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Estimation of Anxiety Level Based on Multi-Modal Biosignal Classifier

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Abstract— **Anxiety is known as a natural response of the body to stress. It is normal to experience anxiety occasionally, however, frequent episode of intense anxiety which interferes with daily activities might be diagnosed as anxiety disorder. There are several self-reporting questionnaires to examine the level of anxiety, such as Beck's Anxiety Inventory. However, these self-reports might be biased by repetitive examination or individual personalities. For the past decade, various attempts were made to establish quantitative diagnostic method for anxiety disorder using bio-signals such as electroencephalogram (EEG) , electrocardiogram (ECG), and photoplethysmography (PPG). In this study, we have investigated the performance of a multi-modal biosignal-based classifier to estimate the anxiety level of 137 participants.**

I. INTRODUCTION

Anxiety disorder is one of the mental disorders caused by frequency and abnormal anxiety or fear. There are standard procedures and criterions to diagnose anxiety that requires carful observation by a trained psychiatrist [1]. The severity of the anxiety disorder is evaluated using self-reporting questionnaires such as Beck's Anxiety Inventory or State-Trait Anxiety Inventory, which is often exposed to test-retest and individual biases. In this study, we have examined how well the multi-modal biosignal-based classifier can estimate the symptom severity of anxiety. We used three common biosignals, electroencephalogram (EEG), electrocardiogram (ECG), and photoplethysmograph (PPG), that is frequency used to estimate the anxiety level [2].

II. METHODS

Total 137 participants were recruited for this experiment. According to Beck's anxiety inventory (BAI), participants were classified into 'low anxiety' group (BAI score : 0-7, number of group : 106) and 'high anxiety' group (BAI score : 8-63, number of group : 31).

For the experiment, whole participants were instructed to gaze on the fixation cross that was given on the center of the monitor. We recorded the eyes-closed resting state of the participants' EEG, PPG, and ECG for 6 minutes.

EEG, PPG, and ECG were analyzed using MATLAB 2018b (Mathworks, MA, USA). We extracted total 112 features from EEG, PPG, and ECG. To avoid overfitting, the dimensions of the features were reduced by selecting the features that are significantly different between the two groups.

To classify the severity of the anxiety to 'low' and 'high', we used logistic regression model. Whole data were separated the 90 percent of train-data set and the 10 percent of test-data set. Train data set were used 5-fold cross-validation to avoid overfitting problem. Normal control and anxiety disorder group had different sample size, so we conducted random sampling to equalize the sample size with two groups. Features were selected through sequential forward search algorithm that best represents acquired data.

III. RESULTS

TABLE I. shows the uni-biosignal based classification performance and multi-biosignal based classification performance. Accuracy (AC), sensitivity (SE), Specificity (SP), positive predictive value (PPV) and area under curve (AUC) were reported below the TABLE I.

TABLE I. RESULT OF CLASSIFICATION PERFORMANCE

Modality	Result				
(# of features)	AC*	SE*	SP*	PPV*	AUC*
ECG(5)	0.771	0.305	0.904	0.507	0.740
PPG(5)	0.775	0.424	0.876	0.515	0.775
A_EEG(8)	0.836	0.617	0.900	0.645	0.884
R_EEG(7)	0.84	0.625	0.903	0.661	0.876
Multi(10)	0.793	0.688	0.850	0.729	0.860

A_EEG : absolute EEG power; R_EEG: relative EEG power; Multi: Multimodal features

IV. DISCUSSION & CONCLUSION

In this study, we have examined the performance of the multi-modal signal-based classifier for anxiety level classification. The result shows that the classifier using does not perform better than EEG-based classifier. Further investigation is needed whether the performance of the classifier can be enhanced using more sophisticated classifier algorithms or with additional features.

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