Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF EPILEPTIC SEIZURES DETECTION BASED ON EEG SIGNALS ANALYSIS USING MATLAB

MOHAMAD AIMAN BIN ABDUL LATEF

Bachelor of Electronics Engineering Technology with Honours

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DEVELOPMENT OF EPILEPTIC SEIZURES DETECTION BASED ON EEG SIGNALS ANALYSIS USING MATLAB

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DEDICATION

This thesis is dedicated to Abdul Latef bin Ahmad Sawri and Azizah binti Talib, my beloved parents for their constant love, encouragement, and inspiration. To my supervisor Ts. Khairul Azha Bin A. Aziz who never giving up to taught and guide me to complete my project. To my helpful classmate and housemate who always keep supporting me.

ABSTRACT

Brain epilepsy is classified as a brain-related disorder that affects the entire brain's nervous system and is caused by brain waves undergoing high-frequency voltage changes or seizures. The disease is one of the uncontrolled movements performed by unconscious epilepsy patients. Therefore, the purpose of this study is to develop the detection of epilepsy seizures based on EEG signal analysis using Matlab. For results, this study initially used the feed-forward neural network technique. The feed-forward neural network technique is used in machine learning to execute the exact processes of the human brain. The system was inspired by the way the human brain thinks. This study uses input data such as standard deviation and mean, and then this epilepsy detection procedure is implemented using MATLAB software. Testing was performed sequentially from 10 to 20 neurons to obtain the best values. In addition, this study also uses an electroencephalogram (EEG) to diagnose and access activity in the human brain using a data set obtained from the University of Bonn (UBonn), which other researchers in this epilepsy study have widely used. A MindLink EEG sensor was used, and the sensor sent data via PLX- DAQ software to detect healthy or epilepsy. The standard deviation provides the best overall accuracy compared to mean, which is 80.8% at seventeen neuron while mean highest overall accuracy only 72.6%. Then, a Matlab Graphical User Interface (GUI) is used to execute editor Matlab file by pressed the pressed the button. GUI acts as shortcut keys to perform a task that takes couple of actions.

ABSTRAK

Epilepsi diklasifikasikan sebagai salah satu gangguan berkaitan otak yang mempengaruhi keseluruhan sistem saraf otak dan ini disebabkan oleh gelombang otak yang mengalami perubahan voltan berfrekuensi tinggi, atau disebut sebagai sawan. Penyakit ini adalah salah satu pergerakan tidak terkawal yang dilakukan oleh pesakit epilepsi tanpa sedar. Oleh itu, kajian tesis ini adalah untuk mengembangkan pengesanan kejang epilepsy berdasarkan analisis isyarat EEG menggunakan Matlab. Kami menggunakan Teknik Rangkaian *Neural Feed-forward*. Teknik Rangkaian *Neural Feed-forward* digunakan dalam pembelajaran mesin sebagai alat untuk melaksanakan proses persis otak manusia. Sistem ini diilhamkan dengan bertujuan untuk mencipta kembali cara pemikiran otak manusia. Tesis ini menggunakan pengekstrakan ciri seperti sisihan piawaian dan min dan kemudian prosedur pengecaman epilepsi ini dilaksanakan dengan menggunakan perisian MATLAB. Pengujian dilakukan secara berturutan daripada 10 *neuron* sehingga 20 *neuron* untuk mendapatkan nilai yang paling terbaik. Selain itu, kajian ini juga menggunakan elektroensefalogram (EEG) yang kemudiannya digunakan untuk mendiagnosis dan mengakses aktiviti didalam otak manusia dengan menggunakan set data yang diperoleh dari University of Bonn (UBonn), yang telah banyak digunakan oleh penyelidik lain mengenai kajian epilepsi ini. Sensor MindLink EEG digunakan dan data dihantar melalui perisian PLX-DAQ untuk mengesan kejang normal atau epilepsi.Selain itu, selepas ujian dibuat, kami mendapati bahawa sisihan piawai memberikan keputusan ketepatan yang terbaik iaitu 80.8% dibanding dengan min iaitu hanya 72.6%. Kemudian, Antaramuka Pengguna Grafik (GUI) digunakan untuk memaparkan ketepatan keseluruhan dengan latihan pengesahan. GUI bertindak sebagai kekunci pintasan yang digunakan untuk memudahkan pengguna.

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LIST OF SYMBOLS

μV	Microvolts
α	Alpha
β	Beta
γ	Gamma
Δ	Delta
θ	Theta
Hz	Hertz
V	Volt
dB	Daubechies
ψ	Wavelet coefficients
rrrr	Tau
VCC	Voltage Common Collector
GND	Ground
RX	Receiver
TX	Transmitter
a	Scaling Parameter
b	Location of the Parameter
%	Percentage

LIST OF ABBREVIATIONS

EEG	Electroencephalogram
MIT	Massachusetts Institute of Technology
CNN	Convolutional Neural Network
CHB	Children's Hospital Boston
CWT	Continuous Wavelet Transform
BoW	Bags-of-Words
SVM	Support Vector Machine
DWT	Discrete Wavelet Transform
FFT	Fast Fourier Transform
AR	Autoregressive or Autoregression
MLPNN	Multilayer Perceptron Neural Network
ANFIS	Adaptive Neuro-Fuzzy Interference System
KDD	Knowledge Discovery in Database
RNN	Recurrent Neural Network
LSTM	Long-Short-Term Memory
GRU	Gated-Recurrent Unit
STFT	Short-time Fourier Transform
WT	Wavelet Transform
GPS	Global Positioning System
ANN	Artificial Neural Network
UBonn	University of Bonn

CHAPTER 1

INTRODUCTION

1.1 Background

Epilepsy is the second most prevalent neurological condition after stroke, and one of the most prominent neurological disorders characterized by epileptic seizures, according to the World Health Organization (WHO). Contamination can occur irrespective of the host conditions or characteristics (Ahmadi, 2018). Unregulated seizures in patients with epilepsy are in danger of asphyxia, death or injury from collapse or traffic accidents and are unable to defend themselves (Mutlu, 2018, Yan, 2016). To date, drugs and surgery are the main therapies for this disease; there is no cure and anticonvulsant medication for all forms of epilepsy has not been fully effective (López-Hernández, 2011, Yan, 2015).

Electroencephalography (EEG) is beneficial in detecting epilepsy because it measures ionic currents flowing inside brain neurons and identifies voltage variations between electrodes along the subject's scalp. It also provides temporal and geographical information about the brain (Misulis, 2013, Pachori and Patidar, 2014). EEG detection involves a physician's direct observation as well as a large amount of time and effort. Furthermore, professionals with various degrees of diagnostic experience may hold opposing viewpoints on diagnostic outcomes (Wang, 2016, Yan, 2017). As a result, it is critical to create an integrated, computer-aided approach for epilepsy diagnosis (Iasemidis, 2005, MARTIS, 2015).

The data for this study were acquired from the Bonn University site, which is a publicly accessible database utilised by Andrzejak et al. for epilepsy diagnosis. This resource includes five sets of EEG signals. Each package comprises 100 single channel EEG segments that last 23.6 seconds. The five sets are listed below. Datasets A and B were created utilising a consistent electrode implantation methodology on five healthy volunteers. Set A is made up of signals from people in a slowed-down state with their eyes open. Set B comprises the same signal as Set A, but with the eyes closed. Interictal and ictal epileptic events are recorded from epileptic participants employing intracranial electrodes in datasets C, D, and E.

Following the gathering of data, numerous feature extraction strategies were investigated. DWT has been discovered to be the most effective and powerful methodology for processing EEG signals in one-dimensional format. As a result, this procedure was applied using MATLAB, and the results were obtained. Following feature extraction, multiple machine learning approaches were applied to assess how these strategies performed in an epilepsy detection classification task on an EEG data.

1.2 Problem Statement

Epilepsy is a neurological disorder that involves recurrent seizures and a sudden behavioural change due to increased brain electrical activity. The effects of this abnormal electrical brain activity will cause seizure. Seizure can cause unconsciousness and excessive body shaking. The epilepsy patient constantly getting seizure event without having to know when and how it might happen. With helps of Electroencephalogram a typical pattern of brain activity changes when seizure happen can be seen on the EEG reading (Szczypka et al., 2001). The EEG signals help to examine the neuronal disturbances that happen because of epilepsy.

The EEG records consists of a large number of hours-to day details and making it very complicated, prolonged, and costly task with a large number of epileptic patients admitted to the hospitals. This will require a huge number of data need to be recorded. Therefore, this method needs to be optimized strongly. A suitable epileptic seizure detection method (Fernandez et al., 2007) in EEG signals based on DWT can be used to analysed EEG signals at different frequency sub-bands and classify using an Artificial Neural Network (ANN).

Essentially, EEG records are rarely observed because the oscillation is complex, pure, and plain. The EEG signal analysis requires the algorithm for accurate measurement (Kreitzer and Malenka, 2008); hence the interpretation is not carefully studied by the analytics. This proposed work investigates the flexibility of using wavelet transform as a pre-processor of an Artificial Neural Network (ANN) based on EGG decomposed data. To solve the problem whether the data is suitable or not, the data is developed by using MATLAB Neural Network toolbox. From the parameter data adopted, the capability of the ANN techniques to classify healthy and epileptic individuals based on their EEG parameters can be proven.

Generally, neurophysiologists or accredited neuro-clinicians have never had their EEG recordings visually inspected for epilepsy detection. It would interrupt the diagnostic process and, in several cases, take many hours or more to record the EEG. Aside from that, they need a framework due to the large number of long-term EEG records (M. Winterhalder, T.Maiwald., 2003) and their increaseduse for successful neurological disorder evaluation and treatment, including epilepsy. It will also limit the expert's willingness to misread the data and make an incorrect judgement. They must also ensure that the data is accurately collected and measured, which is more difficult tocompare and analyse than visual data.

1.3 Project Objective

A detailed evaluation of the EEG signal can help treat a variety of neurological conditions. These signals are predominantly responsible for a wide range of brain disorders. Due to excessive equipment costs and a lack of competent engineering sciences, studying these signals was difficult decades ago. These constraints, however, have lately been overcome, and a variety of low-cost hardware options for capturing the EEG signal are now available. As a result, a variety of methods for recording these signals and directly visualizing the graphs using the software have been created, which may then be assessed by a professional and some observations on the functioning of the brain made. As a result, the following is the project's goal:

a) To develop an EEG Epilepsy Recognition System using Feed-forward Neural Network as Artificial Neural Network (ANN).

b) To identify which sort of input data should be utilised to investigate epileptic seizures detection and obtain the optimum results for usage with a neural network.

c) To test and compare real brainwave data, obtain from EEG sensor by using Artificial Neural Network (ANN) and execute using Matlab's.

1.4 Scope of Project

The scope of this project are:

a) The epilepsy dataset used for training, testing, and validation was obtained from the Department of Epileptology at the University Hospital of Bonn.

b) Extracting raw data into sub-bands using the Discrete Wavelet Transform (DWT) methodolody.

c) Used standard deviation and mean for feature extraction to compare which has better accuracy.

d) Used the Feedforward neural network (patternet) approach as an Artificial Neural Network (ANN) classifier to analyses data and classify it.

e) Obtaining raw EEG data with MindLink Sensor for comparing real-time brainwave data from EEG sensor using Feed-forward Neural Network approach as Artificial Neural Network (ANN) and training the data with EEG dataset from University of Bonn.

f) Used Matlab to execute real-time brainwave data from EEG sensor.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The EEG signal is commonly used to record the electrical movements of the brain signal, which is invented in the human brain. The currents that flow during the synaptic processes of numerous neurons in the cerebral cortex make up an EEG signal (Sanei S, Chambers JA). During activation, small magnitude currents are generated within the dendrites of brain cells. As a result, the currents produce a magnetic field that may be measured using electromyogram equipment.

To determine the state and stimulation of the human brain, depth psychology, and EEG signal monitoring are used. EEG is often used because, like PET and MRI, it can provide great temporal resolution at a reasonable cost. A significant number of neurons make up the human brain. When information enters the brain, these neurons collide. This technique produces very small amounts of power that are merely temporary in nature. Because the frequency of this signal does not remain constant over time, it is also known as a nonstationary signal. Synaptic currents are considered to form within the dendrites of brain cells during activation (Sanei S, Chambers JA).

Hans Berger was the first to measure EEG waves in 1929. He was the first to observe electrical activity in the brain of a human. The collision of distinct neurons produces these signals, which can be read by inserting electrodes into the human scalp. It can be implemented in human brain physiology research and provides a full view of neural activity. Because of their small size, these signals are measured in microvolts. These signals change based on a person's mental state. Distinct human behaviors can result in different EEG signal frequencies. EEG is a test done on the human brain to record these signals and visualize the brain's condition (D. Mantini, M. G. Perrucci). Many neurological disorders can be cured by appropriately analyzing these signals. Neurons are charged most of the time by pumping ions across their membrane. These ions are exchanged on a regular basis by neurons. Ions that have been polarized are attracted to one another. As a result, a number of ions repel each other through their neighbors. Volume conduction is the term for this. Data flows in a mental capacity using this technique, resulting in the development of a little electric arc.

MRI, magnetoencephalography, functional magnetic resonance imaging (Zhang Q, LeeM), and electroencephalograms are used to measure brain activity. The EEG is commonly utilized in BCI research to detect brain activity because it has a faster response time and is less expensive than other technologies (Sanei S, Chambers JA). Figure 2.1 depicts the general architecture of a human neuron.

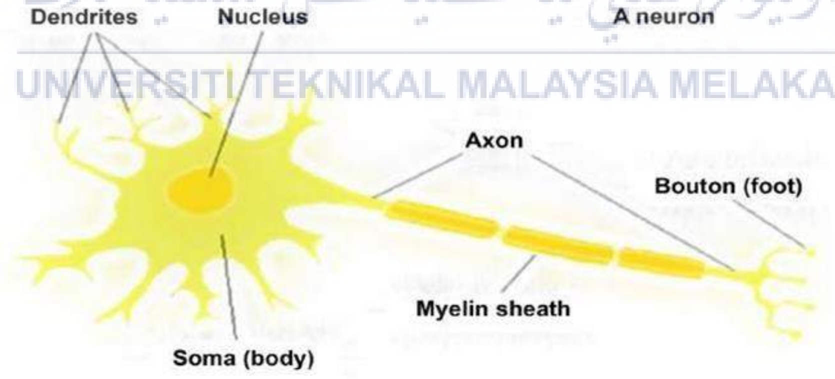

Figure 2.1 Basic Structure of a Neuron