sEMG-Based Action Classification Using Machine Learning and Deep Learning Models

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Abstract:-

We analyze surface EMG signals for multi-class human action classification using machine learning and deep learning architectures. Extending a recent IEEE Access paper that employed traditional machine learning models, we implemented and compared advanced neural models including MLP, 2D CNN, RNN, LSTM, and Transformer across various feature sets. The Transformer and LSTM models outperformed conventional classifiers, validating their ability to capture sequential dependencies in biomedical signals.

Problem Definition and Motivation:-

- Classifying human activities using sEMG is crucial for applications in rehabilitation, prosthetic control, and human-computer interaction (HCI).
- Prior methods relied on handcrafted features and shallow models, which often failed to capture complex temporal dependencies in EMG signals.
- Our objective is to assess whether deep learning models can learn discriminative patterns from preprocessed sEMG signals and outperform traditional classifiers.

Prior Work:-

- The base paper *"Machine Learning and Signal Processing Based Analysis of sEMG Signals for Daily Action Classification"* focused on feature-based classification.
- Traditional classifiers such as SVM and k-NN were used for model training.
- We adopted a similar preprocessing pipeline for fair comparison.
- Our work extends model variety and dataset settings to enable deeper experimental analysis.

Progress:-

- Used a custom EMG dataset containing 7 gesture classes.
- Preprocessed signals and segmented them into 80-dimensional time windows.
- Extracted time-domain features including RMS, MAV, WAMP, and ZC.
- Implemented and evaluated multiple models: LogReg, RF, SVM, KNN, MLP, 2D CNN, LSTM, and Transformer.

Summary of Contributions and Novelty:-

- Implemented deep models (MLP, CNN, LSTM, Transformer) for EMG classification.
- Benchmarked against classical ML models under identical conditions.
- Conducted feature-wise comparisons to evaluate model sensitivity.
- Demonstrated superior performance of deep models on biomedical signals.

Experiments and Results:-

Transformer and LSTM achieved the highest accuracies across all feature combinations, outperforming SVM and KNN from the base paper. Transformer peaked at 98.89% accuracy.

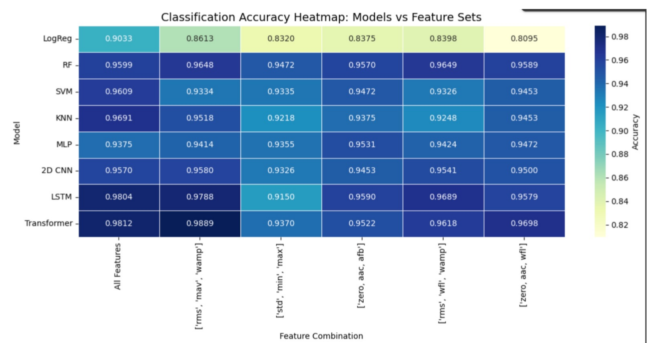

Figure 1: Figure 1: Accuracy heatmap: Models vs Feature Combinations

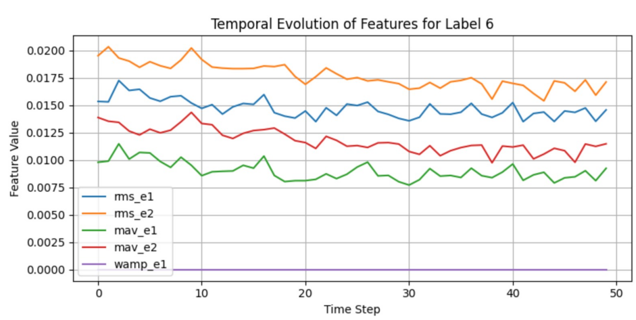

Figure 2: Figure 2: Temporal evolution of selected EMG features for Label 6

Responsibility of Individual Members:-

Ankita Meena: Data preprocessing, feature extraction, SVM/kNN baselines, reporting.

Anatap Mitra: Deep model implementation, experimentation, heatmap generation, result analysis.

References

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