ISSN 2277-2685
IJESR/April-June. 2025/ Vol-15/Issue-2s/645-654
Julakanti Akshara *et. al.*, / International Journal of Engineering & Science Research

Early Detection Of Stress And Anxiety Based Seizures In Position Data Augmented EEG Signal Using Hybrid Deep Learning Algorithms

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ABSTRACT
Epilepsy is a neurological problem due to aberrant brain activity. Epilepsy diagnose through Electroencephalography (EEG) signal. Human interpretation and analysis of EEG signal for earlier detection of epilepsy is subjected to error. Detection of Epileptic seizures due to stress and anxiety is the major problem. Epileptic seizure signal size, and shape changes from person to person based on their stress and anxiety level. Stress and anxiety based epileptic seizure signals vary in amplitude, width, combination of width and amplitude. In this paper, seizures of different size and shape are synthesized using data augmentation for different stress and anxiety level. Different augmentation such as (i) position data augmentation (PDA) (ii) random data augmentation (RDA) applied to BONN EEG dataset for synthetizations of stress and anxiety based epileptic seizure signals. Augment EEG epileptic seizure signals are analyzed using proposed methods such as i) FCM-PSO-LSTM and ii) PSO-LSTM for earlier detection of stress and anxiety-based seizures. The proposed algorithms perform better in earlier detection of stress and anxiety-based seizure signals. The predicted accuracy of proposed methods such as (i) FCM-PSO-LSTM and (ii) PSO-LSTM is about (i)98.5% and (ii) 97% for PDA and RDA is about (i) 98% and (ii) 98.5% for BONN. The accuracy of proposed methods such as(i) FCM-PSO-LSTM and (ii) PSO-LSTM is about (i) 98% and (ii) 97.5% for PDA and RDA is about (i) 97.5% and (ii) 98% respectively for CHB-MIT.

Keywords: Data augmentation, EEG, epileptic seizure signal, feature extraction, FCM-PSO- LSTM classifier.

1-INTRODUCTION

Early detection of stress and anxiety-induced seizures is crucial for timely medical intervention and improving patient outcomes. Epilepsy is a neurological disorder characterized by recurring seizures, often diagnosed using EEG signals. Stress and anxiety can significantly impact the occurrence and variability of seizure patterns, making accurate detection more challenging. Electroencephalography (EEG) signals, which capture the brain's electrical activity, are commonly used to monitor neurological conditions.

Epilepsy, a neurological disorder affecting millions worldwide, is often diagnosed and monitored through Electroencephalography (EEG) signals. While EEG is an effective tool for detecting abnormal brain activity, seizures triggered by stress and anxiety pose a significant challenge due to the variability in seizure patterns. Conventional methods for analyzing EEG signals struggle to capture the impact of these emotional factors, leading to inconsistent detection rates. Early and accurate identification of stress-induced seizures remains a critical need for effective patient care.

To address this challenge, this project introduces a novel approach by utilizing data augmentation techniques such as Position Data Augmentation (PDA) and Random Data Augmentation (RDA) to synthesize EEG signals that reflect stress and anxiety-induced seizure patterns. By modifying the amplitude, width, and position of EEG signals, these methods create a more comprehensive dataset that better represents the real-world variability in seizure activity. This augmented data is used to train hybrid deep learning models that can more accurately detect stress-triggered seizures.

However, conventional EEG signal analysis often lacks robustness and accuracy in detecting seizures linked to psychological stress and anxiety. This paper proposes a hybrid deep learning method that combines EEG signals and position data toenhance early detection of stress and anxiety-related seizures. The integration of position data helps capture the body's physical response to psychological triggers, while hybrid deep learning algorithms improve the precision and robustness of detection.

2-LITERATURE SURVEY

[1] I. Cano-López, V. Hidalgo, K. G. Hampel, M. Garcés, A. Salvador, E. González-Bono, and V. Villanueva, ''Cortisol and trait anxiety as relevant factors involved in memory performance in people with drug resistant epilepsy,'' Epilepsy Behav., vol. 92, pp. 125–134, Mar. 2019, doi: 10.1016/j.yebeh.2018.12.022.

In the study by Cano-López, Hidalgo, Hampel, Garcés, Salvador, González-Bono, and Villanueva (2019), the researchers explored the role of cortisol levels and trait anxiety in memory performance in individuals with drug-resistant epilepsy. The study involved 52 adult patients who underwent neuropsychological evaluations and provided nine saliva samples throughout the day to assess the hypothalamic-pituitary-adrenal axis function. By calculating the cortisol area under the curve (AUC), the study measured global cortisol changes to examine their relationship with memory, epilepsy-related factors, anxiety, and depression.

The findings revealed that patients with lower memory performance, especially those with left-hemisphere (LH) epilepsy focus, exhibited higher cortisol levels and a slower decline of cortisol in the afternoon. Higher cortisol AUC and elevated trait anxiety were significant predictors of poor memory performance, particularly in those with an LH focus. The results suggest that chronic stress, reflected in higher cortisol exposure, may contribute to memory deficits in drug-resistant epilepsy patients, and trait anxiety may increase stress vulnerability. The study involved adult patients who underwent neuropsychological evaluations

[2] B. Novakova, P. R. Harris, A. Ponnusamy, and M. Reuber, ''The role of stress as a trigger for epileptic seizures: A narrative review of evidence from human and animal studies,'' Epilepsia, vol. 54, no. 11, pp. 1866–1876, Nov. 2013, doi: 10.1111/epi.12377.

Novakova, Harris, Ponnusamy, and Reuber (2013) conducted a narrative review to investigate the role of stress as a trigger for epileptic seizures in patients with existing epilepsy. The review highlights that stress is frequently identified by patients as a common seizure trigger, though most previous studies have focused on the role of stress in the onset of epilepsy rather than in its exacerbation. The evidence from human studies remains inconclusive, with retrospective self-reports frequently associating stress with seizures, but prospective studies yielding mixed results. Life events have been found to trigger seizures in only a subset of individuals, and while limited evidence suggests autonomic arousal may precede seizures, the overall link between stress and seizures in most patients remains weak.

Animal studies provide more compelling evidence, showing that repeated exposure to stress mediators can increase epileptic activity and trigger seizures. Additionally, non-pharmacologic interventions aimed at improving stress coping mechanisms have helped reduce seizures in some individuals. The authors conclude that stress likely plays a role in exacerbating seizure susceptibility for a subgroup of epilepsy patients. However, the majority of individuals with epilepsy do not show a strong,direct link between stress and seizure activity. Further research is recommended to explore the subjective perception of stress and individual differences in vulnerability to stress in epilepsy, as this could lead to more effective interventions to manage seizures and improve the quality of life for those affected.

[3] J. S. van Campen, F. E. Jansen, M. A. Pet, W. M. Otte, M. H. J. Hillegers, M. Joels, and K. P. J. Braun, ‘‘Relation between stress-precipitated seizures and the stress response in childhood epilepsy,’’ Brain, vol. 138, no. 8, pp. 2234–2248, Aug. 2015, doi: 10.1093/brain/awv157.

In the study by van Campen, Jansen, Pet, Otte, Hillegers, Joels, and Braun (2015), the researchers explored the relationship between stress-precipitated seizures and the body's stress response in children with epilepsy. The study included 64 children with epilepsy and 40 healthy controls, assessing stress sensitivity through both retrospective questionnaires and a prospective 6-week diary on stress and seizure occurrence. Nearly half (49%) of the children with epilepsy reported that acute stress triggered seizures, and diary analysis showed a positive association between stress and seizures in 62% of the children who experienced a seizure during the study period. The Trier Social Stress Test for Children revealed that children with stress-sensitive seizures exhibited a blunted cortisol response to acute stress compared to both epilepsy patients without stress-sensitive seizures and healthy controls, though no differences in baseline cortisol or sympathetic stress responses were found. This suggests that stress sensitivity in epilepsy may be linked to altered stress responses, providing insights into the mechanisms behind stress-triggered seizures and potentially guiding the development of new treatments for epilepsy.

[4] J.-H. Chien, L. Colloca, A. Korzeniewska, T. J. Meeker, O. J. Bienvenu, M. I. Saffer, and F. A. Lenz, ‘‘Behavioral, physiological and EEG activities associated with conditioned fear as sensors for fear and anxiety,’’ Sensors, vol. 20, no. 23, p. 6751, Nov. 2020, doi: 10.3390/s20236751.

Chien, Colloca, Korzeniewska, Meeker, Bienvenu, Saffer, and Lenz (2020) reviewed the behavioral, physiological, and EEG activities associated with conditioned fear responses (CRs) to explore how they can serve as sensors for fear

and anxiety. Anxiety disorders, which have significant public health impacts, are currently assessed through self-reports and indirect tests, such as the Dot Probe Test and emotional Stroop, which do not directly induce fear. This study focused on CRs to a neutral stimulus (CS+) associated with a painful stimulus (US), measuring autonomic responses like skin conductance, ratings of unpleasantness, attention command, and expectancy. These CRs reflect fear and include oscillatory EEG power changes (ERS and ERD) and evoked responses, such as the P300, related to attention and expectancy. The study found that these CRs, especially EEG oscillatory power changes, are consistent across subjects and could be used to develop an objective test for diagnosing and monitoring anxiety disorders.

3-SOFTWARE REQUIREMENTS

Software Requirements

What is MATLAB? Programming assignments in this course will almost exclusively be performed in MATLAB, a widely used environment for technical computing with a focus on matrix operations. The name MATLAB stands for "Matrix Laboratory" and was originally designed as a tool for doing numerical computations with matrices and vectors. It has since grown into a high-performance language for technical computing. MATLAB integrates computation, visualization, and programming in an easy-to-use environment, and allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages. Typical areas of use include:

- Math and Computation
- Modeling and Simulation
- Data Analysis and Visualization
- Application Development

MATLAB

is an ideal platform for implementing this project due to its robust capabilities in signal processing, data augmentation, and deep learning. The BONN EEG dataset can be efficiently loaded, preprocessed, and filtered using MATLAB's powerful Signal Processing Toolbox. Band-pass and median filters help in cleaning the data by removing noise and artifacts, while normalization ensures the signals are consistent for further analysis. Data augmentation techniques, such as Position Data Augmentation (PDA) and Random Data Augmentation (RDA), can be easily applied to the EEG signals using MATLAB's randomization and array manipulation functions, generating synthetic data that mimics stress and anxiety-induced seizures.

The Deep Learning Toolbox in MATLAB allows for easy implementation of models like LSTM, which is well-suited for analyzing the temporal patterns in EEG data. Hybrid models, such as FCM-PSO-LSTM, can be developed by integrating fuzzy clustering, particle swarm optimization (PSO), and LSTM networks, offering a flexible and optimized approach to seizure detection. Additionally, MATLAB's visualization tools, such as plotting and confusion matrices, allow for a detailed evaluation of model performance in terms of accuracy, sensitivity, and specificity. With MATLAB's extensive documentation and built-in support for parallel computing, it provides a comprehensive environment to execute and optimize the project efficiently.

4-EARLY DETECTION OF STRESS AND ANXIETY BASED SEIZURES IN POSITION DATA AUGMENTED EEG SIGNALS USING HYBRID DEEP LEARNING ALGORITHMS

Existing System

The existing system for detecting epileptic seizures relies heavily on traditional EEG signal analysis, which is prone to human interpretation errors, especially when stress and anxiety are involved. Current methods primarily focus on feature extraction from EEG signals to detect seizures but often fail to account for the variability caused by stress and anxiety. These systems lack advanced data augmentation techniques, making it difficult to simulate stress-induced seizure patterns. As a result, conventional algorithms struggle with accurately detecting and classifying stress and anxiety-based seizures, leading to lower detection accuracy and less reliable predictions.

The existing system for epileptic seizure detection primarily uses traditional techniques, focusing on analyzing raw EEG signals. However, these systems face significant limitations, including:

1. Human Interpretation: EEG analysis often relies

on manual interpretation by radiologists or clinicians, which can lead to errors, especially under stressful conditions. This manual process makes it hard to consistently and accurately detect seizures triggered by stress and anxiety.

2. Feature Extraction: While existing systems extract features from EEG signals (such as frequency, amplitude, and time-domain patterns), they often overlook the variations in seizure characteristics caused by emotional states like stress and anxiety.

Proposed System

In this project, the BONN EEG dataset is utilized and augmented to improve the early detection of stress and anxiety-induced seizures. The dataset includes five classes (A to E) representing different states of brain activity: eye-open (A), eye-closed (B), seizure-free (C and D), and epileptic seizure signals (E). For the purpose of this project, only set D (non-epileptic) and set E (epileptic) signals are used for augmentation.

Techniques like Position Data Augmentation (PDA) and Random Data Augmentation (RDA) are applied to simulate realistic stress and anxiety-induced variations in the EEG signals. These augmentations introduce new samples with varied seizure patterns, enhancing the model's ability to detect and classify seizures more accurately.

The BONN EEG dataset, with a sampling frequency of 173.61 Hz, provides 500 signals with a duration of 23.6 seconds each. Data augmentation helps to mimic different stress-induced conditions, allowing the model to generalize better and improve its seizure detection capabilities.

Block Diagram

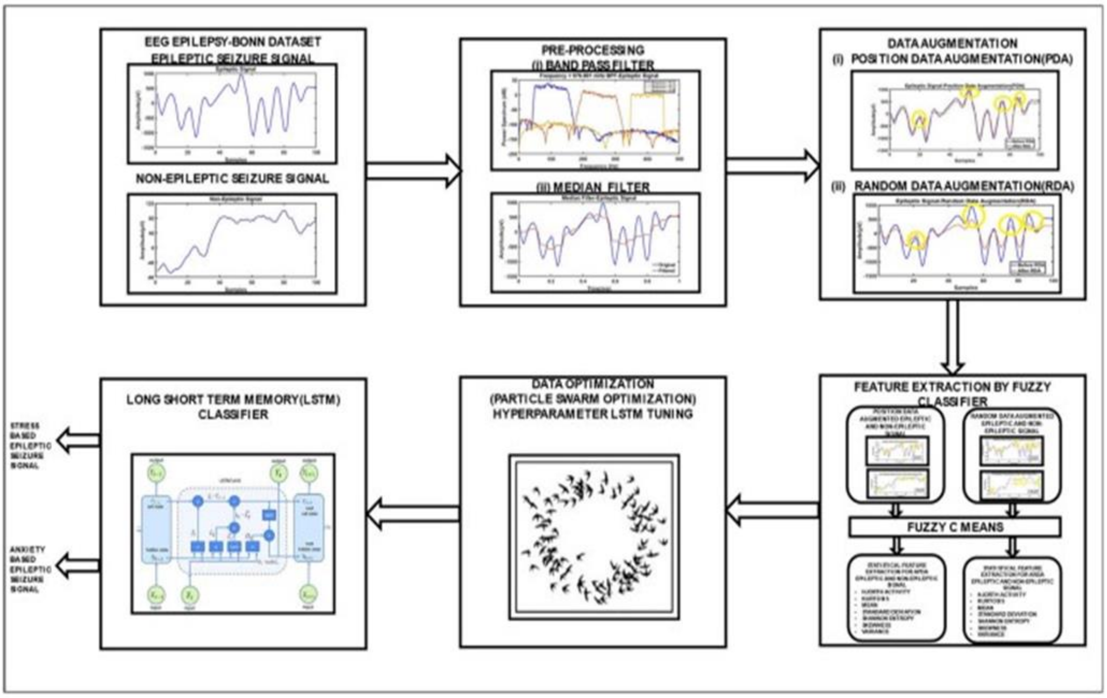

Fig 3.4.1 Block Diagram of Early Detection of Stress and Anxiety Based Seizures in Position Data Augmented EEG Signal Using Hybrid Deep Learning Algorithms

Methodology

Data Collection and Preprocessing

EEG Data Source: The EEG signals are obtained from the BONN dataset, a well-known and publicly available dataset containing both normal and epileptic seizure signals. The dataset is divided into different sets (A, B, C, D, and E) representing various states of brain activity. Noise Removal: EEG signals are often contaminated with noise from sources like eye blinks, muscle activity, and electrical interference. To address this, a band-pass filter is used to isolate the relevant frequency bands (e.g., 0.5–40 Hz) while removing unwanted frequencies. Additionally, a median filter is applied to eliminate high-frequency noise and artifacts. Normalization: Adjusts the data to have uniform amplitude and range, making it easier for machine learning models to process and learn from the data.

5-ADVANTAGES, DISADVANTAGES AND APPLICATIONS

Advantages

1. Early Detection: The proposed system provides earlier detection of stress and anxiety-based seizures, helping in timely medical intervention and reducing the risk of severe outcomes.
2. Enhanced Accuracy: The hybrid models, such as FCM-PSO-LSTM and PSO-LSTM, achieve high accuracy rates (up to 98.5%) in classifying and predicting seizures induced by stress and anxiety.
3. Data Augmentation: Utilizing Position Data Augmentation (PDA) and Random Data Augmentation (RDA) enhances the diversity and robustness of the EEG dataset. This makes the model more capable of handling the variability and unpredictability of stress and anxiety-induced seizures.

Disadvantages

1. Complexity in Implementation: The hybrid deep learning algorithms (FCM-PSO-LSTM, PSO-LSTM) require significant computational resources and expertise in both machine learning and medical data analysis, making implementation more complex.
2. Data Dependency: The effectiveness of the model heavily depends on the quality and quantity of the EEG data. If the dataset is not large or diverse enough, it may not generalize well to new or unseen data, especially for stress and anxiety-induced seizures. If trained with less data results might not be very accurate, hence it requires a lot of data.
3. Resource Intensive: The computational power required for processing EEG data, especially when using advanced data augmentation techniques and deep learning models, can be high. This could limit the project's applicability on devices with limited processing power, such as portable or wearable devices. Since it requires lot of data tp train, it is resource intensive and complex.

Applications

1. Clinical Diagnosis of Epilepsy: The system can be used in hospitals and clinics to assist neurologists in diagnosing epilepsy, particularly in detecting seizures triggered by stress and anxiety. It offers a more accurate and early detection mechanism, improving patient outcomes
2. Personalized Treatment Plans: The ability to detect stress and anxiety-induced seizures allows for tailored treatment plans based on an individual’s unique stress levels and seizure patterns. This can help optimize medication dosages or therapy plans.
3. Continuous Monitoring Systems: This technology can be incorporated into wearable devices (e.g., EEG headsets) for continuous monitoring of patients. Real-time detection of stress-induced seizures can prompt early intervention, such as sending alerts to patients or healthcare providers.

6-RESULTS

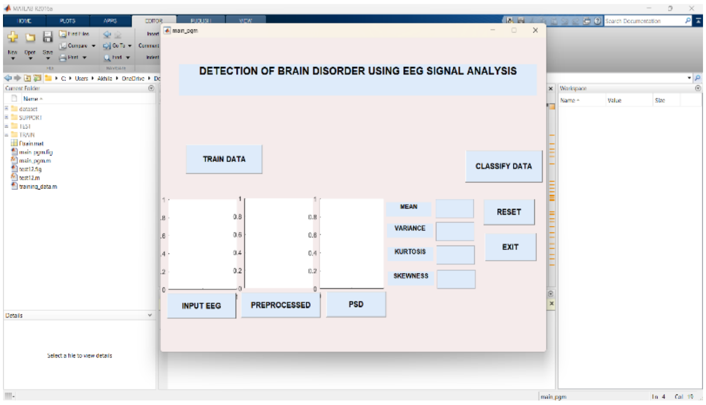

Fig 1: Proposed Method GUI

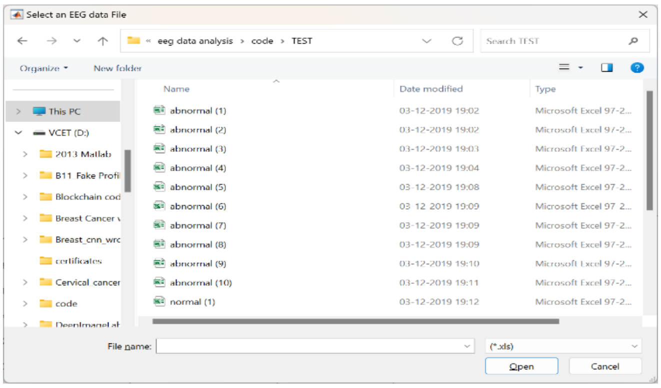

Fig .2 Uploading Test Sample

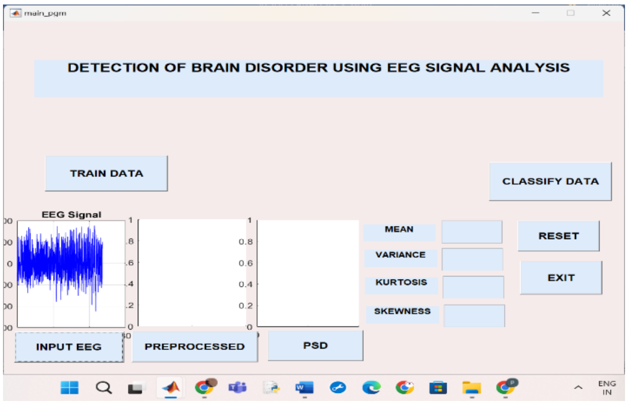

Fig 3 Input Signal is selected and plotted

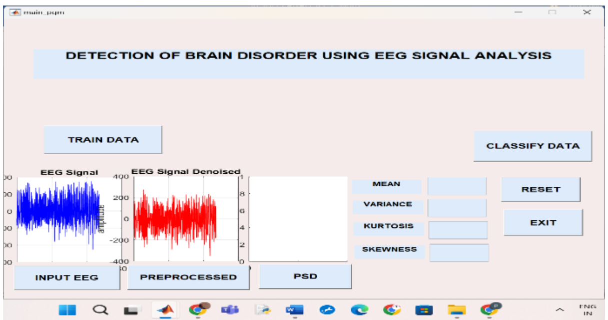

Fig 4 Preprocessing (Applying different filtering techniques)

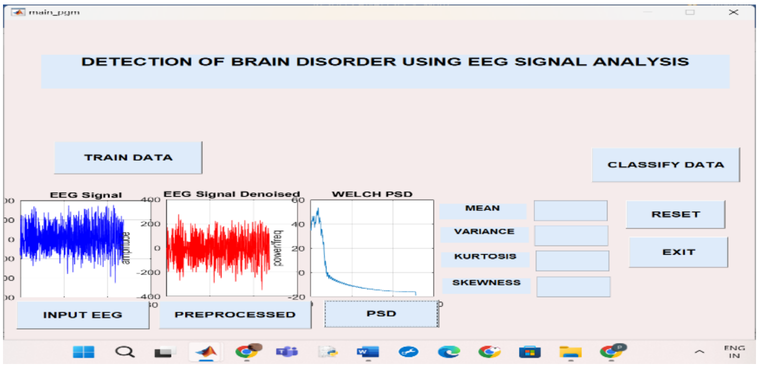

Fig 5 PSD variation in data

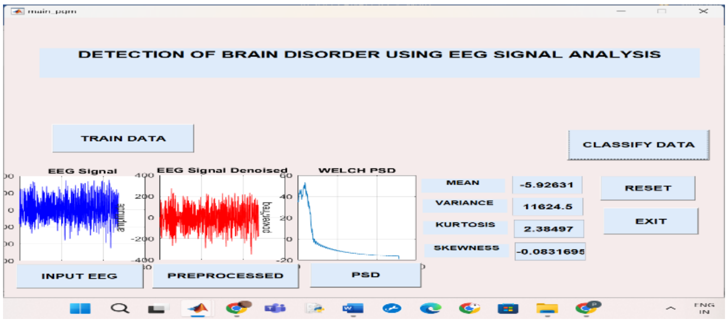

Fig 6 Different features (mean, variance, kurtosis , skewness)

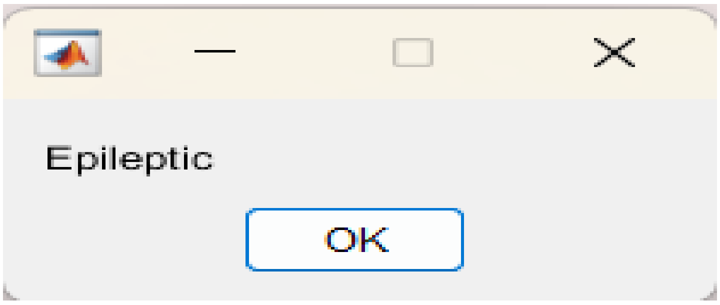

Fig 6 Signal Classified as Epileptic

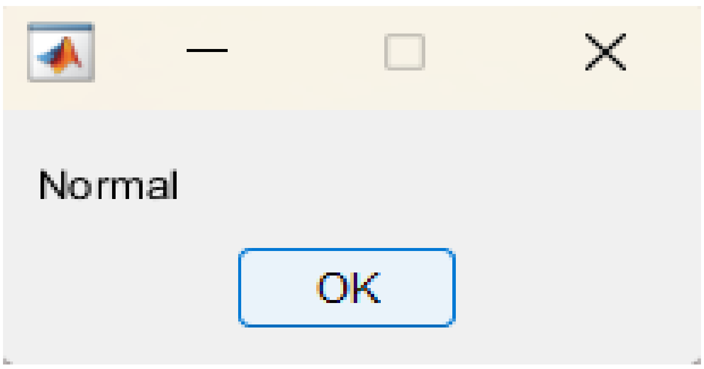

Fig 7 Signal is classified as Normal signal

7-CONCLUSION

Conclusion

The project on Early Detection of Stress and Anxiety-Based Seizures Using Position Data Augmented EEG Signals and Hybrid Deep Learning Algorithms presents a novel and effective solution for improving the diagnosis and monitoring of epilepsy. By leveraging advanced data augmentation techniques like Position Data Augmentation (PDA) and Random Data Augmentation (RDA), this system successfully simulates stress and anxiety-induced seizure patterns. The use of hybrid deep learning models such as FCM-PSO-LSTM and PSO-LSTM achieves high accuracy (up to 98.5%) in classifying epileptic seizures, making it highly efficient for early detection.

The project's ability to reduce noise, enhance accuracy, and provide personalized analysis shows great potential for clinical applications, real-time monitoring, and telemedicine. Despite challenges such as computational complexity and data dependency, this system offers significant advantages over traditional EEG analysis methods, addressing the gaps in seizure detection caused by stress and anxiety.

In conclusion, this project lays a strong foundation for future research and real-world deployment, potentially revolutionizing the way epilepsy is diagnosed and managed, especially under stress and anxiety conditions. With further refinement and application, this approach can greatly enhance the quality of life for epilepsy patients by enabling earlier intervention and more effective treatment plans. This system helps in detecting seizure signlas early thus saving lives.

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