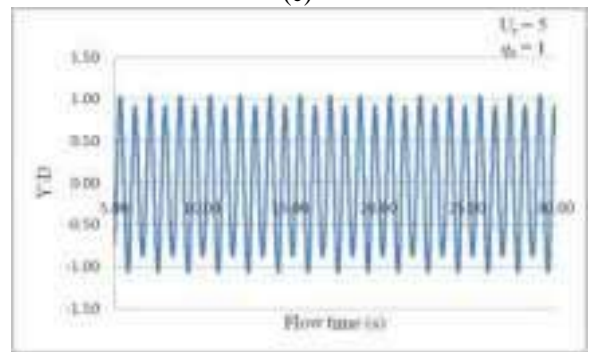Table 2 Hydrodynamic and structural parameter off cylinder with SDOF and TDOF

Parameters	SDOF	TDOF ($\eta_b = 1$)
C_L	0.57	0.69
C_D	1.49	1.43
$f_{osc\ C_L}(f_v)$	1.16	1.14
$f_{osc\ c_D}$	2.5	2.32
f_{CF}	1.26	1.15
f_{IL}	-	3.28
St	0.18	0.17
Y/D	1.06	1.2
X/D	-	0.17

The non dimensional amplitude in the CF direction obtained with TDOF is 11.3% more than that with SDOF. *X/D* is approximately 0.2.Time histories of major parameters obtained from the SDOF analysis are shown in Figure 3 (a) – (c) and that for TDOF in Figure 4(a) – (c). Frequency of oscillation of the cylinder in the CF direction obtained from SDOF case is found to be more closer to the theoretical value of vortex shedding frequency obtained from the normal value of $St = 0.2$ ($f_v = 1.3$). For TDOF case the frequency of oscillation deviates from the vortex shedding frequency.

For TDOF case the frequency of oscillation of C_L and the oscillation frequency of cylinder in the CF direction remains same. In SDOF case C_L oscillation frequency remains same as that in the TDOF case, but the cylinder vibration frequency in the CF shifts towards the natural frequency of cylinder in CF direction.
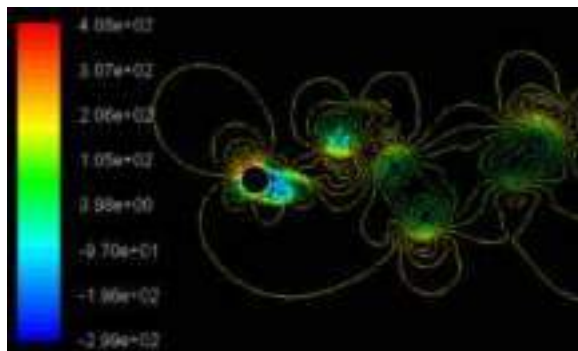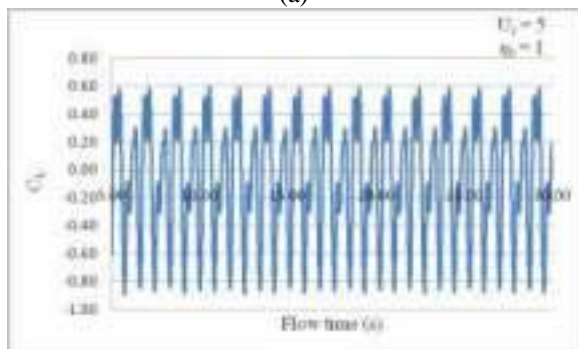

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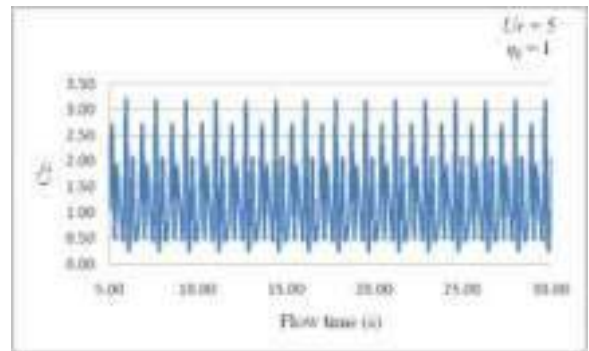
(c)

(d)

Figure 3 Pressure contours and Time histories of various hydrodynamic and structural parameters (a) Vortex shedding pattern behind cylinder with SDOF showing 2P mode (b) C_L of cylinder with SDOF (c) C_D of cylinder with SDOF (d) Motion history of cylinder with SDOF.

In the present analysis the natural frequency in both directions are specifically fixed to be equal to the theoretical value of vortex shedding frequency. Hence the phenomenon can be looked upon as the lock in of vortex shedding frequency on to the natural frequency of the cylinder. It can be concluded that a cylinder with SDOF is more prone to lock in vibration compared to that with TDOF.
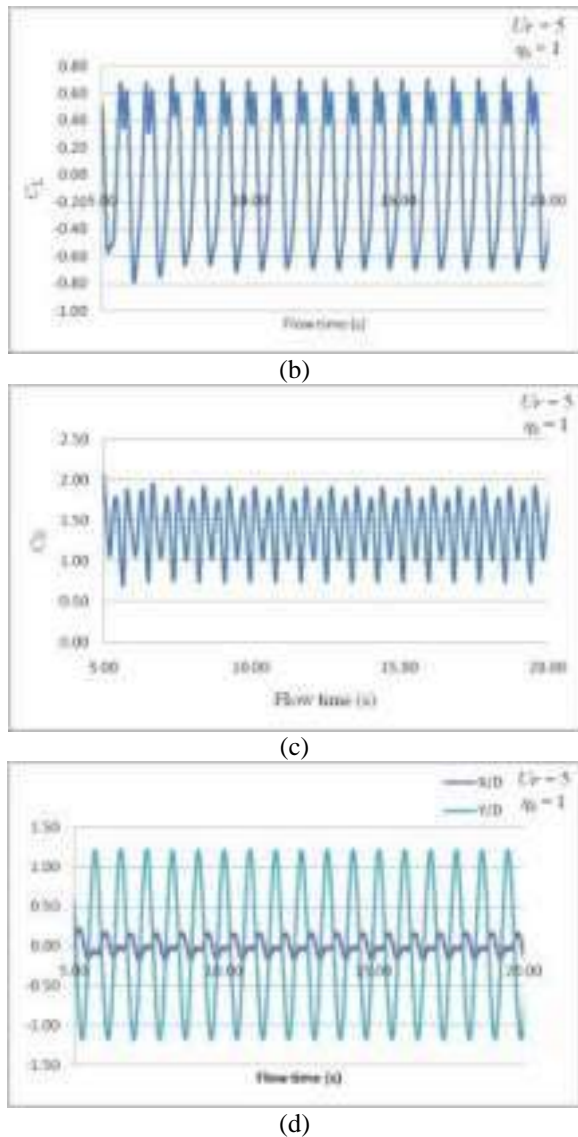

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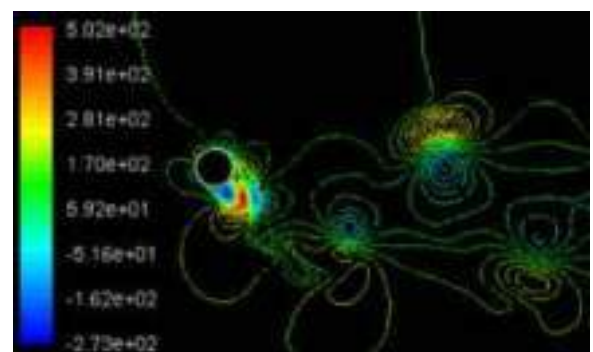
Figure 4 Pressure contours and time histories of various hydrodynamic and structural parameters (a) Vortex shedding pattern behind cylinder with TDOF showing 2S mode (b) C_L of cylinder with TDOF (c) C_D of cylinder with TDOF (d) Motion history of cylinder with TDOF.

This observation can be related to the shifting of the vortex shedding pattern from 2S to 2P mode when motion in IL direction is arrested. The shedding patterns for SDOF and TDOF cases are shown in Figure 3(a) and 4(a) respectively. *St* obtained also is with the range of normal value for cylinders during lock in. Even though the values of C_D for both cases are almost same, the oscillating frequency varies significantly.

The trajectory of oscillation of cylinder in TDOF case is represented in Figure. 5. A clear eight figure trajectory is observed which is typical for VIV of cylinders [10]. Also it has been observed that the motion the IL direction lags behind that in CF direction by a phase angle 30°. The represented trajectory in Figure 5 corresponds to 30° phase lag [11].
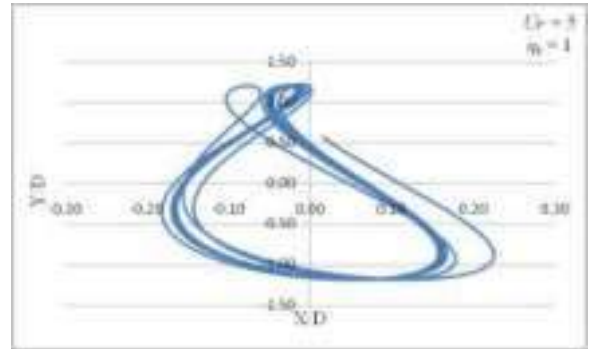

Figure 5 Trajectory of the cylinder with TDOF oscillating under VIV

4. CONCLUSIONS

Permitting an additional degree of freedom seems to have significant effect on the magnitude of lift coefficient but the frequency of oscillation of C_L remains constant for both the cases. C_D is independent of the degree of freedom of the cylinder but the frequency of oscillation varies significantly.

Oscillation amplitude of the cylinder in the CF direction is more in TDOF case which can be related to the increase in C_L.

It has been clearly observed that with SDOF the cylinder is more prone to lock in vibration since the vortex shedding frequency locks on to the natural frequency of the cylinder in the CF direction. But with TDOF no such shifting of frequency is observed. Shedding pattern shifts from 2S during TDOF motion to 2P when motion in IL direction is arrested.

An eight figure trajectory typical for VIV is obtained from the 2D simulation. Hence the efficacy of 2D CFD as a tool to predict response of cylinder with TDOF under VIV is accomplished. The observations made above are definitely strong inputs in the design and deployment of marine risers.

5. REFERENCES

1. A. Khalak, C. H. K. Williamson, 'Investigation of the relative effects of mass and damping in vortex induced vibration of a circular cylinder', *Journal of Wind Engineering. Ind. Aerodyn. vol. 69-71, pp. 341 – 350*, 1997.

2. Jauvtis, N. and Williamson, C. H. K., 'The effect of two degrees of freedom on vortex-induced vibartion at low mass and damping', *Journal of Fluid Mechanics 509, 23 – 62, 2004.*

3. Moe, G. and Wu, Z. J., 'The lift force on a cylinder vibrating in a current', *Journal of Offshore Mechanics and Arctic Engineering 112, 297-303*,1990.

4. T. Sarpkaya., 'Hydrodynamic damping, flow-induced oscillations, and biharmonic response', *ASME Journal of Offshore Mechanics and Arctic Engineering,117:232-238*, 1995.

5. Yin, D.,'Experimental and Numerical Analysis of Combined In-line and Cross-flow Vortex Induced Vibrations', *Ph D Thesis, Norwegian University of Science and Technology pp 7*, 2013.

6. Narendran, K., Murali, K., Sundar, V., 'Vortex-induced vibrations of elastically mounted circular cylinder at Re of the O (10^5)', *Journal of Fluids and Structures, 54, 503 – 521*, 2015.

7. Schlichting, H., 'Boundary layer theory', *McGraw-Hill Book Company, New York*, 1979.

8. Chandran, V., Sekar, M., Janardhanan, S., Menon, V., 'A numerical study on the influence of mass and stiffness ratios on the vortex induced motion of an elastically mounted cylinder for harnessing power', *Energies, 11, 2580,* 2018.

9. Naudascher, E.; Rockwell, D., 'Flow induced vibration – An engineering guide', *Dover Publications Inc, Mineola, New York, USA*, 2005.

10. Williamson, C.H.K., Govardhan, R., 'Vortex induced vibrations' *Annual review of fluid mechanics, vol. 36 pp 413 – 455*, 2004.

11. W, Jie., L, Halvor., M, L, Larsen., L, Stergios., B, Rolf. 'Vortex-induced vibration of a flexible cylinder: Interaction of the in-line and cross-flow responses', *Journal of Fluids and Structures 63 238–258,* 2016.

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BOOK/CONFERENCE DETAILS 2019

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4	Noel Joseph Gomez				CME1901	CONFERENCE-BOOK
5	Dr.Varun G Menon	CCSE1903CCSE1906,CCSE1907				CONFERENCE-BOOK
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Multi-Criteria Ranking of Best Management Practices for Flood Reduction in Kochi City, Kerala

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Abstract— This paper focuses on the flood management strategies which are appropriate for Kochi while considering water conservation aspects. Best Management Practices (BMP), the structural and non structural measures, to manage the quantity and improve the quality of storm water in cost effective manner were reviewed. The BMPs like permeable pavers, Rain barrels and infiltration trenches were analyzed for their hydrological performances using the Storm Water Management Model (SWMM) by US EPA. The present study applies a multi criteria analysis (MCA) namely analytical network process (ANP) to rank the BMPs for flood reduction in the city. MCA makes it possible to tradeoff various other criteria that can bring about sustainability element to the solution. The ranking was obtained considering multiple stakeholders like people, design engineers and policy makers.

Keywords— Flood reduction, Best Management Practices, Multi Criteria Analysis, SWMM, Analytical network Process

I. INTRODUCTION

Kochi, the most populated city in Kerala, is one of the 20 selected smart cities in India. The city is transforming from early-urban to middle urban stage [1]. Even at this growth stage, Kochi lacks sufficient drainage and sewerage system. The storm water in Kochi is managed through natural inland canals and secondary man made drains, constructed even without considering the actual runoff. Lack of sewerage network causes the households to use storm drains for sewage discharge thereby contaminating and clogging the drainage network of city. Any blockage in these open drains or canals results in inundation of the surrounding area with sewage mixed storm water. On the other side, the city is under acute water scarcity due to contaminated ground water and mostly unreliable and insufficient supply through pubic distribution network [2]. Therefore, managing large volume of storm water without flooding while utilizing it as a resource to enhance urban water security is of prime importance to Kochi.

The present work evaluated some of the Best Management Practices (BMP) [3] for storm water management such as rain barrels, infiltration trench, pervious pavements and permeable interlocking pavements. A ranking of BMPs or their combinations were carried out using multi-criteria analysis (MCA) based on technical, social, economic and environmental criteria with focus on flood reduction and harvesting of rainwater in the urban area.

II. STUDY AREA

49 sq. km of eastern Kochi divided into 137 sub catchments was considered in the present study. Catchments were selected such that they are bounded by water bodies on all sides. Overflow effects from the upper catchments are therefore avoided in such hydrologically isolated catchments. The study area and the catchment subdivision are given in figure 1. A drainage map of the study area, was prepared from the ground contour (created using SRTM- DEM) and inland water way map, as shown in figure 2.

Figure 1 - Catchment area and its subdivisions.

Figure 2 also shows problematic area with 500 m buffer zone created for finding out the weightage factor for problematic area nearness. The nodes coming under these buffer zones are more significant in causing flood problems to the public compared to the other areas.

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ABSTRACT

The issue of extreme episodic air pollution events in the Delhi-National Capital Region (NCR), India, during the month of November has been of concern for the last few years. Recent studies have used satellite observations and transport models, which indicate movement of smoke from stubble burning regions in Punjab and Haryana towards Delhi. Quantification of contribution of these emissions to the air pollution in Delhi, however, remains uncertain. In the present study, a similar attempt was made, and measurements are reported from 16 ground-based continuous air quality monitoring stations (CAAQMS) in the Delhi-NCR for the years 2016 and 2017. Time series $PM_{2.5}$ ground measurements were compared with the total Fire Radiative Power (FRP) from Moderate Resolution Imaging Spectroradiometer (MODIS) onboard Terra and Aqua satellites for the airshed for Delhi-NCR. To quantify the smoke contribution from the fire pixels to the Delhi-NCR, the Navy Aerosol Analysis Prediction System (NAAPS) smoke data were used. NAAPS simulations show that the smoke aerosol contribution to Delhi-NCR from stubble burning was ~5-10 $\mu g/m^3$ during the pollution episodic days in 2016. NAAPS results along with the $PM_{2.5}$ measurements at Ludhiana, Punjab, indicate that the stubble burning emissions may contribute 33-66 $\mu g/m^3$ to the $PM_{2.5}$ at Delhi depending on wind conditions and emission levels at the source. The predominant aerosols over the study area during the episodic period were verified to be

1

Monitoring and Analysis of Gas Emissions from a Closed Landfill Site at Jleeb in Kuwait

Paper # 601336

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ABSTRACT

Lack of monitoring for landfill gas (LFG) emissions increases the hazard risk especially when a landfill site is being developed for further uses. This paper discusses the results from a LFG monitoring study carried out at a closed landfill site in Kuwait which lack engineered gas collection and venting system. Jleeb Al Shuyoukh landfill site was active between 1970 and 1993. The composition and seasonal variations in LFG release were monitored at Jleeb landfill site using Gasclam for the continuous LFG monitoring at 4 boreholes during the period July 2018 – Feb 2019. The monitored gases included methane (CH_4), carbon dioxide (CO_2), Carbon Monoxide (CO), Volatile Organic Compounds (VOCs), Hydrogen Sulphide (H_2S) and Oxygen (O_2). The concentration of these gases in %v/v was monitored at 1 hour interval for the entire study period along with atmospheric pressure, borehole pressure and temperature. Consistent methane release with a concentration of 40- 65 %v/v was observed at the boreholes constructed for this study. Among the monitored gases only CO_2 showed a positive correlation with methane. A constant CH_4/CO_2 ratio and lack of correlation with H_2S indicated that the landfill is in stable phase. Lack of correlation between methane release and the bore hole pressure as well as ambient temperature

Controllability studies on fish-shaped unmanned under water vehicle undergoing manoeuvring motions

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Controllability studies on fish-shaped unmanned under water vehicle undergoing manoeuvring motions

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ABSTRACT: Bio-inspired propulsion systems have many advantages over the conventional ones. They are found to be noiseless and eco-friendly. Most of the aquatic locomotion makes use of oscillations, paddling and water-jet for producing net thrust on the body. In this paper a box-fish shaped unmanned underwater vehicle (UUV) has been considered for studying its controllability. A RANS based CFD method has been implemented for simulating manoeuvring motions in heave and pitch to obtain the forces and moments during such motions.

1   INTRODUCTION

Bio-inspired propulsion is a much researched field these days. The fact that, the noise and vibrations produced during the operation of conventional propellers have adversely affected the bio-diversity of oceans, has made bio-inspired propulsion more enticing to mankind. Getting rid of the conventional rotary components of a propulsion system completely is also not practical. Ocean transport do contribute to a mammoth scale of world's economy. Hence there should be a balance between bio-inspired flapping foil as well as the conventional propulsion systems so that we do not tamper much with the ecological systems and at the same time do contribute to the economy.

Nature is known as the master engineer. The efficiency of propulsion of some aquatic animals have struck us in awe and the values of their efficiency have far outperformed those of man-made vehicles. Now it is time to have a few such vehicles operating in the oceans. There have been many studies in the past decades concentrating on the flapping foil mechanisms on ocean vehicles: both surface and sub-sea. Most of them focused on the determination of propulsive efficiency while others on the controllability.

1.1   *Understanding the locomotion of fish*

The locomotion of the fish is indeed complex yet efficient. Various fins involved in the locomotion or swimming are shown in Figure 1.
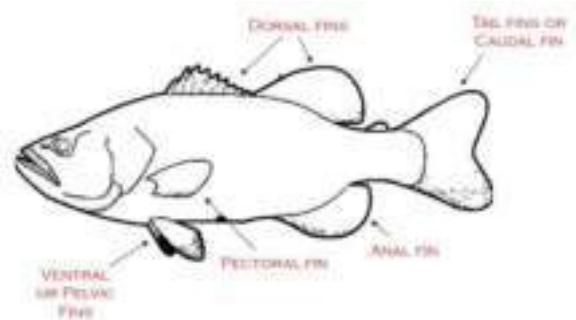

Figure 1: Various fins on the body of a fish

Fishes swim using all the fins. The locomotion a fish swimming with tail fin or the caudal fin and the trunk is broadly classified into angulliform, sub-carangiform, carangiform, thunniform and ostraciiform (Figure 2). From angulliform to ostraciiform the locomotion gets simplified with the deteriorating involvement of the trunk as the undulations of the entire trunk reduces to mere oscillations of the tail during swimming. Locomotion of the fish with varying involvement of the trunk and tail is shown in Figure 3.

In ostraciiform models, the undulation is confined mostly to the caudal fin without moving the body. The thrust for this model is generated with a lift-based method, allowing cruising speeds to be maintained for long periods. This form is considered to be the sim-
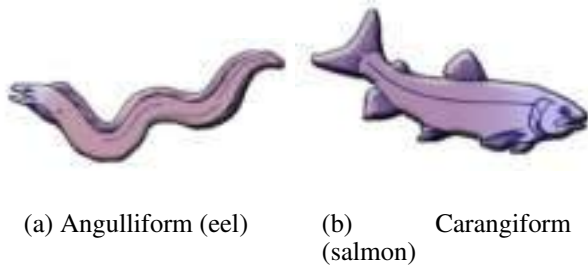
(a) Angulliform (eel)   (b)   Carangiform (salmon)
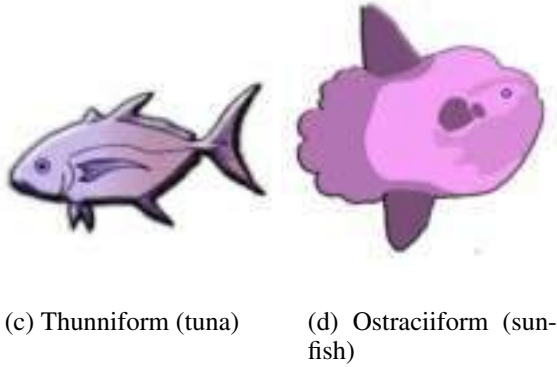
(c) Thunniform (tuna)   (d) Ostraciiform (sunfish)

Figure 2: Fish with different types of tail locomotion

plest of all for carrying out mathematical studies. A UUV with hull form geometrically similar to that of a box-fish, a typical ostraciiform model undergoing manoeuvring motions in heave and pitch, has been analysed for controllability in the present study. UUVs also known as underwater drones are vehicles with no humans onboard during the course of their mission. There are basically two types of UUVs- autonomous underwater vehicle (AUV) and remotely operated vehicle (ROV). AUVs are more or less like robots not entailing human intervention throughout their mission while ROVs are remotely operated from a ground station.

In the case of present work, the vehicle's hull form is more important than its mode of operation. Guidance and control are very important aspects in the design of marine vehicles no matter whether they are surface or underwater vehicles. A motion planning and control system was developed for autonomous surface vehicles by Hinostroza, Guedes Soares, & Xu 2018. This work aims at achieving the first step in controllability predictions-determination of forces and moments during manoeuvring motions. A linear mathematical model combined with a RANS based CFD method has been used for obtaining the thrust generated during the oscillatory motions of the tail with ANSYS FLUENT as the solver. The forces and moments acting on the hull form in both static and dynamic manoeuvres have been estimated. This paper is an initial step towards the controllability and stability prediction of fish-shaped UUVs which could be used in search and rescue as well as surveillance missions. Hence it is imperative to predict the trajectory of such vessels well in advance through controllability studies of its hull form.
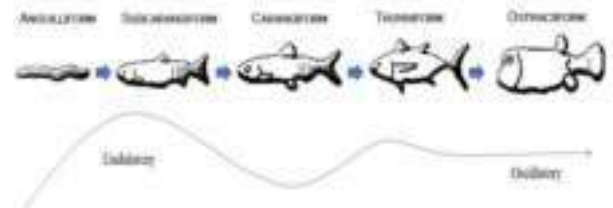

Figure 3: Undulatory motion of the entire trunk to oscillatory motion of the tail

It is quite evident that the ostraciiform type of locomotion is the simplest mode of locomotion. A design based on this type of locomotion will be obviously the most feasible for a UUV. The studies on ostraciiform type of locomotion was reported by Blake 1977. The study made some interesting observations. For slow progression, the caudal fin inclination with the longitudinal axis of the body is about 3 to 6 deg while for fast progression, the angle is 35 deg. 3-D manoeuvring studies were carried out on a fish-like robot by Wu, Yu, Su, & Tan 2014. The robotic fish here was fabricated using multi-link joints to obtain the agility during swimming and hence better manoeuvrability. The present study considers the controllability aspects of a box-fish by numerically simulating the manoeuvring motions.

Not much work has been reported on the determination of hydrodynamic derivatives of the body form for assessing the vessels̋ controllability. This paper presents a method for numerically evaluating the hydrodynamic forces and moments-an initial step towards the estimation of hydrodynamic derivatives and thereby the controllability of a box-fish shaped underwater vehicle.

2 UUV GEOMETRY

A box fish in its three dimensional configuration is shown in Figure 4. The principal particulars of the fish are given in Table 1.

Table 1: Principal particulars of the UUV

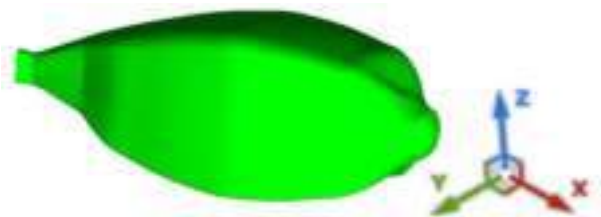| Dimension	Size (metres)
Length (L)	1.3
Breadth (B)	0.5
Depth (D)	0.5

Figure 4: Three dimensional representation of the box-fish shaped UUV

3 MATHEMATICAL MODEL

The Cartesian co-ordinate system of the UUV is shown in Figure 5. The conventional North-East-Down (NED) system is followed here.
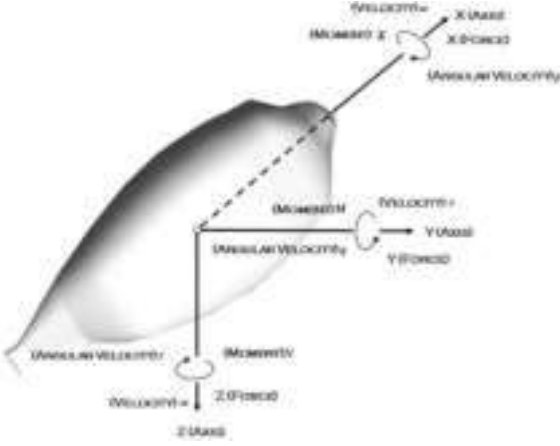

Figure 5: Co-ordinate system used in the study

A linear mathematical model describing the manoeuvring motions of the UUV is represented by Equations (1) through (6)

$$X = X_{\dot{u}}\dot{u} + X_{u|u|}u^2 + X_w w$$
$$+ X_q q + X_\delta \delta + X_T \tag{1}$$

$$Y = Y_{\dot{v}}\dot{v} + Y_v v + Y_p p + Y_r r + Y_\delta \delta \tag{2}$$

$$Z = Z_{\dot{w}}\dot{w} + Z_w w + Z_u u + Z_q q + Z_\delta \delta \tag{3}$$

$$K = K_{\dot{p}}\dot{p} + K_p p + K_v v + K_r r + K_\delta \delta \tag{4}$$

$$M = M_{\dot{q}}\dot{q} + M_q q + M_w w + M_u u + M_\delta \delta \tag{5}$$

$$N = N_{\dot{r}}\dot{r} + N_r r + N_v v + N_p p + N_\delta \delta \tag{6}$$

where subscript T represents thrust and δ, the rudder angle.

4 NUMERICAL EVALUATION OF CONTROLLABILITY IN VERTICAL PLANE

4.1 *Numerical Modelling and Meshing*

For studying the hydrodynamic forces and moments on the UUV during manoeuvring motion there are two basic methods, viz. numerical and experimental. While experimental methods involve prohibitively expensive and rare facilities, numerical methods offer the ease of bringing tedious tasks to desks. However numerical methods have not yet become self sufficient to completely replace experiments. They definitely offer promising inputs to the conceptual design. In this paper an attempt has been made to simulate
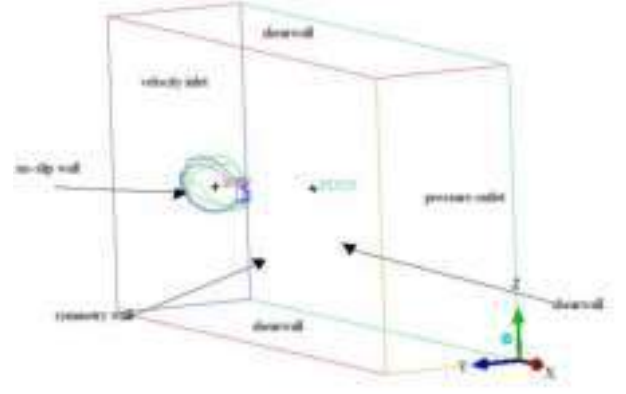

Figure 6: Computational domain with its boundaries

the manoeuvring motions in the vertical plane of the UUV's motions.

Geometric modelling and meshing has been carried out using the commercial package ANSYS ICEM CFD. Figure 6 shows the computational domain. Its extends are $2.0L \leq x \leq 5.0L$, $2.0L \leq y \leq 2.0L$ and $0 \leq z \leq 2.0L$.

An unstructured meshing strategy is employed here. The minimum cell size has been calculated following the method described by Chandran, Janardhanan, Menon, et al. 2018.

Boundary layer thickness and the near wall element size have been calculated from boundary layer theory. The thickness of laminar sub-layer is obtained from Equation (7) (Schlichting & Gersten 2016).

$$\delta' = \frac{11.6v}{V^*} \tag{7}$$

where V^* is the frictional velocity given by Equation (8)

$$V^* = \sqrt{\frac{\tau_0}{\rho}} \tag{8}$$

and τ_0 , the wall shear stress, is obtained as in Equation (9).

$$\tau_0 = \frac{0.664}{\sqrt{Re_L}} \cdot \frac{\rho V^2}{2} \tag{9}$$

where, V is the flow velocity and Re_L the length based Reynolds number.

The mesh generated in the computational domain in shown in Figure 7(a). The magnified view around the fish body is shown in figure 7(b).

A velocity corresponding to $Re = 0.5 \times 10^6$ is imposed on the velocity inlet. The outlet is considered to be a pressure outlet. Half-fish model is used with the plane holding mid x-y plane as a symmetry wall. Non-slip boundary condition is assigned to the UUV body and slip walls to the far-field.
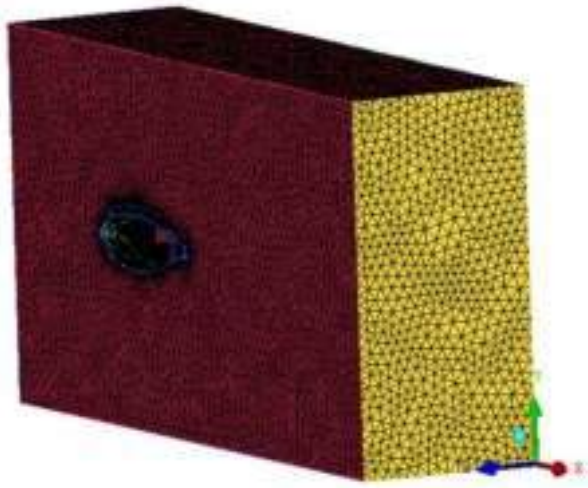
(a) Mesh in the domain
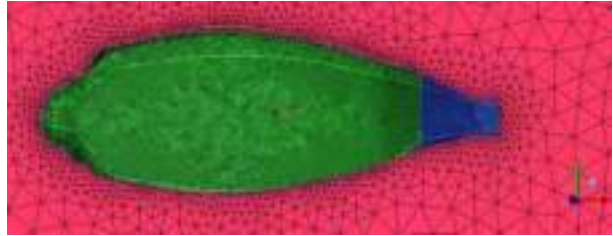
(b) Magnified view around the UUV body

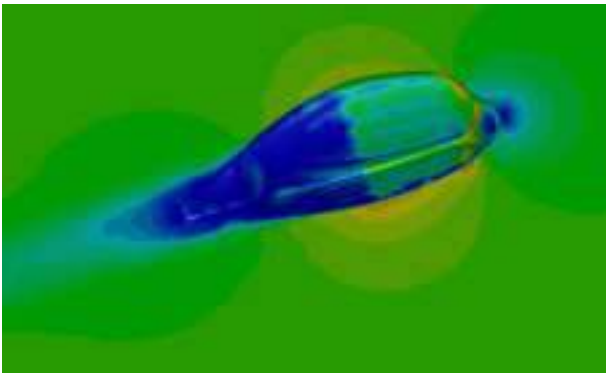Figure 7: Unstructured mesh for computation

Figure 8: Dynamic pressure contours on the half-UUV

4.2 *Steady-state predictions*

Steady simulations are carried out with $k - \omega$ SST two equation model. PISO scheme is used for pressure velocity coupling. The convergence criteria is set to 10^{-7}. The simulations have been carried out using ANSYS FLUENT version 18.1. Dynamic pressure contours on the half-fish model is shown in Figure 8.

4.3 *Static manoeuvre simulations*

As the 3D simulations were time consuming, for faster predictions, a cut section of the UUV in the 2D plane is used for further analysis. The coefficients of drag (C_D) and lift (C_L) obtained from 3D simulations discussed in the previous section have been used as the reference. The challenge in 2D CFD simulations to yield results close to 3D simulations lies in defining the reference value in the third dimension. As this value remains constant and doesn't consider the variation in the geometry of the model, 2D computations provide only approximate values. Nevertheless, these computations provide enough insights into the flow physics as well as hydrodynamic forces and moments in the initial phase of any design.

Simulations have been carried out by varying the drift angle (β) from 0 to 12.5 deg in the vertical plane. The velocity contours around the UUV obtained from the simulation are presented in Figure 9. Figures from 9 (a) to 9 (f) represents different contours for various drift angles.

4.4 *Propulsion Tests*

Propulsion tests have been carried out on a 2D model through prescribed rigid body motions on the tail using the displacement function given by Equation 10

$$\phi = -\phi_a \sin(\omega t) \tag{10}$$

through the user defined functions (UDF) module of the solver.

Here ϕ is the sinusoidal tail oscillation about y-axis, ϕ_a the amplitude of motion taken here as 12.5 deg, ω is the angular frequency, 0.5 rad/s and t, the instantaneous time. The wake oscillations indicating the effective production of thrust is depicted in Figure 10.

4.5 *Dynamic manoeuvre simulations*

Hydrodynamic forces and moments are predicted here by simulating the manoeuvring motions in heave and pitch. Roll motions are not considered.

The sinusoidal motions in heave and pitch have been brought in using UDF module of the solver. The displacement functions in pitch and heave are as given by Equations 10 and 11 respectively.
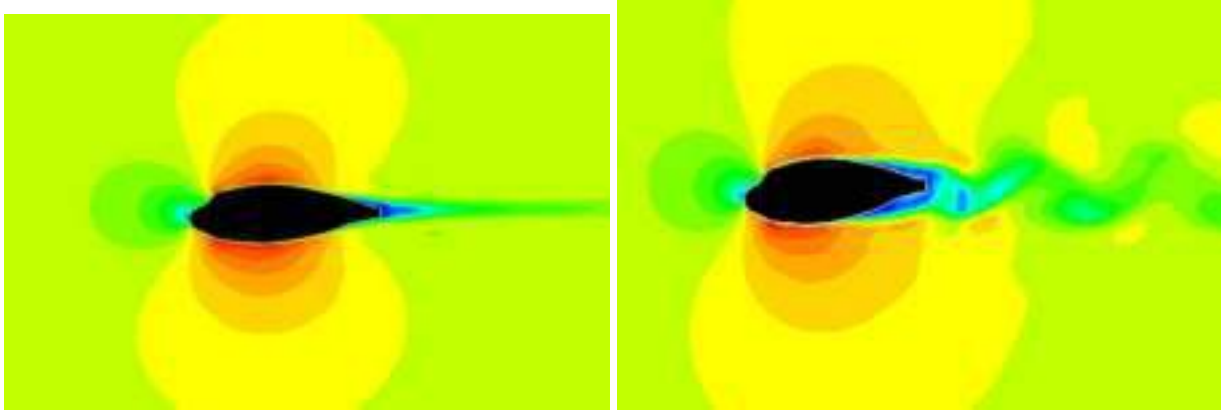
$$z = z_a \sin(\omega t) \tag{11}$$

Here z_a is taken as $D/4$. Simulations have also been carried out imposing combined heave and pitch on the UUV body. Contours of total pressure around the UUV body in heave, pitch and combined motions are shown in Figures 11, 12 and 13 respectively.
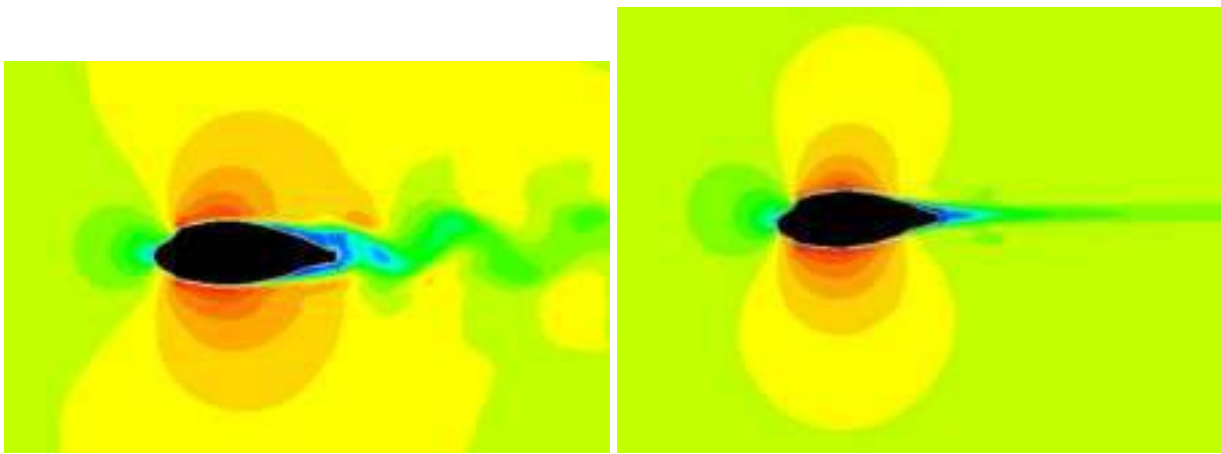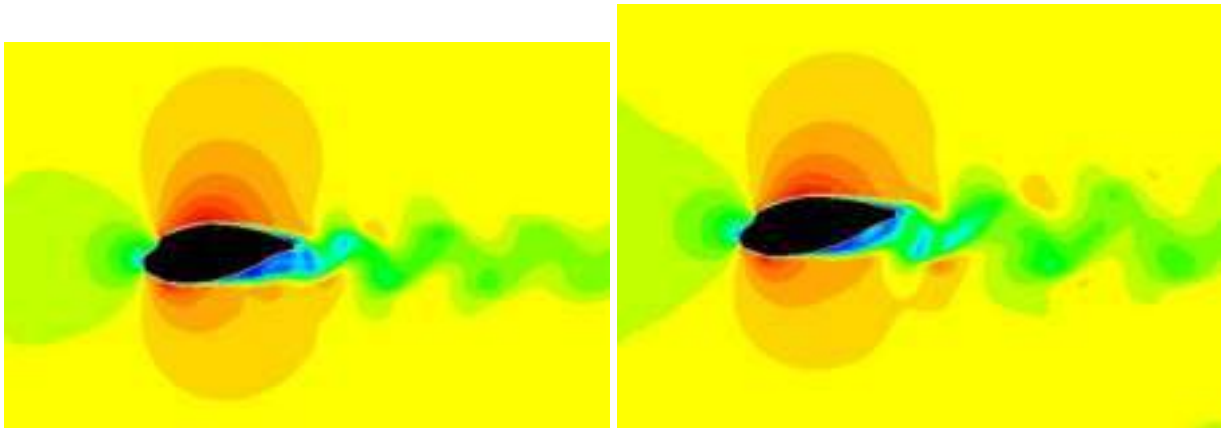
(a) 0 deg   (b) 2.5 deg

(c) 5 deg   (d) 7.5 deg

(e) 10 deg   (f) 12.5 deg

(g) Velocity Range

Figure 9: Velocity contours around the UUV at various angles of attack.
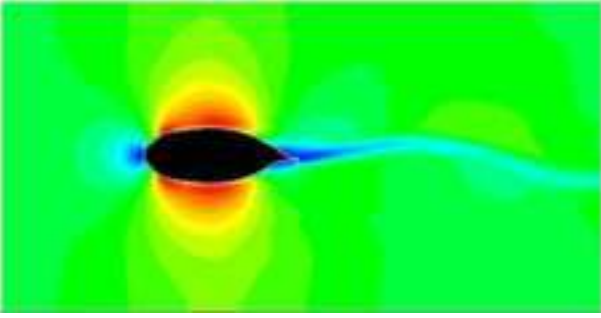
Figure 10: Wake oscillations due to tail motions
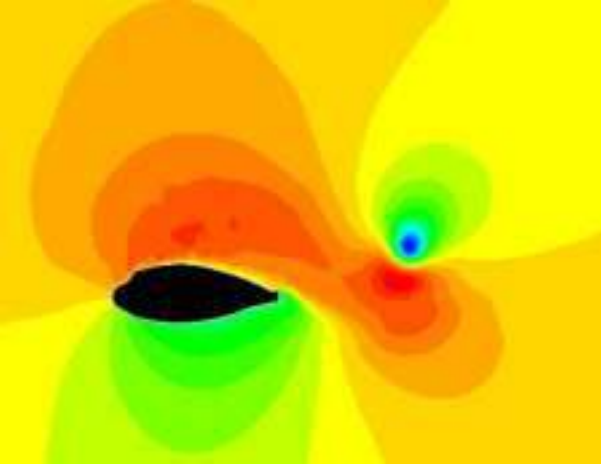

Figure 11: Total pressure contours in heave
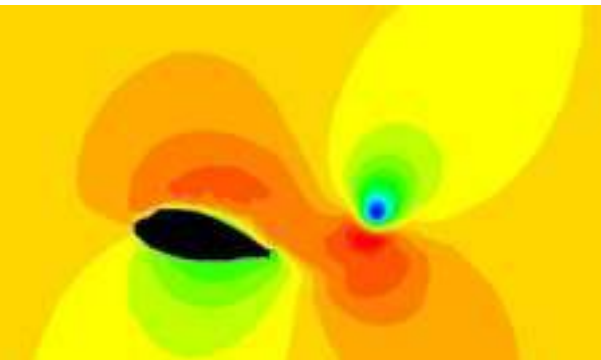

Figure 12: Total pressure contours in pitch

Figure 13: Total pressure contours in combined mode

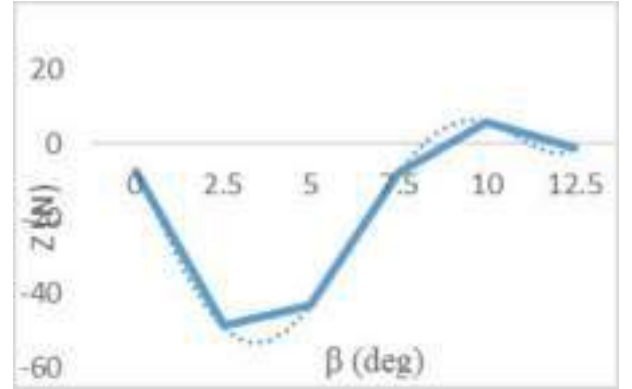Figure 14: Variation of surge force with angle of attack

Figure 15: Variation of heave force with angle of attack

5   RESULTS AND DISCUSSIONS

In the present work manoeuvre motion simulations have been carried out on an ostraciiform locomotion inspired box-fish shaped UUV. At the outset, steady state simulations were carried out on a half model of the UUV for $Re = 0.5 \times 10^6$. The simulation yielded the value of drag coefficient, C_D as 0.019 and lift coefficient, C_L as 0.0684. The 2D simulations with an approximation of the third side yielded $C_D = 0.021$ and $C_L = 0.074$. The results show that 2D simulations can yield better results. Net surge and heave forces have been estimated using the Equations (12) and (13) respectively. As there are not much literature on this study, the results could not be verified.

$$X = F_D \cos\beta + F_L \sin\beta \qquad (12)$$

$$Z = -F_D \sin\beta + F_L \cos\beta \qquad (13)$$

Variation of the surge force, heave force and pitch moments with the angle of attack, β are shown in Figures 14, 15 and 16 respectively. The plots are also supplemented by a smoothing trend line.

The prediction of hydrodynamic forces and moments in the case of box-fish like bodies is not as straight forward as in the case of streamlined ships and submarines. The body being bluff, sheds vortices at moderate angles (say 7.5 deg) of attack which shows a sudden drop in surge and heave forces as well as in pitch moment. Later beyond 10 deg, the formation of vortices stabilizes and are expected to contribute to induced components of surge, heave and
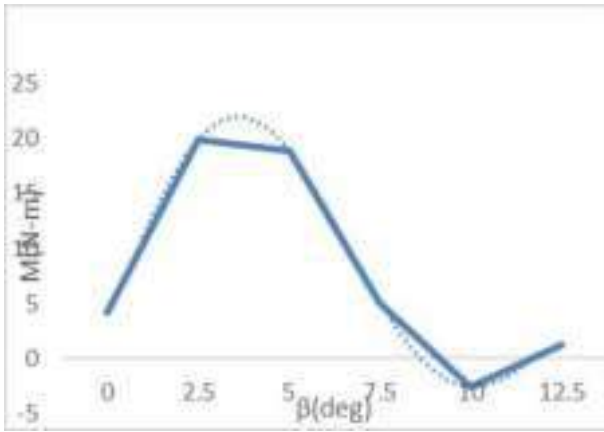
Figure 16: Variation of pitch moment with angle of attack

pitch and hence a rise in the trend is seen.The static manoeuvre simulation tests on further analysis provide the w dependent derivatives.

The propulsion simulation using the oscillation of the tail show an oscillating wake with very weak vortices shedding and disappearing in no time. Hence ostraciiform fish exhibits sluggish locomotion. The maximum thrust generated due to tail motion is found to be $X_T = 2.4N$.

Time histories of surge force, heave force and pitch moment when the UUV is subjected to pure sinusoidal heave motion is shown in Figure 17 plotted for one complete time period of oscillation ($12.56 rad/s$).

Similarly, the time histories of forces and moment in pitch and combined mode is shown in Figures 18 and 19.

These plots reveal that box-fish, due to its asymmetry about y-z plane doesn't produce symmetrical surge forces while its symmetry in x-z as well as x-y planes resulted in symmetrical heave forces and pitch moments. From heave simulations, the hydrodynamic coefficients that can be evaluated are X_w, Z_w and M_w. From the pitch simulations the derivatives X_q, Z_q and M_q can be evaluated. Combined mode simulations yield coupled derivatives which are not of interest to this paper. The other derivatives can also be evaluated considering the motions in the horizontal plane and also by considering roll into account.

6 CONCLUSIONS

Box-fish owing to its non-streamlined shape has poor controllability. They need extra thrust from the pectoral fins to supplement the thrust produced by the caudal fin. Their tail length is too short to generate reverse Von-Kármán vortex street of vortices for improved power. This tail form helps the fish in sustaining power for a longer time. Nevertheless, this work provides an initial frame work for the estimation of hydrodynamic derivatives for a UUV in the form of a box fish-the simplest possible mode of implementation for bio-inspired propulsion. 2D results have helped us in reasonable qualitative predictions. Quantitatively, the results are yet to be verified either

with experimental or published ones. For more accurate prediction, overset grids and 3D models are suggested.

7 FUTURE WORK

Nature has its own way of compensating for the shortcomings imposed on its own creation. The carapace on the fish's body is believed to reduce drag and direct flow such that the fish attains better manoeuvrability (Van Wassenbergh, van Manen, Marcroft, Alfaro, & Stamhuis 2015). Moreover, the role of the pectoral fins in augmenting the thrust produced by caudal fin is unexplored in the present work. The present work will be extended with the inclusion of carapace and pectoral fins in the future works. The hydrodynamic forces and moments will be analyzed using a Fourier series method (Janardhanan & Krishnankutty 2009) for obtaining the hydrodynamic derivatives of the hull form.The trajectories of the UUV in standard manoeuvres such a turning circle and zig-zag will be predicted to finally arrive at its controllability, counter-controllability and stability characteristics.

REFERENCES

Blake, R. (1977). On ostraciiform locomotion. *Journal of the Marine Biological Association of the United Kingdom 57*(4), 1047–1055.

Chandran, V., S. Janardhanan, V. Menon, et al. (2018). Numerical study on the influence of mass and stiffness ratios on the vortex induced motion of an elastically mounted cylinder for harnessing power. *Energies 11*(10), 2580.

Hinostroza, M., C. Guedes Soares, & H. Xu (2018). Motion planning, guidance and control system for autonomous surface vessel. In *ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering*, pp. V11BT12A016–V11BT12A016. American Society of Mechanical Engineers.

Janardhanan, S. & P. Krishnankutty (2009). Prediction of ship maneuvering hydrodynamic coefficients using numerical towing tank model tests. In *12th Numerical Towing Tank Symposium*.

Schlichting, H. & K. Gersten (2016). *Boundary-layer theory*. Springer.

Van Wassenbergh, S., K. van Manen, T. A. Marcroft, M. E. Alfaro, & E. J. Stamhuis (2015). Boxfish swimming paradox resolved: forces by the flow of water around the body promote manoeuvrability. *Journal of the Royal Society Interface 12*(103), 20141146.

Wu, Z., J. Yu, Z. Su, & M. Tan (2014). Implementing 3-d high maneuvers with a novel biomimetic robotic fish. *IFAC Proceedings Volumes 47*(3), 4861–4866.
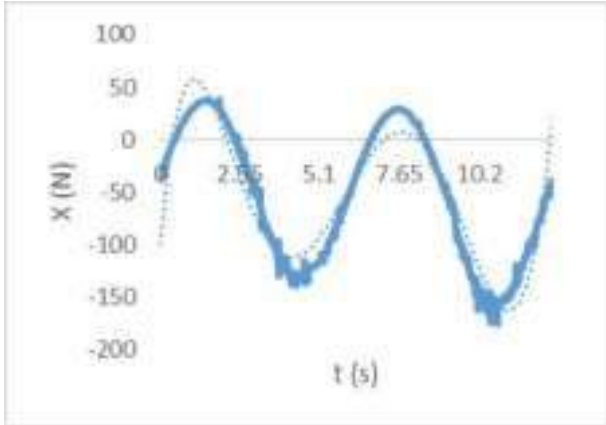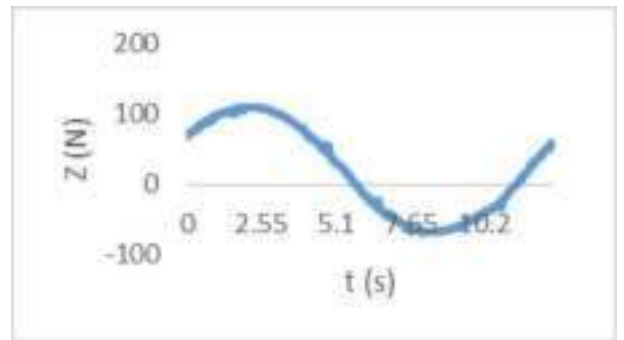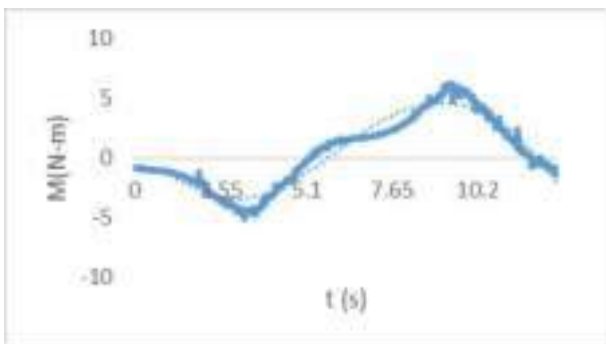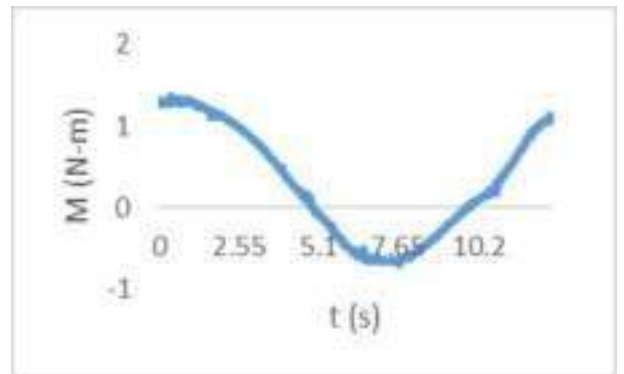
(a) Surge force
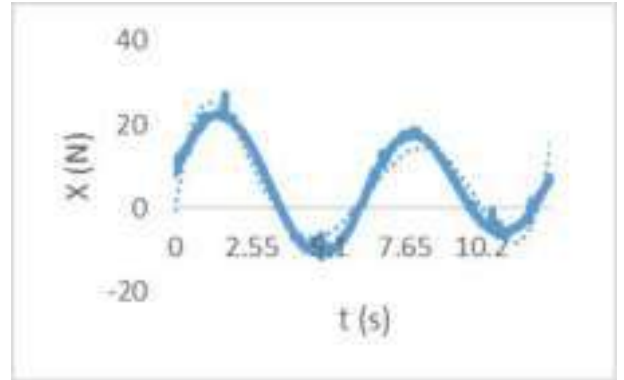
(a) Surge force
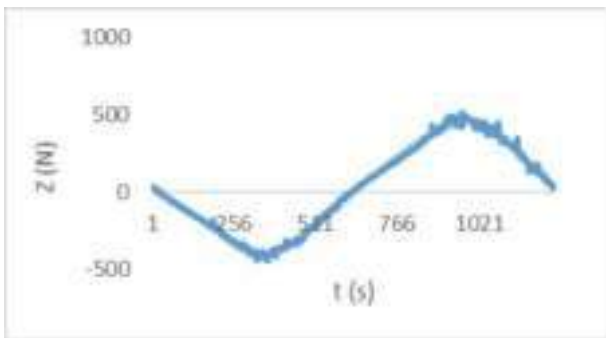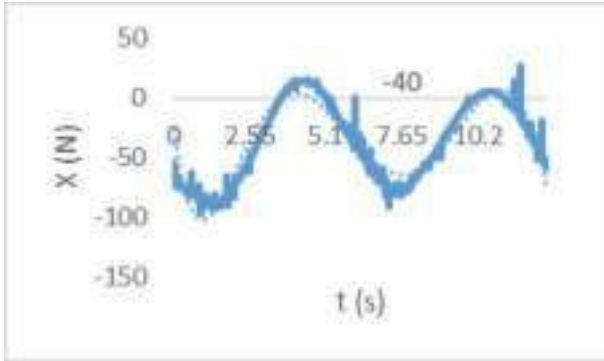

(b) Heave force

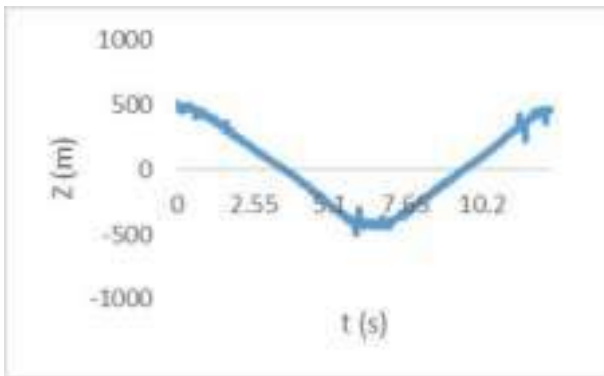(b) Heave force

(c) Pitch moment

(c) Pitch moment

Figure 17: Time histories of forces and moment in heaving motion
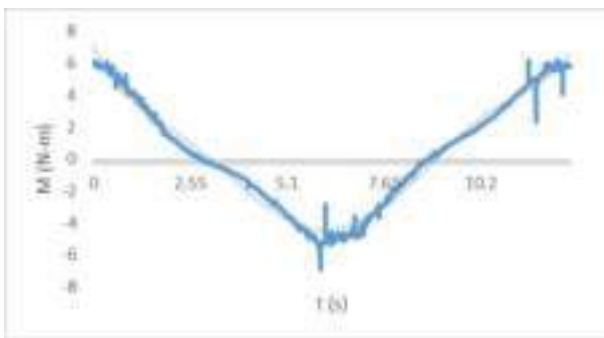
Figure 18: Time histories of forces and moment in pitching motion

(a) Surge force

(b) Heave force

(c) Pitch moment

Figure 19: Time histories of forces and moment in surge motion

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Abstract:
Support Vector Machine (SVM) is one of the main classification techniques used in many security-related applications like malware detection, spam filtering, etc. To incorporate SVM into real-world security applications they must be able to cope up with the attack patterns that will lead to misclassifications. In this system, the vulnerability of SVM to evasion attacks are measured. A simple but effective approach is presented that can be exploited to systematically assess the security of widely-used classification algorithms against evasion attacks. To identify the vulnerabilities some transformations are applied to the testing set of handwritten digit images. The obtained result is plotted as a confusion matrix that allows the visualization of the performance of the algorithm against evasion attack. The work demonstrates the correctness and performance of existing adversarial systems. This work also compares the performance level of feature descriptors like Speeded Up Robust Features (SURF) and Histogram of Oriented Gradients (HOG) and their level of vulnerability to the evasion attacks are also measured. It can be inferred from our system that, even though both HOG and SURF are vulnerable to evasion attacks, those images that are extracted using SURF is less vulnerable compared to those images extracted using HOG features.

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☰ Contents

I. Introduction

Nowadays machine learning algorithms are used in a wide range of applications. It is widely used in security sensitive applications such as malware detection and spam detection because of its ability to detect attacks or variants of known ones. Evasion attacks [6] are the most popular type of attack that can occur during system operation in adversarial settings. Evasion attacks manipulate the input data at test time and cause misclassifications. Even though many pattern recognition techniques are used in security sensitive applications to distinguish between malicious and legitimate samples, still there exist some attackers who intend to classify malicious data as legitimate data at test time. Current research shows the fact that SVM are vulnerable to evasion attacks as they never consider the existence of an attack. Adversarial machine learning algorithms [7] are built to exploit the vulnerabilities in a machine learning algorithm. These vulnerabilities are simulated by training the learning algorithm under various attack scenarios and policies. To better understand the vulnerability of SVM classifier in adversarial settings some manipulations are made in the input data at test time.

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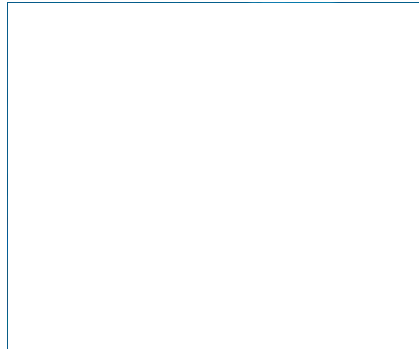
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The NLP applications uses the parts of speech tagging as the preprocessing step. For making POS tagging accurate, various techniques have been explored. But in Indian languages, not much work has been done. This paper describes Part of Speech Tagger by incorporating Hidden Markov Model is built. Supervised learning approach is implemented in which, already tagged sentences in Malayalam is used to build Hidden Markov Model.

Published in: 2019 International Conference on Smart Systems and Inventive Technology (ICSSIT)

Date of Conference: 27-29 November 2019

Date Added to IEEE *Xplore*: 10 February 2020

▶ **ISBN Information:**

DOI: 10.1109/ICSSIT46314.2019.8987786

Publisher: IEEE

Conference Location: Tirunelveli, India

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☰ Contents

I. Introduction

Linguistic processing uses Part of Speech (POS) as a feature to translate the sentences. A POS Tagger is a translator that takes the sentences and outputs the word sequences with its part of speech tags. Tagger examines each word with its context in the sentence during the analysis process.

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Simulation-Based Performance Analysis of Location-Based Opportunistic Routing Protocols in Underwater Sensor Networks Having Communication Voids

Sonali John, Varun G. Menon ✉ & Anand Nayyar

Conference paper | First Online: 25 October 2019

Abstract

Recently, Underwater Wireless Sensor Networks (UWSNs) have emerged as a prominent research area in the networking domain due to their wide range of applications in submarine tracking, disaster detection, oceanographic data collection, pollution detection, and underwater surveillance. With its unique

characteristics like continuous movement of sensor nodes, limitations in bandwidth and high utilization of energy, efficient routing and data transfer in UWSNs have remained a challenging task for researchers. Almost all the protocols proposed for terrestrial sensor networks are inefficient and do not perform well in an underwater environment. Recently Location-Based Opportunistic Routing Protocols have been observed to perform well in UWSN environments. But it is also observed that these protocols suffer from performance degradation in UWSN networks with communication voids. The objective of this research paper is to discuss the working of major Location-Based Opportunistic Routing Protocols in UWSNs with communication voids and to highlight their issues and drawbacks. We analyzed the Quality of Service parameters, packet delivery ratio, end-to-nd delay, throughput, and energy efficiency of two major Location-Based Opportunistic Routing Protocols, i.e., Vector-Based Forwarding (VBF) and Hop-by-Hop VBF (HH-VBF) in UWSNs with communication voids using NS-2 simulator with Aqua-Sim extension. Simulation results state that both VBF and HH-VBF protocols suffered from performance degradations in UWSNs with communication voids. In addition to this, the paper also highlights open issues for UWSN to assist researchers in designing efficient routing protocols for UWSNs having multiple communication voids.

Keywords

Aqua-Sim   **Communication void**

Hop-by-Hop Vector-Based Forwarding (HH-VBF)

NS-2   **Opportunistic routing**

Performance analysis   **Quality of Service (QoS)**

Underwater Wireless Sensor Networks (UWSNs)

Vector-Based Forwarding (VBF)

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References

1. Chen, Y., Jin, X., Xu, X.: Energy-efficient mobile data collection adopting node cooperation in an underwater acoustic sensor network. China Commun. **14**(6), 32–42 (2017)

2. Wang, Z., Han, G., Qin, H., Zhang, S., Sui, Y.: An energy-aware and void-avoidable routing protocol for underwater sensor networks. IEEE Access **6**, 7792–7801 (2018)

3. Akyildiz, I.F., Pompili, D., Melodia, T.: Underwater acoustic sensor networks: research challenges. Ad Hoc Netw. **3**(3), 257–279 (2005)

4. Akyildiz, I.F., Pompili, D., Melodia, T.: State-of-the-art in protocol research for underwater acoustic sensor networks. In: Proceedings of the 1st ACM International Workshop on Underwater networks —WUWNet '06 (2006)

5. Açar, G., Adams, A.: ACMENet: an underwater acoustic sensor network protocol for real-time environmental monitoring in coastal areas. IEE Proc. Radar Sonar Navig. **153**(4), 365 (2006)

6. Partan, J., Kurose, J., Levine, B.N.: A survey of practical issues in underwater networks. In: Proceedings of the 1st ACM International Workshop on Underwater Networks—WUWNet '06 (2006)

7. Biswas, S., Morris, R.: ExOR. ACM SIGCOMM Comput. Commun. Rev. **35**(4), 133 (2005)

8. Bruno, R., Conti, M., Nurchis, M.: Opportunistic packet scheduling and routing in wireless mesh networks. In: 2010 IFIP Wireless Days (2010)

9. Chakchouk, N.: A survey on opportunistic routing in wireless communication networks. IEEE Commun. Surv. Tutor. **17**(4), 2214–2241 (2015)

10. Nayyar, A., Batth, R.S., Ha, D.B., Sussendran, G.: Opportunistic networks: present scenario—a mirror review. Int. J. Commun. Netw. Inf. Secur. (IJCNIS) **10**(1), 223–241 (2018)

11. Menon, V.G., Prathap, P.M.: Comparative analysis of opportunistic routing protocols for underwater acoustic sensor networks. In: 2016 International Conference on Emerging Technological Trends (ICETT) (2016)

12. Menon, V.G.: Opportunistic Routing Protocols in Underwater Acoustic Sensor Networks: Issues, Challenges, and Future Directions. Magnetic Communications: From Theory to Practice, pp. 127–148. CRC Press, Boca Raton (2018)

13. Menon, V.G., Prathap, P.M.: Moving From Topology-Dependent to Opportunistic Routing Protocols in Dynamic Wireless Ad Hoc Networks: Challenges and Future Directions. Algorithms, Methods, and Applications in Mobile Computing and Communications, pp. 1–23. IGI Global, Hershey (2017)

14. Menon, V.G.: Analyzing the performance of random mobility models with opportunistic routing. Adv. Wirel. Mob. Commun. **10**(5), 1221–1226 (2017)

15. Han, M.K., Bhartia, A., Qiu, L., Rozner, E.: O3. In: Proceedings of the Twelfth ACM International

Symposium on Mobile Ad Hoc Networking and Computing—MobiHoc '11 (2011)

16. Menon, V.G., Prathap, P.M.: Survey on latest energy based routing protocols for underwater wireless sensor networks. Int. J. Comput. Netw. Wirel. Commun. **6**(6), 52–55 (2017)

17. Ayaz, M., Abdullah, A., Faye, I., Batira, Y.: An efficient dynamic addressing based routing protocol for underwater wireless sensor networks. Comput. Commun. **35**(4), 475–486 (2012)

18. Yan, H., Shi, Z. J., Cui, J.: DBR: depth-based routing for underwater sensor networks. In: NETWORKING 2008 Ad Hoc and Sensor Networks, Wireless Networks, Next Generation Internet, pp. 72–86 (2008)

19. Jafri, M.R., Sandhu, M.M., Latif, K., Khan, Z.A., Yasar, A.U., Javaid, N.: Towards delay-sensitive routing in underwater wireless sensor networks. Proc. Comput. Sci. **37**, 228–235 (2014)

20. Wang, C., Zhang, G., Zhang, L., Shao, Y.: Improvement research of underwater sensor

network routing protocol HHVBF. In: 11th International Conference on Wireless Communications, Networking and Mobile Computing (WiCOM 2015) (2015)

21. Xie, P., Cui, J., Lao, L.: VBF: vector-based forwarding protocol for underwater sensor networks. In: NETWORKING 2006. Networking Technologies, Services, and Protocols; Performance of Computer and Communication Networks; Mobile and Wireless Communications Systems (2006)

22. Ghoreyshi, S., Shahrabi, A., Boutaleb, T.: A novel cooperative opportunistic routing scheme for underwater sensor networks. Sensors **16**(3), 297 (2016)

23. Nicolaou, N., See, A., Xie, P., Cui, J., Maggiorini, D.: Improving the robustness of location-based routing for underwater sensor networks. In: OCEANS 2007—Europe, pp. 1–6. Aberdeen (2007)

24. Ghoreyshi, S.M., Shahrabi, A., Boutaleb, T.: Void-handling techniques for routing protocols in underwater sensor networks: survey and

challenges. IEEE Commun. Surv. Tutor. **19**(2), 800–827 (2017)

25. Menon, V.G., Joe Prathap, P.M.: Opportunistic routing with virtual coordinates to handle communication voids in mobile ad hoc networks. In: Advances in Intelligent Systems and Computing, pp. 323–334 (2015)

26. Ghoreyshi, S.M., Shahrabi, A., Boutaleb, T.: An opportunistic void avoidance routing protocol for underwater sensor networks. In: 2016 IEEE 30th International Conference on Advanced Information Networking and Applications (AINA) (2016)

27. Menon, V.G., Prathap, P.M.: A review on efficient opportunistic forwarding techniques used to handle communication voids in underwater wireless sensor networks. Adv. Wirel. Mob. Commun. **10**(5), 1059–1066 (2017)

28. Darehshoorzadeh, A., Boukerche, A.: Underwater sensor networks: a new challenge for opportunistic routing protocols. IEEE Commun. Mag. **53**(11), 98–107 (2015)

29. Hwang, D., Kim, D.: DFR: directional flooding-based routing protocol for underwater sensor networks. In: OCEANS 2008 (2008)

30. Coutinho, R.W., Boukerche, A., Vieira, L.F., Loureiro, A.A.: GEDAR: geographic and opportunistic routing protocol with depth adjustment for mobile underwater sensor networks. In: 2014 IEEE International Conference on Communications (ICC) (2014)

31. Chen, Y.S., Juang, T.Y., Lin, Y.W., Tsai, I.C.: A low propagation delay multi-path routing protocol for underwater sensor networks. J. Internet Technol. **11**, 153–165 (2010)

32. Hao, K., Jin, Z., Shen, H., Wang, Y.: An efficient and reliable geographic routing protocol based on partial network coding for underwater sensor networks. Sensors **15**(6), 12720–12735 (2015)

33. Noh, Y., Lee, U., Wang, P., Choi, B.S., Gerla, M.: VAPR: void-aware pressure routing for underwater sensor networks. IEEE Trans. Mob. Comput. **12**(5), 895–908 (2013)

34. Jornet, J.M., Stojanovic, M., Zorzi, M.: Focused beam routing protocol for underwater acoustic networks. In: Proceedings of the Third ACM International Workshop on Wireless Network Testbeds, Experimental Evaluation and Characterization—WuWNeT '08 (2008)

35. Li, Z.L., Yao, N.M., Gao, Q.: Relative distance-based forwarding protocol for underwater wireless sensor networks. Appl. Mech. Mater. **437**, 655–658 (2013). https://doi.org/10.4028/www.scientific.net/amm.437.655

36. Nayyar, A., Puri, V., Le, D.N.: Comprehensive analysis of routing protocols surrounding underwater sensor networks (UWSNs). In: Data Management, Analytics and Innovation (pp. 435–450). Springer, Singapore (2019)

37. Nayyar, A., Singh, R.: A comprehensive review of simulation tools for wireless sensor networks (WSNs). J. Wirel. Netw. Commun. **5**(1), 19–47 (2015)

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RubiCrypt: Image Scrambling Encryption System Based on Rubik's Cube Configuration

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This paper proposes an image-encryption algorithm based on the Rubik's cube configuration,allowing for multi-dimensional security keys. The input image is scrambled using the random configuration of a Rubik's cube. Here the aim is to encrypt or decrypt an image using a custom pixel scrambling algorithm. It uses a Rubik's Cube as the encryption & decryption key, which allows for 43,252,003,274,489,856,000 (43 quintillion) distinct key configurations. RubiCrypt makes use of several image processing algorithms from OpenCV for scanning the cube in real-time. Finally, Analysis along with experimental results shows that the proposed encryption scheme can achieve good encryption as well asconsiderable hide-ability. Which can resist all the elements related with statistical and differential attacks.

Published in: 2019 IEEE International Conference on System, Computation, Automation and Networking (ICSCAN)

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1. Introduction

Privacy is one of the key factors governing a technological deployment. The end user privacy is always kept in mind by developers all over the world. Especially in areas such as cloud computing which holds large contents of digital user data, mere raw input to these systems makes the user data unsafe.

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A Comparative Study of Performance and Security Issues of Public Key Cryptography and Symmetric Key Cryptography in Reversible Data Hiding

S. Anagha ✉, Neenu Sebastian & K. Rosebell Paul

Conference paper │ First Online: 21 May 2019

518 Accesses │ **1** Citations

Part of the Advances in Intelligent Systems and Computing book series (AISC,volume 939)

Abstract

Security of data is the main aspect to be considered in the digital network. Data transmission can be made secure by performing reversible data hiding in images. Here the data can be hidden and transmitted inside a host image. Security to the image can be provided by various algorithms like symmetric key algorithm and public key algorithms.

This paper provides a comparative study of AES and RSA algorithms for image encryption and reversible data hiding. Data embedding in both cases is done by histogram shifting method. The RSA algorithm can be used for encrypting the image to provide higher security but consumes more time whereas the security of image in AES algorithm is comparatively small but consumes only small amount of time for both encryption and decryption.

Keywords

Encryption **Data hiding** **Data embedding**

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References

1. Li, M., Li, Y.: Histogram shifting in encrypted images with public key cryptosystem for reversible data hiding. Signal Process. **130**, 190–196 (2017)

2. Zhang, X., Wang, J., Cheng, H.: Lossless and reversible data hiding in encrypted images with public key cryptography. IEEE Trans. Circuits Syst. Video Technol. (2015). http://dx.doi.org/10.1109/TCSVT.2015.2433194

3. Lee, X., Zhang, W., Gui, X., Lang, B.: A novel reversible data hiding scheme based on two-dimensional difference-histogram modification. IEEE Trans. Inf. Forensics Secur. **8**(7), 1091–1100 (2013)

4. Zhang, X.: Reversible data hiding in encrypted images. IEEE Signal Process. Lett. **18**(4), 255–258 (2011)

5. Tian, J.: Reversible data embedding using a difference expansion. Trans. Circuits Syst. Video Technol. **13**(8), 890 (2003)

6. Ni, Z., Shi, Y., Ansari, N., Su, W.: Reversible data hiding. IEEE Trans. Circuits Syst. Video Technol. **16**(3), 354–362 (2006)

7. Celik, M.U.: Lossless generalized LSB data embedding. IEEE Trans. Image Process. **14**(2), 253–266 (2005)

8. Hong, W., Chen, T., Wu, H.: An improved reversible data hiding in encrypted images using side match. IEEE Signal Process. Lett. **19**(4), 199–202 (2012)

9. Zhang, X.: Separable reversible data hiding in encrypted image. IEEE Trans. Inf. Forensics Secur. **7**(2), 826–832 (2012)

10. Standard picture collection: gray scale images and color images. http://www.media.cs.tsinghua.edu.cn/_ahz/digitalimageprocess/benchmark.htm. Accessed 1 Jan 2016

11. Advanced Encryption standard (AES). https://nvlpubs.nist.gov/nistpubs/fips/nist.fips.197.pdf

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Moving From Topology-Dependent to Opportunistic Routing Protocols in Dynamic Wireless Ad Hoc Networks: Challenges and Future Directions

Varun G. Menon (/affiliate/varun-g-menon/340140/), Joe Prathap P. M.

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Abstract

Mobile ad hoc networks (MANETs) are a collection of wireless devices like mobile phones and laptops that can spontaneously form self-sustained temporary networks without the assistance of any pre-existing infrastructure or centralized control. These unique features have enabled MANETs to be used for communication in challenging environments like earthquake-affected areas, underground mines, etc. Mobility and speed of devices in MANETs have become highly unpredictable and is increasing day by day. Major challenge in these highly dynamic networks is to efficiently deliver data packets from source to destination. Over these years a number of protocols have been proposed for this purpose. This chapter examines the working of popular protocols proposed for efficient data delivery in MANETs: starting from the traditional topology-based protocols to the latest opportunistic protocols. The performances of these protocols are analyzed using simulations in ns-2. Finally, challenges and future research directions in this area are presented.

<div align="center">Chapter Preview</div>

Introduction

Recent advances in wireless technology have led to the exponential growth and usage of wireless mobile devices worldwide. Today billions of wireless devices are connected with the help of infrastructure like access points and base stations. These infrastructure supported wireless networks provide an increasing number of wireless local area network (LAN) hot spots, allowing travelers and users with portable laptops and mobile phones to surf the Internet from hotels, airports, railway stations, coffee shops and other public locations. However, these infrastructure supported wireless network comes with a number of limitations. They consume plenty of time and money for installation and maintenance; have constraints in flexibility, suffer from low utilization of local wireless resources and are particularly vulnerable to natural disasters and unpredicted failures. To overcome these limitations, self-sustained, infrastructure-less and decentralized wireless networks have been proposed, known as mobile ad hoc networks (Giordano and Lu, 2001; Chlamtac et al., 2003; Menon & Prathap, 2016).

Mobile ad hoc networks (MANETs) are a collection of wireless devices like mobile phones, laptops, PC's and iPads that can form instantaneous temporary networks without the support of any pre-existing network infrastructure or centralized control. It works as an autonomous system of mobile hosts connected by wireless communication links. The network is configured in a way that all the devices can dynamically join or quit the network at any time without disrupting communication between other devices. Every device in the network plays the dual role of a router and a host, cooperates and coordinates with each other to make routing decisions in the network. Data is transmitted in the network in a store and forward manner from the source node to the destination node via the intermediate nodes. Ease of deployment, speed of deployment and the ability to self-organize and self-adapt without the help of any underlying infrastructure has contributed to the growing popularity of MANETs in research as well as in industry. Today MANETs are used for communication and resource sharing in numerous challenging environments like earthquake and volcano affected areas (Mase, 2011; Menon et al., 2016), underground mines, battlefields etc. Figure 1 shows an example MANET used in disaster recovery operations

Figure 1. MANETs in disaster recovery operations

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One of the major challenges in these highly dynamic networks is to efficiently deliver data packets from the source to the destination device. Ensuring reliable and continuous communication between the devices is yet another major challenge in these networks. Over these years a number of routing protocols have been proposed for data delivery and communication in MANETs. Figure 2 gives the taxonomy of all the protocols proposed for MANETs. Recent advancements in wireless technology have enabled mobile devices in MANETs to move freely with higher speeds in random directions. The mobility and speed of these wireless devices have become highly unpredictable and is increasing day by day. Also the number of connected devices in the network is increasing rapidly leading to highly dense and scalable ad hoc networks. As the mobility and number of devices increases in the network the performance of most of the existing routing protocols comes down drastically leading to low transmission efficiency and reduced Quality of Service. Very few researches have been done to identify the reasons behind this performance degradation.

Figure 2. Taxonomy of protocols proposed for MANETs

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Chapter

Opportunistic Routing Protocols in Underwater Acoustic Sensor Networks: Issues, Challenges, and Future Directions

By Varun G. Menon *(/search?contributorName=Varun G. Menon&contributorRole=author&redirectFromPDP=true&context=ubx)*

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Edition	1st Edition
First Published	2019
Imprint	CRC Press
Pages	22
eBook ISBN	9781315156477

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Retinal Image Enhancement by Intensity Index Based Histogram Equalization for Diabetic Retinopathy Screening

Arun Pradeep (ID)**, X. Felix Joseph** (ID)**, and K. A. Sreeja** (ID)

1 Introduction

Retinal exudates that can be visually identified as yellow flecks in fundus images and is considered one of the symptoms arised due to Diabetic Retinopathy. These are mainly due to leakage of lipids in the eyes from the damaged capillaries as shown in Fig. 1. Diagnosis done at an earlier stage can control the degree of impairment caused by leakage of lipids that can ultimately lead to loss of eyesight. Patient friendly studies are centered on the accuracy of exudate detection from RGB fundus images with the help of machine learning.

These images are captured using a fundus camera which may contain effects of noise and uneven illumination and contrast. In order to filter out these undesired effects, literature suggests that pre-processing and image enhancement should be more focused before image segmentation and classification. The study presented by [1] identifies retinal exudates established on spider monkey optimization using an SMO-GBM classifier. Likewise, the image enhancement was done using contourlet transform. The method proposed in [2] uses classification based on Top-k loss method instead of Class Balance Entropy (CBCE) to reduce misclassification in exudate detection.

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The analysis in [3] proposes that Convolutional Neural Network (CNN) can be utilized for a deep learning technique, for exudate detection, but the efficiency is deprived when compared with Residual Network and Discriminative Restricted Boltzmann machines. The color space used in our work is HSI instead of RGB, which gives more attenuation to noise. This method is reiterated by the work suggested by Khojasteh et al. [4] for exudate detection. Holistic texture features of fundus images were extracted and trained to four different classifiers in the study [5] conducted on a public database. Classification of hard exudates from soft exudate using fuzzy logic was the area of interest in [6]. Segmentation of exudates using dynamic decision thresholding was the focus of study in [7]. Their results were validated using lesion and image based evaluation criteria. Circular Hough Transform(CHT) and CNN based detection of exudates were suggested in [8]. A reduced pre-processing strategy for exudate based macular edema recognition using deep residual network was put forward in [9]. Multilayer perceptron based supervised learning is studied in [10] to identify exudate pixels. Further segmentation was done using unsupervised learning with the help of iterative Graph Cut (GC). The entire image is segmented into a series of super pixels in [11] which are considered as candidate pixels.

Also each candidate is characterized by multi-channel intensity features and contextual features. The study in [12] using a neighborhood estimator presents detection of blood vessels followed by segmentation with the help of in-painting the exudates with the help of this estimator. A new approach called voxel classification by a strategy based on layer dependent stratified sampling on OCT image was introduced in [13]. Grayscale morphology based segmentation of exudates was presented in [14] where the candidate pixels' shape was determined with the help of Markovian Segmentation model. Another method using Partial Least Squares (PLS) for detection of exudates is studied in [15]. An image segmentation based high level entity known as splat is used to identify retinal hemorrhages in [16] where pixels sharing similar properties are grouped together to form non-overlapping splats and the features are extracted and classified using supervised learning. The research
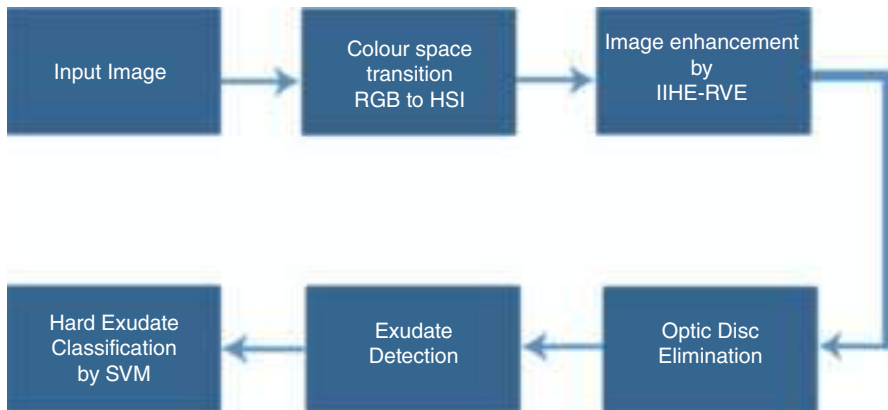
Fig. 2 Depiction of total work flow

study presented in this paper is a modification of our existing algorithm presented in [17]. The method associates both the principles of mathematical morphology operation for detection of exudates and classification and extraction of exudates using a trained classifier. Before the mathematical binary operation, initial pre-processing is done to enhance the fundus image where an algorithm called Intensity Index based Histogram Equalization Technique for retinal vessel enhancement (IIHE-RVE) is proposed. The algorithm of the total work is depicted in Fig. 2.

2 Methodology

Color plane transition from RGB to HSI is performed because the Optic Disc (OD) as well as exudates have analogous brightness characteristics. Many of the imperfections caused by noise and texture in the image can also be reduced by transition to HSI plane [18]. Median filter is applied to reduce the noise in the intensity band of the image. A novel method called Intensity Index based Histogram Equalization Technique for retinal vessel enhancement (IIHE-RVE) is applied to enhance the contrast of the noise free image.

IIHE-RVE is based on the estimation of under radiance of the image which is more effective than the existing Contrast limited adaptive Histogram equalization (CLAHE) algorithm or any other Gaussian function equalization algorithms. The following step is involved in the removal of Optic Disc (OD). It is assumed that the OD exist as the largest bright circular shape component in the image. Finally, exudates are classified into hard and soft exudates using a supervised classifier. Clinical images as well as images from publically available database are validated for the proposed algorithm.

2.1 Image Enhancement

The pre-processing steps involved in this work are shown in Fig. 3. RGB to HSI transition is followed by median filtering and contrast enhancement is done the new technique of histogram equalization.

Applying a tunable parameter ξ, histograms are divided into sub-histograms by computing the split value using the following set of Eqs. 1 and 2

$$\alpha_c(i) = \frac{\phi(i)}{\epsilon} \quad \text{for} \quad 0 \le i \le I - 1 \tag{1}$$

$$\Gamma(k) = \sum_{i=0}^{k} \alpha_c(i) \quad \text{for} \quad 0 \le k \le I - 1 \tag{2}$$

where ϕ denotes the histogram of the image, i represents the intensity value, ϵ represents the pixel numbers for the whole image, and I signifies the total brightness levels in numbers. The parameters Γ and α_c give accumulated normalized histogram count and normalized histogram count, respectively, for the given image. The controlling parameter Γ_p is found by Eq. 3.

$$\sum_{j=0}^{\Gamma_p} \Gamma(j) \approx \xi \quad \text{for any } 0.1 \le \xi \le 0.9 \tag{3}$$

Input Image   HSI image   Intesnity Band Of Image

Image after IIHE-RVE   Median Filtered Image
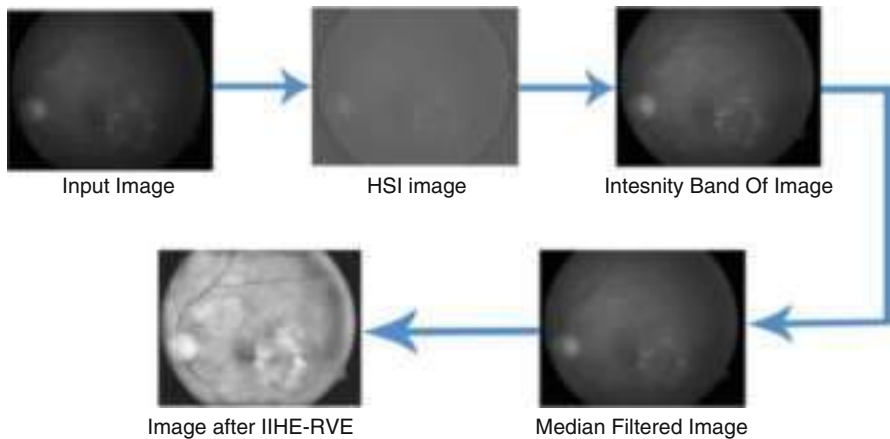
Fig. 3 Steps involved in pre-processing

The split value S_v is found from Eq. 4.

$$S_v = (I - 1) - \Gamma_p - 1 \tag{4}$$

The value of tunable parameter ξ is inversely proportional to enhancement level of the image. Also when ξ increases the value of Γ_p also increases. For a certain low value of ξ, we can acquire a first sub-histogram and for another high value of ξ we can acquire a second sub-histogram. The first and second sub-histograms are equalized specifically. Due to the extendedness of these histograms, the range of pixels having lower intensity can be mapped to a range of higher intensity. Whereas, in the second sub-histogram, the range is less and contains only larger intensity range pixels. Because of this small range, the larger intensity pixels are saved from over enhancement.

2.2 Intensity Index Based Histogram Equalization Technique for Retinal Vessel Enhancement (IIHE-RVE)

According to the algorithm, when the two histograms are obtained, successive integration based on difference of intensity parameters obtained from the iteratively enhanced images is performed. Integration is continued till the absolute difference between the intensity values ω_1 and ω_2 obtained from Eq. 5, for the given image and the equalized image is lower than error referred to as threshold, e. Here, the value of e is taken as 0.002.

Algorithm 1 IIHE algorithm

1: Compute histogram ϕ for image f.
2: Compute intensity values for input image from Eq. 5 for $I = 256$.

$$\omega_1 = \frac{\sum_{i=0}^{I-1} \phi(i) \cdot i}{I \cdot \sum_{i=0}^{I-1} \phi(i)} \tag{5}$$

3: S_v which is the split value is calculated from Eq. 4.
4: Separate the histogram into sub-histograms ϕ_l from radiance range 0 to S_v and ϕ_u from S_{v+1} to $I - 1$.
5: Equalize histograms ϕ_l and ϕ_u in the respective intensity range.
6: Reiterate Step 2 to find the intensity values ω_2 of equalized image.
7: Repeat steps 1–6 until $|\omega_1 - \omega_2| \le e$.
8: Integrate ϕ_l and ϕ_u to re-establish histogram ϕ.

2.3   Optic Disc Elimination

The exudates have similar intensity values as that of optic disc. Opening and Closing
are the two binary operations used for detection of OD in retinal image. The shape
of the OD is obtained from the image I by employing the mathematical closing
operation. Using a threshold operation, the suitable binary image is produced.

The binary image Ω contains various connected components known as C_i which
is based on Eq. 6.

$$\Omega = \bigcup_{k \in m} C_k, C_i \bigcap C_j = 0, \quad \forall \quad i, j \in m, \quad i \neq j \tag{6}$$

where m varies from 1 to k, k symbolizes the connected components. The disc shape
structure when compared to the background pixels are the components of C_i. This
includes the OD also. Hence, an effective separation of OD from other structures is
established. Now, R_i becomes the greatest component that is connected in C_i . The
conciseness of R_i is calculated using Eq. 7:

$$C(R_i) = 4\pi \frac{A(R_i)}{P^2(R_i)} \tag{7}$$

In this equation, $A(R_i)$ signifies pixels' number in the ith region and $P(R_i)$
represents the pixels in region (R_i). Another threshold method is obtained from P-
tile method [19] and Nilback's method[20, 21] in order to obtain the binary image.

The weight factor chosen is 1.3 based on previous conclusions in our method
[17]. In order to delineate the OD on the retinal image, Circular Hough Transfor-
mation (CHT) is employed as studied in[22]. The OD elimination is depicted in
Fig. 4.

2.4   Detection of Exudates

After optic disc elimination, exudate pixels are identified. Using binary closing
operation a 16-pixel radius, flat disc shaped structuring element is utilized and
the exudates pixels are directly identified. Binary closing operation follows this
threshold operation. The blood vessels have a contrast component which is similar
to the contrast component applied in this operation. Hence the image's Standard
Deviation (SD) is calculated using Eq. 8.

$$I_3(x) = \frac{1}{N-1} \sum_{i \in W(x)} \left(I_2(i) - \overline{I_3(x)} \right)^2 \tag{8}$$

| Binary Closing Operation | Threshold Image from Nilback's Method | Threshold Image from p-tile method |

| Optic Disc Eliminated | Circular White Component's Inverted Image | Optic disc depicted as circular white component |
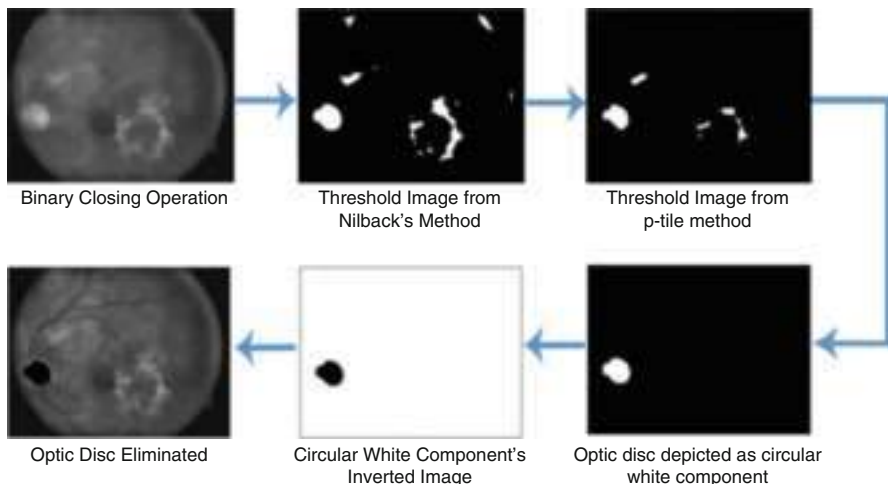
Fig. 4 Steps involved in OD elimination

In this above equation, $W(x)$ symbolizes available pixels available for a sub-window, N symbolizes pixels available in $W(x)$ and $\overline{I_3(x)}$ give the average value for the image $I_3(x)$ where the local contrast image is symbolized by I_3. Using a method called Triangle based threshold [23], the bright regions can be precisely detected and the components can be differentiated. Followed by identification of the high intensity regions, unwanted pixels on the image are eliminated using binary operation called dilation. This method is followed by a flood fill operation that is done on holes so as to regenerate the image. Next, the final step involved in exudate detection is difference image acquisition between from the output image from the threshold image, which is nothing but the brightness based image. As a result, the difference image is superimposed on the original image in order to extract exudate features from the pixels. The whole process of detection of exudates is illustrated in Fig. 5.

2.5 Hard Exudate Classification

The final operation which is the classification of hard exudates from the exudate pixels comprises of a valuation using the features that are usually employed by ophthalmologists to visually distinguish hard exudates. The same features are employed as SVM Classifier's input. The set of features is mentioned in Table 1.

Compared with features published in algorithms [24–26], the above eight features were measured important to decrease processing time by not compromising the efficiency for hard exudate classification. The features mentioned in Table 1 are given to the input of an SVM classifier where the output shows the classification
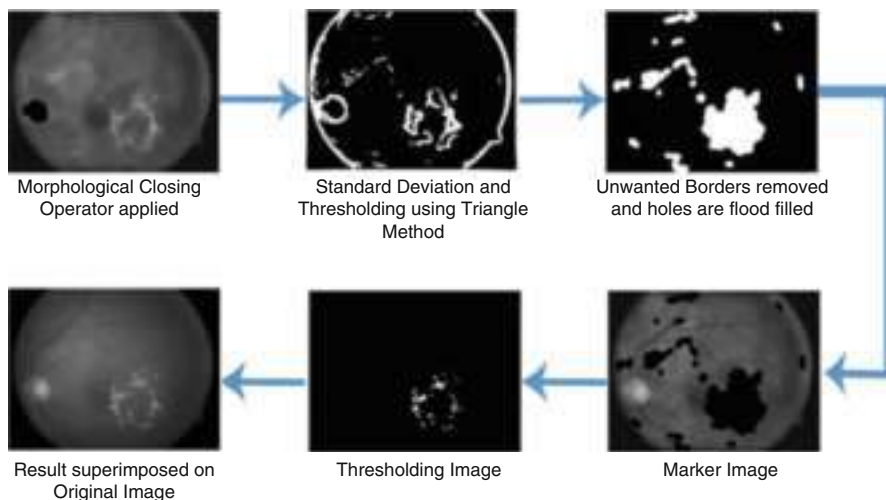
Fig. 5 Steps involved in exudate detection

Table 1 Feature sets for hard exudate classification

Feature sl. no.	Feature type	Description
f_1	Green intensity of mean channel	The green channel image is applied with a 3×3 size Mean filter in order to find each pixels's gray scale intensity
f_2	Gray intensity	Pixel's gray scale value
f_3 f_4 f_5	Mean saturation, mean hue and mean intensity of HSI color model	A 3×3 size Mean filter is respectively applied to the images I_h, I_s, I_i. Now, f_4 and f_5 refers to saturation and brightness as exudates can be seen as bright lesions
f_6	Energy	Intensity square of pixels and its summation
f_7	Standard deviation	SD is performed and the foreground regions are preserved in the image which have characteristics similar to structuring element
f_8	Mean gradient magnitude	The edge pixels' intensity in terms of directional change in magnitude

results in the form of a binary matrix. SVM is applied over Radial Basis Function (RBF) kernel. The evaluation using cross validation was performed using the gold standard images obtained from Dr. Bejan Singh Eye Hospital and selected by an expert. A total of 72 images were selected from the gold standard for training. The pixels were categorized as non-exudate regions and exudate regions. The cross validation was performed in ten folds to check the SVM classifier's efficiency.

The database images from DIARETDB1 were selected and split arbitrarily into ten subsets (ten folds) which were mutually exclusive and has exudate connected

components. They are $B_1, B_2, B_3 \ldots B_{10}$ that have same size. Sixty-seven images were trained on the classifier from the gold standard and the remaining 5 were employed for testing. The output obtained was a binary matrix. And for cross validation the process was repeated ten times with each subset. Thus every pixel provided a vector set containing all the features mentioned in Table 1 as:

$$a_i = (f_1, f_2, f_3 \ldots f_8) \tag{9}$$

Another entity b_j is defined as a flag to define the category which is represented as

$$b_j = \begin{cases} -1 & a_i \in A \\ +1 & a_i \in B \end{cases} \tag{10}$$

where $j \subset \{1, 2, 3 \ldots W\}$ denotes the dimensions of the vector set sample. The hard exudate region is represented by A and the non-hard exudate region is represented by B.

The SVM classifier was trained using the sample set (a_i, b_j). The value of W is chosen as 4200, which means 4200 pixels in 67 samples were categorized by the expert.

2.6 Evaluation Parameters

In this research work, the database candidate subset is considered as $\{B_1, B_2, B_3, \ldots B_N\}$ and gold standard subset is $\{T_1, T_2, T_3, \ldots T_M\}$.

The equation for a pixel to be True Positive (TP) is given in Eq. 11

$$\{B \cap T\} \cup \left\{ B_i \Big| \frac{|B_i \cap T|}{B_i} > \sigma \right\} \cup \left\{ T_j \Big| \frac{|T_j \cap B|}{T_j} > \sigma \right\} \tag{11}$$

In this research work the σ value is fixed at 0.2 which has a global range of $\{0,1\}$. The equation for a pixel to be False Positive (FP) is given in Eq. 12.

$$\{B_i | B_i \cap T = \phi\} \cup \left\{ B_i \cap \overline{T} \Big| \frac{|B_i \cap T|}{|B_i|} \le \sigma \right\} \tag{12}$$

The equation for a pixel to be False Negative (FN) is given in Eq. 13

$$\{T_j | T_j \cap B = \phi\} \cup \left\{ T_j \cap \overline{B} \Big| \frac{|T_j \cap B|}{|T_j|} \le \sigma \right\} \tag{13}$$

Finally, all the remaining pixels can be referred to True Negatives (TN).

3   Results and Discussions

There are mainly two sources for the fundus image acquisition. Dr. Bejan Singh
Eye Hospital provided with the clinical image which were captured by "Remidio
Non-Mydriatic Fundus On Phone (FOP-NM10)" [27] Fundus camera having a
Field-Of-View: 40°, having 100–400 ISO range and has a 33 mm working distance.
The public database DIARETDB1 was utilized for images required for validation.
Table 2 shows the observations of 30 images that were validated.

Since there is an asymmetry between the classes of TP, FN, and FP when com-
pared with TN, by computing just the Area Under Curve (AUC) of Receiver operator

Table 2 Performance matrix evaluated for 30 fundus images

	TP	FP	FN	TN	Accuracy	Sensitivity	Specificity	PPV	*F*-score
Image 1	349	78	35	431,651	99.97%	90.89%	99.98%	81.73%	86.07%
Image 2	372	106	35	431,487	99.97%	91.40%	99.98%	77.82%	84.07%
Image 3	6835	83	52	419,183	99.97%	99.24%	99.98%	98.80%	99.02%
Image 4	54	89	30	431,946	99.97%	64.29%	99.98%	37.76%	47.58%
Image 5	321	34	23	431,630	99.99%	93.31%	99.99%	90.42%	91.85%
Image 6	1488	31	80	429,122	99.97%	94.90%	99.99%	97.96%	96.40%
Image 7	409	26	37	431,420	99.99%	91.70%	99.99%	94.02%	92.85%
Image 8	964	40	54	430,947	99.98%	94.70%	99.99%	96.02%	95.35%
Image 9	6543	56	67	422,555	99.97%	98.99%	99.99%	99.15%	99.07%
Image 10	811	80	78	430,774	99.96%	91.23%	99.98%	91.02%	91.12%
Image 11	1166	49	52	430,535	99.98%	95.73%	99.99%	95.97%	95.85%
Image 12	3522	39	40	427,474	99.98%	98.88%	99.99%	98.90%	98.89%
Image 13	818	30	67	430,259	99.98%	92.43%	99.99%	96.46%	94.40%
Image 14	435	88	23	431,328	99.97%	94.98%	99.98%	83.17%	88.69%
Image 15	1536	40	57	428,684	99.98%	96.42%	99.99%	97.46%	96.94%
Image 16	623	56	35	431,002	99.98%	94.68%	99.99%	91.75%	93.19%
Image 17	3421	38	22	427,567	99.99%	99.36%	99.99%	98.90%	99.13%
Image 18	4090	49	25	427,468	99.98%	99.39%	99.99%	98.82%	99.10%
Image 19	233	39	55	431,731	99.98%	80.90%	99.99%	85.66%	83.21%
Image 20	785	30	22	431,053	99.99%	97.27%	99.99%	96.32%	96.79%
Image 21	327	88	15	431,563	99.98%	95.61%	99.98%	78.80%	86.39%
Image 22	1053	33	24	430,947	99.99%	97.77%	99.99%	96.96%	97.36%
Image 23	188	70	22	431,441	99.98%	89.52%	99.98%	72.87%	80.34%
Image 24	2213	44	21	429,216	99.98%	99.06%	99.99%	98.05%	98.55%
Image 25	964	33	37	430,750	99.98%	96.30%	99.99%	96.69%	96.50%
Image 26	521	25	6	431,650	99.99%	98.86%	99.99%	95.42%	97.11%
Image 27	848	90	5	429,132	99.98%	99.41%	99.98%	90.41%	94.70%
Image 28	904	24	56	431,480	99.98%	94.17%	99.99%	97.41%	95.76%
Image 29	842	99	34	430,927	99.97%	96.12%	99.98%	89.48%	92.68%
Image 30	4543	35	68	422,565	99.98%	98.53%	99.99%	99.24%	98.88%

characteristic (ROC) is not appropriate. So 5 different evaluation parameters are taken into consideration. They are

$$\text{accuracy} = \frac{\text{TN} + \text{TP}}{\text{TP} + \text{FP} + \text{TN} + \text{FN}} \tag{14}$$

$$\text{sensitivity} = \frac{\text{TP}}{\text{TP} + \text{FN}} \tag{15}$$

$$\text{specificity} = \frac{\text{TN}}{\text{TN} + \text{FP}} \tag{16}$$

$$\text{Positive Prediction Value (PPV)} = \frac{\text{TP}}{\text{TP} + \text{FP}} \tag{17}$$

$$F \text{ score} = 2 \times \frac{\text{sensitivity} \times \text{PPV}}{\text{sensitivity} + \text{PPV}} \tag{18}$$

The table shows good results with respect to the average sensitivity, specificity as well as accuracy having a value of 87%, 98%, and 98.7%, respectively. The F-score as well as the precision calculated were far higher than other works published in the literature in [28, 29] that is F-score = 89.91% and precision = 88.10%. Table 3 shows a comparative study with algorithms that were already published and it can be inferred that accuracy as well as specificity of this research work is greater than the other methods in literature.

Table 4 gives a comparison of the improved method of image enhancement that is IIHE-RVE with our previous method—contrast limited adaptive histogram equalization (CLAHE) which shows a reasonable increase in the value of specificity, PPV, and F-score.

Table 3 Comparison with existing algorithms

Methodology	Sensitivity	Specificity	Accuracy
Chen et al. [29]	83	75	79
Travieso et al. [30]	91.67	92.68	92.13
Barman et al. [31]	92.42	81.25	87.72
Proposed method	87.90	99.97	99.92
A Hajdu et al. [26]	92	68	82
R Sinha et al. [25]	96.54	93.15	N.A.
Pourreza et al. [28]	86.01	99.93	N.A.

Table 4 Performance matrix of 30 images evaluated

Methodology	Sensitivity	Specificity	Accuracy	PPV	F-score
CLAHE [17]	99.81%	80.06%	99.96%	88.03%	81.90%
IIHE-RVE	99.92%	87.90%	99.97%	89.91%	88.10%

4 Conclusion

The proposed work is a novel technique to detect exudates using morphological operation. The new enhancement method IIHE-RVE was used to increase the sensitivity of our existing algorithm that originally involved enhancement using CLAHE. A considerable increase in specificity indicates that the algorithm is more accurate while considering low intensity images. Using the same feature set to the classifier, the score of evaluation parameters could be increased by changing the enhancement technique. Further studies can be implicated to increase the PPV and F-score of this algorithm.

References

1. Badgujar RD, Deore PJ (2019) Hybrid nature inspired SMO-GBM classifier for exudate classification on fundus retinal images. Innov Res BioMed Eng 40(2):69–77
2. Guo S, Wang K, Kang H, Liu T, Gao Y, Li T (2019) Bin loss for hard exudates segmentation in fundus images. Neurocomputing 392:314–324
3. Khojasteh P et al (2019) Exudate detection in fundus images using deeply-learnable features. Comput Biol Med 104:62–69
4. Khojasteh P, Aliahmad B, Kumar DK (2019) A novel color space of fundus images for automatic exudates detection. Biomed Signal Process Control 49:240–249
5. Frazao LB, Theera-Umpon N, Auephanwiriyakul S (2019) Diagnosis of diabetic retinopathy based on holistic texture and local retinal features. Inf Sci (NY) 475:44–66
6. Kumar RS, Karthikamani R, Vinodhini S (2018) Mathematical morphology for recognition of hard exudates from diabetic retinopathy images. Int J Recent Technol Eng 7(4S):367–370
7. Kaur J, Mittal D (2018) A generalized method for the segmentation of exudates from pathological retinal fundus images. Biocybern Biomed Eng 38(1):27–53
8. Adem K (2018) Exudate detection for diabetic retinopathy with circular Hough transformation and convolutional neural networks. Expert Syst Appl 114:289–295
9. Mo J, Zhang L, Feng Y (2018) Exudate-based diabetic macular edema recognition in retinal images using cascaded deep residual networks. Neurocomputing 290:161–171
10. Kusakunniran W, Wu Q, Ritthipravat P, Zhang J (2018) Hard exudates segmentation based on learned initial seeds and iterative graph cut. Comput Methods Programs Biomed 158:173–183
11. Zhou W, Wu C, Yi Y, Du W (2017) Automatic detection of exudates in digital color fundus images using superpixel multi-feature classification. IEEE Access 5:17077–17088
12. Annunziata R, Garzelli A, Ballerini L, Mecocci A, Trucco E (2016) Leveraging multiscale Hessian-based enhancement with a novel exudate inpainting technique for retinal vessel segmentation. IEEE J Biomed Health Inform 20(4):1129–1138
13. Xu X, Lee K, Zhang L, Sonka M, Abramoff MD (2015) Stratified sampling voxel classification for segmentation of intraretinal and subretinal fluid in longitudinal clinical OCT data. IEEE Trans Med Imaging 34(7):1616–1623
14. Harangi B, Hajdu A (2014) Detection of exudates in fundus images using a Markovian segmentation model. In: 36th annual international conference of the IEEE Engineering in Medicine and Biology Society, 2014, vol 2014, pp 130–133
15. Agurto C et al (2014) A multiscale optimization approach to detect exudates in the macula. IEEE J Biomed Health Inform 18(4):1328–1336
16. Sreeja KA, Kumar SS (2019) Comparison of classifier strength for detection of retinal hemorrhages. Int J Innov Technol Exploring Eng 8(6S3):688–693

17. Pradeep A, Joseph XF (2019) Retinal exudate detection using binary operation and hard exudate classification using support vector machine. Int J Innov Technol Exploring Eng 8(9):149–154
18. Arpit S, Singh M (2011) Speckle noise removal and edge detection using mathematical morphology. Int J Soft Comput Eng 1(5):146–149
19. Taghizadeh M, Mahzoun MR (2011) Bidirectional image thresholding algorithm using combined edge detection and P-tile algorithms. J Math Comput Sci 02(02):255–261
20. Rais NB, Hanif MS, Taj IA (2004) Adaptive thresholding technique for document image analysis. In: 8th international multitopic conference, 2004. Proceedings of INMIC 2004, pp 61–66
21. Leedham G, Chen Y, Takru K, Tan JHN, Mian L (2003) Comparison of some thresholding algorithms for text/background segmentation in difficult document images. In: Seventh international conference on document analysis and recognition, 2003. Proceedings, vol 1, pp 859–864
22. Long S, Huang X, Chen Z, Pardhan S, Zheng D (2019) Automatic detection of hard exudates in color retinal images using dynamic threshold and SVM classification: algorithm development and evaluation. Biomed Res Int 2019:1–13
23. Baisantry M, Negi DS, Manocha OP (2012) Change vector analysis using enhanced PCA and inverse triangular function-based thresholding. Def Sci J 62:236–242
24. Akram MU, Tariq A, Khan SA, Javed MY (2014) Automated detection of exudates and macula for grading of diabetic macular edema. Comput Methods Programs Biomed 114(2):141–152
25. Haloi M, Dandapat S, Sinha R (2015) A Gaussian scale space approach for exudates detection, classification and severity prediction. In: ICIP, May 2015
26. Harangi B, Hajdu A (2014) Automatic exudate detection by fusing multiple active contours and regionwise classification. Comput Biol Med 54:156–171
27. Remidio Non-Mydriatic Fundus On Phone (FOP-NM10)
28. Imani E, Pourreza H-R (2016) A novel method for retinal exudate segmentation using signal separation algorithm. Comput Methods Programs Biomed 133:195–205
29. Liu Q, Chen J, Ke W, Yue K, Chen Z, Zhao G (2017) A location-to-segmentation strategy for automatic exudate segmentation in colour retinal fundus images. Comput Med Imaging Graph 55:78–86
30. Rekhi RS, Issac A, Dutta MK, Travieso CM (2017) Automated classification of exudates from digital fundus images. In: 2017 international conference and workshop on bioinspired intelligence (IWOBI), 2017, pp 1–6
31. Fraz MM, Jahangir W, Zahid S, Hamayun MM, Barman SA (2017) Multiscale segmentation of exudates in retinal images using contextual cues and ensemble classification. Biomed Signal Process Control 35:50–62

Chapter 6
Automated Detection of Retinal Hemorrhage Based on Supervised Classifiers and Implementation in Hardware

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Abstract Supervised machine learning algorithm based retinal hemorrhage detection and classification is presented. For developing an automated diabetic retinopathy screening system, efficient detection of retinal hemorrhage is important. Splat, which is a high level entity in image segmentation is used to mark out hemorrhage in the pre-processed fundus image. Here, color images of retina are portioned into different segments (splats) covering the whole image. With the help of splat level and GLCM features extracted from the splats, two classifiers are trained and tested using the relevant features. The ground-truth is established with the help of a retinal expert and using dataset and clinical images the validation was done. The trained classifier's output is evaluated and the classifier with the best output is chosen for implementation in hardware.

6.1 Introduction

The World Health Organization estimated that by 2030, there will be nearly 366 million people with Diabetic Mellitus (DM) [1]. A microvascular complication of DM that is responsible for a major share of cases of blindness in the world is the Diabetic Retinopathy (DR). The severe complications like Microaneurysms, Exudates,

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Occlusion, hemorrhages, etc., together known as DR. The early diagnosis can reduce the risk of losing vision. In order to reduce the diagnosing time, human error and increase the accuracy, several methodologies were developed for early diagnosis of DR and most of them use machine learning techniques. In this paper, classification of hemorrhage and non-hemorrhage fundus images, carried out using two different classifiers is presented. The classifier that performs the best, is chosen for realization in a Raspberry Pi computer system. The techniques used to develop the algorithm was chosen based on recent researches. When compared to large hemorrhages, it is seen that hemorrhages of small size are irregular in shape. Several algorithms were developed to find these abnormalities. In our work one of the classifier decisions is based on Neural network (NN) as described in [2]. Kumar et al. [3] presented a radiomics-driven Computer Aided Diagnosis (CAD) based method. In order to overcome the limitations with current CAD approaches such as decision making a CLass-Enhanced Attentive Response Discovery Radiomics CLEAR-DR is proposed to aid clinical diagnosis of DR. Another important symptom of diabetic retinopathy is exudates, which are similar to hemorrhage pixels. An Early detection of exudates is presented by Wisaeng [4] using Morphology Mean Shift Algorithm (MMSA). Detection of bright and dark lesion which can be hemorrhages or exudates, using a combination of matched filter response(MFR) and Laplacian of Gaussian Response (LoG) [5] produced a 96.10–96.99% accuracy for various publicly available database in hemorrhage detection.Multi-resolution analysis(MRA) is given importance in the work done by Lahmiri [6]. The statistical features obtained after MRA is fed to a support vector machine to grade retinal hemmorhage. Detection of hemorrhage pixels from the bright optical disc is always a constraint. Many methods are already prevailing in order to remove optical disc from the fundus image. Five optic disc detection methods with an algorithms committee having waited voting is presented by Silva et al. [7] where, 6 public benchmark databases with 1566 images are employed. Even though, in our work the optical disc is not removed, this method is useful when pixel based approach is considered. One such method of optic disc removal is used in exudate detection that involves mathematical morphology [8]. After morphological operation, the hard exudates are extracted using adaptive fuzzy logic. The purpose of this research is to develop a supervised classification model using two different classifiers and compare the output based on their sensitivity, specificity and accuracy. Retinal hemorrhages are demarcated with the help of an ophthalmologist who use a high-level representation entity known as splat [9]. Splats are a collection of pixels that have similar fundamental features. A two-step feature selection process is carried out to remove redundant features from the splat and these features are applied to a supervised classification to predict the possibility of hemorrhage splats in the whole image. The hemorrhage is finally detected and shown as bright spots on the dark opponency image. The two classifiers are tested, and their responses are tabulated. Section 6.2 describes the research method. Feature extraction, classification and embedded system realization are portrayed in this section. Section 6.3 gives the result and discussion and Sect. 6.4 summarizes and concludes the work.

6.2   Methodology

After Initial Pre-processing of fundus images by strategies performed in [28, 29] an enhanced image is obtained in which pixels that are assumed to have similar spatial location and share same structural features such as color and intensity are partitioned into non-overlapping splats and spread over the entire image [10]. Splat based method uses several re-sampling strategies. In a fundus image with hemorrhage, the total number of hemorrhage pixels is comparatively less when the entire image is considered [11]. Therefore, a splat-based method is more likely to have better diversity in training the samples. Splats are generated using watershed segmentation algorithm [10]. In order to create meaningful splats, a scale specific over segmentation is performed. This is done in two steps. At first the gradient magnitude of contrast enhanced dark-bright opponent image is taken using different scales. It is done because of the variability in appearance of hemorrhages. All these values are aggregated and the maximum of the gradient value with its scale of interest (SOI) is taken to perform watershed segmentation. Lin et al. [12] The gradient magnitude is computed using Eq. 6.1.

$$|\nabla I(x, y; s)| = \sqrt{I_x(x, y; s)^2 + I_y(x, y; s)^2} \qquad (6.1)$$

where $I_x(x, y; s)$ is the image. Now establishing a scale-space representation of the image using Gaussian kernels G_s, the gradient magnitude is calculated from its horizontal and vertical derivative. The maximum of the gradient magnitude is given in Eq. 6.2

$$|\nabla I(x, y)| = \max_i |\nabla I(x, y; s_i)| \qquad (6.2)$$

Splats are created using a modified watershed algorithm. The watershed segmented image is shown in Fig. 6.1. All the splats generated throughout the total image area is refrained to a threshold limit. Even though the number of splats increase accuracy, the computation time tends to increase. So a compromise between the efficiency and accuracy has been considered.

6.2.1   Feature Extraction from Splats

After assigning reference labels for splats, a classifier can be trained to detect the target objects. An altogether of 352potentially relevant features are taken to train the classifiers. They are: *Color, Difference Of Gaussian (DoG) Filter, Responses from Gaussian Filter Bank, Responses from Schmid Filter Bank, Responses from Local Texture Filter Banks.* These features are aggregated to obtain a meaningful response image which has low inter splat similarity and high intra splat similarity [13–19].

Fig. 6.1 Watershed segmented image
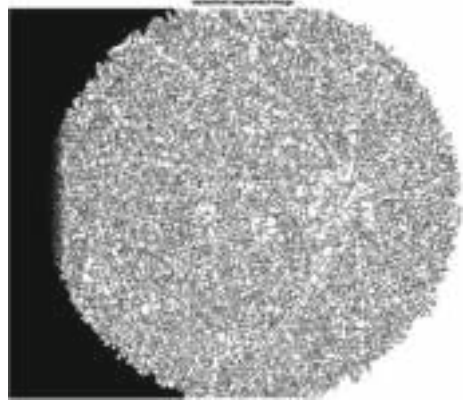
The features mentioned are pixel- based responses. In addition to these features, we take splat wise features according to Gray-Level Co-occurrence Matrix (GLCM) [16–22] statistics.

6.2.2 Preliminary Feature Selection and Classification

A two-step feature selection method is taken here so as to take only the relevant features and discard the irrelevant and redundant ones [23]. The preliminary feature selection is done using a filter approach in order to eliminate the features that are immaterial in discriminating hemorrhage and non-hemorrhage splats. A quadratic discriminant analysis (QDA) [24] is performed and by inspecting the features' variation with Misclassification Error (MCE) [25]. The preliminary features are chosen when the smallest MCE is reached. After preliminary selection, a wrapper approach is performed in order to get an optimal combination of relevant features with minimum redundancy. It is the peculiarity of the wrapper approach that it assesses different combinations of feature subsets customized for a certain classification algorithm with higher computation time [26].The combinations are evaluated using a kNN Classifier. All the selected features are now applied to a sequential forward feature selection subset(SFS). After feature selection, two distinct trained classifiers are set up with the set of features and reference label instances.

kNN and ANN Classification: The kNN algorithm assigns soft class labels. The two classes defined or the outputs are hemorrhage splat or non-hemorrhage splat. The classifier decides the class of a particular splat based on the Euclidean distance of the features in an optimized feature space. The feature vector dimension is 19. As the value of k is increased the computation time increases and the splats are more accurately identified. But since all the k nearest neighbors are not near, an optimum value of k is chosen instead of an arbitrary value. In this work, the value of k is chosen

as 100 with a compromise between computational time and accuracy based on the work in [27]. For ANN, the features are selected that are required to train the neural network. These are the 19 features that were selected by wrapper approach. The neural network is initialized and the number of layers are defined. The weights are assigned arbitrarily small value so as to start the computation. The value of output for each layer is computed and error is calculated. The weights are updated for the output and the hidden layers and is repeated till the all the layers are trained. After training all the layers, it is checked whether all the splat features are used in training purpose. If not the process is repeated until the selection of all splat features is performed. The network is trained τ epochs each time irrespective of whether the network is convergent or not. When the difference of error between the current training series and the previous series is smaller than a threshold , then it can be concluded that the network is convergent and the training is stopped. After the training is completed, the classifier is validated for its accuracy using the validation set. The validation set does not change the trained values of the classifier and it is done only to ensure that overfitting has not occurred. To determine the class of splat sigmoid transfer function $S(x) = \frac{1}{1+e^{-x}}$ is used. When $S(x) = 1$ then it comes under a hemorrhage splat and when $S(x) = 0$, it is a non-hemorrhage splat.

6.3   Results and Discussions

Histogram equalization is done using the strategy proposed in [28, 29]. Also each image is normalized according to its prevailing pixel value at the three colour channels. The pixel values that occur frequently are shifted to the beginning of RGB colour space. Among the total of 1500 images obtained from from the publically available database DIARETDB1 and the clinical images from Dr. Bhejan Singh's eye hospital, Nagercoil, 1050 were taken for training, 225 images for testing and 225 for validation. 10,500 splats were created among which 300 are hemorrhage splats. Images with at least 6 splats are taken for training. After sequential forward feature selection subset (SFS) only the relevant features were considered whereas the insignificant and redundant ones were removed from the feature set. The final feature set consists of 50 features from the 352 features obtained by filter approach and from this set 19 features were finally obtained by wrapper approach. The details of the final selected features are given in Table 6.1.

6.3.1   Classification of Splats Using kNN and ANN Classifiers

The splats are represented as a 19 dimensional feature vector. The kNN classifier and the ANN Classifier are trained on these features. Different values of k were tested whose values are chosen between 15 and 160 that involves both feature selection as well classification. After repeated iterations, the value of k was fixed at 100 without

Table 6.1 Details of final selected features

Features	Number	Description
DoG filter bank	s2–s0.5	From Green channel
DoG filter bank	s4–s0.5	From db and rg opponency
DoG filter bank	s8–s0.5	From db opponency
Gaussian filter bank	s = 8 orientation: 2, 3	Mean of second order Gaussian derivative from green channel
Gaussian filter bank	s = 1, 2, 4 orientation: 1, 2, 3	Mean of second order Gaussian derivative from green channel
Schmid filter bank	Response = 11	From db opponency
Mean of Gaussian	s = 8, 16	From Green channel

compromising the computation time and prediction accuracy. The target class for the classifier or the output consists of two classes: Hemorrhage or Non-Hemorrhage. The two classifiers were tested with the equal number of images and the results were compared. The splat centered Region of Convergence (ROC) curve for the fundus image given in Fig. 6.2 using the two classifiers are shown in Figs. 6.3 and 6.4. For a fundus image with 469 splats, the level of accomplishment of these classifiers are represented in the ROC curve. From the ROC curve for various threshold values, it is found that, among the two, ANN outperforms kNN classifiers in terms of sensitivity with an Area Under Curve (AUC) of 0.80 than 0.75 of kNN classifier. The confusion matrix calculated is given in Figs. 6.5 and 6.6 where n denotes the total number of splats for 520 images. A total 22574 splats were identified from the 520 images and they provide different accuracy at a certain threshold. The best classifier that performed in evaluation which is the ANN is now chosen for implementation in hardware.

6.3.2 Implementation in Hardware

Image preprocessing, processing and classification was done in MATLAB using Intel i5 dual-core processor which has 8 GB RAM memory specification and a clock speed of 1.6 GHz. The motivation behind this work was to develop an aid to assist medical practitioners for an early and accurate diagnosis of DR. An easy diagnosis is accomplished if the whole process of detection was implemented on an integrated hardware. The tested and successfully executed algorithms were then implemented in Raspberry-Pi system as seen in Fig. 6.7. The inclination towards Raspberry-Pi board is the ease of designing a portable convenient handheld device. The Mobile Industry Processor Interface (MIPI) interface is connected to a fundus camera by which the real time images can be directly processed to detect hemorrhages which

Fig. 6.2 Splats identified
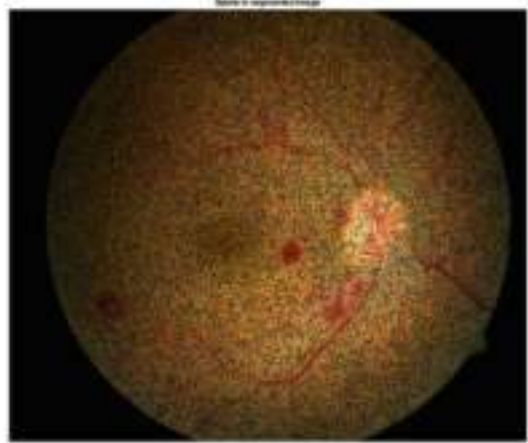
Fig. 6.3 ROC for ANN
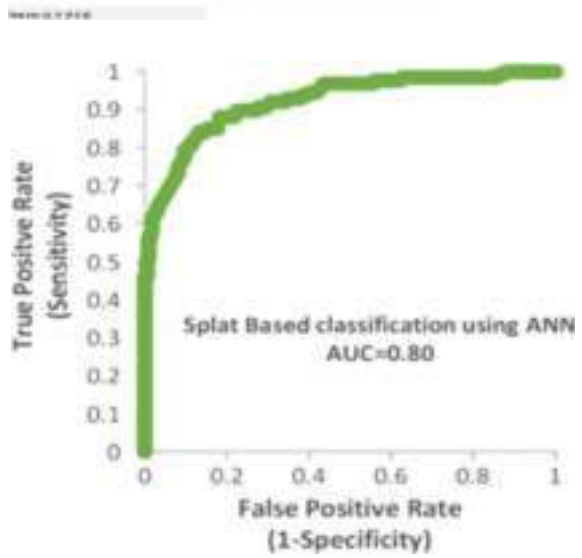
can predict the possibility of DR. This system can also be used with the help of a smart-phone camera and an aspheric lens to capture retinal images. Two Fundus

Fig. 6.4 ROC for kNN
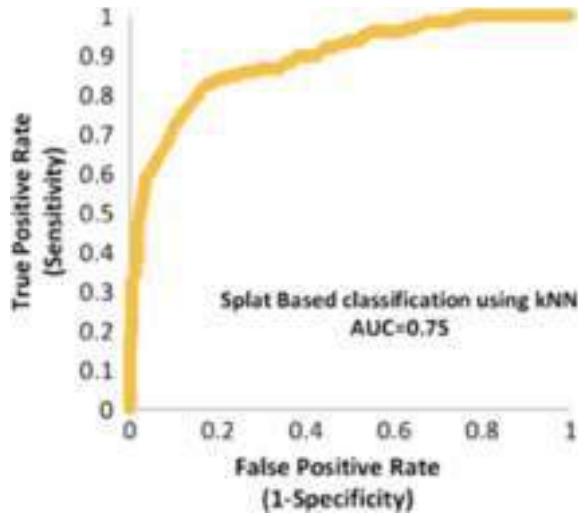
Fig. 6.5 Confusion matrix for ANN

n= 18892	Predicted NO	Predicted YES	
Actual NO	TN= 9246	FP=202	9548
Actual YES	FN= 669	TP=8775	9344
	9915	8977	

Fig. 6.6 Confusion matrix for kNN

n=22574	Predicted NO	Predicted YES	
Actual NO	TN= 11257	FP=139	11396
Actual YES	FN= 720	TP=10458	11178
	11977	10597	

images 1 and 2 were taken from standard diabetic retinopathy database DIARETDB1 and from clinical database for testing. Figures 6.8 and 6.9 shows the various stages of hemorrhage detection on images obtained from these source.

6.4   Conclusion

The presented work is a novel technique to detect exudates using morphological operation. The new enhancement method IIHE was used to increase the sensitivity of our existing algorithm that originally involved enhancement using CLAHE. A considerable increase in specificity indicates that the algorithm is more accurate while considering low intensity images. Using the same feature set to the classifier, the score of evaluation parameters could be increased by changing the enhancement technique. Further studies can be implicated to increase the PPV and F-Score of this algorithm. Thus a splat-based feature classification using Raspberry Pi is presented for the detection of retinal hemorrhage. The proposed classification strategy can model different lesions with different texture size and appearance. The algorithm is

Fig. 6.7   Raspberry Pi implementation

Fundus Image 1   Enhanced Image   Splats Generated   HE Detected

Fig. 6.8   Hemorrhage detection process applied on DIARTEDB1 fundus image

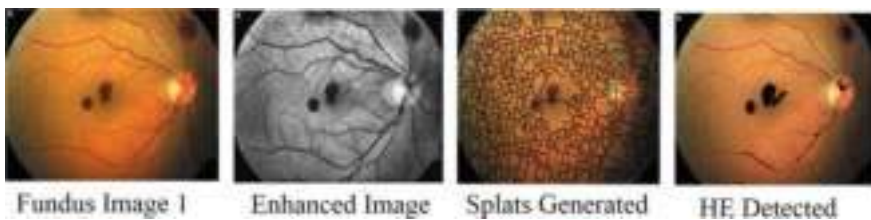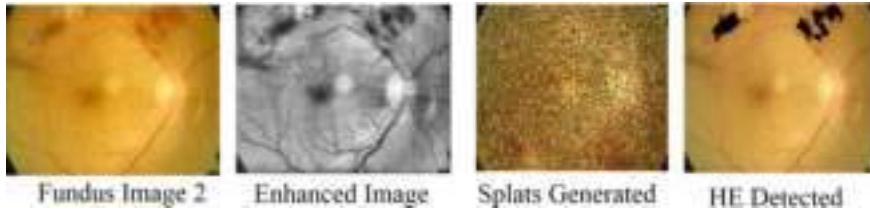**Fig. 6.9** Hemorrhage detection process applied on Clinical fundus image

validated on the publically available database DIARETDB1 and clinical image which was captured using a "Remidio Non-Mydriatic Fundus on Phone (FOP-NM10). The proposed detector can be incorporated into comprehensive DR assisting system for ophthalmologists.

References

1. World Health Organization: Prevent ion of blindness from diabetes mellitus (2006)
2. Zeng, X., Chen, H., Luo, Y., Ye, W.: Automated diabetic retinopathy detection based on binocular siamese-like convolutional neural network. IEEE Access **7**, 1 (2019)
3. Kumar, D., Taylor, G.W., Wong, A.: Discovery radiomics with CLEAR-DR: interpretable computer aided diagnosis of diabetic retinopathy. IEEE Access **7**, 25891–25896 (2019)
4. Wisaeng, K., Sa-Ngiamvibool, W.: Exudates detection using morphology mean shift algorithm in retinal images. IEEE Access **7**, 11946–11958 (2019)
5. Kar, S.S., Maity, S.P.: Automatic detection of retinal lesions for screening of diabetic retinopathy. IEEE Trans. Biomed. Eng. **65**(3), 608–618 (2018)
6. Lahmiri, S.: High-frequency-based features for low and high retina haemorrhage classification. Healthc. Technol. Lett. **4**(1), 20–24 (2016)
7. Silva, R.R.V.E., De Araújo, F.H.D., Dos Santos, L.M.R., Veras, R.M.S., De Medeiros, F.N.S.: Optic disc detection in retinal images using algorithms committee with weighted voting. IEEE Lat. Am. Trans. **14**(5), 2446–2454 (2016)
8. Ranamuka, N.G., Meegama, R.G.N.: Detection of hard exudates from diabetic retinopathy images using fuzzy logic. IET Image Process. **7**(2), 121–130 (2013)
9. Tang, L., Niemeijer, M., Reinhardt, J.M., Member, S., Garvin, M.K., Abrà moff, M.D.: Splat feature classification with application to retinal hemorrhage detection in fundus images. IEEE Trans. Med. Imaging **32**(2), 364–375 (2013)
10. Fairfield, J.: Toboggan contrast enhancement for contrast segmentation. In: 1990 10th International Conference on Pattern Recognition, vol. 1, pp. 712–716 (1990)
11. Chawla, N.V., Japkowicz, N., Ko, A.: Editorial: special issue on learning from imbalanced data sets. SIGKDD Explor. Newsl. **6**, 1–6 (2004). https://doi.org/10.1145/1007730.1007733
12. Lin, Y.-C., Tsai, Y.-P., Hung, Y.-P., Shih, Z.-C.: Comparison between immersion-based and toboggan-based watershed image segmentation. IEEE Trans. Image Process. **15**(3), 632–640 (2006)
13. Abraoff, M.D., et al.: Automated segmentation of the optic disc from stereo color photographs using physiologically plausible features. Investig. Opthalmology Vis. Sci. **48**(4), 1665 (2007)
14. Romeny, B.M.: Front-End Vision and Multi-scale Image Analysis: Multi-scale Computer Vision Theory and Applications, 1st edn. Springer, Berlin (2003)

15. Tang, L., Niemeijer, M., Abramoff, M.D.: Splat feature classification: detection of the presence of large retinal hemorrhages. In: 2011 IEEE International Symposium on Biomedical Imaging: From Nano to Macro, pp. 681–684 (2011)
16. Engler, O.: Introduction to Texture Analysis: Macrotexture, Microtexture, and Orientation Mapping, 2nd edn. CRC Press LLC, Boca Raton (2017)
17. Varma, M., Zisserman, A.: A statistical approach to texture classification from single images. Int. J. Comput. Vis. **62**(1/2), 61–81 (2005)
18. Alharan, A.F.H., Fatlawi, H.K., Ali, N.S.: A cluster-based feature selection method for image texture classification. Indonesian J. Electr. Eng. Comput. Sci. **14**(3), 1433–1442 (2019)
19. Hasan, A.M.: A hybrid approach of using particle swarm optimization and volumetric active contour without edge for segmenting brain tumors in MRI scan. Indonesian J. Electr. Eng. Inform. **6**(3), 292–300 (2018)
20. Tamura, H., Mori, S., Yamawaki, T.: Textural features corresponding to visual perception. IEEE Trans. Syst. Man. Cybern. **8**(6), 460–473 (1978)
21. Niemeijer, M., Staal, J., van Ginneken, B., Loog, M., Abramoff, M.D.: Comparative study of retinal vessel segmentation methods on a new publicly available database. In: Proceedings of the SPIE 5370, Medical Imaging 2004: Image Processing (12 May 2004). https://doi.org/10.1117/12.535349
22. Niemeijer, M., Abramoff, M.D., van Ginneken, B.: Segmentation of the optic disc, macula and vascular arch in fundus photographs. IEEE Trans. Med. Imaging **26**(1), 116–127 (2007)
23. Kohavi, R., John, G.H.: Wrappers for feature subset selection. Artif. Intell. **97**(1–2), 273–324 (1997)
24. Srivastava, S., Gupta, M.R., Frigyik, B.A.: Bayesian quadratic discriminant analysis. J. Mach. Lear. Res. **8**, 1277–1305 (2007)
25. Duda, R.O., Hart, Peter E., Stork, D.G.: Pattern Classification, 2nd edn. Wiley, Hoboken (2000)
26. Tarassenko, L., Roberts, S.: Supervised and unsupervised learning in radial basis function classifiers. IEE Proc. Vis. Image Signal Process. **141**(4), 210–216 (1994). https://doi.org/10.1049/ip-vis:19941324
27. Sreeja, K.A., Kumar, S.S.: Comparison of classifier strength for detection of retinal hemorrhages. Int. J. Innovative Technol. Exploring Eng. (IJITEE.org) **8**(S63), 688–693 (2019)
28. (9) (2019)
29. Arun, P., Felix, J.X.: Intensity index based histogram equalization technique for retinal image enhancement and classification of hard exudates using supervised learning. Int. J. Eng. Adv. Technol. (IJEAT.org) **8**(5) (2019)

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Intelligent vehicle collision avoidance system using 5G-enabled drone swarms

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ABSTRACT

The number of vehicular collisions is on a toll worldwide. Despite enforcing stringent laws and incorporating various safety features, the causalities are still on the rise. Existing techniques such as vision zero strategy and safe system approach provides only post-crash aid. Although numerous works have been carried out on Intelligent Transportation Systems (ITS), a well-coordinated vehicular collision avoidance system is still missing. In this paper, we utilize the tremendous opportunity provided by ITS, Light Detection and Ranging (LIDAR), Wireless Sensor Networks (WSN), 5G, and propose an effective system using drones with swarm intelligence that can automatically control the

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networks and always ensures a safe distance between the vehicles using the principle of magnetic levitation. The system is further investigated for optimizing the power, altitude, and angular

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References

1. Zhao, J., Xu, H., Liu, H., Wu, J., Zheng, Y. and Wu, D., 2019. Detection and tracking of pedestrians and vehicles using roadside LiDAR sensors. *Transportation research part C: emerging technologies*, 100, 68--87.

2. Abbasi, M. et al., 2020. An efficient parallel genetic algorithm solution for vehicle routing problem in cloud implementation of the intelligent transportation systems. *Journal of Cloud Computing* 9, 1, 1--14.

3. Garg, S. et al., 2019. SDN-based secure and privacy-preserving scheme for vehicular networks: a 5G perspective. *IEEE Transactions on Vehicular Technology* 68, 9, 8421--8434.

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Wang H, Jiang J, Huang G, Wang W, Deng D, Elhalawany B, Li X and Ye Y. (2022). Physical Layer Security of Two-Way Ambient Backscatter Communication Systems. *Wireless Communications & Mobile Computing*. **2022**. Online publication date: 1-Jan-2022.

https://doi.org/10.1155/2022/5445676

Li X, Zheng Y, Khan W, Zeng M, Li D, Ragesh G and Li L. Physical Layer Security of Cognitive Ambient Backscatter Communications for Green Internet-of-Things. *IEEE Transactions on Green Communications and Networking*. 10.1109/TGCN.2021.3062060. **5**:3. (1066-1076).

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Morphological Operators on Hypergraphs for Colour Image Processing

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Abstract—This article is an extension of morphological operators on hypergraphs to work with colour images. Morphological operators on hypergraphs are useful for binary and grayscale image processing. The preliminary experimental results related to the extension of these operators to colour images is presented in this paper. The results on colour images are promising and is a better alternative for the existing methods.

Index Terms—Hypergraph, Mathematical Morphology, Image Processing, Salt and pepper noise.

I. Introduction

Mathematical morphology is the first consistent non-linear image analysis theory. Originally it was defined on a set theoretic framework and used for processing binary images and extended to grayscale images. Despite its continuous origin, it was soon recognised that the roots of the theory were in algebraic theory, notably the framework of complete lattices. This allows the theory to be completely adaptable to non-continuous spaces, such as graphs [4], hypergraphs [3] and simplicial complexes [5]. Extending Mathematical Morphology to colour images is an active area of research in image processing [8, 18, 9]. There is no natural extension of the morphological operators to colour images. This is because colour images does not admit a partial ordering [11]. Image denoising is one of the most important operations in image processing. Salt and pepper noise is very common in image processing applications and noise reduction is a very active area of research in this field [12]. Morphological filtering is one of the most reliable techniques for salt and pepper noise reduction [2, 4, 5]. Our objective is to utilise the morphological operators defined on hypergraphs to remove this noise from colour iamges [2, 16].

This article is organised as follows. We introduce the preliminary definitions from mathematical morphology and morphological operators on hypergraphs in section II. In Section III, we present the hypergraph representation of a digital image. Experimental results of the operators and filters on a colour image are presented in Section IV. Conclusion and future works are presented in Section V.

II. Preliminaries

A. Mathematical Morphology

Definition 1. [6, 7, 14, 17] Given two lattices $\mathcal{L}_1$ and $\mathcal{L}_2$, any operator $\delta : \mathcal{L}_1 \to \mathcal{L}_2$ that distributes over the supremum and preserves the least element is called a dilation. An operator that distributes over the infimum and preserves the greatest element is called an erosion.

Definition 2. [6, 7, 14] Two operators $\varepsilon : \mathcal{L}_1 \to \mathcal{L}_2$ and $\delta : \mathcal{L}_2 \to \mathcal{L}_1$ form an adjunction (ε, δ) if for any X $\in \mathcal{L}_2$ and any Y $\in \mathcal{L}_1$, we have $\delta(X) \leq_1 Y \Leftrightarrow X \leq_2 \varepsilon(Y)$, where $\leq_1$ and $\leq_2$ denote the order relations in $\mathcal{L}_1$ and $\mathcal{L}_2$ respectively.

Definition 3. [6, 7, 17] Let δ be any operator on a lattice $\mathcal{L}$, then δ is

- increasing if X $\leq$ Y implies $\delta(X) \leq \delta(Y)$;
- extensive if $\delta(X) \geq X$ for every X $\in \mathcal{L}$;
- anti extensive if $\delta(X) \leq X$ for every X $\in \mathcal{L}$;
- idempotent if $\delta^2 = \delta$;
- a morphological filter if δ is increasing and idempotent;
- an opening if δ is increasing, anti-extensive and idempotent;
- a closing if δ is increasing, extensive and idempotent.

B. Morphological operators on hypergraphs

A hypergraph is denoted as a pair H = (H$^\bullet$,H$^\times$) where H$^\bullet$ is a set and H$^\times$ is a family $(e_i)_{i \in I}$ of nonempty subsets of H$^\bullet$. Let X and Y be two hypergraphs. If X$^\bullet \subseteq$ Y$^\bullet$ and X$^\times \subseteq$ Y$^\times$, then X is a subhypergraph of Y and is denoted by X $\subseteq$ Y. Let H = (H$^\bullet$, H$^\times$) be a hypergraph and consider

the sets $\mathcal{H}^\bullet, \mathcal{H}^\times$ and $\mathcal{H}$ of respectively all subsets of H$^\bullet$, all subsets of H$^\times$ and all subhypergraphs of $\mathcal{H}$[2, 16]. The vertex-hyperedge correspondence defined in [2,16] by the operators $\delta^\bullet$, $\epsilon^\bullet$ from $\mathcal{H}^\times$ into $\mathcal{H}^\bullet$ and $\delta^\times$, $\epsilon^\times$ from $\mathcal{H}^\bullet$ into $\mathcal{H}^\times$ act as the building blocks for morphological operators on hypergraphs. These operators are used to process colour images in this work.

Definition 4 [2]

- Vertex dilation $\delta = \delta^\bullet \circ \delta^\times$ and vertex erosion $\epsilon = \epsilon^\bullet \circ \epsilon^\times$.
- Opening $\gamma_1 = \delta \circ \epsilon$ and closing $\phi_1 = \epsilon \circ \delta$.
- Half opening $\gamma_{1/2} = \delta^\bullet \circ \epsilon^\times$ and half closing $\phi_{1/2} = \epsilon^\bullet \circ \delta^\times$.

Property 1. If $X^\bullet \subseteq H^\bullet$, then $\gamma_1(X^\bullet) \subseteq \gamma_{1/2}(X^\bullet) \subseteq X^\bullet \subseteq \phi_{1/2}(X^\bullet) \subseteq \phi_1(X^\bullet)$.

Property 2. The operators $\gamma_{1/2}$ and γ_1 are openings on $\mathcal{H}^\bullet$ and $\phi_{1/2}$ and ϕ_1 are closings on $\mathcal{H}^\bullet$.

C. Flat morphological operators on weighted hypergraphs

Let n denote any positive integer and K = $\{0, \ldots, n\}$. Let E be any set. Let *Fun(E)* denote the set of all maps from E to K. By threshold decomposition [2], the lattice $\mathcal{H}$ of all subhypergraphs of H induces a lattice Fun(H$^\bullet$)$\otimes$Fun(H$^\times$) of pairs of functions weighting respectively the vertices and the hyperedges of H such that the simultaneous threshold of these two functions at any given level yields a subhypergraph of H.

The operators acting on the lattices $\mathcal{H}^\bullet, \mathcal{H}^\times$ or $\mathcal{H}$ are all increasing and, they induce stack operators [1, 10, 13, 15, 19] acting on the lattices Fun(H$^\bullet$), Fun(H$^\times$), and Fun(H$^\bullet$) $\otimes$ Fun(H$^\times$). This implies that the properties presented for hypergraph operators on the lattices $\mathcal{H}^\bullet, \mathcal{H}^\times$ or $\mathcal{H}$ also hold good for operators on the lattices Fun(H$^\bullet$), Fun(H$^\times$), and Fun(H$^\bullet$) $\otimes$ Fun(H$^\times$).

The following definition is the stack analougues to the operators $\delta^\bullet$, $\epsilon^\times$, $\epsilon^\bullet$, $\delta^\times$ on weighted hypergraphs [2].

Definition 5 [2] Let $F^\bullet \in$ Fun(H$^\bullet$) and let $F^\times \in$ Fun(H$^\times$)

- $\delta^\bullet(F^\times)(x) = max_{x \in v(e_i)}\{F_\times(e_i)|e_i \in H^\times\} \forall x \in H^\bullet$
- $\epsilon^\times(F^\bullet)(e_i) = min\{f^\bullet(x)|x \in v(e_i)\} \forall e_i \in H^\times$
- $\epsilon^\bullet(F^\times)(x) = min_{x \in v(e_i)}\{F_\times(e_i)|e_i \in H^\times\} \forall x \in H^\bullet$
- $\delta^\times(F^\bullet)(e_i) = max\{f^\bullet(x)|x \in v(e_i)\} \forall e_i \in H^\times$

This idea is used to define Alternating Sequential Filters on binary and grayscale images represented as uniform hypergraphs. The same idea can be extended to be utilised for colour images also. Further it can also be used to define ASFs on colour images by suitable choice of a partial order on colour images.

III. COLOUR IMAGE REPRESENTATION

We represent the RGB components of a colour image by means of a vertex weighted hypergraph. Each pixel correspond to the vertices of the hypergraph and the weights are assigned according to the intensity values of the corresponding pixels. We use the 3-uniform hypergraph presented in Figure 1 to represent the hyperedges. This is because this structure gives the best results for binary and grayscale image filtering
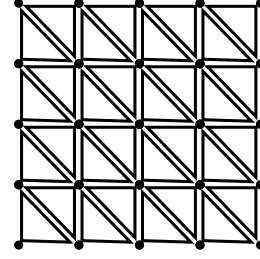
Fig. 1: Hypergraph structure used to represent an image.

applications. The vertex weights are propogated along the hyperedges to obtain the morphological operators, thereby producing the component images [2]. The component images are then combined to generate the resultant colour image.

IV. EXPERIMENTAL RESULTS

The definitions and results presented in the previous sections are used to obtain the dilated and eroded colour images. This is achieved by propagating the vertex weights of the hypergraphs along its hyperedges to obtain the flat morphological operators presented in [2]. Composition of these operators produce the resultant images to generate half opened ($\gamma_{1/2}$) half closed ($\phi_{1/2}$), opened (γ_1) and closed (ϕ_1) images as shown in 2 (c) to (f).

By property 1, half opening and half closing of the vertex set of a hypergraph are more close to the original vertex set than that of opening and closing. Moreover both of them are filters and capable of removing noise from the image, where the image is represented as a hypergraph. In this paper we utilise this idea on colour images to illustrate the effectiveness of these operators.

Figure 2(a) is a colour image taken from [11]. The noisy version of this image added with salt and pepper noise is shown in Figure 2(b). The mean square error (MSE) for this image is 32.72%. The half opened ($\gamma_{1/2}$) image is shown in Figure 2(c). Almost all the salt kind of noise is removed by this operation and causes less damage to the image. Figure 2(d) shows the half closed ($\phi_{1/2}$) image in which the pepper noise is almost completely removed. Figure 2 (e) and (f) shows the results of opening (γ_1) and closing (ϕ_1) of (b) respectively. Here also the noise is removed but the damage caused to the image is more compared to the previous cases. The composition ($\gamma_{1/2}$) $\circ$ ($\phi_{1/2}$) or half closing followed by half opening is an alternating sequential filter (ASF) and capable of removing impulse noise effectively from binary and grayscale images [2]. The result of this operation on the tested colour image in Figure 2(b) is shown in Figure 3(b). The mean square error is reduced to 2.75% in this case. The open-close filter (γ_1) $\circ$ (ϕ_1) reduces the mean square error to 3.57%. This is shown in Figure 3(a).

Experimental results shows that the resultant colour images obtained by half opening and half closing are better than the images obtained by opening and closing operations. This is because half opening and half closing are better approximations to the original image and cause less damage to the image

(a) Original Image

(b) Noisy version MSE = 32.72%

(c) Half Opening

(d) Half Closing.

(e) Opening.

(f) Closing.

Fig. 2: Illustration of the operators on a colour image.

(a) $\gamma_1 \circ \phi_1 MSE = 3.57\%$

(b) $\gamma_{1/2} \circ \phi_{1/2} MSE = 2.75\%$

Fig. 3: Illustration of colour image filtering.

than opening and closing. Thus half opening and half closing can be used more effectively than opening and closing for colour image denoising. In this work we do not use any partial ordering of colour vectors.

V. CONCLUSION AND FUTURE WORKS

The objective of this study is to identify the possibilities of using morphological operators on hypergraphs for colour image processing. Morphological operations like half opening and half closing are not at all possible using traditional morphological image processing using structuring elements. Graph and hypergraph structures to represent digital images allows this kind of operations. The results are required to be tested on a large dataset of colour images inorder to validate the consistency of the proposed method. The initial results are promising and the future works are directed towards a more suitable hypergraph representation of colour images incorporating partial ordering on the colour components. The possiblility of false colours in morphological colour image processing is not completely removed in this method but the effect of which is minimized. Use of partial ordering of colours on hypergraphs is a solution for this problem.

REFERENCES

[1] Gilles Bertrand, "On topological watersheds," in Journal of Mathematical Imaging and Vision, vol. 22(2-3), pp.217–230 , 2005.
[2] Kannan Balakrishnan Bino Sebastian Vadakkenveettil, Avittathur Unnikrishnan and Ramkumar Padinjare Pisharath Balakrishna," Morphological filtering on hypergraphs", in Discrete Applied Mathematics, 216 pp.307–320,2017.
[3] Isabelle BLOCH and Alain BRETTO, "Mathematical morphology on hypergraphs, application to similarity and positive kernel," in Computer vision and image understanding, vol. 117(4), pp.342-354 2013.
[4] Jean Cousty, Laurent Najman, Fabio Dias, and Jean Serra, "Morphological filtering on graphs," Computer Vision and Image Understanding,vol. 117(4), pp.370–385 , 2013.

[5] Fabio Dias, Jean Cousty, and Laurent Najman, "Dimensional operators for mathematical morphology on simplicial complexes," in Pattern Recognition Letters, 2014.

[6] Henk JAM Heijmans.a, "Composing morphological filters," IEEE Transactions on Image processing,vol. 6(5), pp.713–723 , 1997.

[7] Henk JAM Heijmans and Christian Ronse,"The algebraic basis of mathematical morphology i. dilations and erosions",Computer Vision, Graphics, and Image Processing,vol.50(3),pp.245–295,1990

[8] J. B. T. M. Roerdink J. J. van de Gronde, "Group-invariant colour morphology based on frames.," IEEE Transactions on Image Processing, vol. 23(3), pp.12761288 , 2014.

[9] Yao Wu Yong Li Jing Hu JunpingWang, Gangming Liang, "New colour morphological operators on hypergraph," IET Image Processing,, vol. 12, pp.690–695 , May 2018.

[10] Romain Lerallut, Etienne Decenci'ere, and Fernand Meyer, "Image filtering using morphological amoebas," Image and Vision Computing, vol.25(4) , pp.395–404 , 2007.

[11] Olivier Lezoray, "Manifold-based mathematical morphology for graph signal editing of colored images and meshes",In IEEE International Conference on Systems, Man, and Cybernetics (SMC 2016), Budapest, Hungary, October 2016.

[12] Mehdi Mafi, Harold Martin, Mercedes Cabrerizo, Jean Andrian, Armando Barreto, and Malek Adjouadi.,"A comprehensive survey on impulse and gaussian denoising filters for digital images.",Signal Processing,,vol.157,pp.236–260,2019

[13] Petros Maragos and Ronald W Schafer,"Morphological filterspart i: Their set-theoretic analysis and relations to linear shift-invariant filters",in IEEE Transactions on Acoustics, Speech and Signal Processing,vol.35(8),pp.11531169,1987.

[14] Laurent Najman and Hugues Talbot,"Mathematical Morphology.," John Wiley and Sons, 2013

[15] Christian Ronse, "Flat morphology on power lattices," Journal of Mathematical Imaging and Vision,vol. 26(1-2), pp.185–216 , 2006.

[16] Bino Sebastian, A Unnikrishnan, Kannan Balakrishnan, and PB Ramkumar, "Mathematical morphology on hypergraphs using vertex-hyperedge correspondence,"ISRN Discrete Mathematics, 2014.

[17] Jean Serra., "Lecture notes on morphological operators.,"Mittag-Lefflers matematiska stiftelse, 2014.

[18] Marcos Eduardo Valle and Raul Ambrozio Valente,"Mathematical morphology on the spherical cielab quantale with an application in color image boundary detection",in Journal of Mathematical Imaging and Vision,vol.57,pp.183201,2016

[19] P Wendt, Edward J Coyle, and Neal C Gallagher Jr. Stack filters,IEEE Transactions on Acoustics, Speech and Signal Processing,vol.34(4),pp.898911,1986

PERSPECTIVES ON CONTEMPORARY LITERATURE AND LITERARY THEORIES IN ENGLISH

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PERSPECTIVES ON CONTEMPORARY LITERATURE AND LITERARY THEORIES IN ENGLISH

Living in the Wilderness

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Abstract

Nature makes us feel alive and energetic. It has the power to bring our mind, body, and soul back to life. Nature's healing powers are absolutely amazing. It is therapeutic for everyone and is open to both the rich and the poor. Recognizing Nature's healing power, many people travel to places around the world that offer consolation and comfort. Nature is not just around us, it's within us as well. This provides an unexplained sense of calm consciousness. Several studies are now available that show nature's psychological benefits. All the research points the fact that the closer we find ourselves to nature, the happier we feel. Nature is, in fact, a strong antidepressant.

The paper is about the consoling power of nature experienced by the characters when they are in the natural settings in the novel *The Tree of Man* written by Patrick White. The study is an eco-psychological re-reading of the text which will allow readers to witness how the environment becomes an inevitable part of human life that reflects the interconnectedness of all that the nature has created. The escape to nature has another appeal besides its beauty and tranquillity. Ecological interactions touch an individual's physical, spiritual, emotional and psychological facets of life. Eco psychology is a modern social and intellectual movement aimed at recognizing and harmonizing the relationship between people and the Earth. The emerging field of eco-psychology shows how our human psyches are closely bound to the elemental earth.

Earth centred faiths strives to honour the strength of nature's consoling power. This eco psychological study shows how the text demonstrates the character's harmonious and balanced eco human bonding. It shows how far identities of characters are shaped by the surroundings in which they live. The study describes how the ecological lifestyle is an encompassing transformation that touches every facets of an individual's life. The experiences encountered by the characters in the novel shows how the experiences in life with the natural environment move them towards a greater appreciation and concern for the natural world. Thus the paper studies *The Tree of Man* as an ecological writing with a literature of hope.

Keywords-

Eco criticism, Biophilia, Eco psychology, Self revelation

Living in the Wilderness

I wandered lonely as a cloud
That floats on high o'er vales and hills,
When all at once I saw a crowd,
A host, of golden daffodils;
Beside the lake, beneath the trees,
Fluttering and dancing in the breeze.

(William Wordsworth)

The paper is about the consoling power of nature experienced by the characters when they are with the natural setting in the novel *The Tree of Man* written by Patrick White. The study is an eco psychological re-reading of the text which will allow readers to witness how the environment becomes an inevitable part of human life that reflects the interconnectedness of all that the nature has created. The escape to nature has another appeal besides its beauty and tranquillity. It is freely available to the poor as well as to the rich. Ecological interactions touch an individual's physical, spiritual, emotional and psychological facets of life. Eco psychology is a modern social and intellectual movement aimed at recognizing and harmonizing the relationship between people and the Earth. The emerging field of eco psychology is showing how our human psyches are closely bound to the elemental earth.

Earth centred faiths strives to honour the strength of nature's consoling power. This eco psychological study shows how the text demonstrates the character's harmonious and balanced eco human bonding. It shows how far identities of characters are shaped by the surroundings in which they live. The study describes how the ecological lifestyle is an encompassing transformation that touches every facets of an individual's life. The experiences encountered by the characters in the novel shows how the experiences in life with the natural environment move them towards a greater appreciation and concern for the natural world. Thus the paper studies *The Tree of Man* as an ecological writing with a literature of hope.

In the novel, the characters sufferings in life get consoled as they get along with nature. When they remain in both wild and domesticated environments, most often in places of natural beauty, there are revelatory experiences awakening their wisdom and modesty. Experiences with the destructive sides of nature can test the commitment of ecological followers to provide a powerful reminder that a turn of earth is not peace, safety, or limitless abundance. In its natural cycles and changing ecology, the environment offers great stability, but this constancy is not fully chaos-free. Biophilia, the love of nature and living things, is an essential part of the human condition. Those who spend extensive time in the environment observe to respect the extreme spontaneity of nature.

Patrick White's novel evokes a diversity of landscapes that often enter into the texture of the novel's narrative. He is quite a few steps ahead of the other contemporary writers. His works reveal the depth of his understanding of Australia as a region and its atmosphere. White considers it not only as a land of mystical values but also as a separate entity in human life. The depth in which he depicts the landscape of the Australian nation, reality encounters with nature thereby resulting in idiosyncratic revelations makes his works stand apart from other writers. Patrick White's *The Tree of Man* evokes a diversity of landscapes that often enter into the texture of the novel's narrative.

People are less stressed when they are with nature. Eco criticism helps us to realize that all living organisms are connected when we step into nature. Nature gives comfort to all troubles. The word

tree ' in this novel's title stands for the search for growth of Stan, for the unbounded life. Stan was a person who loves to be with nature. The novel begins with the description of two big trees as:

A cart drove between the two big stringy barks and stopped. These were the dominant trees in that part of the bush, rising above the involved scrub with the simplicity of true grandeur (1)

The novel is a beautiful evocative description of the nature. Patrick White has paid a lot of attention to the nature that surrounds his protagonist Stan Parker. "He smelled the smell of green wood. The name of this man was Stan Parker."(5 White) It is a suburban drama that tells a story of the lives and fortunes of the Parker family over many decades. Stan is a son of blacksmith and an educated mother. Stan's mother expects him to be a teacher or a preacher. After the death of the parents of Stan Parker, he decided to begin a new life. Stan had no intention of remaining in the confining atmosphere of the Australian bush town where he grew up. "At Willow Creek, God bent the trees till they streamed in the wind like beards. In the streets of towns the open windows, on the dusty roads the rooted trees, filled him with the melancholy longing for permanence."(13)

He leaves his hometown and travels to an unsettled area outside Sydney, where he has inherited some property. He manages to makes out a house in the woods and starts farming. Stan had come to the woods in search of peace. "Stan Parker began to tear the bush apart. His first tree fell through the white silence with a valley of leaves...Many days passed in this way, the man clearing his land...Seen through the trees; it was a plain but honest house that the man had built."(17)

White's heroes suffer from alienation when they are in the midst of human society. Stan loved living in the woods devoid of all the rush of the busy world. He wanted a peaceful life in the calm and soothing nature. Stan is a lonely man whose most outstanding characteristic is his quality of being silent. He loved to be part of nature and wished to settle his life there. Many days passed in this way, Stan clearing his land. At last he built his house amongst the woods. "Seen through the trees, it was a plain but honest house that the man has built."(17)

One day Stan brought with him a woman. Her name was Amy Fibbens. Stan's union with Amy Fibbens played a key role in shaping his goal and his efforts to achieve it. When they came to the place where Stan's house stood, they were on the outskirts of the town, where they could smell sheep, and of water drying in a mud hole. The place was home to incredible scenery and delicate ecosystems. Stan's cart jolts through the windy countryside "The girl lazily smiled at the landscape, holding her hat."(25) It was a long ride through the bush road. The travel through the woods consoled her ill thoughts.

The girl sat with her eyes on the road. She was not concerned, as at odd moments, her husband was afraid she might be. Because in her complete ignorance of life, as it is lived and the complete poverty of the life she had lived, she was not sure but that might have to submit thus, interminably bolt upright in a cart. Life was perhaps a distances of stones and sun and wind, sand coloured and monotonous."(26)

Amy always had a feeling that Stan remains distanced from her. Her only relief is observed from the surrounding she lives. This consoling power of nature has brought Amy Parker to live in the midst of the beauty of nature. Amy Parker had grown greedy for love. She had not succeeded in keeping her husband with her all the time. She had promised herself in moments of indulgence that she would achieve this at some future date. But she fails every time. Amy's only relief was the moments she had with the nature. Amy loved animals and enjoyed planting trees. "She should plant the white rose,

where the slope of the land was still restless from the jagged stumps of felled trees."(28) The nature which surrounded her spoke to her in its silence from her consoling depths.

"She walked slowly on, taking care of herself, and the harsh blue of her wooden jacket flickered through the evening colours of the garden, the colour of moss, almost of foreboding, and her skirt in passing stirred up an intolerable scent of rosemary and thyme that lingered after she had gone."(57)

The Parkers continued their life. When Stan leaves the house into the woods he can still hear the voice of Amy when he was alone in nature. To discover what life actually is, the more humble Stan Parker turns to Nature. Stan's greatest strength is his endurance. His mind can withstand pain and torture to the degree that it can help him achieve his goal. Other people came to live in that place after few years and there is a rose bush now, growing against the veranda, a white rose, of which Amy had thought and spoken to Stan, and which he had brought to her from the town.

The major event that took place was a great flood, which fortunately did not destroy their farm. The still air became more charged the closer they got to the centre of the storm, the sky darker. The storm continued most of the days: "The whole earth was in motion and streaming trees, and was in danger of being carried with it."(47)

The constant rain that swells into the flood of Wallonia, causes trouble to people's lives, and Stan is brought to the point that he understands how weak man is. He joins other volunteers and helps rescue settlers stranded by the flood.

The great trees had broken off, two or three fell". "He remembered the face of his mother before her burial, when the skull disclosed what the eyes had always hidden; some fear that the solidity of things around her was not assured. But on the dissolved world of flowing water, under the drifting trees, it was obvious that solidity is not. (73)

Stan learns to humble himself from his surroundings and to embrace continuous changes as the only solidity. Two children are born to the Parkers, a daughter, Thelma, and a son, Ray. Later, during a raging bushfire, Stan rescues Madeleine from the burning manor house. World War I begins soon after the great fire, and Stan enlists in the army. After Stan returns from the battlefields of France, he once more works his farm while his wife carries out her domestic duties faithfully and his children grow into adults. "One was born. One lived". (104) Stan felt that staying isolated in the nature is the only way to consolation. It reflects one's self confidence. He admires the land which gives shape to his life. Also he is also looking for a sense that lies beyond the visible environment. The solitary life in nature helps to develop internally from which a person eventually must reach the innermost core of his own being. "Society, as such, fills him with discomfort and it has always remained an "unrealized ambition". (186) Stan feels the land is an indomitable power, bringing misery, suffering and desolation. These ecstatic experiences faced with the nature makes a person stronger.

Works Cited

1. White, Patrick. *The Tree of Man*. London: Vintage, 1994. Print.

Evaluation of Current Design Practices for Horizontal Curves on Rural Highways Based on Vehicle Stability and Safety

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Abstract: All over the world India bangs the top most position in deaths caused by road crashes. Over 1 lakh people are killed or seriously injured in road crashes in India every year, that is more than the number of people killed in all our wars put together. Sixteen children die on Indian rroads daily and there is at least one death every four minutes. Majority of the crashes are found to take place on rural highways. Rural highways are characterized by a low traffic volume and hence, speed of the vehicles is mainly controlled by the geometry. The topological conditions of India have resulted in very complex curves which include combination of horizontal curve and steep gradients up or down. In such environment, the drivers tend to choose the speeds that they perceive to be comfortable to them based on their perception of the criticality of the road geometrics ahead. Any unexpected road feature in the highway may surprise the drivers and may result in erroneous driving manoeuvres, which in turn, may end up in road crashes. As highways are meant for high speed travel, the impact of any collision that takes place will be grievous or fatal. Hence, the highways have to be designed such that their geometry directs the drivers to choose the operating speed which is in harmony with the environment.

A large number of studies are done to evaluate the effect of geometry on operating speed of rural curves. But only a few researches are done to assess the effect of geometry on the stability of vehicles. Skidding and rollover crashes are increasing dramatically, the first being more common in small vehicles like cars and the latter being more common in heavy commercial vehicles like trucks. The availability of sufficient lateral friction to counteract centrifugal force experienced by a vehicle on curve is least studied, especially in India. The values of lateral friction adopted for design of horizontal curves were developed eighty years ago by Barnett 1936; Moyer and Berry 1940. Since then, vehicle fleet has changed completely and hence the demand for lateral friction may also have changed. But the point mass equation widely used for design of horizontal curve relies on lateral friction values developed by them. Also, the equation ignores the effect of vehicular characteristics or complexity of curve geometry. So, studies focusing on revision of geometric design criteria of horizontal curves based on vehicle stability and assessment of existing margin of safety or in other words, a quantitative assessment of risk involved affecting the stability of vehicles is very important. In this paper an effort has been made to identify the gaps in current design practices and to exhibit current status of study in the field of vehicle stability on rural highways.

Keywords: Skidding, Friction, Vehicle Stability, Rollover.

I.   INTRODUCTION

When a vehicle travels along a horizontal circular curve, it experiences centrifugal force outward the centre of the horizontal curve. This centrifugal force is inversely proportional to the radius of horizontal curve. Vehicle stability is achieved by the resistive forces that resist the centrifugal force. These forces include frictional interaction between the tires and pavement, and a component of the vehicle weight that acts parallel to the road surface. The frictional interaction between the tires and pavement depends on road surface side-friction factor, which in turn depends on many other factors, including road surface condition, weather and climatic condition, tire condition, and vehicle kinematics. The component of the vehicle weight that acts parallel to the road surface depends on the side slope of the highway, which is usually termed as superelevation. This approach is usually referred to as the point-mass (PM) model, which is adopted by North American design guides due to its simplicity.

Based on the point-mass model, when a vehicle travels along a vertical curve, there is obviously no centrifugal force, and consequently no potential risk for skidding or rollover. However, for 3D(combined) alignments, where a horizontal curve is superimposed by a vertical alignment, the vertical alignment affects the available side friction. For 3D alignments, traditional design guides (AASHTO 2001; TAC 1999) calculate the minimum radius assuming a side friction on a horizontal plane using the point-mass model, thus ignoring the effect of vertical alignment. This approach simplifies cornering dynamics by reducing the vehicle into a point mass travelling on a 2D horizontal alignment.

Salinity reduction in well water using zeolite

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Abstract. Saline water intrusion is one of the global issues, which increases the demand for freshwater around the coastal region. The saline content in drinking water makes so many health impacts on human beings. There are many new technologies available for reducing salinity such as desalination, membrane technologies, reverse osmosis, etc. But these are expensive too. There is a need for cost-effective treatment which is suitable for domestic purpose in coastal regions. In this paper, a new technique is introduced which reduces the saline content in groundwater by installing this barrier device in wells of coastal regions. A non-woven Geo textile along with natural zeolite is used as a filter cum adsorption unit. Tests results show a decrease in electrical conductivity and total dissolved solids with an increase in filter thickness for all selected salt concentrations irrespective of the adsorbent materials used viz., natural zeolite and thermally activated natural zeolite. This indicated a reduction in chloride ions as the only salt added to the water samples tested was commercial salt. Authors suggest that a thermally activated zeolite filter could be a possible cost-effective, efficient and easy solution for increasing saline water intrusion issues in coastal drinking water wells.

1. Introduction

Saltwater intrusion, which is the induced flow of saline or brackish water into freshwater, is an ever-increasing problem in coastal areas. Seawater intrusion is often regarded as the only factor causing saltwater contamination. But, there are seven other causes of salinity in groundwater like tidal and storm surges, pollution from agricultural land, etc [1].Once saltwater intrusion occurs, the changes in the aquifer may be permanent or may take many years to recover.

Saline water intrusion impacts are associated primarily with losses of freshwater resources and contamination of water supply wells, and only a few studies consider adverse ecological impacts directly linked to saline water intrusion. Environmental degradation arising from this is commonly linked to the application of high salinity groundwater in agriculture, resulting in modified soil chemistry and reduced soil fertility [2]. While the direct and indirect intrusion of salinity in fresh groundwater affects human well-being, its serious implications on population health must be clearly understood. Owing to the use of saltwater, numerous diseases including skin ailments, hair fall, diarrhoea, gastric diseases, and high blood pressure are suffered.

A lot of techniques have been used to manage/control salt/seawater intrusion and protect groundwater resources. The principle is basically to reduce the volume of saltwater intrusion and increase the volume of freshwater. Mahesha [3] and Rastogi et al. [4] combined the methods of injection of freshwater and extraction of saline water to increase the volume of freshwater and to reduce the volume of saltwater pose effective but the setback is the cost factor involved in the construction and maintenance of the wells. Several of these methods are costly and some might not be

Liquefaction resistance improvement of silty sands using cyclic preloading

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Abstract. Liquefaction induced damages are plenty and cause various levels of destruction to civil engineering infrastructure. It is possible to prevent liquefaction-induced hazards by understanding the mechanism and adopting some improvement techniques or design the structure to resist the soil liquefaction. In the present study, the influence of cyclic preloading on the liquefaction resistance of sand-silt mixtures is analyzed by conducting undrained cyclic triaxial tests on the cylindrical samples reconstituted at medium dense conditions ($D_r = 50\%$). All samples were tested at an effective confining pressure of 100 kPa by varying the cyclic stress ratios (CSR) in the range of 0.127 to 0.178 using a sinusoidal waveform of frequency 1 Hz. The results are presented in the forms of the pore pressure build-up, axial strain variation and liquefaction resistance curves. Test results indicate that the liquefaction resistance of silty sands is increased substantially with the application of preload under drained conditions.

1. Introduction

Liquefaction induced damages are plenty and cause various levels of destruction to civil engineering infrastructure. It is possible to prevent liquefaction-induced hazards by understanding the mechanism and adopting some improvement techniques or design the structure to resist the soil liquefaction. The first possibility is to avoid the construction on liquefiable soil deposits as far as possible. However, it is mandatory to utilize the available land for the various infrastructure developments due to scarcity in the availability of land even it does not satisfy the required properties. Hence, the second option is to make the structure resistant to liquefaction by adopting deep foundations. Nevertheless, the deep pile foundations may not prevent liquefaction damages in all cases. Piles are causing to deflect in liquefaction susceptibility zones. Hence, the third option is liquefaction mitigation which involves improving the strength, density, and drainage characteristics of the soil. The selection of the most appropriate ground improvement method for a particular application could depend on many factors including the type of soil, level, and magnitude of improvement to be attained, required depth and extent of the area to be covered. This paper presents an experimental study regarding the applicability of preloading for the improvement of liquefaction resistance.

2. Literature review

Preloading of the soils occurs naturally (for eg., erosion, the flow of groundwater, etc) or artificially (purposeful preloading to improve the soil properties, demolition of structures, etc). A few researchers have analyzed the liquefaction resistance of preloaded soils. The details are given in Table 1.

A review on the use of ferrocement with stainless steel mesh as a rehabilitation technique

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A R T I C L E   I N F O

A B S T R A C T

One of the major issue faced by the construction industry is the degradation of structures due to different loads acting on the structure. So retrofitting and rehabilitation has become quite inevitable and it can help in regaining the original strength of the structure. Use of ferrocement is an effective method and it is used in developed countries as it is considerably cheap and materials of construction are easily available. Ferrocement is a system of construction using reinforced mortar or plaster applied over an armature of metal mesh, woven expanded-metal or metal-fibers and closely spaced thin steel rods such as rebar. The skill required is of low level and it has superior strength properties as compared to conventional reinforced concrete. The main drawback of ferrocement is corrosion. Thus to avoid corrosion stainless steel jacketing is employed for rehabilitation within the study that opens the scope for a new jacketing methodology.
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Selection and peer-review under responsibility of the scientific committee of the Second International Conference on Recent Advances in Materials and Manufacturing 2020.

1. Introduction

Concrete is the most popular construction material which is made of cement, aggregate and water. Water is acting as the bonding agent between the component. On adding water, the concrete is in a plastic state and acquires strength with time. Portland cement is the ordinarily used type of cement for production of concrete. Concrete is used in the construction of the major structural elements like foundations, columns, beams, slabs and other load bearing components. The use of traditional construction materials such as steel and concrete showed signs of deterioration due to prolonged action of loads which results in degradation of overall strength of the structure which makes it futile. This degradation is a result of poor construction techniques, flaws in designing process or may be due to poor updating of the methods specified in design codes. Proper maintenance is a partial solution. So is a necessity of an effective rehabilitation technique which will improve the life expectancy of the structure. Earlier studies focused on steel meshes which is prone to corrosion. My study focuses on a non corrosive technology for rehabilitation. The scope of stainless steel as a jacketing method is not studied formerly.

In most of the developed countries, the development trade has almost reached saturation. So there is an increasing demand to ameliorate and strengthen the existing structure instead of demolishing. The damages are mainly due to the environment degradation, design inadequacies, poor construction practices, irregular maintenance, requirement of revision of codes in practice, increase in the loads and seismic conditions etc. Rehabilitation is one of the practical solution for such structural collapse and it can be done effectively by strengthening the load bearing components or by strengthening the vital components of the building which results in the failure of the building. Therefore, rehabilitation and upgrading of degraded structure has become one among the foremost vital challenges in development industry. In several cases, the whole demolition of the existing structure is not an economical answer as it becomes an exaggerated money burden. So upgrading or repairing the structure is an effective practical approach. Column is the major compression load bearing component member and the failure of which results in the failure of the whole building. During earthquakes, columns are likely to undergo brittle failure. So the ductility of columns has to be improved to prevent the inelastic deformation occurred during earthquakes. Whereas repair and rehabilitation using ferrocement enhance the strength and ductility of the column. Proper selection of the strengthening material is inevitable to enhance the properties of the column.

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Effect of Plasticity of Fines on Properties of Uniformly Graded Fine Sand

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1 Introduction

Even though researchers separate soils based on particle size as sand, silt and clay, in the field, soil always exists as a combination of all these. There are many studies concentrating on the effect of fines on the shear characteristics of sand [1–3] and liquefaction [4–7] but only a few studies have considered the other properties.

Yang and Wei [8] have analysed the change in critical state friction angle for Fujian and Toyoura sands. For clean sand without fines, the critical state friction angle tends to decrease with increasing roundness of sand particles. When those sands were tested with fines (round shape), the critical state friction angle of the mixture tends to decrease with an increase in fines content. But for fines with an angular shape, the critical state friction angle tends to increase with fines content. Phan et al. [9] have conducted one-dimensional consolidation tests on sand–silt mixtures (with low-plastic fines at a constant void ratio and constant relative density) and indicated that the behaviour of the mixtures were similar to those of loose sand. The effect of fines on void ratios was studied by Cubrinovski and Ishihara [10]. The authors reported that the void ratio initially decreases as the fines content increases from 0–20% and above 40% fines, the maximum and minimum void ratios were seen to increase steadily.

It is clear from the literature that the studies on the effect of plasticity of fines on the properties of sand are limited. Hence, the present study is focused on the effect of the amount of fines and the type of fines (or plasticity index of fines) on various properties of sand like specific gravity, limiting void ratios, grain size characteristics, angle of internal friction and compression index.

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Modernizing Traditional Methods of Farming using Farming Robot

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ABSTRACT

This paper pertains to the study of a prototype which modernizes the agricultural sector. It has the ability to perform basic operations such as irrigation activity and monitoring of plants frequently without much manual labor. In addition to the above-mentioned functionalities, the system is trained for detecting diseases in plants. Agriculture is an area of prime importance in the existence of humanity. It is a process of cultivating land and plants to provide food, fiber, medicines and other products to enhance the quality of life. It is considered to be the main pivoting point in the rise of our civilization. In the proposed system ROFAR, detection of plant disease is achieved with the help of image processing and machine learning methods. Prompt and accurate detection of plant diseases is crucial for the quality and yield of crops. Advanced diagnosis and intervention can lower the cost of plant diseases and trim down the use of unnecessary pesticides. Images of leaves of different plant species were gathered and feature extraction was performed. As a result, the system was able to classify the plants based on its ailments accurately. The ROFAR gathers the images of the plants for disease detection from the field and were given as input to Convolution Neural Network (CNN) which then classifies the images as healthy or infected. The proposed system ROFAR undergoes a training phase and a testing phase. The system is trained by providing various samples of the normal and diseased plants. On completion of training phase, the system can identify any new images of plants as healthy, late blight, viral or bacterial. The system also facilitates the moisture detection in the soil. With these functionalities, crops with better quality and yield can be obtained from the field.

Keywords: ROFAR, Convolution Neural Network (CNN), Training phase, Testing phase, moisture detection, late blight, bacterial, Feature extraction.

1. Introduction

One of the most promising and upcoming technologies that has the capacity to boost almost all the sectors of the economy, from medical to space sectors is Robotics. However, the sector that is constantly lagging is agriculture. It's due to the fact that many farmers are being used to heavy equipment, tools and conventional agricultural strategies. Although the application of robotics in this sector is slow, it's persistent.

The utilization of technologies that are linked with robotics and automation, can provide important values to both farmers as well as the agricultural sector [1]. These automated bots are being used for conventional applications which includes plant classification, fruit picking, seeding, spraying, etc. Machine-driven agricultural operations introduce many advances to the field improving the overall productivity and efficiency. Automation provides countless perks to farmers or landowners which makes the job performed in a uniform method, with less expense and higher accurately. The processor located at the centre of the Raspberry Pi framework is a Broadcom BCM2835 framework on-chip (SoC) mixed media processor. This indicates by means of a ways most of the framework's segments, consisting of its illustrations and focal preparing units beside the correspondence's equipment and sound, constructed onto that solitary segment beneath the memory chip of 256MB situated at the centre point of the board. The fact that makes BCM2835 different from the processor determined for your workplace or PC is not simply its SoC structure. In addition, it makes use of an Industry Standard Architecture (ISA) which is known as ARM [2]. The significance of water splashing is one of the principal applications performed. Water transports vital supplements within the plant. The

supplements are extracted from the earth and used by the plant. Inadequate water in the plant cells causes the plants to stop growing, so water allows the plant to stand upright. The water carries the disintegrated sugar and various necessary supplements through the plant. So, without the correct equalization of water, the plant is not exclusively undernourished, however it is too physically weak and can't bolster its very own load. Various sorts of plants require various measures of water [3]. With open air plants, we can't manage the plants getting an excess of water if the area gets a great deal of downpour, so we have to ensure that the dirt has the correct seepage, since large amounts of water will influence plant development the same amount as excessively little. Video observing of the plants is additionally of most extreme significance. The programmed plant checking framework had a huge enthusiasm because of the promising applications in rising innovation. Although, this strategy is used to enhance the execution of existing methods or to make and structure new procedures for the growth of plants. The plant checking framework is mainly used for watering the plants and to transmit a couple of parameters for growth of plants. Plant illness recognition is the fundamental utilization of the pack. Plant malady, a weakness in the plant's normal condition that hinders or regulates its vital capabilities. All kinds of flora, wild and evolved alike can suffer from disease [4]. The percentage of plant infections varies from season to season, natural conditions, contact with the pathogen and the crops and assortments developed. Some assortments of the plants are prone to disease outbreaks, while others progressively resistant them. Fossil proof demonstrates that plants were influenced by illness 250 million years back. Loss of yields from plant maladies may likewise result in appetite and starvation, particularly in less-created nations where access to ailment control techniques is restricted and yearly misfortunes of 30 to 50 percent are normal for real harvests. In certain years, misfortunes are a lot more prominent, creating calamitous outcomes for the individuals who rely upon the yield for sustenance. Real ailment flare-ups among sustenance crops have prompted starvations and mass movements since forever [5].

The proposed automated system captures the images of the plants and has a detecting mechanism for classifying the plant as diseased or healthy. A real-time video monitoring system incorporated in the proposed system facilitates the user to be aware of the conditions in the field. In addition to these features humidity of the soil is measured and decision on spraying water to the plants is taken care.

The remainder of the paper is structured as follows: Section 2 deals with Literature Survey. Section 3 describes the Hardware and Software Components used to build the prototype. Section 4 illustrates the proposed model, working principle and the implementation. Section 5 deals with the experimental analysis and the result. Section 6 describes the conclusion. Section 7 describes the future scope of the project. Lastly, Section 8 lists all the references used in this paper.

Nomenclature

ABC   Atanasoff Berry Computer
AI   Artificial Intelligence
ANN   Artificial Neural network
ARM   Acorn/Advanced RISC Machine
BCM   Body Control Module
CNN   Convolution Neural Network
DNN   Dynamic Neural Network
GNU   GNU's Not Unix
GPIO   General Purpose Input/output
GUI   Graphical User Interface
IDE   Integrated Development Environment
IDLE   Integrated Development and Learning Environment
IoT   internet of Things
ISA   Industry Standard Architecture
ML   Machine Learning
(N;P;K)   (Nitrogen; Phosphorus; Potassium)
PC   Personal Computer
pH   Potential of Hydrogen
RFB   Remote Frame Buffer convention

SoC	System on a Chip
VNC	Virtual Networking Computing

2. Literature Survey

2.1. Algorithm for Line Follower Robots to Follow Critical Paths with Minimum Number of Sensors

The main challenge faced in the area of robotics is that going along a specified path [6]. Either the path could be designed by the user or it could sense a particular color and move along that path. When specified by the user's intermediate counters for stopping and turning could be initially kept precise. However, each color has its own threshold, and the robot senses its movement with respect to the color. This paper discusses line follower robots, their configuration and inculcates a concept for the robot to move along curves, junctions and 90-degree bends. Therefore, the line follower robots are autonomous, having the ability to follow and detect a line ensuring the base to an efficient system. The project employs Arduino Uno as the main circuit board for the robot and four sensors for following the path. The robot uses 4 IR sensors S_{LL}, S_L, S_R and S_{RR} arranged on a straight path for detecting the line as shown in the Fig. 1. The sensors S_{LL} and S_{RR} are used to perform 90-degree rotation on left of right respectively.
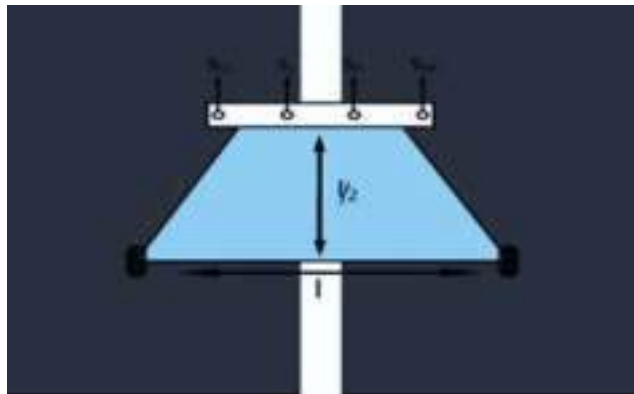
Fig. 1- Robot sensor diagram

If any of the sensors deviate from its original position, then the robot corrects itself by moving along right or left. If any of the two sensors come on the white line, then a 90-degree turn is done according to the algorithm. Therefore, based on two main algorithms it can follow the path given to it. When implemented the robot also must account for obstacles in its path and proper halts in the junctions to do the specific jobs that it aims to do. The paper resembles such an algorithm for following the path with precision and proper configuration of the sensors. A prototype built by J S Tan et. al. known as Jackbot Mark1 is a cheaper, light weight and small robot that has an ability to move and carry load incorporating obstacle detection, line following algorithms [7]. Mehran Pakdaman et. al. discussed various technical problems that could arise in any line following robot [8]. The challenges involved while navigating in a constrained environment like greenhouse and polytunnels are addressed using an autonomous row following robot [9,10].

2.2. Design and Implementation of Semi-Autonomous Anti-Pesticide Spraying and Insect Repellent Mobile Robot for Agricultural Applications

The authors discuss on the application of robots in agriculture. It focuses on designing a robot called "x-bot" which is an insect repellent robot and a pesticide sprayer [11]. The main problem with the manual spraying of pesticides is the over spraying causing harm to both plants and humans. Thus, the robot is designed to overcome this problem. An additional unit of insect repelling mechanism with the help of a sonar is also built and attached to the robot. The robot body is Lynx Motion Rover Kit with 3D

printed acrylic chassis and four dc motors are used to drive the robot. Arduino Mega Microcontroller is the control unit with diaphragm pump to spray pesticide and solar panel attached buzzer to repel insects. Proportional Integrative Derivative algorithm is employed to control the robot and as the robot reaches each of its spots, pesticide is sprayed at a precise amount. Alongside the insect repellent is also done. In addition, the ultrasonic sensors are calibrated by the neural networks.

2.3. Design of automatic nutrition supply system using IoT technique in modern cities

Today, the main problem faced by Terrace Gardening is the lack of time for the planters to look after the garden on a regular basis [12]. The one available solution is by employing smart farming which modernizes the current conventional methods of farming in modern cities. Modernizing includes automation of almost every process in the area of farming. This paper discusses the automated system by applying the concept of IoT. The primary objective of this study is to provide the plants with the necessary nutrients, such as potassium, phosphorus, nitrogen and calcium, which is computed from the data provided by the sensors. The pH value of the soil is taken by the pH sensor attached to the Raspberry Pi. The pH value is processed along with the Humidity sensor. Value of the humidity sensor is considered on the basis that when Humidity increases the chance of plants to get caught by disease is high and the rate of growth of plants will be low and vice versa. Therefore, based on these values and calculations the nutrients are supplied to plants. The authors developed an automatic nutrient supply system which is capable of passing nutrients mixed with water automatically to the plants as required thus reducing the human labor to a great extent. Measurement of the pH of the solution provides data about the nutrient's availability in the soil. The quantity of fertilizer is supplied according to the requirement of the crops. This system could help in the better use of fertilizer and to enhance the quality of soil. The limitations to this system are, absence of weed detection and control mechanism, seed plantation and the system is immobile in nature. Sajjad Yaghoubi et. al. suggested an autonomous robot that aims to reduce manpower and to improve the quality and productivity of farming [13].

2.4. Real-time Video Monitoring and Micro-Parameters measurement using Sensor Networks for Efficient Farming

One of the main challenges faced in the area of farming is that there is no system that monitors the field which gives the advantage to the farmer to monitor the farm on a real-time basis [14]. The solution to this problem is to design a Robot that can monitor the system on a real-time basis which is equipped with a camera along with a Robotic arm and sensors that helps to monitor the plant growth. The robotic arm is used to measure and manage agricultural parameters. The robotic design in this study is composed of sensor, control, camera, planning subsystem and a system comprising an online image and video transmitter. The constituent of potassium, phosphorus and nitrogen present in the soil is measured in order to depict the amount of fertilizer required by the soil. This mechanism also aids in managing the content measurement while preparing the fertilizer. The primary goal of this design is the reduction in the number of nodes required for the conventional measurement schemes. There are mainly two blocks. One block indicates the transmitter, which is actually, the Robot and the other block depicts the receiver. The System is employed to design, develop and optimize a feasible solution to agricultural control and monitoring. The proposed system utilizes sensors for Micro parameter measurement (K, P, N), Humidity measurement, Soil moisture, Motion detection, temperature detection, Soil PH for maintaining agricultural environment. It also includes Agricultural Parameters measurement and Real-time Video Monitoring using Sensor Networks for Precision Agriculture. After the proper measurement of K, P, N content from soil it will be easy to figure out the fertilizer combinations. On implantation, it is found that System results in the designing, development and optimization of a feasible solution for application to agricultural control and monitoring. The limitations to this system are, absence of weed detection and control mechanism, seed plantation and the inability to supply nutrients and water to the plants.

2.5. Design of automatic nutrition supply system using IoT technique in modern cities

The most prominent troubles faced in farming is that much vegetation are laid low with sickness. Every 12 months illness of the plant, fungal and viruses' attacks result in crop losses as much as 30% of the overall production [15]. The plant disease control mechanism relies upon speedy, correct detection and identification of the diseases. The paper discusses correctly figuring out the

disease with the help of an artificial neural network. The different image processing performed on the input image are image enhancement and image segmentation. The Fig 2 shows the block diagram of plant disease detection and depicts the various texture feature values that are computed from the processed image. The classification of text image is performed at last by giving the extracted feature values as an input to the pertained artificial neural network (ANN). Finally, the predicted result (disease) is sent to the person.
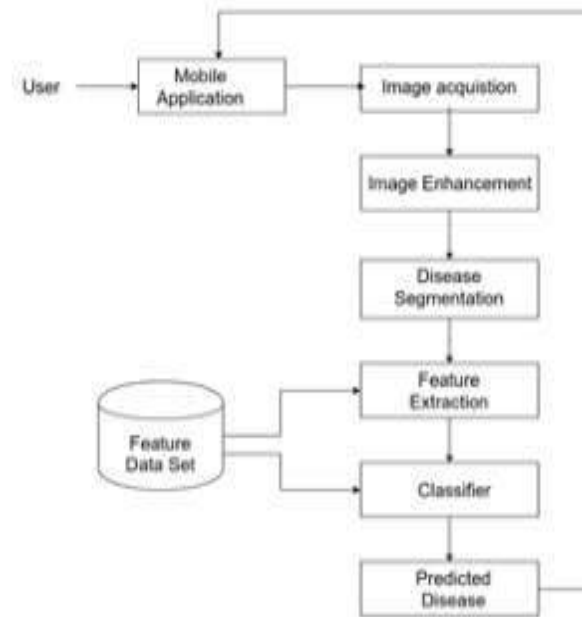
Fig. 2: Block diagram of plant disease detection

The network used is a feed forward neural network of two layers with one hidden layer, in which number of neurons for hidden layer is 10. The method specified in the system can be used to design a plant disease detector for farmers for the early detection of plant disease infection and providing a cure remotely.

2.6. Design and development of Automatic weed detection and smart herbicide sprayer robot

Traditional method of destroying the weeds in a crop plantation is achieved by spraying herbicides throughout the plantation [16]. This has a bad effect on food crops and yield. This paper discusses the image processing algorithm which captures the images of plantations and the herbicides sprayed only on the weeds on identifying the weeds from the image. By this method, the wastage of herbicides can be reduced to a great extent thus making the weed control system smarter. The color images will be converted to binary images and the green parts of the image are extracted. Total amount of white pixels is found out, if it is above threshold then that region is weed. In this arrangement, a container filled with herbicide is fitted with water pump motors which is attached to the spray nozzles. In this experiment Ragi plants (narrow) are taken as the plantation crops and any other plants as weeds (broad leaves). In the absence of plants on the region of interest, the processed image will encounter only black pixels with few small stray groups of white pixels. On identifying narrow leaves, the number of white pixels could be greater than case 1 but less than threshold. If there are broad leaves the count of white pixels will be greater than threshold. Herbicide will be sprayed on this region since its weed. This approach is dependent on the quality of the lighting conditions required for capturing images which is one of the disadvantages faced by smart weed control robots. By incorporating targeted spraying on the weeds, wastage of herbicides can be reduced to a great extent [17-21].

3. Hardware and Software Components

3.1. Algorithm for Line Follower Robots to Follow Critical Paths with Minimum Number of Sensors

The Raspberry Pi, (Fig. 3) is intended to run a working framework called GNU/Linux—from this point forward alluded to just as Linux. In contrast to Windows or OS X, Linux is open source: it's convenient to download the source code for the whole working framework and add whatever improvements you want. Nothing is hidden, and all progressions are made in full perspective on people in general. This open source improvement attribute has enabled Linux to be immediately transformed to keep running on the Raspberry Pi, a process known as porting. At the time of this composition, a few adaptations of Linux known as appropriations have been ported to the Raspberry Pi's BCM2835 chip, including Debian, Fedora Remix and Arch Linux. The different appropriations take into account various requirements, but still they all are open source.

Fig. 3: Raspberry Pi

Since its demonstration, Python has developed in ubiquity on the account of what is viewed as a reasonable and expressive grammar created with an importance on guaranteeing that code is meaningful. Python is an abnormal state language. This means Python code is written in generally prominent English, making the Pi with directions in a way that rushes to learn and simple to pursue. This is in checked difference to low-level accent, similar to constructing agent, which are nearer to how the PC "considers" yet practically inconceivable for a human to pursue without involvement. The abnormal state nature and clear language structure of Python makes it a gainful instrument for any individual who needs to figure out how to program. Another option is to make use of a coordinated improvement condition (IDE, for example, IDLE, which gives Python-explicit usefulness that is absent from a standard content manager, including punctuation checking, investigating offices and the capacity to run your program without leaving the supervisor. The VNC watcher is seen as the primary programming device utilized for the venture. At registration, Virtual Network Computing (VNC) is a graphical workspace that shares a framework which uses the Remote Frame Buffer (RFB) convention to remotely control another PC. It transmits the mouse and console occasions starting with one PC then onto the next, handing off the graphical screen refreshes back the other way, over a system [22]. It is stage free, there are customers and servers for some, GUI-based running frameworks and for Java. Meanwhile, several clients can interact with a VNC server. Common applications for this innovation include remote expert assistance and capturing work PC logs from home PC or vice versa. There are several versions of VNC that offer their own particular utility, For example, some efficient for Microsoft Windows or offering record exchange (not part of VNC legitimate), etc. Many are perfect (without their additional highlights) with VNC appropriate as in a watcher, as of one type can bind to a server of another. Others depend on the VNC code, but don't work well with standard VNC. In the typical strategy for an activity, a watcher interacts with a port on the server (default port: 5900). On the other hand, (depending on usage) a program can bind to the server (default port: 5800). Also, a server can interact with a watcher in "listen mode" on port 5500. The correct position of the listen mode is that the server site does not need to configure its firewall to allow access on port 5800 (or 5900), the obligation is the watcher, which is useful if the server site does not have PC capability and the watcher client is progressively competent.

The ROFAR system is shown in Fig. 4. The camera component is connected to one of the USB-A ports in the raspberry pi. For the dc motor connection, a L293D motor driver is used. For that import the time module and the GPIO pins. The output pin is comprised of Pin 22, 18 and 16. The enable pin of L293D is connected to the pin 22 of raspberry pi in order to enhance the

motor's running time. The motor is turned off when low. Motor 1 and Motor 2 are input pins. The IR sensors are powered by +5V pin to enable the movement of the kit. Next, utilizing the black wire, the ground pins are connected to the ground of IR sensor and motor driver module. With the help of the yellow wire, the output pins of the sensors both 1 and 2 are connected to the GPIO pins and 3 respectively. The motors are operated using four pins (AB, A, B). These four pins are connected from GPIO 14, 4, 17 and 18 respectively. The white and orange wire collectively are used to form the connection for a single motor. Such that, there are two pairs for two motors. The motor driver module L293D is used to which the two motors are connected and is powered using a power bank. We have to ensure that the ground of the Raspberry Pi is connected to that of the power bank, only then our connection will work. Rest of the part is done from the user's system.
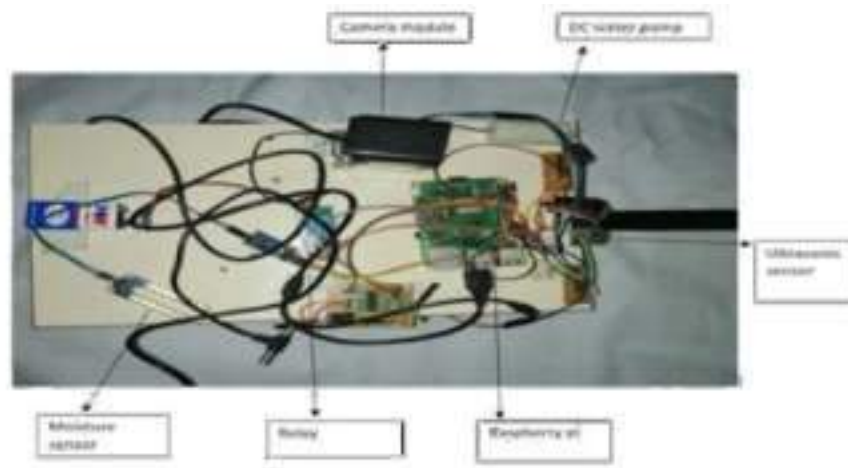
Fig. 4: ROFAR system

The raspberry pi is remotely accessed by the VNC viewer. There are mainly two python files accessed for the working one is named robot.py and the other named mail.py. The image of the plant is taken by the camera and is sent to the respective mail id set in the program.

4. Proposed Model

The proposed venture is completed for the most part by the raspberry pack and the plant leaf recognition by utilizing profound learning techniques in AI. Ongoing video observing is likewise included alongside the unit. The unit likewise showers the plant with water basically or by estimating the dampness of the dirt. At the point when the unit arrives near a plant it captures the images of the leaves and is sent back to a separate framework for malady recognition. The framework marks the plants with classes healthy(h), late-blight(l), viral(v) or bacterial(b). The robot then pursues a dark line utilizing the line following idea with the goal that it catches and plays out the splashing capacity up and down the way of the robot.

4.1. Line following Concept

The game plan of the plants is structured dependent on the way of the robot. The robot moves along the dark line taking the picture of the plants and in the meantime watering the plants. The robot distinguishes a line as a basic line and pursue basic line following calculation if both of its external sensors are on dark surface. Over a white surface and the other way around and goes through it. It takes a shot at the reflection property of light. At the point when infrared light falls on a white surface, it gets reflected completely. Then again, when it falls on the dark or dim surface, it gets assimilated all things considered. The measure of reflected light will be extremely less.

4.2. Water Spraying

Soil Moisture Sensor measures the moisture level of soil and gives the dirt condition either wet or dry. On the off chance that the soil content is decreased beneath the predefined esteem it will send the flag water will begin to siphon. Generally, plant spots in order to water the plants by utilizing separation esteems from Ultrasonic Sensor. The water content in soil will be detected by the soil dampness sensors. A dirt moisture test is made up of several soil moisture sensors. A regular kind of soil moisture sensor in commercial use is a Frequency space sensor, for example, a capacitance sensor. An alternative sensor, the neutron moisture check, uses the intermediary properties of water for neutrons. Soil moisture content might be changed by means of its impact on the dielectric constant by estimating the capacitance between two cathodes embedded in the dirt. Where soil moisture prevails as free water (e.g., in sandy soils), the dielectric constant rightly corresponds to the moisture content. The test is ordinarily given a recurrence excitation to allow estimation of the dielectric constant. The readout from the test isn't straight with water content and is impacted by soil type and soil temperature. Consequently, cautious alignment is required, and long-haul security of the adjustment is faulty.

4.3. Disease detection of plants

The robot can recognize the plant leaf sicknesses by employing AI systems. One of the main tasks was to correctly identify the illness affected leaf and can discover the sort of malady by utilizing profound learning strategy in ML (Fig. 5).
The main modules included are:

- Data set: data set of plant leaves are collected which contains labelled images.
- Data resizing: images are resized which is to be given as input to the neural network.
- Training: the resized data set is used to train the neural network. The training data consist of 4000 plants which are classified as h, l, v, b.
- Testing: the testing data set contains both healthy and unhealthy leaf images. After testing images are classified as healthy or unhealthy
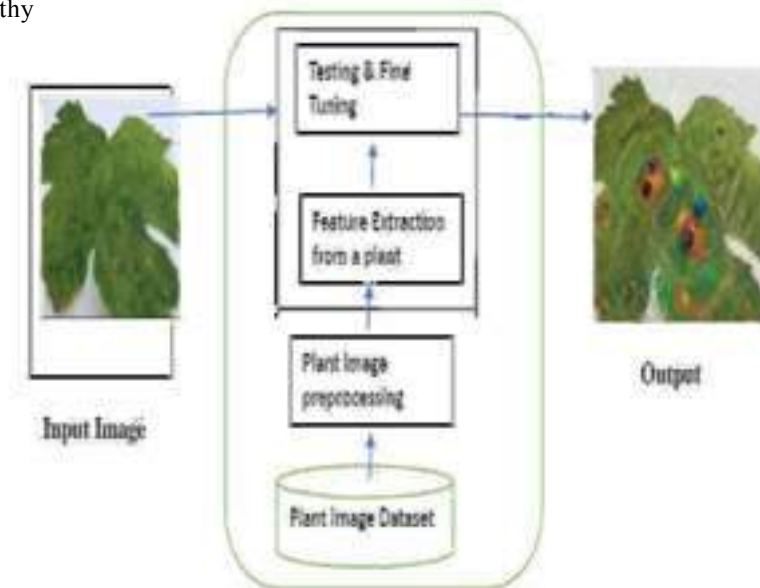
Fig. 5: Processing plant leaf

The testing generates a result either as healthy or diseased by comparing the input image with the known image data set and returns the result with a percentage of accuracy. The input data will be images of data that is the plants. There are two categories in leaf images which are healthy or unhealthy and there are four class labels: healthy(h), late-blight(l), viral(v), bacterial(b) [23].

Also, there are 4000 training images each with resolution 256x256. The input training data as well as testing data will be converted into a numpy array with input filename and its label. The label will be in the one hot encoded format. Cv2, numpy, os, tqdm libraries are imported for data resizing. The image is resized into the resolution 50*50 by using the packages in imported libraries. The training process involves creating a DNN and then passing the train data for training the network [24]. Here the tensor flow framework is used to create a neural network. The input data shape is in the form of (50,50,3), then the first layer which is the input layer to the neural network will have the same shape. There are a total of 6 hidden layers mentioned with the input size as well as the activation function that's being used. The last layer is where the fitting or converging takes place and we finally get output in that layer. It is fully connected. Here we are using two activation functions [25] 'relu' and 'softmax', 'relu' means Rectified Linear Unit [26]. This is mainly used in hidden layers in neural networks. 'softmax' is used to calculate the probability of the class labels in the output layer [27]. Dropout function is used in the fully connected layer to avoid the overfitting of the input data. Training and testing done by using 'model.fit' function. In supervised training, both the inputs and the actual outputs need to be provided. The neural network process the input and produces output. The output which is generated is compared with the desired output. If any errors in the output, it will back propagate. Feature extraction in a neural network is explained by the concept of convolution. Convolution is considered as the main building block of a CNN [28]. By Convolution we mean the mathematical mixture of two functions to produce a third function. With respect to Convolution Neural Network (CNN), the convolution is executed by the mechanism of sliding the filter or kernel over the input data. Matrix multiplication is accomplished at each location and the sum of the results are added on to the feature map. The region of our filter is also called the receptive field which is named after the neuron cells. The size of this filter is 3x3 [29].

In the testing stage, we will have a plant leaf image without label, meaning we won't know which class (h,l,v,b) the image will fall into. The already trained saved model will be loaded and then the test image will be then passed as input to the already trained model. The model based on what features it has learned will output the class which it belongs to with the help of 'model. Predict' function. By adding a new type of plant to the image data set, we can detect almost all types of diseases. we do not need external hardware devices The system will generate output with approximately 90% accuracy and the system can be fine-tuned any time for any new types of diseases, simply by adding the new disease leaf images.

4.4. Working Principle

The module is mainly divided into two. The first is a kit that performs function such as image capturing, water spraying and real time video monitoring. The second module is the diseases detection part that classifies plants based on diseases using an Artificial Neural Network. The kit moves along the black line by the black line following the algorithm and stops at each position when an obstacle is encountered which it recognizes as a plant. Fig 6 demonstrates the same.
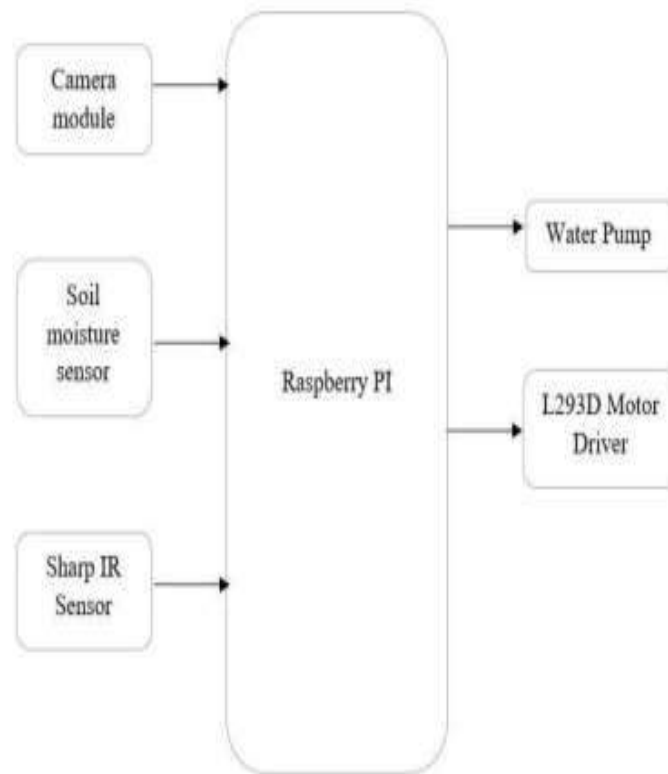
Fig. 6: Block diagram of robotic kit

The camera attached to the module captures the images and at the same time humidity of the soil is detected. On encountering the humidity value below the threshold value, water is sprayed to the plant. A real time video streaming is also provided to the user. The captured image is sent to the user's system through mail and the image is given as an input to the plant disease detection algorithm using the Convolutional Neural Network of the system which classifies the image as healthy, late blight, viral and bacterial. The heart of the system is Raspberry Pi and the corresponding function and application is done with the help of a VNC viewer. The L293D motor driver helps to convert the signals from the raspberry pi to the dc motors.

617
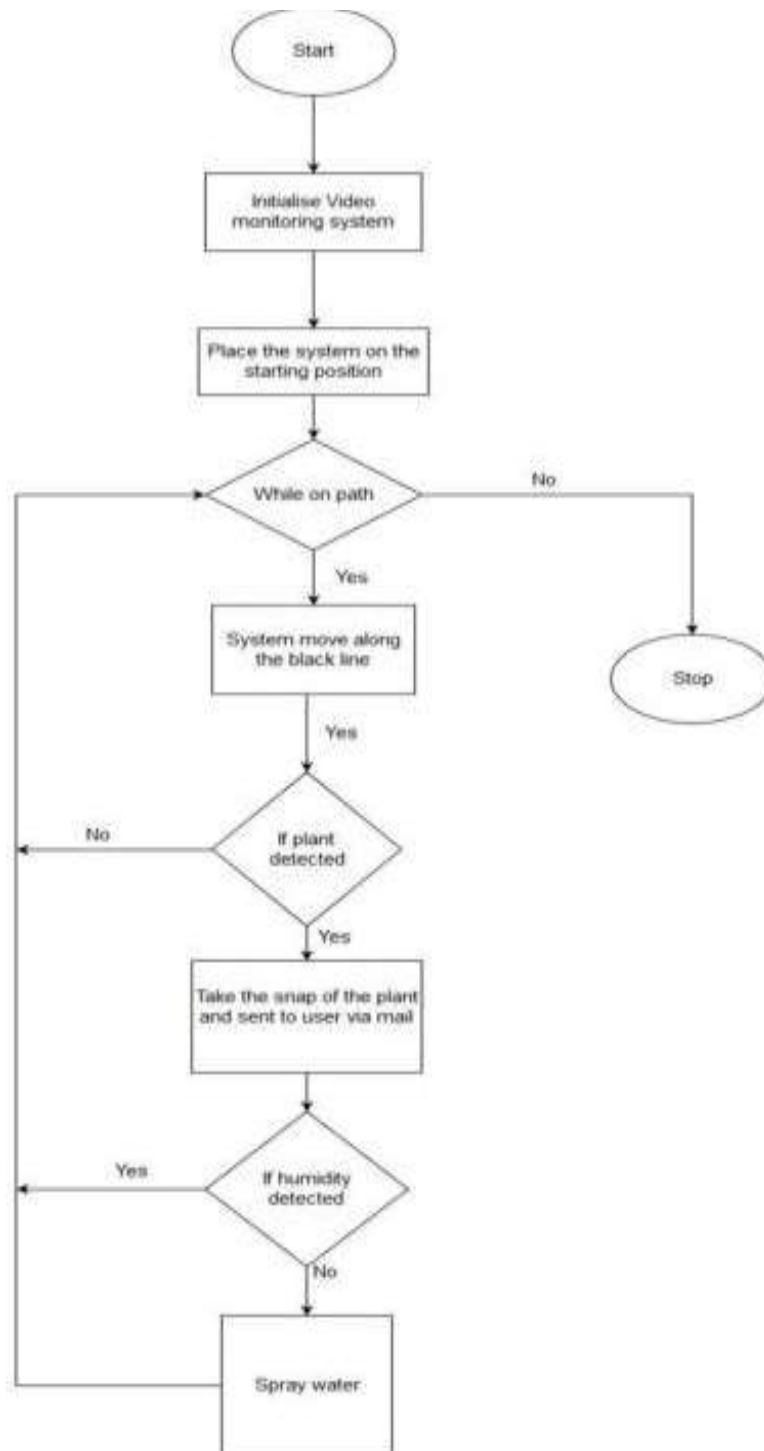
Fig 7: System Flowchart

5. Experimental Analysis

The black line following algorithm is employed in guiding the robot in the correct path. It's working is similar to that of Line following robots as depicted in Fig.8. The Line Following robot is one that identifies a black path [30]. The two IR sensors are kept in between the black line. If it detects a white line it stops. If it encounters an object it recognizes it as a plant and the image of the leaf is sent.
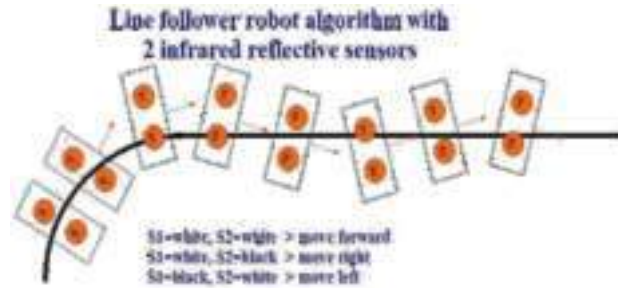
Fig. 8: Black line following adaptation

The water spraying is done uniformly for each plant as it encounters a plant. Water spraying also depends on the moisture of the soil. If there is moisture content it does not spray water. Along with this the video streaming is also done along the path till the end. Based on the leaf image captured by the system a table for the image and the corresponding result incurred for the leaf the table is depicted as shown below Table 1.

Table 1 - Captured leaf image Analysis.

Captured leaf image	Leaf name	Expected result	Experimental Result
	Tomato leaf	Late blight	late blight (correct)
	Tomato leaf	Healthy	Healthy (correct)

	Mango leaf	Healthy	Healthy (correct)
	Money plant	Late blight	Bacterial (wrong)
	Tomato leaf	Viral	Viral (correct)
	Tomato leaf	Bacterial	Bacterial (correct)

The raspberry pi console and video streaming as shown in Fig 9 and 10 respectively.

Fig 9. Raspberry Pi Console   *Fig 10. Video Streaming*

For a live plant the training was completed in 96.65 seconds and the test result was that it was bacterial.

6. Conclusion

Agriculture is one of our most important sectors for providing food, feed and fuel necessary for our existence. Autonomous kits are playing an important role in this field. In the present scenario, a wide range of such kits are available to perform different applications on various levels of agricultural process. The proposed system ROFAR concentrates mainly on disease detection and

it accurately distinguishes plants based on diseases. By inculcating new species of plants to image data set, we can detect almost all types of diseases. The system will generate an output with approximately 90% accuracy. The system can be fine-tuned any time for any new type of diseases, simply by adding the new disease leaf images. Most detection systems can detect fungal diseases only, but our system detects almost all. With this system there is no need for farmers to be present at that time and he/she could perfectly detect the diseases if it is present in the plants

7. Future Scope

We have to keep in mind that a learning curve will be present as the technologies improve in their operation capacity and sensitivity. The industrial trends appear to be moving towards large-scale efforts, so kits like this should be continuously developed. The kit designed by us, if further developed, could also do the necessary function for treatment of the detected diseases among plants. Thus, the fully autonomous kit could be developed. By making use of a gripper circuit the kit can dip the moisture sensor into each plant at each position to measure the moisture content.

REFERENCES

[1] Ji-Chun Zhao, Jun-Feng Zhang. The study and application of the IOT technology in agriculture. 2010 3rd International Conference on Computer Science and Information Technology.

[2] Pritish Sachdeva, Shrutik KatchiiB. A Review Paper on Raspberry Pi 2015.

[3] Thomas F. Scherer. Soil, Water and Plant Characteristics Important to Irrigation Dec. 2017.

[4] George N. Agrios. Plant Pathology, Fifth Edition 25th January 2005.

[5] S. P. Raychaudhuri, J. P. Verma, T. K. Nariani, B. Sen. The History of Plant Pathology in India Vol. 10:21-36.

[6] Nakib Hayat Chowdhury, Deloara Khushi, Md. Mamunur Rashid. Algorithm for line follower robots to follow critical paths with minimum number of sensors. Accepted to International Journal of Computer (IJC) 2017.

[7] J. S. Tan ; V. Teh ; H. M. Teck ; Z.H. Lim, Future farming robotic delivery system jackbot mark I, 2016 IEEE Conference on Wireless Sensors (ICWiSE).

[8] Mehran pakdaman, Mehdi Sanaatiyan, Mahdi Rezaei Ghahroudi (2010) "A Line Follower Robot from design to Implementation: Technical issues and problems" proceedings on 2010 The 2nd International Conference on Computer and Automation Engineering (ICCAE) Page(s) 5 -9.

[9] Tuan D. Le, Vignesh R. Ponnambalam, Jon G. O. Gjevestad, Pål J. From, A low- cost and efficient autonomous row- following robot for food production in polytunnels, Volume 37, Issue 2, Pages: 309-321, Journal of Field Robotics, WILEY Online library, June 2019.

[10] Jawad Iqbal, Rui Xu, Shangpeng Sun, Changying Li, Simulation of an Autonomous Mobile Robot for LiDAR-Based In-Field Phenotyping and Navigation, Robotics, 10.3390/robotics9020046, 9, 2, (46), (2020).

[11] Ege Ozgul ,Ugur Celik,.Design and implementation of semi-autonomous anti-pesticide spraying and insect repellent mobile robot for agricultural application, 5th International Conference on Electrical and Electronic Engineering (ICEEE) 2018.

[12] P. B. Sowmiya , B. K. Nagaswetha , D. Priyadharshini. Design of automatic nutrition supply system using iot technique in modern cities, 2017 International Conference on Technical Advancements in Computers and Communications (ICTACC).

[13] Sajjad Yaghoubi, Negar Ali Akbarzadeh, Autonomous robots for agricultural tasks and farm assignment and future trends in agro robots, International Journal of Mechanical & Mechatronics Engineering IJMME-IJENS Vol:13 No:03

[14] Khakal Vikas Shivaji, S. G. Galandereal. Real time video monitoring and microparameters measurement using sensor networks for efficient farming. International Conference for Convergence for Technology-2014.

[15] Jagadish Kashinath Kamble. Plant disease detector. 2018 International Conference On Advances in Communication and Computing Technology (ICACCT).

[16] Aravind, M. Daman, B. S. Kariyappa. Design and development of automatic weed detection and smart herbicide sprayer robot. 2015 IEEE Recent Advances in Intelligent Computational Systems (RAICS).

[17] Oberti R, Marchi M, Tirelli P, Calcante A, Iriti M, Tona E, et al. Selective spraying of grapevines for disease control using a modular agricultural robot. Biosyst. Eng, 2016; 146: 203–215.

[18] Gonzalez-de-Soto M, Emmi L, Perez-Ruiz M, Aguera J, Gonzalez-de-Santos P. Autonomous systems for precise spraying – Evaluation of a robotised patch sprayer. Biosyst. Eng., 2016; 146: 165–182.

[19] Adamides G, Katsanos C, Parmet Y, Christou G, Xenos M, Hadzilacos T, et al. HRI usability evaluation of interaction modes for a teleoperated agricultural robotic sprayer. Appl. Ergon. 2017; 62: 237–246.

[20] Tanha Talaviya, Dhara Shah, Nivedita Patel, Hiteshri Yagnik, Manan Shah,Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides, Artificial Intelligence in Agriculture,Volume 4, 2020, Pages 58-73, ScienceDirect, https://doi.org/10.1016/j.aiia.2020.04.002. (http://www.sciencedirect.com/science/article/pii/S258972172030012X).

[21] Midtiby H S, Mathiassen S K, Andersson K J, Jørgensen R N. Performance evaluation of a crop/weed discriminating microsprayer. Comput. Electron. Agric., 2011; 77(1): 35–40.

[22] Choudhury D. Roy. Networks and Systems Paperback Jun 2013.

[23] Noa Schor, Avital Bechar. Robotic Disease Detection in Greenhouses: Combined Detection of Powdery Mildew and Tomato Spotted Wilt Virus. IEEE ROBOTICS AND AUTOMATION LETTERS. PREPRINT VERSION. ACCEPTED December, 2015.

[24] Schmidhuber. Deep learning in neural networks: An Overview of Neural networks. vol. 61, pp. 85–117, 2015.

[25] Chigozie Enyinna Nwankpa, Winifred Ijomah. Activation Functions: Comparison of Trends in Practice and Research for Deep Learning. arXiv:1811.03378v1 [cs.LG] 8 Nov 2018.

[26] Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook 25 August 2018.

[27] Christopher Bishop. Neural networks for pattern recognition, 23 Nov 1995.

[28] Muluken Hailesellasie, Syed Rafay Hasan. FPGA-Based Convolutional Neural Network Architecture with Reduced Parameter Requirements 2018 IEEE International Symposium on Circuits and Systems (ISCAS).

[29] Alex Krizhevsky, Ilya Sutskever. ImageNet Classification with Deep Convolutional Neural Networks. Advances in neural information processing systems January 2012.

[30] Juing-Huei Su, Chyi-Shyong Lee. An intelligent line-following robot project for introductory robot courses. World Transactions on Engineering and Technology Education Vol.8, No.4, 2010.

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DIO messages and trickle timer analysis of RPL routing protocol for UAV-assisted data collection in IoT

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ABSTRACT

Routing protocol for low-power and lossy networks (RPL) is an widely-used IPv6 routing protocol for lossy wireless networks with the power constrained devices in Internet of Things (IoT). It is a proactive protocol that constructs a destination oriented directed acyclic graph (DODAG) rooted at the single destination called the root node that resides at unmanned aerial vehicle (UAV). Specifically, a DODAG

messages incur additional energy consumption, RPL uses the Trickle algorithm to dynamically adjust the transmission windows. In this paper, we analyze the effect of the two parameters, namely, DIO-

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algorithm and the rate of message generation. Through experiments, we show that an optimal selection of these parameters saves a significant amount of energy with different parameter settings in UAV-assisted IoT networks.

References

1. Hazrat Ali. 2012. A performance evaluation of rpl in contiki.

2. Cosmin Cobarzan, Julien Montavont, and Thomas Noel. 2014. Analysis and performance evaluation of RPL under mobility. In *2014 IEEE symposium on computers and communications (ISCC).* IEEE, 1--6.

3. Badis Djamaa and Mark Richardson. 2015. Optimizing the trickle algorithm. *IEEE Communications Letters* 19, 5 (2015), 819--822.

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Due to the availability of numerous image manipulation tools, fraud images can be generated very easily and effectively. These fraud images are quite difficult to recognize. A section of the image is copied and pasted at some other location on the same image in copy-move forgery to drop meaningful objects or to bring additional information which is not present actually in the image. Whereas, the image recoloring techniques normally change the images via a variety of mechanisms like contrast enhancement and colorization. In the proposed method, copy move forgery detection is based on similarities in the images and finding the forged part by using threshold and contouring techniques. Recolored image detection uses a convolution neural network with three layers which outputs the probability of recoloring. As the techniques for image forging are developing faster, the necessity of highly efficient and accurate image forgery detection also increases. Here, this proposed system focuses on both recoloring and copy-move forgery detection.

Published in: 2020 Fifth International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN)

Date of Conference: 26-27 November 2020   **INSPEC Accession Number:** 2030111

Contents

I. Introduction

Numerous digital images are generated by different devices nowadays. These images are spread by various newspapers, television channels, and different media. Various legal and scientific businesses use digital images as confirmation of certain situations and are used to make crucial decisions. Forgery in images can be defined as the manipulation of images to hide some useful information about the image. Different types of software tools, like Photoshop, are applied to make forged images, and these forged images look like the real images by human vision. Unluckily, there are a lot of inexpensive and high-resolution digital cameras and advanced photo editing software available nowadays, hence it is very easy to produce fraud images and the discovery of these manipulated images is much challenging through human eyesight since they may not be leaving any visual clues that indicate the image forgery. These facts challenge the authenticity of digital images/photographs. Therefore, image forensic techniques for forged images discovery are crucial.

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Morphological Operators on Hypergraphs for Colour Image Processing

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V Bino Sebastian ; Nuja M Unnikrishnan ; Neenu Sebastian ; Rosebell Paul   **All Authors** •••

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This article is an extension of morphological operators on hypergraphs to work with colour images. Morphological operators on hypergraphs are useful for binary and grayscale image processing. The preliminary experimental results related to the extension of these operators to colour images is presented in this paper. The results on colour images are promising and is a better alternative for the existing methods.

Published in: 2020 Advanced Computing and Communication Technologies for High Performance Applications (ACCTHPA)

Date of Conference: 02-04 July 2020

Date Added to IEEE *Xplore*: 06 October 2020

▸ **ISBN Information:**

INSPEC Accession Number: 20033605

DOI: 10.1109/ACCTHPA49271.2020.9213191

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I. Introduction

Mathematical morphology is the first consistent non-linear image analysis theory. Originally it was defined on a set theoretic framework and used for processing binary images and extended to grayscale images. Despite its continuous origin, it was soon recognised that the roots of the theory were in algebraic theory, notably the framework of complete lattices. This allows the theory to be completely adaptable to non-continuous spaces, such as graphs [4] , hypergraphs [3] and simplicial complexes [5] . Extending Mathematical Morphology to colour images is an active area of research in image processing [8 , 18 , 9] . There is no natural extension of the morphological operators to colour images. This is because colour images does not admit a partial ordering [11] . Image denoising is one of the most important operations in image processing. Salt and pepper noise is very common in image processing applications and noise reduction is a very active area of research in this field [12] . Morphological filtering is one of the most reliable techniques for salt and pepper noise reduction [2 , 4 , 5] . Our objective is to utilise the morphological operators defined on hypergraphs to remove this noise from colour iamges [2 , 16] .

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2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC)
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Copy-Move Forgery Detection and Performance Analysis of Feature Detectors

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Now a days, the digital image integrity are remarkably important for the exchange of data which are generally utilized for different applications like fraud detection, therapeutic imaging, reporting, and advanced crime investigation. Digital images can easily be forged with the advancement of image manipulation tools and information technology. The commonly used image forgery technique in digital forensic filed is Copy-move forgery. The two fundamental classifications for identifying copy-move forged images are keypoint-based and block- based method. Block-based strategies have the burden of high computational expense because of the enormous number of image blocks and it fails to deal with different geometric transformations. On the contrary, keypoint-based methodologies can overwhelmed these two draw-backs however are discovered hard to manage smooth locales. As a result, these two methodologies are combined and proposed a effective copy-move forgery detection. Also, we accomplish a comparative study between different keypoint detectors and feature matching algorithms used to determine computational complexity of each.

Published in: 2020 International Conference on Communication and Signal Processing (ICCSP)

Date of Conference: 28-30 July 2020   **INSPEC Accession Number:** 19914092

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I. Introduction

W ITH the development of computer technology duplication related to images have increased exponentially. In past few decades more and more researches have been undergoing to detect and rectify tampered images. Copy-move forgery is one of the most popular image forgery techniques in which a region of an image is copied and pasted into another region of the same image. Since the copied region is from same image thus it may have same color characternoise component etc. There have been various techniques which are prevalent for matched keypoints –3] but are ineffective for forgery detection very well. To achieve both the requirements with moderately high accuracy we implement a segmentation method and feature point matching.

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IEEE Geoscience and Remote Sensing Letters

Published: 2008

Feature Extraction and Image Matching of 3D Lung Cancer Cell Image

2009 International Conference of Soft Computing and Pattern Recognition

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A Review on Studies Based on Vehicle Stability and Safety on Rural Horizontal Curves

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ABSTRACT

All over the world India bangs the top most position in crash deaths. Nearly 1.2 lakh people die every year on Indian roads. Crashes involving rolloverand lateral skidding are now responsible for almost 1/3 of all highway vehicle occupant fatalities. So, rollovers and skidding are more serious than other types of crashes. One of the major reasons for such incidents is vehicle instability at curves due to its inconsistent geometric design. This necessitates a review on current design guidelines followed in India. Many researchers have pointed out drawbacks of current design approach and a few have identified various influential factors which are significant in curve design to reduce rollover and lateral skidding. When some researchers conducted field studies to measure vehicle stability at selected curves, some carried out computer simulations. There are efforts to incorporate vehicular characteristics in curve design which is much appreciable. This paper aims to project efforts made by researchers to reduce vehicle instability at horizontal curves. Moreover, gaps in these research works and scope for further research are highlighted.

Keywords: crash, rollover, skidding, vehicle stability

1   Introduction

As per Ministry of Road Transport and Highways, New Delhi (MORTH), about 15% of road crashes on highways occur at horizontal curves among which 8% is due to vehicle overturning or lateral skidding. A closer look at the crash statistics records of a few years reveals that road crashes involving vehicle overturning and lateral skidding are increasing drastically, especially heavy vehicle crashes. Several studies are conducted to identify the factors causing road crashes and prevent them. Crashes are multi causal and are affected by numerous factors like geometric design, traffic volume, traffic composition, variation in speed between vehicles of the same class and different classes, weather, motivation for travelling, driver's attentiveness and so on (Aljanahi et al., 1999).

James McKnightet. al., 2008 conducted 'Large Truck Crash Causation Study' for 967 crashes, with 1,127 large trucks, 959 non-truck motor vehicles, 251 fatalities, and 1,408 injuries. The identified causes are misjudged speed, insecure loading, inattentiveness, loss of steering control, vehicle characteristics like tire, brake and suspension. Numerous research works are carried out by researchers across the world to identify influence of geometry on crash rate. Yingxue Zhang et al, 2009 identified curve radius, width, superelevation, transition curve and sight distance have important effect on traffic accidents. According to Sunanda Dissanayake and

Bio-reactor Landfill for Sustainable Waste Management – A Review

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Abstract - **To improve personal satisfaction in any country, the strategies for strong waste management should be reinforced. In India, the concept of engineered landfilling is not fully utilized. On the off chance that enough land is usable, it is viewed as a savvy practice. Aside from certain progressions, for example, reusing and source moderation methodologies, it has been found that garbage removal in landfills will stay an unavoidable piece of the strong waste administration framework. The bioreactor landfill concept changes the purpose of landfilling from storage to treatment of waste. The working hypothesis is that they encourage and speed up the natural exploitation of waste by safeguarding ideal dampness content inside the cells where the squanders are handled. The distribution of leachate assists with controlling dampness and microorganisms help to settle natural waste. The development of Bioreactor landfills can give natural and monetary advantages, and it is a promising strong waste administration framework for a thickly populated and emerging nation like India. This paper examines the possibility of a Bioreactor landfill for waste handling in the Indian context. The main features, types, operations, advantages, disadvantages and differences to the conventional landfills are discussed in detail.**

Keywords—bioreactor landfill, waste disposal, sustainability

I. INTRODUCTION

Attributable to different sources of strong waste with quick development in the populace worldwide, maintainable metropolitan strong waste administration has become a necessity. The age of MSW has become an inexorably significant worldwide issue throughout the most recent decade. The expanded age of strong waste has provoked the execution of coordinated MSW the board, which incorporates reusing, fertilizing the soil, incineration and landfilling. About 80% to 90% of metropolitan waste is discarded in landfills without proper administration strategies or open copying, as indicated by gauges prompting air, water, soil contamination. Natural substances and actual cycles in landfill conditions encourage the biodegradation of natural squanders in MSW. Natural boundaries, like landfill liners and covers, are regularly utilized in ordinary landfills to keep dampness out, which is essential for waste biodegradation. Therefore, wastes are caught in a "dry burial place" and stay unharmed for extensive stretches going from 30 to 200 years, possibly outliving the landfill obstructions and covers. Liner disappointment in customary dry landfills is a chance, later on, representing a critical danger of groundwater and surface water pollution. Today, one idea that has got a ton of

consideration is the "Bioreactor landfill." Within 5 to 10 years of presenting the bioreactor interaction, a bioreactor landfill is a sterile landfill that utilizes improved microbiological cycles to change over and balance out the promptly and respectably decomposable natural waste constituents. In contrast with what might somehow occur in a landfill, the bioreactor landfill incredibly builds the level of natural waste decay, transformation rates, and cycle adequacy. The expansion of leachate or other fluid revisions, the expansion of sewage muck or different alterations, temperature control, and a "bioreactor landfill" give control and cycle streamlining, mostly through the expansion of leachate or other fluid changes, temperature control, and supplement supplementation. Additionally, the activity of a bioreactor landfill can require the option of air. Various types of "bioreactor landfills, for example, anaerobic bioreactors, oxygen-consuming bioreactors, and vigorous anaerobic bioreactors have been created and worked around the planet dependent on waste biodegradation mechanisms.

This paper means to raise peruse consciousness of the bioreactor landfill as a possibly reasonable waste management tool. It is required to be an essential commitment to future conversations among landfill proprietors and administrators, lawmakers, controllers, preservationists, and the overall population.

II. WASTE MANAGEMENT IN INDIA

It has been found that MSW, which ordinarily contains half biodegradable materials, 20% recyclable materials, and 30% dormant and inorganic materials including sands, rocks, and rock, has enormous energy potential. The metropolitan urban communities and towns of India's different states produce about 0.5 kg of MSW per capita each day. Only 12–14 % of MSW is formally taken care of in India, with the rest going to open unloading and landfill removal choices. As per the Planning Commission Report (2014), around 377 million individuals living in metropolitan territories produce 62 million tons of MSW each year, with 165 million tons each year and 436 million tons each year projected later on. The MSWM rules are set up to decrease the measure of waste that winds up in landfills by reusing likely material and assets from MSW. The various waste management methods for Indian MSW are listed below (Nandan et al., 2017; Pujara et al., 2019)

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Litty Koshy ; Ajay S ; Akhil Paul ; Hariharan V ; Ashil Basheer   **All Authors** •••

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With the widespread use of digitally interactive multimedia such as audio, images, and video, there has been a
significant increase in the mode and motivation to create digital forgeries. The widespread availability of video
information and services, as well as the low cost of devices such as cameras, camcorders, and CCTVs, has led to
widespread use of video information and services in our society for a variety of purposes such as video surveillance,
forensics investigation, and entertainment. Previously, video editing techniques were mostly employed to improve
digital information. However, as the popularity of low-cost, easy-to-use video editing software has grown, so has the
number of negative repercussions and risks associated with such editing procedures. By merging, changing, or
synthesising new footage, video forgery is a technique for creating changed or fraudulent videos. A method based on
deep learning is given in the proposed system for classifying videos as tampered or original. The video clip that is used
as input is divided into two categories: original and modified. The video is segmented into non-overlapping frames, and
the authenticity of the movie is determined by whether or not all of the frames are genuine. The suggested method
uses a deep CNN model that has two types of layers: (1) CNN layers which involve convolutional, pooling and fully
connected layers and (2) Parasitic layers.

Published in: 2021 Smart Technologies, Communication and Robotics (STCR)

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I. Introduction

In the present digital age of internet and social media, our day to day life is permeated with digital video content as one of the prominent means for communication. Developments in video technologies such as generation, transmission, storage and retrieval along with applications like Video sharing platforms, Video-conferencing, etc. have served relating people and society in many ways. Sign in to Continue Reading Applications such as the entertainment business, video surveillance, legal evidence, political films, video tutorials, ads, and other social networking platforms, such as YouTube, Facebook, and Instagram, demonstrate their unparalleled role in today's context.

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A study on various thermographic methods for the detection of diseases

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Fever is a common symptom for various infectious diseases that are reporting nowadays in a massive amount like COVID-19, Ebola and so on that will directly affect our whole human cells and are showing a lot of chromosomal aberrations too. Since there was not a unique way are to predict how these diseases will affect our body both physically and mentally, since they can create some aftereffects in future too, there should be a suitable system which will efficiently detect these type of pandemic. In all these situations thermal screening had emerged as a remedial method for the detection of temperature variations. Among this Infrared thermography had been used as the best and effective method for fever screening. This survey presents some of the important papers which discussed how Infrared thermography can be effectively utilized for the detection of these epidemics by analyzing the temperature variations done in fever screening. Infrared thermography (IRT) is a method which uses an imaging scheme that gives you an image which is a thermal diagram that shows the temperature variations of various intensities. IRT uses the basic working principle from Stefan- Boltzmann Law, where the relationship between the temperature and the emissive power is established and the camera which is the infrared camera will capture this infrared energy and is converted into corresponding electronic signals. This paper gives a brief idea about various techniques used for fever screening which can be used to detect various diseases.

☰ Contents

SECTION I.
Introduction

In December 2019, COVID has vanquished our everyday life measure by detailing its first case from the Huanan fish market in Wuhan, Hubei, China. Scientists had recognized a novel Covid (SARS-CoV-2, additionally alluded to as COVID-19) from affirmed contaminated pneumonia patients [1]. Also, later on, COVID has changed its structure to extremely intense respiratory conditions (SARS) and the Middle East respiratory disorder (MERS). By April 13, 2020, instances of COVID-19 which was affirmed had surpassed 1,800,000. The World Health Organization (WHO) has proclaimed COVID-19 as both a pandemic just as a general wellbeing crisis of worldwide concern. By April 13, 2020, cases of COVID-19 which was confirmed had exceeded 1,800,000. The World Health Organization (WHO) has declared COVID-19 as both a pandemic as well as a public health emergency of international concern.

Infrared Thermography had wide range of applications like Non-Destructive Material Testing for interior analysis of material layers, Thermography in Aerospace where making high end machines, in Chemical industries for monitoring chemical reactions and so many other areas. Where the area focussed by this research paper was Thermography in Medicine.

In like manner, fever is the key manifestation of a few pestilences like extreme intense respiratory disorder (SARS) in 2003, flu A (H1N1) in 2009, Ebola infection sickness (EVD) in 2014, and Covid illness 2019 (COVID-19). As a safety measure government has implemented fever screening as a countermeasure for preventing these disease to its extreme for the people who are crossing international as well as national borders and in places like hospitals, malls, railway stations, and in all places where the crowd assembles fever screening is the one and only remedial measure to detect these diseases.

This research paper provides an idea regarding the momentum situation, where how to focus viably and productively utilize image processing techniques for the recognition of different ailments which contribute to COVID19 detection. Secondly, since the virus was showing variations of symptoms a single symptom called fever cannot be relayed for identifying the virus. So the research paper gives a comparative study of different types of disease symptoms that can be a cause for the detection of corona virus. Third factor was the sensors, since the images were captured by IR cameras an equal focus was given on various sensors used by different methods. The disease mainly focused by the research paper are fever detection, respiratory infections, thyroid, osteo based problems, diabetes, blood flow analysis and cancer detection.

SECTION II.
Background

Image Processing is one of the recent trends in analyzing a digital image where the images were grouped as pixels. In this survey the images were concentrated mainly to thermal images. Thermal images were obtained using a thermal camera in which an array of thermophile sensors were embedded in the lens of camera. These sensors will be of varying resolutions which captures the image. The thermal images obtained will be gray scale images and the RGB coloring model was incorporated to identify each areas based on thermal variations. Infrared Thermography (IRT) comes under infrared imaging science. Radiation in the long-infrared scope of the electromagnetic range (about 9,000–14,000 nanometers or 9–14 μm) is identified by thermographic cameras and produces pictures of that radiation which are named as thermograms. There is a wide scope of utilizations for thermography which can be utilized in a few conditions as an analytic instrument, for arranging the treatment and assessing the impacts of treatment. Thermography can be joined with other imaging strategies and Artificial Intelligence ideas, play a vital role essentially in the adaptation of numerous ailments [2]. Infrared radiations are emitted by all objects above absolute zero, which is stated in black body radiation law. These infrared radiations lie in the range of 0.75–1000 micrometers [3]. Thermography utilizes a non-obtrusive, non-contact strategy that utilizes the warmth from your body to help in making the conclusion of a large group of medical care conditions. So this method was completely safe since it uses no radiations.

SECTION III.
Literature Survey

A. Clinical evaluation of fever-screening thermography

In the research paper, a clinical study of over 596 subjects has been conducted [4]. They made an experimental set up to capture the thermal image where they used a tripod to obtain a full face. The graphical user interface was developed with MATLAB and two IRTs. The analysis was for the duration of fifteen minutes, where four measurement readings were taken. For limiting the impact of outside temperature each subject was asked to meet a relaxation time of 15 minutes and all initial humidity factors were defined properly. Temperature readings were taken on each stage, focusing on the region's facial and forehead so that two IRTs were used. In each round of capturing the image, the webcam acquires a standard color image and the IRTs will acquire three consecutive frames that were reduced to the midpoint from which a solitary mean temperature image was obtained. As the last stage, thermal images of sublingual tissue were captured by instructing them to open their mouth. To establish a reference temperature, oral thermometry was used and the corresponding temperature readings were taken from the region of study. The two temperature measurements will help to modulate two models, a fast model and a monitor model were formulated. The monitor model had an accuracy of ± 1. From the monitor mode, the oral temperature measurements average value was calculated and the final reference temperature was developed. As a subsequent stage facial district depiction and temperature counts were finished. Here temperature from several facial areas was compressed. For the delineation of facial key points, a new approach called image registration was done. This technique uses a matching method by which facial landmarks are mapped to thermal images which will give the main facial points whose temperature measurements are to be recorded.

The calculated values of temperature which are recorded from the selected regions were compared with the reference and from this, the pairwise differences were recorded. Based on this data, the final result was generated which shows the temperature measurement values of the five regions of interest.

Advantages: Gives an efficient method for monitoring temperature especially in the region inner canthi region. Provides a better system performance.

Further enhancement: The effect of puzzling elements identifying with between subject and ecological fluctuation can be remembered for clinical investigation.

B. Development of a Low-cost Thermal Imaging System as a Preliminary Screening Instrument

This study aims at establishing a modest and efficient temperature screening instrument. The methodology uses an AMG8833 thermal camera. The camera is connected to an Arduino by a 12C bus. The picture caught by the camera which is essentially the IR camera is in the form of 64 individual pixels and the pixel values are stored in the Random Access Memory (RAM) of the camera. The IR camera and its in-constructed sensor, which is corresponding to the surrounding temperature and sensor work in sustained, uninterrupted mode. Numerous methods were done to obtain the temperature of the subject which is under study like considering the normal room temperature, pixel offset cancelling, and normalization and thereby compensating the emissivity of the object. The temperature values in the form of an 8X8 matrix were generated which will give the resultant values for analysis by running an Arduino program. And an efficient image can be developed by adding an extra feature, a thin film transistor LED to the original setup.
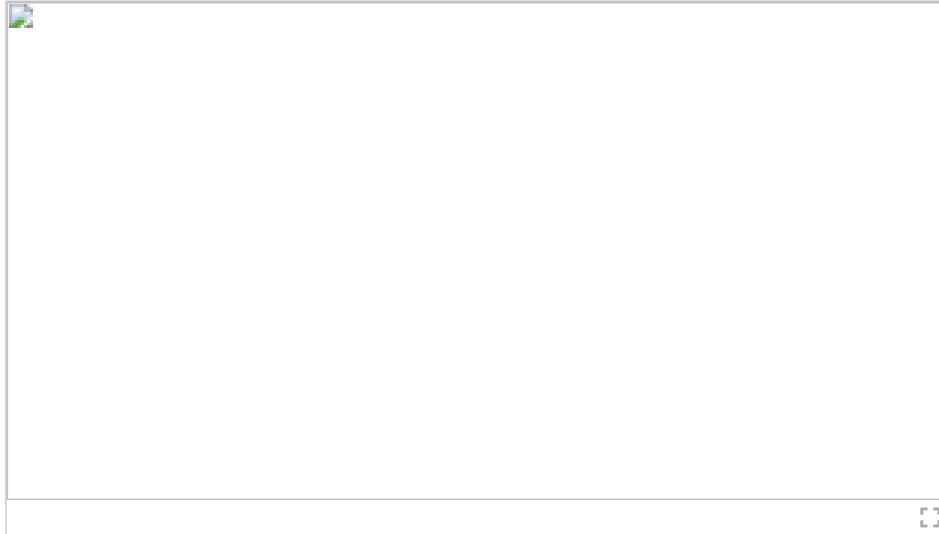
Fig. 1.
Steps in Development of Low-cost Thermal Imaging System as a Preliminary Screening Instrument.

In a microcontroller, a sensor and display module is attached, which senses thermal data by AMG8833. An Arduino IDE captures the thermal images and the images are saved in an SD card which is inserted in the display module. Fig. 1, demonstrate the general working of the proposed method. To this image processing operations are carried out to detect abnormalities in image regions [5].

Advantages: Able to develop an economical, compact easily carrying thermal camera.

Further enhancement: Uses a low pixel ratio when compared to other high quality thermal imaging cameras. The analysis can be made more understandable if the resolution can be increased to 64X64 pixels.

C. A low cost thermal imaging system for medical diagnostic applications

This system uses an infrared sensor which belongs to Melexis IR sensors and it is a thermophile based one. It also constitutes a microcontroller and other hardware related components. The infrared sensor is a completely aligned 16x4 pixels industry-standard IR cluster. It has two chips: an IR array and the 24AA02 (256x8 EEPROM) chip which are embedded into a single sensor. The sensor has a committed low noise chopper-settled enhancer and is quick ADC incorporated which contains 64 IR pixels. By employing a Proportional to Absolute temperature sensor, ambient temperature measurement of the chip is integrated. The temperature sensations in the form of recorded thermal values of both the infrared and proportional to absolute temperature sensors are stored on an internal RAM. The pixel array had a versatile frame rate and every pixel is designed in such a manner that they are cohesively combined with an amplifier and an Analog to Digital convertor. The remaining hardware part contains the control unit which is connected with a triggered mode and an adjustable digital interface [6].

The thermal sensor captures the image as a 16X4 matrix, which is an array of pixels. A microcontroller module calculates the temperature value of each pixel and it will read the calibration values and raw temperature data from the sensor's EEPROM and RAM. With these calculated values microcontrollers calculate the corresponding temperature values of each pixel. A PC will read the serial data and divide the temperature values into different ranges which is an RGB value. During analysis, different variants of temperature recordings were taken, from which an average temperature value was calculated as a unique measurement [7].

Advantages: This framework there use no direct contact with the object so it is safe. It has no radiation too.

Further enhancement: This mechanism can be improved to be used for certain diagnostic applications.

D. Screening for Fever by Remote-sensing Infrared Thermographic Camera

In this model, three different infrared cameras were used. In all these cameras they use a similar system such that they can detect a temperature difference of 0.1. For the measurement of accurate temperature readings, a program was designed in such a way that the parameters for taking correct readings are incorporated in this program like, the object whose temperature has to recorded was at which particular distance from the infrared camera and the surrounding environmental parameters for each dataset. The temperature readings from several points were recorded and the maximum infrared temperature was taken from all these measured temperature values. Six different regions in the body were taken for temperature measurements and two referential measurements were taken. For every person, the IRT measurements and normal body temperature were taken and the same process was repeated after fifteen minutes where they are asked to do exercise. Then by using correlation and regression analysis the two readings, the IRT and ambient body temperatures were analyzed. Finally, the classification was done as false-positive in which the temperature shows a considerable change above the reference value and as false-negative where the temperature is within the normal range [8].

Advantages: This method give an accurate result even if the person whose temperature has been captured was moving. Further enhancement: Additional research can be done for various factors like texture, the application of external makeup and other biological factors.

E. Multi-person fever screening using a thermal and a visual camera

This method involves the fusion of an ordinary visual camera, which gives a clear identifiable image, and an infrared camera that can record the correct temperature measurements of the object which was under investigation. The existing system uses a Forward-looking Infrared Camera (FLIR) of 640x512 pixels resolution and an image capturing camera which belongs to Microsoft LifeCam Studio. The visual camera selected was of higher resolution and has a very high frame rate. Recognized appearances where set apart with rectangular boxes that make use of various inclinations of shadings. Three colors are selected in which each has its own temporal meanings and they are yellow, red, and green. If the measured temperature value shows not much robustness it was recorded with a yellow color gradient. Green is for ordinary ambient temperature and if the recorded temperature was above a referential value that should be considered as a high-risk zone hence indicated in red color. By using a sliding window technique and Random Forest classification the face detection was done smoothly.

The basic working of the proposed system is depicted in Fig.2. In the face, the main area of focus was the corners of the eyes and these features where extracted using random forest repressors. Thermal image coordinators are obtained from the thermal image coordinates of the transformed visual images of corner positions of the eye. For face detection, a modified version of standard Viola-Jones faces detection is used [9]. Then the image is processed with a course of binary classifiers at all sensible positions and scales. If all these stages were fulfilled completely the image will be identified as a face. After the detection of faces, a multi-face tracker was used that will detect faces in a new frame, irrespective of what happens before. And a multi-target tracker will associates the multi-frame face detection. Once the detection of face is completed, as a problem of regression eye corner detection was performed. This technique will forge a regression tree based estimator. With an ensemble, the prominence point position is measured with regression tree focused on binary standards for pixel correlations. The precision of this system highly reliant on the dimension

of rectangle where the calculation was conducted. A rectangle selection of small dimension would reduce the risk factor than with large dimensions even though the localization was more stable. In this view the eye corner detection algorithm was prominent where a key point dimension selection of window can be selected. This method was performed on a recursive basis till the output was obtained. The orientations of camera were focused to obtain a high orientation image. The actual orientations and speed of objects were detected using Kalman filters. By analyzing the assignment matrix, the auction algorithm which is an association method was developed [10]. Thus, the estimation of temperature is generally insensitive toward a wrong surrounding temperature. A bias factor was estimated to consider if the ambient temperature shows a variation than the referential value [11].
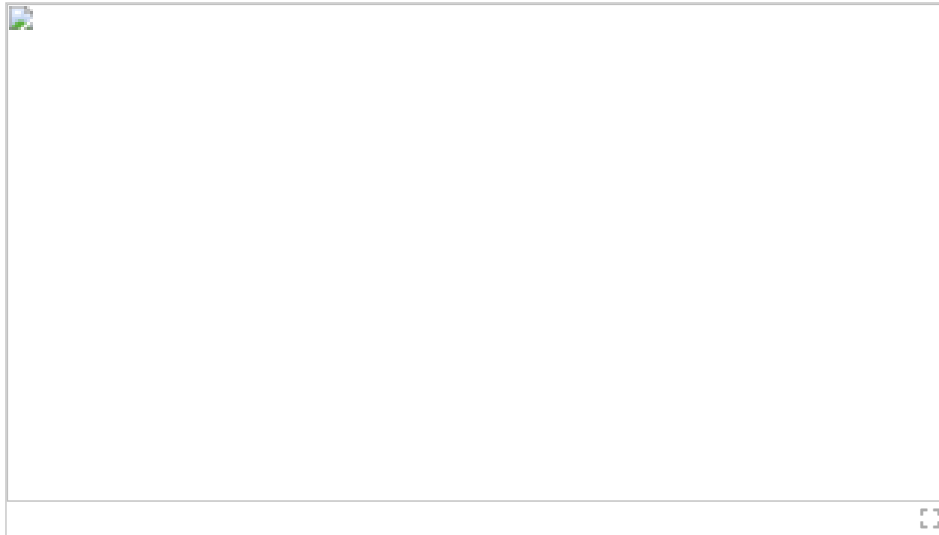
Fig. 2.
Steps in Multi-person fever screening using a thermal and a visual camera

Advantages: Multiple persons can be fever screened at the same time. This method can be used at the airport thus saving a lot of time.

Further enhancement: For identifying glasses in the images obtained by IR camera, a detection algorithm can be developed. Cameras can be properly calibrated to produce a single optical axis.

F. Combining Visible Light and Infrared Imaging for Efficient Detection of Respiratory Infections Such As Covid-19 on Portable Device

This research paper [12] discuss an aberrant breathing detection which uses a deep learning technique. The method incorporates the combination of RGB and thermal videos which are acquired using a dual-mode camera. With the aid of a portable and intelligent screening device, RGB and thermal videos were obtained. For achieving this a FLIR one thermal camera was used which collaborate two cameras one is for taking RGB and the other for thermal. As a part of the respiratory study, the face regions of the videos were focussed, and by a face detection method, the nose and forehead areas were extracted. By using a time series analysis of the breathing data the respiratory patterns of test cases are obtained. There is a chance of occurring temperature fluctuations due to the normal breathing process and the usage of a mask may hide many of the facial features. For avoiding those defects a method where two parallel placed RGB and infrared cameras are placed which capture the images of face and mask regions. An algorithm for the detection of face which is covered by a mask is based on the pyramid box model suggested by Tang et al. [13]. This method makes use of the tactics like the Gaussian pyramid box in deep learning and by implementing a Gaussian pyramid algorithm. After this, the masked areas are extracted and the area from RGB is portrayed as thermal. As most of the calculations are based on the region of interest, as the next step of developing a tracking method was used which analyses the images which is having a mask and that without a mask as the temperature variations cannot be effectively captured while having a mask. As a foremost step for the final classification which systematizes the respiratory condition between a healthy and infected person, a BiGRU-AT neural network is used. Being a time series data the classification uses a bidirectional Gated Recurrent Unit with an attention layer is used. For processing time-series data a Recurrent Neural Network (RNN) was

used. RNN is a feed-forward neural network that had an internal memory. Since RNN can remember past data it encounters a problem of vanishing gradient problem. So as a remedy another network called Long Short Term Memory (LSTM) will resolve this problem [14]. The bidirectional recurrent neural network will intensify the interrelation between the context of sequence and a bidirectional GRU will provide more statistics regarding periodic sequence. While performing the respiratory data analysis, the complete waveform in time sequence is considered and there may be a chance of immediate acceleration occurring. So by the discussed networks, these features may enfeeble because the time series data are given one by one which can generate a larger error. To avoid that an attention layer is affixed.

Advantages: Accurate and robust respiratory data detection algorithm was obtained.

Disadvantages: Limitation in the angle of the camera during measurement.

Further enhancement: Can use a more efficient algorithm that reduces the effect on breathing conditions by wearing various masks. To ensure high detection accuracy on respiratory infections.

G. Non-contact monitoring of human respiration using infrared thermography and machine learning

The Respiration Rate (RR) varies under different contexts. So the breathing waveforms under varying circumstances where obtained. As the first step volunteers were selected for study [15] and with the support of an A325 Infrared camera [16] thermal images were captured. The ROI was nostrils and they were selected by a FLIR software [17]. For efficient tracking of nostrils, Vahid Kazemi et al., proposed a tracking algorithm and this was used [18]. This algorithm uses an ensemble of Regression tree which gives decisions by comparing the threshold differences between the intensities of two pixels. But this will spawn the drawback that pixel differences may be large. Due to the influence of numerous environmental conditions, the breathing waveform obtained was having a low signal to noise ratio. Since the signals involve a number of noise contents, it has to be get filtered with the help of a low pass IIR filter. Breaths per minute (BPM) is an important variable for tracking our health. For this calculation, this work proposes a Breath detection algorithm where two counters are initialized to zero in which one counter will count the number of abnormal breaths and the other will count the normal breath. Here a normal and abnormal breath was obtained by analyzing the actual signal with the measurement of background noise ratio where the duration of the breath cycle is compared with a threshold value. For the classification between a normal and abnormal breath, a K-Nearest Neighbour (k-NN) classifier was used [19]. And the analysis of data points that are given to the k-NN classifier is tracked using the t-Stochastic Neighbour embedding algorithm. The information which is getting looked at was separated into training and testing information and the training dataset was again partitioned with the help of a cross-validation technique as training and validation datasets.

Advantages: Efficient Breath detection algorithm was implemented.

Disadvantage: For checking the validation accuracy it uses different k values.

Further enhancement: Instead of checking for different k values other classifiers can be considered such as Support Vector Machines and so on.

H. Detecting Fever in Polish Children by Infrared Thermography

Since the immune system of children is under development they may be more prone to sickness. So there should be an efficient method to detect fever in children. So this research paper gives a method in fever detection especially in children who were within an age span from 1 to 17 years [20]. In this research, three types of FLIR IR cameras were used. The temperature from four regions of interest was considered axilla, ear, eye, and forehead. For the analysis, both temperatures taken from an ordinary clinical thermometer and thermographic measurements were considered. During the analysis, the forehead temperature and the temperature taken from the ear especially focussing on the tympanic region are not reliable because of various factors. Physical exercise can cause a huge impact on the variation of forehead temperature and for ear, the variations in the ear channel, the occurrence of ear wax and air will affect the temperature. But there occurs a good similarity between the eyes especially the inner canthus region and axilla region. So by using software the region of interest was located. The temperature readings were taken which can trigger an audible alarm. During the analysis, the temperature values from different recordings should be considered

by taking an average value and the temperature value of single pixel should not be considered. But the parameters that affect the temperature measurement should be optimal so some standardization technique is very crucial. Also, to acquire the greatest number of pixels inside the located interested regions the picture should fit the frame.

Advantages: Accuracy is more especially in the axilla and eye areas.

Disadvantages: For optimizing the parameters, standardization techniques are required.

I. Early Detection of Diabetes using Thermography and Artificial Neural Networks

This work will confer a method for early identification of diabetes by combining thermal imaging with a neural network technique where the training of the network was in the similar way the human brain will function [21]. Thermography is an effective tool in the diagnosis of many diseases like diabetics, fever screening, breast cancer detection, and so on [22, 23]. Initially pre-processing of thermal images were done to reduce noise and regions of interest were extracted to which a neural network model was applied to obtain the status of the patient. Thermal imaging has emerged as a prominent tool in the field of medicine for the early detection of various diseases as most of the diseases will start with a variation in temperature as the beginning symptom [24, 25]. This study makes use of a FLIR thermal camera which will record the images of thermal distributions on the patient foot. The temperature values obtained from various points from the patient's foot are mapped to a matrix representation and were later stored on a personal computer for data analysis. As the thermal images are captured and data is given to a personal computer the next step is the implementation of the Artificial Intelligence (AI) model which has a data-driven approach. An artificial neural network [26] is an efficient way of computation which consists of different number of layers like input, hidden and output layers. And by an activation function which is a mathematical function the inputs which are given to hidden and output layers are summed to generate the desired output [27]. For data analysis, MATLAB was used which can provide more accuracy by using different MATLAB functions. Two sets of data was used in the case study analysis of which one can be used for training and the other for testing. This method uses an artificial neural network where the number of hidden layers were three and the input layer uses four input variables. For analyzing different ANN model Root Mean Square Error was used.

Advantages: Early detection of diabetes.

Disadvantages: Used a three hidden layer network since it fits the model.

Further enhancement: Can use improved artificial intelligence tools for improving the performance of the existing system.

J. A Non-Invasive Human Temperature Screening System with Multiple Detection Points

By using a 2D thermal imaging camera there are some limitations in identifying the temperature in periorbital areas which makes it difficult to compare with the reference values [28, 29]. So to avoid this difficulty the research paper [30] suggests several image processing techniques that select human faces for the maximum skin temperature. This system proposes a non-contact temperature screening system on a real-time basis. By using an inherent 2D space a quite number of people can be maintained from the infrared thermal camera at a considerable distance. And the others will be directed to stand a few distances behind the currently analyzing people. Then the focal length of the lens will be adjusted that focus the maximum number of people whose temperature is screened. And the camera will be able to capture thermal images of people who are walking at a normal speed. For monitoring the fluctuations of surrounding temperature an outside temperature and humidity sensors are interfaced with the existing system. For the good capturing of images the thermal imaging camera of the FLIR system was used and the lens should be focussed at a particular degree along the vertical and horizontal axes. So the selection of camera lens is an issue. Then by restricting the number of people in front of the camera the thermal images are captured and the next step is face detection. So a face searching technique in one image frame is used to detect the faces [31]. For

that, several image processing techniques were done on the captured thermal image like morphological processing, hole filling, and so on and coordinates of the face were obtained. A field test was used to capture the efficiency of the camera for detecting multiple faces at a time. The result shows that the system can trace the real-time display of the maximum skin temperature.

Furthermore, on remunerating, the worries it was evident that on the core body temperature once the aggravation from the general climate, the temperature esteem got from the thermal imaging camera has less variation. At the point when the temperature limit level and the balance temperature esteem are fittingly picked Hyperthermic patients can be related to 100% accuracy. The choice of the number of human countenances on the thermal image marginally influences the framework speed which has a rate of 7 milliseconds for one face, and up to 10 milliseconds for four appearances.

Advantages: System introduces a real-time display system in which the maximum skin temperature can be monitored. There is less fluctuation in the temperature value obtained from the thermal imaging camera.

For febrile detection the proposed system can give 100% efficiency.

Future works: By embedding an outside temperature and relative humidity sensor to the ThermScreen framework, the estimation connection with aural temperature information can be improved.

K. Thermographic analysis of thyroid diseases

In this work [32], a FLIR infrared camera which is of the model ThermaCAM S65 system was used for handling thermal images. The camera was working in a programmed self-adjustment mode and the patients were treated under conducive conditions [33, 34]. For the detection of the thyroid, the region of interest was captured by considering the camera calibrations and proper orientations. The cytological study was conducted and the smears were identified and these results were compared with the results of ultrasonography. The result analysis gives a massive contribution to the detection of disease based on detecting hyperthyroid and hypothyroid by the temperature variations. The analysis clearly shows that the comparison of thyroid disease type with the mean skin temperature shows the pieces of evidence of temperature variations. By using this method a clear classification of good and affected thyroid nodules can be detected [35].

Advantages: Uses the least invasive and low cost method for the detection of thyroid nodules.

Further enhancement: For predicting thyroid pathologies, the temperature gradient of thermograms can be used.

L. Dynamic Infrared Thermography Study of Blood Flow Relative to Lower Limp Position

For the proper heat distribution within the body, blood flow plays a very crucial role. This research paper discusses how infrared thermography can be used in the analysis of blood flow in the lower limp positions [36]. For the easy understanding of the temperature behaviour of skin, dynamic infrared thermography is used [37]. And for relating the vascularity of tissues, temperature measurements of the human leg were acquired [38]. By using a FLIR T440 thermographic camera, dynamic thermography of lower limp was obtained. It has a focal plane array of 320X240 pixels and for absolute temperature measurements depends on emissivity, ambient temperature, relative humidity, and distance [39]. Temperature variations of five distinct points of limp were recorded. During analysis, the average temporal temperature restorations of the foot from both vertical and horizontal positions were considered. The spots which show a temperature difference gives a faster return to thermal balance.

Advantages: Dynamic thermographic study gives a clear detection of temperature variations in lower limp regions. Disadvantages: The heat transfer mechanism was affected by the opposite gravity of blood flow.

M. A Study on Implementing Physiology-Based Approach and Optical Flow Algorithm to Thermal Screening System for Flu Detection

In this method [40] a physiology-based approach was used so that the area of selection was the human face. The face consists of hot and cold tissues which can be modelled as a collection of these two normal distributions [41]. In this study, using a thermal camera five different angular positions

were taken as the reference around the selected area of the human face and the temperature variations were recorded. For detecting a minor flow of motion of the object an Optical Flow Algorithm was used which provides higher accuracy for temperature

detection [42]. For better performance, this method makes use of a Parabolic Regression and Radial Basis Function Network. An algorithm known as the Adaptive Network-Based Fuzzy Interferences System has been used for this purpose [43]. Then the thermal images will be classified using the Image Classification Pre-processing module. Fig. 3 shows the basic working model of the discussed system.
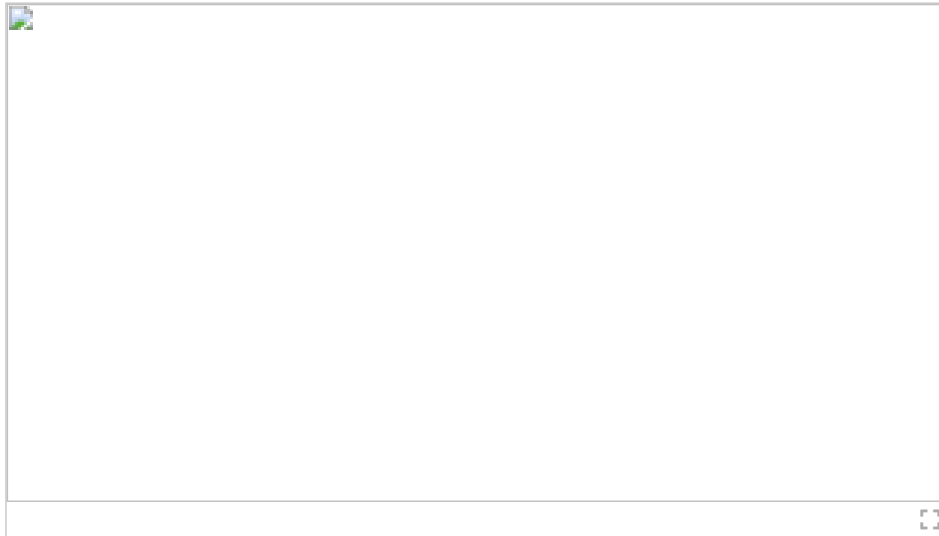
Fig. 3.
Flow diagram of A Study on Implementing Physiology-Based Approach and Optical Flow Algorithm to Thermal Screening System for Flu Detection.

Advantages: This system gives a good performance especially in hospitals, airports and other places where huge crowd assembles for effectively recording the temperature of person who are in motion.

Further enhancement: Can integrate more crowd, for thermal screening system which can be utilized in public areas like airports and hospitals to reduce the rate of transmissible infectious diseases.

N. Supportive Noninvasive Tool for the Diagnosis of Breast Cancer Using a Thermographic Camera as Sensor

This research paper provides a tool for breast cancer detection by Infrared thermography [44]. For establishing the method the image acquisition basically the thermogram images were taken using the thermographic sensors. To this captured image, image processing algorithms were applied to obtain the breast area segmentation. Thermographic image acquisition will in either static or dynamic form and the different images of a single patient from different orientations were taken [45, 46]. The image acquired was processed for the avoidance of background noises and thresholding using Otsu's method was done to the required thermogram [47]. From the preprocessed image the area of interest was segmented and since the paper focused on breast cancer detection, two regions where the right and left breast images were segmented from the initial thermographic image. The automatic segmentation module does all the related task of segmenting the images into different separate independent images so that the temperature variations can be done more effectively. For identifying the temporal variations on the right and left breast it was necessary to convert the grayscale values to their corresponding thermal intensities. The thermographic values are represented in a matrix format. Average temperature values are estimated, and the region with a temperature greater than the referential temperature was detected as infected areas. For detecting the tumor areas, regions with the highest temperature values were used and segmentation of these regions using the watershed technique was used [48]. By using the same segmentation technique apart from the cancer detection another phenomenon called Angiogenesis was also able to be detected.

Advantages: Is an effective method for the analysis of women of varying age group and health situations.

Further enhancement: The automatic segmentation method used can be modified to set the target values for attaining thermal stabilization.

O. Automated Analysis Method for Screening Knee Osteoarthritis using Medical Infrared Thermography

Osteoarthritis is a common degenerative disease that is most frequently occurring in people nowadays [49, 50]. This research paper presents an idea for identifying knee osteoarthritis with the aid of IR thermography [51]. This disease will be affecting knees, so they are the region of interest. Images of the knee were captured using an infrared thermal imaging system. Based on certain predefined parameter settings, the thermographic image obtained was later processed for the patella- centering procedure. During the first step, the left and right knees were compared and in the second step, the sub-regions temperature variations were obtained. After the segmentation and sub-regional segmentation then the feature extraction and classification were done. During the feature extraction module, the sub-regions were evaluated and the defective portions and normal portions were identified. The statistical features were calculated using histogram analysis and the entropy features were calculated [52]. By using the feature extraction method the features were extracted and these were given as the input to the classification module and the classifier used in the proposed method is a classification by Support Vector Machine (SVM) [53]. SVM gives an efficient classification for the diagnosis of knee Osteoarthritis.

Advantages: Method was a cost-effective tool that can easily detect various diseases that too the chronic ones.

When compared to other medical imaging techniques the proposed method was especially desirable to be highly useful in the detection of rheumatism and most geriatric-related issues.

Further enhancement: Further analysis should also be carried out to ensure the accurate quantitative portrayal of specific anatomical positions in a thermal image using techniques such as CT and MRI multi-image fusion, which would dramatically increase the precision of the screening procedure.

SECTION IV.
Analysis and Discussions

As a comparative study most research papers give a better explanation for detection of diseases in an efficient way. The major classification tools used were K-means classifiers, artificial neural networks and in common most of the research papers used thermal sensors for disease detection. An important factor which influence the performance of temperature measurement was the thermal camera resolution. As the resolution varies the thermal image capture was influenced. Fig. 4 describes the influence of pixel resolution on thermal distributions.
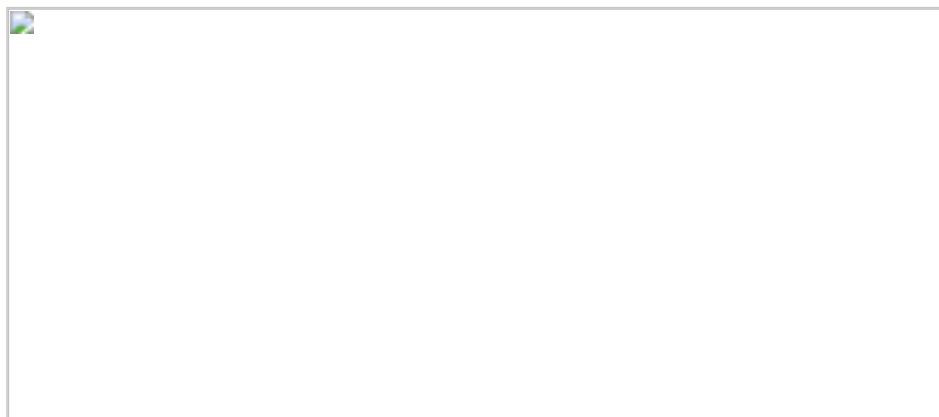
Fig. 4.
Pixel ratio and efficiency

Performance analysis of various research work based on sensitivity and specificity was depicted by TABLE I. Based on the selection of various sensors and the number of sensors the efficiency of thermal detection was also improving.

TABLE I Comparison of Various Methods Based On Sensitivity and Specificity

TABLE II Gives a comparative study on various methods discussed and the advantages, disadvantages and various methods used by different research papers. so in all the research works, the thermal images were captured and various image processing techniques were used for the efficient detection of diseases where the focus was on thermal screening. this survey will give a better study for covid-19 detection since the primary symptoms were fever, osteo-based problems and thyroid variations. based on the selection of various sensors and the number of sensors the efficiency of thermal detection was also improving.

TABLE II Comparision of Various Methods

So based on the relevance of the application to be developed, the sensors can be chosen. For critical application where the minute details are to be captured focus should be placed on the selection of sensors rather than cost. Whereas for basic applications only, commercial cameras with less cost can be given ten priority.

SECTION V.
Conclusion

Here a comparative study of various thermometric methods is done to find an effective system especially in the fever screening scenario that can be used for COVID-19 detection. So when two separate cameras were used in the analysis, a thermal camera for temperature measurements and an ordinary visual camera for image capture most of the system face synchronization problems. And the correct correlation of the optical axis is also a factor that affects efficient calculations. Thus by considering all these factors a low cost, easy to use thermal imaging system was hence developed so that with the help of image processing techniques combined with other detection and classification methods an efficient disease detection method can be developed.

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Fast advances in information gathering and capacity have empowered associations to collect huge measures of information and hence extracting the only relevant and useful information from large volumes of data is a challenging task. The conventional techniques for data analysis and evaluation cannot be utilized subsequently on the huge measure of the data-set and-so new methods were developed for mining data. Frequent pattern mining algorithms like Apriori, FP-Growth, etc. may sometimes miss the rare but important patterns of a database since they are dealing only with the number of times an item appears in the database. In business environments like retail shops or online markets, identifying the profit-generating items is more important than finding the items which are sold many times. The high utility item set mining with the time cube concept helps us to find the relevant, profit-generating item sets from the transactional data set by performing the calculations using the quantity that is purchased, total cost and unit gain of each item in the database. The concept of time cubes implemented here helps to efficiently deal with the temporal parts of the transactional data set. Considering total cost decides the frequent customer of particular product set. The proposed system is mainly applicable in online markets, FMCG Sectors, large retail stores, and manufacturing plants for improving the revenue by promoting the profit-generating item sets.

☰ Contents

I. Introduction

Data mining is the process of extracting relevant and appropriate data from huge databases. Data mining is also known as 'Knowledge Discovery' or 'Data Discovery'. The traditional data analysis methods are blended with sophisticated algorithms to process large volumes of data. [3] In data mining, previously unknown, interesting patterns and co-relations are identified. Data mining is also related to classical statistics, artificial intelligence, and machine learning in many aspects. It comes under the field of computer science and statistics intending to analyze data. After that, the extracted data is presented to humans for an easy understanding. In general, the data mining task includes data pre-processing, data transformation, data mining, and data post-processing steps

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Chapter

Analysis of Sybil Attacks in Online Social Networks Using SyPy

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Abstract

This paper examines the relevance of a fast approaching highly secure and fast data transmission technique using Li-Fi. It describes the upcoming technology Li-Fi and its applications as well as the developments made in it so far. It enlightens on the new era that will soon be used in almost all domains like health sector, school, bank and so on. An application framework design has been studied to analyze the role of Li-Fi in the process of communication. © The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2021.

... The advent of 5G is envisioned to boost the performance of C-V2X. There have been several other communication protocols suggested for data transmission in vehicular environments [19, 20] . These technologies would enable the infrastructures to become smarter and eventually self-capable of detecting incidents. ...

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April 2012

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Object detection is the process of determining the presence, location, and type or class of at least one object using a bounding box. The person detection process produces a bounding box and allot a class label as a person based on YOLO v3. In YOLO v3 the features are learned, divides the image cells and each cell says a bounding box and entity classification directly. There could be more than one bounding box per person, but the system makes use of non-maximum suppression to reduce the number of bounding boxes to one per person. Finally, the number of persons in the image and video are calculated using the count of the bounding boxes. The dataset used for static pedestrian detection is the INRIAdataset and ShanghaiTech dataset. Yolo_Mark is used for marking bounding boxes of persons and gets its annotation files using 243 images from the INRIA dataset. Darknet is used as the framework for implementing YOLOv3. From INRIA Dataset 120 images are used for testing purposes. Testing on the INRIA dataset resulted in an accuracy of 96.1%. From the Shanghai tech-B, dataset 56 images are used for testing. Testing resulted in an accuracy of 87.3%.

Published in: 2021 International Conference on Innovative Trends in Information Technology (ICITIIT)

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Computer vision is the region of study that expects to build up a technique that upholds computers to watch and comprehend the substance of advanced pictures, for example, photos and recordings. Computer vision has a number of multidisciplinary applications like military human -computer interaction, mobile robot navigation, industrial inspection, and medical image analysis. Many popular computer vision applications like object classification, object identification,object verification, object detection [3], and object recognition recognize objects in images or videos.

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Bio-inspired Metaheuristic Optimization Technique for the Detection of Phishing Emails

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AbstractThe most trending cybersecurity threat all over the world is Phishing, which uses the public through various media especially e-mail, to gather the individuals private particulars. This rapid rise of undesired information needs to be coped with, raising the need to develop suitable and efficient anti-phishing methods. This paper emphasizes a process to detect email phish- ing based on optimization algorithms using deep belief networks. At the first, the emails are subjected to pre-processing using stemming and stop word removal mechanisms are implemented to assure that the significant words are identified for further processing. Term-Frequency (TF) is used for feature extraction from the significant words, followed by the Bhattacharya distance for feature selection. The features selected are fed as input to the deep belief neural network (DBN), which is then trained using the proposed Earth Worm optimization (EWA) Algorithm. The analysis of the spam mail detection is performed using the datasets and found that the accuracy, sensitivity, and specificity of the proposed EWA DBN are found to be a maximal value of 0.671, 0.814, and 0.804, respectively.

Index TermsE-mail, Phishing, Optimization, deep learning, spam mails, Deep Belief Network(DBN)

1. INTRODUCTION

Technology enhancement brings out fresh criminal ways and many new types of crimes. The Web is upright for develop- ing and refining worldwide commerce to already far-fetched statures, cultivating momentous headways in instruction, and inspiring round-the-world communication that was once seen to be constrained and exorbitant. Regardless, the Web, with its boundless measure and as of now unimaginable capacities, remembers a despairing side for that it has opened windows of effectively dark criminal openings that not in a manner of speaking test, but rather too transcend every actual limit, boundaries, and limitations to detect, rebuke and lessen what appears at being a creating social issue of overall degrees. Cybercrime is

an offense to data, the public, associations, or governments. The idea of digital infringement isnt radically different from the idea of standard bad behavior. Both fuse directly whether act or prohibition, which causes a break of rules of law counterbalanced by the support of the state. [1] Computer-based wrongdoing insinuates any bad behavior that incorporates a system and an organization.

Phishing is the technique for delicate data, similar to pass- words, usernames, and credit card data for noxious purposes, through dissimulating as a dependable individual in electronic correspondence. Phishing messages consist of sites linked with malware. Phishing is subsequently performed utilizing

texting or email parodying, which makes the clients give their subtleties in any phony site that looks and seems indistin- guishable from the real site. Phishing remains an occurrence for social designing strategies that misleads clients, and ad- ventures helpless convenience of present security advances in the web. Phishing is a danger that forces huge negative effects on online media, similar to Twitter, Facebook, and Google+. Programmers clone a site and demand the web clients to give the individual data that is at last sent to the programmers [2]. Additionally, there are various anti-phishing procedures to perform phishing and smishing is a consolidation of Phishing assaults that use a basic instant message or Short Messaging Service (SMS) on mobiles to claim the individual credentials

[3] [4]. Accordingly, it is outstanding that phishing irritated the clients as well as caused financial damage for people and associations [5].
Spam is the undesirable message of a sender sent elec- tronically to a beneficiary, who doesnt have any relationship with the individual [6]. Email spam alludes to a subset of electronic spam that takes enormous time since the clients participate in recognizing and eliminating the undesired mes- sages. The common issues on the web are in regards to email spam. [7]Spamming is the consistently enduring issue that is accessible from the hour of the presence of mailboxes. The methods utilized for separating are progressing with time and the level of spam messages are rising definitely with time, causing tremendous traffic in the messages. In this way, a successful spam channel is utilized for upgrading the efficiency of the client and limits the utilization of the assets related to the data innovation, similar to help work areas.

There are various spam filters utilized alongside the AI techniques, similar to decision trees, Naive Bayes classifiers, k-closest neighbor algorithm, SVM, K-means algorithm, and many more8. Machine Learning techniques consequently build up the word records alongside their weights for arranging the messages as two classes. The input

messages could be either spam or not. Also, there are various strategies utilized for identifying spam.

The main aim of this research is to develop an approach for eliminating phishing by recommending an optimization algorithm. The proposed method involves four steps, which include pre-processing, feature extraction, feature selection, and classification of phishing emails. Initially, the stop word elimination and stemming of the input dataset is performed

in the pre-processing stage followed by the feature extraction process. The features are selected based on extracting the keyword frequency from the output of the pre-processing. The next step is the feature selection using Bhattacharya distance to identify the significant features for the classification stage. The selected features are subject to classification using the Deep Belief Network and trained using the proposed EWA.

2. RELATED WORKS

The review of various methods is deliberated in this section. Smadi, S et al. [9] developed an algorithm to detect the zero- day phishing attacks using 2 techniques namely Feature Eval- uation and Reduction algorithm and (DENNuRL) Dynamic Evolving Neural Network using a Reinforcement learning algorithm. As per the algorithm, the result revealed a higher performance and provided reasonable error rates. The main drawback of this technique was due to the insufficient amount of dataset chosen for classification, which was critical to group the spam mails.

Barushka. A and Hajek P [10] designed an algorithm to effectively handle the class distributions which shows the imbalance and misclassification costs with some difficult forms of text patterns. The Algorithm namely Distribution-based balancing along with the regularized deep multi-layer percep- trons NN model with rectified linear units (DBB-RDNN-ReL) can help in effectively tackling the class distributions with imbalance. The disadvantage of the method is that it makes use of numerous hidden layers and the units in the model would exhibit noise in the data, which leads to unsatisfactory performance.

Kovalluri, S.S et al. [11] designed a system based on Artificial Intelligence using LSTM. This helped in reducing the application of fake mails to sneak the data, proliferate, and made it difficult to track the victims. The disadvantage of this technique was that this model had errors during sentence generation.

Ruano-OrdaÂ´s et al. [12] designed a model using the Genetic programming algorithm to be used for datasets hat were large and also identified the patterns which improved the accuracy to great extent. However, it further helped in the reduction of the computational overhead related to the e-mail filter server. The main drawback of this technique was the requirement of security features to prevent False Positive errors.

Sonowal, G and Kuppusamy, K.S [13]designed an algorithm that used the SMIshing Detection based on the Correlation Algorithm (SmiDCA) that accomplished higher efficiency to confront datasets based on both the English and non-English. However, to improve the accuracy the system had to depend on deep learning technologies.

3. DBN BASED SPAM MAIL CLASSIFICATION

An Email Spam causes affliction in the digital world and it imprints the loss of time, space, and communication bandwidth. Almost more than 40% of the mails are fake nowadays that implies that more than 15 billion emails a day, thereby increasing the price of cyberspace users. This research

work focused on the spam mail classification technique using the Deep Belief Network classifier, tuned perfectly using the Earthworm Algorithm. The dataset is first pre-processed based on which the keywords are identified and followed by feature extraction. This is then followed by feature selection. The selection of features is performed using the Bhattacharya dis- tance. The features retrieved using the Bhattacharya distance are then subjected to spam mail classification in which Deep Belief Network is used which identifies the spam mails. Fig

1. shows the proposed plan for spam mail detection.

Fig. 1. Proposed plan of Email Phishing Detection

1. Pre-processing

Pre-processing is the first step in the identification of phish- ing attacks. [14] This phase involves 2 processes which include the elimination of stop words and stemming. The dataset for the email is chosen from UCI and Enron and the mail has words as a sentence or a paragraph. The stop words mainly a, an, in, and so on searched are eliminated from the mail. This is followed by stemming in which certain words in the mail document are changed

to their root word. The output of the pre-processing step is known as dictionary words. This in turn acts as input to the feature extraction.

2. Feature extraction

The dictionary words are then put through the feature ex- traction using Term Frequency which identifies the frequency of the dictionary words used in the particular mail. TF is an arithmetic method of retrieving the significant word from a dataset. Term frequency is an efficient algorithm to extract the frequency of terms from dictionary words and also in the method of assigning word weights. Therefore Term Frequency expresses the total number of times an individual word appears in an email.

3. Feature selection

Feature selection is the method of selecting prominent features from the identified dictionary words. The Bhat- tacharya distance is computed between the individual feature

and the class and the feature with the maximal Bhattacharya distance is selected as the effective features for the classifica- tion using the DBN. The Bhattacharya distance is calculated based on,

(1)

where BD(gk, Cl) refers to the Bhattacharya distance be- tween the kth feature and the lth class. The mean of the kth feature and the lth class is denoted as $Âµk$ and $Âµl$, and varianceof the kth feature and the lth class is denoted as k and l.

4. Classification using Deep Belief Neural Networks

The features identified from the feature selection are classi- fied using the DBN. The classified data are first given as input to the classifier and then trained using the proposed Earthworm Algorithm which in turn tunes the optimal weights of DBN. This helps in differentiating spam mails from relevant mails.

1. Deep Belief Neural networks (DBN):

Deep Belief Network is a generative network and it is implemented by stacking several layers with each middle layer consisting of the visible and hidden neurons [15]. The DBN layers include Restricted Boltzmann Machine (RBM) layers and a Multilayer perceptron (MLP) layer. Each RBM layer in turn consists of its inputand hidden layers and the MLP layer comprises the input, hidden, and output layers [16]. The effectiveness of DBN is theinterconnection between the hidden and the input neurons that are interlinked by a set of tunable weights. The architecture of the DBN network is shown in Fig 2.

Step 1: Train the 2 layers RBM1 and RBM2. Step 2: Train the MLP layer

The first step involves providing an RBM1 layer with the input data and then subjected to a probability distribution. The data is then encoded using weights to compose an output which forms the input to the RBM2 layer.

The process of training the DBN can be further repeated to retrieve the input to the MLP layer.

- Initialization of MLP weights

- Determine the output of the MLP layer

- Determine the error of the network

- Weight calculation in the MLP layer

- Termination

The following steps are repeated for a maximum number of iterations till a globally optimal solution is obtained.

3) Determination of weights of DBN based on Optimization algorithm: Earthworm Algorithm is a bio-inspired metaheuris- tic algorithm based on the reproducing pattern of the earth- worms [17]. This can be viewed as 2 types of reproduction and the new obtained solutions are calculated by counting the weights for producing new earthworms. The searching tendency in EWA was enhanced by the use of Cauchy op-

erators. In the reproductive capability of the Earthworm, the type-1 Reproduction produces only 1 offspring and the type-2 Reproduction produces 2 or more offspring.

Type-1Reproduction: In this type of reproduction, the single earthworm is involved in reproduction as earthworms are known as hermaphrodites.

Type-2 Reproduction: This type of reproduction produces two or more two offspring. Crossovers are considered as parents can be changed accordingly to produce the offspring to ensure that offspring produced is not less than zero. The crossover mentioned is single-point, multi-point, and uniform crossover. The parents selected for crossover are based on the strategy named roulette wheel selection.

Case 1: With 2 parents and 1 offspring and it follows a single-point crossover. The multipoint crossover with 2 parents is based on two random numbers generated.

Case 2: With 2 parents and 2 offspring

Case 3: With 3 parents and 3 offspring

The position of the earthworm based on the 2 types of offspring generated can be calculated as,

u+1 = .u1 + (1).u2 (2)

Fig. 2. Proposed plan of Email Phishing Detection p,q p,q p,q

where, up,q is the qth element of up, which is the position

2) Training phase of DBN:

The DBN classifier has to be trained to acquire the correct weights and biases that help to reveal the spam mails.

of pth the earthworm and is the proportional factor.

The Cauchy operator gives the position of the earthworm based on the formula,

This phase points at fine-tuningthe RBM and MLP layers,

u 1 u

* R

(3)

which entirely depends on the optimal weights derived using the proposed EWA algorithm.

p, q

p, q q

The newly enhanced optimization algorithm helps in fine- tuning the optimal weights and biases and therefore ensures a minimal level of error values. The following steps are followed in the training of DBN are:

p,q

p,q

where, R indicates the random number obtained by performing the Cauchy distribution and q denotes the weight assigned for the qth position, and u+1 determines the qth position of the pth earthworm at time .

4. EXPERIMENTAL SETUP

The proposed algorithm is implemented using JAVA and the datasets utilized for the analysis include Enron and UCI. The effectiveness of the proposed algoithm for spam mail de- tection is computed based on three metrics, namely accuracy, specificity, and sensitivity. The datasets like Enron and UCI have the original messages which include both ham and spam mails in non-Latin encodings.

1. Performance metrics

The algorithm is analyzed based on the performance met- rics, mainly accuracy, specificity, and sensitivity. The accuracy can be determined by calculating the accurate number of spam mails, Specificity is the metric to determine the negatives which are correctly detected and sensitivity determines the positives correctly identified.

Fig. 3. Comparative analysis based on the training percentage using dataset accuracy

Accuracy = Tn + Tp

Tn + Tp + Fn + Fp

Tn

(4)

Specificity =

Sensitivity =

Tn + Fp Tp

Tp + Fn

(5)

(6)

where refers to the values as true positive, refers to true negative, denotes the false negative values, and denotes the values as false positive.

2. Comparative Analysis

The proposed algorithm is being compared with the fol- lowing methods namely Naive Bayes (NB) [18], Deep Belief Networks (DBN), and Neural Networks (NN). The proposed EWA-DBN algorithm is employed for the detection of email phishing and compared with the above methods to determine its effectiveness.

1. Analysis of Dataset by varying the data percentage : The figure below denotes the comparative analysis based on the data chosen for training. Fig 3 denotes the comparative analysis based on the accuracy of the algorithm chosen.When the percentage of the data is 50, the accuracy of the methods, NB, DBN, NN and EWA-DBN is 0.5333, 0.5455, 0.5556 and 0.5714, respectively. Fig 4 denotes the comparative analysis on the sensitivity of the algorithm chosen. When the percentage of the data is 50, the sensitivity of the methods, NB, DBN, NN and EWA-DBN, is 0.4558, 0.5531, 0.7035 and 0.7223 respectively. Fig 5 denotes the comparison based on

the specificity of the algorithm chosen. When the data percentage is 50, the specificity of the methods, NB, DBN, NN and EWA- DBN, is 0.5052, 0.5631, 0.7028 and 0.7104, respectively.

3. Comparative discussion

Table 1 shows the comparative results based on the various methods chosen depending on the performance metrics from the dataset ENRON [19] and UCI [20]. The accuracy value of the methods, NB, DBN, NN and EWA-DBN is 0.5233, 0.5465, 0.5568 and 0.6714. The sensitivity range of the

Fig. 4. Comparative analysis based on the training percentage using dataset Sensitivity

Fig. 5. Comparative analysis based on the training percentage using dataset Specificity

methods, NB, DBN, NN and EWA-DBN is 0.4978, 0.5642,

0.7235 and 0.8145 respectively. Similarly, the specificity value of the methods, NB, DBN, NN and EWA-DBN is 0.5152, 0.5845, 0.7238 and 0.8040 respectively. It is evident from the comparison that the proposed new algorithm has accomplished the maximum value with regards to accuracy, sensitivity, and specificity in comparison with the already existing methods.

TABLE I COMPARATIVE DISCUSSION

Metrics	NN	DBN	NN	EWA-DBN
Accuracy	0.5233	0.5465	0.5568	0.6714
Sensitivity	0.4978	0.5642	0.7235	0.8145
Specificity	0.5152	0.5845	0.7238	0.8040

5. CONCLUSION

The email phishing has created a havoc among the inter- net users. The phishing detection is carried out using the optimization-based deep learning networks. The mail

received are first pre-processed to furnish only the selected words to the next step namely feature extraction. The extracted features are then provided to feature selection using the method of Bhat- tacharya distance. This is in turn fed to the classification algorithm based on the deep belief neural networks. The classifier after fine tuning based on the proposed EWA aims at detecting the spam mails effectively. The comparison is performed using the datasets, UCI and Enron, which is analyzed based on the performance metrics, such as accuracy, sensitivity, and specificity, which is 0.671, 0.814, and 0.804, respectively. The research can be further extended by performing hybrid optimizations so as to enhance the phishing detection ratio.

REFERENCES

1. J. Ma, Y. Zhang, Z. Wang, and B. Chen, A new fine-grain sms corpus and its corresponding classifier using probabilistic topic model., TIIS, vol. 12, no. 2, pp. 604625, 2018.

2. P. Patil, R. Rane, and M. Bhalekar, Detecting spam and phishing mails using svm and obfuscation url detection algorithm, in 2017 International Conference on Inventive Systems and Control (ICISC), pp. 14, IEEE, 2017.

3. S. J. Delany, M. Buckley, and D. Greene, Sms spam filtering: Methods and data, Expert Systems with Applications, vol. 39, no. 10, pp. 9899 9908, 2012.

4. L. Zhang, J. Zhu, and T. Yao, An evaluation of statistical spam filtering techniques, ACM Transactions on Asian Language Information Processing (TALIP), vol. 3, no. 4, pp. 243269, 2004.

5. G. DalklcÂ¸ and D. Sipahi, Spam filtering with sender authentication network, Computer Communications, vol. 98, pp. 7279, 2017.

6. B. Zhou, Y. Yao, and J. Luo, Cost-sensitive three-way email spam filtering, Journal of Intelligent Information Systems, vol. 42, no. 1, pp. 1945, 2014.

7. G. V. Cormack, Email spam filtering: A systematic review, 2008.

8. C. Laorden, X. Ugarte-Pedrero, I. Santos, B. Sanz, J. Nieves, and P. G. Bringas, Study on the effectiveness of anomaly detection for spam filtering, Information Sciences, vol. 277, pp. 421444, 2014.

9. S. Smadi, N. Aslam, and L. Zhang, Detection of online phishing email using dynamic evolving neural network based on reinforcement learning, Decision Support Systems, vol. 107, pp. 88102, 2018.

10. A. Barushka and P. Hajek, Spam filtering using integrated distribution- based balancing approach and regularized deep neural networks, Ap- plied Intelligence, vol. 48, no. 10, pp. 35383556, 2018.

11. S. S. Kovalluri, A. Ashok, and H. Singanamala, Lstm based self- defending ai chatbot providing anti-phishing, in Proceedings of the first workshop on radical and experiential security, pp. 4956, 2018.

12. D. Ruano-OrdaÂ´s, F. Fdez-Riverola, and J. R. MeÂ´ndez, Using evolution- ary computation for discovering spam patterns from e-mail samples, Information Processing & Management, vol. 54, no. 2, pp. 303317, 2018.

13. G. Sonowal and K. Kuppusamy, Smidca: an anti-smishing model with machine learning approach, The Computer Journal, vol. 61, no. 8, pp. 11431157, 2018.

14. R. M. Silva, T. C. Alberto, T. A. Almeida, and A. Yamakami, Towards filtering undesired short text messages using an online learning approach with semantic indexing, Expert Systems with Applications, vol. 83, pp. 314325, 2017.

15. E. Benavides, W. Fuertes, S. Sanchez, and M. Sanchez, Classification of phishing attack solutions by employing deep learning techniques: A systematic literature review, Developments and advances in defense and security, pp. 5164, 2020.

16. G. Tzortzis and A. Likas, Deep belief networks for spam filtering, in 19th IEEE International Conference on Tools with Artificial Intelligence (ICTAI 2007), vol. 2, pp. 306309, IEEE, 2007.

17. G.-G. Wang, S. Deb, and L. D. S. Coelho, Earthworm optimisation algorithm: a bio- inspired metaheuristic algorithm for global optimisation problems, International Journal of Bio-Inspired Computation, vol. 12, no. 1, pp. 122, 2020.

18. I. Androutsopoulos, J. Koutsias, K. V. Chandrinos, and C D. Spyropou- los, An experimental comparison of naive bayesian and keyword-based anti-spam filtering with personal e-mail messages, in Proceedings of the 23rd annual international ACM SIGIR conference on Research and development in information retrieval, pp. 160167, 2000.

19. http://nlp.cs.aueb.gr/softwareanddatasets/Enron

    Spam/index.html, 2021(accessedMarcp02021).

20. https://archive.ics.uci.edu/ml/machine-learning-databases/00228,   2021   (accessed
    March 20 2021).

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Thwarting Cyber Crime and Phishing Attacks with Machine Learning: A Study

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Abstract:
Almost over 4 billion people are currently making rampant usage of the internet. The massive utilization of mobile technology along with the rise of the digital era caused a socio-technical threat to the Government and to the public. Many new developments in the internet and modern technologies give rise to new illegal and unethical opportunities among which some of them are crime. Cyber crime is an unlawful means which makes use of a digital media either as a tool or as a target or both. Cyber crime cases, which includes mainly the Phishing attacks and many other attacks in the prevailing COVID -19 situation, have reached an alarming rate with the outburst of numerous forms of crime. This paper focuses on various types of cyber crime and targets some of the present day cyber crime attacks based on Phishing, Artificial Intelligence, Cloud technology and Block chain. The principal objective of this work is to identify how Machine Learning can be deployed in detection of diversified fields of cyber crime. The application of various Machine Learning models in the prediction, identification and mitigation of complex threats is also discussed.

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Abstract:
Emotion recognition from text is crucial Natural Language Processing task which can contribute enormous benefits to different areas such as artificial intelligence, human interaction with computers etc. Emotions are physiologic thoughts engendered in human reactions to the events. Analysis of these emotions without facial and voice modulation are critical and requires a supervisory approach for proper interpretation of emotions. In spite of these challenges, it's essential to acknowledge the human emotions as they progressively communicate using mistreatment text through social media applications such as Facebook, Twitter etc. In this paper, we propose a sentimental classification of multitude of tweets. Here, we use deep learning techniques to classify the sentiments of an expression into positive or negative emotions. The positive emotions are further classified into enthusiasm, fun, happiness, love, neutral, relief, surprise and negative emotions are classified into anger, boredom, emptiness, hate, sadness, worry. We experimented and evaluated the method using Recurrent Neural Networks and Long short-term memory on three different datasets to show how to achieve high emotion classification accuracy. A through evaluation shows that the system gains emotion prediction on LSTM model with 88.47% accuracy for positive/negative classification and 89.13% and 91.3% accuracy for positive and negative subclass respectively.

Published in: 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)

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I. Introduction

Twitter is a social networking web site where members can post messages in the form of "tweets". This is a platform where individuals can share ideas or sentiments on diverse subjects, fields or themes.It is a collection of user thoughts and sentiments spanning across various topics including standard net articles and net blogs. The quantity of pertinent data is bigger for twitter, when contrasted with former social media and blogging platforms. When compared to other blogging sites, the response rate on Twitter is much more quicker. Sentiment analysis is widely utilized by different parties such as shoppers or marketers to gain insights into merchandise or understand the market trends [1].

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Abstract:
Today, the lifestyle of people has paved the way for rise in spinal cord disorders. Severe cases have been reported
which could be treated if diagnosed early. Scoliosis is a deformity to spine and ribs which is the primary cause of spinal
curvature. The major challenge of scoliosis disease is the unnoticeable change in the orientation of spinal column at its
early stage. Moreover, it is visually detectable only in the prodromal stage. The early diagnosis could help cure the
disease through exercises and minor surgeries. Depending on manual diagnosis techniques is a tiring task as it can
deliver inaccurate results. An automatic segmentation method which helps in the early diagnosis is proposed in this
paper. Initially, CT image which is the input is fed into the system. CT images have high contrast between bone and
adjacent tissues. Sagittal view datasets have been chosen in order to calculate the cob angle for the measurement of
scoliosis intensity. Further, distortions are removed from the image and pre processing is performed followed by K-
means clustering which detects the spinal canal. In order to segment the required features, the output of clustering is
loaded to Active Contour Model. Finally, segmentation of spinal canal is completed. Experimental results prove the
accuracy of 95%,86.86%,92.22% for Lumbar Vertebrae CT , Lumbar spine CT, Lumbar spine CT with multiple
compression fractures respectively for the proposed system which is greater than traditional diagnosis methods.
Subsequently, this would be a revolutionary study which assists the doctors for the early diagnosis of the disease.

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I. Introduction

The progress in technology has altered the lifestyle of people which resulted in spinal disorders. People hardly identify the disease at its early stage. Subsequently, the disease becomes the part of their life as it cannot be cured as whole. Early diagnosis could save the patient affected with the disorders and give a complete cure. The major challenge in disease detection is the unnoticeable change in early stages. Today, various techniques are available for the early diagnosis. Relying on manual detection techniques could provide inaccurate results. Spinal curvature defects refer to the deformity in the column. The vertebrae in human body constitute thoracic, cervical, lumbar and sacro coccygeal vertebrae. The deformities in these vertebrae results in spinal disorders which further affects the posture and body movement. The paper mainly focuses on the patients affected by scoliosis disease. The experiment is conducted based on the various stages of scoliosis disease. Scoliosis is a disease affecting spine which cannot be cured if not diagnosed early. It is commonly observed in thoracolumbar region.

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Abstract:
Sentiment evaluation is the problem of examining texts,critiques, mind and conditioned emotional response published with the aid of various users in microblogging systems. Twitter is one of the maximum extensively used micro running a blog systems and has proved to be the biggest source of statistics.Twitter can give a clear cut view about the current trends. A big dataset of tweets is used to perform sentiment evaluation. The tweets are labeled into two classes, positive and negative. There are various techniques which can be utilised to perform this task. In this paper we aim to perform a comparison between a multilayer perceptron and a factorization machine for classification of tweets in the Sentiment 140 dataset. We apply this approach using two different lexical resources namely AFFIN dictionary and SentiWordNet. The generated models are compared based on the lexicon used as well as the classifier adopted (multilayer perceptron or factorization machine) for their accuracy and training time.

Published in: 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)

Date of Conference: 04-06 February 2021

INSPEC Accession Number: 20513047

Date Added to IEEE Xplore: 31 March 2021

DOI: 10.1109/ICICV50876.2021.9388434

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I. Introduction

Artificial Intelligence (AI) deals with making computers work like humans. This is accomplished by observing human ways of thinking and decision making and applying the outcomes to develop software and systems comparable to human capabilities. AI has been utilized in numerous fields like speech recognition, hand writing recognition, gaming and robotics. Natural Language Processing (NLP) which is a subfield of AI has a range of techniques for the purpose of obtaining human-like language processing for different tasks or applications [1]. It is an effort to get computers closer to human level understanding of language. Sentiment Analysis falls under NLP. It is a process by which all the content can be evaluated to represent the ideas, beliefs and opinions of the public. It can be accomplished at various degrees like document, section, paragraph and phrase level. With the upward push of social networking tendencies there was a surge of online generated content material. Many people import their thoughts and opinions on microblogging websites. Twitter is one of the broadly followed micro blogging platform for expression of opinion and experience. It was created and launched in the year 2006 [2]. It evolved as a golden platform for companies to disclose about their brands and success. Twitter users include a variety of users ranging from regular users, celebrities, politicians, entrepreneurs, veterans and other persons of influence. The primary advantages of performing sentiment analysis encompass scalability and real time evaluation. Efficiency and cost effectiveness of processing large huge data contributes to scalability. Real time analysis is performing analysis on real time data which can be tweets that are tweeted in a certain scenarios or even critical situations. Sentiment analysis systems help the companies to get meaning of the sea of data by automating business process which saves long hours of manual data processing.

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Detection of Obfuscated Mobile Malware with Machine Learning and Deep Learning Models

K. A. Dhanya ✉, O. K. Dheesha, T. Gireesh Kumar & P. Vinod

Conference paper | First Online: 06 February 2021

Abstract

Obfuscation techniques are used by malware authors to conceal malicious code and surpass the antivirus scanning. Machine Learning techniques especially deep learning techniques are strong enough to identify obfuscated malware samples. Performance of

deep learning model on obfuscated malware detection is compared with conventional machine learning models like Random Forest (RF), Classification and Regression Trees (CART) and K Nearest Neighbour (KNN). Both Static (hardware and permission) and dynamic features (system calls) are considered for evaluating the performance. The models are evaluated using metrics which are precision, recall, F1-score and accuracy. Obfuscation transformation attribution is also addressed in this work using association rule mining. Random forest produced best outcome with F1-Score of 0.99 with benign samples, 0.95 with malware and 0.94 with obfuscated malware with system calls as features. Deep learning network with feed forward architecture is capable of identifying benign, malware, obfuscated malware samples with F1-Score of 0.99, 0.96 and 0.97 respectively.

Keywords

Obfuscated malware detection

Machine learning   **Deep learning**

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Classification and regression trees

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1. Kaspersky Lab. https://securelist.com/it-threat-evolution-q3-2018-statistics/88689/. Accessed 4 May 2019

2. McAfee Labs Threats Report. https://www.mcafee.com/enterprise/en-us/assets/reports/rp-quarterly-threats-sep-2018.pdf. Accessed 20 May 2020

3. Gartner Report. https://www.gartner.com/en/newsroom/press-releases. Accessed 15 Apr 2019

4. Scott, J.: Signature Based Malware Detection is Dead. Institute for Critical Infrastructure Technology, Illinois (2017)

5. Mirzaei, O., de Fuentes, J.M., Tapiador, J., Gonzalez-Manzano, L.: AndrODet: an adaptive Android obfuscation detector. Future Gener. Comput. Syst. **90**, 240–261 (2019)

6. Mohammadinodooshan, A., Ulf, K., Nahid, S.: Comment on "AndrODet: an adaptive Android obfuscation detector". arXiv preprint arXiv:1910.06192 (2019)

7. Ikram, M., Beaume, P., Kâafar, M.A.: DaDiDroid: an obfuscation resilient tool for detecting android malware via weighted directed call graph modelling. arXiv preprint arXiv:1905.09136 (2019)

8. Suarez-Tangil, G., Dash, S.K., Ahmadi, M., Kinder, J., Giacinto, G., Cavallaro, L.: DroidSieve: fast and accurate classification of obfuscated Android malware. In: Proceedings of the Seventh ACM on Conference on Data and Application Security and Privacy, pp. 309–320 (2017)

9. Wang, Y., Atanas, R.: Who changed you? Obfuscator identification for Android. In: 2017 IEEE/ACM 4th International Conference on Mobile Software Engineering and Systems (MOBILESoft), pp. 154–164. IEEE (2017)

10. Garcia, J., Hammad, M., Malek, S.: Lightweight, obfuscation-resilient detection and family identification of Android malware. ACM Trans. Softw. Eng. Methodol. (TOSEM) **26**(3), 1–29 (2018)

11. Google Play Store. https://play.google.com/store?hl=en. Accessed 25 Feb 2019

12. Virustotal. https://developers.virustotal.com. Accessed 25 Feb 2019

13. Arp, D., Spreitzenbarth, M., Hubner, M., Gascon, H., Rieck, K., Siemens, C.E.R.T.: Drebin: effective and explainable detection of android malware in your pocket. In: NDSS, vol. 14, pp. 23–26 (2014)

14. PRAGard Dataset. http://pralab.diee.unica.it/en/AndroidPRAGuard Dataset. Accessed 5 Mar 2019

15. Android Asset Packaging Tool. https://developer.android.com/studio/command -line/aapt2. Accessed 15 Mar 2019

16. Android Debug Bridge. https://developer.android.com/studio/command -line/adb. Accessed 15 Mar 2019

17. Android Monkey Runner. https://developer.android.com/studio/test/monk ey. Accessed 15 Mar 2019

18. Gościk, J., Łukaszuk, T.: Application of the recursive feature elimination and the relaxed linear separability feature selection algorithms to

gene expression data analysis. Adv. Comput. Sci. Res. **10**, 39–52 (2013)

19. Zakharov, R., Dupont, P.: Ensemble logistic regression for feature selection. In: Loog, M., Wessels, L., Reinders, M.J.T., de Ridder, D. (eds.) PRIB 2011. LNCS, vol. 7036, pp. 133–144. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-24855-9_12

20. Biau, G.: Analysis of a random forests model. J. Mach. Learn. Res. **13**(1), 1063–1095 (2012)

21. Loh, W.-Y.: Classification and regression trees. Wiley Interdiscip. Rev.: Data Min. Knowl. Discov. **1**(1), 14–23 (2011)

22. Cunningham, P., Delany, S.: K-nearest neighbour classifiers. Technical report. UCD School of Computer Science and Informatics (2007)

23. Srivastava, N., Hinton, G., Krizhevsky, A., Sutskever, I., Salakhutdinov, R.: Dropout: a simple way to prevent neural networks from overfitting. J. Mach. Learn. Res. **15**(1), 1929–1958 (2014)

24. Nwankpa, C., Ijomah, W., Gachagan, A., Marshall, S.: Activation functions: comparison of trends in practice and research for deep learning. arXiv preprint arXiv:1811.03378 (2018)

25. Hossin, M., Sulaiman, M.N.: A review on evaluation metrics for data classification evaluations. Int. J. Data Min. Knowl. Manag. Process **5**(2), 1 (2015)

26. Agarwal, R., Srikant, R.: Fast algorithms for mining association rules. In: Proceedings of the 20th VLDB Conference, pp. 487–499 (1994)

27. Alzaylaee, M.K., Yerima, S.Y., Sezer, S.: DL-Droid: deep learning based Android malware detection using real devices. Comput. Secur. **89**, 101663 (2020)

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Analysing Gender and Age Aspects of Cyberbullying through Online Social Media

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Mariya Raphel ;   P J Parvathi ;   Rizwana Yasmin Hashim ;   Rohan J Thevara ;   P Deepasree Varma.   **All Authors** •••

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Abstract:
In this paper, we focus at tracking down cyberbullies and categorize them based on their age and gender. The dataset that we use to analyze this information is provided by the MySpace group data labeled for cyberbullying. Machine learning classifiers are trained using this data to detect cyberbullies and later we analyze the age and gender patterns of those cyberbullies. We look for features that are simple to extract as well as yield good outcomes. As appropriate training data is often tough to obtain in machine learning-specially in the domain of cyberbullying detection - we also examine to what extend does lesser amounts of training data would contribute to better outcomes by performing cross-validation. Our findings show that employing a few yet expressive features has a significant benefit in detecting cyberbullies, particularly when size of training data is small.

Published in: 2021 International Conference on Advances in Computing and Communications (ICACC)

Date of Conference: 21-23 October 2021   **INSPEC Accession Number:** 21623484

Date Added to IEEE *Xplore*: 15 February 2022   **DOI:** 10.1109/ICACC-202152719.2021.9708197

Publisher: IEEE

Conference Location: Kochi, Kakkanad, India

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I. Introduction

Social networking sites are the platforms where a person can interact with other users despite any location and physical limitations. Billions of users are part of the ever-changing and ever-evolving social media. Individuals have completely accepted the web for mingling and conveying. Throughout the most recent decade, advancements in the internet have empowered everybody across topographical partitions. Along with these technological improvements, the negative impact of cyber activity has also received a lot of attention.

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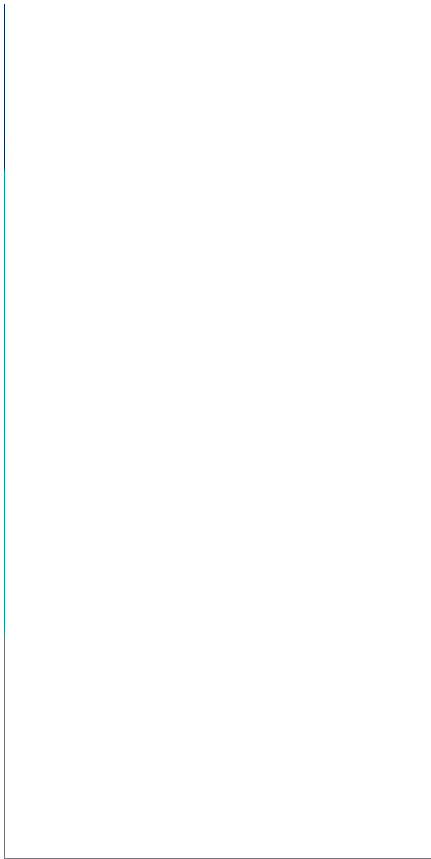
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Smart Computing Techniques and Applications pp 415–424

Real-Time Proximity Sensing Module for Social Distancing and Disease Spread Tracking

Sreeja Rajesh, Varghese Paul, Abdul Adil Basheer & Jibin Lukose

Conference paper | First Online: 14 July 2021

Abstract

Low energy proximity sensing devices are being used in our daily life for various purposes. The concept of making a dedicated hardware module for measuring the distance arose from this concept, so as to provide reliable and accurate measurements for various applications. Analysing the need and severity of the present situation due to the spread of COVID-19, the proposed hardware and software architecture can be tuned for the efficient practice of social distancing. It also provides an effective measure to track the disease spread by the integration of a secure database. NTSA—a cryptographic algorithm that is specifically designed and developed to run on low energy microcontrollers can protect the identity of every user. Since the encryption is done by the embedded device, NTSA can ensure enhanced privacy protection compared to any algorithm run on the server. This also ensures the reliability of the collected data. The hardware module actively transmits and receives signals from similar hardware modules. The proximity or distance between the two modules is measured by analysing the signal strength received by each module. To achieve disease spread tracking the users can track their status or level of exposure on a scale of 4 and hence would provide a metric for having external interactions like first-hand contact with COVID-19 patients, secondary contact, tertiary contact, and so on.

Keywords

COVID-19   **NTSA**   **Proximity sensing device**

Disease spread tracking

References

1. Stalling, W.: Text Book: Cryptography and Network Security, Principles and Practices (2006). Retrieved on 8 Dec 2006

2. Schneier, B.: Applied Cryptography, 2nd edn. Wiley, New York (1996)

3. Wheeler, D., Needham, R.: TEA, a tiny encryption algorithm. https://www.cl.cam.ac.uk/ftp/papers/djw-rmn/djw-rmn-tea.html; https://www.cix.co.uk/~klockstone/tea.pdf. Accessed 21 May 2007

4. Needham, R.M., Wheeler, D.J. (1997). TEA extensions. Technical Report, Computer Laboratory. Cambridge: University of Cambridge

5. Wheeler, D., Needham, R.: XXTEA: correction to XTEA. Technical Report, Computer Laboratory. University of Cambridge (1998)

6. Tang, H., Sun, Q.T., Yang, X., Long, K.: A Network coding and DES based dynamic encryption scheme for moving target defense. IEEE Access **6**, 26059–26068 (2018). https://doi.org/10.1109/ACCESS.2018.2832854

7. Banik, S., Bogdanov, A., Regazzoni, F.: Atomic-AES: a compact implementation of the aes encryption/decryption core. In: Dunkelman, O., Sanadhya, S.K. (eds) INDOCRYPT 2016, 10095. LNCS. Springer, Heidelberg, pp. 173–190 (2016). https://doi.org/10.1007/978-3-319-49890-4_10

8. Hoffman, N.: A simplified IDEA algorithm. Cryptologia **31**(2), 143–151 (2007)

9. Standaert, F.X., Piret, G., Gershenfeld, N., Quisquater, J.J.: SEA: a scalable encryption algorithm for small embedded applications. In: Workshop on RFID and Light weight Crypto, Graz, Austria (2005)

10. Choi, J., Kim,Y.: An improved LEA block encryption algorithm to prevent side-channel attack in the IoT system. In: 2016 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA), Jeju, pp. 1–4 (2016). https://doi.org/10.1109/APSIPA.2016.7820845

11. Abdullah, D., et al.: Super-encryption cryptography with IDEA and WAKE algorithm. In: 1st International Conference on Green and Sustainable Computing (ICoGeS) 2017. J. Phys. Conf. Ser. **1019**, 012039 (2018)

12. Ramakrishna Murthy, M., Murthy, J.V.R., Prasad Reddy, P.V.G.D, et al.: Homogeneity separateness: a new validity measure for clustering problems. In: International Conference and Published the Proceedings in AISC and Computing. Springer (indexed by SCOPUS, ISI proceeding DBLP etc), vol. 248, pp. 1–10 (2014). ISBN 978-3-319-03106

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Asha S ; Vinod P ; Varun G Menon ; Akka Zemmari   **All Authors** •••

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Abstract:
Recent years have observed an exponential growth in the popularity of audio-based authentication systems. The benefit of a voice-based authentication system is that the person need not be physically present. Voice biometric system provides effective authentication in various domains like remote access control, authentication in mobile applications, customer care centers for call attests. Most of the existing authentication systems that recognize speakers formulate deep learning models for better classification. At the same time, research studies show that deep learning models are highly vulnerable to adversarial inputs. A breach in security on authentication systems are not generally acceptable. This paper exposes the vulnerabilities of audio-based authentication systems. Here, we propose a novel downsampling attack to the speaker recognition system. This attack can effectively trick the speaker recognition framework by causing inaccurate predictions. The proposed threat model achieved remarkable attack effectiveness of 75%. This system employs a custom human voice dataset recorded in real-time conditions to achieve real-time effectiveness during classification. We compare the attack accuracy of the proposed attack against the adversarial audios generated using the CleverHans toolbox. The proposed attack being a black box attack, is transferable to other deep learning systems also.

☰ Contents

I. Introduction

Recent research trends witnessed tremendous advancement in the area of voice authentication. Nowadays various applications such as smart speakers, personal digital assistants, biometric frameworks, and forensics, enforce voice-based commands for authentication. Voice biometric system is more convenient to use as it is a contactless means of authentication. Voice biometric system incorporates identifying the human voice and finally verifying the speaker of the audio. As the use of voice-command-based applications are increasingly rising, the need to endorse security in such systems has become a demanding issue. The limitations in uniquely recognizing the owner of the voice brings the possibility of malpractices. Any person who is aware of specific voice commands can operate such systems. Hence these voice-command-based systems should also incorporate a voice recognition system that identifies and verifies genuine speakers from voice.

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Network on chip (NoC) is the communication infrastructure used in multicores which has been subject to a surfeit of security threats like degrading the system performance, changing the system functionality or leaking sensitive information. Because of the globalization of the advanced semiconductor industry, many third-party venders take part in the hardware design of system. As a result, a malicious circuit, called Hardware Trojans (HT) can be added anywhere into the NoC design and thus making the hardware untrusted. In this paper, a detailed study on the taxonomy of hardware trojans, its detection and prevention mechanisms are presented. Two case studies on HT-assisted Denial of service attacks and its analysis in the performance of network on Chip architecture is also presented in this paper.

Published in: 2021 8th International Conference on Smart Computing and Communications (ICSCC)

Date of Conference: 01-03 July 2021

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DOI: 10.1109/ICSCC51209.2021.9528249

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I. Introduction

Mobiles and handheld devices are becoming part and parcel of our day today life. More number of applications have to be executed concurrently and the performance of the device cannot be compromised at any level. Also, we are going to the era of machine learning where more computation intensive tasks have to be performed. In all these scenarios the prior requirement is that performance of the processor must be high enough to get the expected work done.

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Sonal Ayyappan ;   Navaneeth Asok ;   Nandu Shaji   All Authors •••

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Abstract:
The use of biometric authentication has seen an exponential increase in recent years ranging from smartphones to even forensic analyses. Fingerprints are obtained and used in crime scenes, old monuments and excavated relics and to the day-to-day authentication including attendance marking. Determination of age has always been an ardent task as they experience virtually zero changes as a person ages. Also, with the increased attacks and bypassing on the fingerprint authentication systems, it is also important to confirm the genuineness of the fingerprints. This brings forth a need for a spoof detection for fingerprints. Since fingerprints have been used as an effective method for authentication, their correlation with the age of a person is to be identified, if any. This paper aims in using Convolutional Neural Networks and other machine learning techniques to estimate age of a person from fingerprints and also spoof detection. The models we compare include three pre-trained CNNs which are fine-tuned with the fingerprint images, and a classical Local Binary Pattern approach. It is found that pre-trained CNNs along with Dataset Augmentation can produce good results with no need for any hyperparameter selection. NIST dataset was used for age detection and LiveDet 2013 dataset was used for spoof detection. It was able to achieve a top accuracy of 84% for age detection and 94% for spoof detection. The paper also focuses on identifying the best scanner for our purposes and also the possible materials used for spoofing.

≣ **Contents**

I. Introduction

Individuals can be identified and verified using their bio-metric characteristics such as the finger prints, palm prints, vein, and iris and these traits have been widely used in the modern day to day life. Fingerprints are generally used for the identification or verification of a person and for official documentation. It is one of the most mature biometric technologies and is considered as a legitimate proof of evidence for judiciary purposes. The demand for increased security and better authentication techniques has pushed fingerprint biometrics to be developed into a key technology, especially in this age of computerised access control systems. [13].

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Edition	1st Edition
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Parked Car Thermal Management and Air Quality System 2021-28-0150

The motivation of this work is to respond to high cabin temperatures within a parked/stationary vehicle which may cause discomfort and lead to vehicular heatstroke. The system also intends to ensure sufficient limits of oxygen within the vehicle cabin to prevent asphyxiation to the cabin occupants. The rise in global temperature is affecting the quality of air and comfort of occupants inside a parked car. There have been several cases reported of pets and children being left unattended or unsupervised in a parked car for a long period of time which have led to their deaths due to asphyxiation. The use of cost-effective materials like high density plastics for interior cabin trim have also been proven to contribute to cancer because of the emission of benzene a carcinogen by these plastics when exposed to extreme temperatures for long periods of time. This paper proposes a system where an oxygen sensor is used to measure oxygen levels within the cabin and an arrangement to lower the windows when a low level of oxygen is detected. The system also includes a temperature sensor with a suction and blower fan arrangement where the suction fan pulls the hot air out and the blower fan pushes fresh air in. This air flow will ensure air circulation in a parked car and prevent the stagnation of hot air within the vehicle cabin. It was also a crucial factor that this system should not interfere or hinder with any other workings of the car. This system will be powered by a compact solar system.

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MANAGEMENT CHALLENGES AND OPPORTUNITIES
During and after Pandemic Situations

Narendra Kumar
Arjun Gupta

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MANAGEMENT CHALLENGES AND OPPORTUNITIES
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Preface

World have seen many calamities in the past but those all were natural phenomena. A calamity again struck the world in the end of year 2019. If media reports are to be believed this calamity aka Covid-19 pandemic was man-made however the source of the pandemic is yet to be identified. Many of the commoners in current generation in India never even heard the word pandemic before the beginning of covid-19. The scale and magnitude of this pandemic was never thought by anyone. Media reports said that world is struck by pandemic in every hundred years however very few is living to tell the tale of last pandemic happened in year 1918.What current generation is facing could have not been imagined by anyone. The way a human think and act it is changed in the pandemic situation. Companies have to adapt in new situation to work and sell their products/services. Pandemic have affected the life of everyone. This book tried to explore this pandemic phenomenon.

First paper by Dr. Thimmaiah Bayavanda Chinnappa studied the best customer relationship management practices in tourism industry. Tourism industry is source of income for many people thus the paper tried to explore the best suited customer relationship practices to enhance revenue through tourism.

Second paper by Dr. Pradeepta Benerjee and Mr. Somnath Mukhuti studied the impact of covid-19 on Bank Nifty. Stock market is one of the indicators of any country's GDP growth. Country like India where service sector contributes more than 50% to GDP banking needs to be strong thus studying Bank Nifty volatility analysis will

show the direction Indian banking sector is heading.

Third paper by Dr. Sushma singh has tried to look into the impact of herd behaviour on financial risk tolerance after covid-19.Whenever individual investors make any investment; they want return on in it. Impact of human psychology through hearsay of other members in the herd can be seen on financial decision making. In this paper a research was conducted in five Different cities of Uttar Pradesh, India to look into the herd behaviour and financial risk tolerance by using GL-RTS scale.

Fourth paper by Dr. Nazia Sultan talked about business resilience during the covid-19. It is said that when faced with the extreme condition human tend to show the strength even unknown to him. During the covid-19, when lockdown was imposed businesses were shut. Businesses were needed to think outside the box, they come up with the financial, operational, organizational and financial resilience to keep-up their business running. This paper tried to look into the business resilience shown during covid-19 by the businesses. The practices and strategies adopted by the businesses were discussed in this paper.

Fifth paper by Divya MS talked about work life balance in new normal. After the covid-19 situation everybody was forced to change his ways of Living. Companies wanted their employees to work from home, teachers were teaching students through online mode. During the lockdown period everybody was looked into their own houses. Daily life of everyone was affected. This paper talked about the work life balance in this new normal scenario where partial or full restrictions are imposed by government or by self for safeguard of everybody.

Sixth paper by Dr. Periasamy P and Dr. Dinesh found about the data driven marketing strategic trends in 2020. A model called EPCMASQ of authors emphasized on how customer data helps in formulating marketing strategy to the sellers. Through this model authors discussed about

customer's ethical information, personalized marketing automation, better customer experience, multi-channel experience, artificial intelligence, Search Engine Optimisation and qualitative data. With this marketing concept any marketer can push his product to the customers easily and efficiently.

Seventh paper by Dr. M. Sharmila Devi and Mrs. J. Manjula Devi talked about the impact of covid-19 on FMCG sector. Fast moving consumer goods (FMCG) is one of the largest sectors contributing to be Indian GDP. Use of FMCG goods were also impacted due to many factors such as labour moving to their native places, Logistic issues. This paper shares about the impact of covid-19 pandemic on FMCG sector in India.

Eighth paper by Mr. Manoj Kumar Dewtwal tried to explore the e-Learning dimensions during pandemic situation. Teacher-student learning is impacted due to pandemic is looked upon in the paper. Every stakeholder in teaching-learning process is forced to learn through online mode and it impact is explored with this paper.

Ninth paper by Dr Ashima Garg, Mr. Amit Kumar & Dr. Veeralakshmi B. found out the organisational role stress among University teacher in Haryana state with respect to nature of job. The paper explored about the stress in university teaching staff in Haryana state. Over 500 respondents were used as sample size in this study to determine how much organisational stress is faced by University teachers in Haryana state.

Tenth paper by Dr. D S Parihar tried to look into the impact of covid-19 on tourism industry in Himalayan state Uttarakhand India. During any pandemic such as covid-19 tourism industry is bound to be impacted through this paper author looked into the impact, challenges and opportunities in tourism industry due to covid-19 pandemic in Himalayan state Uttarakhand, India. Uttarakhand is internationally known for beautiful glaciers, flower Valley, snow-capped

mountains, and diversity in animals, vegetation as well as society and great cultures. Due to covid-19 the tourism was badly impacted. This paper tried to explain the impact of lock down due to covid-19 on tourism industry in Uttarakhand.

Eleventh paper by Mr. Ravindra Verma and Mr. Mohan Kumar investigates into the work from home culture in pandemic era. This paper tried to explore the change of work culture in person's life due to pandemic situation. Employees were forced to work from home. How this have affected the behaviour of employees and how the work routine is changed has been tried to explored in this paper.

Twelth paper by Dr. Pulidindi Venugopal, Dr. S. Anjani Devi and S. Aswinipriya talked about the problem faced by GAP inc.GAP is clothing brand old and reputed company established in 1969 employing more than one lakh people in different countries under different brand names. This paper focused upon the problem faced by GAP INC. The solution and marketing strategies to overcome these problems bynGAP INC. are discussed in the paper.

Thirteenth paper by Mrs. Rajimol K P and Dr. Rajesh B, provides the overview of e- commerce industry in India and its evolution in India. Challenges faced by e-commerce and future prospects for e-commerce are also discussed in the paper.

Fourteenth paper by Dr. Sanjay Keshaorao Katait, talked about the impact of corona virus lockdown impact on health of women workers in construction industry in Maharashtra. In order to meet the growing infrastructure demand and developing economies women workers are bound to work in construction industry. When lockdown was imposed due to covid-19 these women workers were left stranded due to non-availability of work. Construction industry where health problems and unsatisfactory work conditions are common the women workers felt trapped. This paper talks about the situation of women workers in construction industry in Maharashtra during covid-19 lockdown.

Fifteenth paper by Mr. Ajay Yadav and Ms. Pooja Yadav looked into the digital marketing practices followed by the company. During the unprecedented times of covid-19 businesses needed to make sure that they reach to their customer. Authors in this paper tried to look into the digital marketing practices followed by the companies by discussing how online media is a way to connect to the world? People can discuss their thoughts opinions by eliminating the barriers of any boundaries. With the help of internet any marketer can promote his product and services through digital medium.

Sixteenth paper by Dr. Thimmaiah Bayavanda Chinnappa and Dr. Basheer Garba talks about the HR initiatives in banks. Banking system is backbone of any country's economic growth thus it needs to be robust and strong enough to serve its economic needs. With the changing scenario due to globalisation modern banking cannot have the same approach, what it used to have in 80's or 90's.Now a days due to competition banks are eager to serve customer at their doorstep thus their employees need to change their attitude. This paper talks about the HR initiatives in bank. The pragmatic approaches banks needs to follow in their HR policies is discussed in this paper.

Seventeenth paper by Mr. Ajay Yadav and Ms. Ramandeep Kaur talked about social media marketing. Social media has become integral part of one's life. Now-a-days social media is not only used for connecting with people online but also for sale and purchase of goods and services. Marketers are reaching to the customer through social media platforms. This paper explored the social media marketing on the basis of survey conducted on 400 respondents. Customer is influenced by social media in making purchase decision is discussed in the paper.

Eighteenth paper by Dr. R. Uma Devi and Dr. S. R. K.talks how covid-19 have disrupted business however human will to conquer those obstacles still pushes human to work harder. As discussed in paper entrepreneur also faced

difficulty in the time of covid-19. The adverse impact was observed in businesses. worldwide and most of the newly formed businesses and start-ups were compelled to dismiss theire mployees, leading to issues such as widespread unemployment, lack of productivity, and the downturn of economies however despite difficulties entrepreneurship is facing the obstacles and emerge victorious. As per paper even in the time Covid-19 many new start-ups were started and human will to remain strong was observed in the entrepreneurs. Entrepreneurs turned disaster into opportunity and earned reward by doing same.

Nineteenth paper by Nistha Adhikari is an article on Corporate Social Responsibility practices in Indian industry:COVID-19impact and way forward.The purpose of the study is toexplore various definition and descriptions of CorporateSocial Responsibility;elaborating upon the scope of corporatesocial responsibility (CSR) by studying deployment of CSRpractices over the last few years specifically the CSR initiativeof corporate during the pandemic situation in India.

Twentieth paper by Shruti Balhara talks about the work life balance among the women during the covid-19 situation. In Indian scenario where women are supposed to manage home along with their job, this paper explored the working women work life balance situations during pandemic lockdown. How working women were managing their work from home scenario and their families while working from home, since they are the key figure in their families is looked upon in this paper. Findings of this paper suggested that organisation must come with some new work life balance approaches, policies and practices with special reference to women employee to manage their job and home.

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5

Work Life Balance in the New Normal

Divya M S*

Abstract

Life after the pandemic Covid 19, will not be the same as we have seen or experienced. The epidemic has caused significant social and economic disruption, including the largest global recession since the 1930s Great Depression. It has resulted in massive supply shortages caused by the intensified panic purchasing, agricultural disruption, food shortages. Many educational institutions and public areas have been partially or completely closed. The industry and educational sectors experienced major and significant changes. The unanticipated shift to work from home during Covid-19 is taking a toll on employee's mental health with many unable to find breathing space, even in the comfort of their own homes. Most employees have experienced stress in their professional lives, personal finances, and family lives because of this predicament.

Keywords: *Covid-19, Pandemic, Depression, Mental Health*

Introduction

The pandemic Covid-19 has altered our entire way of life and work. Our life will not be the same as it was before the pandemic had struck on us. We have all become used to the new lifestyle, including small children and elderly parents. Changes prevailed in all fields and sectors, affecting every

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corner of the globe. The epidemic has caused widespread social and economic disruption, including the worst global recession since the Great Depression of the 1930s. Increased panic buying, agricultural disruption, and food scarcity have resulted in massive supply shortages. Misinformation has been widely spread on social media alleviating political tensions all around the nation. Concerns about racial, geographic, and financial discrimination, unhealthiness, and the balance between public health imperatives and individual rights have increased because of the pandemic. Along the many draw backs caused by this, there are many take aways also. The world has imposed curfew/lockdown measures to limit human mobility as the symptoms of the corona virus got worsened day by day. The restriction of quarantine halted all commercial activity that has a significant impact on the various important environmental parameters that are directly or indirectly related to human health. As all forms of social, economic, industrial, and urban activities had an abrupt cease, nature reaps the benefits, demonstrating improvements in air quality, cleaner rivers, less noise pollution, and undisturbed and calm wildlife. As we have seen during these two years the pollutant emissions were comparatively very less that what it was before. Our environment had reaped the major benefits out of this threat. Nature is what we should rely on as our future is dependent on it.

The industry and educational sectors experienced major and significant changes. Many of the educational institutions have opted on a new term called as work from home, which was only familiar to IT companies till now. Schools and colleges have always followed on a conventional mode of teaching starting from the ancient Gurukul system onwards. Now both the students, teachers and also parents are struggling with the innovative mode of teaching and E-learning. The employees in industrial sector is also facing a major unbalanced shift in their career. Balance between work and life became crucial and many failed to cope up

with maintaining a healthy balance between personal and professional life. Because your office is now at your house, remote working or working from home has become a part of our everyday routine life, which is no longer limited to the office but also includes our families. Employees find it difficult to maintain a pleasant working environment at home as they are struggling between official duties and homely chores.

Employee well-being is critical, as good physical and mental health can only lead to happiness and job satisfaction. A healthy environment can only determine and motivate employees to be their best. It has become quite a normal phenomenon to think that working from home can make most of us feel like we are working all the time. It is not a good indication as extended working hours will impact the productivity of individuals, as employees will not be able to focus on tasks to be completed on a given deadline. If they are stressed up, then there will not be any consistent productive performance. Employees who are disorganised will be unable to fulfil their responsibilities, either professional or personal. Such behaviour does not go a long way and they will feel suffocated being surrounded by workload all the time. Working parents will always be stresses up as they need to focus on both the family and their work. When children and aged parents are at home, full time attention need to be given to them. This diversion of time and focus can badly affect anyone's health. Work life balance is an important aspect in maintain a rhythm between personal and professional life. If that rhythm goes wrong, then its will be extremely difficult to rectify it. Nearly every day, an increasing number of cases of frustration, stress, disinterest, hypertension, and depression are being reported. There is an urgent need to focus on such rising cases, and effective interventions must be identified to put a halt to this threating issues. Employees can focus on tasks and feel more accomplished at the end of the day if they have and follow a proper schedule. We need to recharge ourselves for the second half of the day by relaxing and using

simple but effective techniques. We cannot escape from our responsibilities but can handle it effectively. These simple techniques can reduce the intensity of stress and makes you feel better and refreshed for the next day.

Literature Review

Work-life balance is a concept that describes how employees perceive their professional and personal lives in a balanced and amicable way by not affecting each other. An investigation into the effects of both the work stress and parental expectations, on job satisfaction, marital satisfaction, and overall life satisfaction among accounting professionals proves always to be on an increased rate. Both the working parents were messed up by childcare arrangements and shift-based jobs, that was the prevalent concept before. Women becomes the prime victims even at workplace or with kids at home, as its their entire responsibility to run and balance with the two poles (Bedeian et al.,1988). Studies shows that stress will be immense on a single parent than others. Women especially had to endure more struggle than their male counterpart (Duxbury et al., 1994). A relevant study among U.K academics has observed there is more job satisfaction among high ranked female faculties than on IT sectors, their Job position and Job nature makes it more relax able to them (Oshagbemi, 2000). However, this study does not define a demarcation between job satisfaction and life satisfaction. Attention has been more focused on classifying types of HR strategy especially on existing models of corporate strategy. Miles and Snow (1984) cites a relevant example on earlier work on strategy and structure. They pronounce that each of their strategic types of human resource management will need to adopt a different set of human resource management policies and they are clearly precise with some variations. The notion is that those institutions, corporates or managements that have a definite demarcation and strategy between their business strategy, structure and human resource management policy and practice will always and definitely have superior performance. To sum up, those employers

RE-SPACING
MENSTRUAL
NARRATIVES

RAZEENA P R

Re-Spacing Menstrual Narratives

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Technical Support & Publishing Assistance
AIFEST

Typesetting & Layout
Bijeeshkumar Shaji

Acknowledgements

Foreword

Making visible the invisible, speaking about unspoken experiences, engaging with the most silenced in the most intense, passionate and politically committed manner is the spirit behind all movements of resistance and assertion. And the feminist movement has been no less in following this motto to the hilt. It is by unlocking centuries of silence around the female bodily and mental experiences that women have tried to express their dissent towards the dominant discourse around gendered realities all over the world. We realize today that even after almost two centuries of conscious activism and assertion on a global scale, women still have a lot to fight for. Our struggles to be seen, heard and understood in all our complexities and diversities are far from over. Each generation of spirited feminist women has pushed the boundaries of accepted questions and answers, and this generation is doing it to the menstrual discourse which has been actually existing through centuries. It is not a static discourse but a dynamic one, evolving in response to historical changes, negotiating the breakthroughs in science and technology and redefining gendered spaces symbolically and literally. Different cultures and societal formations have engaged with this biological process differently and constructed elaborate apparatuses of rituals and narratives to understand this mysterious process assigned to the female of the species. Chris Knight, one of the prominent researchers in the area of menstrual culture has pointed out that some of the primal human symbols are drawn from the semiotics of menstruation. And it becomes crucial to historicize every moment of this articulation in order to avoid falling into simplistic explanatory models and binary modes of thinking.

We are trying not only to produce narratives but also to listen to different narratives which might often conflict with each other. They may not fit into any theoretical framework and may demand an entirely different mode of understanding. The intention is to revise, revisit and reshape the dominant narratives built around menstruation – religious, scientific and commercial. Production of sanitary napkins is one of the

most lucrative industries today. As a product of capitalist modernity, it constructs the woman as a menstruator/consumer of certain kind of sanitary pads which wreak havoc on an already fragile ecosystem. It is in this context that the articulations of this experience compiled and collected into a book become significant interventions in the emerging global discourse on menstruation. The book enables a plethora of narratives to interact with each other thus highlighting the diverse perspectives and positions which make possible more productive conversations – at the level of theory and practice. It goes to the credit of the editor Razeena P R that she took the initiative to venture into a field which people are still hesitant to talk about and is actually mired in a lot of misconceptions. I am sure any reader who picks up this book will find many layers of darkness falling away from them regarding their understanding about this vital process in the female body, which structures a woman's being in this world in so many crucial ways. I hope this book will generate more questions leading to more creative discussion and action beyond the spaces of the academia.

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Resilience Speaks the Beauty of Pain

Divya M S

Abstract

"Your understanding of your inner self holds the meaning of your life.
As rightly penned by Leo Tolstoy, our life's journey starts with self
discovery. If we can't define ourselves, then how could we follow our
heart to reach its destiny. A woman's journey starts with self
defining herself in her own words. Self-awareness is the stepping stone
of all people who have said to fulfil their dream, it is the only key to
self-mastery. In our life's journey we have been caressed with a
bundle of responsibilities tagged on us. Some gets unfolded on its way
and others are befitted on us by the rich legacy of generations. I would
like to venture through the written memoirs of women narratives
especially in the works of Anne Frank The Diary of a young Girl and
Nadia Murad The Last Girl: My Story of Captivity and My Fight
Against the Islamic State. We all are familiar with such experiences but
ashamed to voice out or even pen down such thoughts. Somehow our
gut feelings stop such thoughts, even now we are ashamed of saying
aloud of our monthlies. We change into a staunch mode when we hear
someone say about it. I would often associate it with the dialogue of
Harry Potter movie, when they say about the evil 'Voldemort' as 'Do
Not Say It Aloud'. It's the same we are doing when we restrict our
thoughts and conversation about the "curse" that every woman is
facing. This curse is the very reason behind what she is, she is complete
only with all this so-called indifference.

Key Words: Resilience, Self-awareness, Self-discovery, Monthlies

Concept Note

"Resilience is knowing that you are the only one that has the power and
the responsibility to pick yourself up." In the words of Mary Holloway,
resilience is the powerful weapon that defines you and have the
potential to uplift yourself from all atrocities. When we began to
confine and reflect ourselves, shedding all the wounds heaped on us in
our life's journey, our life takes on a new track. We began to live than
being mere existence. There have been many narratives on women but a
few to be short listed as depicting their self-portrayal. When we depict
our self completely without any deletions or veil, we tend to be
perfectly complete. When our emotions and expressions are being
curtailed there will not be perfect depiction. We need to come out of the
taboo long imposed on us. We believe nature to be pure and sacred,

when nature is mother, she in the real life should also be considered pure and sacred. Mother is the epitome of love, care, selflessness, comfort, from where our journey begins. Stories and personal narratives on and about women had always an everlasting authentic impact on us. Only a handful had dared to open up themselves to come beyond the restricted taboo. Our long-inherited customs and traditions taught us to be silent, calm, loving, caring like Sita. She becomes the epitome of sacrifice, love and care. History has also reminded us of our great leaders, and women with exceptional courage and devotion like Jhansi Rani, Mirabai, Rani Padmini, Anandi Gopal Joshi, Indira Gandhi, Justice Anna Chandy, Kalpana Chawla, Mother Teresa, Ahilyabai Holkar, Arati Saha, Aruna Asaf Ali, Durga Bhabhi, Mahaswetah Devi, Kamala Das, M S Subbulakshmi, Rudrama Devi, the names are endless. They have dared to think beyond their limitations imposed by the patriarchal society. Women have always exhibited exceptional courage, bravery, wisdom and knowledge to lead the world wisely than their counter parts. When we began to voice out our opinions, suggestions or findings we are type casted and stands out to face all the humiliations and sufferings from others. The worst atrocities are from the dearest ones. Menstruation had always been imposed on us as a taboo, like that of an untouchable. Apart from the generations ahead, we are moving on far more away from those uncivilized notions on womanhood. When there was a drastic shift from joint family to nuclear family and when we began to work and get involved in the financial decisions of a family, a change from house keeper to decision maker evolved. It wasn't that easy for us to enter into the dominated world of science and business. Now, we have learned to overcome the resilience imposed on us and to define ourselves. Is the menstrual cycle woman's curse, or is it an unexplored resource?".Judy Blume's *Are You There God? It's Me, Margaret* (1970) was a hall mark of the time, which made a reverberation of the preconceived notions and prejudiced mind. Menstruation was always believed and considered to be "Eve's curse", a long hereditary curse on us. The experience we had during the first period varies from person to person, but mood swings, emotional and hormonal imbalance that we experience are more over the same. We all forget to acknowledge the basic fact that it's the essence of our life. We need our monthlies, it's vital for mental and physical health, that's what makes us normal from all the abnormalities. The taboo imposed on us by our society is the basic reason for the inequalities happening to us. Women and girls are denied of their essential resources in many of the developing nations due to the fact that they are physically weak. I

would like to cite certain facts from google regarding the tab...
conceived by many nations. - In Ghana, 90% of girls in rural areas...
they feel ashamed during their period and 95% of girls sometimes mi...
school when they are menstruating. - 67% of girls from Nepal are n...
allowed to attend religious functions while menstruating. - 51% of gir...
in Iran do not take a bath eight days after the onset of their period....
high time to unveil the inequalities in her, it's this taboo which mak...
her unequal. She is complete only with the taboo imposed on he...
becomes pure as her. Personal narratives and instructions of menarche,
menstruation and menopause has been passed from mother to daughter
or sister to sister or peer groups. Throughout history, we can find
innumerable lives deprived of humanity and had undergone cruelties
that's beyond their worst dreams. Time and again we have exhibited
extraordinary courage to overcome those atrocities. The agonies and
resilience faced by many have occupied pages in histories as memoirs
and their wounds has caused many to rise and turn back. I would like to
dwell into the real-life experience of Nadia Murad and Anne Frank, in
their works *The Last Girl: My Story of Captivity, and My fight against
the Islamic state* and *The Diary of a Young Girl*. The theme of
resilience dominates the memoirs of holocaust faced by the Jews during
Hitler's reign as marked in the writings of Anne Frank in her famous
work *The Diary of a Young Girl*. Nadia Murad narrates her enduring
pain, humiliation and sexual exploitation in *The Last Girl: My Story of
Captivity, and My Fight against the Islamic State*". Both the memoirs
narrate their life incidents with a sarcastic tone of pain and hope that
they could live upon a life they envisioned, wordings capture their inner
resilient beauty. This silent beauty made the works eternal in the minds
of the readers, who could feel and imagine the pains endured. As rightly
said by Malala Yousafzai, "We realize the importance of our voice only
when we are silenced". Resilience is like a calisthenics training;
experience makes you better for the world to live in. It takes into
account the painful experiences you had come across, the setbacks you
received and the immense courage and strength you acquired on the
way. All this mounts up for you to become a better person, but it takes
time and effort. It's easy to advice someone to endure all the atrocities
and come back to life as a phoenix bird. To say only a few have come
across such sufferings and once they have, eventually they will be at the
top inspiring others with their life experience. When we withstand such
miss happenings in life and is able to bounce back and survive, you
succeed in life. When we experience any kind of hitches, stress,

emotional upheaval and suffering we are resilient, equating with mental toughness and emotional pain and suffering.

Beauty in her Openness – Anne Frank

"I want to bring out all kinds of things that lie buried deep in my heart". As rightly said by Anne Frank, this is exactly what her writings were. Holocaust, had taken the lives of many and had witnessed heights of pain and suffering which got captured in the frame of history. Anneliese Marie Frank, a young girl Jewish girl is forced into exile with her family in their "Secret Annexe". The autobiography tells about the anguish, anxiety and hope of a thirteen-year-old teenager. When Nazi came to power, life was not the same for Jews, they were forced to go on exile leaving behind whatever they possessed. It's been highlighted in her writings how desperately she missed her pet cat. May be this can be the reason why her diary got the name 'Kitty', she always addresses her diary as 'Dear Kitty'. The journal tells us about the daily accounts in her life on exile, her emotions, realisations, experience, family relation, friendship, her first monthlies, first love all that's being happening in a teenager's life. This autobiography makes us to think how a young teenager could be so open minded in her writings, which was rare during those times.

Our conditioned way of thinking doesn't allow us to accept such blunt writings. Nazis believed that the Jews were the root of all the prevailing evils and wanted all of the Jews to go on exile. They were tortured both physically and mentally by denying their basic rights. A brief account of these imposed restrictions is clearly mentioned in the initial pages of the diary: "The rest of our family, however, felt the full impact of Hitler's anti-Jewish laws, so life was filled with anxiety. After 1940 good times rapidly fled: first the war, then the capitulation, followed by the arrival of the Germans, which is when the sufferings of us Jews really began. Anti-Jewish decrees followed each other in quick succession. Jews must wear a yellow star, Jews must hand in their bicycles, Jews are banned from trams and are forbidden to drive, Jews are only allowed to do their shopping between three and five o'clock and then only in shops which bear the placard "Jewish shop". (pg. 20, 21) An account for her journals do tell us about how much Jews had suffered and deprived from the rest of the society. The restrictions imposed on them were even more harsh. They must always wear a yellow star and had to be indoors by eight o'clock and cannot even sit in their own gardens after that hour. They were forbidden to visit theatres, cinema halls and any other places of entertainment. Not

allowed to take part in public sports, swimming baths, tennis court hockey fields and other sports grounds. They cannot visit any Christian and were allowed only to go to Jewish schools, many more such restrictions. Life was horrific for Jews, and they began to flee from Germany to a much safer place with their families. Nazis burned down Jewish owned shops, synagogues, and their books. Jews were fleeing and tried to find shelter wherever they could. Nazis deported these people to forced labour camps, where they worked to produce supplies for the increasingly strained war economy. In most camps the prisoners were devoid of sufficient food, equipment, medicine and clothing. There was a complete disregard, and their health was deteriorating day by day. As a result of these conditions, death rates in labour camps were extremely high. Believing Holland was safe for Jews, Anne's family moved to Amsterdam in 1933. *The Diary of a Young Girl* also known as *The Diary of Anne Frank*, a book of diary writings kept by Anne frank while she was hiding for two years in the secret annex, with her family during the Nazi occupation of the Netherlands. The family was apprehended in 1944 and Anne frank died of typhus in the Bergen-Belsen concentration camp in 1945. The diary was retrieved by Anne's father Mr. Otto frank, the family's only known survivor after the war. The writings were from 14th June 1942 to 1 st August 1944. Her father gifted her a red checked diary on her 13th birthday, June 12 th 1942. It was not like a usual diary writing, she wrote as letters to her best friend that is, diary whom she addressed as kitty. In August 1944, they were caught from the secret annex and were deported to Nazi concentration camps. Anne died when she was just fifteen years old. These letters were not just the experiences of a thirteen-year-old young girl; it gives us an insight into the most terrific inhumane situation that mankind had ever undergone. The wordings which she breathed became eternal and true. In the autobiography by Anne Frank, she tells us about the daily accounts in her life on exile, her emotions, realisations, experience, family relation, friendship, her first monthlies, first love all that's being happening in a teenager's life. Her writings make us to think how a young teenager could be so open minded in her writings, which was rare during those times. Our conditioned way of thinking doesn't allow us to accept such blunt writings. The emotional frustrations and mental outbursts are all evident in Anne's writings. She had openly said about the teenager's frustrations, that we all have experienced while it's our first monthlies. Bodily changes, emotional imbalance, sensitives to certain thoughts and facts all are evident in her writings. She didn't feel to hide anything from her best friend Kitty. But that was found to be

one of the rarest of writings where a young teenage girl exposed her inner most intimate feelings and emotions to the world. She was indeed an inspiration for us, who made use of journaling to stress out her emotional outbursts. "I want to go on living even after my death" as rightly said, these words became eternal like her.

Pain in Resilience: Re-living the Pains of Nadia Murad

"The greatest glory in living lies not in never falling, but in rising every time we fall" – The eternal wordings of Nelson Mandela stand out when we read *The Last Girl: My Story of Captivity and My Fight Against the Islamic State*, a memoir by Nadia Murad. When death and suffering snatches the happiness and existence of our life, we fall in its tragic effect. Some couldn't withstand and they became a part of yesterday, those who bounced back creates history. Nadia Murad is the survivor and not a victim anymore. She is like Malala Yousafzai, Muniba Mazari and yet more. They are the victims who survived and inspired us to move on in life. We have heard a lot about the victims who struggled back to survive and fall apart. Remembering all those unheard heroines, we have to emit the ray hope to others who are still struggling to come out. Nadia speaks about the unspeakable brutality that she has endured in the hands of monstrous men. The memoir narrates to us about a world of extreme depravity of the basic human needs, and an intense struggle to overcome all the hurdles to get back their identity and relive. The writings do narrate a tale of depravity and a test of resilience who faced the worst adversities that any women could ever have faced. All this happens with a beautified synonym called "Call for Peace". Nadia Murad belongs to a large family of Yazidis in Kocho village, Sinjar, Iraq. Atrocities in all its kinds has been the worst nightmare for them. Faith is what kept them moving ahead to face and strive back all the cruelties imposed on them. It's true that Iraq has always been in a state of war, with the Americans in 2003, and with itself and then the Islamic state. Against their promise to protect them, the military forces betrayed them to the militants. Men and older women were slaughtered, and all the young women were made as sex slaves. Being in captivity and especially as a sex slave, life becomes as in a hell. These monsters had no humanity, not even considering there is life in them. Many instances had been narrated by Nadia, where she had to live on like an animal. Basic needs including clothing were denied to them, the punishments they had to face when attempting to escape were beyond imagination. Resilience was the power for her to strive back and come back in life. it's her ability to withstand adversity and bounce back made her what

she is today. She is the survivor and not a victim anymore. She is commonly known as Yazidi survivor, who battled against the terrible atrocities and now an author of the bestselling memoir and the recipient of Nobel Peace Prize. She is the person who had dared to rise up from the torment and went on to do her best to remedy it not only for herself for others who are still suffering. Nadia Murad Basee Taha, she belongs to one of the oldest religious minorities in the world. She and her sister were transported to Mosul like animals and tortured. As slaves, they were sold and traded by the militants and kept as sex slaves in their captor's house. She managed to escape from there and reached Germany in 2015. It's only through her open writings that the world was awakened to the horrors of sexual trafficking and brutalities at the hands of ISIS. In 2015, Amal Clooney appeared before the UN to represent Nadia Murad and said: "She was burned with cigarettes, she just endured the most brutal acts known to humanity". As a woman she had to face innumerable pains that cannot be even imagined by any human. While reading, we can feel the burden of pain and sufferings endured by her, we feel like empathizing with her to the situation. She fought against the cruelties that she had to face only for the fact that no other human being on earth should be in the same situation again. As woman, we feel to be resilient in many situations hoping to strike back on time. Resilience makes us more powerful than being reactive on every situation. We have often heard that there is much power in silence, as it gives us more power and energy to come back. Nadia is just one name than represents many among us who are still fighting in the dark to come out. Let she be a model for others to rise up and take action. Every woman is special in their own way and we come together to be the changing force. We should believe in ourselves and should begin to accept ourselves. Changes should begin from ourselves, we need to remove the taboos and restrictions imposed on us. I would to quote the wordings of Elizabeth Edwars to define the struggles Nadia had to encounter "She stood in the storm and when the wind did not blow her way, she adjusted her sails".

References

Abrams, M.H. *A Glossary of Literary Terms*. Canada: Wadson Cengage Learning. 2009.

Callahan, John. 2001. *In the African-American Grain: Call-and-Response in Twentieth-Century Black Fiction*. Urbana: University of Illinois Press.

Couto, Richard A. 1993. "Narrative, Free Space, and Political Leadership in Social Movements." *The Journal of Politics* 55 (1): 57–79.

Day, Amber. 2011. *Satire and Dissent*. Bloomington: Indiana University Press.

Frank, Anne. *The Diary of a Young Girl*: Lexicon Books. 2011

Gadow, Sally. 1994. "Whose Body? Whose Story? The Question about Narrative in Women's Health Care." *Soundings* 77 (3-4): 295–307.

Murad, Nadia. 2017. *The Last Girl: My Story of Captivity and My Fight Against the Islamic State*. United States: Penguin Books.

Kissling, Elizabeth Arveda. 2018. *From a Whisper to a Shout: Abortion Activism and Social Media*. London: Repeater Books.

Resilient response of mechanical-cement stabilized laterite gravel

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Abstract. Rapid economic growth is leading to ubiquitous expansion in highway projects around the world. Utilization of natural aggregate resources for the construction of flexible pavement has led to uncontrollable quarrying in the state of Kerala, India. The recent landslides in Kerala is the aftermath of extensive quarrying activities. Utilization of treated native soil in the subbase and base layers of flexible pavement can widely avert the danger associated with ecological imbalance due to quarrying. In this study, engineering properties of mechanical-cement stabilized laterite gravel were investigated for their effective utilization as a subbase course material in flexible pavements. The effects of cement content and the curing age on the resilient modulus and permanent strain of laterite gravel-stone chips-cement (LSC) mixes were investigated. A mix of 70% laterite gravel + 30% stone ships stabilized with 7% cement was obtained as the optimum mix. The optimum LSC mix with a 28-day curing period exhibited 55% higher resilient modulus and 78% lower permanent strain than the conventional granular subbase (GSB). On the basis of finite element analyses of flexible pavement, it was found that the pavement with optimum LSC mix in subbase exhibited a design life ratio of 1.29 and 1.13 with respect to that of pavement with conventional granular subbase corresponding to rutting and fatigue failure criteria.

Keywords: Laterite soil, cement, unconfined compressive strength, resilient modulus, California bearing ratio.

1   Introduction

The depletion of natural aggregate resources triggered new technologies for the implementation of marginal materials in road construction. Use of native soil in the base and subbase layers of flexible pavement is an innovative technology to minimize the exploitation of the natural aggregate resources, especially in an environmentally fragile state like Kerala. Several researchers have done various studies on both the mechanical and chemical stabilization of laterite soil.

Joel and Agbede found that partial replacement with 45% sand significantly improved the gradation of the laterite soil [1]. The 55% laterite and 45% sand mix when stabilized with 6% cement resulted to a stiff cemented mix of UCS value > 3 MPa. The compaction characteristics of laterite were significantly improved by the addition of cement [2]. In another study, 8% crushed steel slag were added to laterite for increasing the maximum dry density [3]. Laterite stabilized with 8% crushed steel slag gave a CBR

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Lecture Notes in Mechanical Engineering

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$$V_{st} = V_w\phi + V_s \tag{12}$$

However, the void fraction cannot be measured directly and needs to be calculated using the following equation:

$$\phi = \frac{A}{p} + B.q_s + C.q_f^2 + D.e^{-\left(\frac{dp}{dt}\right)^2} + E \tag{13}$$

The unknown constants A, B, C, D, and E are assumed to be -1 each to determine the value of ϕ. Since, $\frac{dp}{dt}$ cannot be computed for $t = 1$, the initial guess for ϕ is taken as 0.5. The values of ϕ obtained from Eq. (13) are substituted in Eqs. (11) and (12). The values of V_{wt} and V_{st} obtained from Eqs. (11), (12) are substituted in Eq. (10). This was followed by minimizing the sum of squares of errors between the LHS and RHS of Eq. (10). This minimization was performed using the SLSQP optimizer from the SciPy library in Python.

Since the conditions inside a boiler vary rapidly, the predictive model needs to account for these variations. Such an adaptive model can be developed by performing regression on the newly fed data as well and changing the regression coefficients accordingly. To achieve this dynamism, the multivariate regression is performed on sets of 100 data samples. That is, the first set consists of samples from $t = 1$ to $t = 100$, the second set ranges from $t = 2$ to $t = 101$, and so on. The regression coefficients obtained after each iteration are used to obtain the void fraction at the last time step. Using this value, the apparent volume of water at the next time step is calculated and compared with the original value to determine the error. For example, after performing regression on the first set $\{t = 1 : 100\}$, the values of regression coefficients obtained are used to calculate V_w for the 101st time step. Using the V_{wt} and V_{st} values obtained from this process were substituted in the energy balance Eqn. [1] of boiler which is expressed as follows:

$$e_1 \times \frac{dV_{wt}}{dt} + e_2 \times \frac{dp}{dt} = q_f h_f - q_s h_s + Q \tag{14}$$

where

$$e_1 = \rho_w h_w - \rho_s h_s \tag{15}$$

$$e_2 = V_{st}\frac{\partial \rho_s h_s}{\partial p} - V_{wt}\frac{\partial \rho_w h_w}{\partial p} \tag{16}$$

Now, after determining the LHS, the only unknown in Eq. (14) is the heat of combustion, i.e., Q. Since Q cannot be measured, the amount of heat available at an instant is expressed as the sum of fractions of fuel consumptions over a certain period of time. Through trial and error this period was determined to be 25 min. Hence, the amount of heat available at an instant is expressed as:

Table 1 Ergonomic methods for evaluating risk factors for MSDs associated with driving [24, 25]

Types of methods	Name of techniques	Main features
1. Self-reports	1. VIDAR-Self-evaluation of the driver using videos of the driving process 2. Interview, category data, and visual analog scales 3. Evaluation of possible ergonomic risks employing a web-based tracking system	1. Driver load ratings and associated pain and discomfort estimations 2. Identification of variables that increase a driver's psychosocial risk for shoulder and neck pain 3. List of comfortable ergonomic positions that might help prevent discomfort, workplace stress, and functional restrictions
2. Observational methods	1. RULA 2. REBA 3. OWLS 4. QEC 5. LUBA 6. Checklist 7. NIOSH lifting equation	1. Concepts like body postures and force, together with action levels for evaluation 2. Elements of biomechanics include body postures and force, with activity levels for assessment 3. Force and body posture evaluation 4. Driver reactions to major body areas, as well as scores to suggest intervention 5. Angular displacement of the joint from neutral and discomfort evaluation 6. Displacement of neck, legs and trunk for repeated tasks 7. Driving posture is associated with biomechanical stress
2.a. Advanced observational methods	1. Video analysis 2. ROTA 3. TRAC 4. HARBO 5. SIMI motion	1. Hand/finger posture assessment, repetitiveness, force, velocity, and body postures are computed. Task evaluations, both static and dynamic 2. Static and dynamic task evaluation 3. Posture and activity analysis 4. Observation of different driving activities over a long period 5. Dynamic movements of the limbs and upper body are assessed

(continued)

1 Introduction

A space shuttle is a partially reusable rocket-launch vehicle meant to go into orbit about Earth, to transport people and cargo to and from orbiting spacecraft. Recent years have displayed increasing study and advancement in reusable and low-cost space travel with an uptick in the commercial space launch market. A considerable factor for the increase in the expense of space travel is the non-reusability of the space shuttle. During the re-entry of a space shuttle, a substantial amount of heat is generated as it reaches the atmosphere of the earth from space [1]. Temperatures exceeding 2000 K are produced due to the friction between vehicle and air. Since most metals and alloys cannot withstand these temperatures, a special class of materials known as ablators that act as heat shields are used. The ablator will be consumed in the heat, thus dissipating a large amount of heat. However, these conventional wing designs have numerous limitations. Due to the large number of forces acting on the wing during re-entry, the reusability is limited as the wing material gets consumed during re-entry [2]. Also, the wing can get damaged due to the same.

To overcome this, we have developed a new retractable wing mechanism that resembles the Japanese hand-fan, such that the wings of the space shuttle will be completely ducked inside the fuselage during re-entry, thus minimizing the influence of forces (here, the forces of gravity, drag, lift, etc., are considered) acting on the wings, which can result in a safer and economic space journey. The aerodynamic force coefficients of drag and lift forces are estimated numerically using CFD tools for five different deploying phases to study the effectiveness of the novel design. Based on the above analysis, this paper studies the aerodynamic performance of a space shuttle equipped with deployable wings, with an expectation of proving theoretical foundation and technical base for conceptual space shuttle design.

2 Materials and Methods

2.1 Geometry Acquisition

The conceptual modeling was performed in SOLIDWORKS 2016. The material selected for the model is a composite material using a heterogeneous composite material bonded by adhesives for making the wing structure lighter [3, 4]. The dimensions of the model were inherited from the famous Russian space shuttle BURAN, and the wing cross-section was modeled based on NACA 4412 aerofoil profile. It has a maximum thickness of 12% at 30% chord and maximum camber of 4% at 40% chord length, and a side view of the wing profile is presented in Fig. 1. The wingspan is 23.9 m which is equivalent to the BURAN space shuttle wingspan.

10 Effect of Exfoliation on Structural and Electrochemical Properties

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10.1 INTRODUCTION

The term exfoliation represents a process during which the layered bulk materials are expanded through a chemical or physical method to overcome the weak inter-layer forces that hold the layers together. Generally, the stacked layered materials seized together by van der Waals forces can be easily intercalated or exfoliated by solution methods or simple physical means such as shear or ultrasonic vibrations to form 2D nanosheets. The exfoliated 2D nanosheets are often composed of single or few layers of atoms, and most importantly several of their properties are largely deviated from the bulk. Such materials find applications in electronics, photonics, catalysis, supercapacitors, fuel cells, batteries, etc. [1]. The success of graphene triggered the development of other 2D structured nanomaterials, especially by the exfoliation of layered bulk inorganic materials. Unlike bulk materials, 2D nanosheet counterparts exhibit unique electron and phonon transport characteristics, which leads to several fascinating properties such as thermal conductivity, ion transport, and charge carrier concentration, besides the structural and mechanical properties.

Many of the 2D nanosheets are non-toxic and can be handled easily, and they can be cast to any substrate as a thin film for device fabrication [2]. Over the years, exfoliated 2D nanolayers have become an essential part of electrochemistry, mainly in sensing, energy, and environmental applications. 2D carbon allotropes such as graphene and 2D porous carbon are not electrochemically active by themselves; therefore, they are often doped/modified by heteroatoms such as B, P, and N or transition metals. The high charge conductivity of the 2D carbon materials is highly favorable for several electrochemical applications such as batteries, supercapacitors, sensors, and catalysis. The stability of several inorganic 2D nanosheets in acidic and basic media makes them attractive for the aforesaid applications and they are considered as the immediate replacement for expensive noble metal electrocatalysts [3].

MXenes are 2D nanolayers of metal carbides, carbo-nitrides, and nitrides, an important class of electroactive 2D nanomaterials that are developed lately. $Ti_3C_2T_x$ is the first MXene discovered in 2011. So far about 50 different types of MXenes with wide chemical and structural variations are synthesized by exfoliating MAX phases by selective etching and mechanical shearing. MAX phases represent a family of ternary carbides and nitrides. MXenes are unstable in oxygen-containing environments. The hydrophilic nature and high surface charge of MXene nanosheets make them stable in polar solutions for device printing. The ability of MXenes to intercalate various cations including multivalent ions and polar organic molecules between its 2D layers makes them apt for non-lithium-ion batteries and supercapacitors [4]. Alike graphene, MXene exhibits excellent electronic conductivity and can be functionalized, hybridized, and doped for tuning the properties to meet the requirements of a specific application.

Many non-noble metal electrocatalysts are inactive and unstable in acidic mediums. The reaction in an acidic medium is highly efficient at a high current density. Transition metal dichalcogenides (TMDs) are highly active electrocatalysts for sensing, batteries,

supercapacitor, water splitting, etc., especially in acidic and harsh environments. TMDs have the general formula MX_2, where M is the transition metal and X is the chalcogen (X = S, Se, and Te), having a similar layered structure to those of graphene. Alike any other 2D layered nanosheets, TMDs can be doped, functionalized, and hybridized for improving various operating parameters such as selectivity, sensitivity, and affordability in sensing and efficiency, stability, and life span in catalysis. Additionally, TMDs have good electronic and mechanical properties favorable for electrode materials [5].

2D nanosheet of layered hydroxides (LDHs) and oxides are also an important class of electrochemical materials, starting from sensing to fuel cells. The presence of oxyl and hydroxyl groups allows the efficient transport of ions when they are used as electrodes in energy storage. The possibility of intercalation of ions other than Li^+ makes them a promising candidate for non-lithium-ion batteries. The electronic conductivity of LDHs and oxides are poor, therefore these materials are often hybridized with carbon-containing conductive materials as an effective strategy to increase the intrinsic catalytic activity. In this chapter, the electrochemical applications of the exfoliated 2D nanosheets in batteries, supercapacitors, biological sensing, and water splitting are discussed concisely. The underlying mechanism of electrochemical activity of different classes of 2D layered nanosheets is different. Such unique characteristics of different classes of 2D nanosheets favorable for the respective applications are also explored in this chapter.

10.2 ELECTROCHEMICAL SENSORS

A large number of sensors are used in our daily life to monitor and modify ourselves and our surroundings in a positive way. Electrochemical sensors have the largest share among all the chemical sensors, which use an electrochemical reaction (parameters such as a change in current and impedance) of the analyte to quantify the concentrations. Analytes electrochemically interact with the active material to produce signals and the sites on which such interactions happen are known as electrochemically active sites. Usually, the concentration of electrochemically active surface area increases with the surface area of the active material. Interestingly, exfoliation of 2D materials increases the surface area and exposes active sites, which may not be active otherwise. Often, exfoliated materials take part in the electrochemical reaction or act as a host to molecules such as enzymes that catalyze the reaction. Exfoliation, being a top-down approach results in defects that can also have a positive influence on the electrochemical reactions because of their very high activity. Apart from this, the extend of exfoliation, lateral size, etc. is also critical in deciding exfoliated material's electrochemical activity [6].

Graphene, which is a carbon allotrope, is the first known material to be exfoliated into atomically thin layers from its bulk counterpart graphite. Graphite can be easily exfoliated by mechanical cleaving. This can be used as an advantage in sensing where the fouling of the electrode material is a serious concern. The detection of material like bisphenol-A involves the polymerization of the analyte molecules and results in the deposition of the material on the surface of the electrode, which results in the electrode fouling. Exfoliated graphite helps in tackling this issue wherein a mild polishing results in the removal of the polymerized products from the surface as described by Ndlovu et al. [7]. Figure 10.1 schematically represents how exfoliation acts as a tool to challenge the fouling issues in electrochemical sensing.

Graphite oxide samples are usually exfoliated using thermal shock to achieve high quality and are electrochemically active for the detection of hydrogen peroxide and this is extensively reported by many researchers. Moolayadukkam et al. in 2020, in detail, explained the effect of solar exfoliation on the H_2O_2 sensing performance. Exfoliated graphene sheet has more defect concentration, which acts as the electrocatalytically active sites by adsorbing the analyte molecules. These adsorbed analyte molecules are electrocatalytically oxidized and corresponding signals can be recorded with a technique such as chronoamperometry. Figure 10.2 schematically shows graphene layers with defects/pores and their activity in adsorbing H_2O_2 molecules (analyte) [8].

Non-carbonaceous materials are electrocatalytically more active and their exfoliation has revolutionized electrochemical sensing research and developments. Layered 2D TMDs offer a wide variety of materials that can be exfoliated and having electrical properties varying from metallic to semiconducting nature. The peculiar arrangement of each atomic layer in TMDs offers a variety of active sites for the analyte adsorption in each layer after the exfoliation process. This property is widely used in the efficient detection of biomolecules. MoS_2 is one of the most widely used TMDs for sensing and other applications. Ashwathi et al. studied the relation between the analyte affinity and the active material by taking MoS_2 and Hg (II) ions as an example. In this particular example, Hg (II) ions have a high affinity toward S-containing groups. Exfoliation leaves S on both the surfaces of nanosheets exposed while the Mo layer at the center acting as the backbone. This arrangement of atoms improves the sensitivity by many folds clearly showing exfoliation of 2D TMDs could be used as an effective method for fine-tuning sensing capabilities [9].
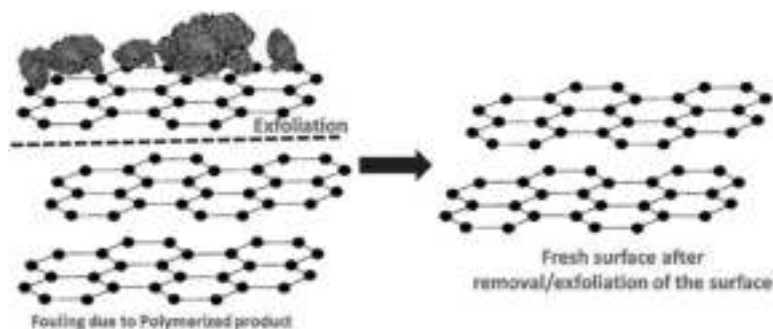
FIGURE 10.1   Shows how exfoliation of the material helps tackle the fouling issues in sensing.
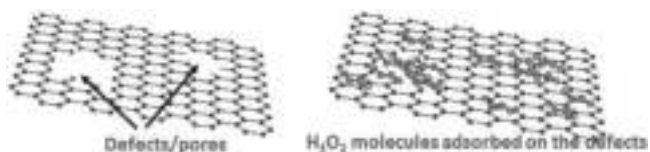
FIGURE 10.2   Schematic representation showing the importance of defects in adsorbing the analyte molecules on the graphene surface.

LDHs are another class of materials that can be exfoliated to form molecular layers with metal as the center layer. Compared to TMDs, LDHs have the advantage that there may be more than one metal in the metallic center layer, and varying the ratios of metals at the center and the metals themselves can tweak the sensing properties [10]. Sahoo et al. studied the sensing properties of ultrasonically exfoliated Ni_2Co-LDH with dopamine, an important biomolecule. The electron transfer rates are reported to be improved on moving from bulk to the monolayers of the LDH. Going from bulk to monolayers could help decrease the electron scattering at the active material, which can have a positive impact on the sensing properties [11]. Strong dependence of the exfoliation on the sensing properties is also reported by Chia et al., Authors explained the effect of exfoliation using enzymatic glucose sensing as a tool. Exfoliated 2D sheets show better sensing properties because of the high surface area and thin nature. Thinner sheets result in a decreased distance between adsorbed enzyme and the electrode, which facilitates efficient electron transfer. Polymeric 2D material, graphitic carbon nitride also shows similar sensing properties upon exfoliation. Kesavan et al. exfoliated graphitic carbon nitride using ultrasonication technique and demonstrated the flutamide (FLT) sensing properties. With the help of impedance spectroscopic studies, they have shown that active sites and conductivity are increased as a result of exfoliation. Along with this, the affinity of FLT and nitrogen on the graphitic carbon nitride played an important role in improving the sensing properties [12].

Irrespective of the layered material, exfoliation is observed to have a significant influence on the sensing properties. Exfoliation results in exposing active sites and the reduction in thickness resulting in better absorption of the analyte molecules and better electron transfer characteristics. Apart from this, the method of exfoliation induces different types of defects on the 2D crystal, the electron density on these defects such as edges and pores have an impact on the electrocatalysis of the analyte molecule. Carefully altering the method of exfoliation, sensing capabilities of the materials could be extended.

10.3 WATER SPLITTING AND FUEL CELLS

Water is an abundant source of energy and splitting water in a most economic route is a serious research concern in recent years for the production of hydrogen and oxygen. Hydrogen is considered the most advantageous renewable source of energy and the availability of oxygen is critical for the treatment of patients affected with COVID 19. Oxygen is also important for the complete combustion of any fuel, including hydrogen. The commercial electrocatalysts containing noble metals are currently used in fuel cells as hydrogen evolution reaction (HER), oxygen evolution reaction (OER), and oxygen reduction reaction (ORR) catalysts. The involvement of noble metals in crucial energy-related applications such as a fuel cell increase the installation and operation cost tremendously. Recently, several non-noble metal electrocatalysts are introduced as a replacement for noble metals and their derivatives. Several 2D layered nanosheets prepared by intercalation/exfoliation are subjected to HER and OER/ORR. Many are identified as potential replacements for noble metals in their respective applications. A list of widely studied exfoliated 2D materials as electrocatalysts are discussed in this session.

10.3.1 Hydrogen Evolution Reaction (HER)

The evolution of hydrogen by electrochemical water splitting can be a feasible way of storing hydrogen for energy-related applications, especially for fuel cells. Over the years, noble metals are broadly used as an efficient catalyst for HERs. However, the high cost of noble metals limits their extensive use as a catalyst at a large scale. To overcome the high cost of noble metal catalysts, electroactive materials that are available in abundance are proposed as catalysts. However, the major challenges of most non-noble materials used in HER are (1) the low efficiency, well below the thermodynamic limits of the water-splitting reaction and (2) the short lifetime [13]. Materials containing transitions metals are very active for HER. Though HER can be performed either in an acid $\left(2H^+ + 2e^- \leftrightarrow H_2\right)$ or basic $\left(2H_2O + 2e^- \leftrightarrow H_2 + 2OH^-\right)$ medium, a basic medium is commonly preferred due to the short-term stability of many materials in the acid medium. Similarly, due to stability issues, pure metals are avoided for HER reactions. To improve the performance of electroactive materials par to the noble metals several strategies are adopted. The suitability of a nanostructured material as an electrocatalyst depends on the surface area, presence of defects such as oxygen vacancies, availability of active sites on the surface, and dopants. The surface area plays an important role in HER since HER is a surface-active reaction.

Materials with the layered structure are identified as a suitable candidate for the HER since the layered materials are often characterized by the presence of multivalent transition metals in their crystal structure and the synergic interaction of these elements can augment the catalysis by offering many active sites for catalyzing the reaction. Interestingly, the conductive flexible 2D nanosheets enable the easy access of the electron from the catalyst substrate to the surface through intimate contact. As a result, the interfacial electron transfer resistance can be reduced and electrons can circulate through the external circuit efficiently [14]. The most active sites of exfoliated 2D materials for HER are located along the edges of the layers, but its performance is currently limited by the density and reactivity of active sites. The unprecedented HER activity of the layered materials is observed when they are exfoliated by intercalating a charged ion such as Li and Na, and thereby surface area is increased enormously in addition to the increased electrical conductivity. The overall HER activity is determined by how well hydrogen atoms can be adsorbed on the catalyst surface [14].

Among the layered materials, the introduction of exfoliated TMDs is a breakthrough in the history of non-noble metal catalysts for HER. Chemically exfoliated layers of dichalcogenides such as MoS_2, WS_2, CoS_2, VS_2, and NiS_2 are extensively studied as a promising electroactive HER catalyst. The above materials exhibit a low overpotential in the range of 100–250 mV vs reversible hydrogen electrode in an acidic medium. Overpotential is the measure of the efficiency of a material for a water-splitting reaction and it represents the loss of the applied voltage. The overpotential of platinum/carbon commercial electrodes are ~30–50 mV. The layered materials without exfoliation or intercalation are often inactive as in the case of MoS_2. The ultra-thinning and 2D nanosheet formation create an abundance of HER active sites at the edges [15]. Moreover, the planar mobility of electrons along the 2D layer guarantees rapid electron transfer from the substrate to active sites. The exfoliated transition metal selenides and tellurides are also reported as electroactive materials for HERs.

For instance, exfoliated WSe_2, $MoSe_2$, $MoS_{2(1-x)}Se_{2x}$, $MoTe_2$, WTe_2, $MoSe_2/WSe_2$, VSe_2, etc. 2D nanosheets exhibited a superior performance than the bulk counterparts. Doping noble metals such as Pt and Ru to the 2D chalcogenides can increase the catalytic activity tremendously. $MoSe_2$ is an n-type semiconductor, converting $MoSe_2$ to a p-type semiconductor by Nb or Ta doping reduces its activity toward HER [16].

MXene (layered metal nitrides and carbides) is a new family of exfoliated materials and potential electrocatalyst for HER, MXene adopts a general formula of $M_{n+1}X_nT_x$ ($n = 1$–3), where M is a transition metal such as Mo, V, or Ti, X is C and/or N, and Tx represents surface functional groups such as H or OH. Despite the high surface area, MXenes are characterized by excellent hydrophilicity and conductivity. Interestingly, the active HER sites for MXene are located on the O^* basal plane, which makes them ideal for HER [17]. The HER activity of MXene is enhanced by modifying the transition metal, during which the Gibbs free energy for hydrogen adsorption is improved, subsequently, one can obtain a decreased barrier energy for hydrogen production [18]. MXene combined with nanostructured platinum is widely used as the electrocatalyst. $Mo_2TiC_2T_x$, $Ti_3C_2T_x$, $V_4C_3T_x$, $Mo_2TiC_2T_x$, etc. are some representative MXene electrocatalysts for HER.

Layered carbon allotropes such as graphene and its oxide exhibit poor adsorption toward hydrogen; therefore, they are not efficient catalysts for HER. However, these materials are extensively used as supporting materials for electroactive elements and nanostructures. The graphene decorated with electroactive nanostructures of Pt, Ni-Mo-N, Ni, CoP, MoS_2, $ReSe_2$, WS_2, etc. is identified as excellent catalysts for HER in a basic medium. In addition to the large surface area, the high conductivity of the graphene/graphene oxide significantly reduces the interfacial electron transfer resistance between the catalyst support and the active sites, which ultimately improves the efficiency toward HER.

10.3.2 OXYGEN EVOLUTION REACTION (OER) AND OXYGEN REDUCTION REACTION (ORR)

The electrochemical generation of oxygen through water splitting is critical in metal-air batteries and fuel cells. The electrochemical OER ($2H_2O \rightarrow O_2 + 4H^+ + 4e^-$) and ORR ($O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$) are four-electron transfer reactions. Due to the complicated multi-electron transfer steps, the ORR/OER suffers from sluggish kinetics. Similar to HER, noble metals and their derivatives exhibit low overpotential for both ORR (e.g., Pt) and OER (e.g., IrO_2 and RuO_2) applications. 2D nanolayers are unique due to a large number of surface atoms as compared to the internal atoms, which makes them highly electroactive for a variety of applications. Exfoliated 2D materials like graphene and graphene oxide, inorganic monolayer materials such as metal oxides, TMDs, LDHs, MXenes, diatomic hexagonal boron nitride, and black phosphorous (BP or phosphorene) are studied as potential candidates for OER and ORR applications. In addition to the planar strength, exfoliated 2D materials are flexible with an atomic or few-layer thickness. Interestingly, the most single or few layers of graphene, carbon nanosheets (CNS), TMDs, LDHs, and MXenes are exfoliated from their bulk, and these are the most extensively studied 2D materials for OER application.

To overcome the scarcity of OER electrocatalysts for acid medium the transition metal dichalcogenides (TMD) are proposed. The exfoliated 2D nanosheets of MoS_2, TaS_2, WS_2, $MoSe_2$, etc. either in 1T and 2H polymorphic forms are the common electroactive catalysts for OER. The performance of the above materials for OER is par to stable IrO_2. Liquid phase and ion intercalation are the most common routes for the exfoliation of TMDs nanosheets from the bulk by overcoming the weak van der Waals interaction among layers. The step-by-step exfoliation of bulk TMDs using Isopropyl alcohol and the preparation of electrodes using exfoliated nanolayers are shown in Figure 10.3. Alike HER, the dominant active sites of TMDs for OER are on the edges rather than the surface [19]. The dichalcogenides of noble metals such as Rhenium-, Ruthenium-, and Iridium- exhibit exceptional activity toward OER and ORR.

Unlike in the HER, MXenes themselves are not directly active for ORR or OER electrocatalysis; however, they serve as excellent supports for various electroactive materials. MXenes are better catalyst support for Pt nanoparticles or Pt/Pd atoms than carbon as in the commercial Pt/C electrode for OER due to the strong interaction between Pt and the respective MXene layers. Likewise, other electroactive materials such as metal-organic frameworks, carbon nitride, LDHs, oxides, borate, sulfides, and metals bound to the surface of MXenes also exhibited superior OER activity par to the commercial noble metal catalysts. Hybrid TMD–MXene-like materials are recently introduced as OER catalysts. The heterostructure of the above hybrids allows the synergistic interactions between TMDs and MXenes and one can achieve a significant improvement in the OER activity.

Carbon allotropes themselves are not active for OER or ORR, though when doped with heteroatoms (B, S, N, P, F, and O) or transition metals (Ni, Co, Fe, etc.), they become excellent ORR and OER catalysts. The conductivity of graphene, 2D porous
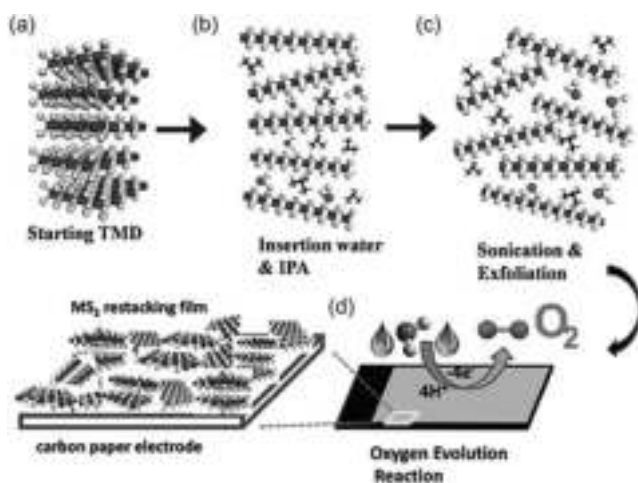
FIGURE 10.3 Schematic representation of step-by-step electrode fabrication process using exfoliated TMDs. (a) Starting TMD, (b) Insertion water and IPA, (c) Sonication and exfoliations, and (d) application for OER (Wu et al. 2016). Reprinted with permission from © 2016 John Wiley and Sons.

carbon, and graphitic carbon nitride (g-C_3N_4) layers can significantly reduce the interfacial resistance between the electroactive materials or the active sites and the current-carrying substrate. Additionally, as discussed in the case MXenes, the exfoliated 2D carbon layers are commonly used as a support for nanosized or atomic catalytic materials. MoS_2, Fe_3O_4, FeP, Ni_2P, CoP_2, CoO_x, NiO, etc. are some representative nanoparticles grown on 2D carbon materials for OER. Nevertheless, the long-term stability of carbon-based electrocatalysts is inferior to MXenes. Both MXenes and 2D carbon allotropes are mostly sought for OER and ORR in a basic medium.

Among the OER catalysts, layered double hydroxides (LDHs) are extensively studied as a potential replacement for noble metal catalysts due to their compositional and structural flexibility in addition to the simple preparation routes. Often LDHs adopt a formula either $M_x^{2+}M_{1-x}^{3+}(OH)_2\left(A^{n-}\right)_{\frac{x}{n}} \cdot yH_2O$ or $M_x^{1+}M_{1-x}^{4+}(OH)_2\left(A^{n-}\right)_{\frac{x}{n}} \cdot yH_2O$; where M is a metal and A is the intercalating anion. In LDHs, every single layer is composed of edge-sharing octahedral MO_6 moieties (M stands for metal) as shown in Figure 10.4. The color code used in the figure are: purple for metals, red for oxygen, and grey for inter-layer anions and water molecules. If d_1 is the inter-layer distance before intercalation, the inter-layer distance increases after intercalation to d_2 and $d_2 > d_1$. One can observe the change in interlayer spacing under an electron microscope and the subsequent change in the crystal structure from X-ray diffraction. The transition metal oxides (TMOs) with d-orbitals can effectively bind oxygen species on its surface, which is an essential requirement for OER/ORR catalyst. The substitution of elements in M^{2+} and M^{3+} sites can fine-tune the electronic as well as the catalytic properties of LDHs. Exfoliated LDHs formed by a combination of the transition metals, Ni-Co, Ni-Fe, Co-Fe, Co-Co, Ni-Mn, Co-Mn, etc. are some representative low overpotential electrocatalysts for OER in a basic medium among the non-noble metal catalysts.

Exfoliated layered perovskite with the general formula ABO_3 (A and B can be occupied by a large number of elements in the periodic table) and delafossite with the general formula AMO_2 is also studied as potential OER catalysts [20]. The above oxides with transition metals such as Co, Ni, and Fe at one of the sites are excellent OER catalysts. Such oxides are stable than the carbon-containing catalysts under oxidative environments and offer a competitive catalytic property comparable to noble metals.
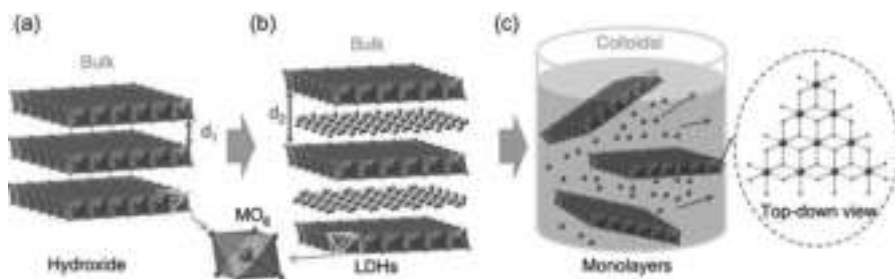
FIGURE 10.4 (a) Structure of layered hydroxides, (b) LDHs intercalated with a layer of anions and water molecules, and (c) exfoliated LDH monolayers in a colloidal solution (Song and Hu 2014). Reprinted with permission from © 2014 Springer Nature.

10.4   SUPERCAPACITORS

Supercapacitors bridge the gap between rechargeable batteries and conventional capacitors. But one of the major restrictions of supercapacitors is their lower energy density than the rechargeable batteries. There are several reported attempts to improve and enhance the energy density of supercapacitors. Supercapacitors mainly consist of electrodes, electrolytes, current collectors, sealants, and separators. The selection and design of the electrode materials have a major role in the overall performance of a supercapacitor as it determines the ionic conductivity, surface area, and chemical and thermal stability [21].

Supercapacitors are categorized mainly into two, based on their charge storage mechanism, one is electric double-layer (EDLC) or faradaic capacitor where energy is stored via non-Faradaic electrostatic interaction and the other one is pseudocapacitor where the energy storage is accomplished through Faradaic redox charge transfer reactions [22]. When 2D layered nanomaterials are used as electrodes in both Faradaic and non-Faradaic storage systems, the charge is mainly stored at the basal plane of the layered nanosheet, i.e., with the larger planar area. Additionally, the presence of active edge sites and the weak van der Waals gap between the nanosheet layers of 2D nanomaterials offer enhanced and suitable electrochemical performance in supercapacitors. Here in this section, the most commonly used exfoliated 2D nanosheets of both carbon-based and non-carbon-based are discussed in detail.

Graphene is one of the most common 2D layered carbon sheets with a hexagonal lattice structure, widely investigated for supercapacitor applications. The kinetics of an electrode material mainly depends on the transportation and diffusion of electrolyte ions. Due to the lack of enough edge planes and surface charges, monolayer graphene is considered one of the most chemically and electrochemically inert materials [23]. During the charge storage process, graphene acts as a superior active material as the electrolyte ions like Na^+, K^+, etc., can be stored electrostatically on the electrode. But the agglomeration of graphene nanosheets due to the strong van der Waals interaction limits the full utilization of graphene surface for ion adsorption. The agglomerated structure extremely limits the direct access to the charge-storage surfaces, which finally leads to the increase in ionic resistance at the electrode [24]. Higher agglomeration, hydrophobicity, and the random orientation of graphene nanosheets restrict the availability of ions on the active surface. Thus, the morphology of the electrode materials plays a vital role in the charge storage mechanism of supercapacitors.

Stoller et al. developed chemically modified graphene (CMG) electrodes with good electrical conductivity and a specific surface area of $705 \, m^2 g^{-1}$, by chemical functionalization of monolayer graphene. The CMG electrode materials exhibited a specific capacitance of 135 F g^{-1} in aqueous electrolyte (5.5 M KOH) and 99 F g^{-1} in the organic electrolyte [25]. Most reported graphene-derived electrode materials exhibited lower specific surface area than their theoretical value ($2,630 \, m^2 g^{-1}$). But the Ruoff group reported KOH-activated thermally exfoliated graphene oxide and microwave exfoliated graphene oxide (MEGO) electrode material, which exhibited an ultrahigh specific surface area value of $3,100 \, m^2 g^{-1}$, a high electrical conductivity (~500 S.m^{-1}), high content of sp^2-bonded carbon, and low hydrogen content. The KOH-activated MEGO electrode exhibited a notable high energy density (~70 Wh kg^{-1})

and power density (~ 250 kW kg^{-1}) at a current density of 5.7 A g^{-1} [26]. El-Kady et al. fabricated a graphene-based supercapacitor via laser irradiation of a graphene oxide film coated on a flexible substrate mounted in a LightScribe DVD optical drive. The graphene oxide sheets stacked in the film were reduced and exfoliated simultaneously upon laser irradiation and this structure restricts the agglomeration of graphene sheets and also the open pores in them facilitate the easy accessibility of electrolyte on the electrode surface. The resultant laser-scribed graphene sheets exhibited a high specific surface area of $1,520$ m^{2}g^{-1}, good mechanical flexibility, and high electrical conductivity ($1,738$ S.m^{-1}) [27]. Miller and his group fabricated supercapacitor electrodes using radio frequency plasma-enhanced chemical vapor deposition in which vertically oriented graphene nanosheets were deposited on a heated Ni-substrate. They showed a specific surface area of $\sim 1,100$ m^{2}g^{-1} and effective filtering of 120 Hz current with a resistance-capacitance time constant value less than 0.2 ms. With the exposed edge planes the vertically aligned graphene nanosheets showed enhanced charge storage as compared to the flat graphene nanosheets [28]. The exceptional properties and promising application of graphene in energy storage devices have triggered a remarkable interest in exploring other non-carbon 2D layered nanostructures with versatile properties.

Non-carbon-based 2D layered nanomaterials have been considered as a potential candidate for supercapacitor electrodes owing to their unique physical and chemical properties such as high electronic conductivity, tunable surface chemistry, more surface-active sites, dual non-faradaic and faradaic electrochemical performances, and larger mechanical strength. 2D non-CNSs include TMDs (MoS_2, WS_2, TiS_2, ZrS_2, $MoSe_2$, WSe_2, etc.), layered metal-oxides, hexagonal boron nitride (h-BN), LDHs, graphitic carbon nitride (g-C_3N_4), and MXenes (Ti_3C_2, V_2C, Ti_2AlC, $TiAlC$, Ti_3CN) [29]. Among TMDs, 2D MoS_2 nanosheets are a potential supercapacitor electrode material that exhibits large electrical double layer capacitance (EDLC) owing to their stacked sheet-like structure, and large pseudocapacitance due to the different Mo oxidation states (+2 to +6). Tour and his co-workers developed vertically aligned/edge-oriented MoS_2 nanosheets that offer a high capacitive property with more van der Waals gaps and rendered reactive dangling bonds sites for the electrolyte ions. Areal Capacitance of 12.5 mF cm^{-2} was obtained for sponge-like vertically aligned MoS_2 electrodes [30]. Layered 2D TMOs exhibit exceptionally high surface area and high conductivity as they are capable of holding charged ions on their surface without intermixing. Supercapacitors based on layered TMOs feature superior cyclic stability, high energy density, and high discharge currents. Commonly used 2D layered TMOs include MnO_2, NiO, Co_3O_4, and RuO_2. MnO_2 possesses low conductivity and thus they require a conductive matrix of graphene or metal foam. Peng et al. fabricated a supercapacitor electrode integrating 2D graphene and 2D MnO_2 into a planar capacitor design that was highly flexible [31].

2D LDH sheets are a class of multi-metal clay materials that consist of metal cations brucite layers octahedrally surrounded by hydroxyls forming $M^{2+}(OH)_6$/M^{3+}/$M^{4+}(OH)_6$ octahedra. Their high redox activities can be attributed to their unique properties like cations, easy tenability in their host layers and they are capable of exchanging anions without disturbing the structure. In NiAl-LDH, its electrochemical

property is due to a mixed mechanism comprising of 'electron hopping' along with the layers of LDH and the migration of protons from the host layer to the solution [32]. MXenes have become a widely accepted supercapacitor electrode material with their impressive electrochemical properties due to their unique 2D structure and well-defined geometry. MXenes are one of the fast-growing materials among 2D materials, which include metal carbides, nitrides, and carbonitrides. One of the promising features of MXene is the exceptionally large interlayer spacing, which helps in the de/intercalation of ions like Na^+, Li^+, etc. Mainly hydrogen bonding and van der Waals bonding interactions act between the MXene layers. To produce MXene single flake suspensions, water, cations, tetrabutylammonium hydroxide (TBAOH), dimethylsulfoxide (DMSO), etc. are intercalated into the MXene interlayer spacing followed by the sonication process. In the H_2SO_4 electrolyte, $Ti_3C_2T_x$ shows a high volumetric capacitance of ~1,500 F cm^{-3} (380 F g^{-1}), and the conductive, transparent $Ti_3C_2T_x$ films are used to fabricate solid-state transparent supercapacitors [33].

10.5   LITHIUM-ION BATTERY

Lithium-ion batteries (LIBs) are the answer to many of the energy storage-related challenges. LIBs become an essential part of everyday life. LIBs work by the rocking chair mechanism wherein the lithium ions are moved between the anodes and cathodes. The electrodes play an important role in storing the lithium ions by the intercalation and deintercalation reactions. Historically, layered materials have played an important role in the development of LIBs by allowing the layered structures of the electrodes like graphite to intercalate lithium ions. Currently, LIBs use a wide variety of electrodes having mechanisms such as insertion, alloying, and conversion reactions [34]. Electrodes with higher rate capability, higher charge capacity, and (for cathodes) sufficiently high voltage can improve the energy and power densities of Li batteries and make them smaller and cheaper. The fast-paced life around the globe is forcing researchers to focus on materials that can be charged faster and hold more energy per volume and weight. Layered materials are often helpful in achieving faster lithium-ion diffusion and have a higher capacitive contribution. Owing to compelling electrochemical and mechanical properties, exfoliated 2D nanomaterials have been propelled to the forefront in investigations of electrode materials in recent years.

Exfoliated 2D nanomaterials are exceedingly desirable as anodes and cathodes. As anodes, the famous candidates are graphene and graphene-based composite materials, including carbon nanotubes/graphene, nonmetal/graphene, TMOs/graphene, sulfide/graphene, and salts/graphene. As cathodes, exfoliated 2D nanomaterials have remarkable electron transport velocity, high theoretical capacity, and excellent structural stability. The exfoliation of bulk material and Li^+ insertion was represented in Figure 10.5, which shows easier paths for lithium-ion storage.

Graphite is the most traditionally used anode in LIBs, which is a layered material. Expansion and exfoliation of the graphite are well reported by various researchers. Graphite as such shows a theoretical capacity of 372 mAh g^{-1}. Due to good electrical conductivity, high surface area, and greater mechanical flexibility, graphite exfoliation has attracted the most attention for fabricating high-performance electrode material for LIB. Lithium may bond both graphene sheet sides as well as edges and
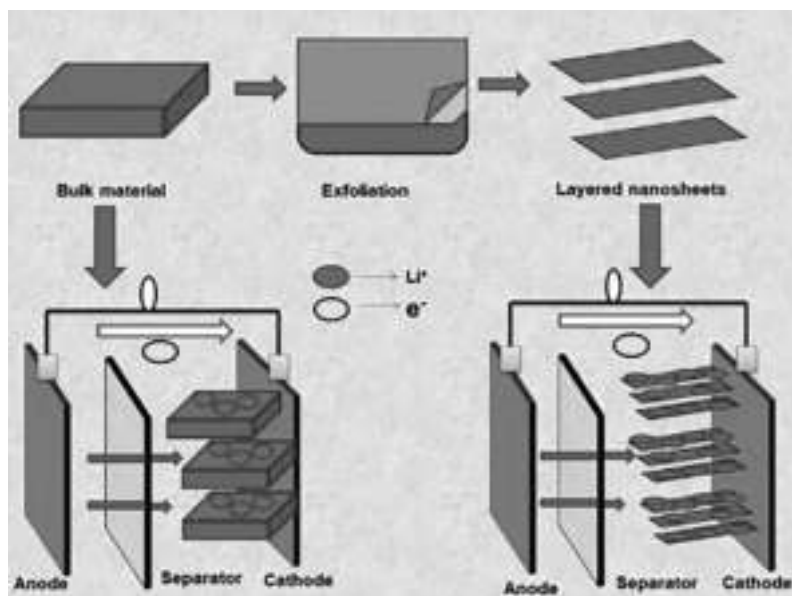
FIGURE 10.5 Sketch of the exfoliated layered material as a cathode for Li$^+$ insertion in LIBs.

covalent sites. Recent studies demonstrated that the small lateral sizes of narrow graphene nano-ribbons can accommodate Li$^+$ ions at the edges sites more efficiently than basal sites, thus leading to maximum Li-storage in the form of Li$_4$C$_6$. The probable defects formed during the exfoliation process become an advantage in such cases. Apart from this, graphene nanosheets are widely used to make composites with other electrode materials. In materials like silicon, graphene sheets are also used to give cushioning effect to accommodate the high volume change during the lithium uptake.

Exfoliated carbons are trustable electrodes for lithium battery electrodes but lack high capacity, which restricts the overall capacity of the batteries. Exfoliated 2D group V nano-crystals have a greater theoretical capacity than graphite. Exfoliation of these metallic electrodes is challenging because of the stability issues. Among them, layered 2D antimony has the potential as electrode material for LIBs, owing to their large interlayer distance in their layered structure, high capacity, long mean free path, and environmental friendliness. The theoretical capacity of antimony is moderate therefore other 2D materials are also explored as LIB electrodes. The layered transition metal oxides (LTMOs) require a special mention in LIBs. The exceptional feature of these materials is the presence of an interlayer region that serves as the host for ion intercalation. The extensive interlayer spacing and weak interlayer bonding of LTMOs permit the intercalation of an enormous variety of guest species, like cations, polymers, and anions. LTMO has excellent electronic and ionic conductivity, the attainability of interlayer sites for the intercalation of cations from the electrolyte, and the ability to undergo redox reaction property for high energy density LIB. Several mechanisms are possible when LTMO is in contact with an electrolyte like intercalation, conversion, double layer capacitance, conversion, and pseudocapacitance [35].

2D TMDs consist of greater specific capacity and larger interlayer spacing, which permit a quick Li^+ insertion/extraction process without persuading noteworthy volume changes [36]. Exfoliated layers of chalcogenides such as MoS_2, $NbSe_2$, WS_2, $MoSe_2$, $TaSe_2$, and $MoTe_2$ nanosheets are widely used for the LIB. Among them, MoS_2 is an exciting electrode material for LIBs due to its high theoretical capacity. MoS_2 nanolayers allow intercalation of Li^+ ions into the structure without noteworthy volume change and charging and discharging prevent the disintegration of active material. Based on the reaction $MoS_2 + 4Li^+ + 4e^- \leftrightarrow 2Li_2S + Mo$, the electrochemical reaction of Li with MoS_2 involves 4 moles of Li per mole of MoS_2. The main concern of MoS_2 layered nanomaterial is low electronic conductivity and poor cyclic stability [37].

Another class of materials that is gaining recent attention is MXenes, which possess 2D layered structure. The main advantage of MXene as electrode material for the energy storage device is the separation between MXene layers that can be controlled systematically. MXenes usage as anode for LIBs was first reported by Naguib et al. [38]. The MXenes prepared by Naguib showed improved surface area by ~10-fold as compared with graphene since MXenes exhibit improved specific capacity. Layered morphology of the electrodes always had a positive impact on LIBs by facilitating the rocking chair mechanism. Fast charging and higher capacities are repeatedly reported as a result of exfoliation. Structural changes during the exfoliation are usually acting in favor of the intercalation of more lithium ions to the electrodes. Therefore, exfoliated 2D materials are going to have a large impact on the future development of LIBs.

10.6 CONCLUSIONS

Exfoliated 2D nanosheets have gained considerable attention from the research community in recent years. The development of various 2D nanosheets of different origins allows the researchers to resolve numerous bottlenecks associated with many electrochemical devices, especially in sensors, fuels cells, supercapacitors, and batteries. Though exfoliation is a top-down approach, it can produce reasonably good quality nanosheets in large quantities, which is essential for device fabrication at a large scale. Interestingly the defects generated during exfoliation favor electrochemical activity than the ones prepared by chemical vapor deposition with fewer defects. The exfoliated 2D materials are expected to play an important role in the further advancements in electrochemical devices in the coming years.

REFERENCES

1. Guo B., Xiao Q., Wang S., Zhang H. (2019) 2D layered materials: Synthesis, nonlinear optical properties, and device applications. *Laser Photon Rev* 13:1800327.
2. Alzakia F.I., Tan S.C. (2021) Liquid-exfoliated 2D materials for optoelectronic applications. *Adv Sci* 8:2003864.
3. Zhou Y., Pondick J.V., Silva J.L., Woods J.M., Hynek D.J., Matthews G., Shen X., Feng Q., Liu W., Lu Z., Liang Z., Brena B., Cai Z., Wu M., Jiao L., Hu S., Wang H., Araujo C.M., Cha J.J. (2019) Unveiling the interfacial effects for enhanced hydrogen evolution reaction on MoS_2/WTe_2 hybrid structures. *Small* 15:1900078.
4. Anasori B., Lukatskaya M.R., Gogotsi Y. (2017) 2D metal carbides and nitrides (MXenes) for energy storage. *Nat Rev Mater* 22(2):1–17.

5. Kumar S., Pavelyev V., Mishra P., Tripathi N., Sharma P., Calle F. (2020) A review on 2D transition metal di-chalcogenides and metal oxide nanostructures based NO_2 gas sensors. *Mater Sci Semicond Process* 107:104865.

6. Huo C., Yan Z., Song X., Zeng H. (2015) 2D materials via liquid exfoliation: A review on fabrication and applications. *Sci Bull* 60:1994–2008.

7. Ndlovu T., Arotiba O.A., Sampath S., Krause R.W., Mamba B.B. (2012) An exfoliated graphite-based bisphenol a electrochemical sensor. *Sensors* 12:11601–11611.

8. Sreejesh M., Huang N.M., Nagaraja H.S. (2015) Solar exfoliated graphene and its application in supercapacitors and electrochemical H_2O_2 sensing. *Electrochim Acta* 160:94–99.

9. Aswathi R., Sandhya K.Y. (2018) Ultrasensitive and selective electrochemical sensing of Hg(II) ions in normal and sea water using solvent exfoliated MoS_2: Affinity matters. *J Mater Chem A* 6:14602–14613.

10. Moolayadukkam S., Thomas S., Sahoo R.C., Lee C.H., Lee S.U., Matte H.S.S.R. (2020) Role of transition metals in layered double hydroxides for differentiating the oxygen evolution and nonenzymatic glucose sensing. *ACS Appl Mater Interfaces* 12:6193–6204.

11. Sahoo R.C., Moolayadukkam S., Thomas S., Asle Zaeem M., Matte H.S.S.R. (2021) Solution processed Ni_2Co layered double hydroxides for high performance electrochemical sensors. *Appl Surf Sci* 541:148270.

12. Kesavan G., Chen S.M. (2020) Sonochemically exfoliated graphitic-carbon nitride for the electrochemical detection of flutamide in environmental samples. *Diam Relat Mater* 108:107975.

13. Strmcnik D., Lopes P.P., Genorio B., Stamenkovic V.R., Markovic N.M. (2016) Design principles for hydrogen evolution reaction catalyst materials. *Nano Energy* 29:29–36.

14. Di J., Yan C., Handoko A.D., Seh Z.W., Li H., Liu Z. (2018) Ultrathin two-dimensional materials for photo- and electrocatalytic hydrogen evolution. *Mater Today* 21:749–770.

15. Gao M.-R., Chan M.K.Y., Sun Y. (2015) Edge-terminated molybdenum disulfide with a 9.4-Åinterlayer spacing for electrochemical hydrogen production. *Nat Commun* 6:1–8.

16. Chua X.J., Luxa J., Eng A.Y.S., Tan S.M., Sofer Z., Pumera M. (2016) Negative electro-catalytic effects of p-doping niobium and tantalum on MoS_2 and WS_2 for the hydrogen evolution reaction and oxygen reduction reaction. *ACS Catal* 6:5724–5734.

17. Handoko A.D., Fredrickson K.D., Anasori B., Convey K.W., Johnson L.R., Gogotsi Y., Vojvodic A., Seh Z.W. (2017) Tuning the basal plane functionalization of two-dimensional metal carbides (MXenes) to control hydrogen evolution activity. *ACS Appl Energy Mater* 1:173–180.

18. Li P., Zhu J., Handoko A.D., Zhang R., Wang H., Legut D., Wen X., Fu Z., Seh Z.W., Zhang Q. (2018) High-throughput theoretical optimization of the hydrogen evolution reaction on MXenes by transition metal modification. *J Mater Chem A* 6:4271–4278.

19. Hemanth N.R., Kim T., Kim B., Jadhav A.H., Lee K., Chaudhari N.K. (2021) Transition metal dichalcogenide-decorated MXenes: Promising hybrid electrodes for energy storage and conversion applications. *Mater Chem Front* 5:3298–3321.

20. George G., Ede S.R., Luo Z. (Professor of materials science) (2020) *Fundamentals of Perovskite Oxides: Synthesis, Structure, Properties and Applications*. CRC Press, Boca Raton, FL.

21. Forouzandeh P., Pillai S.C. (2021) Two-dimensional (2D) electrode materials for supercapacitors. *Mater Today Proc* 41:498–505.

22. Gholamvand Z., McAteer D., Harvey A., Backes C., Coleman J.N. (2016) Electrochemical applications of two-dimensional nanosheets: The effect of nanosheet length and thickness. *Chem Mater* 28:2641–2651.

23. Huang X., Zeng Z., Fan Z., Liu J., Zhang H. (2012) Graphene-based electrodes. *Adv Mater* 24:5979–6004.

24. Dong Y., Wu Z.S., Ren W., Cheng H.M., Bao X. (2017) Graphene: A promising 2D material for electrochemical energy storage. *Sci Bull* 62:724–740.

25. Stoller M.D., Park S., Zhu Y., An J., Ruoff R.S. (2008) Graphene-based ultracapacitors. *Nano Lett* 8:3498–3502.

26. Zhu Y., Murali S., Stoller M.D., Ganesh K.J., Cai W., Ferreira P.J., Pirkle A., Wallace R.M., Cychosz K.A., Thommes M., Su D., Stach E.A., Ruoff R.S. (2011) Carbon-based supercapacitors produced by activation of graphene. *Science* 332:1537–1541.

27. El-Kady M.F., Strong V., Dubin S., Kaner R.B. (2012) Laser scribing of high-performance and flexible graphene-based electrochemical capacitors. *Science* 335:1326–1330.

28. Miller J.R., Outlaw R.A., Holloway B.C. (2010) Graphene double-layer capacitor with ac line-filtering performance. *Science* 329:1637–1639.

29. Yang Y., Hou H., Zou G., Shi W., Shuai H., Li J., Ji X. (2018) Electrochemical exfoliation of graphene-like two-dimensional nanomaterials. *Nanoscale* 11:16–33.

30. Yang Y., Fei H., Ruan G., Xiang C., Tour J.M. (2014) Edge-oriented MoS_2 nanoporous films as flexible electrodes for hydrogen evolution reactions and supercapacitor devices. *Adv Mater* 26:8163–8168.

31. Peng L., Peng X., Liu B., Wu C., Xie Y., Yu G. (2013) Ultrathin two-dimensional MnO_2/Graphene hybrid nanostructures for high-performance, flexible planar supercapacitors. *Nano Lett* 13:2151–2157.

32. Li X., Du D., Zhang Y., Xing W., Xue Q., Yan Z. (2017) Layered double hydroxides toward high-performance supercapacitors. *J Mater Chem A* 5:15460–15485.

33. Hu M., Zhang H., Hu T., Fan B., Wang X., Li Z. (2020) Emerging 2D MXenes for supercapacitors: Status, challenges and prospects. *Chem Soc Rev* 49:6666–6693.

34. Pender J.P., Jha G., Youn D.H., Ziegler J.M., Andoni I., Choi E.J., Heller A., Dunn B.S., Weiss P.S., Penner R.M., Mullins C.B. (2020) Electrode degradation in lithium-ion batteries. *ACS Nano* 14:1243–1295.

35. Augustyn V. (2017) Tuning the interlayer of transition metal oxides for electrochemical energy storage. *J Mater Res* 32:2–15.

36. Wu S., Du Y., Sun S. (2017) Transition metal dichalcogenide based nanomaterials for rechargeable batteries. *Chem Eng J* 307:189–207.

37. Choi W., Choudhary N., Han G.H., Park J., Akinwande D., Lee Y.H. (2017) Recent development of two-dimensional transition metal dichalcogenides and their applications. *Mater Today* 20:116–130.

38. Naguib M., Mochalin V.N., Barsoum M.W., Gogotsi Y. (2014) 25th anniversary article: MXenes: A new family of two-dimensional materials. *Adv Mater* 26:992–1005.

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Published in: 2022 International Conference on Computing, Communication, Security and Intelligent Systems (IC3SIS)

Date of Conference: 23-25 June 2022

INSPEC Accession Number: 22090455

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I. Introduction
Personality refers to an individual's distinctive patterns of thoughts, feelings, and behaviours.
Personality tests can cover a wide range of topics. It can be to figure out what your talents,
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DOI: 10.1109/IC3SIS54991.2022.9885693

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I. Introduction

Today, recording someone's presence through their attendance is crucial for every organization. Being present in an organization is evidence that a person is honoring their commitment to that agency or organization. Attendance is typically taken by hand. It may be signed or referred to individually. To be able to accelerate and give time efficiency in this digital age, a change from this lack is necessary. Face recognition allows us to keep track of attendance for every person present in a company.

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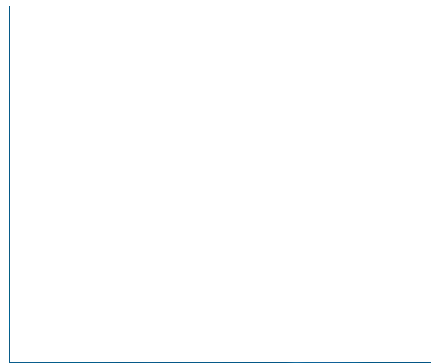
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This paper draws up a summary of the different approaches to sentence similarity methods. Sentence similarity has a important place in different applications of natural language processing. Plagiarism check, question answering, information retrieval, text summarization, text classification are some of the natural language processes where sentence similarity finds its applications. The existing works on text similarity have been discussed by approaching through 3 methods: String-based, Knowledge-based, and Corpus-based similarity. Relatedness between short texts is measured by each approach based on a specific perspective. Moreover, the introduction of datasets that are mostly used as benchmarks for the evaluation of techniques in this field provides an absolute view on this issue. Better results are obtained when approaches that combine more than one perspective are used.

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I. Introduction

Amidst the evolution of the digital world, the internet has become the ultimate information hub. New data keeps getting added on a regular account. Moreover, the addition of all human languages and the digitalization of all data calls for the need for sentence similarity.

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Speech emotion popularity is one of the quite promising and thrilling issues in the area of human computer interaction. It has been studied and analysed over several decades. It's miles the technique of classifying or identifying emotions embedded inside the speech signal.Current challenges related to the speech emotion recognition when a single estimator is used is difficult to build and train using HMM and neural networks,Low detection accuracy,High computational power and time.In this work we executed emotion category on corpora — the berlin emodb, and the ryerson audio-visible database of emotional speech and track (Ravdess). A mixture of spectral capabilities was extracted from them which changed into further processed and reduced to the specified function set. When compared to single estimators, ensemble learning has been shown to provide superior overall performance. We endorse a bagged ensemble model which consist of support vector machines with a gaussian kernel as a possible set of rules for the hassle handy. Inside the paper, ensemble studying algorithms constitute a dominant and state-of-the-art approach for acquiring maximum overall performance.

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I. Introduction

Speech is a very natural way for humans to express themselves. As a result, it's only logical for you to extend this communication to computer programs. Speech recognition systems (SER) are a set of processes that operate together to classify and detect embedded emotions in audio files. The SER has been attracting attention for more than two decades. These unique studies make use of improvements in all areas of computer and technology, necessitating the need to update the current methodologies and procedures that enable the SER.

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Global cybersecurity threats have grown as a result of the evolving digital transformation. Cybercriminals have more opportunities as a result of digitization. Initially, cyberthreats take the form of phishing in order to gain confidential user credentials.As cyber-attacks get more sophisticated and sophisticated, the cybersecurity industry is faced with the problem of utilising cutting-edge technology and techniques to combat the ever-present hostile threats. Hackers use phishing to persuade customers to grant them access to a company's digital assets and networks. As technology progressed, phishing attempts became more sophisticated, necessitating the development of tools to detect phishing.Machine learning is unsupervised one of the most powerful weapons in the fight against terrorist threats. The features used for phishing detection, as well as the approaches employed with machine learning, are discussed in this study.In this light, the study's major goal is to propose a unique, robust ensemble machine learning model architecture that gives the highest prediction accuracy with the lowest error rate, while also recommending a few alternative robust machine learning models.Finally, the Random forest algorithm attained a maximum accuracy of 96.454 percent. But by implementing a hybrid model including the 3 classifiers- Decision Trees,Random forest, Gradient boosting classifiers, the accuracy increases to 98.4 percent.

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I. Introduction

Since approximately a decade, internet usage has exploded, and consumers have utilised it to find and fulfil a variety of needs such as communication, shopping, money transactions, and more by using the web instead of time-consuming traditional methods [1]. The internet facilitates a variety of activities and makes life easier. Despite this, it has flaws and flaws of its own. Cybercriminals take use of the internet's flaws and exploit them to scam unsuspecting users [2]. In a recent work [3] an adaptive time-based approach was proposed for predicting the possibility of harmful assaults with great accuracy by hackers to obtain sensitive information such as account credentials, bank account information, and even social networking information by fooling and misleading the user into paying into the hacker's account, among other things. Every year, Internet users lose billions of dollars due to phishing.Phishing is one of the most known threats on gullible people, in which their private details is revealed through bogus websites. These URLs are used to pilfer the sensitive information of the users like banking and credit card details, and passwords.Those websites that look akin to those of actual websites are the ones used by the phishers. Phishing is one of the most important online security concerns. The Internet has evolved into a critical infrastructure that provides enormous benefits to human society. However, there are many issues with Internet security, such as phishing, malicious software, and data leakage, which have already affected users' finances severely.To get beyond anti-phishing software and approaches, phishers use new and hybrid techniques.Phishing is a criminal activity that uses social engineering and technical deception to obtain a consumer's personal information and bank account credentials.It is defined by the Anti-Phishing Working Group (APWG) as the act of obtaining consumers' financial and personal information through deception such as fraud.[1]. Cyberattacks such as phishing are common strategies used to hack into networks, steal information, and damage property. According to Kaspersky Lab statistics, over the course of the year, 29.4 percent of user computers were exposed to at least one Malware-class web assault, and web antivirus components identified 199 455 606 distinct URLs as malicious [2]. In addition, the percentage of financial phishing detections grew from 47.5 percent to nearly 54 percent in 2017 [2]. Phishing has evolved into one of the most serious Internet security risks. The most unsafe criminal exercise in cyberspace is Phishing. Phishing comes under social engineering, which uses email or malicious websites to trick people for stealing their personal information.The phishers attack the vulnerable users by sending the fake email, which appears to come from a legitimate organization, asking to enter personal credentials like online banking details, login details and other sensitive personal data.These malicious website imitates their legitimate websites reassuring the users. Phishing messages mostly propagate over instant messengers, email, VoIP, social networking sites,short message service and so forth[2]. When users respond to these messages, they get easily trapped by the perpetrator.To prevent phishing attacks, many researches are done by different communities around the world. Some prevention methods include detecting the fake websites by implementing machine learning algorithms such as Logistic Regression, Linear Regression, SVM(support vector machine), KNN, Naive Bayes, Random Forest, K-Means and providing awareness workshops to pinpoint legitimate websites[3].

Authors

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This paper investigates the performance of non-orthogonal multiple access (NOMA) based hybrid satellite-unmanned aerial vehicle (UAV) systems, where a low Earth orbit (LEO) satellite communicates with the ground users via a decode and forward (DF) UAV relay. We investigate a two NOMA users system, where a far user (FU) and a near user (NU) are served by the UAV which is located at a certain height above the origin of the coverage circle. The channel between satellite and UAV is assumed to follow a Shadowed-Rician fading and the channels between UAV and users are assumed to follow a Nakagami-m fading. New closed-form expressions of the outage probabilities for the two users and the system are derived. Different from other work in literature, we take into consideration different parameters affecting the total link budget. Additionally, we propose an algorithm for minimizing the system outage probability. The mathematical analysis is verified by extensive representative Monte-Carlo (MC) simulations. Finally, simulations are provided to demonstrate the impact of important parameters on the considered system as well as the superiority of the NOMA scheme the over reference scheme.

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I. Introduction
Recently, satellite communication (SatCom) has withdrawn an increasing research interest due to the several advantages offering over conventional terrestrial communication such as wide coverage area, covering harsh and isolated geographical regions where conventional wired or wireless communication can't reach including maritime, deserts, and jungles. Moreover, SatCom serves well in disaster areas where the terrestrial networks are compromised. Additionally, SatCom can provide a wide range of flexible applications in the field of navigation, TV and Radio broadcasting services, Weather prediction and climate monitoring, Internet access, and satellite telephony [1]. On the other hand, SatCom networks face several challenges including operation cost [2], propagation delay [3], and signal degradation due to rain and atmospheric disturbances. Additionally, antenna-pointing errors angle caused by satellite perturbation or the user's mobility may lead to communication outage [4]. Furthermore, the line-of-sight (LOS) link may be blocked by heavy shadowing or obstacles that retard communication between the satellite and terrestrial users [5]. To combat such issues, hybrid satellite-terrestrial networks (HSTNs) based on relaying have been proposed in many literature [2], [5]– [7] to increase efficiency, and enhance the performance of the user whose direct link is unavailable or deteriorated. Satellites can be stationed in a variety of orbits including Low Earth orbit (LEO), medium Earth orbit (MEO), highly elliptical orbit (HEO), and geosynchronous orbit (GEO) [8]. Recently, LEO satellites constellation networks have withdrawn a great interest due to their small propagation delay, high data rate, and lower transmit power [9]. Consequently, we consider a LEO satellite setup in this work.

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RESEARCH-ARTICLE

Multi-Domain Network Traffic Analysis using Machine Learning and Deep Learning Techniques

Authors: Dincy Arikkat, Rafidha Rehiman K A, Vinod, Suleiman Y. Yerima, Manoja, Pooja, Shilpa Sekhar, Sohan James, Josna Philomina Authors Info & Claims

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ABSTRACT

Recent heterogeneous computing facilities and data explosion introduce challenges in network traffic analysis and demand intelligence-based approaches to ensure cyber security and the protection of online digital services. Researchers have been proposing various machine and deep learning approaches for network traffic analysis in different problem domains. However, it is also crucial to understand how these algorithms perform across the different domains. Hence in this research work we extend an analysis of diverse machine learning and deep learning techniques across three different problem domains: DDoS attack detection, Malicious URL detection and Tor traffic classification. We ... models for both multi-class and binary classification in our comparative study. Our experiments show ... andom Forest achieved superior performance compared to other machine learning models with

measure of 89% and 100% for multi-class and binary problems respectively.

References

1. Mahmoud Abbasi, Amin Shahraki, and Amir Taherkordi. 2021. Deep learning for network traffic monitoring and analysis (NTMA): a survey. Computer Communications 170 (2021), 19–41.

2. Amirah Alshammari and Abdulaziz Aldribi. 2021. Apply machine learning techniques to detect malicious network traffic in cloud computing. Journal of Big Data 8, 1 (2021), 1–24.

3. Ons Aouedi, Kandaraj Piamrat, Salima Hamma, and JK Perera. 2022. Network Traffic Analysis using Machine Learning: an unsupervised approach to understand and slice your network. Annals of Telecommunications 77, 5 (2022), 297–309.

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Towards energy-efficient UAV-assisted 5G internet of underwater things

Authors: Sandeep Verma, Shahbaz Akhtar, Aneek Adhya, Varun G Menon Authors Info & Claims

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ABSTRACT

Adhering to the requirements of Fifth Generation (5G) communication for seamless data gathering, especially from underwater resources, Unmanned Aerial Vehicles (UAVs)-assisted 5G Internet of Underwater Things (IoUT) have been leaving an everlasting impression. However, the resource-constrained underwater sensor nodes limit the potential of IoUT for reliable data dissemination due to their shorter operational period. To extenuate this concern, in this paper we present an Energy-Efficient Unmanned Aerial Vehicle (UAV)-assisted Routing Architecture (EEURA) for 5G IoUT. The Cluster Head (CH) is selected using Improved-Tunicate Swarm Algorithm (I-TSA). We use Energy-Harvesting (EH)-

...sively better than the state-of-the-art routing methods in IoUT.

1. Kamalika Bhattacharjya, Sahabul Alam, and Debashis De. 2019. CUWSN: energy efficient routing protocol selection for cluster based underwater wireless sensor network. *Microsystem Technologies* (2019), 1--17.

2. Lalit Chettri and Rabindranath Bera. 2020. A Comprehensive Survey on Internet of Things (IoT) Toward 5G Wireless Systems. *IEEE Internet of Things Journal* 7, 1 (2020), 16--32.

3. Amrita Datta and Mou Dasgupta. 2022. Energy Efficient Layered Cluster Head Rotation Based Routing Protocol for Underwater Wireless Sensor Networks. *Wireless Personal Communications* (2022), 1--18.

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Smartphones include multiple sensors to track a device's movement. This research investigated the capability of smartphone motion sensors to determine the user's gender and age in different contexts. A subject's context is an action they engage in, such as sitting or standing. This paper is based on the differences in behavior between male and female smartphone users, precisely, how they hold and manage their devices. To build our approach, we use the MotionSense Dataset. This dataset contains data from accelerometer and gyroscope sensors over time (attitude, gravity, acceleration, and rotationRate). In this study, we consider multiple contexts such as walking, sitting, standing, and jogging. Our method proposes to use smartphone sensors to detect an individual's age and gender with an accuracy of 99.89% if they are seated.

Published in: 2022 International Conference on Computing, Communication, Security and Intelligent Systems (IC3SIS)

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I. Introduction

Smartphones today are multi functional, with the majority of functions being utilized for a variety of reasons. Our daily lives have become heavily dependent on smartphones. But they are particularly vulnerable to being lost, stolen, or easily accessible by non-owners due to their size. Once an intruder has physical access to a device, he or she may be able to mimic the device's original owner for financial or non-monetary gain and mischief. Most modern smartphones feature built-in sensors that can detect motion as well as the ambient and positional conditions in which they are used.

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Underwater Image Enhancement Using Fusion Stretch Method

Litty Koshy ✉ & Shwetha Mary Jacob

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Abstract

Underwater image enhancement is an effective method for improving the captured underwater images that have been damaged owing to medium dispersion and absorption. Based on the principles of fusion, this method derives the inputs and the weight maps from the image's degraded version. Two inputs representing color-corrected and contrast-enhanced versions of the original underwater image and three weight maps that seek to increase the visibility of degraded objects due to

the medium dispersion and absorption are specified here to overcome the limitations of the underwater medium. This method is a single image approach that does not need specialized hardware or underwater conditions or scene expertise. In order to facilitate the transfer of edges and color contrast to the output image, the two fusion images, as well as their associated weight maps, are identified. The detailed qualitative and quantitative assessment show that the enhanced images are distinguished by improved illumination of the dark areas, enhanced global contrast, and sharpness of the edges.

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1. Dalgleish FR, Caimi FM, Kocak DM, Schechner YY (2008) A focus on recent developments and trends in underwater imaging. Marine Technol Soc 42(1):52–67

2. Foresti GL (2001) Visual inspection of sea bottom structures by an au- tonomous underwater vehicle. IEEE Trans Syst Man Cybern B Cybern 31(5):691–705

3. Cavallaro A, Li CY, Mazzon R (2018) An online platform for underwater image quality evaluation. Centre for Intelligent Sensing, Queen Mary University of London

4. Ancuti CO, Ancuti C, De Vleeschouwer C, Bekaert P (2018) Color balance and Fusion for underwater image enhancement. IEEE Trans Image Process 27

5. He D-M, Seet GGL (2004) Divergent-beam lidar imaging in turbid water. Opt Lasers Eng 41:217–231

6. Vaish V, Horowitz M, McDowall I, Levoy M, Chen B, Bolas B (2004) Synthetic aperture confocal imaging. In: Proceedings of ACM SIGGRAPH, pp 825–834

7. Fattal R (2008) Single image dehazing. ACM Trans Graph SIGGRAPH 27(3):72

8. Schechner YY, Averbuch Y (2007) Regularized image recovery in scattering media. IEEE Trans Pattern Anal Mach Intell 29(9):1655–1660

9. Kopf J et al (2008) Deep photo: model-based photograph enhancement and viewing. ACM Trans Graph 27,Art. no. 116

10. Ancuti CO, Ancuti C (2013) Single image Dehazing by multi-scale fusion. IEEE Trans Image Process 22(8):3271–3282

11. Fattal R (2008) Single image dehazing. Proc ACM SIGGRAPH, Art. no. 72

12. Sun J, He K, Tang X (2011) Single image haze removal using dark channel prior. IEEE Trans Pattern Anal Mach Intell 33(12):2341–2353

13. Sun J, He K, Tang X (2009) Single image haze removal using dark channel prior. In: Proceedings of IEEE CVPR, pp 1956–1963

14. Haber T, Ancuti C, Orniana C, EDM Belgium Philippe Bekaert, Hasselt University tUL IBBT, Enhancing underwater images and videos by fusion. Conference paper.

15. Manisrinivas S, Anilkumar D, Hemanth B, Santosh Kumar NT, Poojitha V, Under water image enhancement by fusion. Int J Mod Eng Res (IJMER)

16. Bhandari YS, Negi SS (2014) A hybrid approach to image enhancement using contrast stretching on image sharpening and the analysis of various cases arising using histogram. In: IEEE, International conference on recent advances and innovations in engineering (ICRAIE-2014), September 2014

17. Williams GP, Grundland M, Vohra R, Dodgson NA (2006) Cross dissolve without cross fade: Preserving contrast, color and salience in image compositing. Comput Graph Forum 25(3):577–586

18. Mason JL, Bennett EP, McMillan L (2007) Multispectral bilateral video fusion. IEEE Trans Image Process 16(5):1185–1194

19. Kautz J, Mertens T, Van Reeth F (2009) Exposure fusion: a simple and practical alternative to high dynamic range photography. Comput Graph Forum 28(1):161–171

20. Simo M, Ortiz A, Oliver G (2002) A vision system for an underwater cable tracker. Mach Vis Appl 13:129–140

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Pneumonia is serious infection that affects the air sacs in our lungs of our body. Air sacs plays a vital role in the procedure of our breathing process. When the lungs are infected by bacterial or viral infection these air sacs will get filled with pus or fluid. As a result, this infection causes fever, cough and leads to a serious medical condition called pneumonia. The severity of this infection can range from mild to severe. It goes to a life-threatening situation in case of infants, young children and old aged people. The doctors use chest X-rays for the confirmation infection. Analyzing the chest x-rays for the detection of pneumonia infection by the doctors visually by naked eyes is time consuming process. Computer aided diagnosis helps the doctors for the faster and accurate detection of Pneumonia infection on chest X-rays. Computer aided diagnosis uses the CNN models for the confirmation of pneumonia which have achieved better performance than humanbeings

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Neenu Sebastian
Department of Computer Science and Engineering, Sathyabama Institute of Science & Technology, Deemed to be University, Chennai

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Department of Computer Science and Engineering, Sathyabama Institute of Science & Technology, Deemed to be University, Chennai

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I. Introduction

Pneumonia is a serious respiratory inflammation that affects our respiratory organ lungs. This infection may affect one or both the lungs. The lung consists of small sacs called as alveoli. During the breathing process the sealveoli will be filled with air. These sacs will be filled with pus or fluid which leads to severe infection. As a result of infection, the breathing process becomes painful and also it affects the oxygen intake of theperson.

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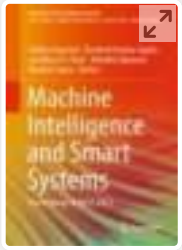
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Date of Conference: 23-25 June 2022

Date Added to IEEE Xplore: 15 September 2022

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I. Introduction

Wireless sensor networks consist of a group of sensors deployed in unmanned area. Each sensor consists of non-removable battery, transceiver, processor etc. In WSN the nodes communicate with each other. Each sensor in the network is called a node. When the node collects data and sends the data it loses some of its energy [9]. In this paper, an optimized scheduling technique based on Machine Learning is proposed to improve the energy efficiency of wireless sensor networks in dynamic environments. Wireless sensor networks transferred data to the base station on a regular basis [2]. The received data consists of multiple entries of same data collected by different sensors. It is very difficult to identify which information are useful and which information are unwanted, so, using a machine algorithm SVM aids in the extraction of relevant information from data. Overall performance can be measured through parameters like throughput, packet delivery ration and routing overhead.

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Li-Fi: A Novel Stand-In for Connectivity and Data Transmission in Toll System

Authors:

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This paper describes an application framework which uses Li-Fi (Light Fidelity) technology to reduce the time delay and congestion caused at the toll system. The Li-Fi is a disruptive technology driven by the visible light spectrum that makes the data transmission process much faster and enhances the system efficiency. In Li-Fi, there is no interference as in radio waves and it provides higher bandwidth. It is a bidirectional wireless data carrier medium that uses only visible light and photodiodes. Everything happens very fast in this world, including transportation. In the present scenario, spending a long time in traffic is irritating. Even after the introduction of FASTag, there is not much change in toll booth queues. It is at this point where we start to think about a different plan to avoid unwanted blocks at toll booths. Hence, we introduce the concept of Li-Fi where vehicles can move through the toll booths without any pause. All that we are using here is DRL (Daytime Running Lights). This will have a corresponding receiver section which will accept the signals from the DRL. This method also has certain extra perks which will provide an interdisciplinary help to many major fields.KeywordsLi-FiLight-emitting diode (LED)TollIoT

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Methodologies used for the detection of malicious applications can be broadly classified into static and dynamic analysis based approaches. With traditional signature-based methods, new variants of malware families cannot be detected. A combination of deep learning techniques along with image-based features is used in this work to classify malware. The data set used here is the 'Malimg' dataset, which contains a pictorial representation of well-known malware families. This paper proposes a methodology for identifying malware images and classifying them into various families. The classification is based on image features. The features are extracted using the pre-trained model namely VGG16. The samples of malware are depicted as byteplot grayscale images. Features are extracted employing the convolutional layer of a VGG16 deep learning network, which uses ImageNet dataset for the pre-training step. The features are used to train different classifiers which employ SVM, XGBoost, DNN and Random Forest for the classification task into different malware families. Using 9339 samples from 25 different malware families, we performed experimental evaluations and demonstrate that our approach is effective in identifying malware families with high accuracy.

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I. Introduction

Malware and its variants are increasingly causing major security issues on the Internet due to its rapid proliferation and thus research in this domain is gaining increased significance.

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Rollover Stability Analysis of Trucks-Effect of Curve Geometry and Operating Speed

Y. K. Remya ✉, Jacob Anitha & E. A. Subaida

Conference paper | First Online: 01 July 2023

Part of the Lecture Notes in Civil Engineering book series (LNCE, volume 347)

Abstract

Road crashes have become a major concern worldwide. Rural highways account for more than 66% of total road fatalities as the speed of vehicles on these highways are very high. Rollover crashes at curved roads in these areas are mostly serious and cause severe damage and injury than other kinds of vehicle crashes. The relatively low rollover stability of heavy commercial

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'Remediability Score' as a tool for selecting the most suitable remediation technology for contaminated sites

Research Article | Published: 05 January 2024

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REMEDIATION

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Determination of the remediability score for remediation liability allocation among polluters

Lakshmi Priya, George K. Varghese ✉ Alberto Pivato

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Abstract

When a pollution incident occurs, there can be impact liability and/or remediation liability on the polluter. The impact liability pays for the loss of life and property due to pollution. The remediation liability is to pay for remediating the environment in accordance with applicable laws and regulations. If there is only one polluter in a pollution incident, the entire liability can be placed on the sole polluter. However, liability allocation becomes complex when there are multiple polluters. To allocate the fractional remediation liability among multiple polluters, it is important to identify the factors that determine the cost of remediation so that a just distribution of liability can be made based on the contribution of each polluting party to the factors identified. Along with factors such as "quantity of the chemical released by the polluter," "distribution of the chemical in the environmental medium," "persistence of the chemical in the environmental medium," and so forth, the ease with which the chemical pollutant can be separated from the contaminated medium, which we name as "remediability," is important in deciding the remediation liability. The "remediability" of a chemical is critical in selecting the remediation technologies to be adopted and, consequently, in deciding the cost of remediation. Determination of a remediability score (RS) for each "chemical–environment medium" pair will help in quantifying the ease with which the site can be remediated. The score is envisaged on a 0–100 scale. The higher the score, the more difficult it is to remediate the chemical in the environmental medium under consideration. The score is estimated based on a set of predetermined factors that are characteristic to the

Effect of Fines on Static Liquefaction of Sand

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Abstract— **Several undrained static triaxial tests were performed on soil combinations to study the effect of initial conditions, fines content and plasticity on the undrained response and liquefaction behaviour of sand and soil mixtures. Soils are more liquefiable if they possess less dilation (or contraction) and low levels of stress ratios at failure strain levels. The results are displayed in the form of stress-strain relations, pore pressure developments, stress paths and liquefaction susceptibility of different soil mixtures is evaluated. Findings show that the stress ratios decrease with the decrease of relative densities and increase of consolidation pressures. Non-plastic silty sands behave as less dilative than fine sands due to the rise of pore pressure ratios with fines content. Stress ratios decrease with increase in the plasticity up to 5, and beyond that, increase with plasticity indices up to 15. The decrease or increase of stress ratios is due to the increase or decrease of pore pressures with plasticity indices.**

Keywords—low plastic fines, liquefaction, undrained response

I. INTRODUCTION

The term soil liquefaction was initially coined by Terzaghi and Peck (1948). The subject is much older than that; however, Dutch engineers have been engineering against liquefaction for centuries in their efforts to protect their country from the sea. Koppejan et al. (1948) brought the problem of coastal flow slides to the soil mechanics fraternity at the 2nd International Conference in Rotterdam. Soil liquefaction is defined as the transformation of granular material from solid to liquid state as a consequence of increased pore water pressure and reduced effective stress (Marcuson, 1978). In general, the liquefaction susceptibility of soils is determined after conducting laboratory triaxial compression tests under static or cyclic loading conditions. Triaxial compression tests have more advantage in controlling all types of drainage conditions.

Monotonically increasing shear stress has to reach the yield shear strength to trigger static liquefaction and strain softening (Fourie et al., 2001; Kramer and Seed, 1988; Wanatowski and Chu, 2008). Strain-softening subsequently follows the initiation of liquefaction until a reduced post-liquefaction strength is mobilised at large shear strains (Terzaghi et al., 1996). After conducting the laboratory tests, Kramer and Seed (1988) demonstrated that there is a marked increase in static liquefaction susceptibility with an increase in principal effective stress ratios. Lade & Yamamuro (2011) explained the mechanism of instability inside the failure surface and showed that in most cases, static liquefaction occurs in loose silty sands. Sina & Siavash (2014) have conducted triaxial tests in Babolsar sand and experienced the possible states of liquefaction of soil. The investigators (Koppejan et al., 1948; Fourie et al., 2001; Bjerrum, 1971; Castro, 1969; Hazen, 1918; Muhammad, 2012; Olson, 2001) described several cases of liquefaction flow failures.

However, the accuracy of test results is affected by various factors like specimen preparation, initial conditions, saturation of soil, type of fines, fines content, plasticity, etc. Among those, specimen preparation is one of the critical factors that influence the test property. It is mandatory to choose the method of specimen preparation to represent the actual field deposit. Previous studies have shown that different specimen preparation methods result in different soil fabrics and stress-strain response at small to moderate strain levels. Various methods used to reconstitute the soil specimens in the triaxial testing are moist tamping, slurry deposition, water sedimentation, air pluviation, dry funnel deposition, under compaction, etc.

The present study deals with the effect of fine content and plasticity on the undrained response and liquefaction susceptibility of sand under static loading. Liquefaction susceptibility under static load is expressed in terms of stress ratios and excess pore pressure ratios.

II. MATERIALS USED

To process non-plastic and low plastic soil mixtures for the present study, soil materials of fine sand, crushed stone dust, kaolinite and natural clay were collected from various locations of Kerala state in India. Totally 17 soil combinations were made after blending the non-plastic fines and clay fractions into the fine sand. The silty sands contain up to 40% non-plastic fines and low plastic soil mixtures contains 5 - 40% clay fraction by varying the plasticity indices of 5, 10 and 15. The details regarding materials and their basic properties are explained in Rangaswamy et al. (2020).

III. TRIAXIAL TESTING

The liquefaction susceptibility of soils can be determined after conducting laboratory triaxial compression tests under static or cyclic loading conditions. Triaxial compression tests have more advantage in controlling all types of drainage conditions. The static triaxial tests in undrained conditions were carried out to investigate the liquefaction susceptibility of non-plastic and low plastic soil mixtures. The stages involved in carrying out the triaxial tests, including test equipment, are discussed below.

An automated digital type of static triaxial testing facility (Mfd. by Heico, India) with a computer display of measurements was used to carry out the experiments. It has the features of cell and back pressure control devices, volume

change, LVDT, load cell and pore pressure indicators. All the digital instrumentations of measurement units are connected to data control and acquisition system. Sophisticated software is also provided to monitor the various parameters on the computer screen. Several triaxial tests were performed on cylindrical specimens of sand, non-plastic and low plastic soil combinations. The testing involves the following stages:- specimen preparation, saturation, isotropic consolidation and shearing under undrained conditions. The cylindrical soil specimens were prepared with 50 mm in diameter and 100 mm in height at 50% relative density. The method of moist tamping with the under-compaction procedure suggested by Ladd (1978) has been used for specimen preparation. The saturation of the specimens has accomplished by following the cell and back pressure incremental process until it reaches the pore pressure coefficient B of 0.98 or more. More details on the soil specimen preparation, saturation and consolidation are explained in Akhila et al. (2018).

After consolidating the saturated cylindrical soil specimen with required effective pressure, shearing of the soil specimen is performed according to the standard testing procedure recommended by Bishop and Henkal (1969). The strain rate of 0.625 mm/min was maintained throughout the test. During shearing of the specimen, continuous records of the excess pore water pressure and axial strains were obtained. Each experiment was continued until it reaches the residual strain level.

IV. RESULTS AND DISCUSSION

A. Undrained response of fine sand

This section begins with a study of the effects of initial conditions, i.e., density and consolidation pressure, on the undrained static triaxial response of fine sand. Further, it discusses the effects of fines content and plasticities on the undrained behaviour of fine sand. Liquefaction susceptibility of soil combinations has to be addressed qualitatively based on the behaviour of soil as either contractive or dilative under undrained static triaxial loading.

In general, liquefaction susceptibility of soil specimens is evaluated in terms of static stress ratios and pore pressure ratios causing failure strain of 20%. Hence the effect of both the relative densities and consolidation pressures on liquefaction susceptibility of sand is explored in terms of stress and pore pressure ratios at 20% strain, as shown in Fig. 1. Herein, deviator stresses and excess pore pressures at 20% axial failure strain are normalised with the corresponding consolidation pressures to obtain the static stress ratios and pore pressure ratios respectively.

The results show that the stress ratios decrease with a decrease in relative densities and increase in consolidation pressures. At low levels of relative densities, Fig. 1(a) indicates that the reduction in stress ratios with consolidation pressures is less significant; however, it is more predominant at higher relative densities. The decrease in stress ratios is due to the increase in pore pressures with consolidation pressures as shown in Fig. 1(b). At low consolidation pressures, the reduction of stress ratios is very high due to the increase of pore pressure ratios with a decrease of relative densities. The results illustrate that the soils consolidated at low pressures

have high static stress ratios and more resistance to liquefaction. The dense soil specimens are more resistant to liquefaction due to high-stress ratios. Table 1 shows the quantitative increase in stress ratios causing liquefaction with the decrease of consolidation pressures. The increase in stress ratios with the decrease in the pressures from 150 to 50 kPa was found to about 37 - 95%. The quantitative increase in stress ratios causing liquefaction with relative densities are reported in Table 2. The increase in stress ratios with increase in the relative densities from 25 to 75% was found to about 562 - 719%.
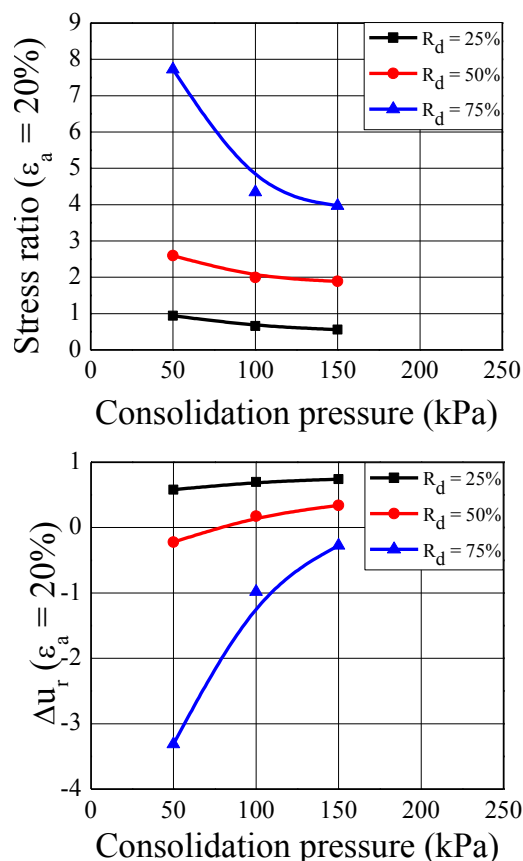
Fig. 1: Effect of consolidation pressure with the denseness of sand

Table 1: Percentage increase in stress ratios with pressures

Consolidation pressures, kPa	Percentage increase (at difference D_r)		
	25%	50%	75%
150	--	--	--
100	16.72	5.71	9.34
50	67.79	37.5	94.6

Table 2: Percentage increase in stress ratios with densities

Relative densities, %	Percentage increase (at different pressures)		
	150	100	50
25	--	--	--
50	236	204	175
75	606	562	719

B. Effect of fines

Several undrained static triaxial tests were performed on sand-silt mixtures (with the fines content of 10, 20, 30 and 40% constituted at different relative densities) to study the effect of fines content on the undrained response of fine sand. Effect of fines content on liquefaction susceptibility of sand is mentioned in terms of stress ratios and pore pressure ratios causing 20% strain. The results illustrate that the silty sands with high fines content have low static stress ratios and are more susceptible to liquefaction. It is observed from Fig. 3(a) that, at higher relative densities, decrease in stress ratios with fines content is clearly visible; however, the stress ratios of silty sands are almost identical at a low relative density of 25%. It indicates that the effect of fines on liquefaction strength of sand at loose condition is virtually insignificant. It is evident that the trend of the pore pressure build-up during shearing is same in all the silty sands as shown in Fig. 3(b).

The quantitative decrease in stress ratios causing liquefaction with the increase in the fines content is shown in table 3. The reduction in stress ratios with increase in the fines content from 0 to 40% was found to about 34.5 - 50.4% depending upon the applied consolidation pressures. At a relative density of 75%, the maximum reduction of stress ratio with fines content was found to be 55%. However, loose silty sands with 25% relative density have almost similar stress ratios within a maximum of 5% variation.
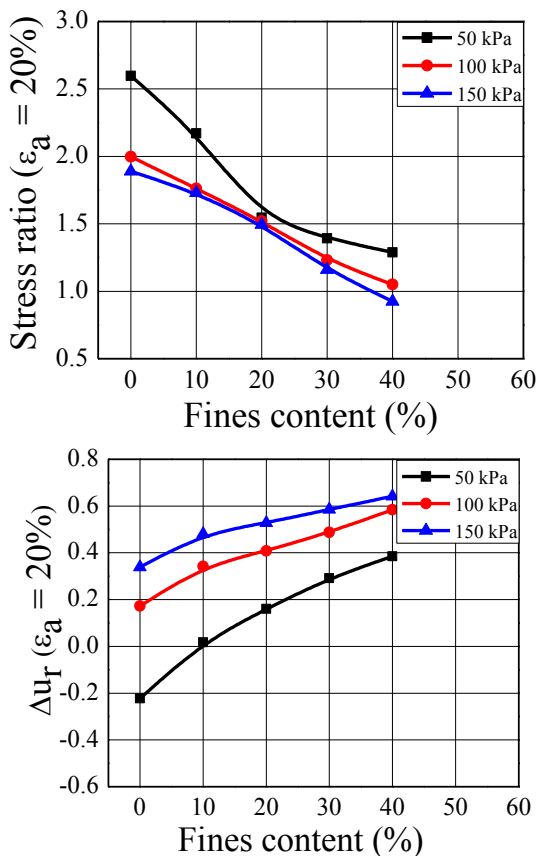
Fig. 2: Effect of non-plastic fines with consolidation pressures on (a) stress ratios and (b) pore pressure ratios at 20% strain level
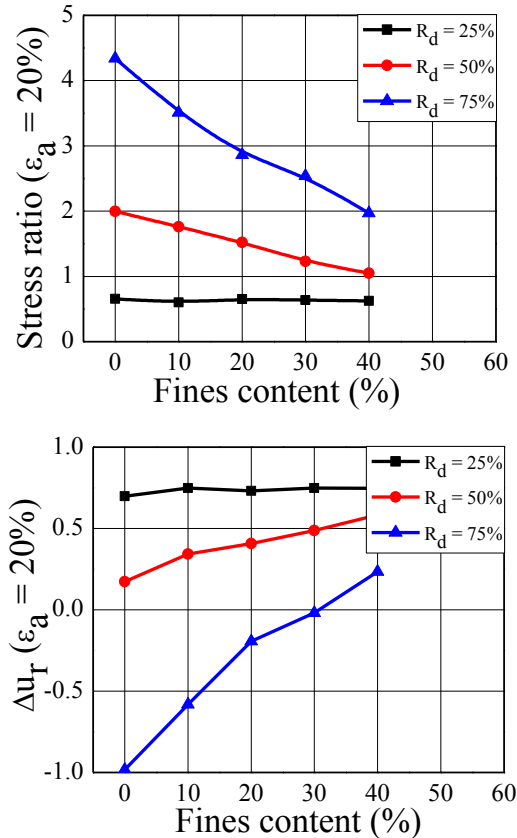
Fig. 3: Effect of non-plastic fines with the denseness of soils on (a) stress ratios and (b) pore pressure ratios at 20% strain level

Table 3: Percentage decrease in stress ratios at 20% strain level with fines content

Fines content (%)	Percentage decrease in stress ratios at a particular density of				
	R_d=50%			R_d=25%	R_d=75%
	σ_3=150 kPa	σ_3=100 kPa	σ_3=50 kPa	σ_3=100 kPa	σ_3=100 kPa
0	--	--	--	--	--
10	8.3	11.8	16.4	4	19
20	20.8	23.9	40.5	1	34
30	28	38.3	46.4	3	42
40	34.5	47.4	50.4	5	55

C. Effect of plasticity

Undrained static triaxial tests were performed on soil mixtures possessing plasticity indices of 0, 5, 10 and 15 to study the effect of plasticity on the undrained response of fine sand.

Effect of plasticity on liquefaction susceptibility of soil mixtures with fines content is explored in terms of stress ratios and pore pressure ratios causing 20% strain as shown in Fig. 4(a) and Fig. 4(b) respectively. Results show that the stress ratios decrease with the increase of plasticity index up to 5 and beyond that, it increases with plasticity index up to 15. The decrease or increase of stress ratios is due to the

increase or decrease of pore pressures with plasticity indices, as shown in Fig. 4(b).

Table 4 shows the quantitative decrease or increase in stress ratios at 20% axial strain with the increase of plasticity indices. The reduction in stress ratios with an increase in the plasticity from 0 to 5 was found to be about 11 - 31% depending upon the fines content. Further, the increase in stress ratios with an increase in plasticity from 5 to 15 was found to be about 3.7 - 50.1 %.
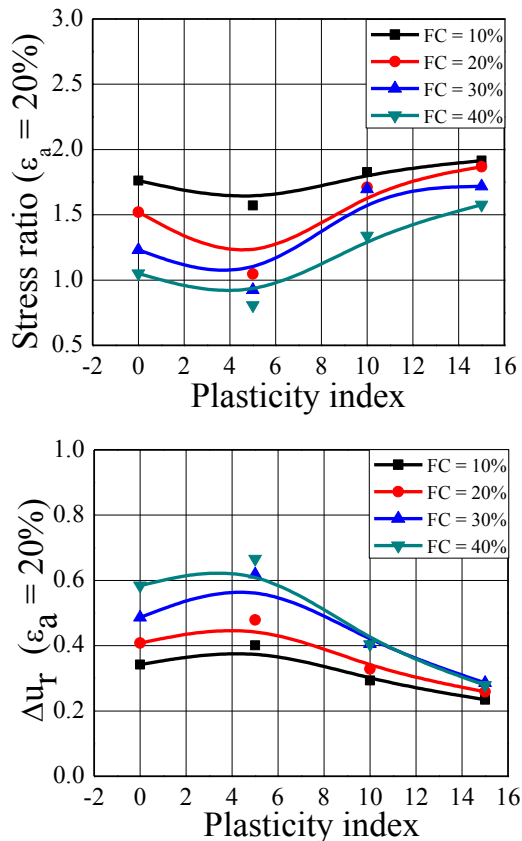
Fig. 4: Effect of plasticity on (a) stress ratios and (b) pore pressure ratios at 20% strain level

Table 4: Percentage decrease or increase in stress ratios at 20% strain level with plasticity indices

PI	Percentage decrease or increase in stress ratios of soil mixtures with			
	FC=10%	FC=20%	FC=30%	FC=40%
0	--	--	--	--
5	-11	-31	-24	-23.1
10	+3.7	+12.6	+37.8	+27.5
15	+8.7	+22.8	+39.5	+50.1

V. CONCLUSIONS

i. Stress ratios decrease with the decrease in the relative densities and an increase in the consolidation pressures. However, the reduction in stress ratios with the increase of consolidation pressures or decrease of relative densities is less significant at low relative densities and high pressures respectively. The decline in stress ratios is due to the increase of pore pressures. Soils confined at low normal pressures exhibit as more dilative and highly resistant to liquefaction.

ii. The reduction in stress ratios with an increase in the fines content from 0 to 40% has found to about 34.5 - 50.4% by decreasing the application of consolidation pressures from 150 to 50 kPa. At a relative density of 75%, the maximum reduction of stress ratio with fines content has found to 55%. However, loose silty sands with 25% relative density have stress ratios within a maximum of 5% variation.

iii. Stress ratios decrease with increase in the plasticity up to 5 and beyond that, it increases with plasticity indices up to 15. The decrease or increase of stress ratios is due to the increase or decrease of pore pressures with plasticity indices. The reduction in stress ratios with increase in the plasticity from 0 to 5 has found to about 11 - 31% depending upon the fines content. Further, the increase in stress ratios with increase in the plasticity from 5 to 15 has found to about 8.7 - 50.1 %.

REFERENCES

[1] Akhila M, Rangaswamy K and Sankar N: Undrained response and liquefaction resistance of sand-silt mixtures, Geotechnical and Geological Engineering, doi: https://doi.org/10.1007/s10706-018-00790-0, 2018.

[2] Bishop A W and Henkel D J: The Measurement of Soil Properties in the Triaxial Test, William Clowes AND Sons Ltd., London, 1969.

[3] Bjerrum L: Sub-aqueous slope failures in Norwegian fjords, Norwegian Geotechnical Institute, Oslo, Norway, 1971.

[4] Castro G: Liquefaction of sands, PhD Thesis, Harvard Soil Mechanics Series, Harvard University, Cambridge, MA, 1969

[5] Degregorio B V: Loading systems, sample preparation and liquefaction, Journal of Geotechnical Engineering (ASCE), No.116, 1990, pp 805-821.

[6] Fourie A B, Blight G E and Papageorgiou G: Static liquefaction as a possible explanation for the Merriespruit tailings dam failure. Canadian Geotechnical Journal, Vol.38, No.4, 2001, pp 707–719.

[7] Hazen A: A study of the slip in the Calaveras Dam, Engineering News-Record, Vol.81, No.26, 1918, pp 1158–1164.

[8] Koppejan A W, van Wamelen B M and Weinberg L J H: Coastal landslides in the Dutch province of Zeeland, Second International Conference on Soil Mechanics and Foundation Engineering, Rotterdam, Holland, 1948, pp 89–96.

[9] Kramer S L and Seed H B: Initiation of soil liquefaction under static loading conditions, Journal of Geotechnical Engineering., (ASCE), Vol.114, No.2, 1988, pp 412–430.

[10] Ladd R S: Preparing test specimens using undercompaction, Geotech. Testing J., ASTM, 1(1), 1978, pp 16—23.

[11] Lade P V and Yamamuro J A: Evaluation of static liquefaction potential of silty sand slopes, Canadian Geotechnical Journal, Vol.48, 2011, pp 247-264.

[12] Li and Dafalias: Anisotropic critical state theory: Role of fabric, Journal of Engineering Mechanics, Vol.138, No.3, 2012, pp 263-275.

[13] Marcuson W F III: Definition of terms related to liquefaction, J. Geotech. Engrg. Div., ASCE, Vol.104, No.9, 1978, pp 1197–1200.

[14] Muhammad K: Case history-based analysis of liquefaction in sloping ground, Department of Civil and Environmental Engineering, University of Illinois, Urbana, 489, 2012.

[15] Mulilis J P, Seed H B, Chan J K, Mitchell J K and Arulanandan K: Effects of sample preparation on sand liquefaction, Journal of the Geotechnical Eng. Div., ASCE, Vol.13 (GT2), 1977, pp 91-108.

[16] Olson S M: Liquefaction analysis of level and sloping ground using field case histories and penetration resistance, Department of Civil and Environmental Engineering, University of Illinois, Urbana, Illinois, 2001.

[17] Rahman Lo and Dafalias: constitutive modelling of static liquefaction of sand with fines, Proceedings of 6th International Conference on Earthquake Geotechnical Engineering, Christchurch, New Zealand, 2015.

[18] Rangaswamy K, Akhila M and Sankar N: Effects of fines content and plasticity on liquefaction of sands, Proceedings of the Institution of Civil Engineers – Geotechnical Engineering, https://doi.org/10.1680/jgeen.19.00270.

[19] Sina and Siavash: Evaluation of Babolsar sand behaviour by using static triaxial tests and comparison with case history, Open Journal of Civil Engineering, Vol.4, 2014, pp 181-197.

[20] Tatsuoka F, Ochi K, Fujii S and Okamoto M: Cyclic undrained triaxial and torsional shear strength of sands for different preparation methods. Soils and Foundations, Vol.26, No.3, 1986, pp 23-41.

[21] Terzaghi K and Peck R B: Soil mechanics in engineering practice: New York, John Wiley and Sons, 1948.

[22] Terzaghi K, Peck R B and Mesri G: Soil Mechanics in Engineering Practice, Third Edition Wiley, New York, 1996.

[23] Thevanayagam S and Martin G R: Liquefaction in silty soils—screening and remediation issues," Soil Dynamics and Earthquake Engineering, Vol.22(9), 2002, pp 1035- 1042.

[24] Vaid Y P, Sivathayalan S and Stedman D: Influence of specimen- reconstituting method on the undrained response of sand, Geotech. Testing J., ASTM, Vol.22, No.3, 1999, pp 187–195.

[25] Wanatowski D and Chu J: Effect of specimen preparation method on the stress-strain behaviour of sand in plane-strain compression tests. Geotechnical Testing Journal, Vol.31, No.4, 2008.

[26] Zlatovic S and Ishihara K: Normalized behaviour of very loose nonplastic soil: Effects of fabric, Soils and Foundations, Tokyo, Vol.37, No.4, 1997, pp 47–56.

Chapter 9

Corrosion behaviour of additive manufactured materials and composites

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CONTENTS

9.1 INTRODUCTION

Additive manufacturing (AM) or 3D printing has become one of the emerging fields for the manufacture of 3D and complex components [1]. The additive manufacturing (AM) process involves the deposition of powder metals or liquid polymers in layer-by-layer method to obtain the finished object [2,3]. This method is most widely used for the production of complex shapes which is very difficult to manufacture using conventional manufacturing process.

In additive manufacturing the powder materials or polymer wires are melted using laser or electron beam sources and deposited layer by layer as

per the 3D design which is fed into the system [4,5]. Hence the main advantage of AM when compared with other traditional manufacturing processes are obvious; the foremost advantage is the ability to produce most complex components along with very minimal material wastage. The other major advantage is less production time for complex shapes compared to conventional process. Because of the abovementioned advantages the AM process is widely used for the production of complex aerospace components [6]. In the recent past, additive manufacturing (AM) process has improved a lot and a variety of alloys can be developed using AM process. However, it is necessary to explore the different properties of AM manufactured alloys such as mechanical, tribological and corrosion-resistant properties [7,8]. Even though there are more studies which help us understand the mechanical properties of AM manufactured metals and alloys, there are very few studies which let us know about the corrosion behaviour of alloys developed using additive manufacturing process.

The additive manufacturing of metals and its alloys is classified into two main categories, namely powder bed fusion systems and powder-fed systems. The powder-fed systems are also known as direct laser deposition (DLD) technique. In the DLD method metal powders and heating will be supplied to the substrate simultaneously [9–13]. The powder bed fusion systems are further classified into selective laser melting (SLM), selective laser sintering (SLS) and electron beam melting (EBM) [14,15].

Selective laser melting works in a bed in which metal powders are fed through the powder dispenser. The high-energy laser is rastered on to the powder bed as per the computer-aided design (CAD) so as to produce the components layer by layer. Figure 9.1 shows the schematic representation of SLM machine setup. Here the powders are fed into the building platform using recoater arm and then high-energy laser is used to raster the layer for consolidation. After successful consolidation of one layer, this process is repeated to form another layer. The approximate thickness of layers is 80 μm [16]. The entire process was carried out inside the vacuum chamber under argon or nitrogen atmosphere so as to avoid oxidation [17]. The alloys obtained through SLM techniques exhibit fine and smooth microstructure as the result of high cooling rates, which are greater than $6 \times 10^6 \degree C/s$. The cooling rates also play a vital role in achieving good surface roughness (Ra) which is in the range of 9–16 μm in SLM produced alloys [18,19].

The electron beam machining (EBM) process is similar to LM process but utilizes electron beam as the source of heating as shown in Figure 9.2. The production of electron beams requires very high vacuum up to 10^{-6} torr. The vacuum chamber also helps in reduction of oxidation of metals and alloys [21]. It is to be noted that in all types of additive manufacturing process, the microstructures of the alloys obtained depend upon the different production parameters. Thereby the microstructure of the alloys controls the important properties such as mechanical, tribological and corrosion-resistant properties [22,23].
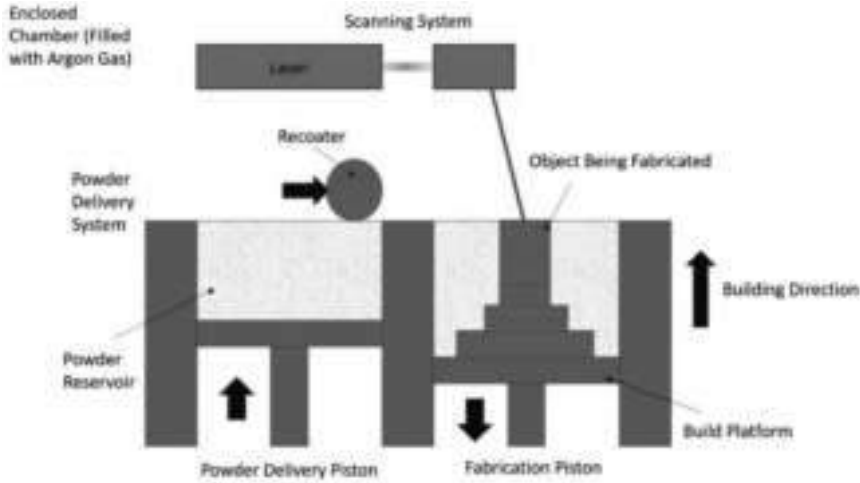
Figure 9.1 Pictorial representation of selective laser melting (SLM) process [20].
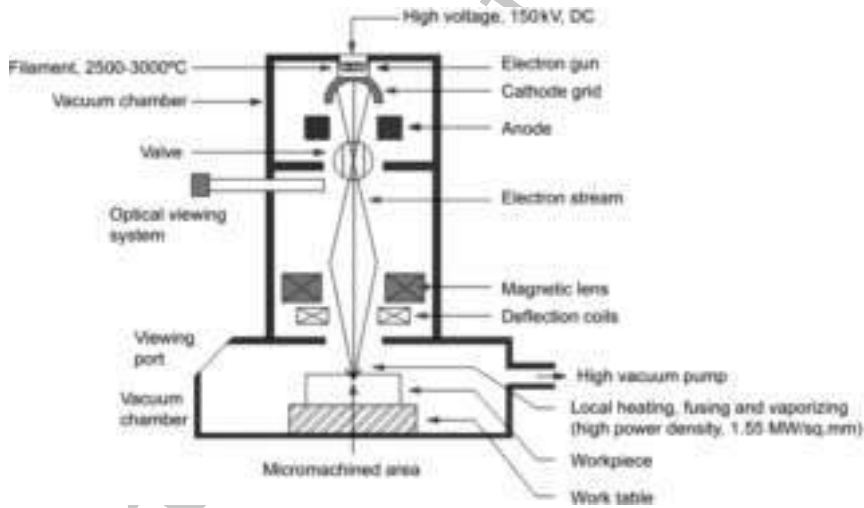
Figure 9.2 Schematic representation of electron beam machining (EBM) process [24].

In powder bed fusion such as SLM, EBM, and SLS the major parameters are the intensity of laser or electron beans, laser/electron spot size and speed of transverse motion. Other important factors which affect the alloy thermal properties are pattern of scanning, thickness of different layers and the temperature of the powder bed. On the other hand, in direct laser deposition powders of size 50–150 μm are fed into the built substrate along with heating through laser source. Also argon gas is passed into the vacuum
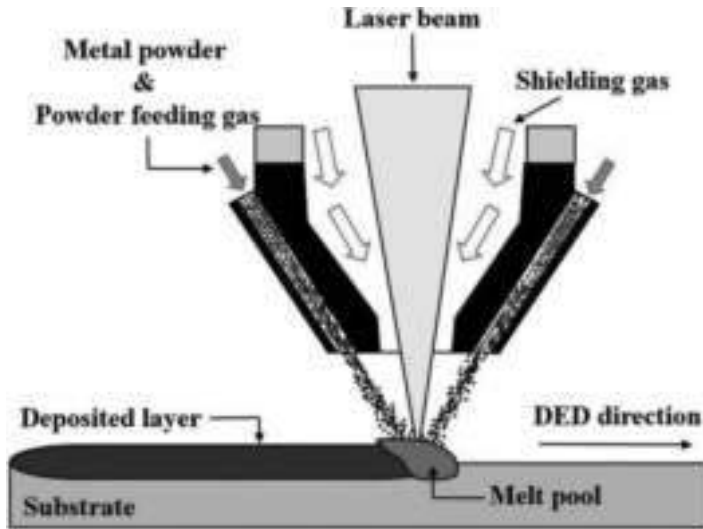
Figure 9.3 Pictorial representation of direct laser deposition (DLD) process [33].

chamber so as to maintain inert atmosphere [25,26]. The important parameters which control the microstructure of the DLD alloys are laser energy, powder size and the amount of powder injected through the nozzle. The raster speed of laser scan and laser spot size also play a vital role in refining the microstructure of the DLD alloys [27,28]. Figure 9.3 shows the pictorial representation of DLD process. It is also to be noted that SLM technique is used to machine stainless steels, titanium-based alloys, aluminium-based alloys, whereas the DLD and EBM methods are widely used to machine titanium-based alloys and stainless steels [29–32].

9.2 EFFECT OF DIFFERENT PROCESS PARAMETERS ON THE REFINEMENT OF MICROSTRUCTURES AND CORROSION-RESISTANT PROPERTIES

As discussed earlier the AM processed alloys possess a different and refined microstructure compared to other conventional manufacturing process because of the influence of different parameters involved in the AM process. In the case of SLM method, the metal powders fed into the powder bed undergo intensive heating normally greater than 2,000°C which is then followed by very fast-paced solidification process [34]. Due to this heating many thermal cycles are involved as the result of heat transfer between powder particles as well as with the surrounding. Due to the high-temperature exposure and very fast cooling rate along with the heat transfer, thermal cycles result in improved and refined microstructures. But as the result of

this rapid heating and cooling there may be formation of few defects such as cracks, surface roughness and porosity [35,36]. Hence these defects might play a vital role in determining mechanical, tribological and corrosion resistance properties of AM manufactured alloys.

9.2.1 Porosity of AM Manufactured alloys

There are few studies which explain the effect of laser energy and scanning rate on the porosity of alloys developed through AM process. Selective laser melting (SLM) method was employed by Shang et al. [37] to study the effect of laser scanning rate on the porosity of 316L stainless steel specimens. In this study the laser energy was kept constant at 195 W, whereas the scanning rate of laser beam is varied in the order between 700 and 1,082 mm/s. The results show that porosity is directly proportional to the scanning rate. The increase in scanning rate results in improper melting which in turn affects the porosity of the alloys. The porosity which occurs in AM manufactured alloys may influence the corrosion-resistant properties of the metals and alloys [38]. The porosity of the additive manufactured alloys, especially Selective Laser Melting method, is classified into two types. One type of porosity can be found at the surrounding of improperly melted powders and another type of porosity is due to the presence of gases in between powder particles during atomization (gas) process, therefore by controlling the machining parameters we can reduce the porosity of additive manufactured alloys which in turn can reduce the corrosion behaviours of the additive manufactured alloys [39–41]. Another more accurate way to study the influence of machining parameters on porosity of additive manufactured of powders, also known as volumetric energy density (E_V) which is calculated by equation (9.1).

$$E_V = \frac{e}{rdt} \tag{9.1}$$

where e is the energy of laser,
r is scanning rate,
d is hatch diameter,
t is thickness of powder layer.

The energy density of laser plays a vital role in controlling the porosity of additive manufactured alloys [42,43]. The Ti6Al4V alloys were produced with porosity less than 0.1% by Hang et al. at an energy density of 120 J/mm^3. The laser density of 105 J/mm^3 was enough to produce 316L stainless steels with porosity of approximately 0.3% using Selective Laser Melting (SLM) process [36]. It is also to be noted that laser energy density is not the only factor reducing the porosity of additive manufactured alloys. Other parameters such as diameter of laser, scanning rate and hatch style are also very important in controlling the porosity of the additive manufactured (AM)
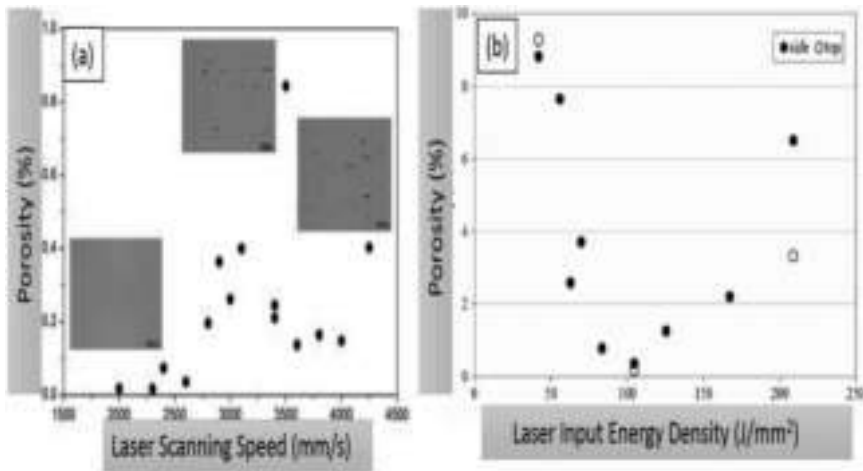
Figure 9.4 Graphical representation (a) porosity vs laser scanning speed [44] (b) porosity vs laser energy density of various SLM manufactured 316L stainless steel [45].

alloys as shown in Figure 9.4. Hence more studies should be carried out to find out the exact relationship between process parameters and porosity.

Porosity is one of the major causes for pitting corrosion in additive manufactured components, especially in selective laser melting (SLM) of 316L stainless steel in acidic media. The corrosion normally initiates at the location of pores [38]. Schaller et al. [46] employed electrochemical corrosion analysis to study the corrosion behaviour of 17-4 PH stainless steel manufactured using SLM process. The results showed that the porosity larger than 50 μm results in pitting corrosion, whereas when the porosity was around 10 μm there is no pitting corrosion. But when the normality of acids was increased and also when highly acidic acids such as sulphuric acid was utilized there is evidence of pitting corrosion in 316L stainless steels [45]. The size and shape of the pores also have a significant effect on the pitting corrosion performance; moreover, the pores which are irregular in shape will corrode easily due to the accumulation of ions at the edges and the corners. However, there are very few studies based on size distribution of pores, and hence more studies are required to be carried out to understand the effect of porosity, which includes size of the pores and *l/d* (aspect ratio) of the pores, on the corrosion behaviour of additive manufactured components.

9.2.2 Surface roughness of AM processed alloys

The selective laser melting (SLM) manufactured components have very high surface roughness (Ra). Wang et al. [47] reported that surface roughness (Ra) of the metals and its alloys are in the range of 10–30 μm, which is

very much higher than that of surface roughness produced by conventional process such as milling. He also found that the energy density of laser (ω) plays a very important role in deciding the surface roughness of SLM manufactured components. He reported that when the ω value is around 100–160 J/mm^3, the surface roughness is low around 10 μm, but when the ω values is reduced to 70 J/mm^3, the surface roughness increases up to 15 μm.

The main reasons for high surface roughness in SLM process are the evaporation and Marangoni force that exists because of melting of powders. The expansion of entrapped gases stops the flow of melt and thereby increases the melt pool which is highly unstable. This melt pool increases the surface roughness (Ra). When the layers of powders are thick, more gas expansion takes place. Hence the surface roughness can be reduced by decreasing the powder layer thickness [45,48]. However, by decreasing the layer thickness, the overall time for completing the machining increases rapidly. The improper melting of powders and formation of metal droplets also known as balling effect are the major reason for increase in surface roughness [49]. When the power of laser is very low the metallic powders are not completely melted and few solid particles stick on to the surface of the solidified components. Hence the increase in laser power can increase the melt rate and thereby increase wettability which in turn reduces the balling phenomenon [50]. Thus surface roughness can be reduced when the energy density of laser is high enough to melt the powder particles as shown in Figure 9.5. It is also to be noted that if the laser intensity is very high it can also reduce the surface finish of the components.

Normally the morphology of the surface is very important for the corrosion resistance properties. The corrosion rate increases with increase in surface roughness of the additive manufactured alloys such as copper, Mg and Al-based alloys [51,52]. Therefore, improving the surface finish by overcoming all defects was the major challenge for 3D printed or additive manufactured components. Thus many research works should be carried out to study the effects of post-processing surface treatments on additive manufactured components.
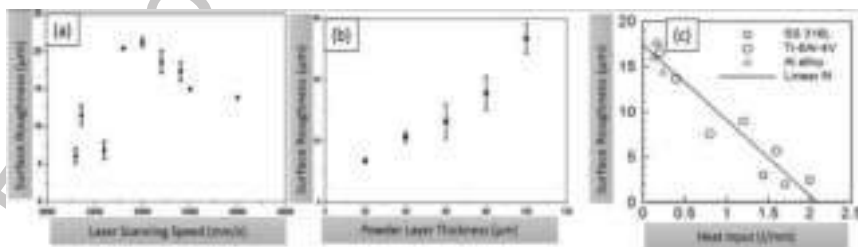
Figure 9.5 The relationship between surface roughness and (a) laser scanning speed, (b) powder layer thickness [44] and (c) heat input [45].

9.3 CORROSION BEHAVIOUR OF ADDITIVE MANUFACTURED ALLOYS

In this section various types of alloys manufactured through additive manufacturing technique are summarized and their corrosion behaviour is explored so as to provide an insight for young researchers who are trying to study the corrosion behaviour of additive manufactured alloys. Recent developments in additive manufacturing (AM) processes have made it versatile and a wide variety of metal alloys can be now prepared using additive manufacturing methods. The common types of alloys are titanium-based alloys, iron-based alloys and aluminium-based alloys.

9.3.1 Titanium-based additive manufactured alloys

Titanium-based alloys have very large industrial applications because of their properties. But a major disadvantage is their machining cost and a very large machining time when machined using conventional manufacturing processes. Hence titanium and its alloys are widely considered for manufacturing through additive manufacturing (AM) process [53–56]. Dehoff et al. [57] reported nearly 50% reduction in production cost for the titanium alloy-based engine bracket manufactured using AM process. Ti6Al4V alloy was one of the titanium alloys which was widely utilized for the production of biomedical, dental and automobile applications. It is also reported that Ti6Al4V alloys fabricated using Selective Laser Melting (SLM) have very minimal pitting corrosion, approximately around 150 mV, in sodium chloride solution. It also exhibits passivation curves which is the measure of corrosion resistance [58]. This improvement in corrosion resistance is due to the presence of a′-martensite as shown in Figure 9.6. The rapid cooling process was the reason for the formation of a′-martensite and it also possesses β-grains. Normally in SLM manufactured Ti6Al4V alloys
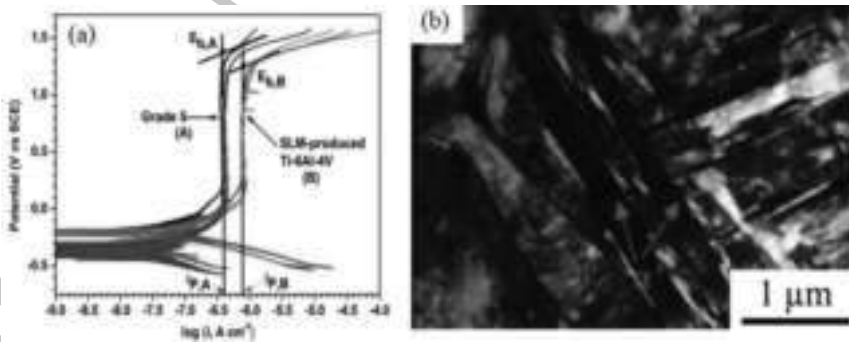
Figure 9.6 (a) Potentiodynamic polarization curves (tafel curves) of SLM manufactured Ti6Al4V alloy and Grade 5 alloy in NaCl solution (3.5 wt.%) [58]. (b) TEM image of SLM manufactured Ti6Al4V alloy [61].

the β-phase contains more vanadium presence along with oxides; hence, the β-phase is more stable compared to the α-phase. The stable β-phase plays a vital role in increasing the corrosion resistance of Ti6Al4V alloys [59]. But the percentage of β-phase present in additive manufactured Ti6Al4V alloys is very less compared to conventional manufacturing process. So it can be concluded that the SLM manufactured titanium alloys show very poor corrosion resistance [60].

9.3.2 Aluminium-based AM alloys

The selective laser melting (SLM) technique was broadly utilized for the manufacture of various aluminium-based alloys such as Al-Zn, Al-12Si, Al-50Si, Al-Cu and Al-10Si-M alloys [62–64]. Among these alloys Al-10Si-Mg alloys were widely studied by the researchers [65,66]. It is also noted as shown in Figure 9.7a and b. The corrosion potential of Al and Si particles differs, that is, Si has higher corrosion potential compared to that of Al which has low corrosion potential. This difference in corrosion potential leads to galvanic corrosion as shown in Figure 9.7c. Hence to overcome
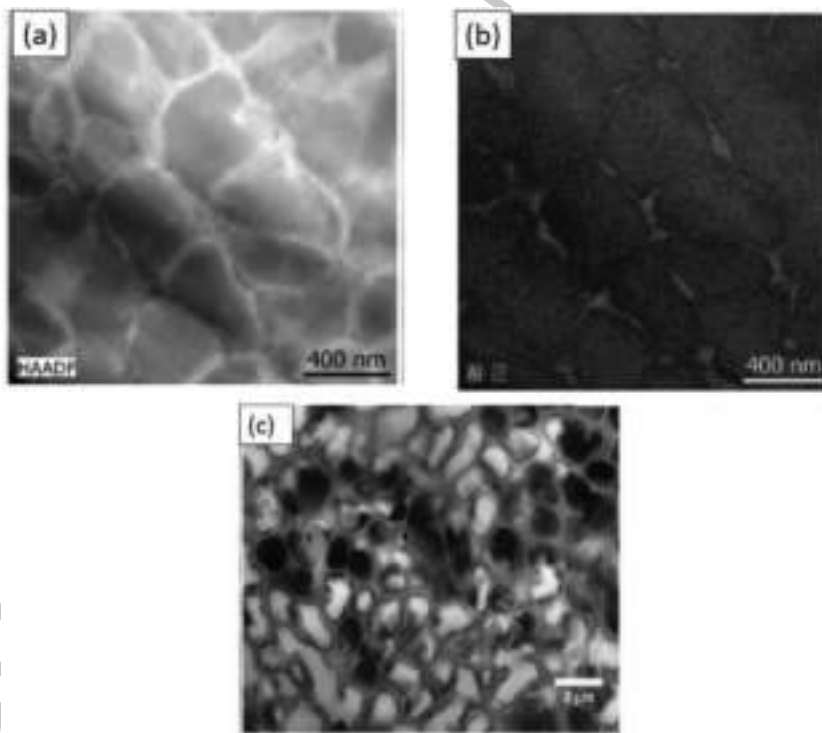
Figure 9.7 (a)STEM image of SLM manufactured Al-10Si-Mg alloy, (b) EDS mapping of Al and Si [68], (c) SEM image of corroded surface [45].

this galvanic corrosion the SLM manufactured Al-10Si-Mg alloys are subjected to heat treatment so as to improve the bonding of alloys and also to enable the formation of intermetallics, which thereby improve corrosion resistance [67].

9.3.3 Iron-based AM alloys

Stainless steels (austenitic) such as 316L and 304L will have austenitic phase when machined using SLM process, whereas only α-phase is formed if it is machined using Direct Laser Deposition (DLD) process [69–71]. The dislocation in grains also plays an important role in improvement of hardness of the alloy steel. It is also to be noted that nanoscale oxide formation has influence in deciding the mechanical and corrosion resistance of iron-based alloys [72]. Some studies also show that there is not much impact of porosity in corrosion behaviour of 316L stainless steel manufactured using SLM process as shown in Figure 9.8. Sander et al. [39] reported the corrosion behaviour of SLM-fabricated 316L stainless steel. They fabricated the 316L specimens at different scan rates and laser energies. The results exhibit that the scan rate and laser energy do not have any effect on corrosion resistance of 316L stainless steel, whereas the increase in porosity due to the faster scan rate and improper melting resulted in reduction in passivation potential, and hence increase in corrosion rate of 316L stainless steel samples as shown in Figure 9.9. The corrosion analysis of normal 316L SS samples and
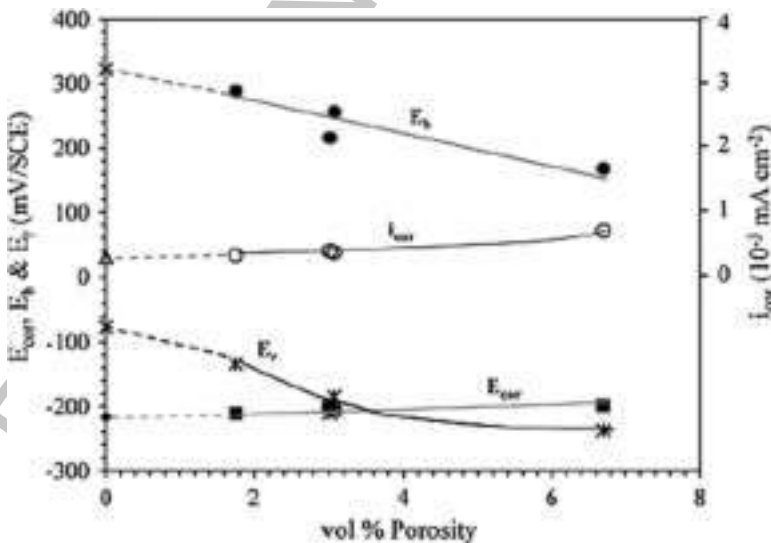
Figure 9.8 Relationship between Vol % of porosity and corrosion potential (E_{corr}), repassivation potential (E_r), breakdown potential (E_b) and corrosion current density (i_{Corr}) of SLM manufactured alloys [74].
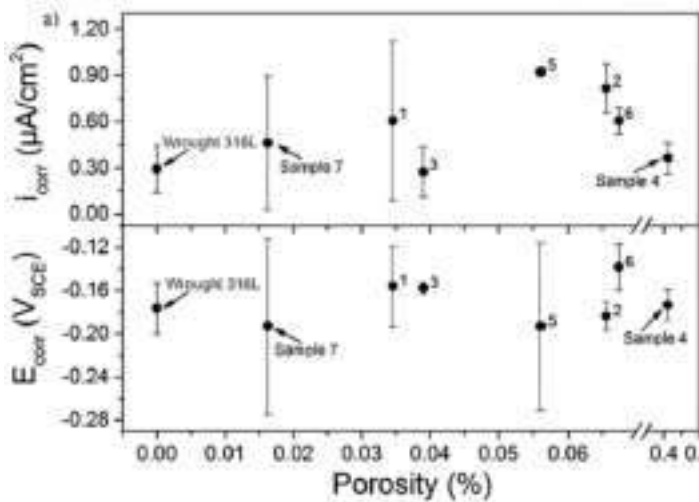
Figure 9.9 Porosity vs corrosion potential (E_{corr}) and corrosion current density (i_{Corr}) [39].

heat-treated SLM manufactured 316L SS was carried out by Hemmasian Ettefagh et al. [73] who reported that the heat treatment process has eliminated the residual stress, thereby increasing the corrosion potential. The corrosion behaviour of Laser Powder Bed Fusion (LPBF) manufactured 316L samples in 0.1 M HCl solution was studied by Trelewicz et al. [4]. Corrosion current density of LPBF manufactured 316L SS samples was much higher compared to wrought samples, when studied using potentiodynamic polarization test. The main reason for the decrease in corrosion resistance was the microstructure of LPBF manufactured 316L SS.

9.4 SCOPE FOR FUTURE WORKS

- The review gives an insight into the corrosion behaviour of AM alloys, many research articles are explored and their findings are reported. Most of the studies are not systematic and concentrate on one specific area and lack in-depth analysis of corrosion phenomena. Hence based on the studies, the following gaps have been identified:
- Corrosion analysis of additive manufactured alloys was carried out in different acidic and brine media and also with various concentration and pH levels, and hence it is very difficult to compare studies on one alloy with other.
- In the same way, corrosion analysis of additive manufactured alloys was carried out using different corrosion studies such as weight loss method, potentiodynamic polarization method, electrochemical

  impedance analysis etc.; hence, it is very difficult to compare studies on one alloy with other.

- The lack of standards for carrying out corrosion test was also one of the important factors to be addressed. Many studies compared wrought or cast irons with AM counterparts but few studies show the difference in properties between cast and AM alloys. Similarly, few studies compared only the different types of alloys produced by AM process but not discussed the alloys prepared by other methods. Hence the conclusions derived from the study may not be conclusive.

- There are very few studies on the exposure of AM alloys to nuclear radiation and also there are very minimal studies on the effect of gases especially hydrogen in AM manufactured alloys.

- Similarly, the corrosion analysis of AM manufactured alloys is limited to materials such as titanium alloys, aluminium alloys and iron-based alloys. But AM process can be utilized to even wide range of metals and their alloys.

- The work has a deficiency in parting the variables, i.e., it is very tedious to show trends from changes in porosity and also chemical factors simultaneously.

9.5 CONCLUSION

An outline of the recent status of some metal matrix alloys manufactured employing additive manufacturing was presented with a focus on correlating the relationship between the defects caused due to the microstructure and their effects on corrosion resistance properties. We can conclude that the high temperature evolved during manufacturing using SLM results in high dislocation densities and refinement of grain size, which in turn improves the tensile strength. Corrosion properties depend on the formation of alpha and beta phases and their structure compared to that of alloys fabricated using conventional methods. In the coming days, many materials can be manufactured using AM process, and hence the optimization of various parameters involved such as laser density, raster velocity and size of powder particles is very important in reducing the surface roughness, porosity and also to increase the strength of the alloys. However, the intrinsic relationship between the microstructural characteristics and the corrosion behaviour of the AM-fabricated components should be actively focused as well. The qualities of the input powder material and their effects on the fabrication process should be the first focus of research. It is critical to include the following three major components when describing a powder: particle microstructure, particle morphology and particle chemistry [75]. The focus of the current research is on the morphological characterization of powders and their impact on the characteristics of manufactured parts.
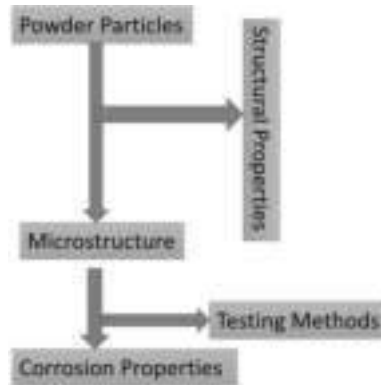
Figure 9.10 Pictorial representation of relationship between powder, microstructure and corrosion properties of AM manufactured alloys.

The mechanical and anti-corrosive qualities of the final consolidated components may be impacted by whether the feedstock powders are argon or nitrogen atomized, and whether the construction chambers are in argon or nitrogen atmosphere [76]. Figure 9.10 is a pictorial representation of AM-produced component powder, microstructure and related corrosion behaviour. The relationship between important structural properties and corrosion resistance must be established. For instance, typical MnS additions formed in wrought 316L SS were exchanged by Mn-Si oxides of nano regime in the SLM manufactured components, which reduces the vulnerability to pitting [77] and also the microstructural irregularities in the SLM manufactured components which otherwise lead to diverse growth rates (SCC) [78]. For the corrosion testing methodologies, there's an egregious lack of norms for which standardized experimentations are enforced, and presently, a wide range of distinct corrosion experimentation techniques (weight loss method, impedance analysis, potentiodynamic polarization) are indeed very difficult to compare. The standardization of testing methods and procedures as formulated by some professional bodies will be a solution for standardization problems. In general, the defects in the SLMed parts (such as pores and MPBs) usually comprise the corrosion resistance; therefore, a heat treatment process combining the hot isostatic pressing should be carried out to homogenize the composition and refine the microstructure, thereby reducing the porosity of the alloys. Thus, further exploration in this area is also warranted. Another post-processing method involves surface treatment, but surface treatment has lot of challenges which have to be addressed with the SLM manufactured metals. The various other techniques such as alkali-acid heat treatment, sandblasting, electrochemical etching and electrochemical deposition can be considered according to the properties of the raw material used. Conversely, the porous

materials manufactured using AM process cannot be easily surface modified compared to solid materials. Therefore, we have very little choice for selecting the methods of manufacture. Therefore, additional exploitation in this area is also required.

REFERENCES

[1] D. R. Eyers and A. T. Potter, "Industrial additive manufacturing: A manufacturing systems perspective," *Computers in Industry*, vol. 92–93, pp. 208–218, 2017, doi: 10.1016/j.compind.2017.08.002.

[2] D. L. Bourell, "Perspectives on additive manufacturing," *Annual Review of Materials Research*, vol. 46, no. 1, pp. 1–18, 2016, doi: 10.1146/annurev-matsci-070115-031606.

[3] D. W. Rosen, "A review of synthesis methods for additive manufacturing," *Visual and Physical Prototyping*, vol. 11, no. 4, pp. 305–317, 2016, doi: 10.1080/17452759.2016.1240208.

[4] J. R. Trelewicz, G. P. Halada, O. K. Donaldson, and G. Manogharan, "Microstructure and corrosion resistance of laser additively manufactured 316L stainless steel," *JOM*, vol. 68, no. 3, pp. 850–859, 2016, doi: 10.1007/s11837-016-1822-4.

[5] M. Attaran, "The rise of 3-D printing: The advantages of additive manufacturing over traditional manufacturing," *Business Horizons*, vol. 60, no. 5, pp. 677–688, 2017, doi: 10.1016/j.bushor.2017.05.011.

[6] P. Han, "Additive design and manufacturing of jet engine parts," *Engineering*, vol. 3, no. 5, pp. 648–652, 2017, doi: 10.1016/J.ENG.2017.05.017.

[7] J. K. Telford, "A brief introduction to design of experiments," *Johns Hopkins APL Technical Digest*, vol. 27, no. 3, p. 9, 2007.

[8] J. Gong, Y. Li, Z. Hu, Z. Zhou, and Y. Deng, "Ultrasensitive NH_3 gas sensor from polyaniline nanograin enchased TiO_2 fibers," *The Journal of Physical Chemistry C*, vol. 114, no. 21, pp. 9970–9974, 2010, doi: 10.1021/jp100685r.

[9] Y. Hu and W. Cong, "A review on laser deposition-additive manufacturing of ceramics and ceramic reinforced metal matrix composites," *Ceramics International*, vol. 44, no. 17, pp. 20599–20612, 2018, doi: 10.1016/j.ceramint.2018.08.083.

[10] M. K. Mallik, C. S. Rao, and V. V. S. K. Rao, "Effect of heat treatment on hardness and wear behavior of weld deposited Co-Cr-Mo alloy," *Matéria (Rio de Janeiro)*, vol. 20, no. 2, pp. 544–549, 2015, doi: 10.1590/S1517-707620150002.0054.

[11] Y. Shi, Z. Lu, Y. Ren, and G. Yang, "Microstructure and tensile properties of laser engineered net shaped reduced activation ferritic/martensitic steel," *Materials Characterization*, vol. 144, pp. 554–562, 2018, doi: 10.1016/j.matchar.2018.08.010.

[12] Y. Li, Y. Hu, W. Cong, L. Zhi, and Z. Guo, "Additive manufacturing of alumina using laser engineered net shaping: Effects of deposition variables," *Ceramics International*, vol. 43, no. 10, pp. 7768–7775, 2017, doi: 10.1016/j.ceramint.2017.03.085.

[13] M. Ziętala et al., "The microstructure, mechanical properties and corrosion resistance of 316L stainless steel fabricated using laser engineered net shaping," *Materials Science and Engineering: A*, vol. 677, pp. 1–10, 2016, doi: 10.1016/j.msea.2016.09.028.

[14] L. E. Murr et al., "Metal fabrication by additive manufacturing using laser and electron beam melting technologies," *Journal of Materials Science & Technology*, vol. 28, no. 1, pp. 1–14, 2012, doi: 10.1016/S1005-0302(12)60016-4.

[15] S. Singh, V. S. Sharma, and A. Sachdeva, "Progress in selective laser sintering using metallic powders: A review," *Materials Science and Technology*, vol. 32, no. 8, pp. 760–772, May 2016, doi: 10.1179/1743284715Y.0000000136.

[16] R. S. Keefe, and P. D. Harvey. Cognitive impairment in schizophrenia. *Handbook of Experimental Pharmacology*, 213, pp. 11–37, 2012. doi: 10.1007/978-3-642-25758-2_2.

[17] P. K. Gokuldoss, S. Kolla, and J. Eckert, "Additive manufacturing processes: Selective laser melting, electron beam melting and binder jetting—Selection guidelines," *Materials*, vol. 10, no. 6, 2017, doi: 10.3390/ma10060672.

[18] J. Suryawanshi, K. G. Prashanth, S. Scudino, J. Eckert, O. Prakash, and U. Ramamurty, "Simultaneous enhancements of strength and toughness in an Al-12Si alloy synthesized using selective laser melting," *Acta Materialia*, vol. 115, pp. 285–294, 2016, doi: 10.1016/j.actamat.2016.06.009.

[19] T. DebRoy et al., "Additive manufacturing of metallic components – Process, structure and properties," *Progress in Materials Science*, vol. 92, pp. 112–224, 2018, doi: 10.1016/j.pmatsci.2017.10.001.

[20] L. Jiao, Z. Chua, S. Moon, J. Song, G. Bi, and H. Zheng, "Femtosecond laser produced hydrophobic hierarchical structures on additive manufacturing parts," *Nanomaterials*, vol. 8, no. 8, p. 601, 2018, doi: 10.3390/nano8080601.

[21] B. Vayre, F. Vignat, and F. Villeneuve, "Metallic additive manufacturing: state-of-the-art review and prospects," *Mechanics & Industry*, vol. 13, no. 2, pp. 89–96, 2012, doi: 10.1051/meca/2012003.

[22] H. Gu, H. Gong, D. Pal, K. Rafi, T. L. Starr, and B. E. Stucker, "Influences of energy density on porosity and microstructure of selective laser melted 17-4PH stainless steel," 2013. http://dx.doi.org/10.26153/tsw/15572

[23] G. Sander et al., "Corrosion of additively manufactured alloys: A review," *Corrosion*, vol. 74, no. 12, pp. 1318–1350, 2018, doi: 10.5006/2926.

[24] B. Bhattacharyya, "Chapter 1 - Introduction," in *Electrochemical Micromachining for Nanofabrication, MEMS and Nanotechnology*, B. Bhattacharyya, Ed. William Andrew Publishing, 2015, pp. 1–23. doi: 10.1016/B978-0-323-32737-4.00001-3.

[25] R. Koike et al., "Evaluation for mechanical characteristics of Inconel625–SUS316L joint produced with direct energy deposition," *Procedia Manufacturing*, vol. 14, pp. 105–110, 2017, doi: 10.1016/j.promfg.2017.11.012.

[26] Q. Chao, T. Guo, T. Jarvis, X. Wu, P. Hodgson, and D. Fabijanic, "Direct laser deposition cladding of AlxCoCrFeNi high entropy alloys on a high-temperature stainless steel," *Surface and Coatings Technology*, vol. 332, pp. 440–451, 2017, doi: 10.1016/j.surfcoat.2017.09.072.

[27] L. Song, V. Bagavath-Singh, B. Dutta, and J. Mazumder, "Control of melt pool temperature and deposition height during direct metal deposition process,"

The International Journal of Advanced Manufacturing Technology, vol. 58, no. 1, pp. 247–256, 2012, doi: 10.1007/s00170-011-3395-2.

[28] N. Shamsaei, A. Yadollahi, L. Bian, and S. M. Thompson, "An overview of Direct Laser Deposition for additive manufacturing; Part II: Mechanical behavior, process parameter optimization and control," *Additive Manufacturing*, vol. 8, pp. 12–35, 2015, doi: 10.1016/j.addma.2015.07.002.

[29] K. Guan, Z. Wang, M. Gao, X. Li, and X. Zeng, "Effects of processing parameters on tensile properties of selective laser melted 304 stainless steel," *Materials & Design*, vol. 50, pp. 581–586, 2013, doi: 10.1016/j.matdes.2013.03.056.

[30] W. Xu, E. W. Lui, A. Pateras, M. Qian, and M. Brandt, "In situ tailoring microstructure in additively manufactured Ti-6Al-4V for superior mechanical performance," *Acta Materialia*, vol. 125, pp. 390–400, 2017, doi: 10.1016/j.actamat.2016.12.027.

[31] W. H. Kan et al., "A critical review on the effects of process-induced porosity on the mechanical properties of alloys fabricated by laser powder bed fusion," *Journal of Materials Science*, vol. 57, pp. 9819–9865, 2022, doi: 10.1007/s10853-022-06990-7.

[32] P. Wang, H. C. Li, K. G. Prashanth, J. Eckert, and S. Scudino, "Selective laser melting of Al-Zn-Mg-Cu: Heat treatment, microstructure and mechanical properties," *Journal of Alloys and Compounds*, vol. 707, pp. 287–290, 2017, doi: 10.1016/j.jallcom.2016.11.210.

[33] J.-S. Lim, W.-J. Oh, C.-M. Lee, and D.-H. Kim, "Selection of effective manufacturing conditions for directed energy deposition process using machine learning methods," *Scientific Reports*, vol. 11, no. 1, p. 24169, 2021, doi: 10.1038/s41598-021-03622-z.

[34] E. Liverani, S. Toschi, L. Ceschini, and A. Fortunato, "Effect of selective laser melting (SLM) process parameters on microstructure and mechanical properties of 316L austenitic stainless steel," *Journal of Materials Processing Technology*, vol. 249, pp. 255–263, 2017, doi: 10.1016/j.jmatprotec.2017.05.042.

[35] J. H. Martin, B. D. Yahata, J. M. Hundley, J. A. Mayer, T. A. Schaedler, and T. M. Pollock, "3D printing of high-strength aluminium alloys," *Nature*, vol. 549, no. 7672, pp. 365–369, 2017, doi: 10.1038/nature23894.

[36] J. A. Cherry, H. M. Davies, S. Mehmood, N. P. Lavery, S. G. R. Brown, and J. Sienz, "Investigation into the effect of process parameters on microstructural and physical properties of 316L stainless steel parts by selective laser melting," *The International Journal of Advanced Manufacturing Technology*, vol. 76, no. 5–8, pp. 869–879, 2015, doi: 10.1007/s00170-014-6297-2.

[37] Y. Shang, Y. Yuan, D. Li, Y. Li, and J. Chen, "Effects of scanning speed on in vitro biocompatibility of 316L stainless steel parts elaborated by selective laser melting," *The International Journal of Advanced Manufacturing Technology*, vol. 92, no. 9, pp. 4379–4385, 2017, doi: 10.1007/s00170-017-0525-5.

[38] E. Otero, A. Pardo, M. V. Utrilla, E. Sáenz, and F. J. Perez, "Influence of microstructure on the corrosion resistance of AISI type 304L and type 316L sintered stainless steels exposed to ferric chloride solution," *Materials Characterization*, vol. 35, no. 3, pp. 145–151, 1995, doi: 10.1016/1044-5803(95)00099-2.

[39] G. Sander et al., "On the corrosion and metastable pitting characteristics of 316L stainless steel produced by selective laser melting," *Journal of the Electrochemical Society*, vol. 164, no. 6, pp. C250–C257, 2017, doi: 10.1149/2.0551706jes.

[40] A. L. Maximenko and E. A. Olevsky, "Pore filling during selective laser melting - assisted additive manufacturing of composites," *Scripta Materialia*, vol. 149, pp. 75–78, 2018, doi: 10.1016/j.scriptamat.2018.02.015.

[41] R. Laquai, B. R. Müller, G. Kasperovich, J. Haubrich, G. Requena, and G. Bruno, "X-ray refraction distinguishes unprocessed powder from empty pores in selective laser melting Ti-6Al-4V," *Materials Research Letters*, vol. 6, no. 2, pp. 130–135, 2018, doi: 10.1080/21663831.2017.1409288.

[42] S. M. Yusuf and N. Gao, "Influence of energy density on metallurgy and properties in metal additive manufacturing," *Materials Science and Technology*, vol. 33, no. 11, pp. 1269–1289, 2017, doi: 10.1080/02670836.2017.1289444.

[43] J. Kluczyński, L. Śnieżek, K. Grzelak, and J. Mierzyński, "The influence of exposure energy density on porosity and microhardness of the SLM additive manufactured elements," *Materials*, vol. 11, no. 11, p. 2304, 2018, doi: 10.3390/ma11112304.

[44] C. Qiu, C. Panwisawas, M. Ward, H. C. Basoalto, J. W. Brooks, and M. M. Attallah, "On the role of melt flow into the surface structure and porosity development during selective laser melting," *Acta Materialia*, vol. 96, pp. 72–79, 2015, doi: 10.1016/j.actamat.2015.06.004.

[45] D. Kong, C. Dong, X. Ni, and X. Li, "Corrosion of metallic materials fabricated by selective laser melting," *npj Materials Degradation*, vol. 3, no. 1, p. 24, 2019, doi: 10.1038/s41529-019-0086-1.

[46] R. F. Schaller, J. M. Taylor, J. Rodelas, and E. J. Schindelholz, "Corrosion properties of powder bed fusion additively manufactured 17-4 PH stainless steel," *Corrosion*, vol. 73, no. 7, pp. 796–807, 2017, doi: 10.5006/2365.

[47] D. Wang, Y. Liu, Y. Yang, and D. Xiao, "Theoretical and experimental study on surface roughness of 316L stainless steel metal parts obtained through selective laser melting," *Rapid Prototyping Journal*, vol. 22, no. 4, pp. 706–716, 2016, doi: 10.1108/RPJ-06-2015-0078.

[48] Y. Tian, D. Tomus, P. Rometsch, and X. Wu, "Influences of processing parameters on surface roughness of Hastelloy X produced by selective laser melting," *Additive Manufacturing*, vol. 13, pp. 103–112, 2017, doi: 10.1016/j.addma.2016.10.010.

[49] N. T. Aboulkhair, I. Maskery, C. Tuck, I. Ashcroft, and N. M. Everitt, "On the formation of AlSi10Mg single tracks and layers in selective laser melting: Microstructure and nano-mechanical properties," *Journal of Materials Processing Technology*, vol. 230, pp. 88–98, 2016, doi: 10.1016/j.jmatprotec.2015.11.016.

[50] J. P. Kruth, L. Froyen, J. Van Vaerenbergh, P. Mercelis, M. Rombouts, and B. Lauwers, "Selective laser melting of iron-based powder," *Journal of Materials Processing Technology*, vol. 149, no. 1, pp. 616–622, 2004, doi: 10.1016/j.jmatprotec.2003.11.051.

[51] R. Walter and M. B. Kannan, "Influence of surface roughness on the corrosion behaviour of magnesium alloy," *Materials & Design*, vol. 32, no. 4, pp. 2350–2354, 2011, doi: 10.1016/j.matdes.2010.12.016.

[52] D. Kong et al., "Surface monitoring for pitting evolution into uniform corrosion on Cu-Ni-Zn ternary alloy in alkaline chloride solution: Ex-situ LCM and in-situ SECM," *Applied Surface Science*, vol. 440, pp. 245–257, 2018, doi: 10.1016/j.apsusc.2018.01.116.

[53] S. Pal, M. Finšgar, T. Bončina, G. Lojen, T. Brajlih, and I. Drstvenšek, "Effect of surface powder particles and morphologies on corrosion of Ti-6Al-4V fabricated with different energy densities in selective laser melting," *Materials & Design*, vol. 211, p. 110184, 2021, doi: 10.1016/j.matdes.2021.110184.

[54] T. Majumdar, N. Eisenstein, J. E. Frith, S. C. Cox, and N. Birbilis, "Additive manufacturing of titanium alloys for orthopedic applications: A materials science viewpoint," *Advanced Engineering Materials*, vol. 20, no. 9, p. 1800172, 2018, doi: 10.1002/adem.201800172.

[55] C. Phutela, N. T. Aboulkhair, C. J. Tuck, and I. Ashcroft, "The effects of feature sizes in selectively laser melted Ti-6Al-4V parts on the validity of optimised process parameters," *Materials*, vol. 13, no. 1, p. 117, 2020, https://doi.org/10.3390/ma13010117.

[56] L.-C. Zhang, H. Attar, M. Calin, and J. Eckert, "Review on manufacture by selective laser melting and properties of titanium based materials for biomedical applications," *Materials Technology*, vol. 31, no. 2, pp. 66–76, 2016, doi: 10.1179/1753555715Y.0000000076.

[57] R. Dehoff et al., "Case study: Additive manufacturing of aerospace brackets," *Advanced Materials and Processes*, vol. 171, no. 3, pp. 19–22.

[58] N. Dai, L.-C. Zhang, J. Zhang, Q. Chen, and M. Wu, "Corrosion behavior of selective laser melted Ti-6Al-4V alloy in NaCl solution," *Corrosion Science*, vol. 102, pp. 484–489, 2016, doi: 10.1016/j.corsci.2015.10.041.

[59] J.-R. Chen and W.-T. Tsai, "In situ corrosion monitoring of Ti–6Al–4V alloy in H_2SO_4/HCl mixed solution using electrochemical AFM," *Electrochimica Acta*, vol. 56, no. 4, pp. 1746–1751, 2011, doi: 10.1016/j.electacta.2010.10.024.

[60] F. Toptan et al., "Corrosion and tribocorrosion behaviour of Ti6Al4V produced by selective laser melting and hot pressing in comparison with the commercial alloy," *Journal of Materials Processing Technology*, vol. 266, pp. 239–245, 2019, doi: 10.1016/j.jmatprotec.2018.11.008.

[61] X. Zhao et al., "Comparison of the microstructures and mechanical properties of Ti–6Al–4V fabricated by selective laser melting and electron beam melting," *Materials & Design*, vol. 95, pp. 21–31, 2016, doi: 10.1016/j.matdes.2015.12.135.

[62] T. Gu, B. Chen, C. Tan, and J. Feng, "Microstructure evolution and mechanical properties of laser additive manufacturing of high strength Al-Cu-Mg alloy," *Optics & Laser Technology*, vol. 112, pp. 140–150, 2019, doi: 10.1016/j.optlastec.2018.11.008.

[63] M. L. Montero-Sistiaga et al., "Changing the alloy composition of Al7075 for better processability by selective laser melting," *Journal of Materials Processing Technology*, vol. 238, pp. 437–445, 2016, doi: 10.1016/j.jmatprotec.2016.08.003.

[64] X. Ai et al., "A high Fe-containing AlSi12 alloy fabricated by laser powder bed fusion," *Journal of Materials Research and Technology*, vol. 18, pp. 4513–4521, 2022, doi: 10.1016/j.jmrt.2022.04.008.

[65] A. Zakay and E. Aghion, "Effect of post-heat treatment on the corrosion behavior of AlSi10Mg alloy produced by additive manufacturing," *JOM*, vol. 71, no. 3, pp. 1150–1157, 2019, doi: 10.1007/s11837-018-3298-x.

[66] J. de Damborenea, A. Conde, M. Gardon, G. A. Ravi, and M. A. Arenas, "Effect of growth orientation and heat treatment on the corrosion properties of AlSi10Mg alloy produced by additive manufacturing," *Journal of Materials Research and Technology*, vol. 18, pp. 5325–5336, 2022, doi: 10.1016/j.jmrt.2022.05.021.

[67] R. I. Revilla and I. De Graeve, "Influence of Si content on the microstructure and corrosion behavior of additive manufactured Al-Si Alloys," *Journal of the Electrochemical Society*, vol. 165, no. 13, pp. C926–C932, 2018, doi: 10.1149/2.0101814jes.

[68] J. Wu, X. Q. Wang, W. Wang, M. M. Attallah, and M. H. Loretto, "Microstructure and strength of selectively laser melted AlSi10Mg," *Acta Materialia*, vol. 117, pp. 311–320, 2016, doi: 10.1016/j.actamat.2016.07.012.

[69] J. Lei, J. Xie, S. Zhou, H. Song, X. Song, and X. Zhou, "Comparative study on microstructure and corrosion performance of 316 stainless steel prepared by laser melting deposition with ring-shaped beam and Gaussian beam," *Optics & Laser Technology*, vol. 111, pp. 271–283, 2019, doi: 10.1016/j.optlastec.2018.09.057.

[70] O. O. Salman, C. Gammer, A. K. Chaubey, J. Eckert, and S. Scudino, "Effect of heat treatment on microstructure and mechanical properties of 316L steel synthesized by selective laser melting," *Materials Science and Engineering: A*, vol. 748, pp. 205–212, 2019, doi: 10.1016/j.msea.2019.01.110.

[71] K. Abd-Elghany and D. L. Bourell, "Property evaluation of 304L stainless steel fabricated by selective laser melting," *Rapid Prototyping Journal*, vol. 18, no. 5, pp. 420–428, 2012, doi: 10.1108/13552541211250418.

[72] R. F. Schaller, A. Mishra, J. M. Rodelas, J. M. Taylor, and E. J. Schindelholz, "The role of microstructure and surface finish on the corrosion of selective laser melted 304L," *Journal of the Electrochemical Society*, vol. 165, no. 5, pp. C234–C242, 2018, doi: 10.1149/2.0431805jes.

[73] A. Hemmasian Ettefagh and S. Guo, "Electrochemical behavior of AISI316L stainless steel parts produced by laser-based powder bed fusion process and the effect of post annealing process," *Additive Manufacturing*, vol. 22, pp. 153–156, 2018, doi: 10.1016/j.addma.2018.05.014.

[74] Y. Sun, A. Moroz, and K. Alrbaey, "Sliding wear characteristics and corrosion behaviour of selective laser melted 316L stainless steel," *Journal of Materials Engineering and Performance*, vol. 23, no. 2, pp. 518–526, 2014, doi: 10.1007/s11665-013-0784-8.

[75] G. Chen, S. Y. Zhao, P. Tan, J. Wang, C. S. Xiang, and H. P. Tang, "A comparative study of Ti-6Al-4V powders for additive manufacturing by gas atomization, plasma rotating electrode process and plasma atomization," *Powder Technology*, vol. 333, pp. 38–46, 2018, doi: 10.1016/j.powtec.2018.04.013.

[76] A. Aksoy and R. Ünal, "Effects of gas pressure and protrusion length of melt delivery tube on powder size and powder morphology of nitrogen gas atomised tin powders," *Powder Metallurgy*, vol. 49, no. 4, pp. 349–354, 2006, doi: 10.1179/174329006X89425.

[77] T. Kurzynowski, K. Gruber, W. Stopyra, B. Kuźnicka, and E. Chlebus, "Correlation between process parameters, microstructure and properties of 316 L stainless steel processed by selective laser melting," *Materials Science and Engineering: A*, vol. 718, pp. 64–73, 2018, doi: 10.1016/j.msea.2018.01.103.

[78] A. Strondl, O. Lyckfeldt, H. Brodin, and U. Ackelid, "Characterization and control of powder properties for additive manufacturing," *JOM*, vol. 67, no. 3, pp. 549–554, 2015, doi: 10.1007/s11837-015-1304-0.

Part II

Fabrication—the art of realization

IOP Publishing

Advances in Flexible and Printed Electronics
Materials, fabrication, and applications
Shanmuga Sundar Dhanabalan and Arun Thirumurugan

Chapter 5

Fabrication techniques for printed and wearable electronics

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K J Nagarajan and D Muthukrishnan**

In the modern era, smart devices play an important role in day-to-day life, and their widespread applications are getting huge demand globally. Innovation in the field of the Internet of Things paves new possibilities for future endeavors of mankind. Printed electronics is a sustainable way for achieving the widespread popularity of smart devices around the world and this technology is in its nascent stage. In the current scenario, massive amounts of e-waste generated due to the digital revolution and its disposal become a greater challenge for sustainability. Printed electronics are composed in a process of registering thin functional material (ink) layer combinations on a low-cost substrate that will degrade naturally. This article discusses the possibilities of printed electronics and its ability to hurdle the limitations of traditional high-cost electronics, based on rigid silicon, and the production of different devices on flexible substrates. Efficient use of materials, optimized energy consumption both in production and utilization, reduction in hazardous substances, and enhanced recyclability are the several benefits associated with printed electronics technology. The additive manufacturing method is used in printed electronics technology and the rate of production is much improved as compared with other processes. The materials used for printed electronics like ink and substrates are derived from synthetic or natural polymers. The above-stated reasons make printed electronics a technology for the future digital revolution. This article discusses various fabrication techniques like lithographic process for the production of printed electronics and its application in a sustainable manner.

Q1
Q2
Q3

5.1 Introduction

Printed or wearable electronics have good potential to be utilized as eco-friendly and biodegradable electronics so as to reduce electronic wastes, which is also known as

e-waste. Electronic wastes are due to the large number of electronic devices, which are disposed of every day [1, 2]. Another advantage of printed or wearable electronics is that it can be used in complex surfaces. Wearable devices thus help in improving the country's economic growth because of the sudden surge in printed or stretchable electronic devices. Now due to the advancement of artificial intelligence, electronic devices with artificial intelligence assistance have a great impact on the electronics industry. There are many conventional manufacturing processes to manufacture printed or wearable electronic devices. But due to the wastage of materials, and in order to avoid secondary operations such as etching and masking, the additive manufacturing process is most preferred in recent times. The printing process is also known as the additive method of manufacturing electronic applications by depositing electronic materials using functional inks along with the normal printing process [3]. As discussed earlier, this process thus eliminates the need for etching and masking and thereby involves environmentally friendly cleaner production compared to that of other traditional methods [4].

Nowadays a lot of sports and fitness equipment utilizes these wearable technologies in monitoring exercise and detecting the glucose level of diabetics [5]. Also, recently many printed and wearable devices have been made up of flexible or stretchable materials, which are used as sensors, that have close contact with human skin [6, 7].

The printing of electronic devices is classified into two types, one is contact type and the other is non-contact type. In the contact printing method, the die or pattern is immersed in a functional ink, and it is transferred onto the substrate by means of physical transfer. Screen printing, offset printing, flexography, and pad printing are the few types of contact printing [8].

On the other hand, in the non-contact printing process, the functional ink is sprayed via a nozzle onto the target substrate. There are two common types of non-contact printing processes, (i) inkjet printing and (ii) aerosol printing [9]. Normally the printing process is characterized by three steps or stages:

   (i) Selection of materials
  (ii) Printing process
 (iii) Sintering/drying process

After transferring ink onto the substrate either by contact or non-contact mode, it is very important to sinter the printed surface so as to achieve the desired properties of ink and the substrate. Figure 5.1 shows the steps involved in printed electronics manufacturing. Even though producing flexible electronic devices with required properties and specification is difficult for mass production, current technology and materials development has shown a positive trend in both performance and biodegradable properties. Because of this development, printed or wearable devices are developed for varying applications such as Radio Frequency Identification devices (RFID), organic light emitting diodes, thin-film transistors (TFT), photo-voltaic cells, energy devices such as batteries, and different types of sensor devices [10–12].
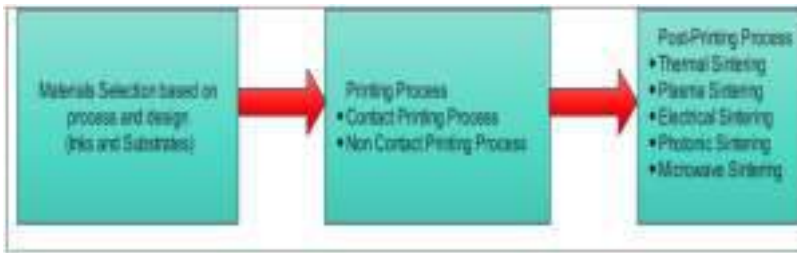
Figure 5.1. The steps involved in printed electronics manufacturing.

In this chapter, we provide the basic principle of various printing or fabrication techniques used for the development of wearable electronics. Further, this chapter will give clear insight into different materials and substrates employed.

5.2 Different types of flexible and printed electronic materials

In this part, we will explore the different types of materials used in flexible or printed electronics.

5.2.1 Inks used in printed electronics

In the production of wearable/printed electronics, inks play a vital role in creating structures or skeleton, which has a particular function. For printing of very complex electronic parts, different types of inks are used such as insulator/dielectric inks, semiconductor inks, and conducting inks. An important property of functional inks is the compatibility with other inks for simultaneous application, and it should be able to form uniform homogenous layers over the substrate. The inks used for wearable devices contain solvents, polymers, or resins. The inks can be made up of either organic or inorganic materials. Sometimes some additives will be added to improve the properties of the inks and avoid clogging of inks [13, 14].

5.2.1.1 Conducting ink materials

There are different types of conductive inks that are synthesized as nanoparticles. The nanoparticle inks are then dissolved onto the conductive polymer matrix [15]. Mostly metal nanoparticles are used as conductive ink material. Even though metal nanoparticle–dispersed inks have better properties, the synthesis of metal nano-particles is very difficult and requires more time and labor. Moreover, stabilizers are necessary to prevent agglomeration in functional inks. The sintering process, which is the post-printing process, requires heating above 100 °C so as to cure macro particle–dispersed inks, whereas, for nanoparticle-dispersed inks, the sintering temperature can be less than 100 °C [16]. Silver nanoparticle inks are one type of conducting inks. The silver nanoparticle–dispersed inks are toxic due to the evolution of silver ions; hence, the application of nanosilver inks is limited [17]. On the other hand, metal-organic decomposition inks use metal particles as precursors and evaporable alcohols as solvents. Thus, the agglomeration of nano-particles is prevented. But due to the evaporation of the solvents, there may be non-

uniformity in the deposited patterns. This non-uniformity will result in a decrease in conductivity [18]. Nonetheless, this drawback can be overcome by applying or printing successive layers one over another using the same ink [19].

The most widely used conductive inks are aluminum, copper, gold, and silver metal-dispersed inks. When talking about properties, silver-based conductive inks have better conductivity compared to that of copper-based inks. The silver-based inks have a good ability to resist oxidation. However, with the increase in oxidation, the conductivity decreases. The oxidation of metal nanoparticle–dispersed inks can be prevented by coating antioxidants over the nanoparticles or *in situ* synthesis in an organic solvent with a protective layer. Whereas the above-said methods are temporary solutions to control oxidation, new methods such as forming a bio-metallic core-shell or formation of a thick shell are made up of non-oxidizing conductive materials [15]. Gold is also one of the important conductive ink materials, which is eco-friendly and can be cured at very low temperatures. Whereas gold conductive inks are costly compared to other conductive inks. Another ink is aluminum-based ink, which can be synthesized using organic solvents, but aluminum inks are reactive in nature and tend to oxidize very quickly.

Apart from metal-dispersed inks, carbon-based inks such as carbon nanotubes (CNTs), graphene, and C60 can be altered and modified for applications such as conductive inks. The CNT's reinforced metallic conductive inks exhibit better stability, conductivity, and flexibility. The conductivity of CNT's reinforced metallic inks increases with the increase in thickness. The graphene and C60 also exhibit good light transmittance, flexibility, and conductivity. The light transmittance decreases when the number of graphene layers increases, whereas the conductivity increases with an increase in graphene layers [16, 20].

The recent development in conductive inks is the conducting polymers-based inks. They are very cheap, very light in weight, flexible in nature, and can be used in aqueous solvents as well as organic solvents. The main disadvantage of conductive polymer inks is their poor conductivity compared to metal inks, and production of conductive polymer inks is very difficult due to their processing difficulties, stability, and lesser solubility compared to metals. The polymer-based conductive inks are classified into the following types:

(i) Organic metal chelates
(ii) Conjugated polymers
(iii) Polymer electrolytes

The poly(3,4-ethylenedioxythiophene) polystyrene sulfonate is one type of conductive polymer that has good conductivity and decent temperature stability. There are a few other conductive polymers for the application of functional inks such as polypyrrole, polyacetylene, and polyacene [21]. Apart from the above materials, there are conducting ceramics, which are doped to improve conducting properties of ceramics. For example, aluminum-coated zinc oxide, indium-coated tin oxide (ITO), and gallium-coated zinc oxide. Among these, the ITO is most widely used for electronics applications, owing to its enhanced conductivity. But it should be noted that indium is a rare earth material, and hence, it is very costly [22]. Normally there

are two types of ITO conductive inks. One type of ink is *in situ* sol–gel-based inks, and another type is nanoparticle-dispersed conductive ink. The sol–gel-derived ITO conductive inks have better conductivity compared to nanoparticle-dispersed ITO inks.

5.2.1.2 Dielectric ink materials

In printed or wearable electronics, the capacitor and insulator layers are made up of dielectric materials. In order to be a good insulator, the layers of dielectric materials should be thick and uniform. However, it is difficult to print dielectric materials as compared to conductive materials. There are some substrate materials that are dielectric in nature such as silk, gelatine, cellulose, etc [2]. There are many dielectric materials based on polymers, with less density, less toughness, and less curing temperature. The most widely used dielectric polymers are polydimethylsiloxane (PDMS), polylactic acid (PLA), polymethyl methacrylate (PMMA), and polyvinyl alcohol [22].

5.2.1.3 Semiconducting ink materials

The semiconducting material is most commonly used as an active layer. There are many semiconducting materials such as silicon, CNTs, and different derivatives of graphene owing to their mechanical and semiconducting properties. The multiple layers of graphene can improve the semiconducting properties of wearable devices. There are few ceramic materials that can be used as semiconductors. But semiconducting ceramic materials are very rare and expensive. They also require high sintering temperatures for curing the printed layers [23, 24].

In flexible and printed electronic applications, the semiconducting functional inks can also be prepared by dissolving polymers in specific solvents. Hence, these types of polymer-based semiconducting inks can be used either as p-type or n-type materials. Polymers like polyfluorenes are most widely used as semiconducting polymers. Poly(3-alkyl thiophene) is an example of a p-type semiconducting material that uses holes for charge transfer, whereas n-type conducting polymers such as poly(9,9-dioctyl-fluorene-co-bithiophene) (F8T2) uses electrons for charge transfer [2].

5.2.2 Substrate materials for printed electronics

The substrate forms the base for any printed electronic devices. This substrate can also act as an insulator. The conventional substrate materials are strong and can remain rigid for quite a long period. Even though these materials possess good rigidity, conventional substrates are more brittle; hence, it is very difficult to machine conventional substrates for flexible or wearable devices. However, the development of flexible, biodegradable, and light polymer substrates has resulted in the rapid improvement of wearable devices with a long service life [25]. The substrate can be made up of natural or synthetic materials. These substrates are highly flexible, heat resistant, thin, low weight, and low cost [21]. Another important step in printed electronics is post-treatment, also known as the sintering process.

This sintering process might damage the surface of the substrate. So, materials with good thermal resistance should be considered for substrates.

5.2.2.1 Biodegradable polymeric substrates

Nowadays paper-based substrates are replacing conventional printed electronics because of their flexibility, biodegradability, and low cost [26]. However, the paper substrates have disadvantages such as porosity, surface roughness, and poor resistance to moisture. But the properties of paper-based substrates can be improved by metallic or ceramic coating as per the application [27]. Nano cellulose is another important contender for substrates because of its heat resistance, better surface smoothness, transparent nature, and good mechanical properties [21, 28]. Similarly, starch, silk, and shellac were also considered for the fabrication of substrates. Silk is a biodegradable material with better properties. Shellac is also a naturally available resin that can be used for preparing substrates in printed electronics. These materials have good surface smoothness, and further, these materials are relatively cheaper [28].

5.2.2.2 Synthetic polymer substrates

Polymer-based substrates are most widely used for printed electronic substrates. Polyethylene terephthalate (PET), polycarbonate, polyethylene naphthalate (PEN), and polyimide are the most commonly uses synthetic polymers in flexible electronic applications [2]. Because of its high flexibility, transparency, and resistance to solvent, PET is the most preferable and commonly used substrate material in flexible electronic devices. Polycarbonate substrates have high rigidity, are light in weight, and possess good mechanical properties. Although PEN has good transparency, it is very costly [29].

There are a few synthetic biodegradable polymers such as PLA, polyvinyl alcohol, PDMS, and polyethylene glycol, which can be utilized for the fabrication of substrates. The PLA is stiff in nature but possesses very poor heat resistance. Whereas PDMS can be used as substrates in flexible or stretchable electronic applications owing to their elastic nature. The need for producing flexible devices increases day by day. The research based on the direct printing of flexible or wearable electronics on polymer and fabric substrates is getting widespread acceptance.

5.3 Fabrication methods for printed electronics

Figure 5.2 shows the different types of fabrication methods in developing printed or wearable electronic devices. It Includes inkjet printing, offset printing, gravure printing, screen printing, and flexography. These methods are also classified into two types: contact and non-contact printing processes [8]. The inkjet printing and aerosol printing are contactless printing processes. There are some methods that involve both printing and deposition or coating techniques. The basic purpose of this printing or deposition is to develop multiple layers of structures that can be a conductive layer, semiconducting structure, or insulating structure for printed
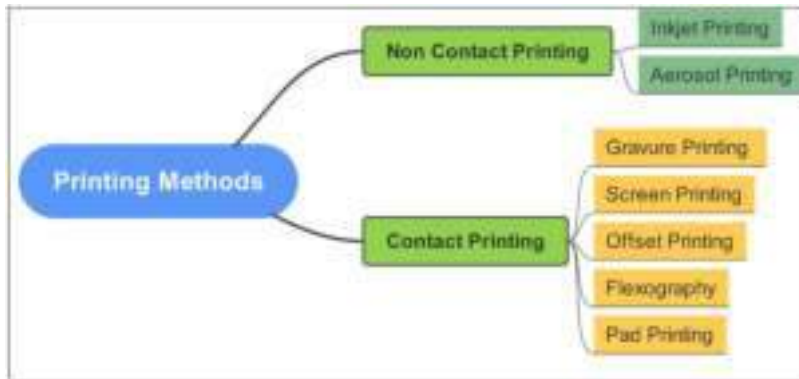
Figure 5.2. The different types of fabrication methods in developing printed or wearable electronic devices.

electronic devices. After the coating or deposition process, the functional inks will change their phase and orientation. This change in phase and flow rate on the coated substrate are mainly due to the viscosity of the ink material. It is also to be noted that the higher the viscosity, the higher the efficiency. The density of the ink is also important property for developing effective wearable devices. The surface tension is the property by which the ink can stick to the surface of the substrate. The evaporation rate and sintering temperature of the ink also play a vital role in the quality of flexible electronic devices [30]. The most commonly available printed electronic device is RFID stickers or flexible antennae, where antennas can be printed. The printing of RFID on flexible or printed substrates is a very efficient method, since it is a lighter, smaller, and cheaper device compared to conventional RFID antennas. The high-volume production techniques for printed electronics are offset printing, gravure method, and flexographic method. These techniques are utilized for the mass production of solar cells, sensors, etc. The organic or inorganic conducting materials can be printed using flexography and offset methods. The organic semiconductors and insulators are coated using the gravure printing method.

Recently, many new novel printing methods are identified and employed in the manufacturing of flexible or wearable devices. Devaraj *et al* developed a method known as the form-fuse method. In this method, silver nanoparticles are coated on polymer films by using an aerosol jet with mask and without mask. The entire process is carried out in a vacuum to develop desired shape and pattern. The sintering process is carried out to reduce the resistivity of printed materials [31]. Constante *et al* [32] also developed a new 4D coating method employing a 3D extrusion process along with melt-electro writing, which proves to be a good potential method for the development of flexible devices. Table 5.1 shows the important parameters of different printing methods. The inkjet method is more suited for high-quality research applications. The screen printing method is most useful for printing multiple layers, whereas the flexographic and gravure methods

Table 5.1. Parameters of different printing methods.

S. No.	Printing methods	Throughputs m^2 s^{-1}	Resolution lines cm^{-1}	Operating speed m min^{-1}
1	Gravure printing process	3–60	20–400	100–1000
2	Screen printing process	2–3	50	10–15
3	Offset printing process	3–30	100–200	100–900
4	Flexography printing process	3–30	60	100–700
5	Inkjet printing process	0.01–0.5	60–250	15–500

are useful for mass production. The output rate of the inkjet printing method is 0.5 m^2 s^{-1}, which is much less compared to other methods.

5.3.1 Contact printing of flexible electronics

In contact printing, the functional ink is transferred onto the substrate directly. This method is also known as roll-to-roll printing or transfer printing. The roll is used to transfer the ink to the substrate. The major disadvantage of this method is the large time consumption and high initial cost of the equipment. But the production cost is low and has good reproducibility, which makes them favorites for mass production [33, 34].

5.3.1.1 Gravure printing method

Gravure printing is the process in which the design to be printed on the substrate is first engraved on the printing cylinder, also known as the gravure cylinder. The doctor blade, which is made of steel, is used to remove the excess ink present in the printing cylinder before the ink is transferred to the impression cylinder from where the design is transferred onto the surface of the substrate as shown in figure 5.3. The printing cylinder is made up of rubber. The printing or gravure cylinder is made up of steel coated with copper. This process utilizes inks with low viscosity and possesses good efficiency. This method of printing proved to be more economical with good-quality printing. The quality of printing can be improved by using electrostatic forces for transferring ink onto the substrate [9].

It is to be noted that many devices such as antennas, TFTs, pressure sensors, surface-enhanced Raman scattering (SERS), and electrochemical sensors are developed using the gravure printing method [35]. Recently a wrinkle-structured solvent-excluded surface substrate developed for the detection of drugs like cocaine was fabricated by Maddipatla *et al* as shown in figure 5.4(A). In this study, the wrinkle-shaped structures were developed on the thermoplastic polyurethane (TPU) substrates by varying the proportions and printing silver ink of 150 nm particle size onto the TPU substrate using the gravure process [36]. Another recent study also utilizes the gravure printing process for fabricating a novel RFID antenna made up of paper substrate as shown in figure 5.4(B). In this work, Zhu *et al* manufactured a

Figure 5.3. The Schematic representation of the Gravure printing process, reprinted from [13] with permission from MDPI, Copyright (2021).
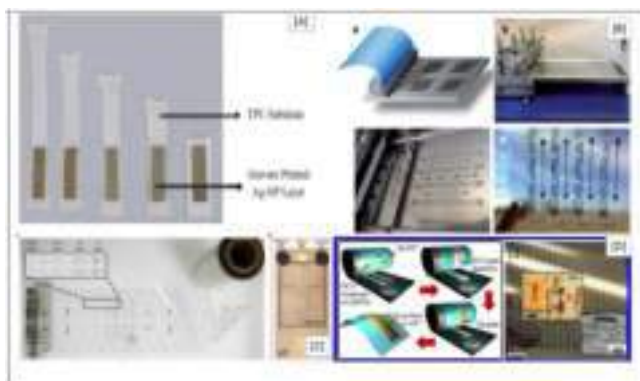
Figure 5.4. (A) Wrinkle SERS substrate, reprinted from [36] with permission from Elsevier, Copyright (2019). (B) RFID antenna made up of nano-paper, reprinted from [37] with permission from RSC, Copyright (2014). (C) PET-based electrochemical sensors for the detection of heavy metals, ions, and metabolites, reprinted from [38] with permission from ACS, Copyright (2018). (D) High-performance TFT made up of CNTs, reprinted from [39] with permission from ACS, Copyright (2013).

nano-structured paper by employing cellulose nanofibers and UHIF RFID tag, also known as squiggle, fabricated by depositing silver ink onto the paper substrate [37]. Bariya *et al* developed electrochemical sensors using PET for the detection of heavy metals, ions, and metabolites as shown in figure 5.4(C). Here the working and counter electrode is the carbon electrode, and silver is used as the reference electrode [38]. Lau *et al* fabricated CNT-based TFTs through the gravure printing process as shown in figure 5.4(D). In this work, silver ink is deposited as drain, gate, and source electrodes on WCNT-coated PET substrates. The nano barium titanate is printed as insulator layers. This gated TFT exhibits better performance, high flexibility, and minimal hysteresis [39]. In the process of gravure printing, the gravure cylinder, also

known as the printing cylinder, contains patterns that are very expensive, and further during the process of printing, a small percentage of the inks gets clogged due to evaporation and dries out in the printing cylinder, thereby reducing the quality of succeeding printings. The availability of functional ink is very low in the case of both gravure and flexography printing processes. These two processes are widely adopted in all graphics and packaging applications because of their ability for mass production. The major disadvantage or task involved in these two printing processes is that the development of functional ink, which requires hours of research and development, incurs more cost. Owing to the above details, the research undertaken based on the gravure and flexography printing process is very minimal when compared to that of the inkjet and screen printing process.

5.3.1.2 Screen printing

The screen printing process is also known as push-through method, which uses an ink of sticky nature. The ink is transferred onto the substrate through a screen, which may be made up of wire, plastic, and metals. This method can be done using bare hands or by using fully or semi-automatic systems. The coating machine consists of the following parts: (i) stencil, (ii) squeegee, and (iii) screen as shown in figure 5.5. The squeegee is the material that is made up of rubber. The design to be printed on the substrate is engraved on the screen, and the ink is allowed to pass through the screen either by means of pushing or squeezing the screen. Thus, the ink is transferred onto the substrate [40].

In this process, the quality of printing depends on wire diameter, the thickness of the emulsion, the mesh count of the screen, offset height, and screen deflection angle. This process has a good output rate at a low cost, and there is very minimal wastage of materials. The screen printing is very famous for its flexibility. There are many flexible or wearable electronics such as wearable sensors fabricated using a screen printing process and exhibiting similar properties to that of conventionally manufactured electronic devices. A piezoelectric touch sensor was fabricated using screen printing by Emamian *et al* [41]. They fabricated the sensor using polyvinylidene fluoride–based piezoelectric layer covered at the top and bottom by silver layers.
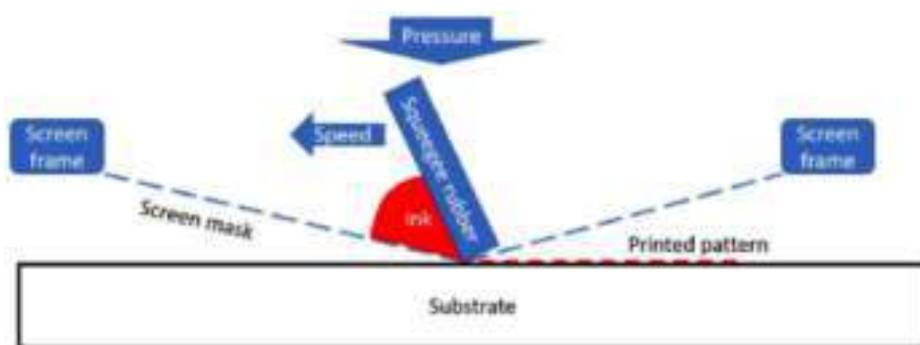
Figure 5.5. Schematic representation of screen printing, reprinted from [13] with permission from MDPI, Copyright (2021). Q4

Figure 5.6. (A) Touch sensor based on polyvinylidene fluoride on PED and paper substrates, reprinted from [41] with permission from Elsevier, Copyright (2017). (B) Schematic representation of the RTD sensor, reprinted from [42] with permission from IEEE, Copyright (2019).

These layers are coated using a screen printing process on PET and paper substrate as shown in figure 5.6(A). This PET substrate sensor has an observed sensitivity of 1.2 V N^{-1}, and the paper substrate sensors exhibit 0.3 V N^{-1} sensitivity. Hence, these sensors have good potential in applications such as robotics and sensors in automobiles. A sensor for temperature detection was developed by Turkani *et al*. They fabricated Ni-coated polyimide substrate sensors for detecting a wide range of resistance temperatures starting from −60 °C to 180 °C. This flexible resistance temperature detector (RTD) exhibits good repeatability and stability at all temperatures [42]. Figure 5.6(B) represents the RTD sensors. A flexible and stretchable sensor was fabricated by Bose *et al* using the screen printing process. The ink used for printing is silver ink, and the substrate is made up of TPU. The outcomes of the above work are that 20% of strain was detected by the wavy configured sensor, and they also exhibited excellent flexibility compared to conventional sensors. There are many studies that show that the screen printing process is the most viable and cost efficient [43–46]. This process can be utilized for the fabrication of flexible, wearable, and stretchable electronics [47, 48].

5.3.1.3 Offset printing process

This method is also known as the indirect printing method, because the ink is transferred from the initial or printing cylinder to the intermediate or blanket cylinder. From the blanket cylinder, the ink is transferred onto the substrate as shown in figure 5.7. The water roller will apply a small amount of water to the undesired part of the pattern so as to remove the ink. Surface engineering is an important aspect of offset printing. The image or desired areas accept the presence of ink but reject water, whereas undesired or non-image areas repel ink and accept water. The spreading of ink can be controlled by the surface energy. The ink is transferred to the paper substrate at pressure. In this process, the multiple layers of inks are coated simultaneously without an intermediate drying process; hence, this process is also called a wet-on-wet printing process. The coated inks are dried due to evaporation, absorption, and polymerization [49, 50].
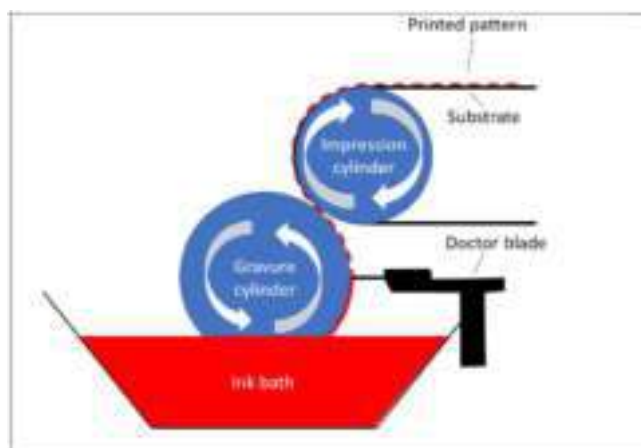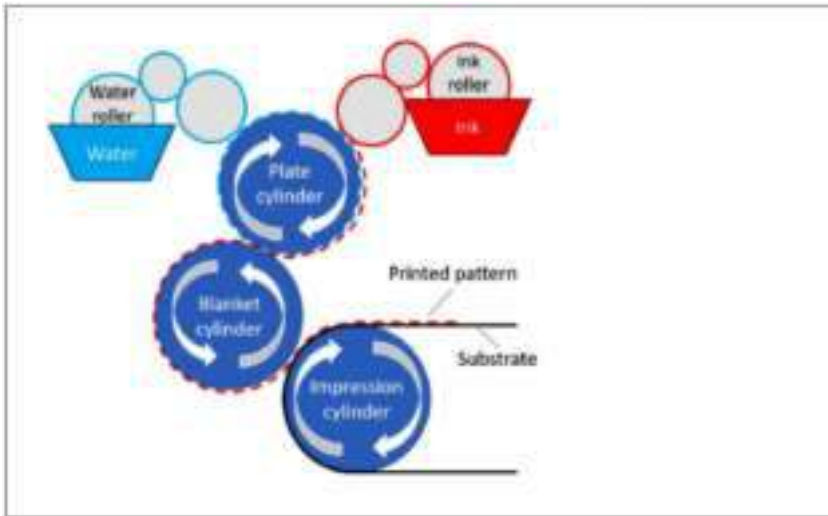
Figure 5.7. Schematic representation of the offset printing process, reprinted from [13] with permission from MDPI, Copyright (2021).
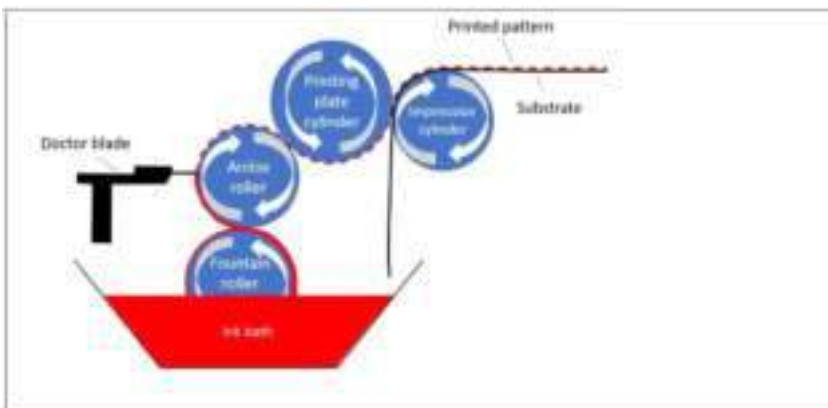

Figure 5.8. Schematic representation of the flexography printing process, reprinted from [13] with permission from MDPI, Copyright (2021).

5.3.1.4 *Flexography printing process*

The flexographic printing process is a kind of roll-to-roll printing process that has high throughput. Flexographic printing is also known as the rotational printing process. This method is an indirect contact-based printing method that has the ability to print ink of varying thicknesses with good resolution. As shown in figure 5.8, the flexography printing machine consists of the following parts [40]:

  (i) Printing cylinder
 (ii) Anilox cylinder

(iii) Impression cylinder
(iv) Ink reservoir
 (v) Doctor blade

A cylinder made of steel, which is otherwise called an anilox cylinder is used to transfer ink from the reservoir. The cylinder is engraved with a design on its surface, normally the anilox cylinder is made up of ceramics or chromium. Then the ink is transferred onto the printing cylinder, which is also known as a printing plate. Then from the printing plate, the ink is transferred to the target substrate. When compared to screen printing and inkjet printing, the flexographic process has high processing speed. This method is most widely used in printing graphics and in printing operations in packaging industries. There are only very few studies in flexible electronics manufacturing through the flexographic printing process [51, 52]. CNT-based flexible TFTs were developed by Higuchi *et al* as shown in figures 5.9(A) and (B). They deposited nano silver ink, resist ink, and polyimide ink as source, gate and drain gates electrodes, CNT patterner, and insulator over a thin film made up of PEN fabricated through a flexographic printing process. The CNTs synthesized using chemical vapor deposition were coated out of the TFT electrodes. The TFT developed using flexographic printing has exhibited good stability and mobility. A paper-based sensor (strain) was developed by Maddipatla *et al*. They developed silver ink–coated strain gauges through a flexographic printing process. The strain gauges are of different lengths. This sensor has the ability to detect even small displacements of the order of 1 mm with good repeatability [53].

5.3.1.5 Pad printing process

Pad printing is a method in which a 2D pattern or cliche is printed on a 3D substrate or object, as shown in figure 5.10. This process utilizes an indirect offset printing method, in which the ink is transferred from the cliché or a stereotype using a silicon pad. This process is widely used as a replacement for the screen printing process. The products such as transistor electrodes are manufactured using this printing process [55].
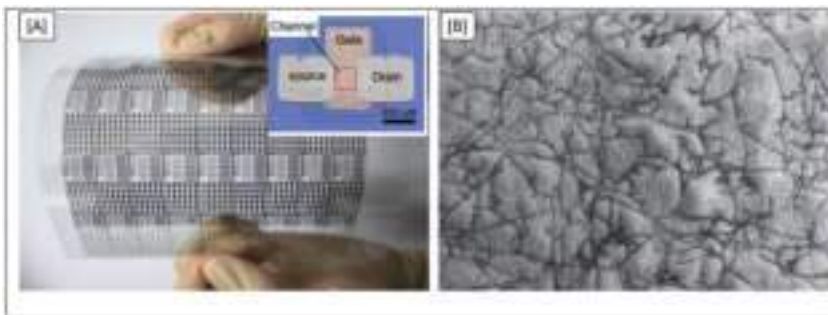
Figure 5.9. (A) TFT sensor based on CNTs fabricated on PEN substrate using flexography process. (B) Scanning electron microscopy image of CNT film [54], reprinted from [54] with permission from IOP Publishing, Copyright (2013).
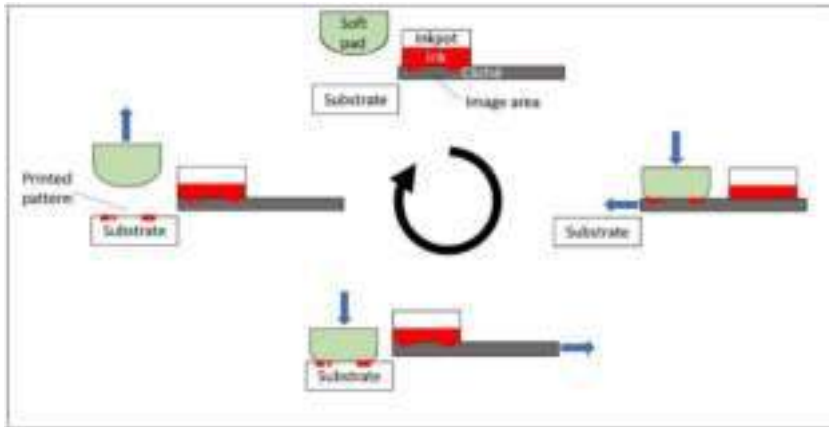
Figure 5.10. Schematic representation of the pad printing process, reprinted from [13] with permission from MDPI, Copyright (2021).

5.3.2 Non-contact printing methods

The non-contact printing process is one in which the nozzles are utilized to spray the ink onto the substrate without any contact with the substrate. The advantage of non-contact printing is that the life of the nozzle is longer because of less contamination, although the non-contact printing process is slow compared to the roll-to-roll manufacturing process. However, the efficiency of the non-contact mode is higher compared to the contact printing process, and it is possible to print computer-aided design (CAD) models, which is not feasible in the contact printing process. Hence, contact printing can be used to manufacture prototypes or used for highly demanded products [56].

5.3.2.1 Inkjet printing process

The inkjet printing process is a type of additive manufacturing process, which transfers ink onto the substrate based on digital CADs and does not utilize any physical patterns. Normally, the inkjet printing process uses inks with low viscosities so that deposition on ink will be easily compared to highly viscous ink. The inkjet printing process is of two types: (i) drop-on-demand and (ii) continuous printing. A voltage source is used to maintain a continuous flow of ink on the substrate. The inkjet printers, which use a thermal source, are very widely used in the packaging and graphic designing industries. In drop-on-demand inject printing, the inks are forced toward the substrate based on the digital signal received from the computers [40, 57]. The droplets can be generated either by means of piezoelectric or thermal methods, which is shown in figures 5.11(A) and (B). In thermal energy–based inkjet printers, the inks are enforced out of the printer nozzle by means of vaporization of ink. The volume of the printer nozzle is compressed or decompressed based on the digital input from the computers and the inks are dispersed out of the nozzle in piezoelectric printers. However, the drop-on-demand–based inkjet printing process was most widely used in flexible or wearable electronic fabrication processes owing
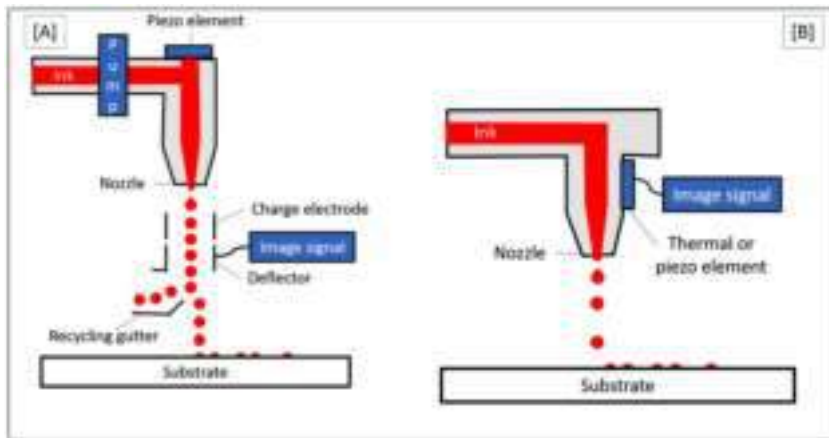
Figure 5.11. Schematic representation of (A) continuous printing and (B) drop-on-demand printing, reprinted from [13] with permission from MDPI, Copyright (2021).
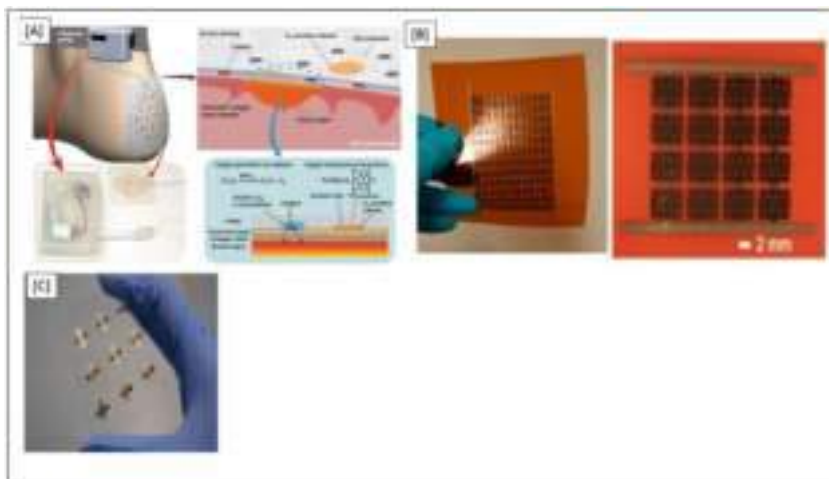
Figure 5.12. (A) Represents the bandage made up of flexible paper for sensing and delivery of oxygen in the treatment of chronic wounds, reprinted from [59] with permission from SPIE, Copyright (2018). (B) Supercapacitors based on graphene used as electrodes, reprinted from [65] with permission from ACS, Copyright (2017). (C) Metal–insulator–metal capacitor fabricated using inkjet printing, reprinted from [61] with permission from Nature, Copyright (2019).

to its advantages such as cost efficiency, high resolution, and easy fabrication without masks [58].

There are various types of flexible or wearable devices that are manufactured through inkjet printing methods. A paper-based oxygen-sensing and delivery sensor in bandage form was fabricated using an inkjet printing process by Ochea *et al.* This bandage was intended to treat chronic wounds as shown in figure 5.12(A). In this work, parchment paper was employed as the substrate over which manganese oxide

and ruthenium inks are deposited, which has the ability to generate and measure oxygen in the wounded area. It is also reported that by varying the thickness of the manganese oxide layer, the oxygen concentration was controlled. The ruthenium coated on the substrate facilitates contactless measuring of oxygen at the wounded region owing to the fluorescence nature of ruthenium ink. These smart bandages also possess good mechanical properties and flexibility compared to that of conventional bandages but also possess additional properties such as oxygen generation, delivery, and therapeutics [59].

The wounds are not the same in nature; it varies according to the type of injuries, location of injuries, and the depth of injuries. Hence, the different concentration of oxygen generation and different therapeutics is necessary. The fabrication of smart bandages that should be done using the inkjet printing process is very important to carry out further research and to customize bandages for mass production. Hence, the importance of this work is in the treatment of wounds [60].

A graphene based super micro capacitors manufactured using exfoliation of graphene using electrochemical process for the application of electrodes and collectors of current and poly(4-styrenesulfonic acid) as ink. The image of the supercapacitors is shown in figure 5.12(B). A metal–insulator–metal capacitor fabricated by Mikolajek *et al* using inkjet printers as shown in figure 5.12(C). The silver ink is coated as metal electrodes and the PMMA/BST is coated as an insulator on PET substrate using inkjet printing process. By using this process, thin, homogeneous, and smooth layers along with better resolution and fewer defects. This PMMA/BST composite insulator layer shows a better dielectric constant when compared to that of pure PMMA [61]. A flexible microfluidic sensor was designed and fabricated by Narakathu *et al* using inkjet printing. This silver-coated sensor has the capacity to detect different hazardous chemicals such as cadmium sulfide, molybdenum disulphate, and mercury sulfide by electrochemical impedance spectroscopy [62]. Because of the attractive characteristics of the inkjet printing process, which includes high resolution and ease of fabrication, a lot of researchers are attracted to develop devices such as SERS substrate sensors for detecting gases, antennas, and bandages [63]. In the inkjet printing process, the clogging of nozzles happens due to the faster rate of evaporation and agglomeration of ink particles, which in turn reduces the efficiency of inkjet printing. Hence, frequent cleaning of the nozzle is a big challenge. Also, the nozzle cartridges for one-time use are usually expensive, owing to the inkjet printing process speed, which is very slow, and the use of the nozzle increases the production time compared to other contact printing processes [64].

5.3.2.2 Aerosol printing process

In the aerosol printing process, the ink is atomized so as to reduce the size of the ink droplets in the range of 1–5 μm in diameter as shown in figure 5.13. The ultrasonic technique or pneumatic method can be utilized to atomize the ink droplets. This system is entirely maintained in vacuum condition, and the ink is directed toward the ceramic nozzle by means of nitrogen gas and transferred onto the substrate under high pressure. It is possible to print on conformal as well as plane surfaces. However,
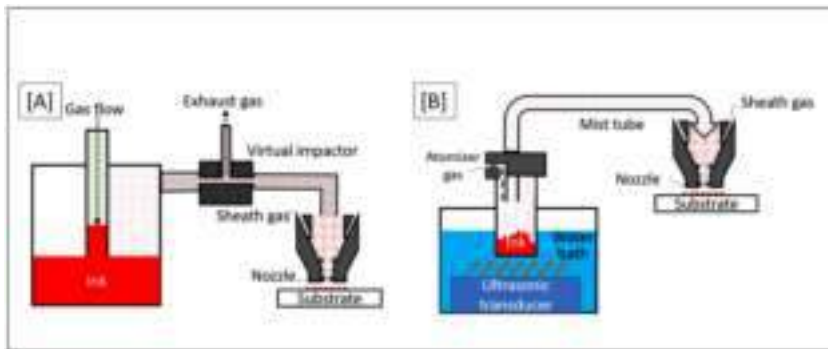
Figure 5.13. Schematic representation of (A) pneumatic aerosol printing and (B) ultrasonic aerosol printing, reprinted from [13] with permission from MDPI, Copyright (2021).

in order to print complex designs, it is necessary to control the beam. Thus, by varying the size of the nozzle, it is possible to control the beam. It is also to be noted that the distance between the nozzle and the substrate should be less than 10 mm or above 1 mm so as to achieve good accuracy because if these boundary conditions are crossed, then there is a possibility of overspray defects in the pattern printed on the substrate. The aerosol printing process also does not need any physical pattern, digital models can be printed using this technique. The following are the advantages of the aerosol printing process: (i) there is no contamination or clogging of the nozzle, and (ii) even small sizes such as 10 μm can be fabricated with high resolution using this process. Conversely, the main shortcoming of the aerosol printing process is the speed. The machining rate is 12 m min^{-1}, which is slow compared to other processes. Hence, this process is not considered for mass production [56, 66, 67].

5.4 Conclusions

The advancement of flexible or wearable electronic devices via different additive manufacturing or printing processes is rising exponentially owing to apparent reasons such as low cost, fast fabrication, light weight, and need for thin devices. In this chapter, the importance of flexible or wearable electronics and the processes to be carried out before and after printing, along with many recently developed flexible electronic devices utilizing different processes, is explored. It is to be noted that there are many scientific difficulties that still exist in manufacturing flexible or wearable electronic devices, which needs to be focused to perform research in a better way, and in adopting suitable advanced printing methods for the fabrication of flexible or wearable devices. One such challenge is the wet film thickness from the screen printing process, which results in more spreading of ink, and the resolution of the printing will be less if the wet ink is not sintered immediately.

Additionally, the evaporation of solvent present in the ink leads to a reduction in the quality of the mesh. This is due to the exposure of the printed surface to the atmosphere for a longer duration during the printing process [68].

In addition, the drawbacks like drying of inks, the viscosity of inks, the quantity of inks, an incorrect volume of anilox roller, and the working speed of the printers result in a squashed ink look at the exterior edges of the patterns printed using the flexographic printing process.

Because of many different issues in fabrication processes, there are enormous inconsistencies in the development of flexible or wearable devices, which leads to unreliability and unsteady performance. To overcome the above-said drawbacks in flexible or wearable devices, the improvisation and standardization of various printing parameters are necessary to develop devices with better reliability, stability, and repeatability. So as to maintain standards and to improve flexible and wearable electronics research to the next level, standardization of all parameters that have a great impact on flexible electronics fabrication is necessary. The parameters include CAD designs, characterization, printing parameters such as deposition time, humidity, and temperatures, post-printing processes such as sintering, mechanical testing, etc. Researchers around the world are working to develop advanced manufacturing systems to develop the research area of flexible or wearable devices to the next level. Hence, implementing these new additive printing methods for flexible or wearable electronic applications would possibly lead to cost-efficient and reliable production. Thus, it is possible to revolutionize the application of flexible or wearable devices in many areas such as agriculture, health, automobile, defense, and food industries.

References

[1] Zeng X, Yang C, Chiang J F and Li J 2017 Innovating e-waste management: from macroscopic to microscopic scales *Sci. Total Environ.* **575** 1–5

[2] Tan M J, Owh C, Chee P L, Kyaw A K K, Kai D and Loh X J 2016 Biodegradable electronics: cornerstone for sustainable electronics and transient applications *J. Mater. Chem.* C **4** 5531–58

[3] Maddipatla D, Narakathu B B and Atashbar M 2020 Recent progress in manufacturing techniques of printed and flexible sensors: a review *Biosensors* **10** 199

[4] Dizon J R C, Espera A H, Chen Q and Advincula R C 2018 Mechanical characterization of 3D-printed polymers *Addit. Manuf.* **20** 44–67

[5] Liu Y, Wang H, Zhao W, Zhang M, Qin H and Xie Y 2018 Flexible, stretchable sensors for wearable health monitoring: sensing mechanisms, materials, fabrication strategies and features *Sensors* **18** 645

[6] Yao S, Swetha P and Zhu Y 2018 Nanomaterial-enabled wearable sensors for healthcare *Adv. Healthcare Mater.* **7** 1700889

[7] Nakata S, Arie T, Akita S and Takei K 2017 Wearable, flexible, and multifunctional healthcare device with an ISFET chemical sensor for simultaneous sweat ph and skin temperature monitoring *ACS Sens.* **2** 443–8

[8] Kipphan H 2001 Printing technologies with permanent printing master *Handbook of Print Media: Technologies and Production Methods* ed H Kipphan (Berlin: Springer) pp 203–448

[9] Kipphan H 2001 Printing technologies without a printing plate (NIP technologies) *Handbook of Print Media: Technologies and Production Methods* ed H Kipphan (Berlin: Springer) pp 675–758

[10] Chang J S, Facchetti A F and Reuss R 2017 A circuits and systems perspective of organic/printed electronics: review, challenges, and contemporary and emerging design approaches *IEEE J. Emerg. Sel. Top. Curcuits Syst.* **7** 7–26

[11] Hashmi S G, Özkan M, Halme J, Zakeeruddin S M, Paltakari J and Grätzel M *et al* 2016 Dye-sensitized solar cells with inkjet-printed dyes *Energy Environ. Sci.* **9** 2453–62

[12] Kjar A and Huang Y 2019 Application of micro-scale 3D printing in pharmaceutics *Pharmaceutics* **11** 390

[13] Wiklund J, Karakoç A, Palko T, Yiğitler H, Ruttik K and Jäntti R *et al* 2021 A review on printed electronics: fabrication methods, inks, substrates, applications and environmental impacts *J. Manuf. Mater. Process.* **5** 89

[14] Magdassi S 2009 *The Chemistry of Inkjet Inks* (Singapore: World Scientific)

[15] Kamyshny A and Magdassi S 2014 Conductive nanomaterials for printed electronics *Small* **10** 3515–35

[16] Izdebska J 2016 Aging and degradation of printed materials *Printing on Polymers: Fundamentals and Applications* (Oxford, UK: Elsevier) PDL Handbook Series 353–70

[17] Martin D P, Melby N L, Jordan S M, Bednar A J, Kennedy A J and Negrete M E *et al* 2016 Nanosilver conductive ink: a case study for evaluating the potential risk of nanotechnology under hypothetical use scenarios *Chemosphere* **162** 222–7

[18] Valentine A D, Busbee T A, Boley J W, Raney J R, Chortos A and Kotikian A *et al* 2017 Hybrid 3D printing of soft electronics *Adv. Mater.* **29** 1703817

[19] Choi Y, dong S K and Piao Y 2019 Metal–organic decomposition ink for printed electronics *Adv. Mater. Interfaces* **6** 1901002

[20] Janczak D, Słoma M, Wróblewski G, Młożniak A and Jakubowska M 2014 Screen-printed resistive pressure sensors containing graphene nanoplatelets and carbon nanotubes *Sensors* **14** 17304–12

[21] Suganuma K 2014 Introduction *Introduction to Printed Electronics* (New York: Springer) pp 1–22

[22] Cui Z 2016 Introduction *Printed Electronics* (New York: Wiley) pp 1–20

[23] Ji T, Sun M and Han P 2014 A review of the preparation and applications of graphene/semiconductor composites *Carbon* **70** 319

[24] Kim M, Safron N S, Han E, Arnold M S and Gopalan P 2010 Fabrication and characterization of large-area, semiconducting nanoperforated graphene materials *Nano Lett.* **10** 1125–31

[25] Hwang S W, Tao H, Kim D H, Cheng H, Song J K and Rill E *et al* 2012 A physically transient form of silicon electronics *Science* **337** 1640–4

[26] Kim S 2020 Inkjet-printed electronics on paper for RF identification (RFID) and sensing *Electronics* **9** 1636

[27] Agate S, Joyce M, Lucia L and Pal L 2018 Cellulose and nanocellulose-based flexible-hybrid printed electronics and conductive composites—a review *Carbohydrate Polym.* **198** 249–60

[28] Välimäki M K, Sokka L I, Peltola H B, Ihme S S, Rokkonen T M J and Kurkela T J *et al* 2020 Printed and hybrid integrated electronics using bio-based andrecycled materials—increasing sustainability with greener materials andtechnologies *Int. J. Adv. Manuf. Technol.* **111** 325–39

[29] Fischer T, Rühling J, Wetzold N, Zillger T, Weissbach T and Göschel T *et al* 2018 Roll-to-roll printed carbon nanotubes on textile substrates as a heating layer in fiber-reinforced epoxy composites *J. Appl. Polym. Sci.* **135** 45950

Q6

[30] Torrisi F, Hasan T, Wu W, Sun Z, Lombardo A and Kulmala T S *et al* 2012 Inkjet-printed graphene electronics *ACS Nano* **6** 2992–3006

[31] Devaraj H and Malhotra R 2019 Scalable forming and flash light sintering of polymer-supported interconnects for surface-conformal electronics *J. Manuf. Sci. Eng.* **141** 041014

[32] Constante G, Apsite I, Alkhamis H, Dulle M, Schwarzer M and Caspari A *et al* 2021 4D biofabrication using a combination of 3d printing and melt-electrowriting of shape-morphing polymers *ACS Appl. Mater. Interfaces* **13** 12767–76

[33] Khan S, Lorenzelli L and Dahiya R S 2015 Technologies for printing sensors and electronics over large flexible substrates: a review *IEEE Sens. J.* **15** 3164–85

[34] Saengchairat N, Tran T and Chua C K 2017 A review: additive manufacturing for active electronic components *Virtual Phys. Prototyp.* **12** 31–46

[35] Reddy A S G, Narakathu B B, Atashbar M Z, Rebros M, Rebrosova E and Joyce M K 2011 Fully printed flexible humidity sensor *Procedia Eng.* **25** 120–3

[36] Maddipatla D, Janabi F, Narakathu B B, Ali S, Turkani V S and Bazuin B J *et al* 2019 Development of a novel wrinkle-structure based SERS substrate for drug detection applications *Sens. Bio-Sens. Res.* **24** 100281

[37] Zhu H, Narakathu B B, Fang Z, Tausif Aijazi A, Joyce M and Atashbar M *et al* 2014 A gravure printed antenna on shape-stable transparent nanopaper *Nanoscale* **6** 9110–5

[38] Bariya M, Shahpar Z, Park H, Sun J, Jung Y and Gao W *et al* 2018 Roll-to-roll gravure printed electrochemical sensors for wearable and medical devices *ACS Nano* **12** 6978–87

[39] Lau P H, Takei K, Wang C, Ju Y, Kim J and Yu Z *et al* 2013 Fully printed, high performance carbon nanotube thin-film transistors on flexible substrates *Nano Lett.* **13** 3864–9

[40] Kipphan H (ed) 2001 *Handbook of Print Media: Technologies and Production Methods* (Berlin: Springer) p 1207

[41] Emamian S, Narakathu B B, Chlaihawi A A, Bazuin B J and Atashbar M Z 2017 Screen printing of flexible piezoelectric based device on polyethylene terephthalate (PET) and paper for touch and force sensing applications *Sensors Actuators* A **263** 639–47

[42] Turkani V S, Maddipatla D, Narakathu B B, Altay B N, Fleming P D and Bazuin B J *et al* 2019 Nickel based RTD fabricated via additive screen printing process for flexible electronics *IEEE Access* **7** 37518–27

[43] Dhanabalan S S, Arun T, Periyasamy G, N D, N C and Avaninathan S R *et al* 2022 Surface engineering of high-temperature PDMS substrate for flexible optoelectronic applications *Chem. Phys. Lett.* **800** 139692

[44] Sundar D S, Raja A S, Sanjeeviraja C and Jeyakumar D 2017 High temperature processable flexible polymer films *Int. J. Nanosci.* **16** 1650038

[45] Sundar D S, Sivanantharaja A, Sanjeeviraja C and Jeyakumar D 2016 Synthesis and characterization of transparent and flexible polymer clay substrate for OLEDs *Mater. Today: Proc.* **3** 2409–12

[46] Shanmuga sundar D, Sivanantha Raja A, Sanjeeviraja C and Jeyakumar D 2016 Highly transparent flexible polydimethylsiloxane films—a promising candidate for optoelectronic devices *Polym. Int.* **65** 535–43

[47] Cinti S and Arduini F 2017 Graphene-based screen-printed electrochemical (bio)sensors and their applications: efforts and criticisms *Biosens. Bioelectron.* **89** 107–22

[48] Cao R, Pu X, Du X, Yang W, Wang J and Guo H *et al* 2018 Screen-printed washable electronic textiles as self-powered touch/gesture tribo-sensors for intelligent human–machine interaction *ACS Nano* **12** 5190–6

[49] Hakola E 2009 Principles of conventional printing ed P Oittinen and H Saarelma *Papermaking Science and Technology* (Finland: Finnish Paper Engineers' Association) pp 40–87

[50] Dhanabalan S S, R S, Madurakavi K, Thirumurugan A, M R and Avaninathan S R *et al* 2022 Flexible compact system for wearable health monitoring applications *Comput. Electr. Eng.* **102** 108130

[51] Shrestha S, Yerramilli R and Karmakar N C 2019 Microwave performance of flexo-printed chipless RFID tags *Flex. Print. Electron.* **4** 045003

[52] Fung C M, Lloyd J S, Samavat S, Deganello D and Teng K S 2017 Facile fabrication of electrochemical ZnO nanowire glucose biosensor using roll to roll printing technique *Sensors Actuators* B **247** 807–13

[53] Maddipatla D, Narakathu B B, Avuthu S G R, Emamian S, Eshkeiti A and Chlaihawi A A *et al* 2015 A novel flexographic printed strain gauge on paper platform *IEEE Sensors* **2015** 1–4

[54] Higuchi K, Kishimoto S, Nakajima Y, Tomura T, Takesue M and Hata K *et al* 2013 High-mobility, flexible carbon nanotube thin-film transistors fabricated by transfer and high-speed flexographic printing techniques *Appl. Phys. Express* **6** 085101

[55] Knobloch A, Bernds A and Clemens W 2001 Printed polymer transistors *1st Int. IEEE Conf. on Polymers and Adhesives in Microelectronics and Photonics Incorporating POLY, PEP & Adhesives in Electronics Proc. (Cat No01TH8592)* pp 84–90

[56] Saengchairat N, Tran T and Chua C K 2017 A review: additive manufacturing for active electronic components *Virtual Phys. Prototyp.* **12** 31–46

[57] Izdebska-Podsiadły J and Thomas S 2015 *Printing on Polymers: Fundamentals and Applications* (Amsterdam: Elsevier)

[58] Corzo D, Almasabi K, Bihar E, Macphee S, Rosas-Villalva D and Gasparini N *et al* 2019 Digital inkjet printing of high-efficiency large-area nonfullerene organic solar cells *Adv. Mater. Technol.* **4** 1900040

[59] Ochoa M, Rahimi R, Zhou J, Jiang H, Yoon C K and Oscai M *et al* 2018 A manufacturable smart dressing with oxygen delivery and sensing capability for chronic wound management *Micro- and Nanotechnology Sensors, Systems, and Applications X* 10639; T George, A K Dutta and M S Islam (Bellingham, WA: SPIE) p 106391C

[60] Maddipatla D, Narakathu B B, Ochoa M, Rahimi R, Zhou J and Yoon C K *et al* 2019 Rapid prototyping of a novel and flexible paper based oxygen sensing patch via additive inkjet printing process *RSC Adv.* **9** 22695–704

[61] Mikolajek M, Reinheimer T, Bohn N, Kohler C, Hoffmann M J and Binder J r 2019 Fabrication and characterization of fully inkjet printed capacitors based on ceramic/polymer composite dielectrics on flexible substrates *Sci. Rep.* **9** 13324

[62] Narakathu B B, Avuthu S G R, Eshkeiti A, Emamian S and Atashbar M Z 2015 Development of a microfluidic sensing platform by integrating PCB technology and inkjet printing process *IEEE Sens. J.* **15** 6374–80

[63] Abutarboush H F and Shamim A 2018 A reconfigurable inkjet-printed antenna on paper substrate for wireless applications *IEEE Antennas Wirel. Propag. Lett.* **17** 1648–51

[64] Martin G D, Hoath S D and Hutchings I M 2008 Inkjet printing—the physics of manipulating liquid jets and drops *J. Phys. Conf. Ser.* **105** 012001

[65] Li J, Sollami Delekta S, Zhang P, Yang S, Lohe M R and Zhuang X *et al* 2017 Scalable fabrication and integration of graphene microsupercapacitors through full inkjet printing *ACS Nano* **11** 8249–56

[66] Dimitriou E and Michailidis N 2021 Printable conductive inks used for the fabrication of electronics: an overview *Nanotechnology* **32** 502009

[67] Chen Y D, Nagarajan V, Rosen D W, Yu W and Huang S Y 2020 Aerosol jet printing on paper substrate with conductive silver nano material *J. Manuf. Processes* **58** 55–66

[68] Joannou G 1988 Screen inks ed R H Leach, C Armstrong, J F Brown, M J Mackenzie, L Randall and H G Smith *The Printing Ink Manual* (Boston, MA: Springer) pp 481–514

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Page 3

Q1
 Please expand the following acronyms in the text as appropriate: "UHIF," "WCNT," and "BST."

Page 3

Q2
 The following acronyms have been expanded in the text: "PEDOT: PSS" as "poly (3,4-ethylenedioxythiophene) polystyrene sulfonate," "PI" as "polyimide," "SES" as "solvent-excluded surface," and "EIS" as "electrochemical impedance spectroscopy." Please confirm or make any necessary changes.

Page 3

Q3
 The following acronyms have been defined in the text: "SERS" as "surface-enhanced Raman scattering," "TPU" has been defined "thermoplastic polyurethane," and "CAD" as "computer-aided design." Please confirm or make any necessary changes.

Page 12

Q4
 Figures 5.5, 5.7, 5.8, and 5.12 are of low resolution. Please provide better resolution figures (at least 300 ppi at 80 mm).

Page 18

Q5
 Please complete the sentence "By using this process, thin, homogeneous, and smooth...".

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 Reference [26] in the original source file was a duplicate of Reference [21], and hence, the repeated version has been deleted from the reference list and subsequent references have been reordered. Please check.

Comparative Performance Evaluation of Wire-bonded Micro Heat Pipes with Acetone and Water as Working fluid

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Abstract— **Thermal management of high-heat-flux dissipation-rate micro-electro-mechanical systems (MEMS) using micro heat pipes is an exciting new field. Desktop computers are cooled using heavy metal sinks and fans. Wire sandwiched micro heat pipes are analysed computationally; they are a novel type of micro heat pipe that uses an array of wires sandwiched between two metallic plates to create the flow channels. Work fluid is carried through the system by the sharp corners between the wires and plates, which serve as liquid arteries. The temperature distribution in the micro heat pipes is obtained by solving the numerical model with a finite difference approach. By calculating effective thermal conductivity values from the temperature profiles, we can compare the heat pipe's performance using acetone and water as the working fluid. With an effective thermal conductivity of 168.83 kW/m^{2}K, acetone shows substantial improvement over water in heat pipes.**

Keywords- acetone, effective thermal conductivity, micro heat pipe, water

Nomenclature

A	=	*area of cross-section in m^2*
k	=	*thermal conductivity in W/m K*
L	=	*length of the heat pipe in m*
Q	=	*heat in W*
q	=	*heat flow rate in W/m^2*
T	=	*temperature in K*
ΔT	=	*temperature difference, T-T$_{amb}$ in K*

Subscripts

c	=	*cross-section*
eff	=	*effective*

I. INTRODUCTION

Progress in modern technology is often driven by innovations in microelectronics, aims at progress in the ability of computing with improvement in speed of processing, and reduction in the size of components and devices. The challenges in the miniaturization of silicon components and the enhancement of their performance have led to the development of high-power electronic devices and CPUs with high packing densities. This has opened the way for the advancement of electronic devices with very high levels of heat generation rates, for a variety of industrial applications. As modern electronics demands very rigid specifications regarding miniaturization, reliability and power-component density, optimal thermal management of microelectronics has become a key issue for the designer and the engineer in recent times.

In general, for cooling electronic devices, there are many existing conventional methods. Passive air cooling is one basic way of cooling electronic devices, where the convective currents occur without the support of external power. The difference in temperature and subsequent changes in the density of the medium causes the flow. Forced air cooling systems are used as a common method for cooling in CPUs, where a fan will enhance the flow over the heat sinks for effective cooling. Liquids like water are used in forced liquid systems which are another set of cooling techniques used in electronic cooling. Of all the three methods, the second one has a prominent usage in electronic cooling due to its simplicity in design and manufacturing and cost-effective nature. Though the method is common and simple, bulky heat sinks utilize more material for manufacturing. The fan also increases the dust deposit over the components which in turn forms to be an insulator as the thickness of the deposit increases.

To remove heat from the source with smaller dimensions to a remote location, micro heat pipes are the best options. The micro heat pipe, as defined by Cotter (1984) has 'channels which are so small, that the mean curvature of the vapour–liquid interface is comparable in magnitude to the reciprocal of the hydraulic radius of the flow channel' [1]. Even though micro heat pipes poses evaporator, adiabatic and condenser sections and rely on the thermal phenomenon similar to that in conventional heat pipe [2], [3], they are physically distinct and compact from the former due to the absence of wick. In micro heat pipes, liquid arteries formed by the non-circular cross sections enables the transfer of working fluid from the condenser to evaporator sections. [7]. Micro heat pipes and heat spreaders continue to be the optimal solution for heat sinks and miniature equipments and devices respectively,

owing to their effective heat transport capability with trivial temperature gradient in the flow direction (high thermal conductance).

The wire-sandwiched micro heat pipe essentially consists of an array of channels, developed from sandwiching an array of wires within the metal plates. The ease in its construction, simple structure and adaptability to many heat-generating surfaces, made the micro heat pipes with wire bonds, a favorable option for cooling electronic devices. Each channel in the array acts as an individual micro heat pipe as depicted in Fig. 1. It comprises of an evaporator which is externally heated, an adiabatic segment devoid of any heat transfer and a condenser experiencing convective cooling. The area of cross-section of the liquid and the vapour change longitudinally from the evaporator end to the condenser end is displayed in Fig 1(c).

The conceptual wire-bonded micro heat pipes were initially presented by Wang and Peterson [4] as a one-dimensional analytical-steady-state model. The liquid-vapour phase interactions were analysed in the model and found the highest heat transfer performance. The fabrication easiness, better integration capability with electronic devices, and suitability for spacecraft applications were major attractions of the new model. The experimental validation in the studies proved the feasibility of the design and determined the optimum values for the design. The combination of aluminium - fluid acetone was used in the proposed design.

The performance investigation of a wire-bonded micro heat pipe array was done by Launay et al. [5]. A copper-water system was used to determine the capillary limitations in the temperature field and experimentally compare the charged micro heat pipes with empty channels. A numerical model was also used for predicting the effects of angle of contact, quantity of charge and fluid distribution.

To evaluate the efficiency of wire-bonded micro heat pipes, Rag and Sobhan [6] created a transient one-dimensional model. In order to derive the velocity, pressure, and temperature distributions, a fully implicit finite difference approach was used to solve the mass, momentum, and energy conservation equations. The efficiency of the wire-bonded micro heat pipe was determined by computing its effective thermal conductivity. Using the working fluid's constant thermo-physical properties, the equations accounted for longitudinal area fluctuations, phase shift, and frictional effects. Rag and Sobhan [7] used the same one-dimensional transient model to analyse the effects of operational and geometrical variables on effective thermal conductivity. Maximum values of effective thermal conductivity were achieved by optimising these parameters within the usable range. The transient variation of thermo-physical parameters was incorporated into a numerical model and quantitative measures of thermal conductivity were obtained by varying the input heat flux at the evaporator and condenser heat transfer coefficient by Rag et al. [8]. More realistic operational and performance characteristics were obtained when it comes to a wide variety of operational parameters.

In the present analysis, the temperature profiles are predicted computationally using an in-house code and evaluated the efficacy of a wire-bonded micro heat pipe which can be used for replacing the existing heat sink in a desktop computer. The already developed transient one-dimensional model is modified to accommodate two different working fluids, water and acetone, compatible with copper as the material of the micro heat pipes [2]. An experiment using acetone-aluminum system was used in a previous study [4] for validation of results in another study [6], acetone is considered as the second fluid for the present analysis. The dimension details of the micro heat pipes were listed in Table 1.
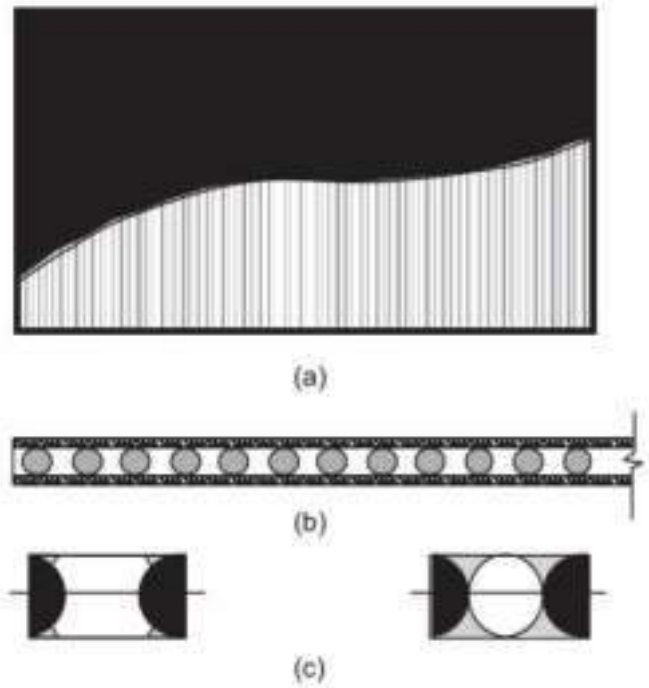
Fig. 1. Schematic of a wire sandwiched micro heat pipe

TABLE I.   PHYSICAL PROBLEM DETAILS

Parameter	Value
Solid Material	Copper
Working Fluids	Acetone/ Water
Heat Pipe length	125 mm
Wire radius	0.8 mm
Wire-pitch	2 mm
Evaporator length	20 mm
Adiabatic section length	85 mm

II.   FORMULATION

Line connections are only present at either end of the wires wedged between the parallel plates. Any two such wires

form a miniature heat pipe, with vapour flowing along the middle and liquid moving around the edges of the plate and wires. The wire-bonded micro heat pipe can be broken down into an evaporator section that takes in heat and releases it to the surroundings, an adiabatic section that does not exchange heat with anything else, and a condenser section that releases heat to the surroundings or the cooling media that is circulating around it. The analysis takes into account the fact that the vapour and liquid cross-sectional areas will change along the length. A one-dimensional numerical model is employed for transient analysis since the most significant changes in flow characteristics occur along the flow's longitudinal axis. These presumptions constitute the basis for the formulation of the governing equations:

1. Vapor and liquid laminar flow.
2. No-slip liquid and vapour boundary conditions.
3. Vapor saturation.
4. Meniscus radius of curvature consistency.

For a quasi-steady state, the Laplace Young equation can be used to connect the pressure differential between the liquid and vapour phases to the meniscus radius at a given axial point. Pressure, velocity, and temperature profiles are analysed to determine the micro heat pipes' efficiency by solving the equations for mass, momentum, and energy in differential form for the liquid and vapour phases. As a function of the radius of the meniscus, the longitudinal area of the liquid and vapour phases are accounted for in their respective governing equations. The equation of state establishes a connection between the vapour pressure and temperature, which is then restated in terms of vapour momentum to ensure convergence. The liquid pressure is approximated using the Hagan-Poisseuille equation, but for more converged results, the numbers are re-entered into the liquid momentum equation. Although triangle-shaped micro heat pipes [5, 9] use the same approach and mathematical formulation, the calculations must account for unique area characteristics. Previous papers contain the area parameters and the governing equations.

III. SOLUTION PROCEDURE

A custom FORTRAN programme is used to implement a Finite Difference technique to solve the governing equations. The first and second-order derivatives in the finite difference formulation were calculated using central differences. The thermo-physical qualities that vary with temperature are accounted for in the programme. In addition to the conventional solution procedure's [6]-[8] phases, a new function is introduced to define the working fluid's characteristics. Choosing the working fluid allowed the code to make use of the fluid's temperature-dependent thermophysical features and produce more accurate predictions. The heat balance test and the grid independent test of the code were conducted and shown in the previous publications extensively [6].

IV. THE TEMPERATURE PROFILE

In this analysis for acetone and water as working fluid, the input heat flux supplied is taken as 2.4 W/cm^2 and the coefficient of heat transfer in the condenser is taken as 650W/m^{2}K, which are reasonable values in electronic devices generating heat [6]–[8]. From Fig. 2 it is clear that the temperature profiles are as anticipated based on the previous literature [6]–[8]. The influence of the evaporator is observed in the smooth behaviour of temperature distribution at the evaporator-adiabatic junction and that of the condenser is seen at the adiabatic-condenser junction. Since the state equation is used to approximate vapour pressure, both vapour temperature and vapour pressure exhibit a consistent longitudinal fluctuation. Micro heat pipe performance is analysed by determining the effective thermal conductivity using the vapour temperature distributions.

V. PERFORMANCE EVALUATION

To evaluate the relative performance of different micro heat pipe designs, researchers use effective thermal conductivity [6]–[8]. According to Fourier's rule of thermal conduction, it is defined as follows:

$$k_{eff} = \frac{Q}{A_c \frac{\Delta T}{L}} \quad (1)$$

Wire-bonded micro heat pipes using acetone as the working fluid are shown to have an effective thermal conductivity of 168.83 kW/mK, while water only has an effective thermal conductivity of 127.27 kW/mK. Acetone is showing better effective thermal conductivity in the selected heat flux input and heat transfer coefficient of a condenser.
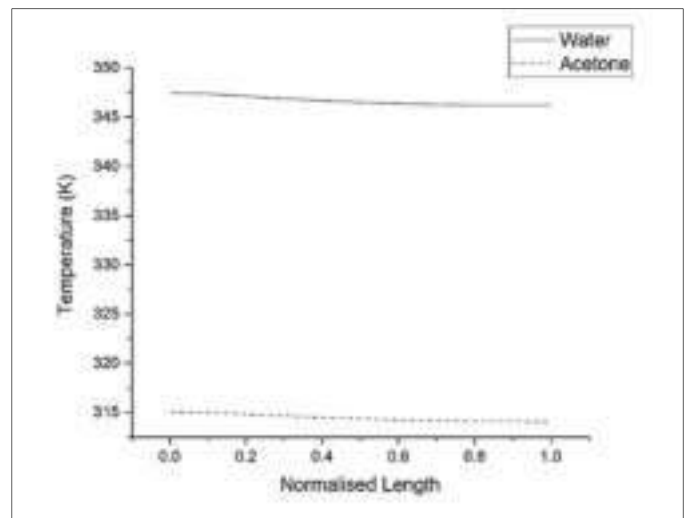

Fig. 2.   Temperature profile for 2.4 W/cm^2 input heat flux and 650 W/m^{2}K condenser heat transfer coefficient

VI. CONCLUSIONS

In order to compare the efficiency of wire-bonded micro heat pipes using acetone and water as working fluid and copper as material, a computational analysis is carried out.

Using a fully implicit finite difference approach, the mathematical model is solved to obtain the temperature profiles for both working fluids. With an effective thermal conductivity of 168.83 kW/mK, acetone proves to be a great medium for a heat pipe, outperforming even water.

REFERENCES

[1] T. P. Cotter, "Principles and prospects for micro heat pipes," in *Proceedings of the 5th International Heat Pipe Conference*, Tsukuba, Japan, Jan. 1984, vol. 1984, pp. 328–335. Accessed: Apr. 27, 2022. [Online]. Available: https://www.osti.gov/biblio/5246927

[2] G. P. Peterson, *An introduction to heat pipes: modeling, testing, and applications*. New York: Wiley, 1994.

[3] C. Sobhan, R. Rag, and G. Peterson, "A review and comparative study of the investigations on micro heat pipes," *Int. J. Energy Res.*, vol. 31, pp. 664–688, May 2007, doi: 10.1002/er.1285.

[4] Y. Wang and G. Peterson, "Analysis of Wire-Bonded Micro Heat Pipe Arrays," *J. Thermophys. Heat Transf. - J THERMOPHYS HEAT Transf.*, vol. 16, pp. 346–355, Jul. 2002, doi: 10.2514/2.6711.

[5] J. P. Longtin, B. Badran, and F. M. Gerner, "A One-Dimensional Model of a Micro Heat Pipe During Steady-State Operation," *J. Heat Transf.*, vol. 116, no. 3, pp. 709–715, Aug. 1994, doi: 10.1115/1.2910926.

[6] R. L. Rag and C. B. Sobhan, "Computational Analysis of Fluid Flow and Heat Transfer in Wire-Sandwiched Microheat Pipes," *J. Thermophys. Heat Transf.*, vol. 23, no. 4, pp. 741–751, 2009, doi: 10.2514/1.44101.

[7] R. L. Rag and C. B. Sobhan, "Computational Analysis and Optimization of Wire-Sandwiched Micro Heat Pipes," *Int. J. Micro-Nano Scale Transp.*, vol. 1, no. 1, pp. 57–78, 2010.

[8] R. L. Rag, C. Sobhan, and G. Peterson, "Computational Analysis of Wire-Bonded Micro Heat Pipe: Influence of Thermophysical Parameters," *J. Thermophys. Heat Transf.*, vol. 32, pp. 1–8, Apr. 2018, doi: 10.2514/1.T5359.

[9] C. Sobhan and G. Peterson, "Modeling of the Flow and Heat Transfer in Micro Heat Pipes," Rochester, NY, Jan. 2004, pp. 883–890. doi: 10.1115/ICMM2004-2426.

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Filtering of Spurious Sonar Signals

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Abstract—Navy uses a harmonic filter to extract the propel sounds in ships. Usually, Sonar processing uses the harmonic filter to remove unwanted harmonics. The proposed system is used for filtering unwanted noise from lower frequency noise using the machine learning technique. Some sonar may have higher frequency sounds, which can be difficult to hear. Using this sound frequency humans can identify their target by experience. Automate these sounds and using a trained neural network, Classify the sounds. Retrieve non-frequency voice and avoid harmonics using a neural network.

Index Terms— MFCC, MLP, High pass filter, Discrete cosine transform.

I. INTRODUCTION

Currently, there is no specialized machine learning technique for the classification of the frequency of sonar: higher frequency and lower frequency. The word "sonar"[1] (short for "sound navigation ranging") refers to a technique for using sound waves to locate and measure the size and location of submerged objects. Sonar equipment detects sound waves emitted by or reflected from the item and analyses them to determine what information is contained.

The main objective of this topic is to classify the frequency of sound, and then remove the noise in high-frequency sonar. This problem was very difficult to deal with because the research on sonar classification and filtering of sonar is processed by normal techniques, in this work using deep learning method is used to process the classification and filtering of sonar sound. The extraction of the needed signal from background noise is one of the most serious issues in many application fields. Background noise is random, as is the appearance and behavior of signals. Basically in navy use a harmonic filter to remove unwanted noises. It is a time-consuming process. In this work, the Classification of sonar sound is done by a Multilayer perceptron algorithm and a high pass filter is used to remove the unwanted noises from high-frequency sonar sound.

Classification of the frequency of sonar and removing noises from sonar sound is helpful to detect the target. Sonar is a method that employs sound propagation to navigate, measure distances, communicate with, or detect objects on or below the water's surface, such as other boats. classification of sonar sound in normal ways returns a time-consuming process, using trained neural network got a better accuracy result of classification. Normally harmonic filter is used for filtering unwanted noise from high-frequency sonar sound, which is also a time-

consuming process, high pass filter is better to use for a filtering process.

II. METHODOLOGY

The classification of frequency of sonar sound using multi-layer perceptron and filtering of high sonar sound is time reducing process. In normal audio, there is a signal and so many noises. first, take input as a wav file with noises and get output as filtered audio only without any spurious signal. Humans can identify their target by experience utilizing sonar that has a higher frequency that can be challenging to hear.

A. MFCC

Mel-frequency cepstrum (MFC)[2], which are employed in sound processing, are representations of a sound's short-term power spectrum that are based on a linear cosine transform of a log power spectrum on a nonlinear Mel scale of frequency. Several coefficients collectively referred to as Mel-frequency cepstral coefficients make up an MFC (MFCCs).
MFCCs are frequently employed as features in speech recognition systems, including those[3] that can automatically identify telephone number pronunciations. Applications for music information retrieval such as genre categorization, auditory similarity measurements, etc. are also increasingly using MFCCs.
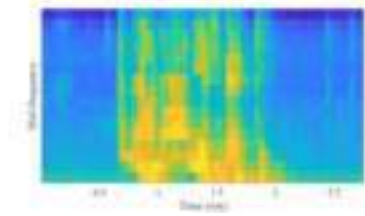

Fig 1:Mel-frequency Cepstrum

B. MLP

The term "Multilayer Perceptron"[4] refers to a fully connected multi-layer neural network (MLP). It contains three levels, one of which is buried. It is referred to as a deep ANN if it has more than one hidden layer. A common illustration of a feedforward artificial neural network is an MLP. MLP is used for [5]a number of applications, including stock analysis, image identification, spam detection, and election voting 11 predictions. Basically, add more parameters to the model by adding more hidden layers and neurons per layer. Then permit the model to fit intricate functions.

C. High pass filter

A high pass filter is a[6] straightforward, efficient EQ curve that removes unwanted low frequencies from any audio source. When used properly to fix sloppy signals and tighten up arrangements, they are great. Low pass filter: The image is smoothed using this particular style of frequency-domain filter. The low-frequency[7] components are preserved while the high-frequency components are attenuated. High pass filter: A high pass frequency-domain filter is used to enhance the sharpness of the image.

III. IMPLEMENTATION

Filtering of spurious sonar signals consists of the following steps:
- Padding of given wav file dataset.
- Feature extraction of audios.
- Classification of frequency of sonar sounds.
- Removal of unwanted harmonics from an audio file.

Sonar sound can be classified by the neural network, in this work, MLP is used for classification purposes.
First, take all datasets; the dataset contains two folders high-frequency sound and low-frequency sound. The dataset contains 250 audios within each folder. categorize and label this dataset into two.
Padding each audio with respect to a fixed sample rate, so get the dataset containing each audio with the same length. In this work, each audio has a size of 5. The dataset is a wav file and Audio padding is necessary for classification. Librosa library[8] is used for padding. This is also a pre-processing step of the dataset. For feature extraction, the MFCC algorithm is used. In this work, the extracted feature is frequencies by the MFCC algorithm. Find the MFCC value of each audio file after padding. The main steps in the MFCC[9] feature

Fig 2: High-Level_Architecture

TABLE I: LIST OF SOUND FREQUENCY

Labels	categories
0	High-frequency sound
1	Low-frequency sound

extraction method are windowing the signal, running the DFT, getting the log of the magnitude, warping the frequencies on a Mel scale, and finally running the inverse DCT.
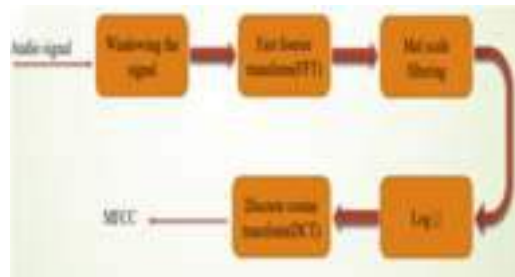

Fig 3: Diagram of MFCC

Building a proper network architecture is required to acquire a trained model immediately after receiving a clean database. Build a model using a multi-layer perceptron algorithm and having 2 hidden layers with 4 neurons.

To train the built model, the training dataset was split into patches, and the training loop sent each batch through an optimizer to train our model, with training accuracy being evaluated for each batch. Then the model is now ready to be tested with new audio after completing the training stage.

After classification, if it is a high-frequency sound remove the noises using a High pass filter. An easy-to-use, efficient EQ curve that removes undesired low frequencies from any audio source is a high pass filter. When properly applied, they are wonderful for cleaning up errant signals and tightening up arrangements.

IV. RESULT AND DISCUSSION

The project was able to build filtering of spurious sonar signals using machine learning techniques, which will classify the sonar sounds as high-frequency sounds and low-frequency sounds using multilayer perceptron and remove unwanted harmonics using a high pass filter. MLP algorithm used was able to classify the sonar sounds. The experimental findings are acquired by training with a number of audios. The sonar sound dataset is used for training purposes, which consists of 2 folders high-frequency sound and low-frequency sound and contains 300 audios within each folder. The classification accuracy is 84%, which is also a good result, it also works properly and very well.

The accuracy is more feasible when optimum iterations are performed. Test an audio file with a trained model, which gives output as 0 as High-frequency sound or 1 as Low-frequency sound. Passing a high pass filter to remove the unwanted noises from High-frequency sound, which save an audio signal without noises.

V. Conclusion and Future Scope

Filtering of spurious sonar signals using machine learning techniques shows a wide range of applications in NAVY. The main objective of this project is the classification of the frequency of sonar sounds and the filtering of noises from high-frequency sonar sounds. Deep learning is the most powerful science in working with pictures by completing feature extractions to categorize what this image includes, according to studies. Related work surveys are conducted by reading several papers written by earlier scientists and developers that attempted to address the classification of sonars and target detection of sonar, some of which used the Fast Fourier transform algorithm and Artificial neural network. Python is utilized to implement this project since it is the most popular language for Artificial Intelligence and Deep Learning. The project has some limitations; because the availability of frequency of sonar sounds and removal of unwanted harmonics from a lower frequency audio file take more time, which is called LOFAR processing. Hence this process is done on high-frequency sonar sounds only. Here the best classification algorithm convolutional neural network (CNN) failed to perform the expected task because of the limited access to the dataset. Later it was executed well using MLP and it was successful.

References

[1] Hartvich, Filip, et al. "Landslide☐dammed lake sediment volume calculation using waterborne ERT and SONAR profiling." Earth Surface Processes and Landforms 45.14 (2020): 3463-3474.

[2] Martin, Betty, and Vimala Juliet. "Extraction of feature from the acoustic activity of RPW using MFCC." Recent Advances in Space Technology Services and Climate Change 2010 (RSTS & CC-2010). IEEE, 2010.

[3] Gupta, Shikha, et al. "Feature extraction using MFCC." Signal & Image Processing: An International Journal 4.4 (2013): 101-108.

[4] He, Yunan, et al. "Surface emg pattern recognition using long short-term memory combined with multilayer perceptron." 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). IEEE, 2018.

[5] Fazeen, Mohamed, Ram Dantu, and Parthasarathy Guturu. "Identification of leaders, lurkers, associates and spammers in a social network: context-dependent and context-independent approaches." Social Network Analysis and Mining 1.3 (2011): 241-254.

[6] Zhang, Kai, et al. "Direct repetitive control of SPWM inverter for UPS purpose." IEEE Transactions on Power Electronics 18.3 (2003): 784-792.

[7] Magid, Salma Abdel, et al. "Dynamic high-pass filtering and multi-spectral attention for image super-resolution." Proceedings of the IEEE/CVF International Conference on Computer Vision. 2021.

[8] Mushtaq, Zohaib, and Shun-Feng Su. "Environmental sound classification using a regularized deep convolutional neural network with data augmentation." Applied Acoustics 167 (2020): 107389.

[9] Phadke, Sujay, et al. "On design and implementation of an embedded automatic speech recognition system." 17th International Conference on VLSI Design. Proceedings.. IEEE, 2004.

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Deep learning architectures for Brain Tumor detection: A Survey

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Abstract:
Deep learning methods are used in various fields of medical imaging like medical image localization/Detection segmentation, classification, and registration. Various medical conditions can be detected, monitored, and treated with deep learning techniques. One such condition is brain tumors. The main cause of brain tumors is the fast and uncontrolled development of brain cells. Over time, numerous techniques for detecting brain tumors have been developed. Manual analysis of brain tumor images will be time-consuming and it requires expert radiologists. Deep learning techniques can solve this issue since it is a fully automated process. Various deep learning architectures are used nowadays for different pattern recognition tasks in medical imaging. This survey aims to deliver different recent deep learning models developed to detect brain tumors and to present the drawbacks of existing techniques.

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I. Introduction

In medical systems, the analysis of medical image services is significant in many fields like Magnetic Resonance Imaging (MRI), Radiography, endoscopy, Computed Tomography, Mammography Images, Ultrasound images, Positron Emission Tomography (PET), etc. Due to the lack of radiologists, manually analyzing medical images requires a significant amount of effort. Thus emerges different deep learning models for analyzing medical images. The most significant models are Convolutional neural networks which belong to the category of supervised deep learning algorithms. Unsupervised algorithms mainly include Generative Adversarial Networks (GAN) and Autoencoders.

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Tiled Chip Multicore Processors (TCMP) with packet switching Network-on-Chip (NoC) have become a common method for on-chip connectivity. The performance of the entire system may suffer if a malicious Hardware Trojan (HT) is present in the NoC routers as it might negatively disrupt communication between tiles. Detecting Trojans in complicated multi-processor System on Chips (SoCs) using traditional pre and post silicon validation approaches is a huge difficulty. In this paper the presence of multiple HTs in the routing unit is modelled and its impact analysis is done for both synthetic traffic and real benchmarks using gem5 simulator. It can be observed that the presence of multiple trojans decrease the overall performance of the system.

Published in: 2023 International Conference on Control, Communication and Computing (ICCC)

Date of Conference: 19-21 May 2023

Date Added to IEEE *Xplore*: 04 July 2023

▶ **ISBN Information:**

DOI: 10.1109/ICCC57789.2023.10165276

Publisher: IEEE

Conference Location: Thiruvananthapuram, India

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I. Introduction

System-on-Chips (SoCs) began containing third party Intellectual Property (IP) blocks to lower the overall cost of microprocessors used in embedded systems and the Internet of Things. Several chip manufacturing firms outsource the automated integrated circuit design, production, and testing due to the high design costs [1]. The logical and operational security of such devices are at danger because suspicious third parties were involved at different stages of chip manufacture. During the SoC's verification and testing process, malicious circuits known as Hardware Trojans (HT) concealed inside a trustworthy blueprint design may go undetected [2]. HTs may modify the system's behaviour in order to launch attacks including data breaches, unauthorised access, functional defects, and service delays [3]. Because these intermittent HTs are only active for a brief period of time, HT identification is difficult [4].

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Image Forgery Detection Using Deep Learning

Litty Koshy ✉ & K. Chithu

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Abstract

Since cameras are so widely available, taking pictures has become more and more common. In order to gain more information, it is frequently necessary to enhance photographs, which are crucial in our daily lives as memories or sources of wealth of information. There are many tools accessible to enhance the quality of photos; however, some of them are also widely used to alter images, leading to the dissemination of false

information. This makes picture forgeries more severe and frequent, which is now a major cause of concern. To identify fake images, many conventional methods have been developed over time. Convolutional neural networks (CNNs) have drawn a lot of interest recently, and they have had an impact on the area of picture fraud detection as well. However, the majority of CNN-based picture forgery detection methods currently used in the literature are restricted to identifying a certain kind of fraud (either image splicing or copymove). As a result, a method that can quickly and precisely identify any hidden forgeries in a picture is needed. We present a powerful deep learning-based approach for detecting picture forgeries in this study. The RGB format images converted to error level analysis (ELA) are used to train our model. The suggested model is compact, and its effectiveness shows that it outperforms cutting-edge methods in terms of speed. The experiment's findings are promising, with a 91.37% total validation accuracy.

Keywords

References

1. Bayram S et al (2006) Image manipulation detection. J Electron Imaging 15(4):041102

2. Al-Qershi OM, Khoo BE (2013) Passive detection of copy-move forgery in digital images: state-of-the-art. Forensic Sci Int 231(1–3):284–295

3. Qazi T et al (2013) Survey on blind image forgery detection. IET Image Process 7(7):660–670

4. Dong J, Wang W, Tan T (2013) Casia image tampering detection evaluation database. In:

2013 IEEE China summit and international conference on signal and information processing. IEEE

5. Yadav S, Singh S (2015) A review on image compression techniques. Int J Adv Res Comput Eng & Technol (IJARCET) 4(9):3513–3521

6. Gregor K et al (2015) Draw: a recurrent neural network for image generation. In: International conference on machine learning. PMLR

7. Ryu J, Yang M-H, Lim J (2018) DFT-based transformation invariant pooling layer for visual classification. In: Proceedings of the European conference on computer vision (ECCV)

8. Ma W, Lu J (2017) An equivalence of fully connected layer and convolutional layer. arXiv:1712.01252

9. Kattenborn T et al (2021) Review on convolutional neural networks (CNN) in vegetation remote sensing. ISPRS J Photogramm Remote Sens 173:24–49

10. Schmidt-Hieber J (2020) Nonparametric regression using deep neural networks with

ReLU activation function. Ann Stat 48(4):1875–1897

11. Dunne RA, Campbell NA (1997) On the pairing of the softmax activation and cross-entropy penalty functions and the derivation of the softmax activation function. In: Proceedings of 8th Australian conference on the neural networks, Melbourne, vol 181. Citeseer

12. Galbally J, Marcel S (2014) Face anti-spoofing based on general image quality assessment. In: 2014 22nd international conference on pattern recognition. IEEE

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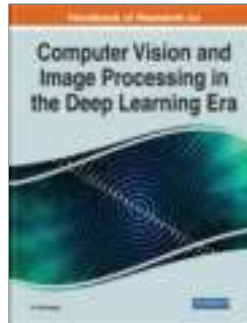
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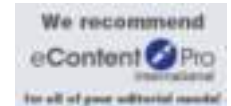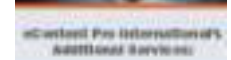
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With the accessibility of healthcare data for a significant proportion of patients in hospitals, using predictive analytics to detect diseases earlier has become more feasible. Identifying and recording key variables that contribute to a specific medical condition is one of the most difficult challenges for early detection and timely treatment of diseases. Conditions such as infertility that are difficult to detect or diagnose can now be diagnosed with greater accuracy with the help of predictive modeling. Infertility detection, particularly in females, has recently gained attention. In this work, the researchers proposed an intelligent prediction for female infertility (PreFI). The researchers use 26 variables for the early diagnosis and determine a subset of these 26 variables as biomarkers. These biomarkers contribute significantly to a better prediction of the problem. The researchers designed PreFI using ensemble methods with biomarkers and improved the performance of the predictive system.

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Malware Detection using Dynamic Analysis

Anandhi V[1], Vinod P[2], Varun G Menon[3], Abhijith Krishna E R[4], Akshay Shilesh[5], Akshay Viswam[6], and Amin Shafiq[7]

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Abstract—**Malware detection is an indispensable factor in the security of internet-oriented machines. The number of threats have been increased day by day. Malware analysis is a process of performing analysis and a study of the components and behavior of malware. The use of dynamic analysis will help the system to classify malware more accurately and to detect any malware samples. Dynamic analysis is a method in which the malware runs in a Sandbox environment, and artifacts are collected. The system uses Cuckoo Sandbox for executing the malware samples in a controlled environment. The system compares bidirectional long short-term memory and convolutional neural network models for machine learning algorithms to detect and classify the malware samples. Unlike a typical signature-based detection, where patterns are checked in the source file, a type of static detection, here, dynamic analysis is used to extract necessary reports, which are then preprocessed to get features like dynamic link library (dlls), kernel module names, services used, etc. to try creating a list of text, which can explain the behaviour of the executable file. These are tokenized and embedded to obtain numerical data, which is passed to the models. The accuracy of trained models is compared, which describes the performance of the models on the dataset. Thus providing grounds for testing future models and later building a better detection system based on it.**

Index Terms—**malware analysis, cuckoo sandbox, bidirectional long short-term memory, dynamic analysis**

I. Introduction

Malware is malicious software distributed over a network that infects, steals, examines, or performs any function an attacker desires. Nowadays, malware detection is important as it serves as an essential alert system for the computer's security against cyber threats. It is the process of identifying malware on a host system and determining whether the particular software is harmful or not. It prevents hackers from gaining access to the computer, and avoids risking sensitive data, altering system settings or contents, or propagating through the network. The best measures against malware are antivirus monitoring and firewall software. The number of malware has expanded at an unprecedented rate due to the extensive use of computer systems and networks. With the expanding usage of susceptible online systems and various operating systems, a growing variety of dangers is emerging. As a result, the issue is to locate and identify risks that can be generalized to avoid future attacks on computer systems.

According to the Symantec threat report [1], 4818 unique websites were victims of form jacking code. Every month, stolen credit card data is sold for up to $2.2 million to cyber criminals. Similarly, McAfee Labs reported that the DarkSide ransomware has resulted in a policy issue between the US and Russia [2]. In 2022, the Trellix company reported that the cyber attackers used the Log4shell flaw, a software vulnerability, and attacked Ukrainian Infrastructure. There were several campaigns conducted for the cyber threats in the region of Eurasia against Ukraine and identified HermeticWiper. This malware steals digital certificates and gains write access to various low-level data structures on the organizations [3].

In the research carried out, the main contributions of this paper are as follows:

- We develop a malware detection system using Convolutional Neural Network over two benchmark malware datasets namely Malware Bazaar and VirusShare.
- We conduct experiments on images using BiLSTMs to classify malware. and show significant improvement in the performance of deep learning models.
- We compare our proposed system with the state-of-the-art approaches and found that a combination of CNN and BiLSTM achieved better classification results.

The paper is organized as follows. Section II discusses related work on static and dynamic analysis. Section III covers the motivation, methodology used including the BiLSTM architecture. In Section IV, we present our dataset used with the experimental results obtained. Finally, Section V concludes the paper, and we mention future work.

II. Related work

In today's world, the vulnerabilities of computer systems are well exploited by cybercriminals. There are several types of malware detection methods [4–7]. They are (a) static detection (b) dynamic detection (c) hybrid (d) ML-based detection (e) DL-based detection and (f) visualization.

In the static malware detection method, a malware file is examined without running the program. The main advantage of the static feature extraction method is that it reduces the feature size by considering the entire binary content, thereby detecting the invariants before runtime [8]. Dynamic analysis involves running the malware executable file and analyzing its behavior to eliminate the infection or prevent it from spreading to other systems [9].

Zhang [10] proposes a deep learning architecture that includes both a CNN layer and an LSTM layer where API call sequences are used to train the model. The CNN model consists of filters, LSTM layer, a dropout layer, and lastly fully connected layer for classification. The proposed model achieved an accuracy of nearly 100%.

Mishra et al. [11] proposed a BiLSTM based model to classify malware in a cloud-based system. CNN layer is the basic block and the model is trained on system call sequences. An accuracy of 90% was achieved. They also made a comparison by substituting the BiLSTM for a normal LSTM layer which resulted in a worse case of detection.

Mcdole et al. [12] records and analyzes the behavior of malware executables using dynamic analysis. The information collected during execution is the memory access, API calls, and network communications.

Usman et al. [13] proposed a novel cyber security techniques on hybrid approach based on dynamic malware analysis that can identify malicious Internet Protocol addresses before communication. Huang et al. [14] propose a malware detection method based on malware visualization and deep learning. The static visualization images are generated by Cuckoo Sandbox. It is used to generate dynamic visualization images. Then form hybrid images that merge the static and dynamic images. Finally, the model train the hybrid images yielding a test accuracy of 92.50% for the hybrid approach.

A novel method for detecting malware by deep learning-based analysis was proposed by Liu et al. [15] on API calls. They used cuckoo sandbox and Filtering techniques were employed to extract the API calls sequence of malicious programs. A comparison on the experimental results with standard models were done. The proposed LSTM has the best performance for malware detection, reaching the accuracy of 97.85%.

Wu et al. [16] proposed an architecture with CNN integrated with attention block used to extract effective features of the load impact factors. Then prediction is forecasted by the LSTM combined with BiLSTM layers and found that the proposed method has better forecasting performance than the state-of-art approaches. Peng et al. [17] proposed a deep learning model based on Bi-directional long short-term memory, sine cosine algorithm, and complete ensemble empirical mode decomposition with adaptive noise for forecasting and found that the model obtained higher prediction accuracy than the existing models.

III. PROPOSED METHOD

The overall method consists of five different modules namely, input data preprocessing, feature representation, feature encoding, feature extraction, and classification.

A. Motivation

The motivation of this paper is that the traditional classification methods have to be improved as there is various limitation in static and dynamic methods. Dynamic malware analysis of new samples is highly time-consuming and requires proper tuning to achieve good performance with an acceptable result.
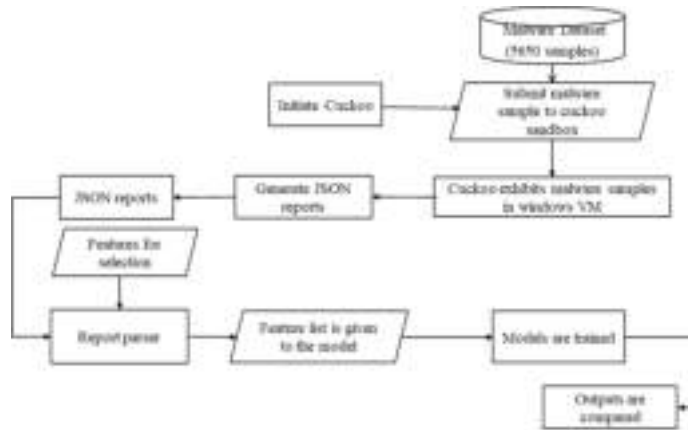

Fig. 1. Flow diagram of proposed system

B. Methodology

Digital security is an important aspect of our daily life. This paper aims to contribute in the direction of classifying malware as accurately as possible. The proposed system is a malware classification system that uses BiLSTM and CNN model to analyse the behavior of malware samples in a controlled sandbox environment and have the model learn to properly identify a malware sample from a benign one. This system being dynamic, can actively classify malware that have not been classified before unlike current antivirus software. The samples are first fed into the sandbox and after receiving a log file containing the executed operations, it is fed into the models, and the results obtained are compared between the models. The proposed block diagram and its interconnection along with the various stages involved are depicted in Fig 1.

The significance of feature selection increases the accuracy and reduces the redundant features, thereby increasing the prediction time.

C. Algorithm

The purpose is to parse the report.json files and extract wanted features into specific files. The input is the location to the output of dumps. The output is files written to the output directory which are text files that contain the features. The detailed step-by-step process is given in Algorithm 1.

D. Cuckoo Sandbox

Basically, a cuckoo sandbox is a Linux Ubuntu host that in turn contains a nested Windows 7 machine in it [18]. The open-source tool called Cuckoo Sandbox is used to analyze malware automatically. This tool works in a controlled and secure environment. This tool makes an intention to the malware that it has affected a true host machine, which then records the malware activity. Finally generates a malware report on the activities done by the malware on the virtual machine (VM).

Linux commands or GUI can be used for accessing the cuckoo sandbox. The malware is submitted to the VM to the

Algorithm 1 Parser Algorithm

Require: Iterate through each folder (classes) for batch folders

Ensure: For each file report file in each batch, perform the following steps to extract the features from JSON files

1: Extract dll from pe_imports
2: Extract name from pe_sections
3: Extract kernel_mod_name from modscan data
4: Extract service from svscan data
5: Extract proc_name from malfind data
6: Extract process from pslist data
7: Extract mut_name from mutscan data
8: Combine these values separated by newline

Require: Write output txt file with features for each malware sample in a fixed output directory

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Windows guest. The malware once submitted runs on the VM. The malware behavior is recorded and this activity is fed to the Ubuntu host and a report is generated based on the activity.

E. Bidirectional long short-term memory

Although LSTM is popular and has more advantages, it could not completely solve the vanishing gradient problem. This model uses more resources and takes more time to get trained. They use high memory and bandwidth because of the layers connected in serial fashion. Thus, LSTMs do not use the hardware efficiently.

LSTM requires more computation as more parameters are required. So Bidirectional long short-term memory or BiLSTM, is used. A Bidirectional Long Short-term Memory [19], is a model that processes information with two LSTMs in a forward and backward direction as shown in Fig. 2. The efficiency of the model is increased by understanding the context, which allows the model to learn the preceding and following words. Bidirectional recurrent neural networks are simply adding up two RNNs where one works forward and the other in a reverse direction.
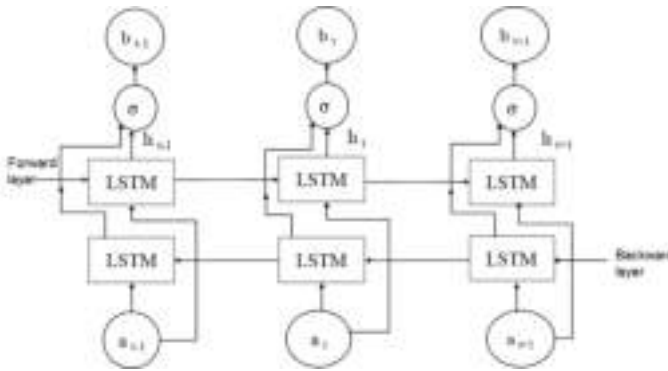

Fig. 2. BiLSTM structure

F. Word Embedding

Word embedding is a technique where words of similar meaning are given the same pattern representation as real-valued vectors. There are fewer dimensions in this type of representation. This method is used to train on any natural language processing task as it is easy to understand.

G. Text Vectorization

The process of converting text into numerical representation is Text Vectorization.

TF-IDF (Term Frequency–Inverse Document Frequency) captures the number of occurrences the word is available in the whole document. The words occurring frequently are given less weight. This inverse weighting for frequently occurring words is known as Inverse Document Frequency. This term gives the relative importance of words in a collection of texts or sets of documents. TF-IDF calculation is used in Natural Language Processing problems where the more frequently occurring words have less weight and words which are not repeated will have more weight. Let w denote TF-IDF weight of any feature x, $tf(x)$ denote frequency of feature x, N be the number of ransomware samples in the document, and IDF denotes the instances that contain the feature x. The following steps are used for calculating TF-IDF as shown in Equation 1.

- Define the term frequency values
- Calculate inverse document frequency values (IDF)
- Multiply the above two values. This indicates how often the words occur in the document

$$w(x) = tf(x) * log \frac{N}{IDF(x) + 1} \qquad (1)$$

H. Convolutional Neural Network

Convolutional neural networks have always become the predominant machine learning algorithm [20] since CNN is a simple feed-forward network that uses automatic feature extraction and uses adjacent pixel information to downsample the image effectively. CNN is a typical neural network in which at least one layer is a convolutional layer. In CNNs, with more hidden layers, the gradient vanishes which stops the learning phase.

IV. EXPERIMENTAL RESULTS

The experiments are conducted using Precision, Recall, F1 measure, and Accuracy as evaluation metrics for the classification.

Categorical accuracy: Categorical accuracy measures the average accuracy rate across all predictions. This is calculated by comparing the one-hot vectors of truths and predictions and then taking an average over the vector. In the proposed system, accuracy is calculated using the metric given below for both training and validation.

$$Accuracy(A) = \frac{TP + TN}{TP + TN + FP + FN}. \qquad (2)$$

where True Positive (TP - indicates the number of malware samples correctly identified as malware), True Negative (TN

- indicates the number of benign samples accurately identified as legitimate.), False Positive (FP - is the number of benign samples misclassified as malware), and False Negative (FN - indicates the number of wrongly classified malware images).

Implementation and Setup: The Linux OS system with Ubuntu 20.04 is installed on the Virtual Machine. The Cuckoo Sandbox and Python with windows are installed on a Virtual Machine. Now both OS can be used without using a separate boot system.

Dataset: The experiments are performed on two malware datasets, Malware Bazaar [21] and VirusShare [22]. In this paper, we used around 5650 executables belonging to 6 classes including 1471 benign samples. 70% of the dataset is used for training and the remaining 30% is reserved for testing. 3955 files for training and 1695 files for validation. A Windows operating system (OS) is installed in the cuckoo sandbox virtual machine and is used to extract the system calls from the malware executable samples.

By using the appropriate measures, the performance of the models is calculated. We conduct the three experiments on the dataset:

- **Experiment-1:** Performance of CNN model in detecting malware executables.
- **Experiment-2:** Performance of BiLSTM model in detecting malware executables.
- **Experiment-3:** Performance of CNN-BiLSTM model in detecting malware executables.

A. Performance of CNN model in detecting malware executables

CNN model consisting of text_vectorization layer, word embedding, three CONV layers, each followed by a Pooling layer, Flattening, and finally the fully connected layer.

A convolutional neural network consists of the following layers:

- Convolutional layers - First layer is the convolution layer which is presented with training and testing malware images. A filter is convolved across the width and height of the input image to extract patterns specific to malware and benign files. Here the kernel size chosen is a 3×3 filter. The kernel is slided over the input and the product is computed at all positions. The convolution layer gives maximum information by reducing the noise in the input features. Parameters include stride, step filter size, and filter count, which is the number of filters used.
- Pooling layers - Next is the max pooling layer which reduces the data processing by taking the maximum value obtained in the first slide of the kernel. A 2×2 is the window size or the filter size used for the max pooling operation. Max pooling takes the maximum value from each group of neurons from the previous layer. This is also called the sub-sampling layer as the computation is performed by downsampling the features, thereby reducing the processing involved.
- Dense layers - Finally, the fully connected dense layer is incorporated where every neuron in one layer is con-
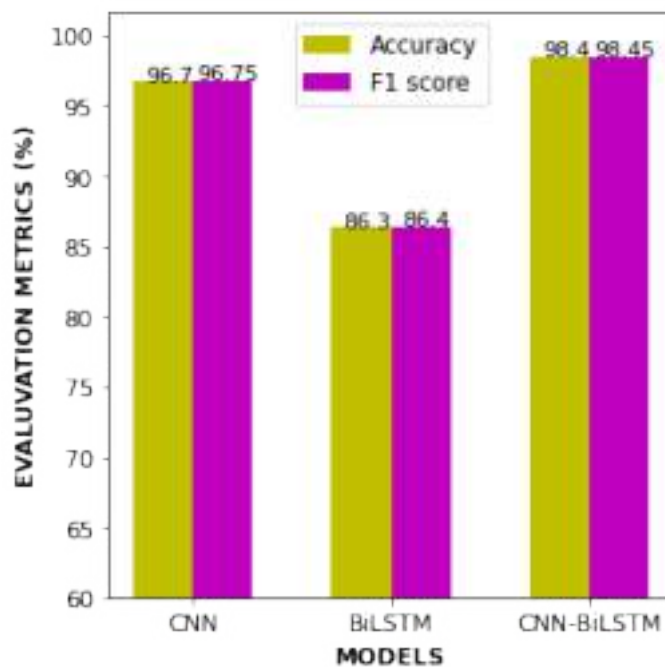

Fig. 3. Accuracy and F1 score for three models

nected to every other neuron in the other layer. The basic principle of CNN is the same as the multilayer perceptron. The flattened matrix after max pooling passes through the fully connected layer to classify the images. The network is trained by the back-propagation method where the weights and bias are updated and the loss is calculated. When the loss function is close to zero, the learning phase terminates.

The model produced an average accuracy of 96.7% as shown in Fig 3. Since the dataset is a balanced set, we get approximately the same scores.

B. Performance of BiLSTM model in detecting malware executables

BiLSTM model consists of text_vectorization layer, input, embedding layer, two BiLSTM layers with dropout layers, and finally the dense layer. In the proposed model, the input to the BiLSTM is an array. By knowing the input, past, and future states of its local neighbors, BiLSTM can predict the present input. We have used a Dropout of 0.25 on the BiLSTM layer. Sigmoid is used as an activation function. Finally, the image vector representation passes through the dense layer. The activation function used by all feed-forward layers is Tanh and the final prediction is achieved using the softmax function. The model produced an average accuracy of 86.3% as shown in Fig 3.

C. Performance of CNN-BiLSTM model in detecting malware executables

The proposed CNN-BiLSTM consists of text vectorization layer, an input layer, word embedding layer, two convolution layers, pooling layers (maxpool), BiLSTM layer, dropout layer, and finally the dense fully connected layer for classification. Figure 3 shows that the model produced an average accuracy of 98.4%.
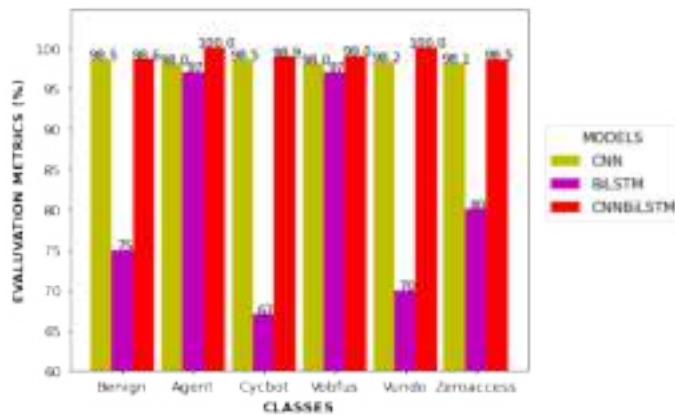

Fig. 4. Classification accuracy for three models

We considered 597 malware executables from agent, 936 from cycbot, 926 from vobfus, 600 from vundo, 1120 from zeroaccess malware families for the dynamic analysis, and 1471 benign files with a total of 5650 files belonging to 6 classes, where 3955 files were used for training and 1695 files for validation phase. Figure 4 shows the evaluation metrics for the six classes considered for all three models. It is observed that the average accuracy of 98.5% is obtained for a combination of CNN with BiLSTM for all families considered. The proposed model has shown efficient performance for the classification, which extracts useful features and better feature representation, resulting in achieving better accuracy.

V. CONCLUSION AND FUTURE SCOPE

In recent times, the amount of malware affecting systems has become enormous and diverse in nature. Automating the detection and classification of new malware helps the forefront of defenders to rest a bit ease. The effectiveness of machine learning has encouraged peers to find methods to tackle this problem. The study here uses Dynamic analysis techniques to extract malware artifacts and process them using BiLSTM and CNN models and experiments with them to classify across five malware classes and a benign class. A combination of CNN-BiLSTM model produced an average accuracy of 98.4%. The CNN-BiLSTM model performs better than the BiLSTM model in classification and detection of malwares. There is a gradual increase in accuracy when compared with the other state of art methods.

In future work, we intend to include more models and more malware classes, specifically towards self-attention models to

improve the overall accuracy further. We also intend to provide a web and android app interface, where one can submit a file, and get a report summary on the file, detecting any malicious instructions within the file. This would help the layman have free, and bleeding-edge access to a malware-detection system, which does not rely on signatures and similar concepts.

REFERENCES

[1] https://docs.broadcom.com/docs/istr-04-march-en

[2] https://www.mcafee.com/enterprise/en-us/assets/reports/rp-ryuk-ransomware-targeting-webservers.pdf

[3] https://www.trellix.com/en-us/threat-center/threat-reports/apr-2022.html

[4] Roundy, Kevin A., and Barton P. Miller. "Hybrid analysis and control of malware", In International Workshop on Recent Advances in Intrusion Detection, pp. 317-338. Springer, Berlin, Heidelberg, 2010.

[5] Wang, Huanran, Weizhe Zhang, and Hui He, "You are what the permissions told me! Android malware detection based on hybrid tactics", Journal of Information Security and Applications 66, 2022.

[6] Ijaz, Muhammad, Muhammad Hanif Durad, and Maliha Ismail, "Static and dynamic malware analysis using machine learning", In 2019 16th International bhurban conference on applied sciences and technology (IBCAST), pp. 687-691, 2019.

[7] Nataraj, Lakshmanan, Sreejith Karthikeyan, Gregoire Jacob, and S. Manjunath, "Malware images: visualization and automatic classification", In Proceedings of the 8th international symposium on visualization for cyber security, pp. 1-7, 2011.

[8] Adel Abusitta, Miles Q. Li, Benjamin C.M. Fung, "Malware classification and composition analysis: A survey of recent developments", Journal of Information Security and Applications, vol. 59, 2021.

[9] Singh, Jagsir, and Jaswinder Singh. "A survey on machine learning-based malware detection in executable files." Journal of Systems Architecture 112, 2021.

[10] J. Zhang, "DeepMal: A CNN-LSTM Model for Malware Detection Based on Dynamic Semantic Behaviours," 2020 International Conference on Computer Information and Big Data Applications (CIBDA), pp. 313-316, 2020.

[11] Mishra, P., Khurana, K., Gupta, S., & Sharma, M. K., "VMAnalyzer: Malware Semantic Analysis using Integrated CNN and Bi-Directional LSTM for Detecting VM-level Attacks in Cloud", Twelfth International Conference on Contemporary Computing (IC3), 2019.

[12] Mcdole, Andrew & Gupta, Maanak & Abdelsalam, Mahmoud & Mittal, Sudip & Alazab, Mamoun, "Deep Learning techniques for Behavioral Malware Analysis in Cloud IaaS", 2020.

[13] Usman, Nighat, Saeeda Usman, Fazlullah Khan, Mian Ahmad Jan, Ahthasham Sajid, Mamoun Alazab, and Paul Watters, "Intelligent dynamic malware detection using machine learning in IP reputation for forensics data

analytics", Future Generation Computer Systems 118, pp. 124-141, 2021.

[14] Huang, Xiang, Li Ma, Wenyin Yang, and Yong Zhong, "A method for Windows malware detection based on deep learning", Journal of Signal Processing Systems 93, no. 2, pp. 265-273, 2021.

[15] Liu, Yingying, and Yiwei Wang, "A robust malware detection system using deep learning on API calls", In 2019 IEEE 3rd Information Technology, Networking, Electronic and Automation Control Conference (ITNEC), pp. 1456-1460, 2019.

[16] Wu, K., Wu, J., Feng, L., Yang, B., Liang, R., Yang, S., & Zhao, R., "An attention-based CNN-LSTM-BiLSTM model for short-term electric load forecasting in integrated energy system", International Transactions on Electrical Energy Systems, 31(1), 2020.

[17] Peng, T., Zhang, C., Zhou, J., & Nazir, M. S., "An integrated framework of Bi-directional long-short term memory (BiLSTM) based on sine cosine algorithm for hourly solar radiation forecasting", Energy, 221, 2021.

[18] Nunes, Matthew, Pete Burnap, Omer Rana, Philipp Reinecke, and Kaelon Lloyd, "Getting to the root of the problem: A detailed comparison of the kernel and user-level data for dynamic malware analysis", Journal of Information Security and Applications 48, 2019.

[19] Zhiyong Cui, Ruimin Ke, Ziyuan Pu, Yinhai Wang, "Deep Bidirectional and Unidirectional LSTM Recurrent Neural Network for Network-wide Traffic Speed Prediction", Computer and information sciences, 2018.

[20] Daniel Gibert, Carles Mateu, Jordi Planes, and Ramon Vicens, "Classification of Malware by Using Structural Entropy on Convolutional Neural Networks", The Thirtieth AAAI Conference on Innovative Applications of Artificial Intelligence, 2018.

[21] https://bazaar.abuse.ch/browse/

[22] https://virusshare.com

Wearable Fabric Tactile Sensors for Robotic Elderly Assistance

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Abstract—**The demand for Robots in Elderly assistance is increasing due to the lack of human caregivers. In the context of Robot coexisting with the human beings in a home environment, for the safe and friendly interaction it is essential to endow the sense of touch through Tactile sensor systems. This paper proposes a novel scalable approach for tactile sensors based on low cost wearable conductive fabric. Fabric tactile sensor (FABTAC) is conformable with the robot body and can be used as a tactile sensing skin that perceives touch and force applied at the contact location. FABTAC sensors are developed as an array of touch sensors sewed on the cloth substrate with the stainless-steel conductive thread. The thermistor sensors are also sewed to fabric to perceive the temperature information. The FABTAC sensors are integrated on to the custom-made 3D printed Robotic hand and the tactile data is processed with a novel wearable electronic FLORA microcontroller platform. The acquired data can be used to provide a real time tactile feedback for performing assistive tasks like grasping objects of diverse profiles, avoiding slippage. The FABTAC sensors has the advantage of utilizing flexible, light weight sensors with good spatial and temporal resolution. Thus, the system can potentially aid the automation of daily life activities of the Elderly thereby enhancing the quality of their life.**

Keywords—Tactile sensing, Human Robot Interaction, Wearable sensors, Fabric sensors, Tactile feedback

I. INTRODUCTION

The number of caregivers is not growing in tandem with the growth of the Elderly population. The high expense of elderly support is due to the relative scarcity of caregivers for the elderly. The enormous expense of providing care for the elderly could be significantly reduced by using robots in this scenario. Robots with a tactile sensing skin is required for interactions to be both secure and safe. Our human brain senses the touch with the somatosensory system containing a large network of nerve endings and touch receptors on skin, which transmit the tactile information to the brain which in turn tells the body how to react to different senses. The tactile sensors being the electronic counterpart of biological skin, enables the robot to perceive their environment and create a reactive behavior in response to human expectations.

Bioinspired, tactile sensing is important for robots which works in close interaction with the human beings as in elderly care applications. Tactile sensors can estimate the contact parameters like mechanical touch, pressure and temperature at the contact area [1].

Unlike the visual and auditory senses, human skin is not a localized sensory organ which makes the tactile sensing more challenging in terms of transduction technology [2]. And the sensors should be distributed throughout the body. As touch can take many forms-shapes, texture, force, pain, temperature it is not one physical property to be sensed which makes the sensor design more complex and thereby making it difficult to mimic the tactile sensing [3].

A. Criteria for Selection of Tactile Sensors

The Criteria for selection of tactile sensors are reported below[3]

a) *Spatial resolution*
b) *Contact Parameters to be measured*
c) *Response profile*
d) *Time resolution*

B. Transduction Techniques

Earlier, the research in the field of tactile sensing focused towards the transduction technology/sensor design.

Various tactile sensor systems have been proposed to cover the robot body for the grasping and manipulation of fine and fragile objects with dexterity. Capacitive tactile sensors are based on changes in the distance between the parallel plates on mechanical touch thereby changing capacitance. This effect can be utilized to detect static touch. They have high sensitivity and has a large dynamic range[4]-[7]. Piezoelectric tactile sensors works on piezoelectric effect where the materials generate an electrical voltage on application of external force . This effect can be utilized for dynamic touch sensing [9][10]. Optical tactile sensors utilizes changes in light intensity to detect external force applied at the point of touch as reported in [11][12].

II. RELATED WORK

The human Interactive Robot RI-MAN [13] embedded with tactile sensors has been developed for assistive care applications to determine the contact load while carrying a dummy human. 320 tactile pressure-sensing elements are integrated on the body with each sensor sheet having 8 x 8 elements placed at the chest and forearms.

A tactile sensor suit, flexible and soft, that has 192 sensing regions has been proposed [14]. The designed robotic suit used electrically conductive cloth and string to build the sensor outfit. Each sensing region functions as a binary switch. The tactile sensing is based on a layered architecture.

A low-cost simple method has been reported [15] to transform a knitted glove to a scalable tactile glove with a sensor array of 548 sensors. The glove has a piezoresistive film connected to conductive thread electrodes. The glove can be utilised to recognise distinguish object and to estimate their weight while grasping.

A fabric-based stretchable tactile sensing skin to measure force and temperature parameters has been reported in [16]. The sensors were integrated on MEKA M1 Mobile Manipulator to make contact on the arms of human being which demonstrated the feasibility of the system for Human Robot Interactive environment.

III. PROPOSED ARCHITECTURE

The Literature reports shows that the large area coverage of sensors at high spatial resolution comes at the expense of high cost technology requirements. This paper presents a novel low-cost approach to tactile sensors for robots based on conductive fabric which can sense human touch utilizing the capacitance transduction effects.

The experimental study was conducted towards creating a tactile sensing skin to perceive touch, force and temperature parameters at the contact area of touch. The work proposed here is the multimodal wearable approach to tactile sensing so as to utilize this tactile information for dynamic feedback control of robotic hand assistance to Elderly people.

The Hardware Configuration of Wearable FABTAC sensors integrated to robotic hand which can be used in grasping assitance for Elderly persons is shown in the Fig. 1.

The robotic hand can be operated in Grasp mode. For the grasp mode operation, dynamic control of hand is achieved based on the real time feedback from the FABTAC sensors to prevent slippage of objects grasped. This paper highlights on the work on the development and integration of FABTAC sensors on the custom made 3D printed InMoov Robotic Hand.

The wearable FABTAC sensors are developed as an array of tactile elements(taxels) with the Conductive Fabric touch sensors and Force Senstive Resistor(FSR) placed on the fabric substrate in a two layer architecture. The current version of the array consists of 12 taxels each of dimension 20mm x 20mm with a spatial resolution of 2 mm. The capacitive touch sensors detect the static touch in response to the human finger based on the predetermined threshold level.The FSR placed under the first layer of sensors seperated with the spacer estimates the force applied at the

taxels corresponding to the resistance variation. The temperature sensors are sewed to the fabric to perceive the temperature of the human finger at the contact area.

The Fabric tactile sensor array consists of strips of woven conductive fabric, fabricated of Copper and Nickel-plated polyester has been sourced from Adafruit Industries.The tactile sensors are sewed to wearable microcontroller electronic platform -FLORA controller using stainless steel conductive thread which has a fairly low resistivity of 10 ohms per foot. The array structure can be scaled up for the full coverage of the dorsal and palmar side of hand and the fingers of robotic hand.

FSRs placed below the fabric layer allows to detect physical pressure applied on its sensing region [Adafruit Industries].FSRs changes its resistive value depending on the external pressure applied on it. The resistance change gives the calculation for the amount of force applied when touched.

NTC Thermistors are also sewed to the fabric substrate to estimate the temperature of the human finger when touched. The tactile data acquired by FABTAC sensors are given to the wearable FLORA microcontroller for further processing and Control action.

IV. METHODOLOGY

The acquired touch sensor data are processed using a FLORA microcontroller which is a fabric friendly wearable electronic platform with ATMEGA 32u4 microcontroller having 14 sewing pads for electrical connections. The FLORA microcontroller is configured in slave mode and reduces the load of high level processing at the Arduino UNO Master controller. This configuration helps for better scalability when large area coverage of sensors on the robotic body is required.

The slave FLORA microcontroller transmits the touch data wirelessly using the module nRF24L01 connected through SPI interface with a data rate of 100 Mbps. The nRF24L01 module is suitable for low power applications. At the receiver side, the tactile data is received using the nRF receiver module and fed to an Arduino Uno controller. For the Experimental study the touch response has been demonstrated using an LED display at the destination side. The Robotic hand with the integrated FABTAC sensors can be activated by elderly touch and dynamic control of the hand can be achieved based on reactive control feedback from the sensors in future work.
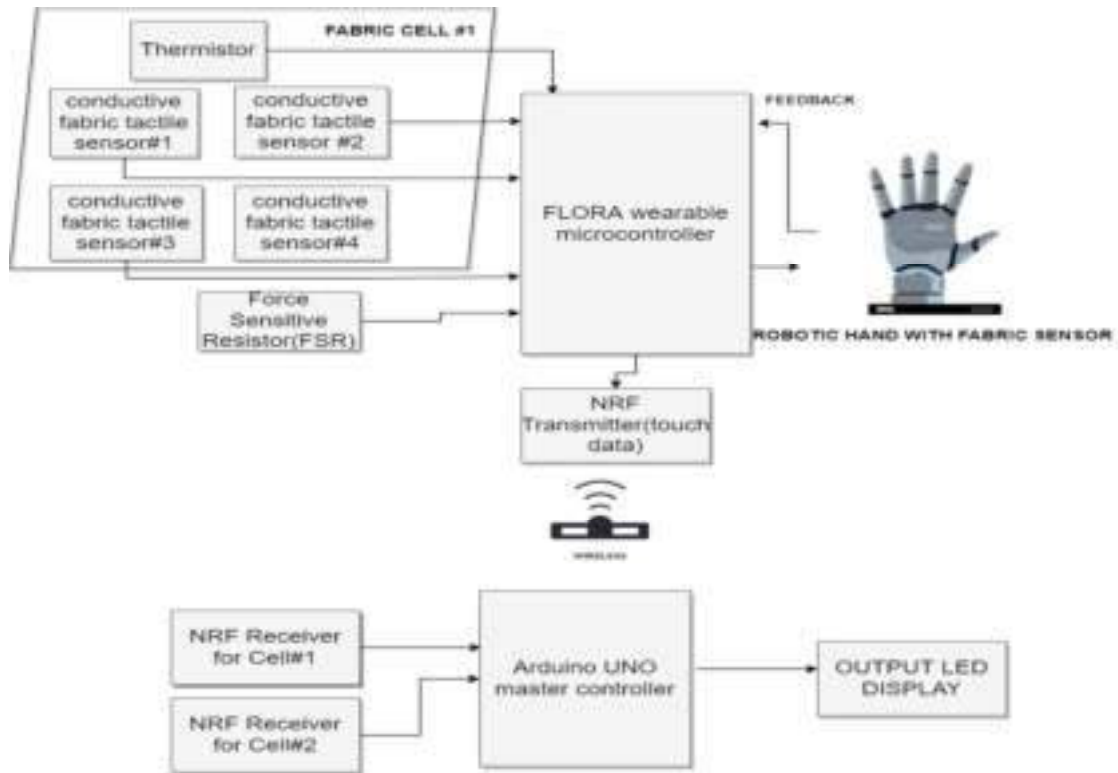
Fig. 1 Hardware Configuration set up of wearable FABTAC sensors for Robotic Hand control

V. RESULTS AND DISCUSSION

The feasibility study of various flexible, light weight, fabric tactile sensors that can be incorporated to Robotic hand Elderly Assistance System has been conducted in this paper.

a) Woven Conductive Fabric Touch Sensor

The experimental results show the response of Woven Conductive Fabric sensor to single finger static touch and a plastic pen. The touch detected with the human finger as shown in Fig 2 (a) has high sensitivity. The dielectric constant increases as a result of the finger's interaction with the capacitor's electric field, thereby increasing capacitance. It has also been inferred that the touch response can be obtained with two fingers simultaneously. The touch response of the plastic material with a low dielectric value could not detect the touch as depicted in Fig 2(b).

The Fig. 2(c) demonstrates the capacitive fabric sensors sewed on the cloth substrate using the conductive thread. The tactile data is fed to the digital pins of the sewing pad of FLORA. A simple hand running stitch is used for sewing the sensors and the microcontroller so as to allow the current flow through the conductive thread. The Fig 2(d) shows the response of touch using the neo pixel RGB LED's which are fabric friendly.

Fig. 2(a)

Fig. 2(b)

Fig. 2(c)

Fig. 2(d)

Fig. 2(a) Single finger touch on Conductive Fabric sensor (b) Touch using plastic pen on Fabric sensor (c) Fabric sensors sewed to FLORA controller using stainless steel conductive thread (d) Touch response of sensor using neo pixel RGB LED

b) Velostat/ Pressure Sensitive sheet Sensor

The study of Velostat sensor was conducted to demonstrate a dynamic touch like vibration on the surface as shown in Fig. 3(a). Velostat is carbon impregnated polyethylene film which can be vibrated and a change in resistance corresponding to vibration was observed.

c) Thermistor

The experimental study of interfacing NTC 10K thermistor with FLORA was conducted. The thermistor was sewed to the cloth substrate and the observations are obtained as in Table 1. Observations are made at Room temperature, soldering iron and a prolonged contact with single finger. It has been observed that the resistance decreases with the increase in temperature and a prolonged contact of finger on the thermistor recorded values as shown in the table. The equivalent temperature T is calculated using Stein Hart Equation as in (1)

$$\frac{1}{T} = \frac{1}{T0} + \frac{1}{B}\ln(\frac{R}{R0}) \qquad (1)$$

T0 is the Room temperature, B is Coefficient of thermistor, R0 is Resistance at Room temperature and R is unknown resistance calculated.

d) Force Sensitive Resistor(FSR) Sensor

The Fig. 3 (b) shows experimental set up of FSR with a 38 mm square sensing region and the change in resistance when force applied at the touch point can be calculated. The resistance variation is converted to analog voltage with a base resistance of 10K. The figure 5 (a) shows the variation of Voltage and Resistance and it can be observed that the resistance decreases with the increase in voltage which corresponds to increase in force applied on the sensing region. The Fig 5(b) shows the Force vs Voltage variation and Fig 5 (c) demonstrates the change in Force vs Resistance. The various types of touch based on Force in Newtons has been indicated. The types of touch observed are Light touch with less than 1 N is recorded, Light Squeeze on the sensing square region showed up the Force between 2 N and 4 N, Medium Touch (5 -9 N) and Big Touch(10- 66 N).

e) Integration of FABTAC sensors on Robotic Hand

The hardware consists of custom - made 3D printed robotic arm InMoov with 2 DOF controlled using MG996R servos. The developed wearable FABTAC sensors are integrated on to the robotic hand and the response of robotic hand when activated by human touch was demonstrated. The Fig 5(a) shows the 3D printed Robotic hand (without tactile sensors) and Fig 5(b) Hand with Wearable FABTAC sensors

TABLE I: TEMPERATURE vs RESISTANCE VARIATION

Temperature (°C)	Resistance (KΩ)	
27.44	8.979	Room temperature
27.53	8.94	
28.09	8.72	Soldering iron used
28.81	8.45	
29.82	8.09	
31.79	7.44	Prolonged Contact with single finger
32.02	7.34	
32.55	7.21	
31.79	7.445	
32.41	7.251	
32.64	7.181	
32.60	7.193	
32.51	7.222	
32.41	7.251	

Fig. 3 (a)Dynamic Touch on Velostat sensor (b) Experimental set up of FSR Interfacing with controller

Fig 4 (a) 3D Printed InMoov Robotic Hand (b)Robotic Hand with wearable FABTAC Sensors
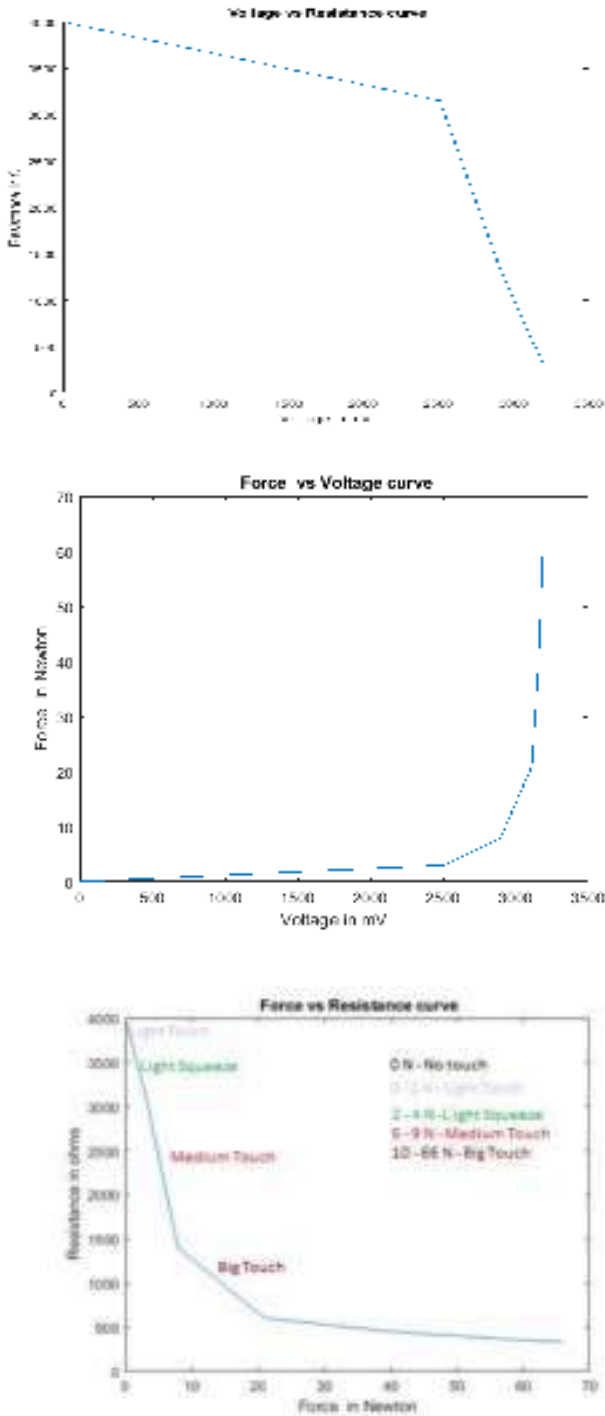
Fig 5(a) Voltage vs Resistance Curve (b) Force vs Voltage Curve (c) Force vs Resistance and classification of touch based on Force applied at the contact area.
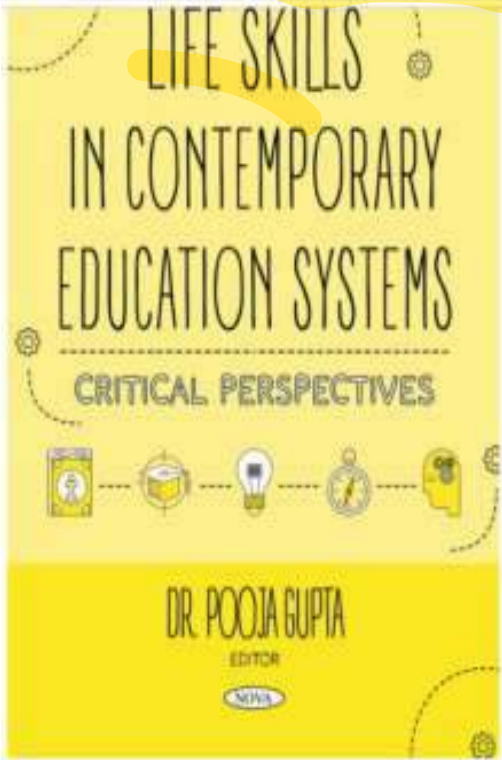
VI. CONCLUSION

The work presented in this paper demonstrates the feasibility study of fabric tactile sensors that can be worn by the robots in an environment where human beings and robots co-exist. The growing demand of robotic platforms in the field of nursing and assistive care emphasize the importance of tactile sensors which are cost effective, scalable and conformable. The tactile sensors and the wearable controller chosen for this work are light weight and flexible thereby providing an advantage of smaller size tactile sensing skin suitable for robotic platforms. The work can be extended in future to provide tactile feedback based on FABTAC sensors for dynamic control of the robotic hand in Elderly assistance.

REFERENCES

[1] Dahiya, R. S., Metta, G., Valle, M., & Sandini, G. (2010). Tactile Sensing.Pdf. IEEE Transactions on Robotics, 26(1), 1–20.

[2] Silvera-Tawil, D., Rye, D., & Velonaki, M. (2015). Artificial skin and tactile sensing for socially interactive robots: A review. *Robotics and Autonomous Systems*, *63*(P3), 230–243. https://doi.org/10.1016/j.robot.2014.09.008

[3] M. H. Lee and H. R. Nicholls, "Review Article Tactile Sensing for Mechatronics—A State of the Art Survey," Mechatronics, Vol. 9, No. 1, 1999, pp. 1-31. doi:10.1016/S0957 4158(98)00045-2

[4] P. A. Schmidt, E. Mael, and R. P. Wurtz, "A sensor for dynamic tactile information with applications in human-robot interaction & object exploration," Robot. Auto. Syst., vol. 54, no. 12, pp. 1005–1014, Dec. 2006

[5] Dahiya, R. S., Mittendorfer, P., Valle, M., Cheng, G., & Lumelsky, V. J. (2013). Directions toward effective utilization of tactile skin: A review. IEEE Sensors Journal, 13(11), 4121–4138. https://doi.org/10.1109/JSEN.2013.2279056

[6] H.-K. Lee, S.-I. Change, and E. Yoon, "A flexible polymer tactile sensor: Fabrication and modular expandability for large area deployment," J. Mircoelectromech. Sys., vol. 15, no. 6, pp. 1681–1686, Dec. 2006.

[7] M. Maggiali, G. Cannata, P. Maiolino, G. Metta, M. Randazzao, and G. Sandini, "Embedded tactile sensor modules," in Proc. 11th Mechatron. Forum Biennial Int. Conf., 2008, pp. 1–5.

[8] P. A. Schmidt, E. Mael, and R. P. Wurtz, "A sensor for dynamic tactile information with applications in human-robot inter- action & object exploration," Robot. Auto. Syst., vol. 54, no. 12, pp. 1005–1014, Dec. 2006.

[9] Dai, Y., & Gao, S. (2021). A Flexible Multi-Functional Smart Skin for Force, Touch Position, Proximity, and Humidity Sensing for Humanoid Robots. IEEE Sensors Journal, 21(23), 26355–26363. https://doi.org/10.1109/JSEN.2021.3055035

[10] C. Domenici and D. De Rossi, "A stress-component-selective tactile sensor array," Sens. Actuators A, Phys., vol. 13, nos. 1–3, pp. 97–100, Mar. 1992.

[11] M. Ohka, H. Kobayashi, J. Takata, and Y. Mitsuya, "Sensing precision of an optical three-axis tactile sensor for a robotic finger," in Proc. 15th Int. Symp. Robot Human Interact. Commun., Sep. 2006, pp. 214–219.

[12] B. Ward-Cherrier, N. Pestell, L. Cramphorn, B. Winstone, M. E. Giannaccini, J. Rossiter, and N. F. Lepora, "The TacTip Family: Soft Optical Tactile Sensors with 3D-Printed Biomimetic Morphologies," Soft Robotics, 2018

[13] Mukai, T., Onishi, M., Odashima, T., Hirano, S., & Luo, Z. (2008). Development of the tactile sensor system of a human-interactive robot "RI-MAN." IEEE Transactions on Robotics, 24(2), 505–512. https://doi.org/10.1109/TRO.2008.917006

[14] Inaba, M., Hoshino, Y., Nagasaka, K., Ninomiya, T., Kagami, S., & Inoue, H. (1996). Full-body tactile sensor suit using electrically conductive fabric and strings. IEEE International Conference on Intelligent Robots and Systems,2,450–457. https://doi.org/10.1109/iros.1996.570816

[15] Sundaram, S., Kellnhofer, P., Li, Y., Zhu, J. Y., Torralba, A., & Matusik, W. (2019). Learning the signatures of the human grasp using a scalable tactile glove. Nature, 569(7758), 698–702. https://doi.org/10.1038/s41586-019-1234-z

[16] Wade, J., Bhattacharjee, T., Williams, R. D., & Kemp, C. C. (2017). A force and thermal sensing skin for robots in human environments. Robotics and Autonomous Systems, 96, 1–14. https://doi.org/10.1016/j.robot.2017.06.008

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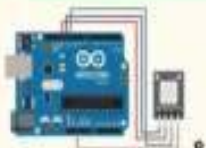
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5. L. Li *et al.*, "Carbon Dot-Regulated 2D MXene Films with High Volumetric Capacitance," *Ind. Eng. Chem. Res.*, vol. 59, no. 31, pp. 13969–13978, 2020, doi: 10.1021/acs.iecr.0c01440.

6. E. E. Elemike, J. Adeyemi, D. C. Onwudiwe, L. Wei, and A. O. Oyedeji, "The future of energy materials: A case of MXenes-carbon dots nanocomposites," *Journal of Energy Storage*, vol. 50, 2022, doi: 10.1016/j.est.2022.104711.

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Copper(II) Based Potential Pharamaceutical Drugs Against Cancer

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The report of the World Health Organization on cancer reveals some fearful results and the report says that in 2020, 10 million people have succumbed to death worldwide owing to this deadly disease and it is the second most common cause of death after cardiovascular diseases. The recent report of Freddie Bray et.al[1]

reveals that by 2040 the rate of this disease is expected to be increased to 28.4 million. So, there is a pressing need to develop a drug which could effectively interact and destroy the affected cell. Herein, we are reporting our work on the developement of a potential metallodrug based on tetradentate Schiff base.

We have systematically designed and synthesized four Cu(II) salen compounds (1 to 4) (Figure 1) and characterized using various spectroscopic and analytical techniques. The binding affinity of the complexes with CT-DNA was explored by UV-visible and fluorescence techniques. The compounds exhibit excellent DNA binding and cleavage activities. The binding mechanism were probed by molecular docking studies. These results display high binding constant values owing to the intercalative type of binding. In addition, binding affinity of the compounds with protein were also studied *via in silico* molecular docking method using Human Serum Albumin as receptors. Cleavage of DNA strands was investigated by gel electrophoresis. All the tested compounds show high binding constant value with both DNA and protein. Preliminary *in vitro* studies with L929 (a mouse fibroblast cell line) and HeLa cells (human cervical cancer cell line) indicated the cytotoxic effect of the complexes; however, detailed molecular studies may be required to confirm the mode of anti-cancer mechanism. Considering the results and comparing the existing reports[2,3], we are proposing a promising candidate (compound 4) for the development of efficient therapeutic drugs.
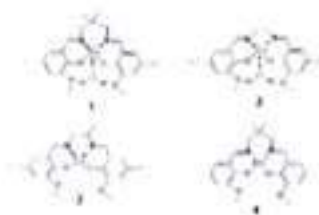
Figure 1. Synthesized pharmaceuticals drugs (1-4)

References

1. S.S.Massoud,A.F.Louka,N.E.Bordelon,R.Fischer,F.A. Mautner, J.Vanco,J.Hošek,Z.Dvorak and Z.Travnicek, *New Journal of Chemistry,* **2019,** *43,* 6186-6196.

2. A.Paul, P.Singh, M.L.Kuznetsov, A.Karmakar, da Silva, B.Koch, A.J.Pombeiro, *Dalton Transactions,* **2021,** *50* (10), 3701-3716.

3. S.Banerjee, P.Ghorai, P.Brandão, D.Ghosh, S.Bhuiya, D.Chattopadhyay, S.Das, A.Saha, *New Journal of Chemistry,* **2018,** *42* (1), 246-259.

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