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Peer Review

Review of: "GAF-FusionNet: Multimodal ECG Analysis via Gramian Angular Fields and Split Attention"

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This paper presents GAF-FusionNet, a novel deep learning model for ECG classification that integrates time-series and image-based representations using Gramian Angular Fields (GAF). The dual-branch architecture applies a 1D CNN-BiLSTM for time-series processing and a ResNet-based CNN for image analysis, fusing these representations. The method is validated on the ECG200, ECG5000, and MIT-BIH datasets, achieving state-of-the-art performance.

Strengths

1. Innovative Multilevel Approach: Combines time-domain and image-based features.

2. Custom Attention-Based Fusion: The proposed dual-layer split attention module effectively enhances feature interaction.

3. Extensive Benchmarking: Evaluated on three datasets, with strong improvements over baseline models.

4. Potential for Real-World Impact: The multimodal approach could generalize to other biomedical signal-processing tasks.

Areas for Improvement

1. Clinical Relevance

- The paper could benefit from a more clinically-oriented approach, stating solid goals for classification from the start and focusing on the gaps in literature and technology in accomplishing them.

2. Computational Efficiency and Deployment Feasibility

- The model requires GAF image transformation and a dual-branch deep learning structure, making it

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computationally expensive. A thorough discussion on justifying the employment of this “heavy” module could be added, emphasizing the need for top-notch performance over efficiency, and suggesting appropriate uses.

3. Interpretability and Clinical Utility

- The model is a black box, with no insight into feature importance. Some XAI technique, like saliency mapping, could be applied to enhance interpretability.

4. Handling of Class Imbalance

- No mention of class balancing techniques (e.g., oversampling, weighted loss) for imbalanced arrhythmia types.

Conclusions

The paper is a strong contribution with an innovative multimodal ECG classification approach, achieving state-of-the-art results. However, minor issues in evaluation methodology, computational feasibility, interpretability, and clarity should be addressed. With these revisions, the paper will be better positioned for clinical relevance and broader adoption.

Declarations

Potential competing interests: No potential competing interests to declare.