ADVANCEMENTS IN EEG ANALYSIS FOR ENHANCED DIAGNOSIS AND TREATMENT OF EPILEPSY: A COMPREHENSIVE PLATFORM APPROACH

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ABSTRACT
The diagnosis and treatment of epilepsy, a complex neurological disorder affecting millions worldwide, has undergone significant advancements with the integration of cutting-edge technology and innovative methodologies. Electroencephalography (EEG) stands as a cornerstone in this domain, offering invaluable insights into brain activity and facilitating the identification of epileptic patterns. This abstract delves into the multifaceted landscape of epilepsy management, focusing on the development and implementation of a Comprehensive Platform for Visualizing and Analyzing Electroencephalograms (EEG).

From a clinical perspective, EEG is indispensable in diagnosing neurological disorders, particularly epilepsy. Specific patterns in EEG signals can indicate epileptic activity and help determine its type and origin. Additionally, EEG is fundamental in sleep disorder research, offering valuable insights into different sleep phases and their possible disturbances. In patients in comatose or altered consciousness states, this technique provides crucial data regarding brain activity levels (Apicella, Isgrò, Pollastro, & Prevete, 2023).

In research, EEG is an essential tool for analyzing how the brain processes information and responds to different stimuli. The study of brain waves during various cognitive tasks and mental states provides key insights into understanding processes such as cognition, emotion, and consciousness. Frequency and amplitude parameters of brain waves are crucial in EEG analysis, enabling physicians and neuroscientists to identify specific patterns associated with various neurological conditions, such as epilepsy, where spikes and sharp waves are key diagnostic markers. In the emerging field of brain-computer interfaces (BCI), detailed analysis of brain wave frequency and amplitude opens new possibilities for developing communication and control systems based on brain activity. Understanding these parameters is vital not only for clinical diagnosis and neurological research but also for advancing innovative technologies that seek to integrate brain activity with external devices more effectively (García-Hernández et al., 2023).

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Epilepsy is a complex neurological disorder affecting millions of people worldwide, manifesting in a wide range of forms and severities. Characterized by a predisposition to recurrent seizures, this condition results from abnormal and excessive electrical activity in groups of brain cells, triggering various physical and cognitive symptoms. Triggers include brain injuries, infections, tumors, genetic anomalies, and other neurological diseases. The episodic and unpredictable nature of seizures poses a significant challenge for those affected (Fisher et al., 2014).

Pre-diagnosis algorithms for detecting and classifying epilepsy using EEG have become fundamental tools in neurology, especially with the advent of advanced signal processing and machine learning techniques. These algorithms not only promise faster and more accurate diagnoses but also facilitate a deeper understanding of the complexity of neurological disorders like epilepsy.

The Discrete Wavelet Transform (DWT) is a powerful and versatile technique employed in signal and image processing, established as a standard tool for analyzing non-stationary signals across various research and industrial disciplines. DWT offers a multi-resolution representation of a signal, allowing its decomposition into components of different frequencies, each temporally localized (Murungi, Pham, Dai, & Qu, 2023).

Pre-diagnosis using EEG is a diagnostic tool for early detection of epilepsy, leveraging abnormal patterns in brain electrical activity to identify potential disorders. This preliminary phase is crucial for deciding whether deeper analysis or treatment options are needed. This is especially vital in epilepsy, where EEG is essential for early detection of abnormalities such as spikes and generalized discharges, pinpointing the origin of seizures, and differentiating between different types of epilepsy, thereby facilitating appropriate treatment selection and clinical management.

Pre-diagnosis helps identify possible cognitive deficiencies associated with epilepsy, brain wave behaviors to detect epileptiform spikes, and determine the need for a more detailed and specific evaluation. This can help professionals design an appropriate intervention plan to address the individual's needs.

The proposed solution is a Comprehensive EEG Visualization and Analysis System, focused on improving classification capabilities in neurology and psychology through advanced technology for EEG analysis and visualization. By combining data analysis, processing infrastructure, and visualization tools, the proposed system addresses current limitations in EEG analysis and establishes an intuitive and robust platform for future research and advances in diagnosing and treating neurological conditions.

The objective is to integrate and apply an algorithm in the web application to process EEG signals and extract relevant features. These features will be used to classify brain activity in terms of adverse elements present in the signal. Specifically, the aim is to classify brain activity into five distinct categories: epileptiform spikes, periodic

lateralized discharges, generalized periodic discharges, lateralized rhythmic delta activity, and generalized rhythmic delta activity.

The ultimate purpose of this classification is to assist physicians in evaluating the effectiveness of therapies applied to their epilepsy patients and to improve the ability to pre-diagnose the patient's condition. The platform implements data analysis techniques to evaluate signals collected by EEG nodes. This approach will enable the detection of epileptiform spikes, providing professionals with reliable pre-diagnosis based on objective data and recognizable patterns. The combination of these technologies provides a complete and cohesive ecosystem for developing prediagnosis systems. From data collection and processing to visualization and user interaction, each component has been selected to optimize the system's performance, scalability, and efficiency. This architecture not only handles large volumes of data and performs complex analyses efficiently but also ensures a smooth and modern user experience, making it an excellent choice for big data analysis projects.

In conclusion, this software development and applied research project highlights the transformative potential of the Comprehensive EEG Visualization and Analysis Platform in advancing the pre-diagnosis and treatment of epilepsy. By integrating cutting-edge technology with clinical expertise, this platform, developed as a final project for the Computer Systems Engineering degree at the University of Monterrey, represents a significant step forward in improving pre-diagnosis outcomes for epilepsy patients and advancing neurological research.

Keywords: eHealth, EGG, Analytics, ML, Cloud, Processing Epilepsy

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