Neural Network Assignment

PREDICTION OF DEPRESSION FROM EEG SIGNAL USING LONG SHORT TERM MEMORY (LSTM)

Department of Computer Science and Engineering

Assignment Name: CSE 443

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Section: 2

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1) Introduction

The prevalence of depression, a significant mental disability impacting social well-being, necessitates accurate diagnosis. Presently, diagnosis relies on detailed evaluations of reported symptoms, events, and occurrences. Depression affects millions globally and is projected to become a leading cause of disability. Its origins are multifaceted, stemming from genetics, neurotransmitter changes, environmental factors, and more. Common symptoms include appetite loss, weight changes, headaches, and palpitations.

Electroencephalography (EEG), a non-invasive method, records brain electrical activity, reflecting neurological conditions. EEG waveforms distinguish healthy from abnormal brain activity. Analyzing EEG waveforms aids in computerized depression diagnosis, facilitating effective treatment. Extracted EEG features contain valuable hidden information. Various feature extraction methods, including time domain metrics and nonlinear characteristics, identify abnormalities.

Computer-aided diagnosis evolution has transformed abnormality prediction. Machine learning, like LSTM (Long Short-Term Memory), an advanced Recurrent Neural Network (RNN), offers automated learning. LSTM effectively handles extensive datasets, mitigating long-term dependency issues. Limited studies have applied LSTM to EEG analysis. LSTM has predicted epileptic seizures, classified motor-imagery EEG, recognized emotions, and even forecasted neonatal EEG signals. LSTM's capacity for accurate prediction of abnormalities, particularly in large datasets, underscores its significance in EEG-based depression prediction.

2) Problem Statement

Key Aspects of the Problem Down Below:

- **Diagnostic Accuracy Enhancement:** The central focus is on improving the accuracy of depression diagnosis by utilizing EEG data. The LSTM model aims to provide a more objective and reliable means of identifying depression-related patterns.
- **Temporal Pattern Recognition:** The challenge involves designing an algorithm that can effectively recognize intricate temporal patterns within EEG signals indicative of

depression. LSTM networks excel at capturing such temporal dependencies, making them well-suited for this task.

- **Complex Data Analysis:** EEG data is multidimensional and dynamic, posing difficulties in preprocessing, feature extraction, and modeling. The study aims to extract relevant features and develop an effective computational framework.
- **Generalization and Clinical Applicability:** The developed model should generalize to unseen EEG data and be practically applicable in clinical settings, aiding healthcare professionals in diagnosis and decision-making.
- **Ethical Considerations:** Given the sensitive nature of mental health data, ethical concerns regarding data privacy, informed consent, and responsible use of the model's predictions are integral to the research.

3) Related Works

The related works mentioned collectively underscore the increasing interest in employing Long Short-Term Memory (LSTM) networks and deep learning methodologies for the prediction of depression using EEG signals. These studies explore a diverse range of applications and approaches while accentuating the critical role of accurate classification, effective feature extraction, and model optimization in achieving dependable depression detection outcomes through advanced machine learning techniques. Noteworthy highlights from these related works include:

- **Exploration of Deep Learning:** Various authors investigate the potential of deep learning, particularly LSTM networks, to predict depression from EEG signals. This approach is demonstrated as versatile and effective for capturing the intricate temporal dynamics associated with depression.
- **Cross-Domain Applications**: The adaptability of LSTM networks is highlighted by studies that predict depression not only in EEG data but also in other domains, such as Parkinson's disease patients. This demonstrates the potential for applying similar methodologies to different neurological disorders.
- **Feature Extraction and Optimization:** The significance of feature extraction techniques and model optimization is emphasized in achieving accurate predictions.

Researchers employ different strategies to extract meaningful information from EEG signals and fine-tune models for improved performance.

- **Comparative Analyses:** Several studies conduct comparative analyses of different machine learning models, showcasing LSTM networks' superiority in depression detection. These analyses underscore the potential advantages of leveraging deep learning for this specific application.
- **Emotion Recognition Insights:** While not directly related to depression, the survey on EEG-based emotion recognition provides valuable insights into the potential adaptation of LSTM networks for predicting depression from EEG signals. This highlights the interconnectedness of research areas within EEG data analysis.

4) Objectives and Contribution

This research aims to predict depression trends using EEG data through Long Short Term Memory (LSTM) neural networks. Key contributions include the application of LSTM for depression prediction, the use of statistical mean features from EEG data, rigorous model evaluation resulting in accurate predictions (RMSE 0.000064), and demonstrating LSTM's superiority over alternative models like CNN-LSTM and ConvLSTM. This work offers insights into mental health diagnostics and showcases LSTM's effectiveness in forecasting depression trends.

5) Flowchart of methodology with proper description

The research utilizes EEG data from depression patients and employs Long Short Term Memory (LSTM) neural networks for prediction. EEG data is collected from the Psychiatry department, and LSTM is chosen due to its effectiveness in predicting time series data. LSTM cells with "Keep" gates are used to retain relevant information.

Time domain features, specifically the mean of EEG data, are extracted and divided into training (80%) and testing (20%) sets. A one-layer LSTM model with 10 hidden neurons and dropout is constructed, followed by dense output. The model is trained on 5600 data points over 100 epochs, using RMSE as the loss function.

The LSTM model accurately predicts the next 1400 mean data points, with an RMSE of 0.000064. In comparison, it outperforms CNN-LSTM and ConvLSTM models in predicting depression trends based on RMSE values. The study concludes that the LSTM model is effective for depression prediction from EEG signals.

6) Algorithm analysis

The research collects EEG data to study depression trends, focusing on the statistical mean from EEG signals. The data is split into training (80%) and testing (20%) portions. An LSTM neural network is trained on the larger dataset to learn patterns in EEG data.

Then, the LSTM model predicts future trends using the smaller dataset. Model accuracy is assessed with Root Mean Square Error (RMSE). The research also compares LSTM with other models (CNN-LSTM, ConvLSTM) to find the most effective predictor for depression trends. In essence, the study uses LSTM to analyze EEG data for depression prediction, comparing its performance with alternative models.

7) Evaluation

In this segment, the study presents an LSTM predictor show with one LSTM layer containing 10 hidden neurons. The model's evaluation centers on its prescient capability utilizing 7000 mean information points from EEG signals of sadness patients. The preparing set comprises of 5600 points, and testing is performed on 1400 points. After 100 training ages, the show accomplishes an astonishingly low RMSE mistake of 0.000064. This preparing envelops different datasets from both left and right brain districts beneath distinctive eye conditions.

Figures 3 to 6 outwardly portray the LSTM model's exact forecasts over different datasets, fortifying its reliability in estimating 1400 information points.

Comparatively, the think about assesses the proposed LSTM demonstrate against CNN-LSTM and ConvLSTM utilizing RMSE calculations. All models are prepared and surveyed utilizing EEG include implies from understanding records over 30 emphasess. Figures 7 to 9 display box and bristle plots exhibiting the RMSE variety and midpoints for each demonstrate. The discoveries clearly set up the essential LSTM model's superior execution, situating it as a strong choice for anticipating depression patterns from EEG signals.

8) Conclusion and Future Work

In substance, this study builds up that the LSTM show is capable at successfully determining future occasions of depression patterns when utilizing EEG-derived measurable mean values. The investigate illustrates that LSTM beats CNN-LSTM and ConvLSTM models in terms of prescient capability, making it a more dependable choice for foreseeing up and coming designs in depression-related EEG signals.