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# Deep Learning System for Social Anxiety Disorder Assessment

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**ABSTRACT:** Neuroimaging investigations have proven that social anxiety disorder (SAD) is associated with aberrations in the connectivity of human brain functions. The assessment of the effective connectivity (EC) of the brain and its impact on the detection and medication of neurodegenerative pathophysiology is hence a crucial concern that needs to be addressed. Therefore, investigating neural connectivity biomarkers of SAD based onDLmodels has a promising approach with its recent underlined potential results. In this study, an electroencephalography (EEG)-based detection model for SAD is constructed through directed causal influences combined with a deepCNNand the LSTM. The EEG data were classified by applying three different DL models, namely, CNN, LSTM, and CNN + LSTM to discriminate the severity of SAD (severe, moderate, mild) and healthy controls (HC) at different frequency bands (delta, theta, alpha, low beta, and high beta) in the DMNunder resting-state condition. The DL model uses the EC features as input, which are derived from the cortical correlation within different EEG rhythms for certain cortical areas that are more susceptible to SAD.

**KEYWORDS :** Effective connectivity network, convolutional neural networks (CNNs), social anxiety disorder (SAD), default mode network (DMN), deep learning models, partial directed coherence (PDC), electroencephalogram (EEG), human brain mapping.

#### I. INTRODUCTION

Social Anxiety Disorder (SAD) is a common, debilitating mental health condition characterized by intense fear and anxiety in social situations. This study investigates the potential of electroencephalography (EEG)-based deep learning (DL) models to detect and classify SAD based on effective connectivity (EC) data. Specifically, it aims to explore whether EC patterns in different brain regions, processed through deep learning models, can serve as reliable biomarkers for SAD and assist in determining its severity.

#### MOTIVATION

Despite the prevalence and impact of SAD, its diagnosis largely relies on subjective assessments, which may be inaccurate or inconsistent. Current objective measures, such as heart rate or skin conductance, lack specificity, and traditional imaging techniques like fMRI are costly and temporally limited. This study seeks to fill this gap by using EEG—a non-invasive, affordable, and high-temporal-resolution method—to provide an objective measure for SAD detection and severity assessment. Incorporating DL models can reveal intricate patterns within EEG data that traditional models cannot capture, offering a more precise tool for SAD diagnosis.

#### **II. LITERATURE SURVEY**

#### Author : A. Al-Ezzi, N. Kamel, I. Faye, and E. Gunaseli(2021)

This study reviews electroencephalographic (EEG) biomarkers in Social Anxiety Disorder (SAD) and proposes integrating EEG with fMRI and MEG to improve treatment selection and understanding of SAD's neuronal endophenotypes.



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#### Author :G. Zhang, V. Davoodnia, A. Sepas-Moghaddam, Y. Zhang, and A. Etemad(2020)

This paper presents a novel LSTM-based method with attention for classifying left/right hand movements from EEG signals, achieving superior results compared to existing methods and analyzing brain activation patterns.

#### Author : A. Al-Ezzi, N. Kamel, I. Faye, and E. Gunaseli(2020)

This study investigates brain connectivity changes in the default mode network related to Social Anxiety Disorder (SAD) using EEG, finding increased causal interactions in mild and moderate SAD compared to severe SAD and healthy controls, with implications for identifying neural biomarkers and treatment targets.

#### Author : A. Al-Ezzi, N. Kamel, I. Faye, and E. G. M. Ebenezer(2020)

This study validates that theta-beta ratio (THBR) and frontal midline theta (FMT) activity in EEG can serve as neurobiological markers to differentiate between state and trait social anxiety in individuals with Social Anxiety Disorder (SAD) compared to healthy controls.

## Author : R. T. Toll, W. Wu, S. Naparstek, Y. Zhang, M. Narayan, B. Patenaude, C. De Los Angeles, K. Sarhadi, N. Anicetti, P. Longwell, and E. Shpigel(2020)

The study validates a connectivity method in healthy controls and then examines resting EEG in veterans with and without PTSD to analyze dysconnectivity and its relationship with clinical features and cognitive performance.

#### **III. PROPOSED SYSTEM**



FIGURE 2. Block diagram for the EEG data analysis module to identify the parameters of the EC network and application of deep

#### Figure 1. System Architecture

This image is a block diagram illustrating an EEG (Electroencephalography) data analysis module to identify parameters of the Effective Connectivity (EC) network and apply deep learning models. Here's a detailed description of each step:

1. Data Collection: EEG data is collected using an array of electrodes placed on the scalp, capturing brain electrical activity.

2. Pre-processing: The raw EEG data undergoes various preprocessing steps, such as filtering and artifact removal, to clean the data for further analysis.

3. Source Reconstruction: This step involves mapping EEG signals to their potential sources within the brain, often using algorithms to estimate where the signals originate within the brain's structure.

4. Computation of PDC Matrices in 5 Frequency Bands: Partial Directed Coherence (PDC) matrices are computed for the EEG data across five different frequency bands. PDC is a measure used to assess directional influence or connectivity between brain regions.



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5. Statistical Analysis: Statistical tests or analyses are performed on the PDC matrices to identify significant patterns or correlations within the data.

6. Selection of 9 Most Influential POC of DMN: From the statistical analysis, the most influential Points of Connectivity (POC) within the Default Mode Network (DMN) are selected. These points are critical in understanding brain connectivity.

7. Training & Testing of DL Models: Different deep learning (DL) models, such as LSTM (Long Short-Term Memory), CNN (Convolutional Neural Networks), and combinations like CNN-LSTM, are trained and tested on the selected features to classify or predict brain states based on the EEG data.

8. Performance Evaluation: Finally, the performance of these deep learning models is evaluated based on various metrics like Sensitivity, Specificity, Precision, and Accuracy.

#### **IV. CONCLUSION**

In conclusion, this study demonstrates that EEG-based effective connectivity (EC) in the default mode network (DMN) can serve as a valuable biomarker for diagnosing and assessing the severity of Social Anxiety Disorder (SAD). The CNN + LSTM model outperformed other deep learning approaches, effectively classifying SAD severity by focusing on key DMN regions. These findings highlight the potential of deep learning and EC analysis in improving SAD diagnosis and monitoring, providing a promising foundation for future clinical applications.

Future work will focus on expanding the dataset to include larger and more diverse samples, improving the model's generalizability. Additional studies should also explore distinguishing SAD from other anxiety disorders to increase diagnostic specificity. Developing the model for real-time monitoring could support continuous, personalized SAD management. Combining EEG data with other biomarkers, such as heart rate and electrodermal response, may further enhance diagnostic accuracy. Lastly, clinical validation is essential to adapt the model for practical use, making it a reliable tool for diagnosing and monitoring SAD in healthcare settings.

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