Adaptive Multi-feature Attention Neural Tree for EEG-based fatigue detection

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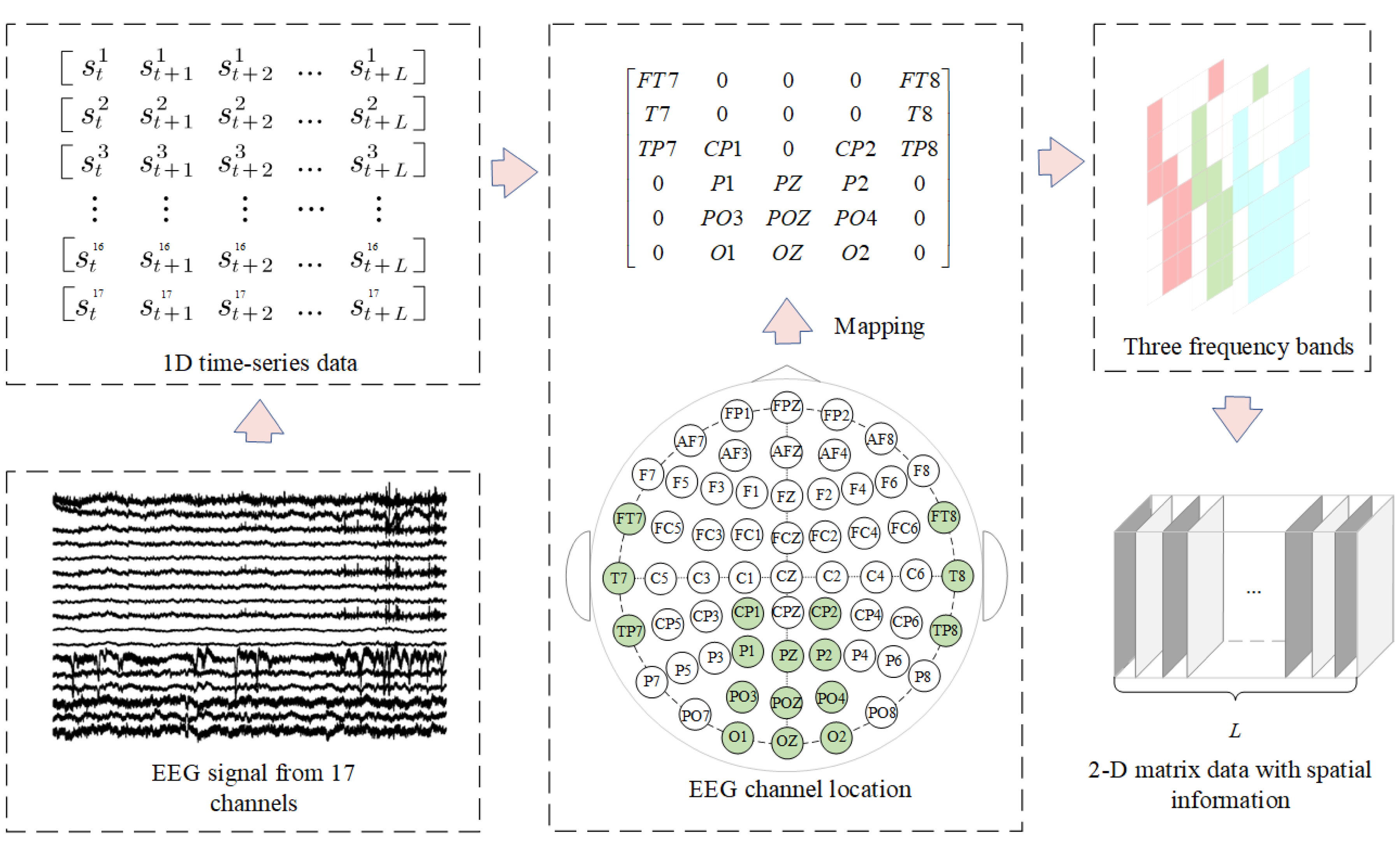
Introduction

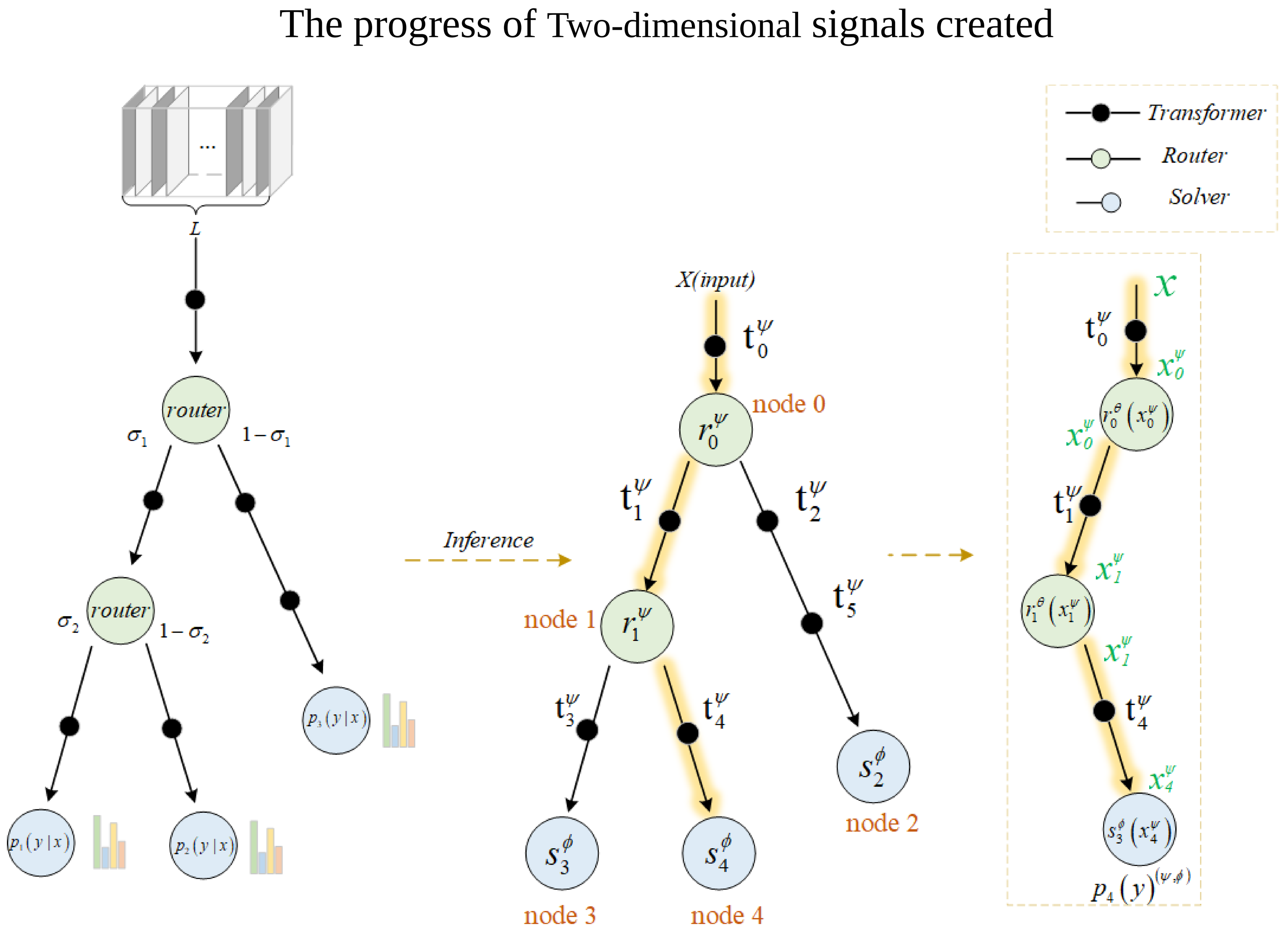
Various methods have been proposed for classifying fatigue signals recently, including subjective and objective detection techniques. However, subjective methods are limited by driver judgment and external factors, while objective methods, though sensor-based, struggle with individual variability. In contrast, physiological signals offer a more reliable and effective means of detecting driver fatigue. EEG is considered the most effective method for identifying driver fatigue due to its direct reflection of brain activity. Fatigue detection approaches using EEG include machine learning (ML) and deep learning (DL) techniques.

Neural networks are characterized by their ability to learn hierarchical representations of data through a series of nonlinear transformation processes, thereby reducing the need for extensive feature engineering. However, they often suffer from poor interpretability. Decision trees (DTs), on the other hand, can learn hierarchical data clusters and use simple models to explain the data within each segmented subset through reasonable partitioning. Both traditional neural networks and deep neural networks have their advantages. The proposed Adaptive Multi-feature Attention Neural Tree (AMANT) leverages the strengths of both neural networks and decision trees. It obviates the need for manual complex feature extraction and offers model interpretability

Methods



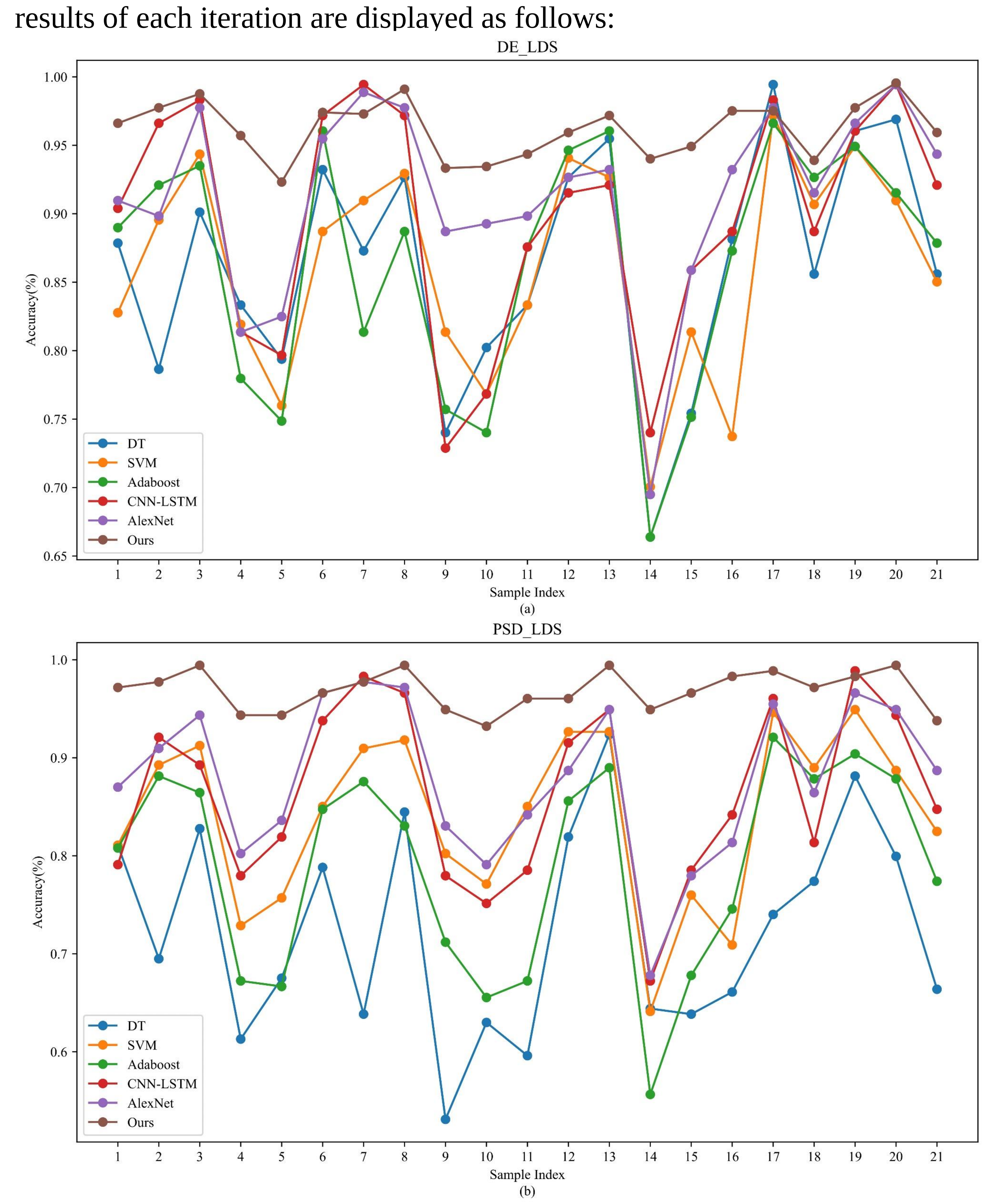
The progress of Two-dimensional signals created



Schematic diagram of AMANT

Results

Our proposed method was compared with DT, SVM, Adaboost, CNN-LSTM, and Alexnet on the dataset SEED-VIG. Each sample underwent 5-fold cross-validation. For the three frequency bands θ, α, β. The average results of each iteration are displayed as follows:



Classification performance of different models employing DE_LDS(a) and PSD_LDS(b)

Conclusions

This paper presents an AMANT-based method for fatigue detection using EEG data. The experimental results demonstrate that the proposed method effectively integrates multiple features, including different frequency bands and spatial information, without necessitating manual feature extraction and selection. This capability facilitates end-to-end fatigue detection from EEG signals, thereby simplifying the task. By integrating neural networks with decision trees, the method achieves good model interpretability without increasing the number of parameters.

The experiments indicate that the proposed method achieves high accuracy levels when extracting frequency features from EEG datasets, reaching 96.38% in differential entropy and 96.85% in power spectral density, demonstrating robust performance. Moreover, the results are statistically significant.

Acknowledgment

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