EEG-based user identification system using 1D-convolutional long short-term memory neural networks

Data Collection and Preprocessing:

- Used the Physionet EEG Motor Movement/Imagery Dataset (Goldberger et al., 2000) with recordings from 109 subjects performing motor and imagery tasks, collected via the BCI2000 system (Schalk et al., 2004) at 160 Hz with 64 channels. Each subject completed 14 experimental runs, including 1-minute eye open/close and three motor/imagery tasks.
- Segmentation: Split EEG signals into 1-second segments (160 samples × 64 channels).
- Normalization: Scaled signals for consistency across channels.
- Dataset Split: Divided data into balanced training and testing sets.

Analysis:

- Explored and implemented a 1D-Convolutional LSTM network for EEG-based subject identification.
- Investigated its suitability by analyzing spatial and temporal feature extraction capabilities, focusing on convolutional layers, LSTM layers, and fully connected layers.
- Examined architectural components, including kernel configurations, activation functions, and temporal modeling mechanisms, to evaluate their impact on classification performance.

Implementation and Enhancements:

- Developed a CNN+LSTM model for EEG biometric identification using TensorFlow/Keras. The model includes 4 Conv1D layers (128-1024 filters) for feature extraction, 2 LSTM layers (192 units) for temporal modeling, and fully connected layers with a softmax output for classification.
- Trained on 1-second EEG segments with 50% dropout for regularization. Fine-tuned LSTM size and dropout rate for optimization.
- Implemented Wavelet Transform and EMD for feature extraction, and extended the model with CNN and LSTM with wavelet transform as standalone models.

Team Member Contributions

Team Member 1: Abhishek Singh Kushwaha

- Conducted **data collection and preprocessing**, including segmentation and normalization of EEG signals.
- Explored the **Physionet EEG dataset** for insights into spatial information and task-specific variations.
- Designed and implemented the **CNN+LSTM model** architecture for EEG-based user authentication.
- Assisted in model evaluation by analyzing performance metrics like accuracy
- Contributed to the **writing and formatting** of the final report.

Team Member 2: Akhilesh Singh Kushwaha

- Implemented advanced feature extraction techniques, including **Wavelet Transform** and **EMD**.
- Designed and trained **CNN with wavelet transform** and **LSTM with wavelet transform** as standalone models.
- Fine-tuned hyperparameters for optimal performance of the CNN+LSTM model.
- Analyzed and visualized experimental results for the proposed models.
- Provided support in interpreting results and their implications.
- Contributed significantly to the **writing and formatting** of the report.