TRANSFORMER BASED CLASSIFICATION OF MI ACTIVITIES FROM EEG-SIGNALS USING STACKED STFT

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ABSTRACT

This project focuses on classifying motor imagery (MI) movements using a transformer-based model within a Brain-Computer Interface (BCI) system, enabling machine control through human brain signals. EEG data were recorded while subjects performed visual tasks, and signals were segmented into Zero Time Windows (ZTW) using task-related timing markers. Variational Mode Decomposition (VMD) was applied to extract relevant frequency bands linked to motor and cognitive functions. These decomposed signals were then converted to the time-frequency domain using Short-Time Fourier Transform (STFT). The resulting features were input into a transformer model for MI classification. The hybrid deep learning approach outperformed traditional methods, showcasing the transformer model's superior capability in EEG-based BCI applications.

INTRODUCTION

This project focuses on classifying motor imagery (MI) signals from EEG data using a transformer-based deep learning model for Brain-Computer Interface (BCI) applications. Due to the non-linear and noisy nature of EEG signals, traditional methods struggle with accurate classification. The approach involves segmenting clean EEG data using Zero-Time Windows (ZTW) and applying Short-Time Fourier Transform (STFT) and Variational Mode Decomposition (VMD) for effective feature extraction. The transformer model enhances classification accuracy and holds strong potential for use in neurorehabilitation and assistive technologies.

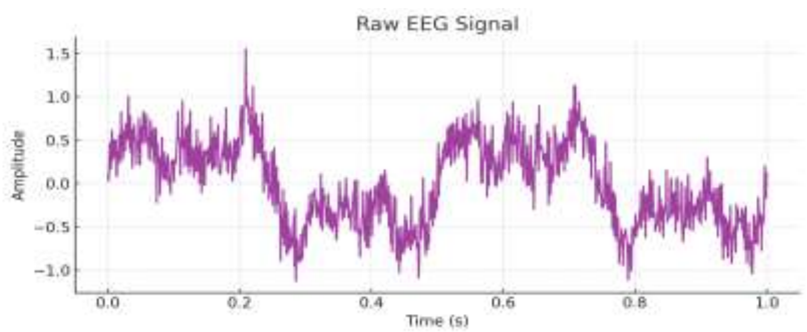

Figure 1: EEG Signal

METHODOLOGY

- **Data Collection:** EEG data from BCI IIIa (C3, Cz, C4) for four MI tasks.
- **Extraction:** Data extracted using MATLAB.
- **Storage:** Saved in Excel for processing.
- **Segmentation:** Applied Zero-Time Windowing
- **Decomposition:** Used VMD to extract frequency modes.
- **Transformation:** Applied STFT for time-frequency analysis.
- **Classification:** Used Vision Transformer (ViT) for MI task classification.

COMPONENTS AND SOFTWARE USED

1.BCI Competition III Dataset IIIa
EEG data with 60 channels for 4 motor imagery tasks (Left Hand, Right Hand, Foot, Tongue).

2.MATLAB
For data extraction and preprocessing from the BCI dataset.

3.Python
For implementing VMD, STFT, and transformer-based classification.

BENEFITS

- High accuracy – Transformer model improves MI classification.
- Better features – VMD and STFT enhance feature extraction.
- Noise reduction – Cleaner signals using ZTW and VMD.
- Efficient processing – Simplifies complex EEG analysis.
- Real-time use – Suitable for BCI and assistive tech applications.

RESULTS

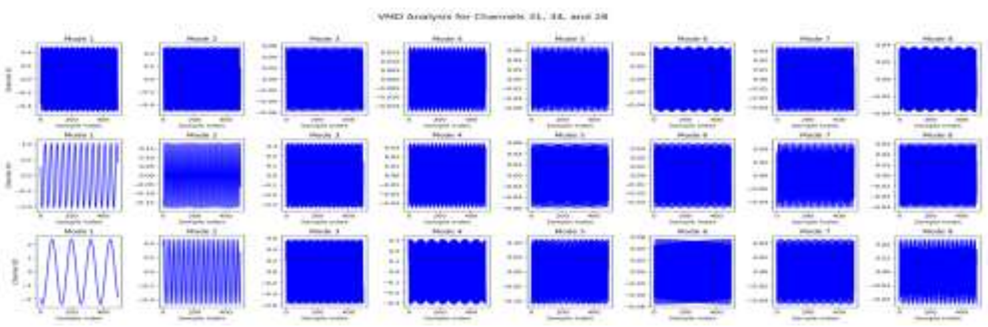

Figure 2: VMD output

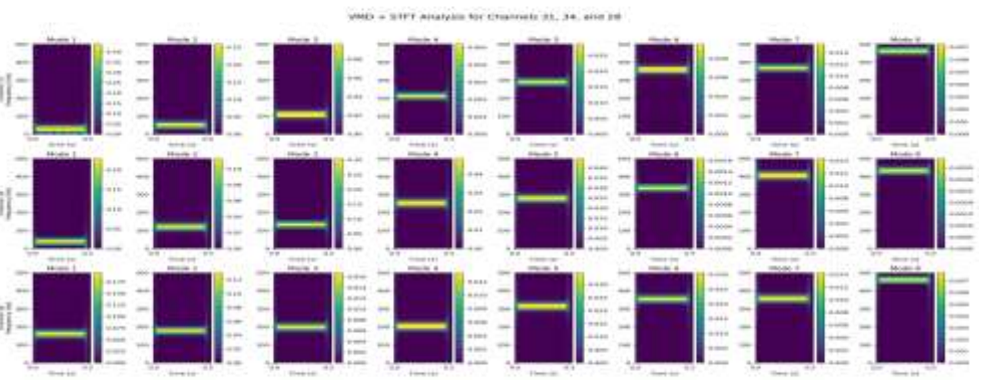

Figure 3:STFT output

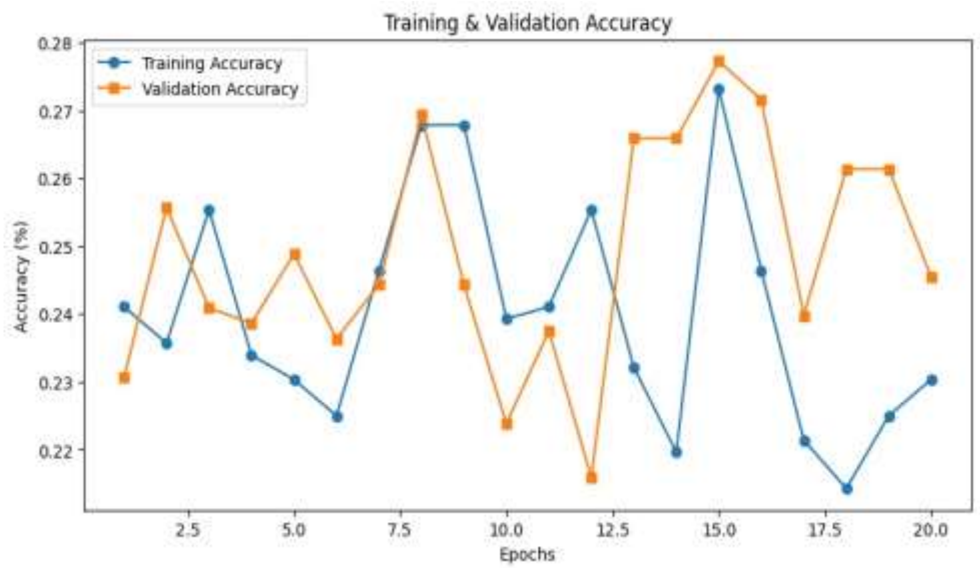

Figure 4:Training accuracy of Transformer model

CONCLUSION

This project successfully demonstrated the classification of motor imagery (MI) tasks from EEG signals using a transformer-based deep learning model. Preprocessing with Zero-Time Windowing, VMD, and STFT enabled effective extraction of time-frequency features. The Vision Transformer (ViT) model enhanced classification accuracy by capturing spatial-temporal patterns in the EEG data. The approach outperformed traditional methods, proving to be robust and efficient for BCI applications. Overall, the project showcases strong potential for real-time use in neurorehabilitation and assistive technologies.

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