DETECTION OF EPILEPTIC SEIZURE SIGNALS USING FUZZY RULES BASED ON SELECTED FEATURES

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Abstract—Epileptic seizure refers to the degree of chaos that occurs in the human body which deviates from the normal behaviour. It can be identified using Electroencephalogram (EEG). In the existing system, much research has been conducted based on sample entropy for various seizure states. However this system lagged behind. To overcome those problems, in our proposed system, we have proposed a new method using fuzzy rules to select features. The method first calculates the Fuzzy logic of EEG signals from different epileptic states, and then classified features is obtained from the selected features. Finally, we use the acquired classification features and a grid optimization method to train support vector machines (SVM). A tool called Bitalino is used in order to find out the seizure and is capable of connecting without wires. Various signals such as EDA, EEG, ECG, ACC, EMG can be recorded using the tool. Later the patients signals which is obtained is checked for match with the normal EEG signal. This will find out whether the person is affected with epilepsy or not.

I. INTRODUCTION

Human brain signal recording is important for both assessment and research purposes of various neurological disorders. For example, EEG is the current method of choice to visualize abnormal epileptic form discharges in patients with epilepsy. Continuous EEG monitoring is used for diagnosing and monitoring of convulsive or non-convulsive status epilepticus and assessment of ongoing therapy for the treatment of seizures in such patients\cite{7} . Some patients may benefit from epilepsy surgery if the epileptogenic zone (EZ) can be identified and resected without harm. There are two step by step procedure for epileptogenic zone localization: a) non-invasive, and b) invasive brain signal monitoring. The non-invasive monitoring can roughly estimate seizure activation region. Moreover, due to the temporal resolution or limited spatial of currently available non-invasive localization techniques, accurate delineation of the EZ may sometimes be endurance, particularly with non-lesion refractory epilepsy. Therefore, following non-invasive studies, an invasive EEG recording may be necessary prior to respective surgery. Near-infrared spectroscopy, which monitors local changes in cerebral blood volume and oxygenation noninvasively is used both in research to identify areas involved in cognitive tasks and in clinical settings to monitor cerebral oxygenation during cardiac or carotid surgeries. Long-term invasive monitoring, over 2–3 weeks, are performed in epilepsy centre’s to record seizures in order to trace the area of seizure onset for low-noise and curative resection preamplifiers would be beneficiary for this application\cite{1} . During these monitoring sessions, patients are connected to relatively bulky machines in a small environment. Wireless portable devices could provide important benefits. For example, a portable wireless EEG-NIRS system should allow researchers to study brain activities during dynamic tasks such as gait rehabilitation following a stroke. Similarly, a wireless invasive EEG system could reduce the risk of infections associated with the use of intracranial electrodes and their exit cables are connected to external amplifiers. One could also envision implant a small recording device chronically which would wirelessly transmit a stream of EEG data allowing online seizure detection and triggering a warning/alarm system or focal treatment \cite{2} . For the latter purposes, 2 kHz sampling rate is required for early detection of low-voltage fast oscillations seen at seizure onset.
The paper is structured as follows. Section I discusses about epilepsy. Section II analyses of hardware specific processor. Section III discusses the data set considered for the entire process. Section IV presents the feature extraction process. Section V discusses the feature selection process. Section VI provides the technique adapted for classification and finally the future scope of this work has been discussed.

II. EPILEPSY

Epilepsy is the most common neurological disorder and it affects people of all ages. Epilepsy means “seizure disorders”. It is characterized by unpredictable seizures and cause many health problems. It is a condition with a wide range of seizure types and control changes from person-to-person.

Epilepsy is a chronic disorder, which is repeated, unprovoked seizures. Many people with epilepsy have more than one type of seizure and may also have some other symptoms of neurological problems as well. The human brain is the source of epilepsy. Seizure affects any part of the body, the electrical events that produce the symptoms occur in the brain. The location of the event, how much of the brain is affected and how it spreads, and how long it lasts all have profound effects. Based upon above factors seizure character is determined and its impact on the individual. Essentially, anything the brain can do, it can do it in the form of a seizure.

III. HARDWARE-SPECIALIZED PROCESSOR

Bitalino is a wireless bio-signal acquisition kit which is used to acquire the ECG, EMG, EEG signals from the humans in Real time. The Signals obtained by using Bitalino can be used for various research purposes. The main advantage of this kit is that it has the ability to send the signals to other computation system without using any wires or cables. The Bitalino is equipped with 9 removable “blocks” which can be used straight out-of-the-box that include an MCU, Bluetooth, Power, EMG, EDA, ECG, Accelerometer, LED, and Light Sensor. True ATMega328 microcontroller can be configured with a sampling rate up to 1000Hz and capable of supporting 6 Analog inputs (four at 10-bit, two at 6-bit), four digital inputs and outputs. With the attached BC417 Tri-axial MEMS accelerometer, Bluetooth module, and physiological sensor inputs will find it difficult to run out of ideas for projects. Open Signals is the software responsible for the handle of all the data acquisition, visualization and processing. This software is used for the connectivity between the Bitalino and the computing system that performs the feature classification and comparison. Bitalino can be connected with the system by using Bluetooth technology [3]. In Open Signals we can have access to two things. They are

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>EEG recordings of five healthy volunteers, with eyes open</td>
</tr>
<tr>
<td>B</td>
<td>EEG recordings of five healthy volunteers, with eyes closed</td>
</tr>
<tr>
<td>C</td>
<td>Seizure-free intervals, from the hippocampal formation of the brain</td>
</tr>
<tr>
<td>D</td>
<td>Seizure-free intervals, from five patients in the epileptogenic zone</td>
</tr>
<tr>
<td>E</td>
<td>seizure activity, selected from all recording sites exhibiting octal activity</td>
</tr>
</tbody>
</table>

Table 1. Five classes of EEG dataset
1. Acquisition: Real time acquisition of bio-signals using a Bitalino.
2. Visualization: Previously acquired signals may be viewed here

FIG 1. BITALINO HARDWARE

IV. DATA SET SELECTION

Here we have used the dataset for both healthy and epileptic subjects made available online by Dr. Ralph Andrzeja of the Epilepsy Centre at the University of Bonn, German. The dataset includes 5 subsets (denoted as A, B, C, D, and E) each containing 100 single-channel EEG segments of 23.6 s duration. Table 1 lists each class and its description. Sets A and B have been acquired from surface EEG recordings of 5 healthy volunteers, with eyes open and closed, respectively [6]. Signals in subsets C and D have been measured in seizure-free intervals, from 5 patients in the epileptogenic zone (D) and from the hippocampal formation of the brain (C). Sets A and B have been taken from surface EEG recordings of 5 healthy volunteers with eyes open and closed, respectively. Signals in two sets have been measured in seizure-free intervals from 5 patients in the hippocampal formation of the opposite hemisphere (C) and the epileptogenic zone (D) from of the brain.

Sets A and B have been recorded extra cranially, whereas sets C, D, and E have been recorded intracranial. All EEG signals were recorded with the same 128-channel amplifier system, using an average common reference [eliminating electrodes containing pathological activity or strong eye-movement artefacts]. After 12-b Analog-to-digital conversion, the data were written continuously onto the disk of a data acquisition computer system which has a sampling rate of 173.61 Hz. Band pass filter settings were 0.53–40 Hz (12 dB/Oct.).

FIG 2. COMPARISON OF EEG SIGNALS

V. FEATURE EXTRACTION

Input data is transformed into set of features which is known as feature extraction. These features will have the characteristics of original signal. It represents the signal without redundancy. Two different domains are used to represent the features such as Time Domain Features (TDF), Frequency Domain Features (FDF) and combination of both TDF and FDF (wavelet domain).
VI. FEATURE SELECTION

Fuzzy rule based selection uses some of the extracted parameters such as average, max, min, standard deviation and variance as input variables.

VII. FUZZY RULES

It extends Boolean logic to handle the expression of complex concepts. To express imprecision, a set membership function maps elements to real values between 0 and 1 (inclusive). The value indicates the “degree” to which an element belongs to a set.

An approach to uncertainty that combines real values [0…1] and logic operations. Extracting features using fuzzy rules is used to give better results which categorize the features as good, bad and best sample values.

VIII. CLASSIFICATION OF THE FEATURES

The classification is performed using most effective method of Support Vector Machines (SVM). The Support Vector Machine proposed by Vapnik has been studied extensively for
classification, density estimation and regression. SVM maps the input patterns into a higher dimensional feature space through some nonlinear mapping chosen a priori [4]. A linear decision surface is then constructed in this dimensional-feature space which is higher in order. The SVM is a binary classifier, which can be extended by fusing several of its kind into a Multiclass classifier. Training the SVM is a quadratic-optimization problem. The SVM is a binary classifier, which can be extended by fusing several of its kind into a Multiclass classifier. SVM’s are trained, each of them aimed at separating a different classes. For 3 classes (A, B, and C) we need three classifiers; one SVM classifies B from A and C, a second SVM classifies A from B and C, and a third SVM classifies C from A and B. The Multiclass classifiers output code for a pattern is a combination of targets of all the separate SVMs.

In our example, vectors from classes A, B, and C have code values (1, −1, −1), (−1, 1, −1), and (−1, −1, 1) respectively. If every separate SVMs classifies a pattern correctly, the Multiclass classifier-target code is met and the ECOC approach reports that there is no error for that pattern. However, if any one of the SVMs misclassifies the pattern, the class selected for this pattern is the target code closest in the Hamming distance senses to the actual output code. It may be an erroneous decision.

FIG 4. DIFFERENT KINDS OF EEG SIGNALS

 IX. EXPERIMENTAL SETUP

MATLAB is a high-performance language for technical computing. It integrates visualization, computation and programming is an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. The version used is 2013a.

FIG 5. EMG, EEG, ECG, EDA, ACC Signal Collection in MATLAB setup
X. RESULT & DISCUSSIONS

Thus the project is to detect epileptic seizure signals for EEG classification, initially the datasets of various subjects (both healthy & epileptic persons) named like Z, O, N, F, S are collected which is the EEG signal for certain duration and then the features of hybrid domains like mean, median, standard deviation, variance, z-score, quantile, trim mean, harm mean etc are extracted.

Thus the extracted features will undergo feature selection process using fuzzy logic and the best features are selected. Finally, it can be classified to obtain higher accuracy and less computational complexity.

<table>
<thead>
<tr>
<th>EEG data sets</th>
<th>Statistical parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity (%)</td>
</tr>
<tr>
<td>Normal EEG</td>
<td>96</td>
</tr>
<tr>
<td>Abnormal EEG</td>
<td>85</td>
</tr>
</tbody>
</table>

TABLE 3. RESULT ANALYSIS

XI. CONCLUSION

The proposed approach demonstrates its potential for real-time seizure detection. With experimental results, we will compare the testing accuracy of our proposed method with some other popular methods with different classifiers. For further work, the comparisons with other methodologies are performed in order to verify the applicability and accuracy of the Modified SVM with different datasets. Potential Features have been extracted from the multi-modal bio signals such as EEG, EMG, EDA, ACC, ECG using Bio Sensors. For learning and classification SVM will be used. Experiments show that our proposed system provides better performance in terms of accuracy and computation time.

REFERENCES

Circuits, Jun.2013, pp. 52–53


