# PERFORMANCE EVALUATION OF CONVOLUTIONAL NEURAL NETWORK (CNN) FOR EEG EMOTION CLASSIFICATION

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# PERFORMANCE EVALUATION OF CONVOLUTIONAL NEURAL NETWORK (CNN) FOR EEG EMOTION CLASSIFICATION

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**This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours**

**Faculty of Electronic and Computer Engineering**
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# APPROVAL

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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Supervisor Name : DR. LIM KIM CHUAN

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# DEDICATION

Dedicated to my beloved family and friends

# ABSTRACT

Emotion classification through facial expression or speech intonation is not reliable as human can hide their emotion when expressing their feelings. Therefore, a deep learning technique, Convolutional Neural Network (CNN) is implemented and optimized in this project to analyze human emotion in a more reliable manner. Experimental paradigm is designed by using audio-visual stimuli selected from IAPS and IADS-2 database to acquire EEG data with different emotions. The proposed CNN algorithm is trained on the collected EEG data and then validated by using an open source dataset (SEED). The proposed CNN algorithm achieves the best accuracy of 65% (2 classes of emotion) and 82% (3 classes of emotion) form EEG data collected in the lab and SEED dataset, respectively.

# ABSTRAK

Klasifikasi emosi melalui ungkapan wajah atau ucapan intonasi tidak boleh dipercayai kerana manusia boleh menyembunyikan emosi mereka ketika menyatakan perasaan mereka. Oleh itu, satu teknik "deep learning", iaitu Convolutional Neural Network (CNN) telah diguna dan diubahsuai dalam projek ini untuk menganalisis emosi manusia dengan cara yang lebih boleh dipercayai. Eksperimen dirancangkan dengan menggunakan rangsangan "audio-visual" yang dipilih dari pangkalan data IAPS dan IADS-2 untuk memperolehi isyarat EEG dengan emosi yang berbeza. Algoritma CNN yang dicadangkan telah dilatih dengan data EEG yang dikumpul dalam makmal dan kemudian disahkan dengan menggunakan dataset sumber terbuka (SEED). Algoritma CNN yang dicadangkan mencapai ketepatan terbaik dengan 65% (2 kelas emosi) dan 82% (3 kelas emosi) daripada data EEG yang dikumpulkan dalam makmal dan SEED.

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| | | |
|---|---|---|
| BCI | : | Brain Computer Interface |
| CNN | : | Convolutional Neural Network |
| DBN | : | Deep Belief Network |
| EEG | : | Electroencephalograms |
| ERP | : | Event Related Potential |
| IADS-2 | : | International Affective Digitalized Sounds |
| IAPS | : | International Affective Picture System |
| ISI | : | Inter-Stimulus Interval |
| KNN | : | K-Nearest Neighbors |
| LDA | : | Linear Discriminant Analysis |
| LR | : | Logistic Regression |
| NB | : | Naive Bayes |
| PNN | : | Probabilistic Neural Networks |
| SEED | : | SJTU Emotion EEG Dataset |
| SVM | : | Support Vector Machine |
| TMSi | : | Twente Medical Systems International Porti System |
| TTL | : | Transistor-transistor logic pulse |
| UTeM | : | Universiti Teknikal Malaysia Melaka |

# CHAPTER 1

# INTRODUCTION

This chapter consists of five sections. The overview of the project is firstly presented in this chapter. The objectives of this study are stated in section 1.2. Section 1.3 is the problem statement regarding to the study. Section 1.4 discusses the scope of work. The thesis outline is presented in the final section of this chapter.

## 1.1 Project Overview

Emotions can be defined as sensory projection to stimuli which involves thoughts, physiological changes and expression of feelings [1]. In recent years, emotion recognition system playing an increasingly important role in enhancing the experience of human-machine interaction. For instance, the importance of emotion recognition in human-machine interaction has clearly shown by a human-like robot named Sophia. Sophia is a social robot created by Hanson Robotics which is able to recognize and process emotional data during conversation with human [2]. The model of Sophia is shown in Figure 1.1.

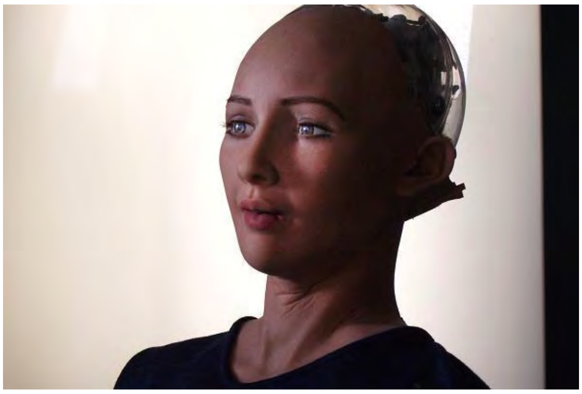

**Figure 1.1: The model of Sophia** [2]

Various research has been carried out to study human emotions. Generally, human emotion can be classified through the external appearance clues and the "inner" emotion reflected by brain activities. Emotion detection through external clues such as text, speech intonation and facial expression are commonly used to classify emotion as it is a direct reflection of emotion which is able to be easily detected. On the other hand, emotion classification through the "inner" emotion reflected in electroencephalograms (EEG) signal with the aid of deep learning technique becoming popular in recent years as EEG decoding plays an important role in most brain computer interface (BCI) for clinical applications. The researches revealed that the characteristic of EEG signals with high temporal resolution allow it to react to emotional stimuli in millisecond. This indicate that emotion classification using EEG signal is a more reliable approach as compared to the external appearance clues that can be hidden and faked in expression [3].

In light of this, a deep learning technique, convolutional neural network (CNN) algorithm is implemented in this project to decode EEG signals with different emotional states. This project begins with experimental design for EEG signal acquisition. The raw EEG signals will be preprocessed and rearranged before fed into the proposed CNN architecture to be classified into different emotional states.

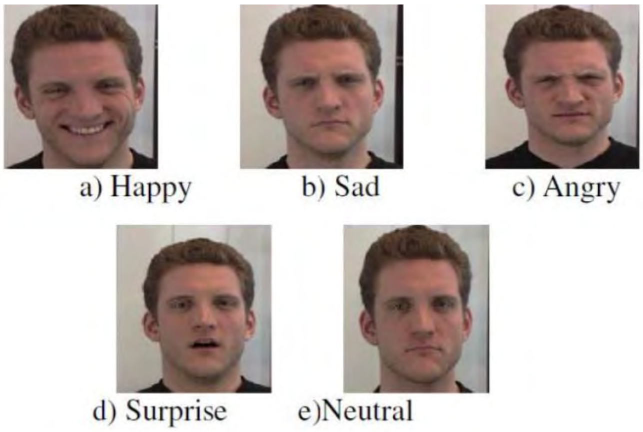


**Figure 1.2: Emotion detection through external clues** [4]

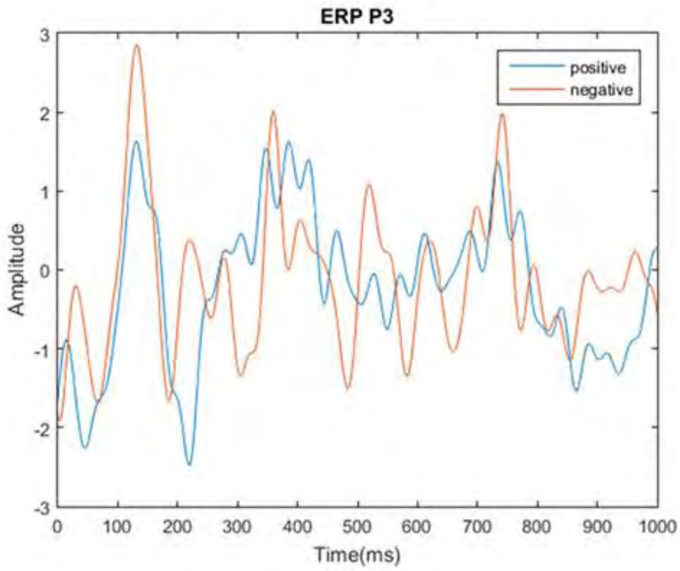


**Figure 1.3: Emotion detection through EEG signal**

## 1.2 Objectives

There are three objectives in this project which listed as below:

i. To design and develop an experiment to acquire EEG signal with different emotions.
ii. To analyze and optimize the parameters of CNN architecture for EEG emotion classification.
iii. To validate the CNN architecture for EEG emotion classification in terms of classification accuracy.

## 1.3 Problem Statement

Emotions detection through text, speech tone and facial expression are not reliable enough as human can fake their expression of feelings. To cope with this situation, an EEG-based emotion classification system has been designed to classify human emotion by using EEG signal. Nevertheless, the EEG-based emotion classification system in study [5] only yield about 59% accuracy with the EEG data collected in the lab. Therefore, this project is aims to develop and optimize the parameters of the CNN model in order to improve the performance for EEG emotion classification. Different modality of stimuli will be designed to induce emotion for EEG data acquisition.

**Table 1.1: Properties of EEG data in study** [5]

| | |
|---|---|
| **Stimuli** | Picture (IAPS) |
| **No. emotional category** | 2 |
| **Classification accuracy** | 59% |

## 1.4 Scope of Work

This project is intended to implement a CNN algorithm that able to classify different emotions by using EEG signal as input. Experimental paradigm is designed to induce two classes of emotion (positive and negative) for EEG signal acquisition purpose. MATLAB script is written for preprocessing of the acquired raw EEG signal. The implementation of CNN algorithm is done in python (v2.7.12) with TensorFlow (V1.0.0) as framework.

The CNN algorithm is trained with both EEG data collected in the lab as well as an open source dataset (SEED). The categorization of emotion for both EEG data collected in the lab and SEED are based on dimensional model of emotion. There are two classes of emotion included in the EEG data collected in the lab, which is positive and negative emotions. On the other hand, a total of three classes of emotions, which is positive, neutral, and negative emotions are included in SEED dataset. The properties of datasets used in the project are summarized in Table 1.2.

**Table 1.2: The properties of dataset used in the project**

| Dataset properties | EEG data collected in the lab | Open source dataset (SEED) |
|---|---|---|
| **Emotion model** | Dimensional model | Dimensional model |
| **Stimuli** | Picture (IAPS) and audio clips (IADS-2) | Movie clip |
| **Category of emotion** | Two emotions (positive and negative) | Three emotions (positive, neutral and negative) |