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Peer Review

Review of: "STEAM-EEG: Spatiotemporal EEG Analysis with Markov Transfer Fields and Attentive CNNs"

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Short Review

This paper presents a novel and comprehensive approach to EEG signal analysis by combining advanced signal processing techniques, attention-enhanced CNNs, and innovative MTF imaging. The methodology shows promising improvements in classification accuracy over several baseline methods, and the ablation studies provide useful insights into the contributions of each component. However, the paper would benefit from further evaluation on multi-channel and clinically relevant datasets, a deeper discussion on computational feasibility, and clearer explanations of the model's integration and interpretability.

With some refinements addressing the points below, this work has the potential to make a significant contribution to the field of EEG signal analysis and its applications in neuroscience.

Major Comments

1. **Evaluation on Multi-Channel and Clinical Data:**

   While the paper demonstrates strong performance on several EEG datasets from the UCR archive, the experiments primarily focus on single-channel EEG signals. Particularly because their method uses a modified attention mechanism with cross-channel dependencies, this feels a bit unsatisfying. For broader clinical relevance, additional validation on multi-channel and more clinically representative datasets is needed to demonstrate the method's generalizability.

2. **Computational Complexity and Real-Time Feasibility:**

   The proposed framework integrates several advanced techniques (SSA, parallel 1D-CNNs with

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attention, MTF imaging, and 2D ResNet). However, the paper does not provide a detailed analysis of computational cost, inference speed, or memory requirements (e.g., inference latency, memory footprint, training time). This is particularly important for applications such as brain–computer interfaces, where real-time processing is critical.

3. **Integration Rationale and Interpretability:**

   Although the integration of SSA, modified attention mechanisms, and MTF imaging is innovative, the paper could benefit from a deeper discussion on why these specific components were chosen and how each uniquely contributes to performance gains. In addition, while visualizations are provided, more insight into the neurophysiological interpretability of the learned features would strengthen the work.

4. **Clarity of Mathematical Formulations:**

   The paper includes detailed mathematical derivations, but some sections are overly dense and could be clarified. Simplifying the notation or adding intuitive explanations would make the paper more accessible to readers who may not be specialists in every component of the framework.

5. **Dataset Diversity:**

   Although the UCR archive is a well-known resource, it might be useful to also use the method on datasets from a different source to avoid bias.

Minor Suggestions

1. **Code Availability and Reproducibility:**

   The paper mentions that the code is available on GitHub, but a direct link is not provided. Including a precise URL and ensuring the code is well-documented would enhance reproducibility.

2. **Figure Enhancements:**

   Some figures (e.g., the model architecture and feature extraction visualizations) could benefit from more descriptive captions and annotations to aid understanding.

3. **Formatting and Proofreading:**

   A thorough proofreading is recommended to address minor grammatical errors and to ensure consistency in terminology and notation throughout the paper.

4. **Discussion of Hyperparameters:**

   More details on the training process, choice of hyperparameters, and optimization strategies

would help readers better understand how the model was tuned and how robust it is across different settings.

5. **Additional Related Work:**

   Expanding the discussion of recent advances in multi-channel EEG analysis and other deep learning approaches in neuroscience could provide a more balanced context for the proposed method.

Declarations

Potential competing interests: No potential competing interests to declare.