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Original Article

A Proposed System for Seizure Prediction and Classification Using Affective Technology

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***Abstract** - Epilepsy is a neurological issue that is described by abrupt and irregular seizures. As indicated by the World Health Organisation (WHO), roughly 1% of the total populace is epileptic patients. The abrupt nature of epileptic seizures constitutes a major disabling aspect of the ailment due to the impediments in patients' daily activities. Therefore, a method that can speculate the event of seizures could essentially improve the wellbeing of epileptic patients. Hence the point of this paper is to build up a model that can anticipate seizures and furthermore characterize them, using a GSR sensor, Temperature sensor and also a Pulse rate sensor.*

***Keywords** - Epilepsy, seizures, affective Computing, prediction, classification*

I. INTRODUCTION

Epilepsy is a neurological issue that is described by abrupt and irregular seizures. As indicated by the World Health Organisation (WHO), roughly 1% of the total populace is epileptic patients. It alters consciousness, perception, behaviour and body movement due to abnormal electrical activity in the brain. Epileptic symptoms may differ in various cases based on the location of the brain tissue that is affected and the extent to which the tissue is affected. Some seizures are brief, i.e. they occur for less than 2 minutes and are not life-threatening. Seizures can be separated into two primary classes they include generalized seizures that include nearly the whole brain and partial seizures that begin from a region of the brain and stay confined to that region [1]. Generalized seizures can further be divided into several types; The Clonic, The Myoclonic, The Tonic, The Tonic-clonic and The Atonic. Likewise, Partial seizures can be divided into two types; The Complex Partial and The Simple Partial seizures.

Patients with epilepsy generally describe seizures as occurring like a bolt out of the blue" due to the sudden and unpredicted way in which the seizures strike. This describes a major disabling feature of the disease, especially in the event that a patient is unable to completely control the seizure, which results in an intense helpless feeling that strongly affects their regular day to day existence. Furthermore, an unexpected loss of consciousness or loss of muscle control can cause serious injury risk or even death if the patient is involved in driving, crossing a busy street, climbing stairs or operating a machine. Therefore, a method that can speculate the event of seizures could essentially improve the wellbeing of epileptic patients.

This paper is therefore organized as follows; first, the definition of terminologies in seizure detection, as well as the analysis of affective Computing, in the next section review of some existing seizure detection and classification methods. The third section covers the overview of the proposed seizure detection and classification system, while the final section offers a conclusion.

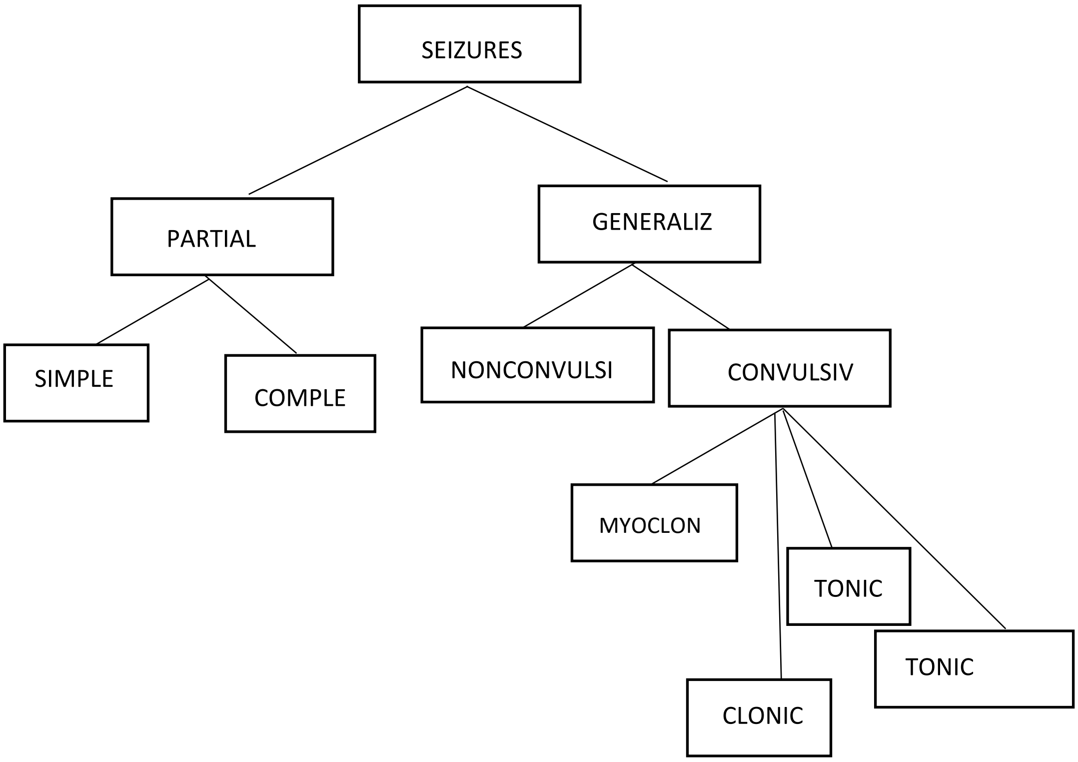

Fig. 1 Classification of Epileptic Seizure.

A. Affective Computing

Affective Computing is the study and development of frameworks and gadgets that can perceive, decipher, process, and reproduce human effects. . It spans psychology, computer science and cognitive science**.** Its origins may be traced back to inquiries into emotions by the early philosophers. The machine should be able to adapt its behaviour to the various emotional state of humans, interpret these emotions and also give a suitable response to the emotions. Clues to the emotional state of the user can be gotten from facial expressions, temperature changes, changes in posture, increase or reduction of the heartbeat via sensors, cameras, microphones and software logic. The more computers we have, the more we would want them to be socially smart and also behave politely with fewer notifications on unimportant messages or information. It is therefore essential that the computer understands the user's emotional state for that kind of smart reasoning. Another approach to affective Computing is human-PC communication with the end goal that a gadget can distinguish and fittingly react to its client's feelings and other upgrades. Besides, the physiological muscle developments that may appear as though an outward appearance may not generally relate with a genuine basic enthusiastic state [2].

a) Seizure Detection Sensors

The detection of seizures is critical in the treatment of epileptic patients and also helps in classifying the various types of seizures. Howbeit, due to the complexity of the seizures, certain sensors are employed to measure some physiological signals in the body such that accurate results can be given as regards the detection of seizures.

b) Electrodermal Activity (EDA)

Due to the essential principle of measurement, EDA can also be described as skin conductance activity. It describes variations in the ability of the skin to conduct electricity that occurs as a result of the relations between the human psychophysiological state and environmental events. It has been related to proportions of feeling, excitement, and consideration. Its readings are normally recognized by two segments; a tonic baseline level and short term phasic reactions. Phasic reactions transitory increases in skin conductance and decide the event-related reactions that happen in a person because of some environmental factors. An environmental factor might be anything from a thought burst to a profound moan. EDA is one of the quickest, generally vigorous and all around contemplated physiological measures. It is engaged as a means of detecting seizures because previous studies have proven that skin conductance increases whenever a seizure is about to occur.

c) Electroencephalogram (EEG)

The brain is described as the most multilateral organ of the human body because of its ability to produce electrical signals to run the whole body directly or indirectly. The Electroencephalogram EEG records the electrical movement in the brain that is produced by a huge number of neurons. EEG is a decent, non-intrusive demonstrative instrument that can be carefully customized to recognize any disorder in the brain. At the point when the EEG sensor is joined to an EEG headset, it is utilized as an instrument known as the Brain-Computer Interface (BCI) that reports the psychological condition of the wearer, alongside other data about the brainwave recurrence groups. The EEG readings of a person without a seizure is distinctively different from that of a seizure patient.

d) Electromyogram (EMG)

The electrical movement in the muscle when very still or when stressed is measured by an Electromyogram (EMG). It refers to the movement of the muscle or how often muscle tension occurs in a certain muscle. Studies have shown that when a person is subjected to stress, muscle activity increases. An unconscious clenching of the muscle due to stress is an indication that a person is in a fatigued or mental stressed state. Impulses that also have an impact on the muscles are measures of how fast and how well the nerves can impart electrical signals to control the muscles in the body.

e) Electrocardiogram (ECG)

The electrical activity generated by the heart muscle is measured by the Electrocardiogram (ECG). The overall activity level of an individual is indicated by the activity of the heart. It can be picked up reliably when ECG electrodes are attached to the skin. For example, there is an acceleration in the heart rate when a person is exercising, stressed emotionally, exposed to sudden loud noise, or when sexually aroused. Whereas when a person is in a relaxed state of experiencing pleasant stimuli, the heart rate is lower.

II. REVIEW ON SOME RELATED WORKS

In the first section, we have discussed that epileptic seizures can be separated into two primary classes they include: Generalized seizures that include nearly the whole brain and partial seizures that begin from a region of the brain and stay confined to that region. The theory that a transition state, otherwise known as the preictal state, exists between the normal (interictal) and seizure (ictal) states has helped researchers in the prediction of seizures. There is a number of clinical pieces of evidence that support this theory. Accordingly, over the last two decades, researchers have made a great effort in attempting to predict epileptic seizures based on EEG signals.

Conradsen [3] proposed a framework for the Identification of Epileptic Seizures with Multimodal Signal Processing, and he introduced a technique where the support vector machine classifier is applied on features dependent on wavelet bands. This was utilized on multimodal information from control subjects. This algorithm was then applied to design a wearable gadget dependent on uni-or multi-modalities that could identify at whatever point a seizure begins and sound an alarm when the seizure is detected, which resulted in the detection of only one type of seizure. In work reported by Alexandros. *et al*., [4] Automated Epileptic Seizure Detection Methods, they reported two automated strategies for analyzing epileptic EEG recordings: those focused on inter-ictal spike detection, and those focused on epileptic seizure analysis and portrayal of unusual EEG activities in long term accounts anyway this work can just help the specialists in the field of EEG signal examination to understand the available techniques and adopt the equivalent for the discovery of neurological issue related with EEG recordings. Milosevic [5] reviewed the potential of automatic epileptic seizure detection in paediatric patients. He used feature selection methods to identify the most relevant features for the distinction between each epileptic seizure class and all other nocturnal movements using ACM signals. He concluded that it is most effective when the patient is not involved in any activity. Thanuskodi. *et al.*, [6] worked on Automated Epileptic Seizure Detection in EEG Signals Using FastICA and Neural Network to distinguish the nearness of epileptic seizure dependent on the autonomous subcomponents got from a FastICA. The information EEG signals are dissected with the guide of Fast Independent Component Analysis, a Factual Sign Handling Strategy, to get the segments identified with the recognition of epileptic seizures; their methodology utilizes the Fast Independent Component Analysis (FastICA) and the Back Propagation Neural Network (BPNN) for accomplishing epileptic seizure discovery from EEG signal, thereby resulting to a seizure detection accuracy that is between 50% and 55%. Ihsan*et al*. [7] proposed an Automated System for Epilepsy Detection using EEG Brain Signals based on Deep Learning Approach. This work was motivated by the manual review of EEG brain signals which is a tedious and difficult procedure. The proposed framework depended on deep learning, which is state-of-the-art Machine Learning. For this framework, memory efficient and simple pyramidal one-dimensional deep convolutional neural network (P-1D-CNN) model was presented, which is a start to finish model, and includes less number of learnable parameters. The framework will be planned as an ensemble of P-1D-CNN models, which takes an EEG signal as input, passes it to various P-1D-CNN models lastly combines their choices utilizing dominant part vote. To beat the issue of the little dataset, two information increase plans were presented for learning the P-1D-CNN model. Because of fewer parameters, the P-1D-CNN model is anything but difficult to prepare, just as simple to convey on chips where memory is restricted. The constraint of this framework is that the epilepsy recognition techniques recognize seizures after their occurrence. In work proposed by Priya*et al.*, [8] Design of Smart Alert System for Epileptic Seizure Detection; this research was motivated by the inability of epileptic patients caregivers to watch over their patients all the time, and as such a seizure could occur in the absence of the caregiver leading to serious injuries or death. The real-time processing algorithms were implemented using Aurdino. The 9 axis sensor, the temperature sensor, is used for motion capturing to detect Seizures. This personal assistance setup acts as a smart band on the user's wrist. Sathish*et al*. [9] presented an

Android Application for Detecting and Alerting Method of Epilepsy Seizures Using Brain Sensor. Their implementation utilizes an Android working framework (operating system) cell phone, the Droid X, which works on a buyer's network with 3G availability, Wi-Fi, Bluetooth, and GPS capacity. The EpSMART application understands a multimodal seizure discovery stage. Be that as it may, this hardware is purposefully particular in structure and might be utilized for physiological checking, symptom detection, and crisis notice in any number of basic clinical applications, for example, persistent EEG observation of intense ischemic stroke or arrhythmic syncope. In such cases, just the specifics, for example, the features extracted from the applicable sensors (for example, EEG or ECG) and the grouping algorithm, need to be changed.

They executed another idea to recognize and alert utilizing a mind sensor or brain monitor. This should be possible by Neurosky Think Gear chip. The Neurosky Think gear implies that it is a maker of Brain-Computer Interface (BCI) technologies for customer item applications. NeuroSky adjusts electroencephalography (EEG) and electromyography (EMG) innovation to fit a consumer market that includes various fields, for example, amusement (toys and games), education, automotive, and health. Le et al. [10] proposed a method to envision seizures utilizing the similarity between ictal reference and the current windows of EEG dependent on nonlinear analysis of zero-crossing intervals. They applied this algorithm to scalp EEG signals from 23 patients with temporal lobe epilepsy (TLE), which brought about 96% sensitivity and an average expected time of 7 min. Analyzing depth EEG recordings from five patients with TLE.

III. PROPOSED SYSTEM OVERVIEW

The pre-ictal state is very important in predicting seizures because it starts a few minutes before the seizure begins. This has made the prediction of epileptic seizures possible. The aim of this research is to design a model that can predict epileptic seizures by detecting when the pre-ictal state will begin several minutes before the onset of a seizure. Since seizures can be prevented with medication, early prediction of seizures is essential for patients. Due to this medication, the patients will be able to perform their routine activities without any fear of interference from seizures. Considering the various limitations of some of the existing works, we propose a model that can detect when the pre-ictal state will begin and sound an alarm to alert the patient and surrounding people of an imminent seizure occurrence and also store seizure patterns for critical examination by neurologists. However, the pulse rate sensor, the temperature sensor as well as the Galvanic Skin Response (GSR) Sensor will be employed in this research to detect changes in the skin conductance. As earlier discussed, studies have proven that skin conductance increases whenever a seizure is about to occur. The department of Neurology at The Federal Medical Centre (FMC) Owo, Ondo State, will be used as a research site for acquiring a dataset.

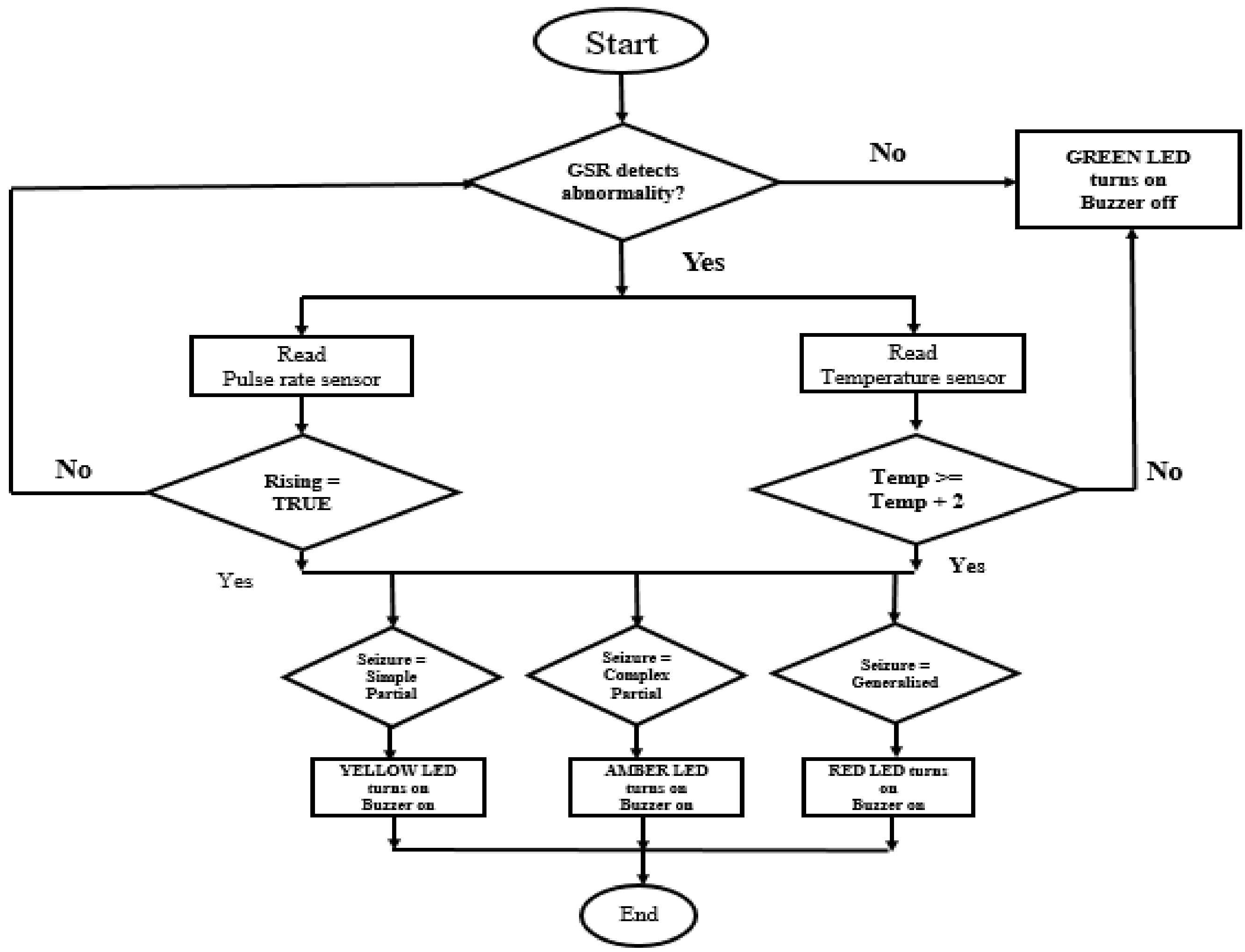

Fig. 2 Flowchart of the Proposed System

A. Methodology

The proposed system will consist of three main input sensors for the detection of epilepsy seizures which are Galvanic Skin Response (GSR), temperature sensor and pulse rate sensor, which are used to determine the seizure occurrence. A Galvanic Skin Response (GSR) sensor is utilized to recognize the skin conductance of the patient in light of the fact that the muscle of the patient will cramp when seizures happen. The temperature of the patient is measured using a temperature sensor; as the temperature of the patient increases from normal temperature, there is a higher possibility that a seizure will occur. Similarly, a pulse rate sensor is used to measure the heartbeat rate of the patient; as the pulse rate increases, there is a tendency for the seizure to happen.

The three main input sensors will be directly connected to the Arduino microcontroller board, which is embedded with the ATmega 328p microcontroller. The microcontroller is the heart of the entire system, which will receive data from the three main sensors and process the data accordingly. The output signal from the microcontroller will be released using three components: buzzer, Light Emitting Diode (LED) and Liquid Crystal Display (LCD).

The buzzer will be triggered by the microcontroller to beep and alert the people in the environment when epilepsy seizure is detected, while the different LEDs turns on to indicate the occurrence of simple partial seizure, complex partial seizure and generalized seizure, respectively.

Some set of signals which may be used for detecting seizures will aid the system to classify the signals coming from sensors into three types of seizures, which includes the simple partial seizure, the complex partial seizure and the generalized seizure. The first necessary step is the extraction of helpful data-bearing features for pattern classification. For seizure detection, prediction and classification, the features of each bio-potential information must be extricated.
Fuzzy logic will be adopted in this research to carry out the following processes;

- Fuzzify all input values from input sensors (GSR sensor, Temperature sensor and Pulse rate sensor) into fuzzy membership functions,
- Execute every single appropriate guideline in the standard base to compute fuzzy output functions,
- De-fuzzify the fuzzy output functions to get crisp output values.

IV. CONCLUSION

This paper presents a framework of a system that can detect epileptic seizures and also classify the various types of seizures by using the GSR sensor, Pulse Rate sensor and also temperature sensor. This framework will have the option to effectively separate the epileptic features from the ordinary GSR signals with high precision, and the least false rate will impact its capacity to effectively predict the beginning of the seizure.

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