BCA Capstone Project (Review III)

AN APPROACH FOR BRAIN COMPUTER INTERFACE USING HYBRID FEATURE EXTRACTION ALGORITHM

Submitted to the Presidency University, Bengaluru in partial fulfillment for the award of the degree of Bachelor of Computer Applications(BCA)

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Problem Statement

- Brain-Computer Interfaces (BCIs) have emerged as a promising technology for enabling direct communication between the human brain and external devices, especially for individuals with motor disabilities or other neurological impairments Inefficient communication causes delays in diagnosis and treatment.
- Despite significant advancements, one of the major challenges in BCI systems is the accurate and efficient extraction of meaningful brain signals from complex and noisy EEG data .
- This is particularly problematic in real-time applications, where the system must quickly interpret brain activity to control devices such as prosthetics, communication aids, or computer interfaces.

Objective

- **To develop a Brain-Computer Interface (BCI) system** capable of interpreting brain signals (such as EEG) and converting them into actionable outputs or control commands.
- **To design and implement a hybrid feature extraction algorithm** that combines multiple techniques (e.g., statistical, time-frequency, and spatial features) for improved signal representation and classification performance.
- **To enhance the accuracy and robustness of brain signal classification** by leveraging complementary strengths of different feature extraction methods.
- **To compare the performance of the proposed hybrid algorithm** with traditional single-method feature extraction approaches using standard BCI datasets.

Literature Survey

1.Introduction

- Brain-Computer Interface (BCI) technology establishes a direct communication pathway between the human brain and external devices, enabling users to control systems using only their brain activity. This has significant applications in assistive technology, neurorehabilitation, and human-computer interaction. The core of any BCI system lies in accurately interpreting brain signals, typically acquired through Electroencephalography (EEG). However, EEG signals are often noisy, non-stationary, and complex, making feature extraction a critical step in achieving reliable classification of mental states. This project proposes a hybrid feature extraction approach that combines multiple techniques—including Discrete Wavelet Transform (DWT), Common Spatial Pattern (CSP), and Fast Fourier Transform (FFT)—to capture both temporal and spectral characteristics of EEG signals. By integrating the strengths of these methods, the system aims to enhance classification performance and improve the overall effectiveness of BCI applications.

2. Scope of the Review

- This literature survey covers the following key areas:
- - Topics:Overview of BCI systems, Importance of EEG-based BCI
- - Time Frame: Studies and research conducted from 2015 to 2024.
- - Key Areas:Brain-Computer Interface (BCI) Fundamentals, EEG Signal Acquisition and Characteristics.

3. Research Methodology

It involves the development of a Brain-Computer Interface (BCI) system using a hybrid feature extraction algorithm to improve the classification of EEG signals. The study begins with a comprehensive review of existing literature on BCI technologies, EEG signal characteristics, and feature extraction techniques. EEG data is obtained from publicly available datasets, focusing on motor imagery tasks. The raw EEG signals are preprocessed using band-pass filtering and artifact removal techniques such as Independent Component Analysis (ICA) to enhance signal quality. A hybrid feature extraction approach is then applied, combining Discrete Wavelet Transform (DWT) for time-frequency analysis, Fast Fourier Transform (FFT) for spectral features, and Common Spatial Pattern (CSP) for spatial filtering. These extracted features are fused into a single feature vector and reduced using Principal Component Analysis (PCA) to minimize dimensionality while retaining essential information.

4. Organization of Sources

The reviewed literature is categorized into the following themes:
. **Brain-Computer Interface (BCI) Fundamentals**:
. The concept of Brain-Computer Interfaces (BCI) dates back to the **1960s**,when early research explored the possibility of directly interpreting brain signals for communication and control purposes. One of the earliest milestones in BCI research was achieved by **José Delgado**, a Spanish neuroscientist, who in 1964 demonstrated the first use of brain signals to control external devices. Delgado’s experiments, which involved stimulating the brain of animals, laid the foundation for understanding how the brain could interact with external systems.

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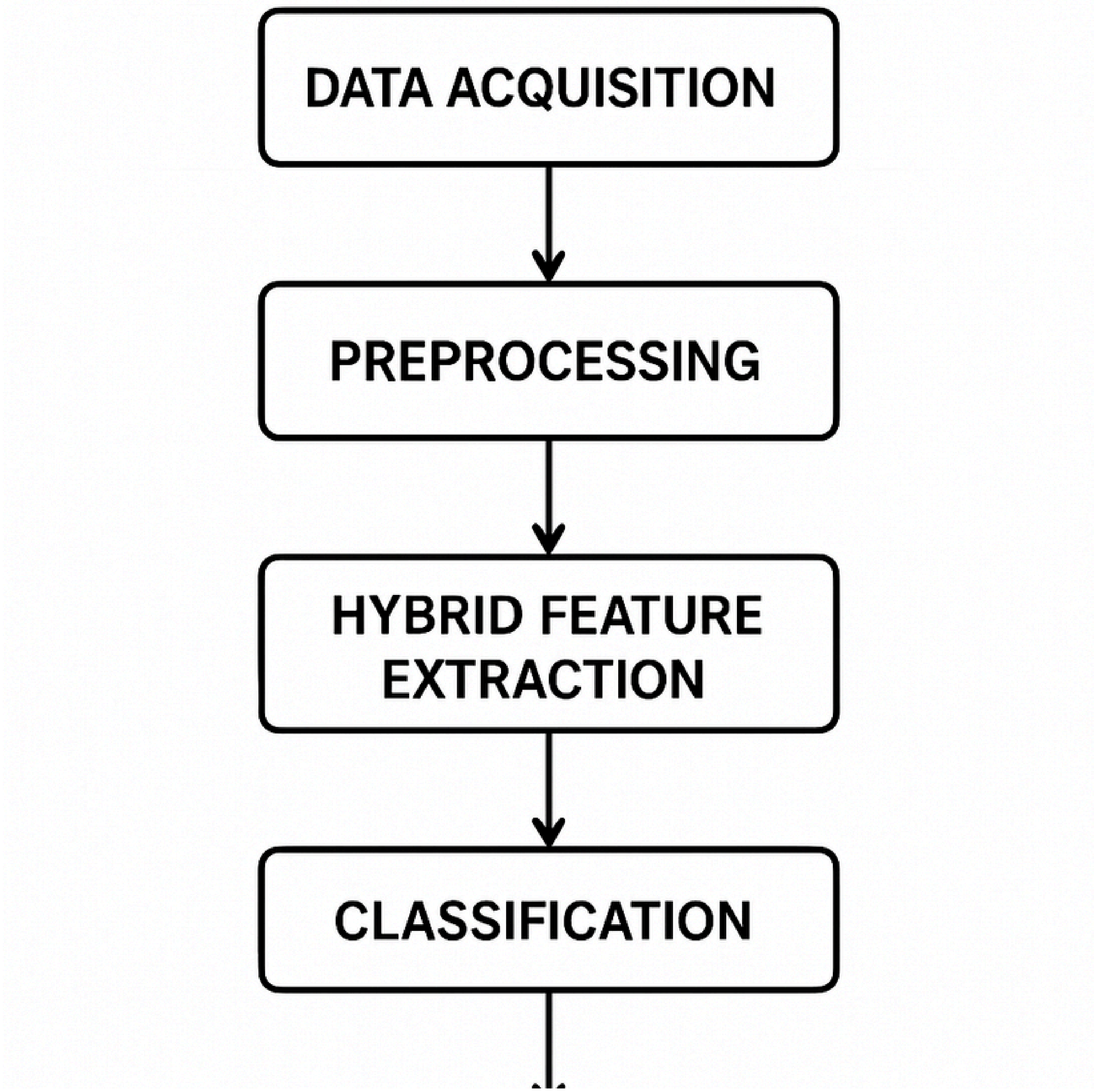
- **EEG Signal Acquisition and Characteristics:**
- **Electroencephalography (EEG)**, the technique used to measure electrical activity in the brain, has been a cornerstone of neuroscience and BCI research since its development in the early 20th century. EEG as a method of brain signal acquisition was first introduced by the German psychiatrist **Hans Berger** in 1924, who is credited with recording the first human EEG. His groundbreaking work demonstrated that the brain emits electrical signals, which could be measured from the scalp, laying the foundation for modern neurophysiological studies. Berger's early experiments revealed that the EEG signals have distinct frequency patterns, which are now known as **alpha**, **beta**, and **theta waves**. His discovery became a key milestone in understanding the brain's electrical activity and its relation to different mental states, such as relaxation and alertness.

- **Conclusion**

This project has presented a novel approach to improving Brain-Computer Interface (BCI) systems through the use of a hybrid feature extraction algorithm. By combining time-domain, frequency-domain, and spatial-domain techniques—specifically Discrete Wavelet Transform (DWT), Fast Fourier Transform (FFT), and Common Spatial Pattern (CSP)—the study demonstrates that integrating multiple feature extraction methods enhances the classification accuracy of EEG signals. The proposed hybrid method effectively captures the diverse characteristics of EEG data, addressing the inherent challenges such as noise and non-stationarity. The results indicate a significant improvement in performance compared to traditional single-feature extraction approaches, offering promising potential for real-time applications in assistive technologies, neurorehabilitation, and communication systems.

Module Design



Tools And Technologies To Be Used

- - Development Tools:

  Open BCI , EmotivPRO
- - Programming Languages:

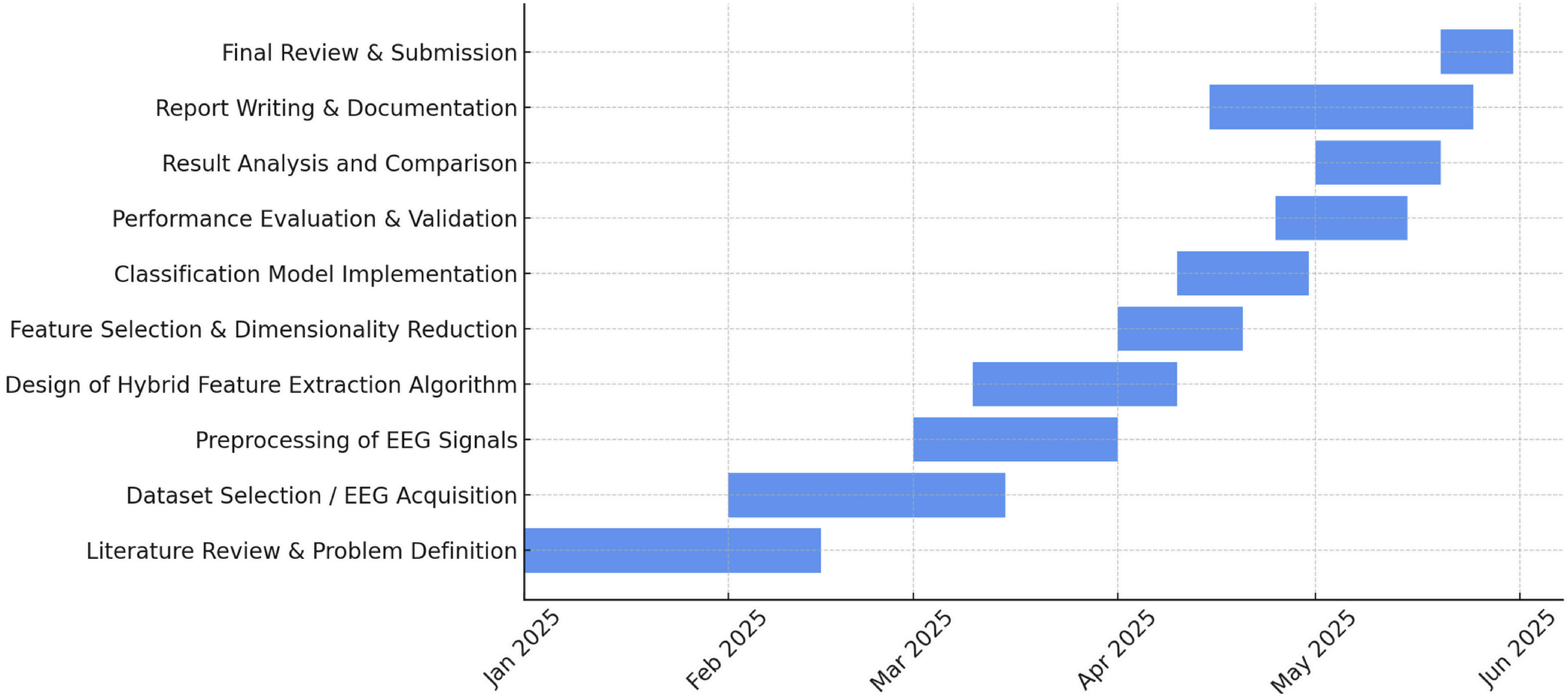
  Front-End –HTML (HyperText Markup Language), JavaScript

  Back-End –Python, Node.js
- - Database: MySQL
- - Version Control: GitHub.
- Additional Tools: Mlflow, Git / GitHub / GitLab.

Github Link

- **GitHub Repository:**

Timeline of the Project (Gantt Chart)



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Thank
You!