SSN COLLEGE OF ENGINEERING KALAVAKKAM-603110

INTERNALLY FUNDED STUDENT PROJECT - 2023

Brain Waves for Communication

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(Ist year CSE)	(Ist year CSE)	(Ist year CSE)	(Ist year CSE)

Dr.A.Shahina, Professor and HOD, IT Department

Budget Rs. 103000

Project Duration (in months)
24

Signature of the Project Students

Signature of the Project Guide(s)

Signature of the HOD

1. Project Title: Brain waves for communication

2. Broad Subject: Developing an Artificial Intelligence based thoughts-to-speech system for military and clinical applications

3. Project Duration *(in months)*: 24

4. Budget *(in thousands)*: One hundred and three thousand

5. Project Summary :

This project is of paramount importance as it seeks to address a critical challenge in military and healthcare contexts. By developing an AI-based Thoughts to Speech system, it offers a breakthrough solution for instantaneous communication, significantly enhancing the safety and operational efficiency of military personnel facing communication limitations, such as speech-affecting injuries or conditions.

While related work is underway both nationally and internationally, this project stands out due to its emphasis on adaptability, scalability, and real-time communication. It focuses on creating a functional prototype with limited vocabulary, a user-friendly interface, and a roadmap for expanding the vocabulary recognition system. This project's execution prioritizes rigorous testing and validation to ensure accuracy and reliability, all while adhering to ethical and security guidelines.

The expected outcome is multifaceted, encompassing the development of a groundbreaking technology. This technology is not only set to revolutionize communication in military clinical applications but also to improve the quality of life for veterans and enhance healthcare for individuals with speech-related disabilities and disorders. Furthermore, it contributes to the broader field of AI and neuroscience and aims to generate a valuable database of knowledge. This project is positioned as a cornerstone for future research, innovation, and meaningful societal impact, both nationally and globally, and is poised to set new standards for communication and assistive technologies in military and healthcare applications.

6. Keywords :

- EEG-Based Communication
- Thoughts to Speech System
- Military Clinical Applications
- Real-time Communication

7. Objectives

- Analyze different EEG patterns on different persons, related to their thoughts arising from visual stimuli.
- Build a system that extracts useful features from the raw EEG signals.
- Explore various machine learning and deep learning models to build a brain-computer-interface system that maps thoughts to objects.

- Practically demonstrate and enhance the working of the device on multiple conditions.

8. Introduction

Effective communication is a cornerstone of military operations, and any hindrance to it can have dire consequences. In many scenarios, soldiers may face challenges in articulating their needs and relaying crucial information, especially when injuries or conditions render them speechless. This project addresses this critical issue by introducing an innovative solution that harnesses EEG technology. Using an EEG machine, we aim to enable instant communication by translating brainwave patterns into speech. Starting with a limited vocabulary, our project paves the way for a future where the entire spectrum of human expression can be conveyed seamlessly, significantly enhancing communication in military contexts.

9. Definition of the Problem

Effective communication within the military is a fundamental pillar of success in both training and operational scenarios. However, a pressing issue exists, wherein soldiers may find themselves unable to communicate effectively due to various challenges. These challenges can range from combat injuries to conditions that limit their ability to speak. In such situations, the inability to relay crucial information promptly and accurately can hinder mission success, compromise safety, and impact overall effectiveness. The absence of an immediate and efficient means of communication presents a significant problem for the military. Soldiers require a reliable method to communicate in real-time, especially when conventional speech is not viable. Addressing this challenge is crucial, as it directly impacts the safety and effectiveness of military personnel in complex and dynamic operational environments.

10. Review of status of Research and Development in the subject

10.1 National Status :

Envisioned speech recognition using EEG sensor by Pradeep Kumar, Rajkumar saini, Partha Pratim Roy, Pawan Kumar Sahu and Debi Prosad Dogra

10.2 International Status

Multiple research works and patents have been published over the years. Research works so far have been focused on motor imagery, neurological activities and raw EEG data

11. Novelty / Importance of the proposed project in the context of current status

Human brain is often considered the most unreadable body part wrapped with unexplored subjects. Our work focuses on unraveling those mysteries. Everytime we hear a noise, see a visual or even simple movement causes a neurological activity. These neurological activities are caused by electrical activities of neurons in the brain. Electroencephalography (EEG) is a

method by which these activities are recorded. We are working towards converting these EEGs to human understandable form using Brain Computer Interface (BCI).

12. Patent details :

Converting Your Thoughts to Texts: Enabling Brain Typing via Deep Feature Learning of EEG Signals by Xiang Zhang, Lina Yao, Quan Z. Sheng,
Salil S. Kanhere, Tao Gu and Dalin Zhang

13. Work plan and Detailed technical information :

Our project, "Brain Waves for Communication," is dedicated to the development of an innovative thoughts-to-speech system. This system's core objective is to decode brainwave signals, particularly EEG (Electroencephalogram), and convert them into text, enabling direct communication through thought. The applications of this technology are far-reaching, with implications specific for military settings.

Background:

EEG technology records the electrical activity in the brain, capturing voltage fluctuations generated by neural processes. These fluctuations give rise to a diverse array of brainwave patterns, each associated with specific cognitive states. Understanding these patterns is the foundation of our project, as we seek to translate them into comprehensible text and speech.

Methodology:

1) Literature Review: We begin with a comprehensive review of the existing knowledge in neurophysiology and EEG signal processing, aiming to grasp the known EEG patterns and challenges related to noise. We first learn the basics of neuron signal processing and explore the topics in the domain in the starting phase.

2) Data Collection and Analysis: Our test cases provide the raw EEG data, which will undergo rigorous denoising procedures. Additionally, we'll utilize publicly available EEG datasets from the internet to expand our dataset and enhance our analysis. We will collect different sets of data varying many factors such as mood of the person, color of the objects, shapes, lighting and sound conditions, and many factors to get a wide sample of data

3) Artifact Detection and Noise Reduction: A critical aspect of our process involves developing advanced techniques for identifying and eliminating common EEG artifacts which are unnecessary information breaches produced by situations not related to the current object in view. Denoising algorithms will be employed to ensure data purity.

4) Thoughts-to-Speech Development: The heart of our project is the development of an advanced AI system. This system will analyze denoised EEG patterns related to

thoughts and convert them into clear and coherent text or speech, achieving the ultimate goal of direct thought-based communication.

Once we familiarize ourselves with processing eeg signals, we will train our algorithm with a small set of vocabulary to identify certain things. Once Its done, we will implement machine learning technologies to make sure the machine becomes more accurate and can also identify or atleast convert signals of unknown objects

Resources:

To achieve our objectives, we require access to EEG equipment, specialized data analysis software, and consultation with subject experts in the field of neurology, electronics, and AI/ML specialists.

14. Time schedule of activities giving milestones

TASK1

Month 1-3:

The initial phase involves a comprehensive literature review and the acquisition of foundational knowledge in EEG technology. We will learn the basics, review pre-recorded EEG data and get familiarized.

TASK2

Month 4-6:

Data collection begins, focusing on baseline EEG features and the commencement of denoising techniques. We first record basic data sets to know what kind of data we receive during the experiment and analyze them

TASK3

Month 7-9:

The experimentation phase commences, involving tests related to mood, cognitive tasks, and environmental factors. We vary every possible factor including the subjects, cases and the surroundings.We refine noise reduction techniques during this period.

TASK4

Month 10-12:

We concentrate on advanced noise reduction methods and finalize artifact detection processes(the processes which remove the unwanted data produced from the stimuli and not the unusable EEG data)

TASK5

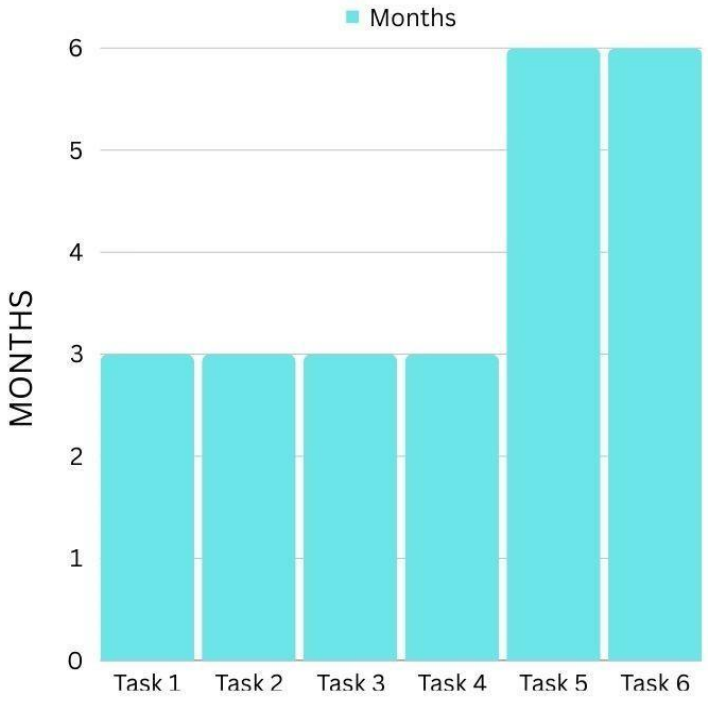
Month 13-18:

The development of the AI system is at its peak, ensuring that it can accurately convert denoised EEG patterns into text or speech.

TASK6

Month 19-24:

The final stage is dedicated to the practical application of our research, as we bring to life the revolutionary capability of direct thought-based communication.



15. Deliverables

- **AI-Based Thoughts to Speech System:** Develop a working prototype with limited vocabulary and a scalable design for military personnel.
- **Real-time Communication Interface:** Create a user-friendly interface for instantaneous communication, including security and ethical guidelines.
- **Testing and Validation:** Rigorously test and validate the system for accuracy, reliability, and user-friendliness, with documentation of the process.
- **Vocabulary Expansion Plan:** Develop a roadmap for expanding the vocabulary recognition system, encompassing various expressions and languages.
- **Training and Deployment:** Provide comprehensive training guidelines for military personnel, veterans, and healthcare professionals on system usage and deployment.

- **Outcome Evaluation:** Generate a report detailing clinical outcomes and improvements observed with the system's implementation, including continuous improvement strategies.

16. Target beneficiaries of the proposed work

The primary beneficiaries of this project are military personnel facing communication limitations, particularly individuals with speech-affecting injuries or conditions. This innovation promises to enhance their operational effectiveness and safety by providing swift communication solutions. As an added benefit, this technology has the potential to significantly benefit veterans who have served in the armed forces. It can assist them in regaining and improving their communication abilities, thereby enhancing their post-service quality of life. Moreover, the project's applications can extend to the broader civilian healthcare sector. It offers a valuable tool for addressing communication challenges in patients with speech-related disabilities and disorders, showcasing the technology's potential to make a lasting impact in diverse areas of society.

17. Suggested plan of action for utilization of research outcome expected from the project

17.1 As journal publication

Publish research findings in well-refereed, peer-reviewed SCI journals to share knowledge with the scientific and academic community. This step ensures that the project's insights are accessible to a broader audience, fostering collaboration and discussion.

17.2 Patent filing

Explore the possibility of patenting any unique aspects of the AI-based Thoughts to Speech system that our research has uncovered. This can protect our intellectual property and may open doors for potential future collaborations, licensing opportunities, or entrepreneurship endeavors under the guidance of a legal expert.

17.3 Project preparation for submission to external funding

Develop a comprehensive project report and proposal to present to potential external funders. This includes a detailed plan for further research, development, and implementation, targeting government grants, private sector investments, or philanthropic sources. Successful external funding would support the project's expansion and real-world application.

18. References

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2) N. E. Md Isa, A. Amir, M. Z. Ilyas, M. S. Razalli, "Motor imagery classification in Brain computer interface (BCI) based on EEG signal by using machine learning techniques", 2019, UniMAP, Malaysia

3) Hamdi Altaheri, Ghulam Muhammad Mansour Alsulaiman, Syed Umar Amin, Ghadir Ali Altuwaijri Wadood Abdul, Mohamed A. Bencherif and Mohammed Faisal, “Deep Learning Techniques for Classification of Electroencephalogram (EEG) Motor Imagery (MI) Signals”,2017, KING SUAD UNIVERSITY

4) S.Yu. Gordleeva, M.V. Lukoyanov, M.A. Khoruzhko, A.Ya. Kaplan and V.B. Kazantsev, ”Exoskeleton Control System Based on Motor-Imaginary, Brain–Computer Interface, 2017, Labachevsky State University

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6) Pradeep Kumar,Rajkumar Saini, Partha Pratim Roy, Pawan Kumar Sahu and Debi Prosad Dogra, “Envisioned speech recognition using EEG sensor”,2018, IIT Roorkee

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8) Bird JJ, Ekart A, Buckingham CD, Faria DR, “Mental Emotional Sentiment Classification with an EEG-based Brain-Machine Interface”, 2018, University of Oxford, UK

9) Natasha Padfield, Jaime Zabalza, Huimin Zhao, Valentin Masero and Jinchang Ren, “EEG-Based Brain-Computer Interfaces Using Motor-Imagery: Techniques and Challenges”,2015,University of Beijing

10)Saeid Sanei, Jonathon A Chambers, “EEG signal processing”, 2007, Nottingham Trent University

19. List of facilities and Equipments available with Department for the project

- High speed and GPU enabled computers (To be used for programming and data analysing)
- Well-equipped labs for performing experiments

20. Budget Estimates

S.no	**Item**	**Cost**
1	Neuphony Headband + Software	₹79000
2	Google Colab Pro	₹24000
	TOTAL	**₹103000**

Apparatus to be shared with two other teams on time basis

TOPIC	GROUP MEMBERS
AN AI BASED STRESS DETECTION USING BRAIN SIGNALS WITH A STRESS-BUSTING YOGA RECOMMENDER SYSTEM	Sowmya C
	Chiranjeev Prasannaa V V
	Dharanikaran S
USING EEG TO AID COMMUNICATION FOR DEAF AND DUMB PEOPLE	Maghizhvanban
	Francis Rohith
	Karanam Hema Sudha Poornima
	Sandhya Sridar

21. Budget Justification

S.No.	Item	Purpose
1	Neuphony Headband (8 channel)	Neuphony is a neurofeedback-based wearable brain device (EEG Headband) that captures key mind parameters and allows users to know their stress and external focus scores.The headband records the electrical activity of the human brain
2	Neuphony EEG headset software Annual	A "NeuPhony EEG headset" is needed to record and study brain activity in various fields, including healthcare, research, and technology.