Pre-Proposal: CSCI 566 - Deep Learning Project

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Title: Benchmarking and Analysis of Deep Learning methods to classify EEG Motor Movement / Imagery signals

Introduction

The electroencephalogram (EEG) represents the brain's electrical activity commonly employed in clinical and research contexts. Analyzing EEG data to classify various brain signal processes, such as motor movements or imagery, is a difficult but essential challenge for advances in neurotechnology and brain-computer interfaces (BCIs). EEG data's complexity is defined by its high dimensionality, non-stationarity, and susceptibility to noise, which requires creation of robust and efficient deep learning models.

Objective

This study will compare and benchmark the performance of several deep learning methods for classifying EEG signals for Motor Movement and Imagery while also testing new methods and options to optimize. The study will also analyze the effects of data manipulation techniques like noise, limiting labels, and other changes to better understand each model's robustness and adaptability. The research aims to offer insights to optimize EEG data classification using various deep learning techniques.

Potential Solution

The project will study a variety of deep learning methodologies, including:

- Convolutional Neural Networks (CNNs): Due to their success in image and signal processing, CNNs will be tailored to the temporal-spatial structure of EEG data in order to find patterns linked with various motor actions or imagery.

- LSTMs: These networks will capture the temporal dynamics of EEG signals, which are critical for successful categorization. We could also use Conv-LSTM models that would use CNNs for feature extraction fed to LSTM

- Triplet Loss Embedding: A method for learning an effective embedding for EEG signals that use a triplet loss function to provide embeddings that could improve the separability of distinct classes in the feature space.

- Stacked Autoencoders: These will be used to extract a compact and representative feature set from EEG data, potentially enhancing classification accuracy despite little labeled data.

Expected Outcomes

The project is expected to yield the following outcomes:

- A comprehensive comparison of different deep learning methods' efficacy in EEG data classification for Motor Movement / Imagery signals.

- Insights into the optimal representations and embeddings for EEG signals that enhance model performance.

- Recommendations for model architectures and training strategies tailored to EEG data characteristics and potential optimization techniques for similar tasks.

- A better understanding of how different types of noise and data limitations impact different models' accuracy and robustness.

Timeline

1. Weeks 1-2: Literature review, dataset familiarization, and setup of development environment.

2. Weeks 3-4: Implementation and initial testing of baseline models.

3. Weeks 5-6: Development and optimizations of models

4. Weeks 7-8: Initial benchmarking and performance evaluation.

5. Weeks 9-10: Final benchmarking, analysis of results, and preparation of the final report.

Conclusion

This project aims to provide potential applications and optimization techniques for EEG signal analysis which can be integrated with BCIs. By benchmarking a variety of models and techniques, it seeks to provide valuable insights into the most effective strategies for EEG classification and other neurotechnological applications.

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