TMAnet: An Innovative Approach for Classifying Motor Imagery EEG Signals Related to Motor Movements

Chaoyue Wang, Juan Yang*
School of physics and Electronics, Shandong Normal University

SHANDONG NORMAL UNIVERSITY

ABSTRACT

The Brain-Computer Interface (BCI) system utilizing Motor Imagery (MI) has diverse applications in medical rehabilitation. This study aims to validate the reliability of self-collected data and classify open-source electroencephalogram (EEG) signals. We introduce a temporal convolution network with multihead self-attention (TMAnet), designed for decoding EEG signals. This network combined with a data expansion approach based on cyclic translation strategy, which effectively expands experimental data without losing original information. To enhance the processing of self-collected signals, the EEG signals undergo the application of a spatio-temporal filtering technique and a low-rank approximation for generalized eigenvalue decomposition to effectively eliminate multiple artifacts .

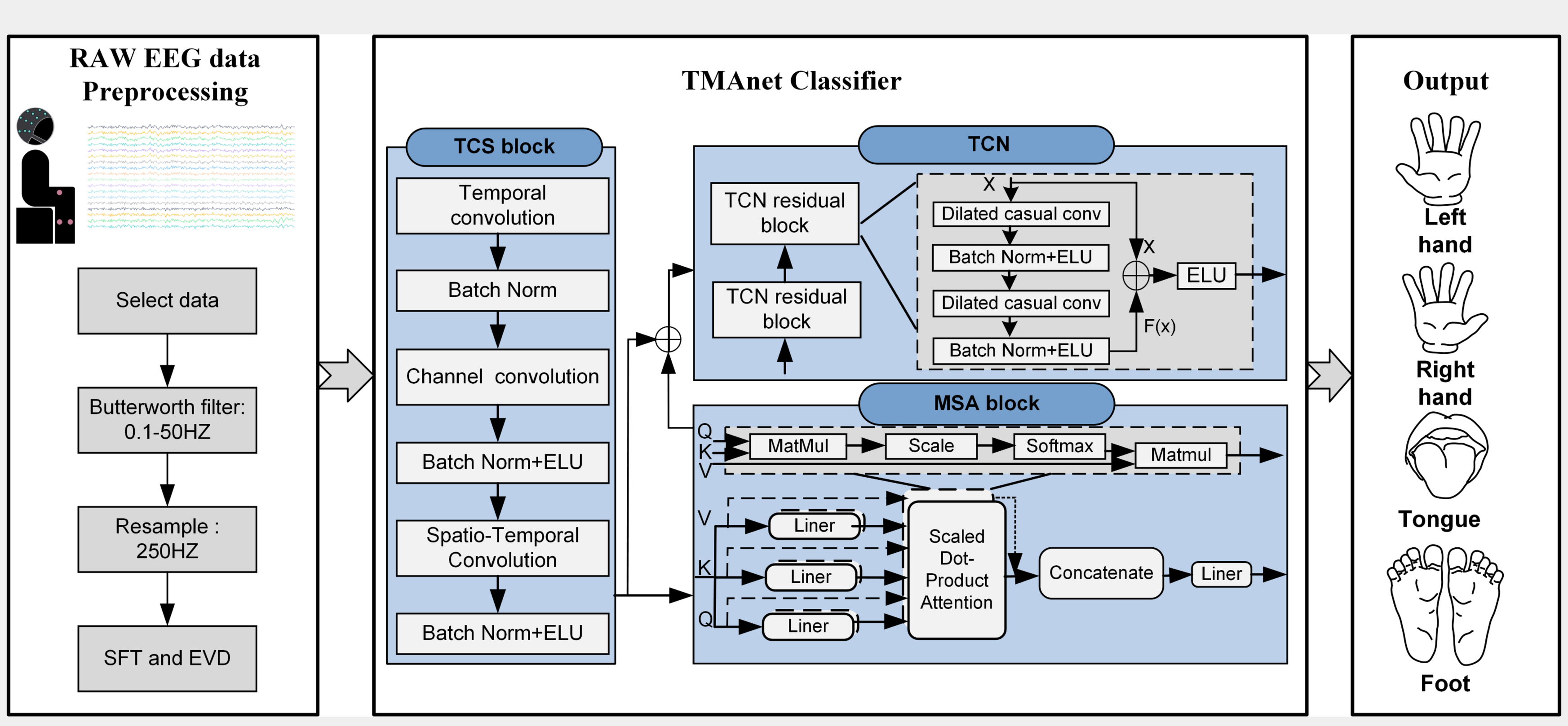
Keywords: Brain-computer interface, motor imagery, Electroencephalogram, data expansion

INTRODUCTION

The Brain-Computer Interface (BCI) is widely used in many industries, such as military, medicine, communication and control. The advancement of this technology primarily relies on the recognition and classification of Motor Imagery (MI) signals. MI based BCI technology is essential for rehabilitating patients with motor disorders like stroke and paralysis, as well as for advancing research in BCI virtual reality devices.

Over the past few years, deep learning has attracted considerable attention for its exceptional performance in computer vision and natural language processing[4]. Consequently, Many researchers have begun to explore how neural networks can be utilized in MI-BCI with excellent results.

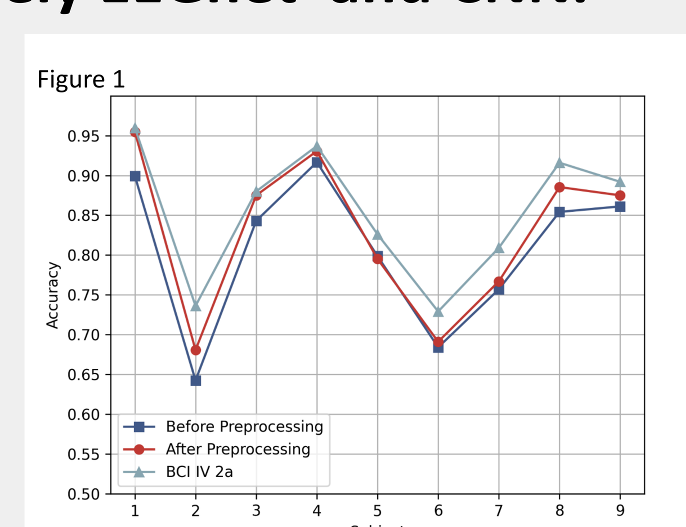
METHOD



In this study, we present a detailed model that produce improved motor imagery categorization results. Firstly, to remove multi-artifacts, we utilize spatio-temporal filtering and eigenvalue decomposition. Secondly, EEG signal is encoded into high level temporal information using convolutional blocks. Multi-head self-attention(MSA) is applied to emphasize critical information in the time-series , followed by a temporal convolutional layer for identifying higher-level temporal features. Additionally, a circular translation strategy is implemented for effective data augmentation.

RESULT

Figure 1 demonstrates the precision of both the BCI IV 2a dataset and the self collected data, both before and after processing. Figure 2 will present a comparative analysis of the performance of TMAnet with that of other reproduced models, namely EEGnet and CNN.



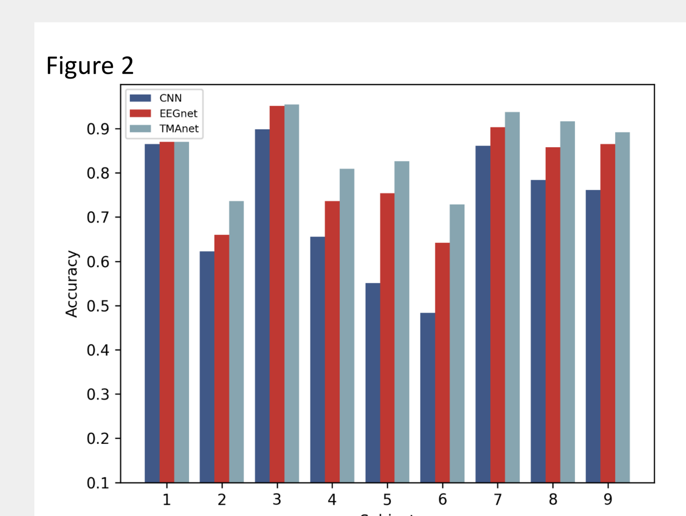
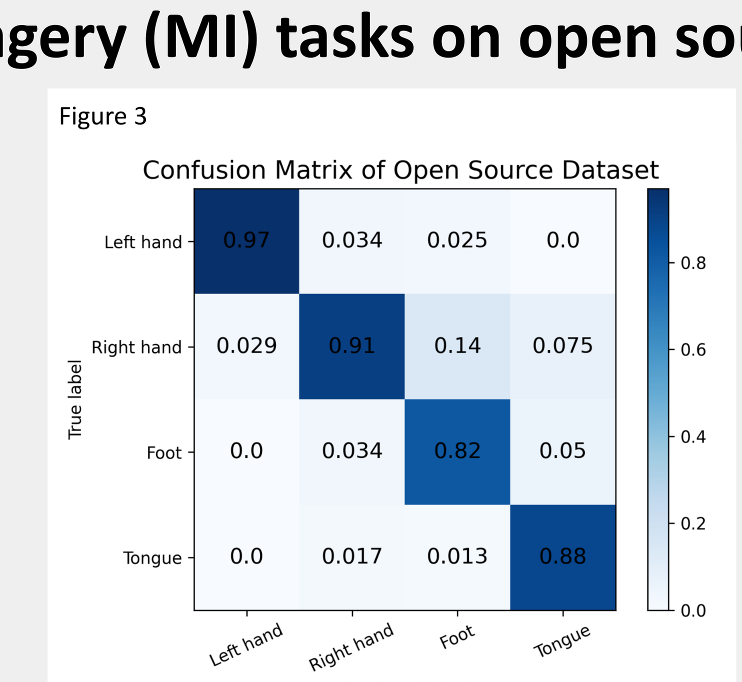
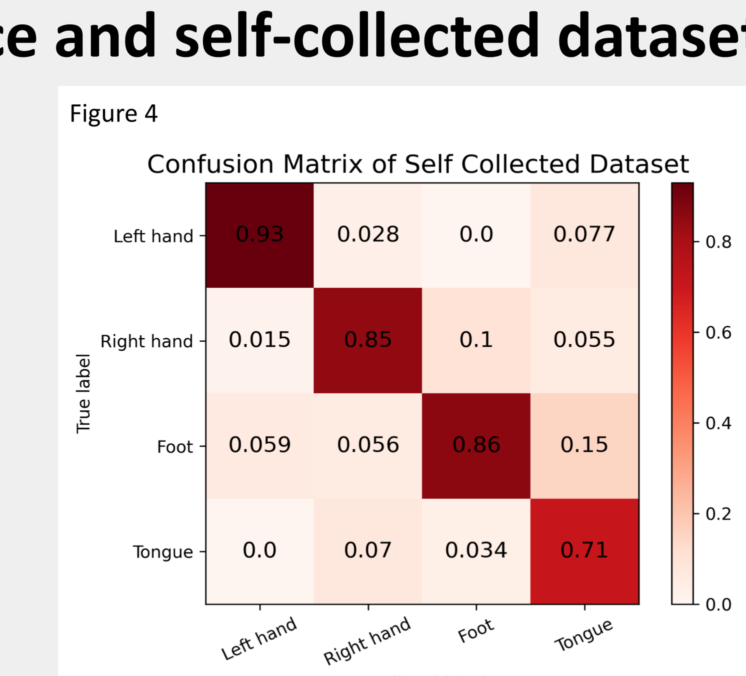


Figure 3 and Figure 4 depict the experimental results, highlighting the performance of the features extracted by the advanced TMAnet model through the survey of the confusion matrices. The results show that when TMAnet is used, there is a significant improvement in accuracy across all four Motor Imagery (MI) tasks on open source and self-collected datasets.





CONCLUSION

This research not only demonstrates the potential effectiveness of multi-head self-attentive temporal convolutional networks in classifying MI-EEG signals, but also extends the dataset of MI-BCI systems and this approach provides a framework for systems that is compatible with existing standards. The findings of this study are expected to stimulate further research in the field of MI-BCI systems, as they have made a significant contribution to the advancement of this area.

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CONTACT
Name: Chaoyue Wang
Organization: Shandong Normal University
Email: wchaoyue2022@163.com