SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY,KARUKUTTY

Utilization certificates of Grants received from Government and non-governmental agencies for research projects / endowments in the institution during last five years

SLNO:	FACULTY NAME	Department	Sanctioned by	Sanctioned for	Sanctioned amount	Current Status	Year
1	Hazel Elza John	ECE	KSCSTE	Research work	9800	Completed	2021-2022
2	Rosebell	CSE	CERD_KTU	Research work	49,860	Completed	2021-2022
3	Vinoj P G	ECE	GYTI- BIRAC SRISTI	Research work	1500000	Completed	2020-2021
4	R.Ajith Kumar	ME	National Physical and oceanography laboratory	Research work	928000	Completed	2020-2021
5	Dr. Nisha L	Civil Engineering	Department of Environment and Climate Change, Kerala State	Research work	1309000	Completed	2019-2020
6	Asha S	CSE	KSCSTE	Research work	13,000	Completed	2018-2019

PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY
VIDYANAGAR, PALLISSERY, KARUKUTTY
ERNAKULAM, KERALA-683 576

Name of institution: SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY
KARUKUTTY
ERNAKULAM

Serial number	Order sanctioning grant	Amount sanctioned Rs.	Year to which the grant relates	Period of utilization	Date of payment	Purpose of the grant	Amount spent	Unspent balance	Remarks
1	2	3	4	5	6	7	8	9	10
1.	No: Do ECC/ AEOI/ R+D/ 2879/ 2019	148607 PREVIOUS UNSPENT BALANCE PLUS 374993 RECEIVED ON 23/3/2022 TOTAL 523600	30/7/2021 TO 31/7/2022	30/7/2021 TO 31/7/2022	23/3/2022 Rs.374993	Conduct OF RESEARCH PROJECT	789210	NIL	AN AMOUNT OF Rs.265610 HAS BEEN SPENT EXTRA FOR CONDUCT OF RESEARCH PROJECT AND THE SAME IS BEING CLAIMED

1. Certified that out of the grant-in-aid of Rs. 523600 sanctioned during the year 2021-2022 in favour of The Principal, SCMS School of ENGINEERING AND TECHNOLOGY as per the orders mentioned above, and Rs. NIL on account of unspent balance of the previous year/years, a sum of Rs.789210 has been utilised for the purpose of for which the grant/grants was/ were sanctioned and that the balance of Rs. NIL remaining unutilized at the end of the year (the period to be specified) has been surrendered to (vide No. N.A. dated N.A.)/will be adjusted towards the grant-in-aid payable for the succeeding year N.A.

1. Certified that I have satisfied myself that the conditions on which the grant-in-aid was sanctioned have been duly fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of check Exercised

1. CHECKED WITH BANK PAYMENT VOUCHERS
2. AND JOURNAL VOUCHERS.
3.

Office Seal

Dr NISHA L
PI

26/9/22

Signature:
Designation:
Date:
22-09-2022

For SUBHASH CHANDRAN ASSOCIATES
CHARTERED ACCOUNTANTS

S.ABHILASH CHANDRAN B.Com, FCA
PARTNER. (M. No. 223576)
FRN 004095S

UDIN - 22223576ATXUAS9784

K.F.C. FORM 44
FORM OF UTILISATION CERTIFICATE
Certificate showing utilisation of Grants-in-aid

Name of institution: SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY
KARUKUTTY
ERNAKULAM

Serial number	Order sanctioning grant	Amount sanctioned Rs.	Year to which the grant relates	Period of utilization	Date of payment	Purpose of the grant	Amount spent	Unspent balance	Remarks
1	2	3	4	5	6	7	8	9	10
1.	No: DoECC/ AE01/ R&D/ 2879/ 2019	523600	03/07/2020 TO 29/07/2021	03/07/2020 TO 29/07/2021	03/07/2020	CONDUCT OF RESEARCH PROJECT	374,993	1,48607	DUE TO COVID-19 SCENARIO SOME OF THE WORKS LIKE SAMPLING ARE PENDING HENCE THE BALANCE AMOUNT WILL BE UTILIZED FOR NEXT YEAR.

1. Certified that out of the grant-in-aid of Rs. 523600 sanctioned during the year 03/07/2020 in favour of THE PRINCIPAL, SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY as per the orders mentioned above, and Rs. NIL on account of unspent balance of the previous year/years, a sum of Rs 374993 has been utilised for the purpose of for which the grant/grants was/ were sanctioned and that the balance of Rs. 148607 remaining unutilized at the end of the year (the period to be specified) has been surrendered to (vide No. — dated —)/will be adjusted towards the grant-in-aid payable for the succeeding year 2021 - 2022

1. Certified that I have satisfied myself that the conditions on which the grant-in-aid was sanctioned have been duly fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Kinds of check Exercised

1. CHECKED WITH BANK PAYMENT VOUCHERS
2.
3.

Office Seal

Signature:
Designation:
Date:
16.08.2021

For SUBHASH CHANDRAN ASSOCIATES
CHARTERED ACCOUNTANTS

S.ABHILASH CHANDRAN B.Com, FCA
PARTNER. (M. No. 223576)
FRN 004095S
UDIN 21223576AAAABR2694

UTILIZATION CERTIFICATE

Certified that out of Rs ....48260/-............ sanctioned by Centre for Engineering Research and

Development of APJ Abdul Kalam Technological University towards financial assistance for the

student project titled ' A SWARM BASED AI AIDED WHEEL BOT SYSTEM TO DETECT CRACKS ON RAILWAY TRACKS ', an amount

of Rs ......41110.3/-..... was utilized for the purpose for which it was sanctioned, leaving a balance

of Rs. 7149.7/-... at the close of 12-09-2022......... as shown in the Statement of Expenditure

annexed.

For SUBHASH CHANDRAN ASSOCIATES
CHARTERED ACCOUNTANTS

S ABHILASH CHANDRAN B.Com, FCA
PARTNER, (M. No. 223576)
FRN 0040055

Name & Signature
of Principal Investigator

Name & Signature
of Head of the Institution

Name & Signature
of Accounts officer/
Chartered Accountant
UDIN Z3223576BGYJBM5227

Dr. ANITHA G. PILLAI
PRINCIPAL
SCMS SCHOOL OF ENGINEERING
AND TECHNOLOGY

CHARTERED
ACCOUNTANTS
KOCHI-36

SUBHASH CHANDRAN ASSOCIATES

Office Seal
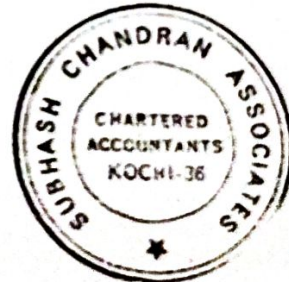
Kerala State Council for
Science, Technology and Environment

16.01.2020

Prof (Dr.) K.P. Sudheer
Executive Vice President
KSCSTE, Pattom

Letter No. 01300 /SPS 64/2019/KSCSTE

Dear Mrs. Hazel Elsa John,

Sub:-Financial assistance for Student Project scheme of KSCSTE reg.
Ref:-Your application received under Student Project scheme

This is to invite your attention to the reference cited and to inform that the project proposal titled "Data abstraction of vehicles on crashing (DAVOC)" submitted by Mrs. Hazel Elsa John as PI and Ajmal P S, Akshay Kumar T V, Adithyan A S, Hafis Abdul Rahim as student investigator(s) has been approved. An amount of 19800/- is sanctioned by the Council. The budget estimate of the project is as detailed below.

SL.NO.	ITEMS	AMOUNT (₹)
		8900
1	Consumables	400
2	Minor equipments	200
3	Travel	200
4	Research Literature & Documentation	100
5	Others (for analysis)	9800
	Total	

The PI has to submit the signed Terms and Conditions (as per the guidelines) and the date of start of the project within two weeks to the undersigned. The project should be completed within six months and submit the certified soft copy of the final report (in pdf to sed.kscste@kerala.gov.in), audited Statement of Expenditure and Utilization Certificate counter signed by the Head of the Institution for releasing the grant. The format for final report, SE and UC can be downloaded from www.kscste.kerala.gov.in .

Thanking you.

Yours sincerely,

Prof (Dr.) K.P. Sudheer

To

Mrs. Hazel Elsa John, Assistant Professor, Dept. of Electronics & Communication, SCMS School Of Engineering And Technology Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576

Copy to:

The Principal, SCMS School Of Engineering And Technology Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576

Ajmal P S, Akshay Kumar T V, Adithyan A S, Hafis Abdul Rahim, Student(s), Bachelor of Technology (BTech) Electronics & Communication, SCMS School Of Engineering And Technology Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576

Statement of Account

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY EDUCATIONAL INSTIT

C/O SCMS SCHOOL OF ENGINEERING & T
SCMS CAMPUS PALISSERY
PADUAPURAM P O ERNAKULAM

	ERNAKULAM
City	KERALA
State	INDIA
Country	683582
Zip	918589054713
Mobile No	
E-mail	SUBHA@SCMSGROUP.ORG

Union Bank of India

Branch	PALISSERY
Customer Id	137305091
Account No	3458010100030000
Account Currency	INR
Account Type	Current Account
MICR Code	
IFSC Code	UBIN0558885

Statement Date 30/11/2021 09:31

Records from 1 to 149.   No more records available.   Statement Period From -23/11/2021 To 30/11/2021

Date	Remarks	Tran Id	UTR Number	Instr. ID	Withdrawals	Deposits	Balance
25/11/2021	NEFT:Mr NOEL JOSEPH GOMEZ SBIN321329393862	S32261023	Sender No:SBIN3213293 93862			20,250.00	1,83,81,384.70
25/11/2021	UPIAB/132975335288 /CR/Mr Vyshn/IDIB/vyshnavkvi nodh	S33060966	-			200.00	1,83,81,584.70
26/11/2021	NEFT:SANIL P B SIBLN21330157518	S40833044	Sender No:SIBLN213301 57518			1,80,000.00	1,85,61,584.70
26/11/2021	UPIAB/133004295763 /CR/JOEL SAB/UBIN/954482472 7@ybl	S41498816	-			200.00	1,85,61,784.70
26/11/2021	UPIAB/133012389259 /CR/ASHKAR /SBIN/ashkarsulaiman	S41503945	-			20,600.00	1,85,82,384.70
26/11/2021	NEFT:RAZORPAY SOFTWARE PRIVATE LIMITED AXISCN01069	S43165614	Sender No:AXISCN0106 972557			1,67,650.00	1,87,50,034.70
26/11/2021	UPIAB/133014833647 /CR/SIVAPRAS/SBIN/ ht.sivaprasad@	S44432277	-			22,250.00	1,87,72,284.70
26/11/2021	WEEKEND PASS	AA784416	-			4,650.00	1,87,76,934.70
26/11/2021	MUHAMMED LAMY MTC/778	AA784416	-			30,000.00	1,88,06,934.70
26/11/2021	IMPSAB/13301680918 0/UBIN0558885/94974 63767	S46400889	-			20,600.00	1,88,27,534.70
26/11/2021	NEFT:KSCSTE SBIN421330046461	S47761762	Sender No:SBIN4213300 46461			7,000.00	1,88,34,534.70
26/11/2021	NEFT:KSCSTE SBIN421330046470	S47763606	Sender No:SBIN4213300 46470			7,249.00	1,88,41,783.70
26/11/2021	NEFT:KSCSTE SBIN421330046465	S47763873	Sender No:SBIN4213300 46465			7,441.00	1,88,49,224.70
27/11/2021	UPIAB/133145668827 /CR/RANDEEP /IOBA/8301027135@i bl	S57550805	-			20,600.00	1,88,69,824.70
27/11/2021	UPIAB/133198999762 /CR/JUNO THA/CNRB/junomathe w139@	S57612168	-			55,000.00	1,89,24,824.70
27/11/2021	UPIAB/133119088420 /CR/ABHIRAM /UBIN/abhiramkv56@ ok	S66543801	-			600.00	1,89,25,424.70

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

Accredited by NAAC, Affiliated to APJ Abdul Kalam Technological University, Kerala and Approved by AICTE, Govt. of India
An ISO 9001:2015 Certified Institution

CAMPUS: VIDYA NAGAR, KARUKUTTY, ERNAKULAM-683576 PHONE: 0484-2882900, 2450330
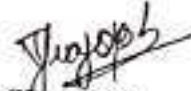E-mail: sset@scmsgroup.org • Website: www.scmsgroup.org/sset

STATEMENT OF EXPENDITURE

Project Title: "Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For paralysed"
Name of Institution: SCMS School of Engineering & Technology, Karukutty,Kerala

Receipts		Amount (Rs)	Payments		Amount (Rs)
1	Amount sanctioned from BIRAC SRISTI	500000/-	1	Development of Prototype	389483
2	Interest	5036	2	Travel	12620
3	Others	65	3	Incubator Rentals	60000
			4	Man Power	NIL
			5	Consumables	24166
			6	Contingencies	18832
	Total	505101 (Five Lakh Five Thousand One Hundred and One)		Total	505101 (Five Lakh Five Thousand One hundred and one)

Certified that I have exercised all kinds of checks to see that the grant has been utilized for the purpose for which it was sanctioned by BIRAC SRISTI (Ref. No. BIRAC SRISTI PMU - 2020/007).

VINOJ P.G

Name & Signature

of the Awardee

Name & Signature

of Head of the Institution

UDIN:22207419AGQASA9799
Name & Signature of
Accounts Officer/
Chartered Accountant

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY
Office Seal

P.K. THOMAS,FCA,DISA (ICA
CHARTERED ACCOUNTANT
SOUTH JUNCTION
CHALAKUDY - TCR - 680 307
MNO: 207419, Ph:0480-2707989

Statement of Account

VINOJ P G

PARAMBALOTH HOUSE

KARTHEDOM MALIPURAM P O

City	ERNAKULAM	Union Bank of India	
State	KERALA	**Branch**	PALISSERY
Country	INDIA	**Customer Id**	212635093
Zip	682511	**Account No**	588802010007430
Mobile No	919446276238	**Account Currency**	INR
E-mail	vinojpg@yahoo.co.in	**Account Type**	Saving Account
		MICR Code	683026004
		IFSC Code	UBIN0558885

Statement Date : 11/01/2023 14:02

Statement Period From -01/04/2022 To 31/12/2022

Records from 1 to 8.   No more records available.

Date	Remarks	Tran Id	UTR Number	Instr. ID	Withdrawals	Deposits	Balance
07/04/2022	588802010007430:Int. Pd:01-01-2022 to 31-03-2022	S30743726	-			441.00	1,099.50
22/04/2022	NEFT:SRISTI-BIRAC PROJECT A/C AXIC221120774962	S517157	Sender No:AXIC221120774962			500,000.00	501,099.50
06/07/2022	588802010007430:Int. Pd:01-04-2022 to 30-06-2022	S7578279	-			2,727.00	503,826.50
29/07/2022	eTXN/To:345801010030000/Exoskeleton phase2	S77994936	-		265,000.00		238,826.50
29/07/2022	eTXN/To:345801010030000/Phase 2 2nd Payment	S78173949	-		200,000.00		38,826.50
06/10/2022	588802010007430:Int. Pd:01-07-2022 to 30-09-2022	S94076175	-			1,250.00	40,076.50
08/11/2022	NEFTO-KAMAL UPRETI 000710536815	S4467353	-		9,500.00		30,576.50
21/11/2022	MOBFT to: VINOJ P G/232523048718	S87239729	-		30,000.00		576.50

Statement of Account

VINOJ P G

PARAMBALOTH HOUSE

KARTHEDOM MALIPURAM P O

City	ERNAKULAM		
State	KERALA		
Country	INDIA		
Zip	682511		
Mobile No	919446276238		
E-mail	vinojpg@yahoo.co.in		

Union Bank of India

Branch	PALISSERY
Customer Id	212635093
Account No	588802010007430
Account Currency	INR
Account Type	Saving Account
MICR Code	
IFSC Code	UBIN0558885

Statement Date : 07/02/2022 19:39

Statement Period From -25/01/2021 To 07/01/2022

Records from 1 to 17.   No more records available.

Date	Remarks	Tran Id	UTR Number	Instr. ID	Withdrawals	Deposits	Balance
25/01/2021	NEFT:SRISTI-BIRAC PROJECT A/C AXIC210252419020	S73603337	Sender No:AXIC2102524 19020			500,000.00	500,000.00
16/03/2021	eTXN/To:3458010100 30000/Gyti fund for purchase	S75750403	-		200,000.00		300,000.00
20/03/2021	eTXN/To:3458010100 30000/Gyti project fund	S27940834	-		295,000.00		5,000.00
05/04/2021	588802010007430:Int. Pd:01-01-2021 to 31-03-2021	S38599092	-			2,158.00	7,158.00
13/04/2021	PRINCIPAL SCMS	AA225319	-			243,000.00	250,158.00
15/04/2021	IMPSAR/1105124534 53/HDFC0001512/151 21140005885	S81000006	-		68,450.00		181,708.00
12/05/2021	NEFTO-UPS EXPRESS PRIVATE LTD 000279775883	S17311805	-		28,015.00		153,693.00
16/05/2021	IMPSAR/1136188144 42/HDFC0001512/151 21140005885	S70693574	-		4,200.00		149,493.00
08/06/2021	IMPSAR/1159157076 17/SBIN0020149/6242 3775910	S53268262	-		750.00		148,743.00
03/07/2021	588802010007430:Int. Pd:01-04-2021 to 30-06-2021	S99506500	-			1,066.00	149,809.00
10/07/2021	IMPSAR/1191102345 06/FDRL0001272/999 80104180893	S11581035	-		19,150.00		130,659.00
20/07/2021	MOBFT to: VINOJ P G/120122372710	S72865166	-		11,200.00		119,459.00
02/10/2021	588802010007430:Int. Pd:01-07-2021 to 30-09-2021	S45903945	-			935.00	120,394.00
07/12/2021	MOBFT to: VINOJ P G/134123338052	S64557773	-		1,025.00		119,369.00
30/12/2021	MOBFT to: VINOJ P G/136414147306	S94662579	-		1,500.00		117,869.00
31/12/2021	MOBFT to: VINOJ P G/136514620927	S15135920	-		4,000.00		113,869.00
06/01/2022	588802010007430:Int. Pd:01-10-2021 to 31-12-2021	S37076477	-			877.00	114,746.00

NPOL/E/GD/7100   04.09.2020

To

The Principal
(Kind Attn: Dr.P Venu, Head, Mechanical Engineering Department)
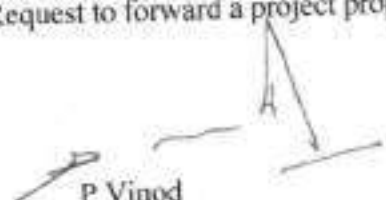SCMS school of Engineering and Technology,
Ernakulam

Sub: Development of hydrodynamic depressor for NPOL project

Naval Physical and Oceanographic Laboratory (NPOL), Kochi is an establishment under Defence Research and Development Organization, Ministry of Defence, Government of India and is involved with the development of sonar systems for the Indian Navy. In one of the ship towed sonar projects, it is proposed to develop hydrodynamic depressor for the purpose of improving the depth performance of the towed system.

It is noted that Department of Mechanical Engineering, SCMS School of Engineering and Technology has done research work in the area of hydrodynamic depressors (Ref: "Analysis of Hydrodynamic Depressor for High Speed Naval Applications" by Sri.R Ajithkumar, ICTCEES, 2020) and also in related areas such as hydrodynamics of underwater vehicles. With this background, it is proposed to initiate a project with Department of Mechanical Engineering, SCMS School of Engineering and Technology with Sri. R. Ajithkumar as the Principal Investigator under the Contract for Acquisition of Research Services (CARS) scheme of DRDO.

Brief scope of work envisaged under the project is attached. Request to forward a project proposal on the same.

Regards,

P Vinod
Scientist-G
Group Director (Engineering)
For Director

नौसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला, कोच्चि -21

NAVAL PHYSICAL & OCEANOGRAPHIC LABORATORY, KOCHI-21.

ठेकेदार का बिल / CONTRACTOR'S BILL

* ठेका करार सं०/Contract agreement No. NPOL/21CR007 तारीख/Date 12/02/2021 सुपुर्दगी की तारीख/Delivery date...............

ठेकेदार का नाम तथा पूरा पता /Name of contractor with full postal address 3CMS School of Engineering &
Technology, Ernakulam - 683576

सुपुर्दगी चालान सं० तथी तारीख /Delivery challen No. & Dates.................

क्रम सं० SI No.	आपूर्ति की गई वस्तुओं या दी गई सेवाओं का विवरण Description of articles supplied or service rendered	ए/यू A/U	स्वीकृत मात्रा या संख्या Qty. or No. accepted	दर (के हिसाब से) ए/यू Rate (Per) A/U		कुल लागत / Total cost		टिप्पणी Remarks
				रु./ Rs.	पैसे /Ps.	रु./ Rs.	पैसे /Ps.	
1.	Inibial Payment on Project Design and Analyss of Hydrodynamic Depressor	No		2,34,000	00	2,34,000	00	
			बि.क. तथा से.प्र. /ST & SC					
			उत्पाद/सीमा प्रभार /EXCISE / CUSTOMS DUTY					
			GST अन्य /OTHERS			42,120		
			कुल /TOTAL					
			कटौतियां /DEDUCTIONS ....%					
			कुल योग /GRAND TOTAL			2,76,120/-		

बिक्री कर, स्थानीय रजिस्ट्रेशन सं० /Sales Tax. Local registration No:......................
बिक्री कर, सेन्ट्रल रजिस्ट्रेशन सं० /Sales Tax Central registration No:......................
आर आर/एल आर/एडब्ल्यूबी/कुरियर सं० /R.R / LR/AWB/ Courier No:......................
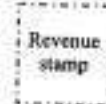बिक्री कर प्रमाण-पत्र की प्रति संलग्न /Copy of Sales Tax Certificate enclosed.

प्रमाण-पत्र /CERTIFICATE & PRE-RECEIPT

प्रमाणित किया जाता है कि उपर्युक्त सूचनाएँ वास्तविक तथ्यों पर आधारित और सही है । वस्तुओं/सेवाओं के लिए अब लिए जा रहे प्रभार संबंधी बिल को प्रस्तुत नहीं किया गया है । यदि उपर्युक्त में से कोई भी सूचना गलत पाई जाती है तो आपके द्वारा की जाने वाली किसी भी कानूनी कार्रवाई का पूर्णतया पालन किया जाएगा । / Certified that the information given above is true and based on the actual facts. No bill has been rendered previously in respect of articles / services now charged for hereon. In case any of the information provided above is false, we agree to abide by for any legal action to be taken by you, 2,76,120/- In words Rupees Two Lakh Seventy Six Thousand One Hundred and Twenty
Received Rs.

स्थान /Station: Kanukkully
दिनांक /Date: 30/10/2001

[Revenue stamp]

ठेकेदार के हस्ताक्षर /Signature of the Contractor
(मोहर /With seal)

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

नौंसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला, कोच्चि -21
NAVAL PHYSICAL & OCEANOGRAPHIC LABORATORY, KOCHI-21.
ठेकेदार का बिल / CONTRACTOR'S BILL

* ठेका करार सं०/Contract agreement No. NPOL /21CP007 .... तारीख/Date. 12/02/2021 ..सुपुर्दगी की तारीख/Delivery date...............

ठेकेदार का नाम तथा पूरा पता /Name of contractor with full postal address. SCMS School of Engineering and Technology, Ernakulam - 683576

सुपुर्दगी चालान सं० तथा तारीख /Delivery challen No. & Dates.................

क्रम सं० SI No.	आपूर्ति की गई वस्तुओं या दी गई सेवाओं का विवरण Description of articles supplied or service rendered	ए/यू A/U	स्वीकृत मात्रा या संख्या Qty. or No. accepted	दर (के हिसाब से) ए/यू Rate (Per) A/U		कुल लागत / Total cost		टिप्पणी Remarks
				रु./ Rs.	पैसे /Ps.	रु./ Rs.	पैसे /Ps.	
1.	First Milestone Payment on Project Design and Analysis of Hydrodynamic Depressor	No		2,34,000	00	2,34,000	00	
			बि.क. तथा से.प्र. /ST & SC					
			चुंगीचुंगी/सीमा प्रभार /EXCISE / CUSTOMS DUTY					
			GST अन्य /OTHERS			42,120 /-		
			कुल /TOTAL			276,120 /-		
			कटौतियां /DEDUCTIONS .... %			0		
			कुल योग /GRAND TOTAL			2,76,120/-		

बिक्री कर, स्थानीय रजिस्ट्रेशन सं० /Sales Tax. Local registration No:....................................
बिक्री कर, सेन्ट्रल रजिस्ट्रेशन सं० /Sales Tax Central registration No:.................................
आर आर/एल आर/एडब्ल्यूबी/कूरियर सं० /R.R / LR/AWB/ Courier No:...........................
बिक्री कर प्रमाण-पत्र की प्रति संलग्न /Copy of Sales Tax Certificate enclosed.

प्रमाण-पत्र /CERTIFICATE & PRE-RECEIPT

प्रमाणित किया जाता है कि उपर्युक्त सूचनाएँ वास्तविक तथ्यों पर आधारित और सही है । वस्तुओं/सेवाओं के लिए अब लिए जा रहे प्रभार संबंधी बिल को प्रस्तुत नहीं किया गया है । यदि उपर्युक्त में से कोई भी सूचना गलत पाई जाती है तो आपके द्वारा की जाने वाली किसी भी कानूनी कारेवाई का पूर्णतया पालन किया जाएगा । / Certified that the information given above is true and based on the actual facts. No bill has been rendered previously in respect of articles / services now charged for hereon. In case any of the information provided above is false, we agree to abide by for any legal action to be taken by you. Received Rs. 2,76,120 /- (in words Rupees Two lakh Seventy Six thousand One Hundred and Twenty)

स्थान /Station: Karukutty
दिनांक /Date: 30/10/2021

Revenue stamp

ठेकेदार के हस्ताक्षर /Signature of the Contractor
(मोहर /With seal)

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

नौसेना भौतिक तथा समुद्रविज्ञान प्रयोगशाला, कोच्चि -21

NAVAL PHYSICAL & OCEANOGRAPHIC LABORATORY, KOCHI-21.

ठेकेदार का बिल / CONTRACTOR'S BILL

* ठेका कचर सं०/Contract agreement No. NPOL 121CR007 .... तारीख/Date 18/02/2022 सुपुर्दगी की तारीख/Delivery date...........

ठेकेदार का नाम तथा पूरा पता /Name of contractor with full postal address. SCMS School of Engineering and Technology, Ernakulam - 683 576.

सुपुर्दगी चालान सं० तथा तारीख /Delivery challen No. & Dates.......

क्रम सं० SI No.	आपूर्ति की गई वस्तुओं या दी गई सेवाओं का विवरण Description of articles supplied or service rendered	ए/यू A/U	स्वीकृत मात्रा या संख्या Qty. or No. accepted	दर (के हिसाब से) ए/यू Rate (Per) A/U		कुल लागत / Total cost		टिप्पणी Remarks
				रु०/ Rs.	पैसे /Ps.	रु०/ Rs.	पैसे /Ps.	
1	Second Milestone Payment on Project Design and Analysis of Hydrodynamic Depressor	No.		2,34,000	00	2,34,000	00	
			बि.क. तथा से.प्र. /ST & SC					
			उत्पाद/सीमा प्रभार /EXCISE / CUSTOMS DUTY					
			GST अन्य /OTHERS		42,120/-			
			कुल /TOTAL		2,76,120/-			
			कटौतियां /DEDUCTIONS ....%					
			कुल योग /GRAND TOTAL		2,76,120/-			

बिक्री कर, स्थानीय रजिस्ट्रेशन सं० /Sales Tax. Local registration No:................................
बिक्री कर, सेन्ट्रल रजिस्ट्रेशन सं० /Sales Tax Central registration No:...............................
आर आर/एल आर/एडब्ल्यूबी/कूरियर सं० /R.R / LR/AWB/ Courier No:...............................
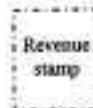बिक्री कर प्रमाण-पत्र की प्रति संलग्न /Copy of Sales Tax Certificate enclosed.

प्रमाण-पत्र /CERTIFICATE & PRE-RECEIPT

प्रमाणित किया जाता है कि उपर्युक्त सूचनाएँ वास्तविक तथ्यों पर आधारित और सही है । वस्तुओं/सेवाओं के लिए अब लिए जा रहे प्रभार संबंधी बिल को प्रस्तुत नहीं किया गया है । यदि उपर्युक्त में से कोई भी सूचना गलत पाई जाती है तो आपके द्वारा की जाने वाली किसी भी कानूनी कार्रवाई का पूर्णतया पालन किया जाएगा । / Certified that the information given above is true and based on the actual facts. No bill has been rendered previously in respect of articles / services now charged for hereon. In case any of the information provided above is false, we agree to abide by for any legal action to be taken by you. Received Rs 2,76,120/- ....(In words... Rupees Two Lakh, Seventy Six Thousand One Hundred, and Twenty

स्थान /Station: Kanaykully
दिनांक /Date: 30/10/2021

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: Revenue :
: stamp :
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ठेकेदार के हस्ताक्षर /Signature of the Contractor
(मोहर /With seal)

DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

GST INVOICE

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

Prathap Foundation ForEducation And Training

Karukutty, Ernakulam, Kerala - 683576

GSTIN: 32AADCP1668B1ZV
Tax is payable on reverse charge: No
Invoice Serial Number: SCMGST001
Invoice Date: 24/11/2021

Details of Receiver (Billed To)	Details of Consignee (Delivered To)
Name: Director NPOL Address: Naval Physical and Oceanographic Laboratory, Kochi Thrikkakara (PO) -682021 State: Kerala State Code :32 GSTIN: Unregistered	Name: Director NPOL Address: Naval Physical and Oceanographic Laboratory, Kochi Thrikkakara (PO) -682021 State: Kerala State Code :32 GSTIN: Unregistered

S.No.	Description of Goods/ Services	HSN/SAC Code (GST)	Qty.	UOM	Rate	Total	Discount	Taxable Value	CGST %	CGST Amount	SGST %	SGST Amount	IGST %	IGST Amount
1.	Initial advance payment for Project "Design and Analysis of Hydrodynamic Depressor" CARS Project No. NPOL/21CR0007 dated 12.02.2021	9981	1	Nos	234000	234000	0.00	234000	9.00	21060.00	9.00	21060.00	0.00	0.00
					Total									276120
					Rupees					Two lakh seventy-six thousand and twenty only				

Category : Research and Development Services

For SCMS School of Engineering and Technology

Dr. PRAVEEN A C
Signatory
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

GST INVOICE

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

Prathap Foundation For Education And Training

Karukutty, Ernakulam, Kerala - 683576

GSTIN: 32AADCP1668B1ZV
Tax is payable on reverse charge: No
Invoice Serial Number: SCMGST002
Invoice Date: 24/11/2021

Details of Receiver (Billed To)

Name: Director NPOL
Address: Naval Physical and Oceanographic Laboratory, Kochi
Thrikkakara (PO) -682021
State: Kerala
State Code :32
GSTIN: Unregistered

Details of Consignee (Delivered To)

Name: Director NPOL
Address: Naval Physical and Oceanographic Laboratory, Kochi
Thrikkakara (PO) -682021
State: Kerala
State Code :32
GSTIN: Unregistered

S.No.	Description of Goods/ Services	HSN/SAC Code (GST)	Qty.	UOM	Rate	Total	Discount	Taxable Value	CGST %	CGST Amount	SGST %	SGST Amount	IGST %	IGST Amount
1.	First Milestone payment for Project "Design and Analysis of Hydrodynamic Depressor" CARS Project No. NPOL/21CR0007 dated 12.02.2021	9981	1	Nos	234000	234000	0.00	234000	9.00	21060.00	9.00	21060.00	0.00	0.00
					Total									276120
					Rupees					Two lakh seventy-six thousand and twenty only				

Category : Research and Development Services

For SCMS School of Engineering and Technology

Authorized Signatory
DR. PRAVEENSAL C. J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

GST INVOICE

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

Prathap Foundation For Education And Training

Karukutty, Ernakulam, Kerala - 683576

GSTIN:32AADCP1668B1ZV
Tax is payable on reverse charge: No
Invoice Serial Number: SCMGST003
Invoice Date: 24/11/2021

Details of Receiver (Billed To)	Details of Consignee (Delivered To)
Name: Director NPOL	Name: Director NPOL
Address: Naval Physical and Oceanographic Laboratory, Kochi	Address: Naval Physical and Oceanographic Laboratory, Kochi
Thrikkakara (PO) -682021	Thrikkakara (PO) -682021
State: Kerala	State: Kerala
State Code :32	State Code :32
GSTIN: Unregistered	GSTIN: Unregistered

S.No.	Description of Goods/ Services	HSN/SAC Code (GST)	Qty.	UOM	Rate	Total	Discount	Taxable Value	CGST %	CGST Amount	SGST %	SGST Amount	IGST %	IGST Amount
1.	Second Milestone payment for Project "Design and Analysis of Hydrodynamic Depressor" CARS Project No. NPOL/21CR0007 dated 12.02.2021	9981	1	Nos	234000	234000	0.00	234000	9.00	21060.00	9.00	21060.00	0.00	0.00
					Total									276120
					Rupees		Two lakh seventy-six thousand and twenty only							

Category : Research and Development Services

For SCMS School of Engineering and Technology

Authorized Signatory
DR. PRAVEENSAL C.J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING & TECHNOLOGY

UTILIZATION CERTIFICATE

Certified that out of Rs. 13,000/-.... sanctioned by Kerala State Council for Science, Technology and Environment (KSCSTE) under the INNOVATE – 2019 Scheme; vide Letter No. CSEI/34/INNOVATE/2019 dated 22|01|2019, towards financial assistance for completing the project entitled SMART MIRROR ....,an amount of Rs. 13,000/- was utilized for the purpose for which it was sanctioned, leaving an unspent balance of Rs. 0 at the completion of the project as shown in the Statement of Expenditure annexed.

For ROSHAN THOMAS & Co
CHARTERED ACCOUNTANTS
FRN - 013611S

CA. SHARON LISS AUGUSTINE, FCA, DISA (ICA)
Membership No: 227227

ASHA S.
Name & Signature
of the Mentor

Name & Signature
of Head of the Institution

Name & Signature
of Chartered Accountant

DR. PRAVEENSAL C.J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

UDIN 19227227AAAAAA6038
04.09.2019

Office Seal with date

Statement of Expenditure

Scheme: INNOVATE – 2019

Project Title: ...... SMART MIRROR ....

....

Name and Official Address of the Mentor : ASHA. S; ASSISTANT PROF, CSE DEPT, SCMS SCHOOL OF ENGG & TECHNOLOGY, VIDYA NAGAR, KARUKUTTY

Phone: 9947448628 .... E-mail: ashas@scmsgroup.org ....

Amount Sanctioned by KSCSTE : ...... 13,000/- ....

Sl. No.	Payments	Amount (Rs.)
1.	Equipment	14,000
2.	Consumables	
3.	Contingencies	
4.	Others: Specify	
	Total	14,000

Certified that I have exercised all kinds of checks to see that the grant has been utilized for the purpose for which it was sanctioned by KSCSTE, vide Letter No. ...... CSEI/314/INNOVATE/2019 ......, dated 22/01/2019

For ROSHAN THOMAS & C
CHARTERED ACCOUNTANTS
FRN - 013611S

ASHA·S.
Name & Signature of the Mentor

Name & Signature of Head of the Institution.
DR. PRAVEENSAL C.J.
PRINCIPAL
SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

CA. SHARON LISS AUGUSTINE, FCA, DISA (IC
Membership No. 227227
Name & Signature of Chartered Accountant

UDIN 19227227AAAAAA6038

Office Seal with date

04.04.2019
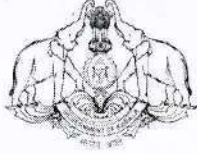
Government of Kerala

Department of Environment & Climate Change

4th Floor, KSRTC Bus Terminal, Thampanoor, Thiruvananthapuram- 695 001

Ph: 0471-2326264 (Off)

E-mail: envt.dir@kerala.gov.in   web: www.envt.kerala.gov.in

PROCEEDINGS OF THE DIRECTOR
Present: Mir Mohammed Ali IAS

Sub: Research and Development - Project Proposal entitled "Micro Plastic Pollution: Source characterization, transport modeling and assessment of impact on fish population in Kadambrayar river and Vembanad backwater region"– Grant – in – aid- Sanctioned-1st Installment released- Order issued.

DIRECTORATE OF ENVIRONMENT & CLIMATE CHANGE

No. DoECC/AEO1/R&D/2879/2019   dated   10.03.2020

Read:

(1) G.O. (Rt) No. 105/2019/ Envt. Dated 30.10.2019.

(2) Proposal received from Dr.Nisha L, Associate Professor, Department of Civil
    Engineering, SCMS School of Engineering and Technology

(3) Minutes of the R&D Committee meeting held on 5-6th August 2019.

(4) Triparty agreement executed on 03.02.2020.

ORDER

As an implementation mechanism for the state plan scheme "Environmental Research and Development", Government vide G.O cited (1) have authorized Director, Directorate of Environment and Climate Change to release the funds to the agencies undertaking the projects. Vide paper (2) cited a proposal entitled "Micro Plastic Pollution: Source characterization, transport modeling and assessment of impact on fish population in Kadambrayar river and Vembanad backwater region" received under R&D scheme and the same was selected by the R&D committee meeting held on 05.08.2019 & 6.08.2019.

Vide paper read (1) Govt. have accorded Administrative Sanction for a total amount of Rs.13,09,000/- for 2 year with first installment of Rs.5,23,600/-. Vide paper read (4) above, Directorate of Environment and Climate Change, the Principal, SCMS School of Engineering and Technology, the Principal Investigator of the project; have executed a Triparty agreement in the prescribed format.

Approval is hereby accorded for the research project entitled "Micro Plastic Pollution: Source characterization, transport modeling and assessment of impact on fish population in

Kadambrayar river and Vembanad backwater region" for a period of 2 years with Dr. Nisha L, Associate Professor, Department of Civil Engineering, SCMS School of Engineering and Technology. The terms and conditions and directions contained in the agreement executed vide paper read (4) and the guidelines of scheme should be complied with scrupulously by the Institution and Principal Investigator and timely submission of prescribed documents shall be ensured.

In accordance with the approved modalities, terms and conditions and as per the agreement read (3) above, the grant shall be released in 3 installments, at the rate of 60:20:20 respectively. Therefore sanction is accorded for the release of **Rs. 5,23,600/- (Rupees Five Lakh Twenty three Thousand and Six Hundred only)** to the Principal, SCMS School of Engineering and Technology as the First Installment of grant for the project in the subject matter with Dr. Nisha L, Associate Professor, Department of Civil Engineering, SCMS School of Engineering and Technology. The Principal Investigator and to credit the amount to the bank account - **A/C No. 345801010030000 IFSC Code: UBIN0558885**. The expenditure shall be met from the Head of account "**3435-03-103-99 -Research and Development- (Plan- Voted)**" in the current year's budget.

The Principal Investigator has to furnish the progress report, Expenditure Statement and Utilization Certificate (in KFC Form 44) to the Directorate within 30 days from end of first year.

Sd/-
Director

To

Dr. Nisha L, Associate Professor, Department of Civil Engineering,
SCMS School of Engineering and Technology.

Copy to:

1. The Accountant General (A&E/Audit), Thiruvananthapuram
2. The District Treasury Officer, Thiruvananthapuram
3. Principal, SCMS School of Engineering and Technology.
4. Accounts section
5. Bill Copy
6. Stock file.

Forwarded By Order

Administrative Officer

Micro Plastic Pollution: Source characterization, transport modelling and assessment of impact on fish population in Kadambrayar river and Vembanad backwater region

Submitted to

The Department of Environment and Climate Change

DEPARTMENT OF CIVIL ENGINEERING

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY, KARUKUTTY

APPLICATION PRO FORMA FOR GRANT FOR RESEARCH PROJECT

(To be filled in by the Principal Investigator)

1.	Title of the Project	: Micro Plastic Pollution: Source characterization, transport modelling and assessment of impact on fish population in Kadambrayar river and Vembanad backwater region.
2.	Name and Designation of the Principal Investigator	: Dr. Nisha.L, Associate Professor, Department of Civil Engineering, SCMS School of Engineering and Technology, Karukutty- 683 576.
3.	Name and Designation of the Co-Investigator	: Dr. Ratish Menon Associate Professor, Department of Civil Engineering, SCMS School of Engineering and Technology, Karukutty- 683 576.
4.	Postal Address of the Principal Investigator and the Co-Investigator	:Associate Professor, Department of Civil Engineering, SCMS School of Engineering and Technology, Karukutty- 683 576.
5.	Name of the institution(s)/organization(s) in which the project will be carried out (Specify whether College (Government / Aided/ Autonomous/ Private), University Department, Government Institution, Non-governmental organization, etc.)	: SCMS School of Engineering and Technology, Karukutty- 683 576 (Private Engineering College affiliated to KTU)
6.	Name of other institution(s)/Organisation(s) involved in the project (Specify whether College (Government / Aided/ Autonomous/ Private), University Department, Government Institution, Non-governmental organization, etc.):	: N.A

7.	Geographic location of research project site (latitude and longitude), wherever applicable	: Brahmapuram(10.0010° N, 76.3788° E), Kochi, River Kadambrayar at Brahmapuram and Lake Vembanad
8.	Participation of public and private sector and/or other government ventures: (Please give details regarding sharing of work components, cost and outputs, including implementation arrangements, and modalities of achievement of the envisaged objectives against the stated milestones of work)	: NA
9.	Duration of the Project	: 24 Months
10.	Total amount of assistance required	: Rs. 13,09,000

Micro Plastic Pollution: Source characterization, transport modelling and assessment of impact on fish population in Kadambrayar river and Vembanad backwater region.

Abstract

The project envisages assessing the presence and abundance of Microplastics in river Kadambrayar flowing near the open solid waste dumping site at Brahmapuram. Two sets of sampling with three sediment samples from nearby Kadambrayar river and five top soil samples from various parts of Brahmapuram waste dumping yard were carried out during the months of January – February 2019. The study confirmed the presence of an average of 100 microplastic pieces per 100 gram of river sediments of Kadambrayar in Brahmapuram and a similar quantity of 178 particles in the top soil of Brahmapuram. The results of the preliminary study carried out indicates that the open dumping site at Brahmapuram acts as a primary as well as secondary source of microplastics, which gets accumulated at the top soil in the area. This gets transported via erosion and run off into the river Kadambrayar. The unprecedented amount of microplastics detected in the sediment samples motivated the planning of this proposal assessing the environmental implications of this observation. Projects aims at detecting and quantifying the microplastics in the top soil at Brahmapuram. It also attempts to model the transport of microplastics from top soil into the river using an erosion model. Once the microplastics reach the aquatic environment, it is highly likely that these will be ingested by the aquatic organisms including fishes. There is a growing body of evidence for microplastic ingestion by freshwater as well as marine fish species. The microplastic ingestion by the fishes and its subsequent incorporation into the food chain is likely to have far reaching economic and environmental consequences for a state like Kerala. The preliminary study conducted in the institute also suggested river Kadambrayar as a major pathway for transport of microplastics into Lake Vembanad. This project would attempt to determine the possibility of incorporation of microplastics into the food chain by assessing and quantifying the presence of microplastics in fish species of both a freshwater ecosystem (River Kadambrayar) and a saline water environment (Lake Vembanad). Finally, the project also proposes to assess the implications of presence of microplastics in the aquatic environment by carrying out laboratory studies for assessing the life cycle changes brought out by microplastics in the identified commercially important species in the river and Lake. This project can be a pioneering work which evaluates the ramifications of microplastics incorporation into food chain due to improper handling and disposal of plastic wastes.

State of Art of the subject

(including work done in India and elsewhere)

Plastics are a versatile material and have been used for making a variety of products that make human life easier. Many materials were introduced later to substitute plastics, but most of these materials couldn't challenge the overall versatility of plastics. However due to their longevity and non-biodegradability, plastics are becoming a major pollutant. The accumulation of plastics in oceans, water bodies, soil and air is becoming a challenging issue [Sruti et.,al 2016; Naidu et.,al 2017]. The longevity of plastics causes long distance conveyance and accumulation in soil, water and air [Sruti et.,al 2016].

As per US NOAA definition, microplastics are small plastic pieces of less than 5mm in size. They can be either primary or secondary in origin. The primary sources include plastic microbeads in personal care products and synthetic fibres from textile industry. The secondary sources includes the degradation of synthetic polymers like high density polyethylene, low density polyethylene, polystyrene, poly propylene, PET etc by physical, chemical or biological ways. Several studies shows the presence of microplastics in marine habitats, fresh water systems, aquatic organisms, sea foods and even in human tissues [Sruti et.,al 2016; Naidu et.,al 2017; Seth et.,al 2018; Barettet.,al 2019].As per the UN Environment agency, one million plastic drinking bottles are produced every minute and about 5 trillion single use plastic bags are purchased every year worldwide. India produces around 5.6 million tonnes of plastic annually [Toxics link 2014].

Studies of microplastics in Kerala, is limited. Kochi city was selected as the broad study area as it is the second most urbanized city on the west coast of India [Naidu et., al 2017] and also due to its high density of population, large riverine discharge and industrial and marine discharges. With its high density of population, solid waste management is one of the challenges faced by the State. The intensity of plastic pollution in Kochi can be assessed by the analysis of soil samples from Brahmapuram, the small village which has became the waste dumping yard of Kochi since 2017.The city does not have proper solid waste disposal methods and the drinking water pollution in the city is around 50%. As per reports, Kochi city generates around 380 tonnes of solid waste per day, of which 150 tonnes are biodegradable and 100 tonnes comprise of plastic waste. The major portion of this waste is dumped at Brahmapuram, a suburban village [Kerala Suchitua Mission 2018; Kerala SPCB Directory 2010]. This subsequently pollutes the rivers of Kadambrayar and Chitrapuzha, which borders the open

dumping yard of Brahmapuram [Kerala SPCB Directory 2010].According to the 'Water and Air Quality Directory 2010' published by the SPCB Kerala, the mean value of DO in Brahmapuram was only 2 mg/litre against the minimum limit of 4 mg/litre prescribed by the Central Pollution Control Board(CPCB).As per Kerala Suchitwa Mission statistics of 2018, Kerala produces 480 tonnes of plastic waste per day as the administration fails to enforce a ban on plastic material below 50 microns [Kerala Suchitwa Mission reports 2018]. On an average, a family in the state produces 60 grams of plastic waste per day and of these Kochi municipal corporation alone generates 16 tonnes of plastic wastes a day [Kerala Suchitwa Mission reports 2018]. The main portion of this plastic waste is dumped into Brahmapuram.

The recent study conducted by Anupama (2019) confirmed the presence of an average of 100 microplastic pieces per 100 gram of river sediments of Kadambrayar in Brahmapuram and a similar quantity of 178 particles in the top soil of Brahmapuram. The size distribution of particles showed that comparatively larger particles of size range between 2.36mm-4.75mm were present in the top soil than that in river sediments which had more number of particles in size range below 2.36 mm. The study found that the major part of microplastics was contributed by polyethylene which is the main constituent of single use plastics. It was followed by polypropylene, which are used as packaging materials. Also there was slight amount of polyethylene terephthalate (PET).

The preliminary study carried out by Anupama (2019) indicated the magnitude of microplastics contamination at Brahmapuram. This unprecedented amount of microplastics detected in both the top soil and the sediments motivated this proposal. The microplastics in the top soil would eventually find its way into the river and from there into Lake Vembanad. The River Kadambrayar is the source of water for nearby panchayats and supports a number of freshwater fish species. Several farmers and families of fishermen had depended on Kadambrayar for their livelihood till a few years ago, but the depleted quality of water in the river has made fishing unsustainable. The presence of microplastics would further accentuate the problem and would have far reaching environmental consequences. Seasonal analysis of microplastics in the river could also identify the contribution of Kadambrayar to the microplastics found in the back water regions of Vembanad lake, a popular Ramsar wetlands in India.

There is a scarcity of information about the occurrence of microplastics (MPs) in edible fish tissues in India, especially in Kerala. Kerala with a network of rivers, lagoons and backwaters flowing into a nutrient enriched coastal sea has an abundance of aquatic resources. This factor,

added to the diversity of the fishing technology, provided the socio-ecological basis for fish becoming an integral part of the cuisine of this region of the Indian sub-continent (http://www.fao.org/3/Y1290E/y1290e0g.htm). The reports of microplastics in tuna in Arabian Sea anchovies in Alapuzha, Indian Mackerel and Honeycomb Grouper in Tuticorin and mackerel caught from the coastal waters off Mangalore indicate that pieces/ strands of plastic enter the food chain [Kumar et al.,2018].

With this background, the objective of this study was to provide a critical assessment of the presence of microplastics in the top soil and in the sediment of river Kadambrayar which is flowing round the dumping yard of Brahmapuram and to investigate the presence of microplastics in the fish species in river Kadambrayar and Lake Vembanad. Effort would also be made to model the transport of microplastics from land to the river and also to assess the effects of microplastics on the life cycle of the identified fish species.

Literature Survey

Several studies have been conducted worldwide to estimate the severity of plastic pollution that we face today. These studies primarily focus on microplastic pollution because of their persistent nature and the adverse effects on our environment. Some of the relevant studies carried out are briefly described here:

The first report of microplastics in lake and estuarine sediments in India were carried out by in Vembanad lake, Kerala [Sruti et.,al 2016]. Vembanad lake is one of the Ramsar sites in India. Samples were collected from 10 different locations during pre-monsoon period from March-April 2016. Out of the 10 sampling location, 8 were in the fresh water zone that is south of Thaneermukkam bund and the remaining 2 were in the salt water zone from north of Thaneermukkam bund. The results obtained shows the mean abundance of 252.8 microplastic particles and consists mainly of polyethylene, polystyrene and polypropylene. Higher concentration of microplastics were found in high salinity areas.

Microplastics enters the living organisms through the food web. The evidence for this have been obtained by the study of benthic invertebrates from the coastal waters of Kochi, south-eastern Arabian sea [Naidu et al.,2018] Studies were conducted on the species of Sternaspis scutata and Magelona cinta. Samples were collected, sieved through 0.5mm mesh and preserved in Formalin-Rose Bengal mixture. The observations were carried out using DXR-microscope. The results disclosed the presence of microplastics in the form of polystyrene fibres. This was postulated to be due to non-selective feeding of polychaetes.

To assess the occurance of microplastics in fishes, a study was conducted in two harbours of Tuticorin, south-east coast of India [Kumar et al.,2018]. Fish species used in the study were Rastrillegar kanagurta (Indian Mackeral) and Epinephalus merra. The intestinal contents of these fishes were removed and digested for 5 days at 60℃. It was then filtered through a millipore filtration unit. Hot needle test was used to confirm the presence of microfibres. Results showed the presence of poly ethylene and polypropylene.

The presence of microplastics were also detected in the inland fresh waters of China [Wang and Li, 2016] Samples were collected at a depth of 0-20cm. After wet peroxide oxidation, the samples were filtered and observed under stereo microscopic and scanning electron microscopy (SEM). It was observed that degradation of large particles of plastic occurred either on land or in water. Biofouling was reported to change the density of particles which in turn leads to its suspension in water.

Microplastic pollution and its reduction strategies were explained in the review paper [Wu et al,2017] The paper estimated that the production of petroleum based plastics is exceeding 300 million tonnes in 2015. The study suggests that, microbeads in the cosmetics can be replaced with natural exfoliating materials. Also the use of biodegradable materials like polyacetide and polyhydroxy alkanoates was reported to limit the pollution caused by non-biodegradable plastics. Reuse, recycle and recovery of plastics need to be improved.

Microplastics acts not only as a source of toxic chemicals but also as a sink for toxic materials [De Sa and Oliveira, 2018]. Microplastics are difficult to clean up because of their small size and widespread distribution

Objectives

The specific objectives of the proposed project are as follows
1. To detect and categorize the microplastics in sediments and topsoil using ATR FT-IR spectroscopy.
2. To quantify the microplastics in each sample.
3. Model the export of microplastics into the river from land
4. The analyse common commerically used fish species of Kadambrayar andLake Vembanad to assess the presence of microplastics and the possibility of transfer of microplastics through food web.
5. To conduct laboratory studies to assess the effects of microplastics on the life cycle of the identified species.

Methodology

Top soil and sediment samples would be collected from various locations of Kadambrayar near Brahmapuram (Fig 1).Sediment samples would be taken from Kadambrayar at different locations and samples of topsoil would be collected from various locations of the open dump at Brahmapuram. The samples would be collected once in every month during the specified tenure of the project. The samples would then be sealed air tight in order to avoid contamination.

Fig.1. Study area

The water quality analysis would be conducted in the laboratory to evaluate pH, electrical conductivity, biological oxygen demand (BOD), hardness, chlorides, iron, nitrite and alkalinity of the water samples. The water quality analysis will serve as a tool to evaluate the magnitude of pollution at River Kadambrayar due to the open dump at Brahmapuram and assess the seasonal variation.

The sediment samples would be analysed as per US National Oceanic and Atmospheric Administration (US NOAA) protocol. Soil and sediment samples would be first oven dried at 90℃ for 24 hours and are then disaggregated manually. The disaggregated samples are then sieved through a series of sieve sets of 25mm, 10mm,

4.75mm, 2.63mm and 1.70mm respectively. Then the sieved samples below 4.75mm are subjected to wet peroxide oxidation using 30% concentrated H_2O_2 and left overnight for 24 hours to digest the organic matter. Then density separation is carried out using sodium chloride of density 1.3g/ml to separate the microplastics using floatation technique. The supernatant would be then filtered using filter paper and microplastics are extracted. The water quality analysis of river Kadambrayar carried out previously has indicated high organic pollution (Average BOD of 125 mg/L). Due to the high organic contamination on plastic pieces, the organic oxidation is repeated for a minimum of 3 times and packed in air tight bags to avoid air borne contamination and for getting accurate results in spectroscopic analysis. Otherwise the organic contamination may lead to erroneous results.

The extracted microplastics are again washed in millipore water just before placing it in the ATR FT-IR spectroscope. Once the specimen is placed properly, scanning is performed and the infrared spectra of the sample is generated with the help of a software called Spectrum. This generated spectrum is compared with the spectra available in the digital library automatically and the best suited match is displayed as the result. Preliminary work carried out indicates that the organic contamination in the samples, would interfere with the generation of good quality peaks in the spectra. Hence, a minimum percentage of 60% match would be selected as the best suited one.

Modelling transport of microplastics from top soil to river

Microplastics from land reaches river and subsequently to backwaters through the surface runoff and soil erosion. The impact of microplastics on the river as well as backwater ecosystem depends on the quantity and characteristics of the microplastics being transported from land. As part of the proposed project a mathematical model would be developed to quantify the transport of microplastics and understand their fate in river as well as in backwaters. Model simulation results will be validated from field measurements. Such a model will be replicable and could be used at other locations in Kerala to understand land to surface water contribution of microplastics.

Assessment of microplastics in fish species in River Kadambrayar and Lake Vembanad

This study proposes to assess and quantify the presence of microplastics in fish species of both a freshwater ecosystem (River Kadambrayar) and a saline water environment (Lake Vembanad). Commercially available fish samples would be collected from the river Kadambrayar and Lake Vembanad. After rinsing the fish in sterile water to remove visible

debris, the fish species would be identified according to the FAO species identification sheets. The fish would then be dissected using stainless steel kit, and would be placed in pre-sterilized zip-lock bags, sealed and stored (−4 °C) for analysis. The intestinal contents of fish would be scraped and transferred to clean crucibles. Three times the volume of content of 10% KOH would then be added to the samples and allowed to digest for 5 days at 60 °C. Once a clear solution is visible, the digested contents would be filtered through Filtration Unit. The filter papers are then labeled, observed and would be photographed under a Microscope for visual identification. Compounds suspected for microbeads and microfibers would be marked on filter paper. Primary confirmation of microfibers would be determined by Hot Needle Test wherein plastic fibers curl or deflect when a hot needle tip is moved around the fiber. Later, the suspected particulates would be photographed, isolated and analyzed by FTIR for confirmation of polymer functional groups.

Assessment of lifecycle changes due to microplastics in the identified fish species

Although some aquatic organisms have been shown to ingest plastic, few studies have investigated the life cycle changes brought about by the effects of plastic waste on animals. Exposure to environmentally relevant concentrations of microplastics could interfere with hatching, growth rates, feeding preferences and innate behaviours of fishes. This coupled with the increased incidence of microplastics in the aquatic environment makes it mandatory that the effects microplastics in inducing lifecycle changes in the fish species be investigated.

Laboratory experiments on microplastic grazing and accumulation in marine organisms have usually been carried out in controlled conditions in small experimental units, where the organisms have been exposed to a known concentration of plastic particles. Such studies have given insight into the potential of microplastic ingestion by various aquatic organisms, and raised questions regarding the hazards due to microplastic ingestion. One possibility for collecting realistic data is to study the processes in aquariums resembling natural environments. Experiments would be carried out in small scale aquarium in a temperature controlled condition provided with aeration. The water quality characteristics maintained in the aquarium will closely resemble the water quality of the natural environment which is replicated. The experimental aquaria will contain contained a selection of fishes that are common in the lake Vembanad and would be left to acclimatize to the experimental conditions for one to two weeks. A control aquarium would also be maintained in the same condition. The experimental set up would then be exposed to a selected range of microplastics mimicking the concentration

detected in the natural environment. The morphology of the microplastics would also be the same as that found in the natural environment. The parameters which would be monitored include the weight, reproductive habits and life cycle changes and behavior exhibited. This would then be compared to the control aquarium which would not be exposed to microplastics. After the study the bodies of the fishes (the viscera and gills and eviscerated flesh (whole fish excluding the viscera and gills)) exposed to microplastics would be studied for microplastics ingestion as described in the methodology section.

Year-wise work plan

Work plan including time schedule & chart

Sl. No.	Activity	1st Year				2nd Year			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
1	Detailed Literature Survey	▓	▓	▓	▓	▓	▓	▓	▓
2.	Identification of relevant fish species for assessing the presence of microplastics in fishes	▓	▓						
2	Sampling and Analysis of Top soil, sediment and water samples	▓	▓	▓	▓	▓	▓	▓	▓
3	Sampling and analysis of fish to determine micoplastics in fish species	▓	▓	▓	▓	▓	▓	▓	▓
4.	Laboratory studies for assessing the life cycle changes in the selected species of fish					▓	▓	▓	▓
5	Modelling Export of microplastics from land to river and Validation					▓	▓	▓	▓
6	Compilation of results, Final report preparation and submission							▓	▓

Minimum required tenure of the project: 24 months

Practical relevance/utility of the project

A number of studies have been carried out indicating presence of microplastics in both freshwater and marine environments. A few studies have also indicated presence of

microplastics in fishes also [Kumar et al.,2018]. But most of these studies have concluded that, though the presence of microplastics in the fish is a matter of significant environmental pollution due to plastics, the concern about its transfer to edible parts of the fish could not be ascertained, since fish sellers usually remove the gut/intestinal tracts prior to selling and gut/intestinal tracts of the selected fish species is not consumed. However, there is increasing evidence of edible parts of the fish also been contaminated due to microplastics. In this project the focus would be on microplastics and its morphology (fragments, films, filaments, beads, and foams) in the viscera and gills and eviscerated flesh (whole fish excluding the viscera and gills) of the species selected. Gills of the fishes are the first organ exposed to anthropogenic particles during respiration and this increases the probability of particles getting stuck in the gills of fishes. The microplastics thus stuck in the gills are more of concern in small fishes which are used for consumption as dried fish, since dried fish are often processed without any cleaning process and evisceration is difficult in case of small fishes like anchovies. The study of life cycle changes in fishes due to its proximity to microplastics has not been reported in India. Hence a study of this nature is of vital importance for a state like Kerala where majority of people consume both freshwater and seawater fishes including dried fish. Moreover, the order of magnitude of the abundance of microplastics detected in the sediments in river Kadambrayar is quite high when compared to the reported values elsewhere.

Socio-economic and environmental relevance of the project

Studies of microplastics in Kerala, is limited. With its high density of population, solid waste management is one of the challenges faced by the State. The intensity of plastic pollution in Kochi can be assessed by the analysis of soil samples from Brahmapuram, the small village which has became the waste dumping yard of Kochi since 2017. As per reports, Kochi city generates around 380 tonnes of solid waste per day, of which 150 tonnes are biodegradable and 100 tonnes comprise of plastic waste. This subsequently pollutes the rivers of Kadambrayar and Chitrapuzha, which borders the open dumping yard of Brahmapuram. Hence, a long term monitoring and assessment may help in forming an accurate picture of the problems due to the microplastics in the aquatic environment. It may also help in exposing the deficiencies with regard to handling of plastics and formulating/developing an alternate policy.

The river Kadambrayar drains into Lake Vembanad. This results of the preliminary study conducted at the institute by Anupama (2019) coupled with the study conducted by Sruthy et., al 2016 clearly indicates that river Kadambrayar is one of the major pathway of microplastics

into Lake Vembanad. The River Kadambrayar is the source of water for nearby panchayats and supports a number of freshwater fish species. Several farmers and families of fishermen had depended on Kadambrayar for their livelihood till a few years ago, but the depleted quality of water in the river has made fishing unsustainable. The presence of microplastics would further accentuate the problem and would have far reaching environmental and economic consequences. It has been proven by many studies that microplastics are entering our food web, and as top predators, human beings are exposed to its potential harms.

These factors make it imperative that the studies of presence of microplastics in the fish species in the aquatic environment be carried out to detect its presence and to assess the life cycle changes in the fishes. The fishworker population of the State in 2016-17 is estimated to 10.29 lakh. Out of this, 7.92 lakh fishworkers belong to marine sector while 2.37 lakh fishworkers belong to inland sector. Ernakulam, Alappuzha, and Thrissur are the leading districts in the case of inland fish production occupying the first, second and third positions respectively. The study conducted would throw light on the impact of microplastics on the fisheries industry. Although this study limits itself to fish species in river Kadambrayar and Lake Vembanad, the microplastics found there would eventually find its way into the sea affecting marine fish population also.

Expected and other physical outcomes of the project
The proposal envisages the following outcomes from the study

1. An accurate picture of the abundance, morphology and characterization of microplastics in the top soil at Brahmapuram and in the sediment in river Kadambrayar.
2. Develops better understanding of sources and routes of travel of microplastics
3. Highlights the implications due to the presence of microplastics in river
4. A model which simulates the transport of microplastics from top soil at Brahmapuram into the river.
5. Assessment of presence and abundance of microplastics in the commercially used fish species of river Kadambrayar and Lake Vembanad.
6. Laboratory assessment to assess the lifecycle changes in the fish species due to the microplastics.

Agencies which can utilize the results of the project

Kochi Municipal Corporation: The Kochi Municipal corporation can make use of the study conducted to reassess their plastic waste management strategies. Sruthy et al.,2016 identified low density polyethylene as the most abundant polymer found in Lake Vembanad. Anupama (2019) also found Polyethelene as the most abundant polymer in sediment samples in river Kadambrayar and in top soil at Brahmapuram. Most of the samples from brahmapuram were from polyethelene bags of thickness less than 50 microns. It was also found that, the low density polyethelene bags are liable to disintegrate easily hence also subject to long distance transport via water or air. If the findings of this study, conducted for longer monitoring period reiterates the findings, then it can help in adopting policies/strategies directed to curbing/reducing the specific polymer.

The Central Marine Fisheries Research Institute (CMFRI): Confirmation of the presence of microplastics in might interfere with the commercial value of fishes in Kerala. Ingestion of microplastics by commercially important species in both Kadambrayar and Lake Vembanad would be determined from field observations. The results of the study can be used by CMFRI to frame suitable preventive measures to ensure that microplastics do not enter the food chain via the fishes consumed.

Techno-commercial feasibility of the project, if any: Nil
Modalities for replication of the outcomes, if any
The study serves as a pioneering effort to link the open dumping area as a source of microplastics into the aquatic ecosystems. The model for transport can be extended to determine the transport of microplastics from top soil to any river body. The study conducted can be used to evaluate new knowledge regarding sources, pathways, loadings, and processes for microplastic in the context of a comprehensive conceptual model to allow prioritization of data gaps. The model predictions would be compared to monitoring results and potential reasons for differences between predicted and measured values would be assessed. The proposed study can be used to predict the modalities of transport of microplastics into the marine environment. The parameters and protocols used in the laboratory experiments can serve a guideline for further work in the area.

Standardization of the design parameters for technology and preparation of protocols/ prototypes for achieving reliable and replicable processes, if any:

The model for transport can be extended to determine the transport of microplastics from top soil to any river body. It can be used to evaluate new knowledge regarding sources, pathways, loadings, and processes for microplastic in the context of a comprehensive conceptual model to allow prioritization of data gaps. The protocols developed can be used to evaluate available data on the impacts of existing and proposed management actions to reduce microplastics in aquatic and terrestrial environments.

Component-wise justification of the costing of the project

- The project involves extensive sampling and laboratory work and analysis. This would cost approximately Rs. 2.0 lakhs
- JRF will be employed for 24 months period to assist the investigator during the field work, sample collection and analysis. JRF stipend will be around Rs. 6.0 lakhs
- Supporting staff (during field data collection) & Technical staff salaries (as and when needed) - Rs. 1.4 lakhs
- Field analysis and laboratory of sediment samples (Glassware and chemical) Rs.1.0 lakh
- Travel cost (for field visits) - 1.0 lakhs
- Contingency expenses – 0.5 lakhs
- Institutional overhead – 10% of the above

Budget Modification: No changes have been proposed for the budget in the revised proposal since there is no modification of the objectives and the scope. Only changes made are in the work plan. The sampling schedule remains monthly throughout the tenure of the project. The final results of the sampling will be used to validate the developed model. In the previous proposal the JRF was proposed for a period of 24 months to assist in field work, sample collection and analysis. In view of the hectic revised schedule of sampling and monitoring, the same period of 24 months is retained for the JRF.

References

1. Anupama S. (2019)- "Detection of microplastics at Brahmapuram using ATR-FTIR spectroscopy and modelling its transfer to water sources for risk assessment" .Project Report for the project work in M.Tech submittetd to KTU.

2. Chandan Krishna Seth and Amritanshu Shriwastav (2018), Contamination of Indian sea salts with microplastics and a potential prevention strategy, *Environmental Science and Pollution Research.*

3. Luis Carlos De Sa and Miguel Oliveira (2018), Studies of the effects of microplastics on aquatic organisms: What we know and what should we focus our efforts in future, *Science of the Total Environment*, Vol:645, 1029-1039

4. S. A. Naidu,V. Ranga Rao and K. Ramu (2018), Microplastics in the benthic invertebrates from the coastal waters of Kochi, Southeastern Arabian Sea, *Environ Geochem Health Springer Nature*.

5. S Sruthy and E V Ramaswamy (2016) - Microplastic pollution in Vembanad lake, Kerala India: The first report of microplastics in lakes and estuarine sediments in India – *Environmental Pollution,* 1-8.

6. Vigneshwari Easwar Kumar, Geetanjali Ravikumar and K. Immaculate Jeyasanta (2018), Occurrence of microplastics in fishes from two landing sites in Tuticorin, South east coast of India, *Marine Pollution Bulletin*, Volume 135, 889-894.

7. Wei-Min Wu, Jun Yang and Craig S. Criddle (2017), Microplastics pollution and reduction strategies, *Front. Environ. Sci. Eng.,* Vol: 11, 1-6.

8. Wenfeng Wang and Zhen Li (2016), Microplastic pollution in inland fresh waters of China: A case study in urban surface waters of Wuhan, China, *Science of the Total Environment.*

9. Economic review SPCB Kerala 2016.

10. Kerala SPCB Directory 2010

11. Kerala Suchitwa Mission reports 2018

Part III - Biographical Sketch of the investigator(s) detailing research credentials and research papers published in the area of the proposed research project

Part IV - Facilities (equipments/instruments) available at institution(s)/organizations for carrying out the project

The Department of Civil Engineering at SCMS School of Engineering and Technology(SSET) has a full-fledged Environmental Engineering laboratory supplemented with modern equipment and research facilities. The Civil Engineering Department also conducts an M.Tech Environmental Engineering programme at SSET since 2013.The Environmental Engineering laboratory is used by both the undergraduate and post graduate students. The laboratory is also utilized by the SCMS Water Institute(SWI) for sponsored research, consultancy and technical services. The preliminary study on detection of microplastics in soil and sediment samples mentioned in the abstract and methodology has been carried out Ms Anupama S, a M.Tech student at SSET as a part of her project work as per KTU norms. The institute also has a Central library with number of online journal subscription. It also has High speed internet facilities and computational facilities to aid research.

Some of the instruments available in the laboratory are as follows.

1. **Water quality analyzer**
2. **UV_VIS digital spectrophotometer**
3. **Compound Laboratory Microscope**

Fourier Transform -Infrared (ATR - FTIR) spectroscopy for the identification and characterization of microplastics will be carried out at either at Department of Civil Engineering, NIT Calicut or Sophisticated Analytical Instruments Facility (SAIF) at Sophisticated Test and Instrumentation Centre.

File Ref.No.KTU/RESEARCH5/467/2022

APJ Abdul Kalam Technological University
Thiruvananthapuram

Abstract

APJAKTU - Financial Assistance to Student Projects 2022 - Administrative Sanction accorded - Orders issued.

RESEARCH SECTION

U.O.No. 964/2022/KTU   Thiruvananthapuram, Dated: 27.04.2022

Read:-1. Minutes of the 1st meeting of Engineering Research Council dated 27.01.2010.
2. Minutes of 2nd meeting of Executive Committee dated 21.10.2010.
3. Meeting of the 2nd Research Council dated 29.02.2017.
4. Proposals of Student Projects for Financial Assistance.
5. Screening Committee meeting held on March/April 2022 for evaluation of project proposals.

ORDER

Vide paper read 1st above, the Engineering Research Council had approved the scheme for Financial Assistance to Student Projects for the Government Engineering Colleges. Vide paper read 2nd above, it was decided to extend the financial assistance to the student projects to the students of the Government aided and Government Controlled Engineering Colleges.

It was decided to extend the financial assistance to Student Projects for all engineering colleges affiliated to the University with NBA accreditation as per paper read 3rd above. It was also decided that the financial assistance will be provided as reimbursement of expenditure occurred for the sanctioned project.

The Screening Committee meetings held in March/April 2022 evaluated the project proposals forwarded from Engineering Colleges affiliated to the University and recommended financial assistance to selected proposals as per the List appended.

Administrative sanction is therefore accorded for financial assistance to student project as detailed in the list attached below. The project shall be completed within a period of 1 year and the project shall be completed with the students who presented the project before the Screening Committee.

The expenditure should be incurred as per the terms and conditions as per Annexure II attached. The amount will be reimbursed to the Principal of the concerned Colleges only after the successful completion of the project and on the production of certified bills & vouchers along with the audited utilization certificate, statement of expenditure and project completion report.

The expenditure shall be met from the Head of Account "S 3022-Innovative Student Project".

Orders are issued accordingly.

Sd/-

Dr. Shalij P.R *
DEAN (Research)

Copy to:-
1. Principals of Engineering Colleges.
2. Principal Investigators.

No	Faculty	Students	Project Title	Institution						Total	Dept
69	Dr. Rajesh Baby Associate Professor	Bilbin Mathew Paul Vargheson Alan Philip Rajan	Development of an automatic height adjusting pillow to relieve chronic neck pain (cervicalgia).	St. Joseph's College of Engineering and Technology Palai.	10,000	25,000	5000	5000		45,000	MECH
70	Ivin Jose Assistant Professor	Thimothy Benny Akhil Krishnan Genesis J Cheruvallil Benchamin Tomy	Tool design and fabrication of hybrid electro discharge grinding setup for microchannels	St. Joseph's College of Engineering and Technology Palai.	10,000	25,000	5000	10,000		50,000	MECH
71	Dr. Madhukumar S Professor	Prince Jose Vijay Varghese Amal Varghese Jubin Thomas	Borewell rescue robot	St. Joseph's College of Engineering & Technology Palai	5000	15,000		1500		21,500	ECE
72	Anto Manuel Assistant Professor	Adithya Sunil, Ben Alphin Binny, Jobin Benny Roshan Rajeev	An Intelligent Device To Predict Cloud Burst	St. Joseph's College of Engineering and Technology Palai.	5000	15,000		1500		21,500	ECE
73	Dr. Praseetha V M Associate Professor	Anjana V M Tinu Sam Rona Mariam Shaji Tressa Mary Joseph	Gesture based device controlling system	St. Joseph's College of Engineering and Technology Palai.	3000	11,500		1800		16,300	CSE
74	Dr.Georgina Binoy Joseph Associate Professor	Akshara Sajeevan Ann Mary Abraham Aswathy Meria Peter Honeymol M Jose	SMART MIRROR	Toc H Institute of Science and Technology	2000	10,000		1500		13,500	ECE
75	Girish.P Assistant Professor	Anagha Biju Betty George KP Manjulika Sneha Baby.KX	ACCI-LERT SYSTEM	Toc H Institute of Science and Technology	2000	8000		1500		11,500	ECE
76	Dr.Rosebell Paul Asst. Professor	Neeraj M Neeraj Sagar Vaibhav Nair Yadukrishnan PS	An AI Based Swarm Wheel fot system to detect Cracks in Railway Tracks.	SCMS School of Engineering and Technology, Ernakulum, KarukuttY	8260	36,000		4,000		48,260	CSE
77	Harish T M Assistant Professor	Nandu Krishnan A U Nasmal Navas Sreekanth K.A	Development and fabrication of Al 7075 composite reinforced with industrial waste and clay	Federal Institute of Science ancl Technology, Ernakulam	10,000	10,000	5000	20,000		45,000	MECH
78	Manu Mohan C M Assistant Professor	Joheon C P Joseph Paul Linto Thomas Rajeev K R	Sign language to speech converter using machine design	Federal Institute of Science ancl Technology, Ernakulam	3500	10,000	500	2500		16,500	ECE
79	Sreevidya P Assistant Professor	Gokul Rejitkumar Godson Thomas	Integrated communication system for deaf and mute	Federal Institute of Science ancl Technology, Ernakulam	3000	10,000		1000		14,000	ECE
80	S Sundararajan Assistant Professor	Bilal Ibrahim P A Rajeena R Sony Shajan	Fruits adulteration detection system	Federal Institute of Science ancl Technology, Ernakulam	1500	5000		1000		7500	ECE
81	Panjami K Assistant Professor	Aleena Garvasis Apsara S Baiju Gayathri S Kumar Gokul S	Study on Effeetiveness of Mobile sensors in deteeting sutrsurface cavities- A step towards early detection of cavities at Kerala	Federal Institute of Science ancl Technology, Ernakulam	10,000		35,000	5000		50,000	CIVIL

A SWARM BASED AI AIDED WHEEL BOT SYSTEM TO DETECT CRACKS IN RAILWAY TRACKS

INTRODUCTION

Indian Railway is one of the largest transportation networks in the world. It has a daily passenger count of 24 million passengers.For such a vast network the possibilities of lapses in safety is alarmingly high.

One of the major causes of hazard would be disruption in locomotive movement. Cracks in railway tracks have been identified as one of the major causes of railway accidents.Currently there isn't a fail proof system to detect and fix cracks on railway tracks. The system still follows the primitive methods of manual checking and solving.The project focuses on providing a real-time solution to the identified cracks on railway tracks. Once identifying a crack as a threat the agent aims at alerting the nearby agents as well as a base station by an active communication channel that updates the status in real-time. The projects implements a wheel-bot (UGV) which is able to differentiate between cracks and intentional gaps(thermal expansion). The Robots Dynamically communicate with other agents (Swarm Robotics approach) and the main workstation to relay information regarding the problems

identified.Once the agent has identified a crack, it is intimated to the nearest base station for the track engineer to address the issue at the earliest.It also communicates to its nearest agents and alerts them regarding the identified setback. The system also tries to provide a safe environment for the locomotive system in the regions of animal crossing.

BACKGROUND AND MOTIVATION

Railway is the most essential form of transport in India, as it provides long-distance, comfortable travel within a budget for a commoner. According to the NCRB Annual Report 2020, there were 27,987 train accidents in 2019, 13,018 in 2020. The report also revealed that as many as 11,986 railway passengers were killed and 11,127 were injured in these accidents during the past year of 2021. Accidents like these can happen to various reasons, one of the most prominent being the cracks in railway tracks. The very concept of the project lies within identifying the type of cracks on the tracks. They are of two types, one being the intentional gaps left on the tracks for thermal expansion during summer. The other being the faulty cracks which can cause a catastrophe as dangerous as derailment of the train of the tracks. The current system lacks any kind of novel technology to identify and rectify faulty cracks. This project tries to work on this problem and provide a real time solution. The project also takes the vast scale of the domain into consideration. So it tries to provide a solution that requires minimal human interference and mobile management.

METHODOLOGY

The system is divided into clusters. Each cluster has a base station and a fixed number of agents. These agents follow swarm robotic architecture. The agents are deployed on the tracks. The number of agents in a cluster is determined by the maximum communication range of an NRF module which is the communication unit used in the product. The aforementioned can be extended up to 3 km. The cluster also has a fixed number of free robots that replace the working agents in case of a fault or low battery. The designed UGV is a four-wheeled bot that is deployed directly onto the railway tracks.
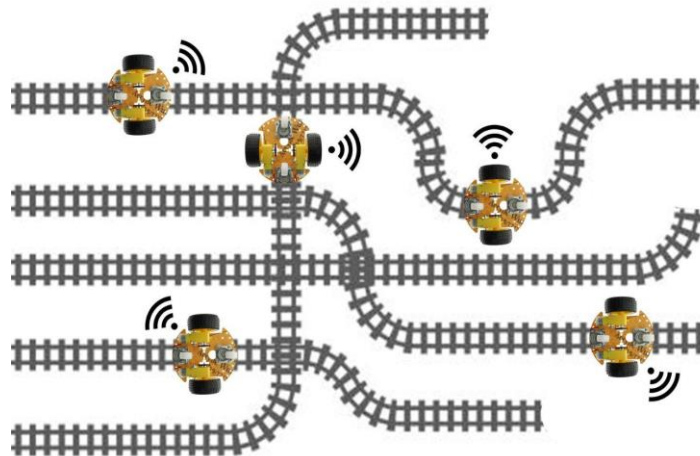
SYSTEM ARCHITECTURE

The system mainly comprises the communication unit and the sensor data processing unit. Communication is responsible for the efficient exchange of data between the agents as well as the base station. The agents communicate to the nearest bots and base station in the case of any kind of hindrance identified by the sensor data processing unit. The sensor data processing unit is responsible for the detection of different types of cracks, obstacles, and faults in the agent itself. Various sensors are integrated and implemented for fault detection. The data is fed to the Arduino board which handles the communication and sensor data processing tasks.

The raspberry module is integrated in the system for image processing. The project aims toward efficient animal crossing detection which is common on the Indian railway tracks due to the terrains it passes through. The agents will be equipped with an FPV camera, which captures images when it encounters live object detection. Then running efficient image processing algorithms it identifies the subject in front of it and starts over only when the path is clear.

The model is also equipped with a GPS module which helps 7the other agents know its current location when it sends out data in case of fault detection. This helps other agents to reach that specific location and aid it. It also helps the base station to know the location of the fault.
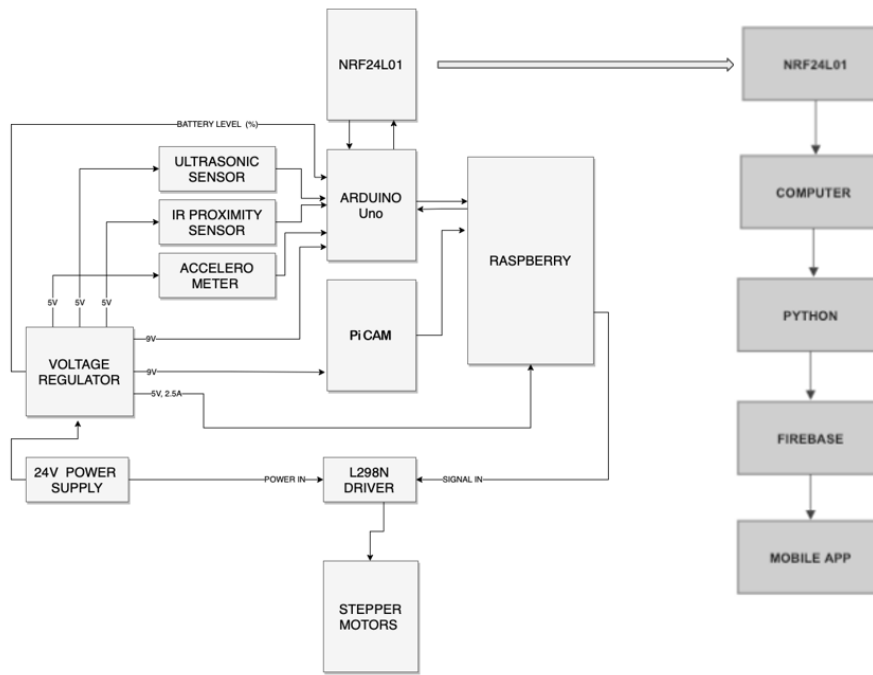
COMMUNICATION UNIT

The communication unit is set up primarily using an NRF24L01 module. The inter-

system communication happens in the case of:

● Crack detection

● Obstacle detection

● Animal crossing detection

● Agent failure

On the onset of any of the aforementioned conditions,the agent sends its location, proximity,

X-Y coordinate values of accelerometer, IR proximity, temperature values to the assigned

base station and nearby agents within communication range. A single RF channel with

multiple communication pipelines is established with a dedicated pipeline for each of the

agents. The agents constantly send data to their respective cluster base station which can be

viewed on the android application. It shows a warning signal along with a trigger alarm when an agent detects an anomaly. It also communicates to the nearby agents when an anomaly occurs. A single agent can communicate up-to 6 agents at a time and has a maximum communication range of 3 km.

SENSOR AND PROCESSING UNIT

The sensor unit mainly comprises:

● Ultrasonic sensor (Obstacle detection)

● IR Proximity sensor (Crack detection)

● MPU6050 (Fault detection)

The ultrasonic sensor mounted in front of the agent continuously sends trigger pulses in front of it till certain proximity. In case of occurrence of an obstacle, it receives an echo back, meaning the pulse has hit a physical object and the agent confirms detection of an obstacle on the track.
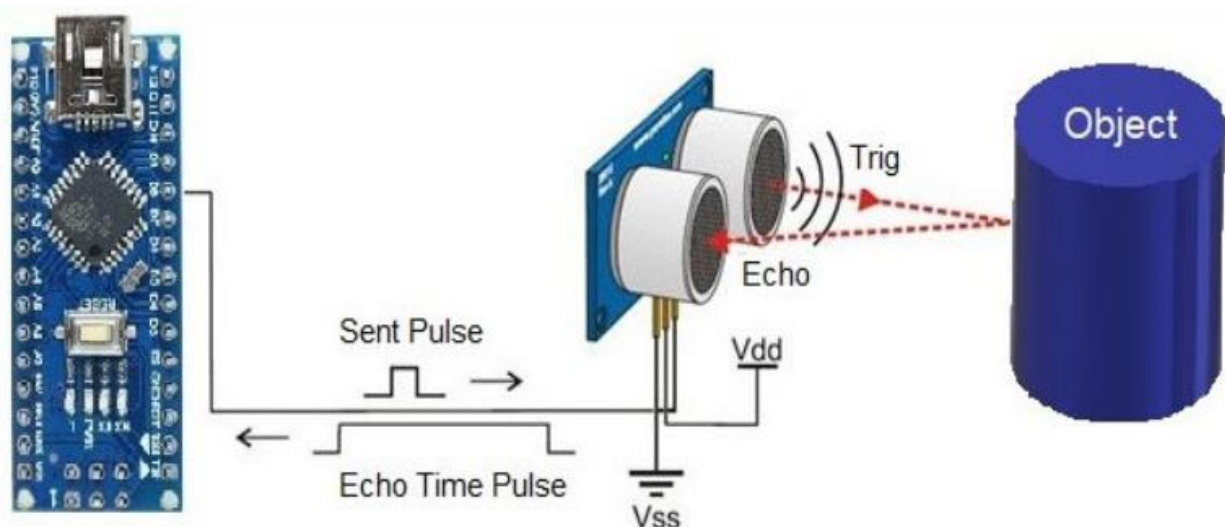
ANDROID APPLICATION

An Android application is developed to alert the officials and the concerned individuals regarding the emergency condition that has to be addressed fast. The developed app gives the provision to know the different values of the sensors which include an IR sensor, a combined sensor module of Temperature and Accelerometer called MPU 6050, and a GPS module. The app gives an alert alarm and a warning image as the sudden response to cracks or any other obstacle encountered by the bot during their routine crack detection checkup. It consists of a parallel display providing a side-by-side view of the status of each bot. The app also consists of the two buttons named BOT_1 and BOT_2 which once clicked will lead to the live location of the robot where they are present. The approximate distance between the two robots will be displayed between the two buttons. This app is basically an interface that helps the authorities to know when to start the accident prevention steps. Basically, this app provides full-fledged access to know all the details regarding the robot including their nearest distance. The alarm system in the application causes a sudden alert throughout and constantly rings until an immediate step is taken. This app will be provided only to the Railway Authority officers as there are high chances of this app getting misused. The distance between the coordinates namely Latitude and the Longitudes are calculated using the Haversine formula. When one robot is getting tampered with or derailed, then the nearest robot will come to assist the damaged robot. The nearest distance is hence calculated with the help of the haversine formula.

ANIMAL DETECTION UNIT

The pathways of the crack detection robots are medalled with a plethora of obstacles and dangers. The bot actively responds against non-living obstacles using its array of proximity sensors. The next challenge are the living obstacles and dangers caused in specific locations like animal crossings and wildlife sensitive areas. Elephant crossings along various railway tracks can cause untimely disruptions in the proper movement of the robot. An efficient way to tackle this problem is a real-time animal detection system that takes in live camera feed and detects elephant crossings present in the frame. On the detection of an elephant the robot is signaled to halt its movement and wait for a safer environment to continue its movement by analyzing the live camera feed. The process of animal detection is carried out on a Raspberry Pi module attached onto the robot. Upon detection the Raspberry Pi is programmed to provide a motor signal to the required L298N motor driver module. Detecting an object entails both stating that an object belonging to a specified class is present, and localizing it in the image. The location of an object is typically represented by a bounding box.

RESULTS AND DISCUSSION

The prototype was successfully run on the simulated railway tracks and the results suggest that the final model can be successfully run on the actual railway track along with the implementation of auto-detachment feature from the track feature. The trains will be set up with proximity sensors and using the geo-location of the trains, when the train is within a proximity threshold distance, the agent proceeds to detach itself off the tracks onto the surface of the tracks. The agent uses actuators to lift itself off the track, then scissor hinges flips the wheels inside the tracks and the actuator proceeds to rest the agent onto the base of the tracks. The agent then lifts back up and places itself back onto the track when the train leaves the proximity threshold region.

The integration of the Indian railway database with the model can make the project extendable across the railway network of the country. With access to geo-location of trains and the thermal expansion tracks along with the train timings and delays, the efficiency of the model can be increased exponentially.

The success of the whole project revolves around the auto-detachment feature. A number of alternatives were brainstormed and discussed out, from the spider-bot model to linear actuators stand alone. After extensive research, cross-hinges along with linear actuators

along the wheels was confirmed to be the most feasible and suitable model for our project. This made sure there was an equal distribution of weight throughout the base of the robot. It also ensured a sturdy, fool-proof and hasty mechanism.

The inclusion of animal detection, arose from the obstacle detection module, when the presence of animal crossing was taken into consideration. When the obstacle detection module was being implemented, it was realized, the agent has to be cautious about not just the static, but the dynamic(animals) obstacles which may hinder the movement of robot on the track. Thus, the concept of image processing was brought up, which will help the agent identify if any kind of animal crossing is going on, on the tracks in front of it. Based on the type of animal crossing and the behaviour the animal exhibits, the robot can accordingly decide the amount of time it has to halt, before restarting its movement.

HIGHLIGHTS

This project consist of many features which enhances the credibility and use of the system. An application that supports the real-time data transfer and an alarm system is added to the app. As a next step to future implementations we have included an advanced feature of image processing. The app which is mentioned above consist of certain features which include an alarm and specific values of the corresponding cracks and defects which are found on the rail. Each feature contains a specific threshold beyond which the alarm starts to beep and a warning message will be popping up. Image Processing section will be dealing with the objects encountered by the bot. The proposed system is a swarm system and supports multiple bots and any damaged or derailed robot will be supported by the neighboring robot.
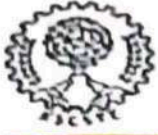
KSCSTE - Student Project entitled –"**Data abstraction of vehicles on crashing (DAVOC)"** submitted by Mrs.Hazel Elsa John, Assistant Professor, Electronics & Communication,SCMS School Of Engineering And Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576 Kerala as PI and Ajmal P S,Akshay Kumar T V,Adithyan A S,Hafis Abdul Rahimas student investigator(s) - financial assistance - Orders issued.

Council (P) Order No366/2021/KSCSTE   Dated: Thiruvananthapuram,05/10/2021

Ref: -   1. Decision of the 64th SP Committee meeting dated December 13, 2019 on item No. SP- 64_ (01300 /SPS 64/2019/KSCSTE)
2. KSCSTE/592/2020-SP

ORDER

Kerala State Council for Science Technology and Environment (KSCSTE) is operating a programme for supporting student projects in colleges and university departments. Mrs.Hazel Elsa John, Assistant Professor, Electronics & Communication, SCMS School Of Engineering And Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576, Kerala, has submitted a student project as PI with Ajmal P S,Akshay Kumar T V,Adithyan A S,Hafis Abdul Rahimas student investigator(s) for financial assistance. The 64th SP Committee meeting dated December 13, has sanctioned ₹9800/-(Rupees Nine thousand and eight hundred only) for the conduct of the above said project. The PI has submitted the final report and financial statements after completion of the project.

KSCSTE has verified the submitted documents and is pleased to accord sanction for the release of ₹7249/-(Rupees seven thousand two hundred and forty nine only)towards financial assistance for the student project titled –"Data abstraction of vehicles on crashing (DAVOC)"submitted by Mrs.Hazel Elsa John, Assistant Professor, Electronics & Communication, SCMS School Of Engineering And Technology Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576, Kerala.The amount will be disbursed to **The Principal, SCMS School Of Engineering And Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576, Kerala**by means of Electronic Fund Transfer as per their bank details given below.

Beneficiary Account Name	SCMS School of engineering and technology
Beneficiary Account Number(SB/CC)	345801010030000
Beneficiary IFSC code	UBIN0558885
Name of bank	Union bank of India , Palissery
Beneficiary Address	The Principal, SCMS School Of Engineering And Technology Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576 Kerala

File No.KSCSTE/592/2020-SP

Beneficiary Phone No.

9446763487

Beneficiary E-mail ID

praveensal@scmsgroup.org

The expenditure in this regard will be met from the Council fund **(III) Schemes and Programmes of KSCSTE - Student project scheme.**

K P SUDHEER
EXECUTIVE VICE PRESIDENT,KSCSTE

To

The Principal, SCMS School Of Engineering And Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576, Kerala

Copy to:

Mrs.Hazel Elsa John, Assistant Professor, Electronics & Communication, SCMS School Of Engineering And Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576
Kerala

Ajmal P S,Akshay Kumar T V,Adithyan A S,Hafis Abdul Rahim, Student(s),Bachelor of Technology (BTech), Electronics & Communication, SCMS School Of Engineering And Technology, Vidya Nagar, Palissery, Karukutty, Ernakulam - 683 576, Kerala

The Cash Section KSCSTE, Auditors file, Stock File/Office Copy

Society for Research & Initiatives for Sustainable Technologies & Institutions

Ref. No. BIRAC SRISTI PMU – 2020/007   December 31, 2020

Subject: Sanction Letter of SITARE GYTI Award

To,

Awardee: Vinoj P.G
Supervisor Dr. Sunil Jacob
Institute Name: SCMS School of Engineering & Technology, Kerala

You have been granted a sum of Rs. 15,00,000/- to further work on Project **"Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralysed"**.

You need to sign an agreement called Grant Award Letter Agreement (GALA) which must contain the relevant Annexures for Specific objective, Plan of work (Activities, Time Period & Milestones) and Output. The GALA had already been sent to you. The budget utilization in all phases must be as per the signed GALA and in all cases GALA guidelines will be followed.

Project Period: 2 Years (3 Semester; 1 Semester = 8 months)

Release of The Grant: In three instalments

vii. 33% (Rs. 5,00. 000/-) after the signing of GALA
viii. Next 67% (Rs. 10, 00, 000/-) in other two instalments of around 33% each after every eight months on completion of at least 80% of that semester's work as per milestones.

You are required to submit the following:

xiii. Progress Report after every eight months.
xiv.   Audited Expenses Report (Utilization Certificate – UC & Statement of Expenditure - SOE) after every eight months and at the end of the project period.
xv.   Compiled Project Report along with compiled UC of all phases at the end of the project period.
xvi.   The next phase will be released after the approval of review committee meeting.

You are also required to return the unutilized grant at the end of the project period. The budget utilization will be done under GALA guidelines.

On successful completion of the project work, you will be issued a Project Completion Certificate from SRISTI.

Thanking you

BIRAC SRISTI PMU

SRISTI
AES Boys Hostel Campus,
Near Gujarat University Library & SBI bank,
Navrangpura, Ahmedabad - 380 009

સૃષ્ટિ
એઈએસ બૉયઝ હોસ્ટેલ કેમ્પસમાં,
ગુજરાત યુનિવર્સિટી લાઇબ્રેરી અને SBI બેંક નજીક,
નવરંગપુરા, અમદાવાદ-૩૮૦ ૦૦૯

SRISTI

Ph No: 079-2791 3293, 2791 2792, web: www.sristi.org, Email: info@sristi.org, honeybee@sristi.org
"SRISTI" Trust Regd.No. F/3538/AHMEDABAD (BOMBAY PUBLIC TRUST ACT1950)

GRANT AWARD LETTER AGREEMENT

THIS AGREEMENT made on this ....4th...... day of DECEMBER......... 2020 at SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY,KARUKUTTY,KERALA (TIME:11:30 AM)....by and between...Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)... hereinafter called as SITARE Partner (which expression shall wherever the context so admits include its successors and assignees), a non-profit organization having its office at ...AES Boys Hostel Campus, Near Gujarat University Library & SBI, Navrangpura, Ahmedabad-380009, Gujarat, India of the **First Part**

And
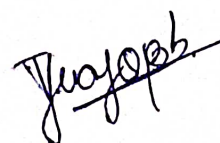
Shri.___VINOJ P G_____S/D/o __P P GEORGE_____ resident of _ERNAKULAM,KERALA_____ ,studying at ___ SCMS SCHOOL OF ENGINEERING ANDTECHNOLOGY,KARUKUTTY,KERALA (Institute/University)and having the Project:" Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed";hereinafter called **AWARDEE** of the **Second Part**:

WHEREAS all the parts are hereinafter referred to as "Parties";

Whereas,SITARE Partner is an organization set up with the objective ofstrengthening the capacity of grassroots and student, inventors, innovators and ecopreneurs in the area of conserving biodiversity and developing eco-friendly solution to local problems; is engaged *inter alia* in the area search, documentation, experimentation, development, diffusion of sustainable technologies and Techpedia, a Sristi initiative aims at putting the problems of micro, small and medium enterprises, informal sector, grassroots innovators and other social sectors on the agenda of the young technology students across the country.

WHEREAS, BIRAC has entrusted the SITARE Partner with implementation of the SITARE Scheme including necessary processing of the proposals, organizing various meetings and training programs, execution of the decisions taken, disbursement of funds, monitoring the physical and financial progress of the Project and to obtain reports and returns and clarifications as required from time to time from the Awardee.

Whereas to promote and encourage young students for embracing translational research to develop innovative products and technologies addressing unmet needs, SITARE Partner under the SITARE Scheme has established two components of the

1

GYTI) and Residentialworkshops called as Biotech Innovation Ignition School (BIIS) administered through the Project Management Unit at SITARE Partner.

WHEREAS Awardee has been selected for SITARE-Gandhian Young Technological Innovation Award for the research Project entitled "Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed" , hereinafter referred to as PROJECT and Appended herein as Annexure-1

WHEREAS all the Annexures to this Agreement shall be read as integral part of the Agreement.

NOW THEREFORE the Parties on valid consideration and mutual covenants enter into this GRANT AWARD LETTER AGREEMENT, hereinafter referred to as "GALA" as provided hereunder:

1. RESPONSIBILITIES OF THE AWARDEE

(a) The Awardee shall:

i. Carry out the activities of the Project and confirm to the specified objectives, outputs, milestones, and targets;

ii. Meet the resources on the Project activities to the extent as agreed to, as per details given in **Annexure 1**;

iii. Submit a utilization certificate and statement of accounts duly audited and/or certified by a chartered accountant for the expenditure incurred on the Project for the half year, ending 30th September and 31st March, to SITARE Partner, within a month of 30th September and 31st March for respective half year, in the format provided by SITARE Partner;

iv. Submit a milestones progress report to SITARE Partner as per the timeline and participate in the meetings organized by SITARE Partner to review the progress of the Project, as and when called for;

v. Obtain all the necessary requisite approvals, clearance certificates, permissions and licenses from the Government/local authorities for conducting its operations in connection with the Project;

vi. Keep the drawls from the grant assistance ina separate no-lien account in the name of the Awardeewith a scheduled bank, the payments from which account shall be subject to verification by SITARE Partner. It shall also obtain and furnish to SITARE Partner a letter from the said bank foregoing the right of set off or lien in respect of such account.

2

vii. Utilize the amounts sanctioned by SITARE Partner for the Project only for the purposes as specified in the Project and shall not entrust the implementation of the Project to another agency or divert the grant-in-aid assistance;

viii. Abide by the decision of SITARE Partner to modify the objectives, outputs, milestones, targets, funding as also the foreclosure of the Project or of its components after mutual discussion;

ix. Acknowledge the assistance of Scheme of BIRAC while publishing or presenting in any manner the details of the Project, its progress or its success.

x. In the case of any ambiguity or conflict or inconsistency between this Agreement and any other associated agreement(s) entered into between Awardee and SITARE Partner on the same subject matter, the provisions of this Agreement shall take precedence.

(b) The Awardee warrants that:

i. It shall obtain prior consent of SITARE Partner in writing before entering into any agreement or arrangement with any other party, national or international, on the Project having overlapping objectives or having impact on Intellectual Propertyfor the Project duration;

ii. It is under no contractual restrictions or legal disqualifications or other obligations which will prohibit the Awardee from entering into this agreement or which will interfere with the execution of this agreement; and

iii. Each and every one of the statement and particulars herein contained in this agreement and in the relevant and supporting documents to this agreement are correct;

(c) The Awardee acknowledges and agrees that:

i. The duties, responsibilities and functions assigned or entrusted to it as specified in the Project document shall be deemed to be the duties, responsibilities and functions assigned and entrusted under this Agreement and unless for reasons beyond control under normal circumstances any undue delay, failure or default in performance of the duties, responsibilities and functions as specified in the Project shall be deemed to be a default under this Agreement;
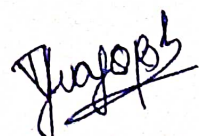
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ii. It shall, at all times, indemnify and keep indemnified SITARE Partner against any claims or suits in respect of any losses, damages or compensation payable in consequences of any accident, death or injury sustained by any other third party resulting from or by any act, omission or operation conducted by or on its behalf;

iii. It shall, at all times, indemnify and keep indemnified SITARE Partner against all claims/damages etc. by any infringement of any Intellectual Property Rights (IPR) while -undertaking its responsibilities/work under the Project and this Agreement; and

iv. It shall notify SITARE Partner of any material change in its status and/or shareholding, in particular where such change would have an impact on performance of the obligations under the Project and this Agreement. SITARE Partner shall reserve the right to reconsider further funding assistance in such circumstances of change of control.

2. FINANCIAL ARRANGEMENTS

The financial arrangements under this Agreement are as here under

i. The total fund approved by BIRAC and granted by SITARE Partner on behalf of BIRAC towards the Project is Rs. __15___ lakhs (Rupees _Fifteen lakhs only___) only on the terms and conditions detailed in this Agreement.

ii. The detailed breakup of the financial assistance is given in **Annexure 2**.

iii. All financial assistance by SITARE Partner will be released as grant award. SITARE Partner shall release the first instalment after signing of the Agreement and subject to the fulfilment of the terms and conditions for such release. Further release of funds shall be subject to satisfactory progress against the objectives, outputs, milestones and targets specified in the Project as determined by SITARE Partner and on submission of statement of accounts/ audited statement of accounts and utilization certificates

iv. The Awardee shall ensure that the funds of the Project are actually utilized only for the Project and as expressly provided in this Agreement. Re-appropriation of funds from one budget head to another shall not be effected without the specific written approval of SITARE Partner;

v. The Awardee shall refund immediately any funds out of grant disbursed to it for the Project remaining unutilized with it on completion of the Project to SITARE PARTNER along with detailed accounts of funds received, utilized and unutilized;

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vi. The capital assets acquired for the Project through SITARE Partner's grant shall not be disposed of without the specific prior written permission of the SITARE Partner. The Awardee shall take adequate care towards custody, safekeeping, and insurance and utilization access of such property at its own cost.

vii. The Methods of controlling the disposal/ granting access/resuming possession of such capital assets acquired for the Project will be at the discretion of the SITARE Partner in the event of completion, foreclosure or termination; and

viii. The manpower engaged in the Project are not the employees of SITARE partner and provision of grant-in-aid does not create any liability, explicit or implicit, on SITARE Partner in respect of the manpower engaged in the Project.

3. SITARE STEERING COMMITTEE (SSC)

SITARE Partner will constitute a SITARE STEERING COMMITTEE (SSC) comprising of eminent expert(s) from the relevant field based on specific aspects of the Project. SSC will assess the progress of the Project in conformity with the outputs, milestones, targets and objectives as contained in the Agreement will make recommendations accordingly and will provide mentorship and handholding services.

4. RESULTS OF THE PROJECT

i. The deliverables from the Project are defined and are included in the Project details at **Annexure 1**.

ii. Intellectual Property (IP) shall be the property of the Awardee. It is the responsibility of the Awardee to protect any IP generated during the conduct of the Project. It shall bear the expenditure involved in protecting such IP. During the Project Duration, the Awardee shall not assign or transfer the IP to any third party directly or indirectly without prior written consent from SITARE Partner.

5. PROJECT DURATION

The Awardee shall complete the Project within the stipulated period of___24____months after the date of execution of this Agreement or as per the corresponding order(s) issued by SITARE Partner from time to time.

6. CONFIDENTIALITY

i. During the tenure of the Agreement, both the Parties, undertake to maintain strict confidentiality and refrain from disclosure thereof, of all or any part of the information and data exchanged/generated from the Project under this Agreement for any purpose other than in accordance with this Agreement. It shall be the responsibility of both the Parties to ensure maintenance of such confidentiality in respect of their behalf and on behalf of their employees, representatives and associates involved in the Project.

ii. The Parties shall not have any obligation of confidentiality with respect to any information that:
   a. is in the public domain by use and/or publication at the time of its disclosure by the disclosing party; or
   b. was already in possession of the recipient prior to receipt from the disclosing party; or
   c. is properly obtained by the recipient from a third party with a valid right to disclose such information and such third party is not under confidentiality obligation to the disclosing party; or
   d. was disclosed to any third party on a non-confidential basis prior to commencement of the Project; or
   e. is required by public authority, by law or decree.

7. FORECLOSURE AND TERMINATION

i. In case, during the tenure of the Project, it is found that the Project or any Project component is not likely to lead to successful completion, SITARE Partner may decide to foreclose the Project or the Project component as warranted. The decision of the SITARE Partner shall be final in all respects. TheGrantee shall immediately refund any funds unutilized out of SITARE Partners disbursements, after deducting the legally committed expenses to third party vendors, to SITARE Partner, along with detailed accounts of funds received, utilized and unutilized. The entire outstanding amount as on the date of foreclosure will become due and payable immediately.

ii. The Granteemay, before the completion of the Project, terminate this Agreement by giving three months' notice in writing to SITARE Partner. SITARE Partnermay also terminate this Agreement by written notice for committing breach of any term of this Agreement and either not rectifying it to the satisfaction of SITARE Partner or not satisfying SITARE Partner about its inevitability within a reasonable period. In the event of termination of the Agreement, no further disbursement shall be made by SITARE Partner and the Awardeeshall be liable to return immediately the amount of grantalready availed of from SITARE Partner with simple interest at the rate of 12 (twelve) per cent per annum within 30 (thirty) days of termination of the Agreement.

In case of failure to repay, without prejudice to any other rights under this agreement, the amount can be recovered by initiating any procedure available in Law.
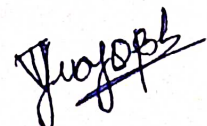
8. FORCE MAJEURE

The Parties shall not be held responsible for non-fulfillment of their respective obligations in successful completion of the Project under this Agreement due to the exigency of one or more of the *force majeure* events such as but not limited to acts of God, war, flood, earthquakes, strikes not confined to the premises of the Party, lockouts beyond the control of the Party claiming *force majeure*, epidemics, riots, civil commotion etc. lying beyond the reasonable control of and not brought about at the instance of the Party claiming to be affected by such event and which has caused the non-performance or delay in performance; provided on the occurrence and cessation of any such event the Party affected has given a notice in writing to the other Party within one month of such occurrence or cessation. If the *force majeure* conditions continue beyond six months, the Parties shall jointly decide about the future course of action on the Project. The validity of the claim of *force majeure* shall be determined by SITARE Partner after due enquiry and the decision in this regard shall be final.

9. DISPUTE RESOLUTION

In the event of any dispute or difference between the Parties hereto upon or in relation to or in connection with this Agreement, such dispute or difference shall be resolved amicably by mutual consultation. If the dispute is not resolved, then shall be referred to (Please insert the standard Arbitration clause of SITARE Partner as applicable)

10. EFFECTIVE DATE AND TENURE OF THE AGREEMENT

i. The Agreement shall be effective from the date of its signing by both the Parties. The Agreement shall be valid for till _24___ months or till full utilization/refund of the Grant award, whichever is later. It can be extended if agreed to by both the Parties.

ii. Two copies of the Agreement shall be signed by both the Parties and one copy each shall remain in the custody of each Party.

iii. Any failure or delay on the part of SITARE Partner to exercise the right or power under the Agreement shall not operate as waiver thereof.

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11. AMENDMENTS TO THE AGREEMENT

No amendment or modification of this Agreement shall be valid unless the same is made in writing by both the Parties or their authorized representatives and specifically stating the same to be an amendment of this Agreement. The modifications / changes shall be effective from the date on which they are made / executed unless otherwise agreed to.

12. SEVERABILITY

In case any one or more of the provisions or parts of a provision contained in this Agreement shall, for any reason, be held to be invalid, illegal or unenforceable in any respect, such invalidity, illegality or unenforceability shall not affect any other provision or part of a provision of this Agreement; and this Agreement shall, to the fullest extent lawful, be reformed and construed as if such invalid or illegal or unenforceable provision, or part of a provision, had never been contained herein.
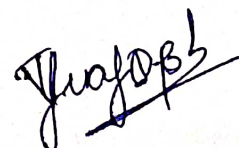
13. NOTICES AND JURISDICTION

i.   All notices and other communications required to be served on the SITARE PARTNERincluding for violation of the terms of this Agreement shall be considered to be duly served if the same shall have been delivered by registered mail at its address as below.

ii. Similarly, any notice to be given to Awardee shall be considered as duly served if the same shall have been delivered by registered mail at its address as below:

Subject to the provisions of **Clause 10** hereof, the Courts at   shall have exclusive jurisdiction in all matters concerning this Agreement including any matter arising therein.

14. NO JOINT VENTURE

Nothing contained in this Agreement will be construed as creating a joint venture, agency, partnership or employment relationship between the Parties hereto, nor will any party have the right, power or authority to create any obligation or duty, express or implied, on behalf of the other Party.

8

15. GOVERNING LAW

This Agreement shall be governed and interpreted in accordance with the laws of India.

IN WITNESS WHEREOF the Parties hereto through its duly authorized representatives have signed this Agreement on the day, month and year mentioned hereinbefore.

Parties

For and on behalf of the SITARE PARTNER	
Signature	
Name:	
Designation:	
Seal	
Witnesses	
Signature	Signature
Place	Place
Date	Date
Name	Name
Address	Address

9

For and on behalf of "Awardee"

Signature	*Vinoj* 4/12/2020
Name	VINOJ P.G
Designation	Research Scholar, SCMS SCHOOL OF ENGINEERING ANDTECHNOLOGY, KARUKUTTY, ANGAMALY

Witnesses

Signature	Signature
Place: KARUKUTTY	Place: KARUKUTTY
Date: 04/12/2020	Date: 4-12-2020
Name Dr. PRAVEENJAL C.J.	Name Dr Sunil Jacob
Address DR. PRAVEENSAL C.J. PRINCIPAL SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY	Address Director SCMS Centre for Robotics SCMS School of Engineering & Technology
Seal of the Institute with Name	**Seal**

SCMS SCHOOL OF ENGINEERING & TECHNOLOGY
KARUKUTTY
ERNAKULAM
683 682

Vinoj   10
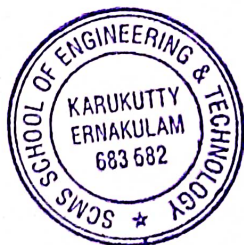
Complete Project document after amendments (as mutually agreed between BIRAC, SITARE PARTNER and Awardee) including work programme, milestones, timelines and corresponding budget shall have to be specifically mentioned.

(This document should be bound as part of the Agreement and labeled as Annexure 1 bearing continuous pagination and should not be submitted as a separate document.)

Key Milestones:

1. Completion of Design of EEG sensor , Muscle stimulation Unit, Mechanical and Electronic prototyping activities
2. Completion of Phase 1 BCLLE working Prototype,Mechanical,Electronic prototyping and integration activities
3. Completion of Phase 2 AMIDL Prototype, Deep-learning Model development, Electronic prototyping and integration activities
4. Usability Testing of the integrated prototype device on paralyzed patients

Work Program:

1. Milestone 1:

1. Design of Mechanical structure of the EEG sensor and the placement of electrodes in the structure
2. Testing and signal analysis of the designed sensor
3. Muscle stimulation unit design using Multichannel TENS device
4. Integrating medical electrodes with the stimulation unit and its testing
5. Integrated Prototype testing on the Upper limb

2. Milestone 2:

1. Design of mechanical structure of exoskeleton and integrating electronic components
2. Establishing communication between EEG Sensors and the exoskeleton
3. Closed loop controller design for different Muscle movements
4. Integrated system testing on Lower Limb

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3. **Milestone 3:**

   1. EMG sensor design and Data recording
   2. Real time EEG data acquisition
   3. Deep learning model development and Training
   4. Integrating electronic and mechanical subsystems and testing the model
   5. System stability and accuracy testing and incorporating aesthetics and ergonomics to the device

4. **Milestone 4:**

   1. Usability test on 10 different paralyzed patients
   2. Incorporating user and Medical Practitioner feedback
   3. Product compliance with India's medical device regulations

Timeline:

1. **Milestone 1 (5 months):**

   - 1-5 months

2. **Milestone 2 (7 months):**

   - 6-12 months

3. **Milestone 3 (7 months):**

   - 13-20 months

4. **Milestone 4 (5 months):**

   - 21-24 months

Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed - Project Plan

Activity	Plan Start (months)	Plan Duration (months)	Period in Months																						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Milestone 1: Completion of Design of EEG sensor , Muscle stimulation Unit,Mechanical and Electronic prototyping activities	1	5	▓	▓	▓	▓	▓																			
Milestone 2: Completion of Phase 1 BCLLE working Prototype,Mechanical,Electronic prototyping and integration activities	6	7						▓	▓	▓	▓	▓	▓	▓												
Milestone 3: Completion of Phase 2 AMIDL Prototype,Deep-learning Model development, Electronic prototyping and integration activities	13	7													▓	▓	▓	▓	▓	▓	▓					
Milestone 4: Usability Testing of the integrated prototype device on paralyzed patients	20	5																				▓	▓	▓	▓	▓

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BUDGET DETAILS

Budget Heads:

Head	Amount (in lakhs)
Development of Prototype (including outsourcing activity)	5
Travel	2
Incubator Rentals	2.20
Manpower	2.16
Consumables	2
Training and conferences	1.14
Contingency	0.50

Budget Justification:

1. Development of Prototype (including outsourcing activity) : 5 Lakhs

- EEG/EMG, Pressure, Accelerometer and gyroscope sensors,cables,Controller boards,shields,Actuators,Motors and Other electronic Components: 3 Lakhs
- Design and Manufacture of Exoskeleton,EEG headset,PCB fabrication: 2 Lakhs

2. Travel, Total: 2 Lakhs
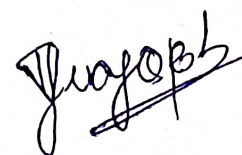
- Travel Budget will be utilized for meeting doctors, patients and subject experts

3. Incubator Rentals: 2.20 Lakhs

- Incubator rental for SSET, Karukutty: 5000 Rupees per month for 24 Months:1.20 lakhs
- Utilization of Fab Lab at SSET, Karukutty for facilities like 3D printer, CNC machine, Laser cutter, Electronics Test bench: 1 lakh

4. Manpower: 2.16 Lakhs

- The manpower budget is utilized by recruiting Technical assistant, having proficiency in hardware and software design and prototyping. Salary for the technical assistant(18,000 Rupees per month for 12 months =2.16 Lakhs)

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5. **Consumables: 2 Lakhs**

- Medical grade Components like EEG-EMG electrode pads, skin preparation spray, silicon rubber: 1 lakh
- carbon fiber,3D printing material, Acrylic sheets,batteries,Drill bits etc.: 1 lakh

6. **Training and Conferences: 1.14 Lakhs**

- Training and Conferences budget will be utilized for attending Training and Conferences related to Biomedical Assistive Technologies

7. **Contingency: 0.50 Lakhs**

- Contingency Fund is utilized for patent filing, medical committee approval, to cover unforeseen risks during patient usability testing.

Total: 15 Lakhs

Project Report

ON

Artificial Deep Learning Brain Actuated Lower Limb Exoskeleton For Paralyzed

BIRAC- SITARE

SRISTI-GYTI Awards

Proposal Reference No.:
BT/BIRAC/SITARE-GYTI-0144/01/19

PHD Scholar: VINOJ P.G

Research Guide: Dr. Sunil Jacob

Institute: SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

UNIVERSITY: APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, KERALA

Table of Contents

Abstract: Due to partial or full paralysis due to stroke, the majority of patients are compelled to rely upon parental figures and caregivers in residual life. With post-stroke rehabilitation, different types of assistive technologies have been proposed to offer developments to the influenced body parts of the incapacitated. In a large portion of these devices, the clients neither have control over the tasks nor can get feedback concerning the status of the exoskeleton. Additionally, there is no arrangement to detect user movements or accidental fall. Rehabilitation is the natural remedy for recovering from paralysis and enhancing the quality of life. Brain Computer Interface (BCI) controlled assistive technology is the new paradigm, providing assistance and rehabilitation for the paralysed. But, most of these devices are error prone and also hard to get continuous control because of the dynamic nature of the brain signals. Moreover, existing devices like exoskeletons bring additional burden on the patient and the caregivers and also results in mental fatigue and frustration. In Phase1 the proposed framework tackles these issues utilizing a Brain-Controlled lower limb exoskeleton (BCLLE) in which the exoskeleton movements are controlled based on user intentions. An adaptive mechanism based on sensory feedback is integrated to reduce the system false rate. The BCLLE uses a flexible design which can be customized according to the degree of disability. The exoskeleton is modelled according to the human body anatomy, which makes it a perfect fit for the affected body part. The BCLLE system also automatically identifies the status of the paralyzed person and transmits information securely using Novel-T Symmetric Encryption Algorithm NTSA to caregivers in case of emergencies. The exoskeleton is fitted with motors which are controlled by the brain waves of the user with an electroencephalogram EEG headset. The EEG headset captures the human intentions based on the signals acquired from the brain. The brain-computer interface converts these signals into digital data and is interfaced with the motors via a microcontroller. The microcontroller controls the high torque motors connected to the exoskeleton joints based on user intentions. Classification accuracy of more than 80 is obtained with our proposed method which is much higher compared with all existing solutions. In phase 2 of our work we created Artificial Muscle Intelligence with Deep Learning (AMIDL) system. AMIDL integrates user intentions with artificial muscle movements in an efficient way to improve the performance. Human thoughts captured using Electroencephalogram EEG sensors are transformed into body movements, by utilising microcontroller and Transcutaneous Electrical Nerve Stimulation (TENS) device. EEG signals are subjected to pre-processing, feature extraction and classification, before being passed on to the affected body part. The received EEG signal is correlated with the recorded artificial muscle movements. If the captured EEG signal falls below the desired level, the affected body part will be stimulated by the recorded artificial muscle movements. The system also provides a feature for communicating human intentions as an alert message to caregivers, in case of emergency situations. This is achieved by offline training of specific gesture and online gesture recognition algorithm. The recognised gesture is transformed into speech, thus enabling the paralysed to express their feelings to relatives or friends. Experiments were carried out with the aid of healthy and paralysed subjects. The AMIDL system helped to reduce mental fatigue, miss-operation, frustration, and provided continuous control. The thrust of lifting the exoskeleton is also reduced by using lightweight wireless electrodes. The proposed system will be a great communication aid for the paralysed to express their thoughts and feelings with dear and near ones, thereby enhancing the quality of life.

INDEX TERMS Artificial Muscle Intelligence, Assistive technologies, BCI, EEG, Exoskeleton, Healthcare, Intelligent solutions, Deep Learning System, Paralyzed, Stroke.

1. Introduction

The recent survey by reeve foundation revealed the impact of paralysis on world population, affecting approximately 5.4 million people [1, 2]. The survey also identified stroke (33.7%) as the major cause for paralysis. Paralysis is the increasing interest and involvement in the field of post stroke rehabilitation. Exoskeleton-assisted technologies have emerged as a reliable means for rehabilitation of the affected upper and lower limbs [3]. Exoskeleton movements were controlled using sensors like gyroscopes, accelerometers, and potentiometers. Recently the focus is on controlling exoskeleton using Brain Computer Interface (BCI) [4]. Javier et al. demonstrated upper limb movement of the paralyzed using EEG signals [5]. A closed loop is established between human thought and movement of paralyzed limbs using non-invasive BCI [6]. Android feedback based BCI training is employed to enhance brain rhythms during motor imagery task. The realistic feedback is realized in training sessions using humanoid robots [7]. Humanoid robot is navigated in a real-time indoor environment based on human intentions. The asynchronous BCI system was designed using two level classifiers [8]. Co-operation and coordination of dual robotic arm is demonstrated using an EEG based system. SSVEP (Steady-State Visual Evoked Potentials) are utilized to improve the user concentration level [9]. Electromyography (EMG) sensors are also used to control exoskeleton movements, EMG returns the information regarding human muscular activity [10]. The motor adaptability of the upper limb is predicted using resting state functional connectivity. The system could identify effectiveness of robotic upper limb rehabilitation in different patients [11]. However, the system does not investigate real time human behaviours and thoughts. The clinical trials to investigate the effectiveness of BCI training sessions on stroke patients with upper limb paralysis are carried out. The results of the trial indicate that BCI based assistive devices are effective for post stroke rehabilitation [12]. Human intentions measured through cortical potentials were used to control upper-limb exoskeleton movements. The BMI system eliminated the need for recalibration but resulted in large false positive rates [13]. The Grasping feature is incorporated into the assistive device for amputees using non-invasive EEG control. The participants were able to grasp the objects, but resulted in low success rate without sufficient training [14]. Brain activity is modulated to control robotic arm with multiple degrees of freedom. The system demonstrated the effective control of robotic arm with few training sessions, but increased the latency periods during certain operations [15]. Hybrid BMI system based on sensorimotor cortical desynchronization (ERD) and electromyography (EMG) activity was designed to control upper limb movements. The integration of BMI, NMES and

exoskeleton improved the system accuracy, but increased the system complexity [16]. The linear control of upper limb is demonstrated using motor imagery based BCI and Functional Electrical Stimulation (FES), support is provided to the arm using passive exoskeleton. The generated limb movement is evaluated to identify the precise positioning [17]. The self-induced EEG variations based on ERD/ERS is utilized for controlling upper limb movements. Distinguishable patterns are obtained for left and right-hand movements in both motor imagery and motor execution experiments [18]. Online robot control using motor imagery based BCI is designed with high classification accuracy. The mental imagination of hand movement is detected for controlling the robot movements [19]. An integrated platform consisting of BCI controlled exoskeleton, functional electrical stimulation (FES) with proprioceptive feedback is developed. Goal directed motor task is used for training and subjects could complete the task with minimum latency period [20]. In our previous works [21-23], we have demonstrated an alternative technology to exoskeletons using non-invasive brain signals. Also, exoskeletons with feedback mechanisms have also been implemented by us [22]. The paralyzed body part is stimulated using Transcutaneous Electrical Nerve Stimulation (TENS) device and Microcontroller [24]. Because of the dynamic and uncertain nature of brain signals, most of the BCI systems result in miss-operation, mental fatigue and it is hard to produce continuous control. The proposed system is designed to address the above gaps in research.

In the phase 1 of the proposed work, we use a gyroscope in the BCI headset to control the directions along with only two mental commands. This reduces the load on the system and increases the speed of the exoskeleton. The exoskeleton interfaced with the brain is controlled based on the decoded brain signals. In correspondence to the mental commands recognized, the high torque motors connected to the joints of the exoskeleton are activated. The exoskeleton is made using carbon fibre which makes it light and hence user-friendly. The exoskeleton replicates the movement of a healthy functioning leg using all the joints. Sensory feedback is introduced to reduce the system false rate. The user intentions given to the system are converted to motor actions. If the produced motor action is not sufficient to trigger the actual limb movement, an adaptive algorithm is used to make the corrective action. The status of the paralyzed and emergency rescue information is transmitted wirelessly to the corresponding caregivers. NTSA encryption and decryption algorithm is used to transmit the information securely to the intended user without interference. Walsh– Hadamard transform is used for feature extraction of brain signals. The extracted features along with Hadamard coefficients are transmitted wirelessly from brain to the lower limb via Bluetooth. At the receiver side using

the Hadamard coefficients, the original brain signals are reconstructed. The feature extraction and reconstruction is implemented for all five different user intentions. The Brain-Controlled Lower Limb Exoskeleton (BCLLE) analyses the human thoughts and transforms it into different movements on a unique lower limb structure. The contributions of our phase1 research are,

- A Brain-Controlled Lower-Limb Exoskeleton (BCLLE) in which the exoskeleton movements are controlled based on user intentions.

- An adaptive mechanism based on sensory feedback integrated with the exoskeleton to reduce the system false rate.

- A flexible design for the exoskeleton which can be customized according to the degree of disability.

- Artificial skin incorporated with sensors which can provide a sense of touch to the body parts of users.

- Automatic identification of the status of the paralyzed person and secure transmission of information to caregivers in case of emergencies

In the phase2 of the research, AMIDL is designed to reduce miss-operation, user fatigue and to enhance user capabilities. In the proposed work, human intentions are monitored in real-time employing 16 channel EEG sensors. TENS machine is integrated with Muscle Inspired Algorithm (MIA) to produce movements on the upper limb. Subjects are relieved from the task of carrying exoskeleton structure. The system is designed to perform six different movements on the affected upper limb. The different hand postures used to trigger the rehabilitation process are Release, Grasp, Rollup, Roll down, Rollup Release and Rollup grab. In the offline phase, Artificial Muscle movements corresponding to each posture are recorded to create the database. The decoded EEG signals are transformed into muscle activation signals in a real-time environment. The captured EEG signal is converted into frequency domain using Walsh Hadamard Transform (WHT) for feature extraction. The extracted features along with WHT coefficients are utilized for the classification of different limb movements. The activation signal is then correlated with the recorded muscle movements. The signal with superior characteristics is passed on to the upper limb electrodes for inducing motion. In case of ambiguity or inadequate EEG signal, the periodic activation of the affected body part will be taken care of by the artificial muscle movements. If the activation is executed by brain signal, the produced gesture is recognized and passed on to the caregiver as voice command. Thus,

AMIDL transforms human thoughts into different movements on the unique upper limb structure. The EEG activated movements are utilized for communicating paralyzed person's emergency needs to the caregivers. The contributions of our research are,

• An Artificial Muscle Intelligence with Deep Learning (AMIDL) system without exoskeleton structure, in which movements of paralyzed body parts are controlled based on user intentions.

• An adaptive mechanism based on recorded muscle movements is integrated with the system to enhance continuous control and facilitate rehabilitation.

• Designed flexible assembly, which can be customized according to the degree of disability.

• Communication aid is incorporated in the system using gesture recognition

• The subject concentration is improved by using multimedia feedback

2. Literature Survey

In this section, we discuss a few existing devices controlled by Brain-Computer Interface designed specifically for paralyzed people. But the problem with most of them is that the users are unable to get continuous control over the device. The users are required to have a high level of concentration to get sufficient control on the device, which results in mental fatigue and frustration. Additionally, there is no arrangement to take care of the miss-operations. The subjects are also burdened with the task of carrying the load of exoskeleton on the affected body parts. Our research focuses on overcoming these major problems and provides an efficient and flexible solution, which can enhance the post stroke recovery process. Our system also provides a communication aid for the paralyzed to express their feelings. The assistive rehabilitation devices and its EEG control techniques are systematically reviewed and the major gaps are identified [25]. Three-dimensional robotic assistance using motor imagery task for upper limb rehabilitation is demonstrated with multi-joint exoskeleton. Desynchronization of sensorimotor oscillations in the β-band is measured to control the different robotic hand movements [26]. Different upper limb exoskeletons like Track hold [27] and Armeospring [28] are employed to track upper limb movements. Both these devices have integrated passive robots with virtual reality environments to help patients carry out their daily routine activities. Control of assistive robots are improved by integrating electroencephalography (EEG) and electrooculography (EOG). This hybrid approach called brain/neural-computer interaction (BNCI) is adopted to control grasping movements of a hand exoskeleton [29]. Multimodal

signal approach is further used to enhance the control system for external devices connected to the upper limb. EEG and EMG signals are integrated to improve the classification accuracy and to reduce the false positive rate [30]. Upper limb robotic orthosis, FES, and wireless BCI are combined in an efficient way on account of EEG signals. EMOTIV EEG device is employed to measure EEG signal, which is used to control grasp/release of an object [31]. An integrated passive robotic system is developed for assisting the paralyzed. The system employs a robotic device which compensates gravitational effects to allow exercise, virtual engines to facilitate interaction and EEG to monitor brain activities. The three components are coordinated in real-time to enhance the rehabilitation process [32]. The effects of BCI therapy on post stroke rehabilitation is analysed based on motor imagery tasks. The analysis is performed by measuring coherence of EEG in different regions of the brain and the best result for motor recovery is obtained for the activation of lesion hemisphere [33]. The online BCI coupled with hand exoskeleton is employed to address the issues related to proprioceptive feedback on the regulation of cortical oscillations. The results show an enhancement in SMR desynchronization with proprioceptive feedback during flexing and extending fingers of the exoskeleton [34]. Multimodal architecture based on BCI, exoskeleton and an active vision system is proposed to enhance BCI control and rehabilitation process. The VR environment coupled with biofeedback helps to reduce mental fatigue and improve user interactions [35]. Few studies have also been conducted in related areas recently [36-42] Feng et al proposed another interesting system using optimal haptic communications [43]. Baoguo Xu et al. [44] proposed a three-dimensional animation to guide upper limb movements using EEG signals. Feature extraction is carried out by Harmonic Wavelet Transform (HWT) and linear discriminant analysis (LDA) classifier was utilized to classify the patterns for controlling the upper limb movements. MR-compatible robotic glove operates pneumatically and doesn't cause any disturbance to functional Magnetic Resonance imaging (fMRI) images during rehabilitation process [45]. The resistance to mechanically actuated movements in an exoskeleton robot is measured based on spasticity. The relevant guidelines for practical neuro-rehabilitation robot design based on degree of spasticity and resistance is established [46]. In most of the design it is hard to get continuous control on the exoskeleton due to the nonstationary nature of the EEG signal. Moreover, the subjects experience metal fatigue and frustration due to lack of superior control. None of the devices in the literature focused on providing communication aid for the paralyzed. Our research focuses on solving these issues in an efficient manner using the AMIDL system proposed in this paper. Table 1 shows the comparisons between AMIDL and existing systems in the literature

Method Reference No., Year	No. of Subjects	Type of Control	Type of EEG Signal	Device Assigned	Task	Accuracy/ Success Rate
Ref [14], 2016	2 amputees	EEG-based control	Motor imagery Low frequency-time domain feature	Prosthetic hand	Grasping objects	63.5%
Ref [15], 2016	13 healthy subjects	EEG-based control	ERD/ERS	Arm exoskeleton	Reach and grasp tasks	77.8%
Ref [12], 2017	64 stroke patients	EEG-based control	Motor imagery 5–30 Hz EEG signal	Hand exoskeleton	Hand open/closed	79.4%
Ref [17], 2016	7 healthy subjects	EEG-based control	7–30 Hz EEG signal	ArmeoSpring and FES	left hand, right hand, and feet	79.6%
Ref [16], 2016	7 stroke patients	EEG-based control	ERD	ArmeoSpring exoskeleton	Wrist extension/flexon	80.7%
Ref [13], 2016	3 chronic stroke patients	EEG-based control	MRCPs	MAHI exoskeleton	Elbow flexion/extension	81.3%
Ref [11], 2018	19 healthy subjects	EEG-based control	15–25 Hz EEG signals	Robotic Arm	Upper limb movement/reaching	83.5%
Ref [18], 2016	4 healthy subjects	EEG-based control	ERD/ERS	Custom upper limb exoskeleton	Left/right hand and left hand versus both feet	84.29%
Proposed System, AMIDL	20 subjects	EEG and EMG based control	Motor Imagery ERD/ERS with multimedia feed back	TENS device with EMG Electrodes	left or right hand movements	87%

Table 1. Proposed system comparisons with existing system (Sorted by success rate)

3. Methodology
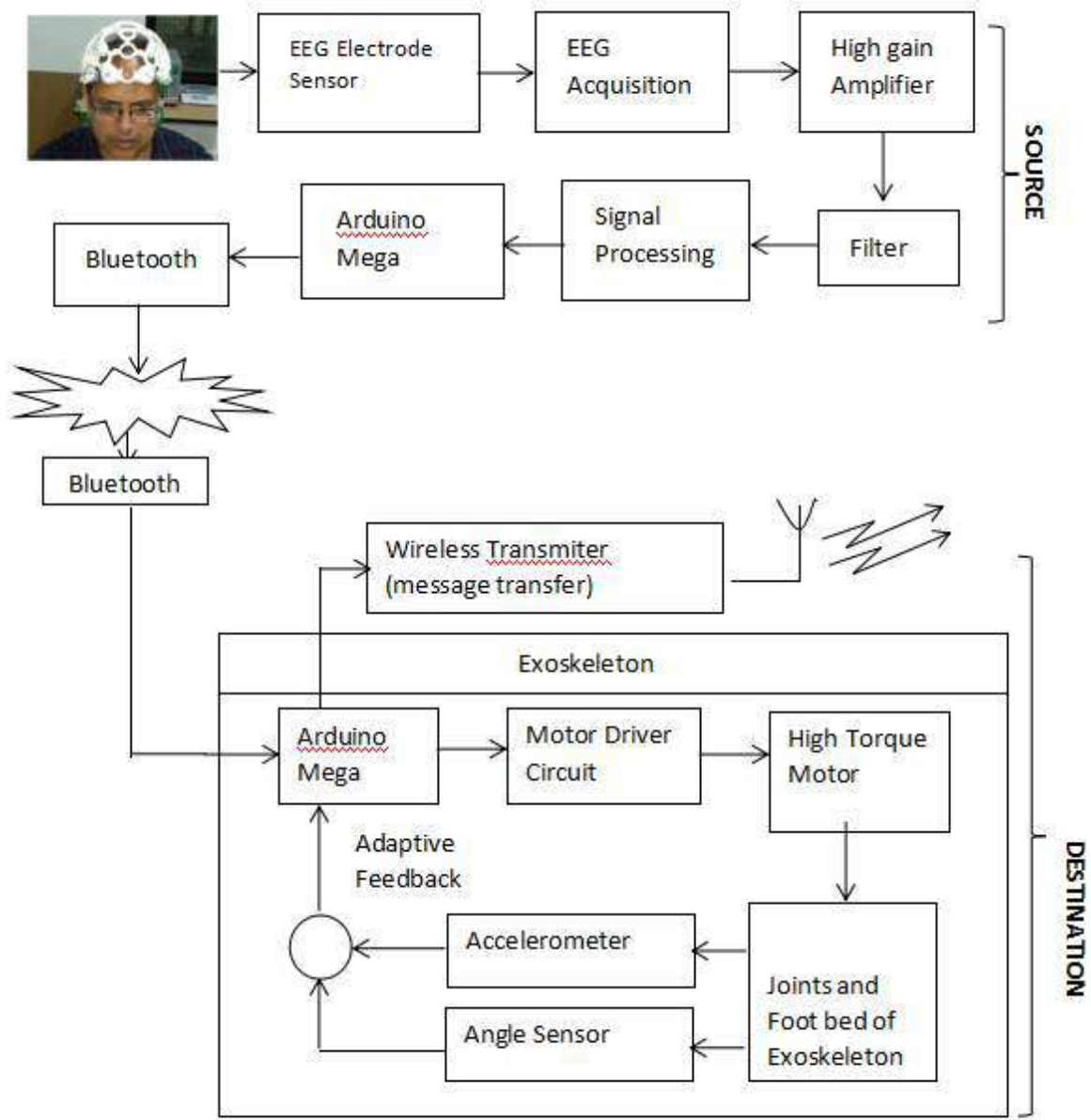
FIGURE 1. System architecture for Brain Actuated Multidimensional Exoskeleton

The architecture of the proposed system is presented in figure 1. The system design comprises an exoskeleton that replicates a lower limb, which is made using carbon fiber. The exoskeleton has total six degrees of freedom including both legs, one on each side of the pelvic bone, one on each knee and one on each ankle. Thus three degrees of freedom on each leg making it total of six degrees of freedom on the entire exoskeleton. Each joint of the lower limb is actuated using high torque motors. The movement of the exoskeleton is facilitated by controlling the degree of rotation of the motors. This exoskeleton is strapped onto the abdomen as well as foot region for improving the stability and balance of the person. Support is also provided on the back side of the ankle region. The angle sensors are placed on the joints to provide feedback

regarding the status of exoskeleton. This sensor is also used to validate whether the applied force is sufficient to stabilize the exoskeleton. The fall detection mechanism is implemented by placing an accelerometer on the back side of the lower limb to measure the tilt. If the measured sensor value crosses the threshold, a message will be given to the caregivers for emergency rescue. The exoskeleton is controlled through human intentions. Electroencephalograph (EEG) sensors use non-invasive methods to collect the brain signals from the scalp of the person. EEG sensor has 16 electrodes incorporated in structure, where two electrodes act as the reference for measurement. The conductivity of the electrodes is improved by using gold plating. The signals collected are amplified using a high gain amplifier and a band pass filter is used for filtering high-frequency noise. In the signal processing stage, the signal undergoes further pre-processing and filtering. The suitable pattern based on the mental command is selected by using windowing technique. The signal is converted into digital data which is given as input to the microcontroller. The microcontroller does the classification of each mental command based on the feature extraction. In the training phase, users will be trained for five basic commands (sitting, standing, forward movement, right turn, left turn). The recorded patterns during the training phase will be used by the microcontroller for decision making. The recognized thought patterns will be mapped to five different commands. During the testing phase, the controller makes use of machine learning to recognize and match patterns in the input data along with the training data that is already stored in the system to make the necessary decision regarding the action to be performed. The activation command to the exoskeleton is given by the controller through the Bluetooth module. At the receiver side the microcontroller converts this command into motor action which in turn moves the desired parts of the exoskeleton. Using a three-level sensing mechanism, feedback is given to the microcontroller regarding the status of the exoskeleton. Based on this feedback the microcontroller makes the desired corrections on the activation signals. The sensory feedback gives more stability to the system, and moreover rescue messaging systems are also implemented in case of emergencies.

The secured communication between the paralyzed person and caregiver is achieved using Novel-T symmetric algorithm (NTSA). This algorithm ensures that the data is securely transmitted to the intended caregiver. NTSA is a symmetric algorithm that uses a single 128-bit symmetric key that is agreed upon by sender and receiver for performing encryption and decryption. The 128-bit key is divided into four partial keys k0, k1, k2 and k3. There are 64 rounds with partial keys k0, k1 applied for odd rounds and k2, k3 applied for even rounds. Multiple XOR and shift operations are performed in each round of encryption. The message

from the paralyzed person is encrypted using NTSA encryption algorithm to produce ciphertext. The cipher text is transmitted to the caregiver either through the internet or wireless module. The NTSA decryption algorithm decrypts the cipher text using the key and the original message is retrieved at the receiver-end by the caregiver. The NTSA algorithm introduces key confusions in each round of encryption that makes the algorithm safe and secure from possible attacks. This algorithm uses minimum system memory and provides faster response.

3.1 system architecture of AMIDL

AMIDL EEG Acquisition Module

The system architecture is designed using a modular approach, it consists of three main modules. They are 1) EEG Acquisition Module, 2) Muscle Stimulation Module and 3) Gesture to Voice Conversion Module. Figure 1 indicates the two main modules of the system. The system captures brain signals using an EEG sensor module, which has 14 electrodes to make measurement and two acts as reference. The acquired signal undergoes pre-processing, feature extraction and classification. The low amplitude EEG signal is amplified using a high gain instrumentation amplifier with a gain of approximately 1000-2000 db. The signal is band limited by employing a band pass filter having a pass band frequency of 5-50Hz.Windowing and pattern selection is utilized for getting finite response. Feature coefficients of the signal are extracted using Walsh Hadamard Transform (WHT). These extracted features are used to classify the thoughts into six different movements. The actual brain pattern is reconstructed using the transmitter Hadamard coefficients. The decoded brain pattern is given to the TENS device, which transforms the thought into muscular actions. The muscle inspired algorithm stored in the controller facilitates the process of conversion. In the offline phase, muscle movements corresponding to the six different predefined hand postures are recorded to create the database. The hand postures are recorded using 7 Electromyography (EMG) sensors on the different hand muscles. Five EMG electrodes are placed on the finger muscles to record finger activity. Two electrodes are placed on either side of the elbow to identify roll movements. In the online phase, brain signals based on human thought are acquired and transformed into muscle movement. This transformed muscle movement is then correlated with the recorded muscle movements. The signal with superior characteristics is selected by the controller for producing movements on the affected body part. If the brain signal fails to provide sufficient activation, periodic movements in the upper limb will be triggered by artificial muscle.
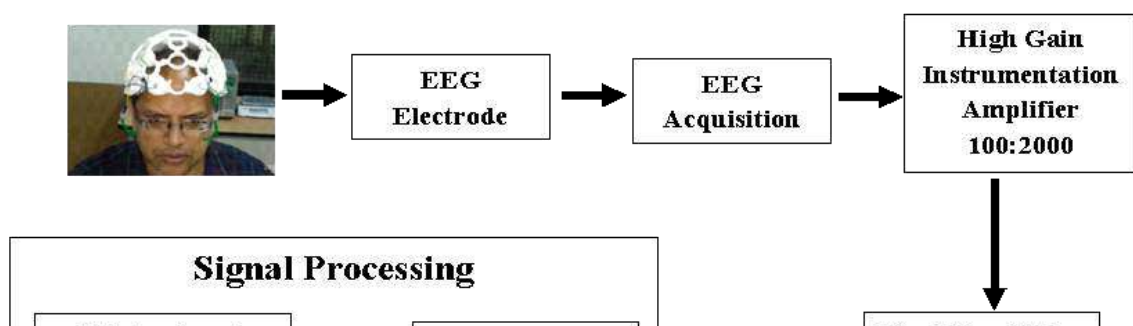
gesture will be recognized by the algorithm and transforms it into voice commands for the care givers. Figure 3 depicts the AMIDL gesture to voice conversion module. This module is used to give emergency alert messages to the caregivers or relatives.
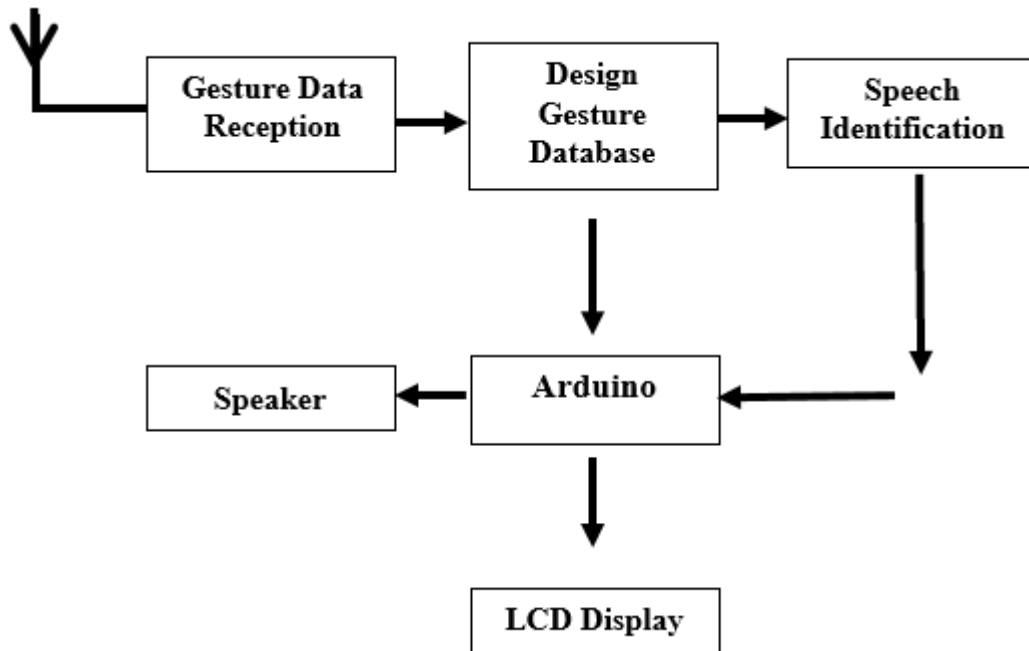

Figure 3. AMIDL Gesture to Voice Conversion

4. Results and Implementations

4.1 Sensor Design

In the initial stages, brain signals are monitored using Emotive EPOC mobile EEG headset. Emotive uses 14 channels to access the raw EEG data and the analysis of acquired data is carried out using integrated software tools. Figure 4 exhibits the Emotive EEG headset deployed in brain signal monitoring. In the latter stages of experimentation Emotive headset is replaced by the designed EEG Sensor. The EEG sensor is manufactured using 3D printer Technology. It has a total of 16 electrodes in which 14 are used for tapping the brain signals and two electrodes act as reference. Figure 5 shows the designed EEG sensor and its electrodes

Figure 4. Emotive EPOC mobile EEG headset
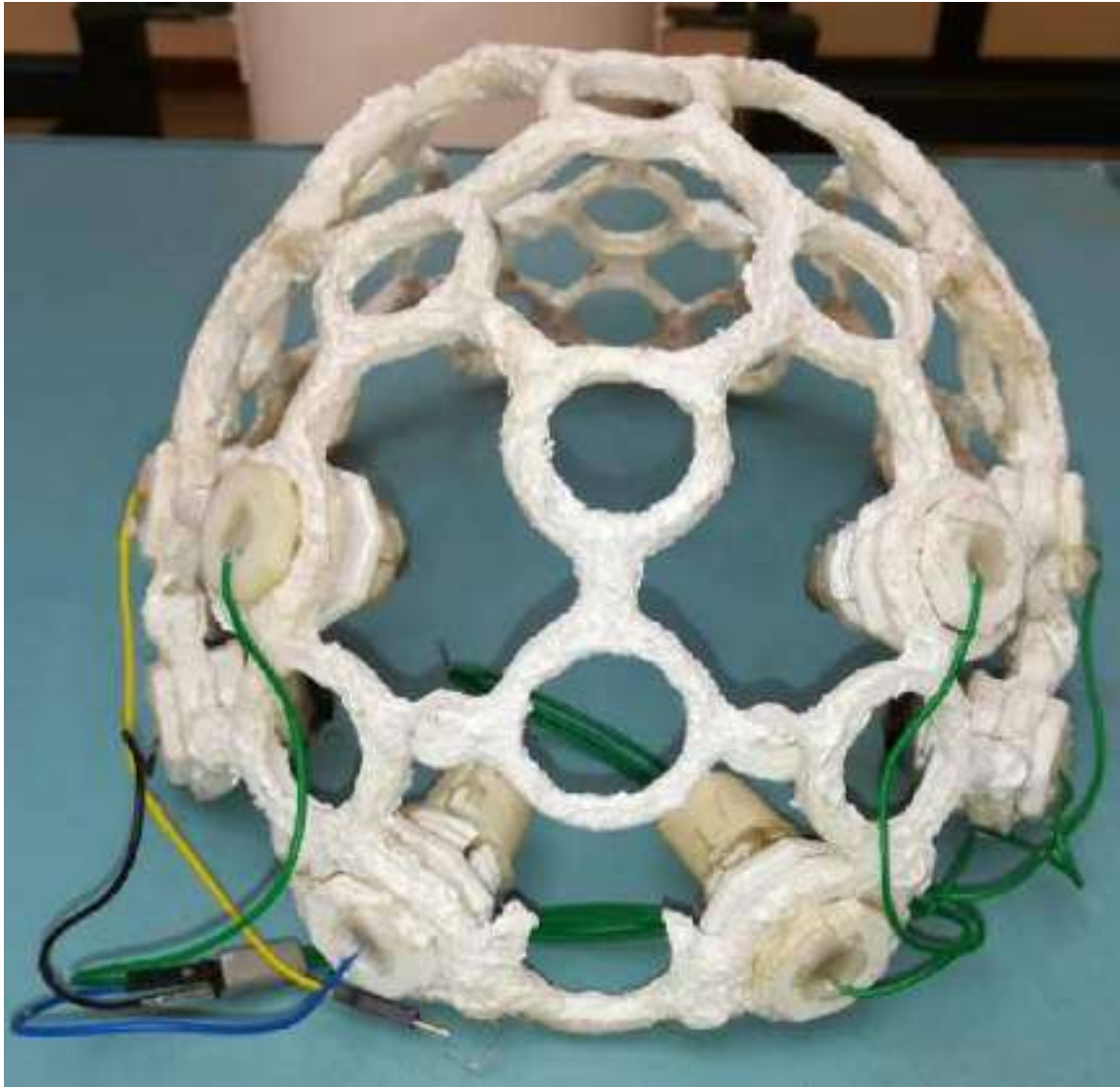
Figure 5. Designed EEG Sensor with electrodes

4.2 *Exoskeleton Design*

The Lower limb exoskeleton is designed matching the characteristics of the human anatomy. Figure 6 depicts the complete lower body exoskeleton designed using 3D software. The important parts of the exoskeleton are labelled as below

A Gluteal Region
B   Hip joint
C   Thigh Region
D   Knee Joint
E   Leg Region
H Ankle Joint
G Foot Region
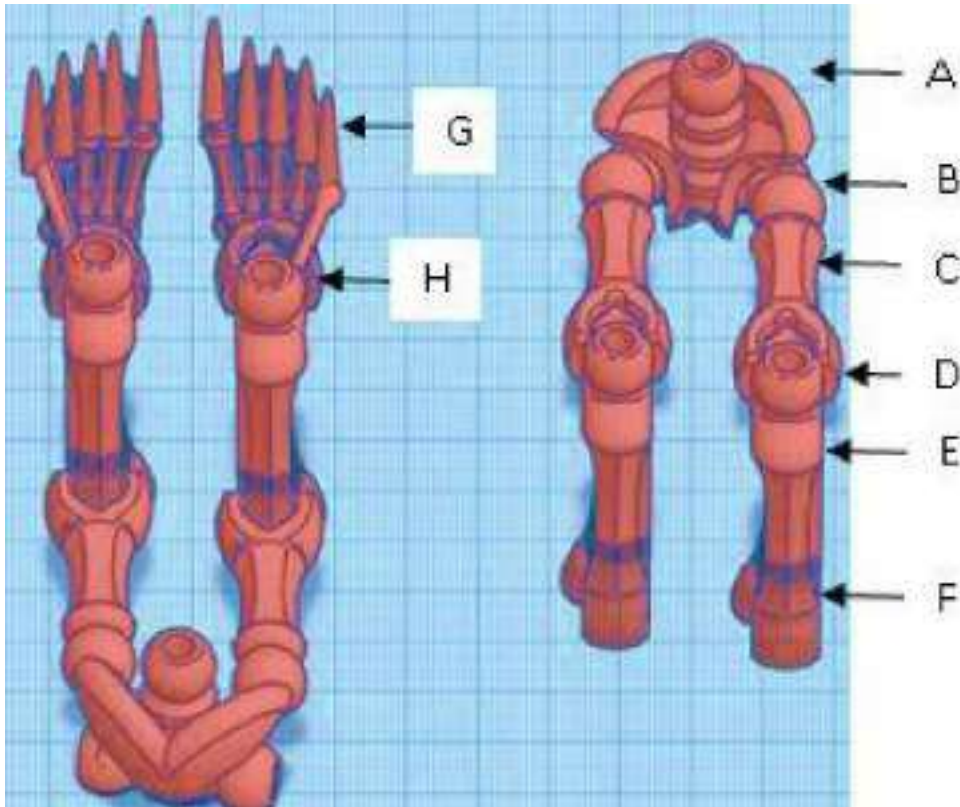
Figure 6: Complete Lower body part exoskeleton

These parts are flexible and allow easy attachment and detachment. For the fully paralyzed, the complete exoskeleton will be used. In case of partial paralysis, we can detach the complete assembly into separate parts. The carbon fiber material is used for the construction of exoskeleton. This provides the exoskeleton, easier mobility and light weight. To get better adhesion to the exoskeleton two supports are designed: one over the foot region and other on the back side of the ankle joint

4.3 Artificial Skin Preparation

The sensor circuit is incorporated in the artificial skin to get the sense of touch or feeling for the exoskeleton. The skin will be placed over the designed exoskeleton model with all the essential circuits. This gives the exoskeleton the functionality and aesthetics similar to the human body parts. Silicon rubber is the material used for constructing the artificial skin. The artificial skin acts as a protective coating and binds together the entire exoskeleton structure. Figure 7 illustrates the developed artificial skin along with its SMD components. ATtiny45 microcontroller is used for capturing vibrations and sense of touch using different sensors integrated into the circuit. The PCB design of the circuit is done using Fritzing software which

is an open source tool for PCB design. The design is optimized for compactness by appropriate placement of components and reducing the line width.
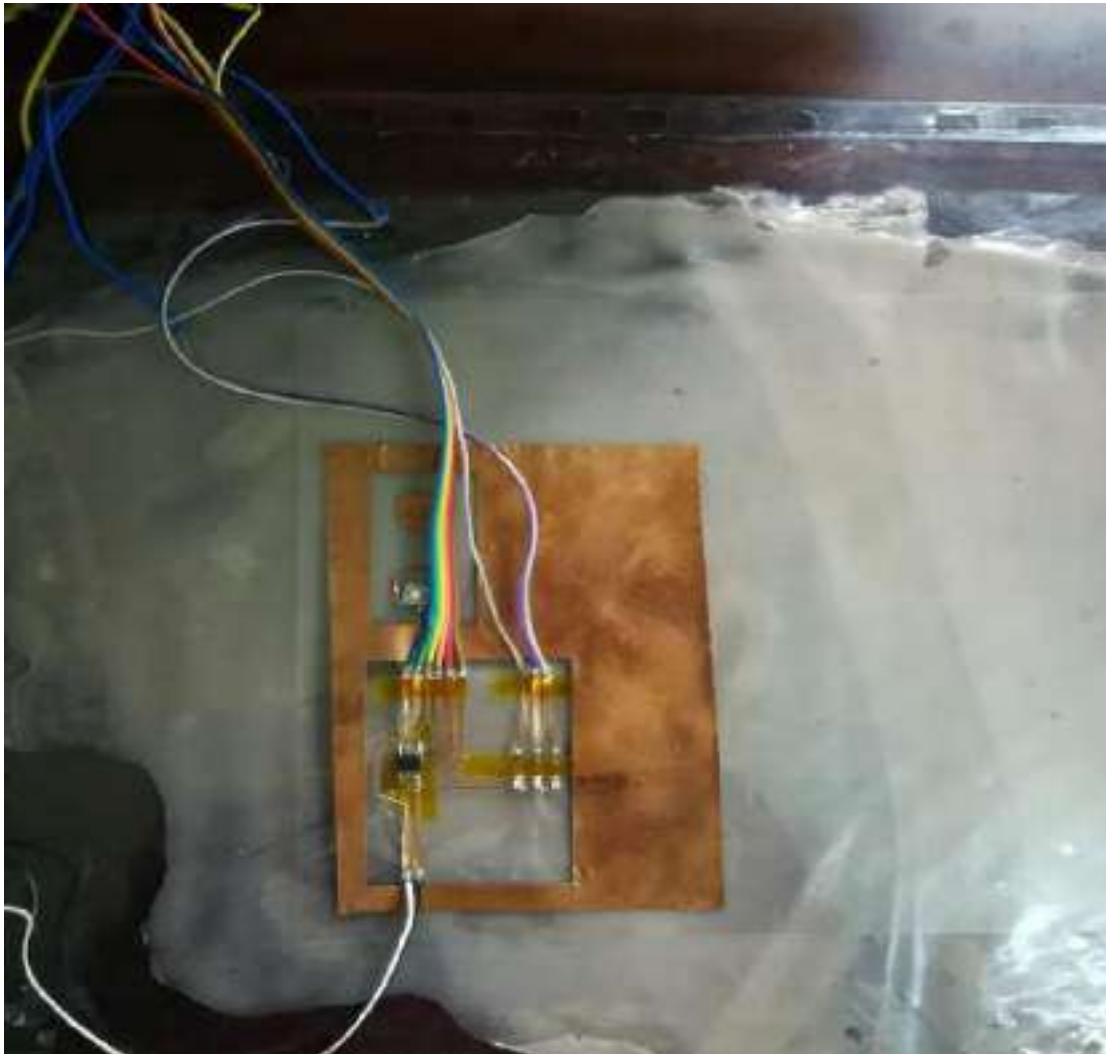
**FIGURE 7**. **Artificial Skin along with processor and sensor circuit**

4.4 Mechanical structure and hardware design of Exoskeleton

The mechanical structure of the exoskeleton is designed using high torque motors with geared mechanisms. Figure 8 shows the subject controlling the internal part of the exoskeleton using his thoughts. This part of the exoskeleton will be encapsulated inside the designed 3D model. The 3D model along with artificial skin gives the exoskeleton the aesthetics and functionality similar to the human body part. Figure 9 displays the PCB of the control unit and associated circuits which control all the movements of exoskeleton. Driver circuits are designed to provide enough current to activate the high torque motors and actuators. The output of the sensors integrated in the artificial skin is connected to the control unit. The PCB of the control unit,

driver circuits and sensor circuit will be embedded inside the exoskeleton module. After powering up, the microcontroller waits for human command, based on the detected posture, the microcontroller activates the corresponding motor rotations. Then the microcontroller scans the sensor value to validate if the applied activation signal is sufficient to make the exoskeleton stable. According to the sensor value, alterations will be made on the excitation signal. Thus using an adaptive mechanism, the system improves the stability and reduces the errors. The sensors are also utilized for providing a sense of touch. The pressure sensors accept the external force on the skin surface, converting it into vibrations with the aid of a control unit. The vibrations produced on the affected body part are proportional to the applied force. These vibrations or sense of touch also assist in the rehabilitation process. Testing and validation of the hardware design are done using different human controlled movements in the online and offline phase.

**FIGURE 8.Controlling the outer structure of exoskeleton using EEG headset**
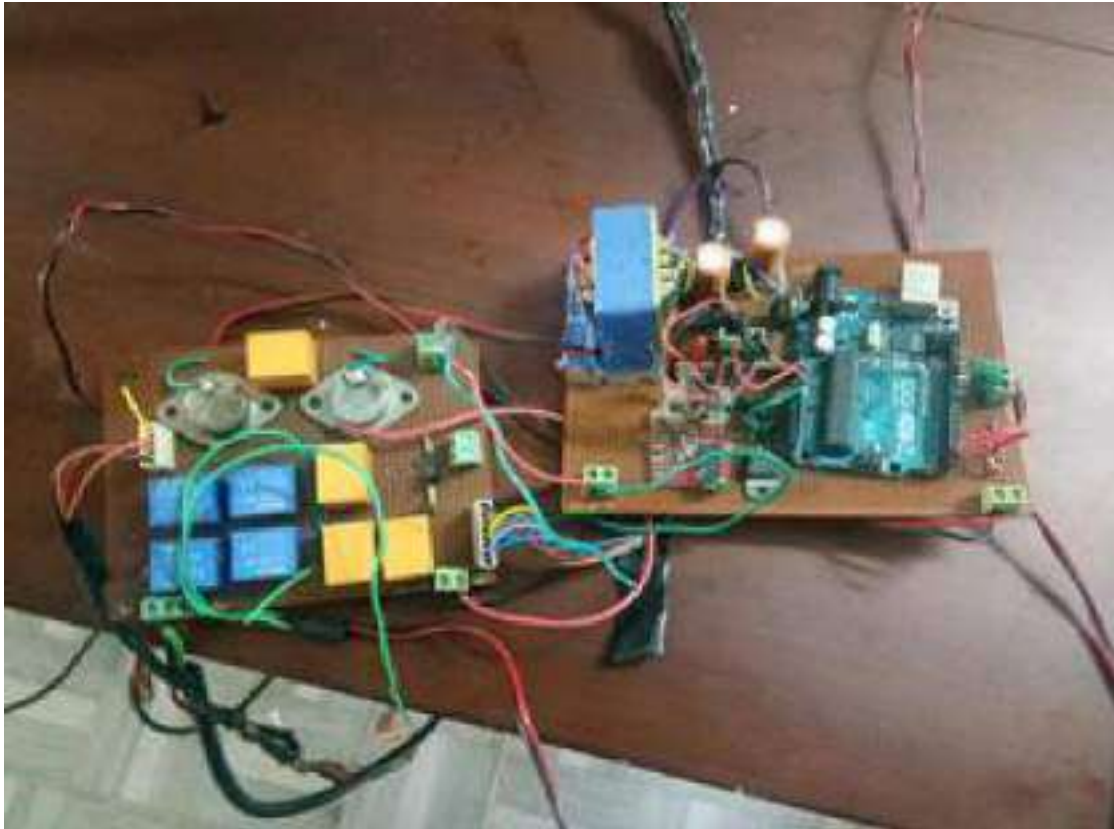
FIGURE 9.PCB of microcontroller and its associated driver

4.4 Results of EEG patterns using Realistic Head models

EEG analysis is carried out using realistic Head models to identify the unique EEG signal features and to validate the brain network connectivity. EEG signal is acquired by 16 electrodes placed in the frontal and parietal regions of the Brain. Figure 10 indicates the electrode placement scheme followed in the experimentation. The electrodes E12, E5, E13, E6, and E7 are placed in the parietal region and remaining in the frontal region, as shown in Figure 10. The power spectral analysis is carried out for each electrode used in the signal acquisition, Figure 11 indicates the brain patterns variations at different frequencies based on power spectral density. The brain signal analysis using realistic head models is carried out for different human intentions and on a variety of healthy and unhealthy subjects with repeated trials. Figure 12 depicts the realistic head models with active and non-active region variations

Channel locations
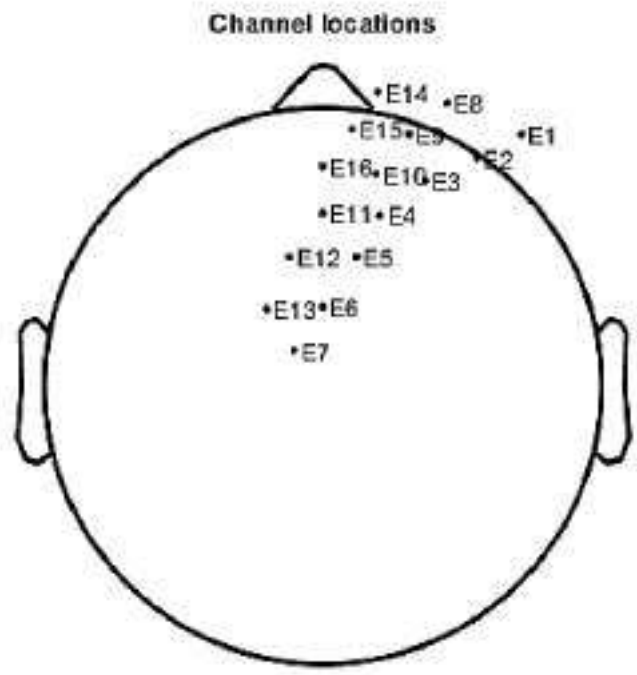
16 of 16 electrode locations shown
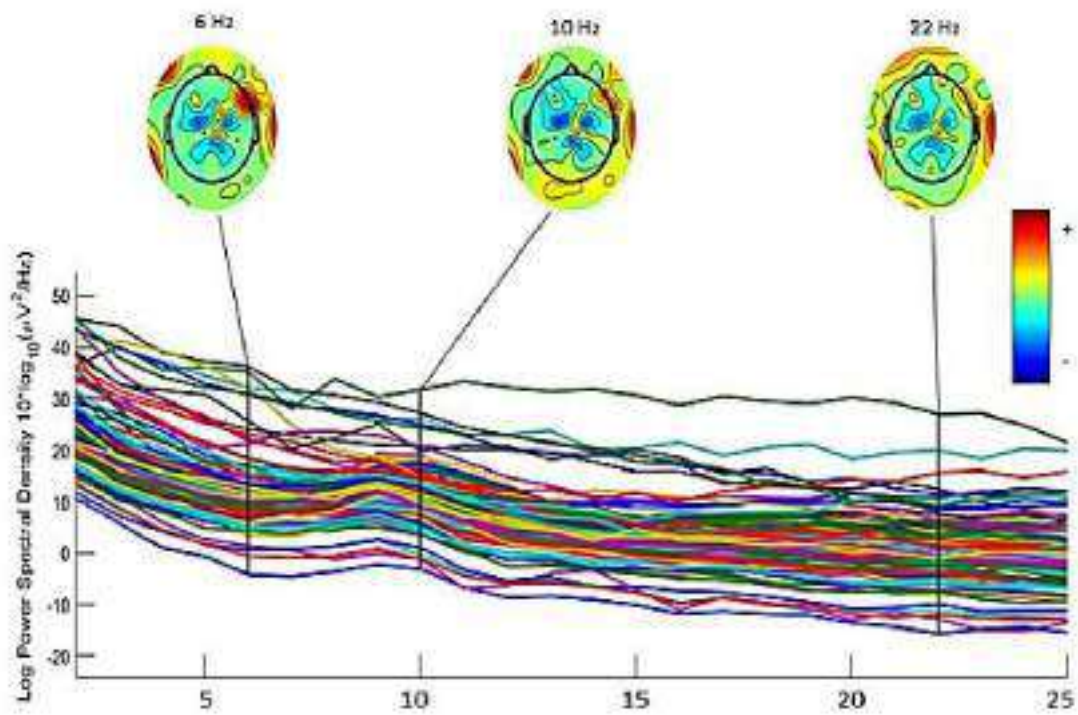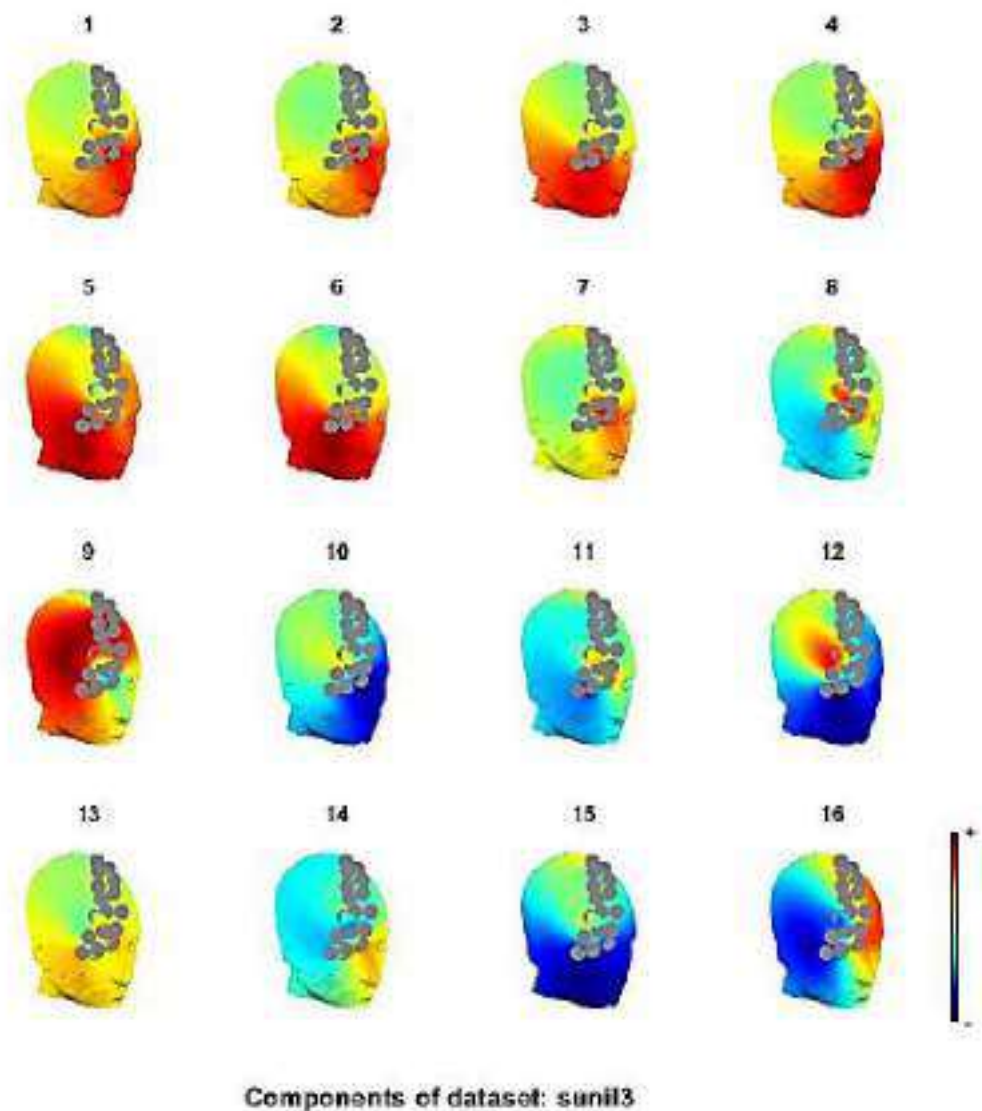
FIGURE 10. Location of 16 different electrodes

FIGURE 11. Brain pattern variations at different frequencies

FIGURE 12. Realistic head model with active region

4.5 AMIDL Acquisition and stimulation process

The muscle stimulation module receives the data using a wireless module. The received data is converted into muscle movements or stimulation using muscle inspired algorithms stored in Arduino along with the TENS device interfaced to it. The output of the TENS is connected to the EMG electrode through EMG shield to activate the affected upper limb movements. The EMG shield helps to customize the stimuli produced by the TENS device. The entire assembly used for acquisition and stimulation is depicted in figure 13. Signal undergoes further pre-processing and filtering to reduce the high frequency noise. Frequency domain conversion of the signal is done by using WHT transform and a finite sample is selected using window technique. The design uses a microcontroller in the acquisition and muscle stimulation module. The microcontrollers communicate with each other using Bluetooth technology. Bluetooth is

selected because the short distance between modules and data rate required is less than 1mbps. EEG sensors and other electronic circuits are interfaced to the microcontroller to design the PCB. Figure 14 shows the electronic assembly used in our experimentation.

Figure 13. Acquisition and stimulation process
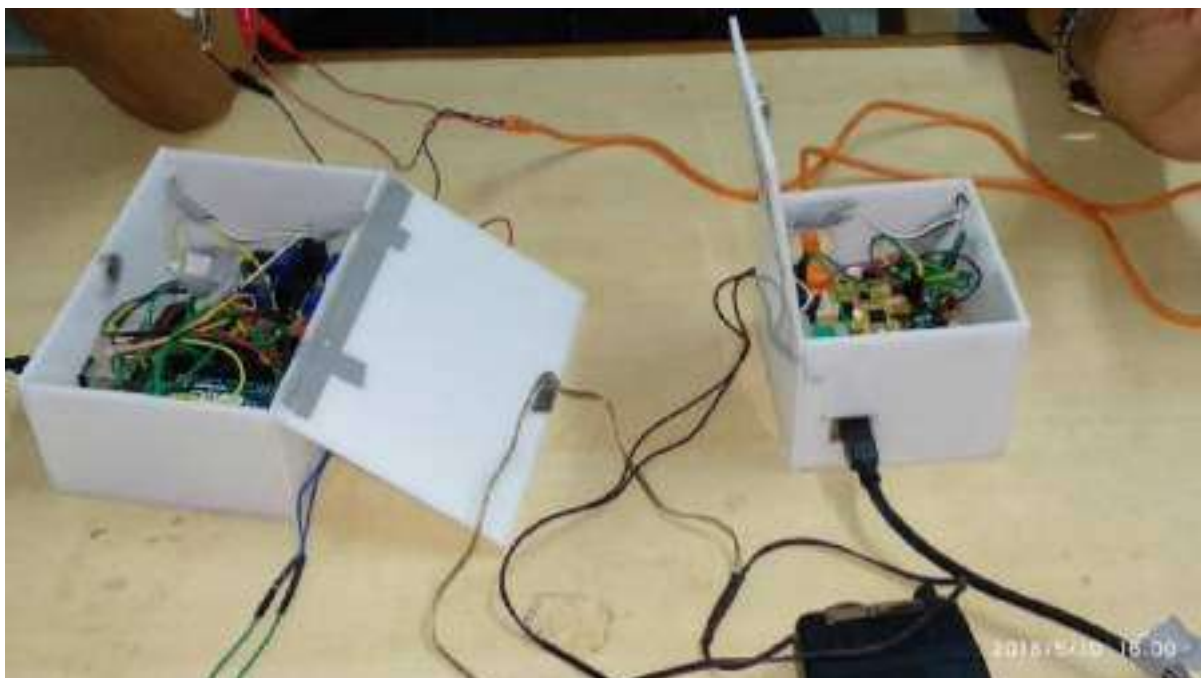
Figure 4. PCB designed for the experimentation

5. Publications

The publications in refereed journals are:

1) Artificial Muscle Intelligence System with Deep Learning for Post-Stroke Assistance and Rehabilitation, published in IEEE Access Journal, ISSN: 2169-3536, DOI: 10.1109/ACCESS.2019.2941491, Page(s): 133463 – 133473, https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8839118 - Impact Factor – 4.098 indexed with SCIE & Scopus Clarivate Analytics

2) Artificial Intelligence Powered EEG-EMG Electrodes for Assisting the Paralyzed, published in IEEE Future Directions, published on September 2019, https://cmte.ieee.org/futuredirections/tech-policy-ethics/september-2019/artificialintelligence-powered-eeg-emg-electrodes-for-assisting-paralyzed/

3) Brain-Controlled Adaptive Lower Limb Exoskeleton for Rehabilitation of Post-Stroke Paralyzed, published in IEEE Access Journal, ISSN: 2169-3536, DOI: 10.1109/ACCESS.2019.2921375 , Page(s): 132628 – 132648, https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8732331 - Impact Factor – 4.098 indexed with SCIE & Scopus Clarivate Analytics

4) Secure thought transfer and processing using Novel-T algorithm, Basic & Clinical Pharmacology & Toxicology (ISSN: 1742-7843),Volume 123, Issue S3, 2018, https://onlinelibrary.wiley.com/doi/full/10.1111/bcpt.13100 No.6

5) Hybrid brain actuated muscle interface for the physically disabled, Basic & Clinical Pharmacology & Toxicology (ISSN: 1742-7843),Volume 123, Issue S3, 2018, https://onlinelibrary.wiley.com/doi/full/10.1111/bcpt.13100 No.10

6) Secure Brain to Brain Communication with Edge Computing for Assisting Post-Stroke Paralyzed Patients, IEEE Internet of Things Journal (Early Access), DOI: 10.1109/JIOT.2019.2951405, 05 November 2019, https://ieeexplore.ieee.org/document/8891712

6. Patents

Patents published

1) The patent published in the version and application of the concept I am attaching the link
http://ipindiaservices.gov.in/PatentSearch/PatentSearch//ViewApplicationStatus
Application No: 201841042113

2)http://ipindiaservices.gov.in/PatentSearch/PatentSearch//ViewApplicationStatus Application No: 201841042115

7. Conclusions/Project Status

As per the timeline of the project,we have completed the implementation of BCCLE.Online and offline testing of the BCLLE on six different subjects was carried out.WH Transform is utilized for feature extraction and reconstruction. The results obtained indicate that it produces good classification accuracy. The SSVEP method is incorporated using a visual interface,

which improves human concentration. The healthy and paralyzed subjects were able to control the exoskeleton for different movements such as backward movement, forward movement, Sitting, Standing, Turn Left and Turn Right. The sensory feedback was implemented using angle sensors and rescue assistance is provided using accelerometers. The adaptive mechanism used helped to reduce the false rate of the system. The secure message transmission is established using NTSA encryption, which helps the caregiver to know the status of the paralyzed. In phase 2 of the work we will be integrating artificial muscle intelligence to the system. The timeline of the project implementations are listed in the Gantt chart below

Gnatt Chart for Project time line

KERALA STATE COUNCIL FOR SCIENCE, TECHNOLOGY AND ENVIRONMENT
An Autonomous body of the Government of Kerala

KSCSTE – INNOVATE scheme of KSCSTE - Project entitled 'SMART MIRROR' - Release of financial assistance – sanctioned – orders issued.

Council (P) Order No1109/2019/KSCSTE	Dated: Thiruvananthapuram,13/08/2019

Ref: -   1. File No. 01/TECHFEST/2018/TDPMD

2. Letter No. CSE1/314/INNOVATE/2019 dt:22.01.2019

ORDER

1. Kerala State Council for Science, Technology and Environment (KSCSTE) has instituted 'TEKON' – a state level contest for Innovative Engineering Products, in order to encourage and promote technological innovations and inventions emerging from engineering colleges in the Kerala state. Another special programme called 'INNOVATE' is also instituted in association with TEKON. INNOVATE scheme is envisaged to foster innovations among engineering students by providing financial assistance to the tune of Rs. 20,000/- for realizing innovative projects. In response to notifications through brochure, 312 proposals from different engineering disciplines were received under the INNOVATE scheme. These proposals were evaluated and 75 proposals were provisionally approved for financial assistance. As per reference (2) cited above, Head of the Institution was informed that financial support limiting to Rs. 13,000/- will be released for the project entitled 'SMART MIRROR' with Smt. Asha S., as the mentor, after evaluating the project and participation in TEKON and also subject to the satisfactory submission of required documents.

2. Smt. Asha S., Assistant Professor, Department of Computer Science and Engineering, SCMS School of Engineering & Technology, Karukutty who is the mentor to the project forwarded the report, audited financial statements and other required documents after participating in KSCSTE TEKON – 2019 held at Government Engineering College, Thrissur. As per the financial statements, the expenses incurred is Rs. 14,000/-. These documents are verified by the council and found acceptable.

3. KSCSTE is pleased to accord sanction to release an amount of Rs. **13,000/- (Thirteen Thousand only)** towards financial assistance for implementing the project entitled 'SMART MIRROR' and the amount will be disbursed to **The Principal, SCMS School of Engineering & Technology, Karukutty** through net banking / e-payment for the above said purpose.

Beneficiary Account Name	SCMS School of Engineering & Technology
Beneficiary Account Number (SB/CC)	345801010030000
Beneficiary IFSC code	UBIN0558885
Beneficiary Name and Branch	Union Bank of India, Palissery
Beneficiary Address	SCMS School of Engineering,Palissery,
Beneficiary Mobile No:	9947448628
Beneficiary email id	ashas@scmsgroup.org

4. The expenditure in this regard for the above said purpose will be met from the Council's Budget under the Head of Account **III Schemes and Programmes of KSCSTE (C-4) Technology Festival.**