EEG based Valence Emotion Recognition by the Cognitive Model of Emotion

Jun-Su Kang and Minho Lee*
School of Electronics Engineering
Kyungpook National University
Taegu, South Korea
E-mails: {wkjuns, mholee}@gmail.com

***Abstract*—In this study, we propose a valence emotion recognition model based on the cognitive model of emotion. The cognitive model of emotion consists of a perceptual system, body response system, schematic system, and propositional system. In the implementation, we build the computational model without the perceptual system. To demonstrate our proposed method, we design an experiment on valence emotion task. From the results, we confirm that the proposed model gives the best results with the most significant electrode pairs (MSP) 15 at the theta band.**

Keywords-EEG; emotion; cognitive model of emotion; phase locking value.

I. INTRODUCTION

In day to day life, humans encode their emotional state in activities such as writing, drawing, speaking, etc. Therefore, decoding or understanding their emotional state plays an essential role in creating social linkages and supporting efficient service [1]. The encoded information of emotion is represented through explicit and implicit expressions [2].

Proposed method uses an EEG signal which is a kind of implicit expressions to recognize human valence emotion as two classes (positive and negative). EEG signal is acquired from the scalp-level of the brain non-invasively and provides good temporal resolution. It is important to identify the differences in brain activities in different regions of the brain to understand brain cognition in EEG analysis. Connectivity analysis can identify the differences in brain activities in different sensor locations of EEG device [3]. Among several connectivity calculations, Phase Locking Value (PLV) method [4] has an advantage over other methods because it is more discriminative. EEG phase differences are used to estimate conduction velocity and synaptic integration time [5]. Phase information is also robust to fluctuation in amplitude. PLV is a possible means to represent the synchronization of EEG signals. In our previous work [6], we successfully classify the human intention using PLV which only considers the relative phase between two different sensors.

The proposed emotion understanding system is based on Leventhal's cognitive model of emotion processing [7], which is primarily derived from the perceptual motor model of emotion. We apply the PLV extraction as the body response system, Fuzzy C-Means clustering (FCM) [8] and Adaptive Neuro-Fuzzy Inference System (ANFIS) [9] are applied for the schematic system and the propositional system, respectively. ANFIS is the implementation of the fuzzy inference system to adaptive networks for developing fuzzy rules with suitable membership functions given the inputs and outputs. This paper is organized as follows. In Section 2, the proposed method is presented. In Section 3, the experimental setup is represented. Results and conclusion are presented in Section 4 and 5, respectively.

II. PROPOSED METHOD

In the proposed hierarchical and multilevel process theory, Leventhal attempted to incorporate biological as well as conceptual aspects of emotion processing. Figure 1 shows the cognitive model of emotion which consists of four systems, and Figure 2 shows the computational model of emotion corresponding to Figure 1. First, the stimuli are perceived through senses (sight, hearing, touch, etc.) in Perceptual system. Then body responds implicitly (feeling, thought, etc.) or explicitly (facial expression, voice, tone, gesture, etc.) to stimuli in Body response system. Third, in the Schematic system the emotional clusters for building abstracts of current emotional states are made. Finally, in the last system, called Propositional system, labels are given to these emotional clusters.

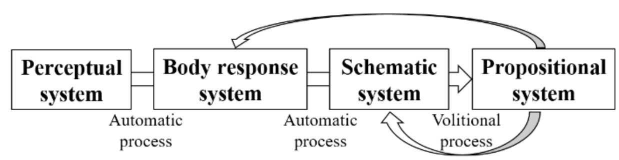

Figure 1. Cognitive model of emotion

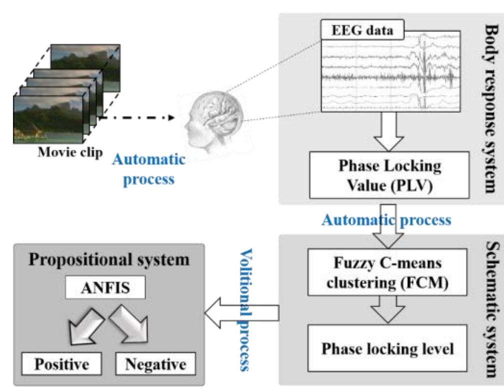

Figure 2. Overall structure of the proposed model

In this study, implementation of the perceptual system remains as future work. In the body response system, which is the first system in our model, the EEG signal is recorded when participants are watching a movie clip. From the acquired EEG signal, the emotional features are extracted by using PLV, which calculates the phase stability between two different EEG sensors. After extracting the PLV feature, MSP are selected [6]. We then build the PLV tensor to represent the dynamics of brain state. The second system in our model is called schematic system wherein the abstract representations of emotional features such as the belongingness of each representation (level of phase stability) are formed by FCM. The PLV descriptor is clustered in three clusters using FCM. The last system of our model is called propositional system wherein the decision process is performed by ANFIS.

III. EXPERIMENTAL SETUP

A. *Dataset description*

Twenty-five healthy university students (twenty-four males and one female) participated in the study. Their mean age was 22.70 years (±2.01 years). Data of 7 participants could not be analyzed because of missed-trigger information (1 participant, male) and noise in EEG signals (6 participants, 5 males and 1 female). There are total 6 blocks for emotion task. Figure 3 shows experiment procedure of this study.

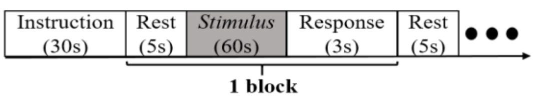

Figure 3. Experiment procedure

After watching the emotion eliciting movie, the subjects were asked to rate the video on a discrete scale ranging from 1 to 7. If the response score of a subject is over 4, we consider it as positive status, otherwise, it is considered as negative status.

B. *Preprocessing of EEG data*

EEG Data is acquired by Biosemi ActiveTwo system. Total 32 channels (Fp1/2, AF3/4, F3/4/7/8, Fz, FC1/2/5/6, C3/4, Cz, T7/8, CP1/2/5/6, P3/4/7/8, Pz, PO3/4, O1/2, and Oz) are used, and the sampling rate is set as 2048Hz. Notch filter is applied to remove the electric line noise, and bandpass filter is applied to extract the 3 to 50Hz frequency representation.

C. *Data processing*

PLV feature is extracted using 2.5 seconds window from the preprocessed EEG data, and FCM is applied to set the PLV level to the three membership. The output of FCM is used as an input to ANFIS. Parameters of ANFIS are default setup of MATLAB R2018b, namely the number of nodes is 12, the number of fuzzy rules are 2, etc.

IV. RESULTS

Based on the cognitive model of emotion processing, the proposed system attempts to determine the negative and positive emotional states by EEG signals while participants watch movie clips. For the performance evaluation, subject-wise Leave-One-Out cross validation was used. In Figure 4, average results of the proposed system are summarized, and white and gray bars are average train and test accuracy, respectively.

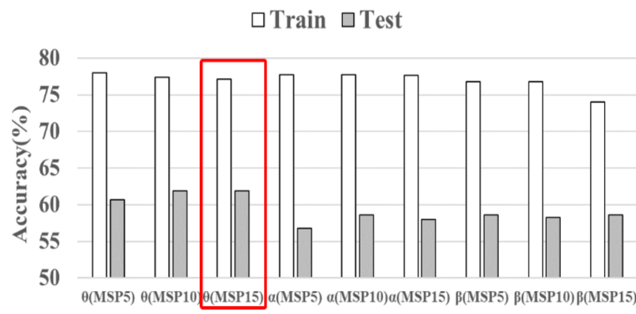

Figure 4. Average train and test performance of the proposed method according to the number of MSP

The best test accuracy (61.904%) in criteria of average accuracy is given with MSP 15 at theta frequency band.

V. CONCLUSION

In this study, we implemented the computational model of valence emotion classification based on the cognitive model of emotion. The proposed model was successfully implemented and the best test performance is given from MSP 15 at the theta frequency band. In the future work, we will implement the perceptual system and link this to the current computational model.

ACKNOWLEDGMENT

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