A DEEP LEARNING ALGORITHM TO DETECT CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD) USING ELECTROENCEPHALOGRAM (EEG) SIGNAL

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I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

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DEDICATION

A very special dedication for my beloved family especially to my father, Rosman Abdul Rahim and always in my heart, my late mother Allahyarhamah Norainun bt Abu Samah. I miss you more than ever, Ibu. Also to my supportive supervisor, Dr Abd Shukur bin Ja'afar and co-supervisor, Dr Syafeeza bt Ahmad Radzi.

ABSTRACT

Autism Spectrum Disorder (ASD), also known as autism is a condition where neurological disorder found in the brain development of the human being. Autistic patient will develop communication disorder and lack of social interaction. The number of children that have been diagnosed with autism increased each year. Therefore, it is significant to have early detection of presence of autism symptom in a child from an early age. This project is aimed to integrate signal from autistic child by using Electroencephalogram (EEG). This project successfully investigated the brain signal database using pattern recognition techniques from a deep learning method. The extracted features will undergo multilayer perceptron network for the classification process. The proposed method is able to give a high intermediate accuracy to detect autism presence in a child. The dataset obtained from University King Abdulaziz, Jeddah Saudi Arabia. The obtained dataset is three normal person and two autistic patients. By using 2D CNN, the obtained accuracy is 70%, while by using 1D CNN the obtained accuracy is 76%. In conclusion, the result achieved has proved that the deep learning method is viable for autism-normal EEG signal classification.

ABSTRAK

'Autisme Spectrum Disorder' (ASD), juga dikenali sebagai autisme adalah satu keadaan dimana terdapat gangguan saraf yang dijumpai dalam perkembangan otak manusia. Pesakit autistik akan mengalami gangguan komunikasi dan kurang interaksi sosial. Bilangan kanak-kanak yang mengidap autisme meningkat setiap tahun. Oleh itu, adalah penting untuk membuat pengesanan awal kewujudan autisme dalam kanak-kanak dari usia awal. Projek ini bertujuan untuk mengintegrasikan isyarat dari kanak-kanak autistik dengan menggunakan peranti Electroencephalogram (EEG). Projek ini akan menyiasat dalam pangkalan data isyarat otak yang menggunakan teknik pengecaman corak iaitu belajar kaedah. Ciri-ciri yang diekstrak akan menjalani rangkaian 'multilayer perceptron' untuk proses pengelasan. Cadangan kaedah ini berupaya memberi ketepatan sederhana tinggi untuk mengesan kehadiran autisme dalam kanak-kanak. Dataset diperolehi daripada Universiti King Abdulaziz, Jeddah Arab Saudi. Dataset mengandungi tiga orang biasa dan dua pesakit autisme. Dengan menggunakan 2D CNN, ketepatan diperolehi adalah 70%, manakala 1D CNN ketepatan diperolehi ialah 76%. Kesimpulannya, keputusan yang dicapai telah membuktikan bahawa kaedah 'deep learning' mampu mengkelaskan isyarat EEG bagi orang autisme dan orang normal.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASD	:	Autism Spectrum Disorder
EEG	:	Electroencephalography
CNN	:	Convolutional Neural Network
REO	:	Resting Eye Open
REC	:	Resting Eye Closed
PSG	:	Polysomnographic
MLP	:	Multilayer Perceptron
MEG	:	Magneto Encephalogram

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Autism Spectrum Disorder (ASD) is a behavioral syndrome that adversely affect a child where the behavioral symptoms starts to appear during the first year of life[1]. This early childhood onset includes symptoms such as lack in social interaction and very slow language skills development as stated by N. Boutros et al.[2]. A continuous characters and behavioral assessment is conducted by specialist in order to detect presence of autism in a child. A documented analysis done by pediatrics stated that, an autistic child at approximately 24 months, are still unable to produce two meaningful words that do not involve imitating and repeating. Despite so much research being conducted, the exact factor his kind of disorder occurred remain unanswered. The reason behind the difficulties on the detection of this

behavioral disorder is due to the barely noticeable changes of the primary neural impairment itself.

The relation of ASD with EEG signal can be seen from a significant decline of EEG complexity perceived in autistic children. The key differences were observed between brain region in the right hemisphere and the central cortex represented by T. Liu et al.[3]. EEG signals are electrical voltage triggered on the electrodes by brain electromagnetic signals (BEMS) [4]. At the hospital, a specialized technicians measures, marks and put about 16-25 electrodes on the patients. Many research shows that the EEG signals, which consists of Alpha, Beta, Gamma, Delta and Theta, of ASD child is not the same as compared to non-ASD child.

Deep Learning is one of the branches in machine learning. As mentioned by D. Rav et al.[5], deep learning includes the use of a lot of hidden neurons and layers, usually more than two, as an architectural benefit, in addition with new training platform. Regardless, it is machine or deep learning, both consist of supervised learning and unsupervised learning [17]. Supervised learning is developing a predictive method based on input and output data. While unsupervised learning is grouping and interpreting data based on input data only.

However, the study conducted by S. Ibrahim et al. [6] did mention that deep learning can be an excellent tool to be applied in clinical brain imaging. This is further supported by studies conducted by K.Audkhasi et al. [7] stating that deep learning is a very reliable method to quickly address patient health condition by classifying of diseases, delete redundancy but at the same time maintains correctness and precision of disease identification. Another research by D.Rav et al. [5] stated that when data availability increases, deep learning systems can be developed

gradually and fill in the gaps where human interpretation is not possible. Eventually, the process of detecting the presence of this disorder becomes less time consuming. Health care personnel can be certain on their diagnosis in the decision-making stage.

1.2 Objectives

This project is carried out based on the following objectives:

1. To analyze Electroencephalogram (EEG) from Autistic Spectrum Disorder (ASD) database using Deep Learning.
2. To investigate the difference between autism and non-autism using EEG signals from autism database.
3. To validate the performance of classification technique of Deep Learning model in term of accuracy.

1.3 Problem Statement

It has been reported that the number of children with autism spectrum disorder is increasing each year. The Ministry of Health reported that 1 over 600 children in Malaysia was autistic in 2004. In more developed country such as the US, it is reported that 1 in 68 is diagnosed with ASD, while in the UK, 1 in 100 is autistic. Another report by J.Wang et al. [8] stated that in estimation, ASD affects 1 in 88 children and in terms of gender, it was 1 in 54 males. The process of diagnosing ASD is very tricky since this disorder is not necessarily inheritance.

The current diagnostic method to detect the presence of autism in a child is based on continuous behavior and developmental history assessed by experienced physicians. Besides, the doctor will conduct surveys with parents in the process of diagnosing a child based on the behavior of the child. During a regular check-up, high risk infant (have siblings with ASD) or suspected child is closely monitored by pediatrics. However, solely depending on behavioral features is not reliable, especially in detecting ASD during the first year of life. This is because ASD is defined behaviorally. The abnormal behavior of ASD only appears mostly on the second or third year of life. In some cases where parents realizes there are abnormalities with their child throughout infancy, it is still almost impossible to detect autism before the age of 18 months as stated by M.S.Mythili et al.[9]. The reason this happens is because autism symptoms such as lack of social and communicative skills, theory of mind and lack of empathy varies according to severity [10]. Thus, detection before the age of three remains highly impossible. In some cases, ASD could be mistaken with other neurodevelopmental condition. All of these factors contribute to the reason why doctors find it difficult to diagnose ASD presence in a child in the early age based on behavioral method. Thus, the need to have such measurable tool is definitely important as proper indicator to measure the presence of ASD based on brain EEG signal. If resting state of EEG signal could be implemented to detect ASD, high risk infant could be detected as early as 6 months age [8].

There is not yet a quantifiable method as a diagnosis tool specialized in detecting presence of autism in a child and EEG is found to be the most fitting to do this job. Late detection may result in an autistic patient did not get a proper treatment. Since autistic child is not the same as normal child, there are reports that shows evidence

autistic child could experience difficulty in their daily lives. In study by N.N Boutros et al. [2] with 25 children with ASD, the result shows that 30% of these child experienced seizures. In an experiment conducted by P.R.P Hoole et al. [4] where autistic subjects perform task of motor movements and opening of eyes, the EEG alpha waves did show the differences between normal child and autistic child- which later, leads to an indication that autistic child may have visual disorder from young age [4]. This shows that before the final diagnosis itself, ASD child already suffer from side effects that is the direct cause of the disorder itself. However, since diagnosis could not be made earlier, the child suffers from health side effect that tends to worsen as they grew up. This is a strong indicator there is a need of effective biomarker for ASD since patients can actually start suffering much earlier from the final diagnosis [8].

1.4 Scope of Project

This project focused on the development of deep learning algorithms to detect the presence of autism. The severity of autism is not discussed in this project. This project are based on the EEG dataset, which show the measurement from the brain signal. The database used in this project is the database of autism and normal EEG brain signal of children. The database is obtained from University King Abdulaziz, Jeddah, Saudi Arabia with a total of 5 persons. The normal person used is three people while the autistic patient is two people. The deep learning libraries used are Keras and Tensorflow. The deep learning algorithm used is CNN while the coding language is Python 2.7. The library, algorithms and the coding language are implemented in Linux (Ubuntu) operating system.

1.5 Brief Description of Methodology

At the beginning of this project, research is carried out about Autism Spectrum Disorder (ASD), Deep Learning and Electroencephalogram(EEG). After these terms and their relations are well understood, it is proceeded to the findings of the dataset and contacting organization that provides this dataset. Next, installation of the required software such as Python, Keras and Tensorflow is conducted and is followed by the algorithm development. Since the beginning of this project, the most important part is finding the existing dataset. After the pre-processing step is done, the training process begins. This involves determining how many hidden layers is used according to previous work. The evaluation of deep learning algorithm begins when coding can start recognizing the signal given. Next, training process begins and the best result is obtained during training. After that, the performance measurement of the systems involves testing the algorithm with random EEG signals from a normal person or an autistic child. Then, the result is analyzed to further discussed and specific conclusion.

1.6 Thesis Organization

This report includes five chapters. Chapter 1 introduces the subject matters, problem statement, objectives, scope of the project and summary of the methodology. Chapter 2 explains in details of the deep learning algorithm and EEG signals implemented to help medical field detect the presence of ASD. A different method used to detect ASD in different papers is discussed in here. Some successful research that uses EEG to detect other diseases using deep learning are also presented here. A brief description of deep learning and CNN is described in this