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Classification of Electroencephalogram (EEG) and graphology for students using Artificial Neural Network (ANN)

Nur Fatin Akila Halim[1,2]*, Norfaiza Fuad[1,2], Engku Mohd Nasri Engku Mohd Nasir[1,2], Mohd Erwandi Marwan[2,3]

[1]Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 86400, MALAYSIA

[2]Brainwave Research Group, Faculty of Electric and Electronic,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, 86400, MALAYSIA

[3]Kolej Poly-Tech MARA, Batu Pahat, Johor, 86400, MALAYSIA

*Corresponding Author Designation

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Abstract : Emotions define an individual's physiological conditions and are created subconsciously. The emotions can be happy or sad emotions. Emotions may have an impact on a person's handwriting. Because emotions have a link with cognitive functions, they have an influence on cognitive tasks such as writing. The emotion also can be identified through the features of handwriting. Handwriting is one of the unique characteristics to represent what is in our minds, to communicate with others. There are many features of handwriting such as baseline, slant, pressure, spacing, and others. So, the aim of this research is to make a scientific proven between the EEG pattern and graphology analysis based on emotion recognition. The EEG data and handwriting data are collected at the same time from the subjects. The Emotive is used to record the EEG data during the subjects are writing. Next, the signal will be processed using empirical mode decomposition (EMD) in order to remove any noise and unwanted data from the EEG signal where a clean EEG signal will be produced. Then, feature extraction for emotion identification is extracted through the power spectral density (PSD) of the subjects. Finally, this sample will be classified using an artificial neural network (ANN) where the accuracy for the happy emotion is 96.2% and for the sad emotion is 95.5%. Happy emotion will have an ascending baseline and higher value of Alpha power while sad emotion will have a descending baseline and the value of Alpha power is decreased compared to happy emotion. In conclusion, both EEG pattern and handwriting reflects the emotion of the subjects.

Keywords: EEG, Graphology Analysis, Emotion Recognition

1. Introduction

**Corresponding author: fatinakila18@gmail.com*

A psychological and physiological condition in which emotions and behaviors are interconnected and evaluated within a context is referred to as an emotional state [1]. Emotions are subconsciously formed and characterize bodily conditions state [2]. The space of the emotional state can be generated from psychological factors using a discrete model or a dimensional model. For the discrete model of emotion, Plutchik recommended eights main emotion of the human such as happiness, sadness, fear, anger, curiosity, surprise, disgust and acceptance [3]. In second model which is dimensional model, the emotions are mapped to valance, arousal and dominance (VAD) emotion acceptance [3].The human brain may be thought of as a computer with an electrochemical mechanism that turns sensory data into electrical data (voltage). EEG correlates of emotion have been identified in a variety of neuropsychological research state [1]. Handwriting also can be used to recognize, appraising, and understanding personality through the handwriting pattern of the human [4]. The EEG features can be obtained either in time domain or frequency domain. In this research, the features extracted in form in frequency domain where Alpha power from the frontal of the brain is correlates valence emotion such as happy, sad and fear. The frontal and parietal lobes, according to this, are the most descriptive about emotional states, while alpha, gamma, and beta waves are the most discriminative. Handwriting analysis, psychological evaluation, voice analysis, and video analysis are all approaches for recognizing emotions. Emotions can also be predicted through psychological analysis and graphology [2]. Graphology is the analysis of the physical characteristics and patterns of handwriting. There are several pattern of handwriting that will illustrate the emotion of the subjects such as baseline, slanting and pressure. For the happy emotion or positive emotion, the baseline is ascending, rightward slanting and even pressure while for sad emotion, the baseline is descending, leftward slanting and the pressure of handwriting is heavy [5]. Handwriting is conscious efforts made by writer by the instructions of brain where the brain will send the information of the emotions through the nervous system. Then, the signal will reach to the arm, hands and fingers. Finally, the emotion will be illustrated through the features of handwriting and the output will be transferred back to brain to capture the emotion of the subject. Thus, the features of handwriting and the reading of the EEG signal will have the same output of the subject emotions

2. Materials and Methods

The data of the EEG and handwriting is collected from the subjects at the same time. The Emotiv is used to record the EEG signal when the subjects are writing. The total number of subjects is 24 where the subjects are the students from University Tun Hussein Onn Malaysia that are volunteer to become the subjects in this research. There are 13 subjects volunteer for happy emotion where there are 7 subjects from engineering background and 6 subjects from non-engineering background. For sad emotion there are 11 subjects where 8 subjects from engineering background and 3 subjects from non-engineering background. Prior to testing, the subjects are given a consent letter as well as a questionnaire. The subject also given a blank sheet of A4 paper and a ballpoint pen. The ballpoint pen is used in order to reduce the error in examining the features of handwriting. Then, the Emotiv will be attached to the head of the subjects. The subjects need to write the happy story for two minutes and sad story for another 2 minutes without copying from any others sources. The features of handwriting are analyse manually. The features of handwriting selected in this research is baseline as baseline will convey the emotional outlay and nature of the subjects. The subjects with an ascending baseline is optimistic, happy, active, and excitable. A descending baseline indicates that the person is pessimistic, sad and mentally exhausted. After selecting the subjects that fit with the features of handwriting with the emotion, the EEG signals of the subject that are recorded during writing and passed through the preprocessing step including noise reduction, band pass filter and empirical mode decomposition (EMD). The features related with the emotional states such as total power spectral density, maximum PSD and minimum PSD are extracted from the EEG signals. These features are used to estimate emotional states by classification methods. **Figure 1** shows the block diagram of the EEG signal process.

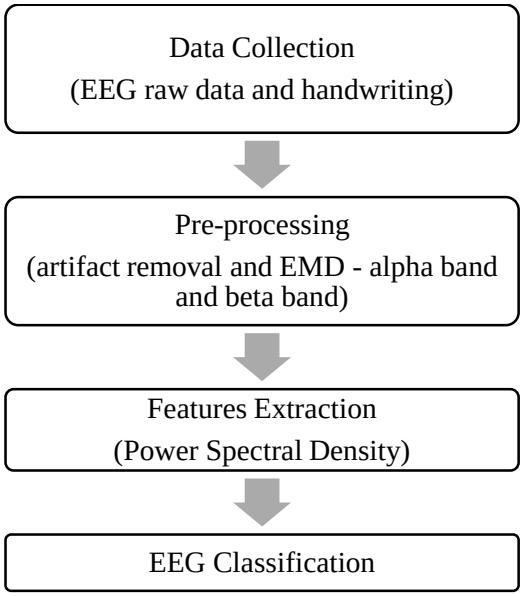

Figure 1: Block diagram of the EEG signal process.

3. Results and Discussion

The result is divided into three parts which are EEG pattern, graphology analysis and cross validation between EEG pattern and graphology analysis. For the EEG pattern, the total power of Alpha during happy is dominant compare to Beta. For sad emotion, total power for Alpha is also higher than Beta but the value of total power for Alpha during sad emotion is lower than during happy emotion (refer **Table 1**). The accuracy for the happy emotion is about 96.2% while for sad emotion is 95.5%.

Table 1: Total High Alpha and Beta Power for Happy and Sad Emotions.

Emotion	AF3		Variable Value	
	Alpha	Beta	Alpha	Beta
Happy	9	4	9	4
Sad	8	3	7	4

For graphology analysis, the emotions categories were defined with their associated handwriting attributes is shown in Table 2 below.

Table 2: Emotions Categories with Associated Attributes.

Emotion	Handwriting Attributes	Number of Students
Happy	Ascending Baseline	13
Sad	Descending Baseline	11

Finally, the cross validation is done in order to find the correlation between the EEG pattern and graphology analysis. From this research, the students that is happy tend to write in ascending baseline and the value of Alpha power is also higher. As the subjects in sad condition, the baseline of the handwriting will be descending and the value of Alpha power is also drop compare to happy Alpha power (refer **Table 2**).

4. Conclusion

In this research, the cross validation between the EEG pattern and graphology analysis can be approved. Both of graphology analysis and EEG can be used in order to determine the emotions of the subjects. This study used the real-time data of 24 subjects, obtained their emotions by writing their emotions on A4 paper and recorded EEG signals at the same time. In addition, the total power of the Alpha band and Beta band were extracted from the original signal. Next, use statistical analysis to analyses the extracted feature vectors. The results also show that happiness can be best classified and dominate the brain. The aim of this research to analyze brain signal features between happy and sad mental state is achieved where the accuracy of the emotions based on these statistical features by using ANN classifiers is about 96.2% for happy emotion and 95.5% for sad emotion. As future scope of work, greater number of categories can be defined for identifying subtle emotions and behavioral traits. And also the greater number is subjects will make the cross validation become stronger.

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