A Study of Familiarity Effects Classification in Human EEG Signal Using Hjorth Descriptor Method

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***Abstract*—There are a lot of researches related to human EEG signal that has been done before, but there are only a few of research related to familiarity effects in human EEG signal. Hence, this paper will classify human EEG signal while feeling familiar. This paper is using secondary data taken from DEAP: A Database for Emotion Analysis using Physiological Signals. The feature extraction method used is Hjorth Descriptor. The feature classification chosen is Coarse K-Nearest Neighbor, because the accuracy is 5.55% higher than the average of all K-NN methods.**

***Keyword*—**EEG**, Familiarity, Hjorth Descriptor, Coarse K-NN, K-Nearest Neighbor.**

I. INTRODUCTION

In this research, we study the classification of familiarity effects in Human EEG signal using Hjorth Descriptor method. This research is using secondary data taken from DEAP. DEAP is a multi-modal dataset for human affective stages. The data in DEAP dataset has been down-sampled, preprocessed and segmented, so we can quickly test the data to a classification. To gain lower computation complexity, this research used Hjorth Parameter as the feature extraction method. The feature classification chosen is Coarse K-Nearest Neighbor.

II. METHOD

DEAP dataset contains data that has been preprocessed before. The preprocessing methods are down-sampling the data to 128 Hz, removing the EOG artifacts, applying band pass frequency filter from 4.0-45.0Hz, averaging data to the common reference, reordering EEG channels to follow Geneva order, segmenting data into 60 second trials, removing a 3 second pre-trial baseline and the last method is reordering the trials from presentation order to video (Experiment_id) order[1]. The fact that the data has been preprocessed means we can continue straight to the feature extraction.

A. Feature extraction

We choose Hjorth Descriptor as the feature extraction method. Hjorth Descriptor is a feature extraction method that was initially used to analyze EEG signal in time domain[2]. And then, Hjorth Descriptor was also used to analyze Electromyogram (EMG), ventricle repolarization from Electrocardiography (ECG) and sound processing in lung[3].

Hjorth Descriptor has three parameter, that is: activity, mobility and complexity[2].

a. Hjorth Activity

Activity represents signal power and variance in time domain. This parameter is used to show the surface from power spectrum in time domain. Activity is represented with the equation:

$$Activity = var(y(t)) \quad (1)$$

where y(t) represents the signal.

b. Hjorth Mobility

Mobility represents the proportion from deviation standard of power spectrum or the mean frequency. This parameter is defined as the square root of variance of first derivative of signal y(t) divided by the signal variance y(t).

$$Mobility = \sqrt{\frac{var(dy(t))}{var(y(t))}} \quad (2)$$

c. Hjorth Complexity

Complexity represents the changes in frequency.

$$Complexity = \frac{Mobility\left(\frac{dy(t)}{dt}\right)}{Mobility(y(t))} \quad (3)$$

B. Coarse K-Nearest Neighbor

K-Nearest Neighbor (K-NN) algorithm is a method to classify objects based on test data with the nearest distance to the object. In training data, more than one nearest neighbor to the test data will be taken, and then K-NN algorithm will be used to determine the class[4]. Below is the illustration of K-NN if the value of k is 3.

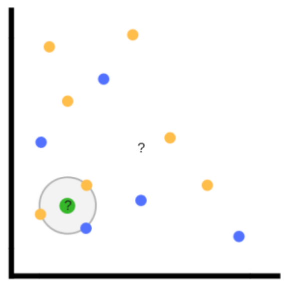

Fig. 1. Illustration of K-NN with K=3

III. RESULT AND DISCUSSION

We do several steps in this paper, using Hjorth Descriptor as feature extraction and Coarse K-Nearest Neighbor as classifier. The first step is extracting the features using Hjorth Descriptor to achieve three parameters (activity, mobility and complexity). Because we have 40.960 data, the mean of all 32 channels in each trial is calculated. After calculating the mean, we put all the parameters to be classified using Coarse K-NN. In this research, every K-NN is tested to be investigated which one will gain the best accuracy. From six K-NN methods tested, turns out that Coarse K-NN gained the best accuracy of 74.6%.

TABLE I. Accuracy of K-NN methods

Type	**Accuracy**
Fine K-NN	64.7%
Medium K-NN	68.9%
Coarse K-NN	**74.6%**
Cosine K-NN	68.7%
Cubic K-NN	68.5%
Weighted K-NN	68.9%

This research is focusing on familiarity effects in human EEG signal. The familiarity ratings in DEAP dataset has only one indicator, which is the familiarity rating itself. Perhaps, the accuracy level can be increased by adding more indicators, or by seeing how arousal, valence and/or dominance affect the familiarity effects of human EEG signal.

The classification method used is coarse K-NN. Coarse K-NN has 5.55% higher accuracy level than other K-NN methods, this might be caused by the k value of nearest neighbors used in Coarse K-NN is 100, much more than other K-NN methods.

IV. CONCLUSION

Classifying familiarity effects in human EEG signals using Coarse K-Nearest Neighbor (K-NN) gains the best result among the other K-NN methods. The features used are the three features of activity, mobility and complexity.

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