

Individual-to-Individual EEG Conversion Using Swin Transformer

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Abstract

In cognitive and computational neuroscience, the challenge of generalizing EEG-based models across subjects stems from inter-individual variability and low signal-to-noise ratios (SNR). Traditional EEG analysis methods often fail to account for these differences, resulting in models that perform well on training data but poorly on new subjects. To address this, we propose SwinEEG, a novel individual-to-individual EEG conversion framework inspired by the Swin Transformer, a vision transformer known for its hierarchical architecture and self-attention mechanisms. SwinEEG leverages contrastive learning and image reconstruction to map neural representations between subjects by incorporating both image stimuli and source-subject EEG data. Experiments on the THINGS EEG2 dataset demonstrate improved inter-subject neural mapping performance, with an average conversion accuracy increase from 71.2 to 74.3 compared to prior methods. This approach highlights the potential of combining vision-inspired transformers and contrastive learning to mitigate individual differences and noise in EEG signals.

Full Text

Individual-to-Individual EEG Conversion Using Swin Transformer

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Abstract

In cognitive and computational neuroscience, the challenge of generalizing models trained on data from one subject to another arises primarily from the inherent

individual differences in brain activity captured through electroencephalography (EEG) signals. EEG is a non-invasive method for recording brain electrical activity, widely used in applications such as brain-computer interfaces (BCI), cognitive state monitoring, and the diagnosis of neurological disorders. However, the low signal-to-noise ratio (SNR) of EEG signals and inter-subject variability present significant obstacles to developing robust and generalizable models.

Traditional approaches to EEG analysis often neglect individual differences, leading to models that perform well on training data but fail to generalize to new subjects. To address this, researchers have explored various techniques, including linear models [1] and convolutional networks [2], to improve the generalization capability of EEG models. Despite these efforts, they discard the original image information, and converting the EEG signals of one individual to another remains a challenging task due to the noisy nature of the data.

In recent years, image denoising and high-quality image reconstruction have witnessed significant advancements with the introduction of Swin Transformer [3]. This hierarchical vision transformer efficiently handles high-resolution images through a combination of local and global self-attention mechanisms. Inspired by the success of Swin Transformer, we propose a novel approach to EEG signal conversion, leveraging the strengths of contrastive learning and image reconstruction models.

We propose SwinEEG¹, an individual-to-individual EEG converter that considers both image stimuli and the source subject's EEG to learn the neural representation mapping from one subject to another. Through contrastive learning between EEG encoding and image stimulus encoding, the model can simultaneously capture raw image features from EEG, while the EEG generator ensures the quality of the brain signals.

Experiments on the THINGS EEG² dataset [4] demonstrate the effectiveness of SwinEEG in learning inter-subject neural representation mappings, as shown in Fig. 2 [Figure 2: see original paper], where the average conversion performance in the overall setting improves from 71.2 to 74.3 compared to previous methods. The experimental results reflect the potential of SwinEEG in addressing the challenges of individual differences and noise in EEG.

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¹Our code is publicly available at <https://github.com/yerayl/SwinEEG>.

Fig. 1 [Figure 1: see original paper]. An overview of our SwinEEG framework.

Fig. 2. Comparison of the accuracy of our SwinEEG model and the EEG2EEG model [2] under different settings.

References

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Note: Figure translations are in progress. See original paper for figures.

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