



Department of Computer Science & Engineering

Pre-Final Year - Project Work Phase - 1 (21CSP67) - Abstract Submission

Academic Year 2023-24

1	Title of the Project	Developing a Brain-Computer Interface framework for Real-Time Neural Signal Decoding and Speech Conversion
2	Group No.	CS24
3	Department	Computer Science & Engineering
4	Project Area/Domain	Brain-Computer Interface, Neural Signal Processing & Speech Synthesis, Machine Learning
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7. Abstract

Development of communication capabilities for individuals with speech impairments is a significant challenge in the medical and assistive technology fields. Brain-computer interfaces (BCIs) that reconstruct and synthesize speech using brain activity recorded with intracranial electrodes may pave the way toward novel communication interfaces for people who have lost their ability to speak, or who are at high risk of losing this ability, due to neurological disorders.

This project aims to build a Brain-Computer Interface (BCI) framework that translates real-time EEG signals into phonetic representations and subsequently into speech. This solution provides a potential communication method for individuals with conditions like Amyotrophic Lateral Sclerosis (ALS) or severe brain injuries. Unlike traditional speech reconstruction approaches, this project focuses on developing a real-time system that operates with high accuracy and minimal latency.

Key objectives of this project include the following:

- **Acquiring and Processing EEG Data:** Using EEG devices to record neural activity associated with phonetics and spoken language.
- **Model Development and Training:** Implementing machine learning models, including Random Forests, RNNs, LSTMs, 1D CNNs, Transformers, and GANs, to classify phonetic representations from neural signals. Each model's performance is evaluated based on precision, accuracy, recall, and F1 scores to identify the best approach for decoding neural signals into phonetic elements.
- **Selecting and Fusing Top-Performing Models:** The top two models, chosen based on evaluation scores, are combined into a hybrid approach to leverage their complementary strengths. The Transformer model captures long-term dependencies in EEG signals, while the 1D CNN excels at identifying local patterns quickly. By integrating these models, the hybrid aims to improve accuracy and robustness in phonetic decoding.



- Data Augmentation with GANs: Utilizing Generative Adversarial Networks (GANs) to generate synthetic EEG signals, which expand the training dataset and improve model robustness.
- Real-Time Speech Synthesis: Converting detected phonetic elements into audible speech through a speech synthesis engine, ensuring intelligibility and adaptability to individual neural patterns for higher accuracy and user experience.

The methodology involves recording EEG signals as participants imagine or pronounce specific phonetics, followed by data preprocessing and feature extraction. Machine learning models, including Transformers for long-term dependencies and 1D CNNs for local patterns, are trained on these features. GANs are used to generate synthetic data, improving model accuracy and generalization. Evaluation metrics such as accuracy, latency, and intelligibility are applied to test datasets. The project leverages TensorFlow and PyTorch frameworks on high-performance computing resources, with phonetic annotations enabling system generalization across users.

Keywords:

Brain-Computer Interface (BCI), Neural Signal Decoding, Speech Synthesis, Electroencephalography (EEG), Machine Learning, Signal Processing, Phonetic Translation, Assistive Technology, Communication Disorders

8.	Signature of Students	
9.	Signature of Guide	
10.	Signature of the Project Coordinator	