Perceiving Stress on Affective State Based on Features from EEG

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***Abstract*— The EEG (Electroencephalogram) from brain signal has been broadly used to reveal human affects based on Valence, Arousal and dominance through computational modelling. Recently, less study on EEG been done in detail, directly to reveal and quantify the stress from affects dynamically based on EEG signal. In addition. There is no study currently perform to identify stress from the features based on EEG signals simultaneously. As for the objective of this paper, this study will only try to do features analysis of stress by comparing the statistical features of affects from the data obtained from three subjects. The data was collected during the trial session for new assembled EEG mobile system at Simulation Centre Akademi Laut Malaysia (ALAM). Subjects consist of three marine pilot who were given tasks to navigate ships in the simulated scenes. Findings and observations from the analysis are reported in this paper.**

***Keywords*—** EEG; Stress; Affective State.

I. INTRODUCTION

Stress terminology were defined into many aspects and terms, for instance in term of Biology, Mechanical Engineering and Psychology area [20]. Stress commonly correlated to human affects in understanding [13], [27], therefore the precise definition for stress in this study is according to Psychology aspects. In Psychology, stress was defined as any uncomfortable emotional experience which is attended by probable biochemical, physiological and behavioural changes [5] while a person experiences in response to threat and an external stimulus. Stress become very serious health crisis nowadays [4] which lead to affected to public work performance. Currently, most of study in stress were done in psychology area [7], [9], very less study on stress were done in neurophysiological in computational studies using EEG signal [11], [15].

EEG (electroencephalogram) is defined as a graphical representation of the brain's electrical activity and one of the neuroimaging tools. EEG systems record electrical potentials from various locations on the scalp using some specific devices. These potentials are generated by neural activity within the brain. Common categorizations of frequencies in EEG include alpha (8–13 Hz), beta (13–30 Hz), gamma (30–600 Hz), delta (<4 Hz), theta (4–8 Hz), and mu (8–13 Hz) [1]. Theta and alpha frequency bands are generally used for studying affects (emotions) [16], [17] From the signal of EEG been captured from the device, it goes through on some process lead to the respond to the affective state.

With relevant to the Affective Stimulation in this study, according to [30], to classify happiness, sadness, neutral and fear affective states, they were captured by EEG signals through channels F3 and F4, over theta and alpha bands. EEG signals captured at C3, C4, F3, F4, P5, P6, T7 and T8 are only captured from alpha frequency band [34].

Currently, in computational studies, some studies on stress were done using EEG to measure the stress level, and the model were developed for the stress detection [19], [32], [34]. Even though, yet the consequence of study shows that there is no study perform to identify stress from the features based on EEG signals. Hence, it is generally not agreed upon which features from EEG most appropriate for affective state recognition [18]. Therefore, it seems crucial for study that can give the immediate outcome for stress detection from EEG signal and simultaneously convey the information for the stress profiling. In addition, from the previous study,

the data collected from EEG signal to detect and measure the stress level, for example, study done by [32] only using single channel of electrode. By means of this, the result is not feasible to generalize the stress level as the other EEG channels were neglected.

Therefore, the objective of this study is to analyze the statistical features on EEG signal and the to identify by perceiving and point the maximum value, minimum value, the mean and standard deviation value from the statistical features which were mostly correlated to the stress. Then this study will report the pre- analysis on EEG data obtained from the subject by analyzing the statistical features from the EEG data through the resting state and affective state

This paper consists of six sections. The abstract summarized the study. Section one, introduction explain about the definition of stress and EEG. Then the problem statement and objective of study. Section two describe the design of study, explained in detail about the experiment protocol, data and data analysis. Section three discuss on the results and some discussion related to the result observed from the graphs and figures. Then section four is the conclusion, discussed on analysis and proposed on the future study to complement. Section five is the acknowledgment to those support and involved in this study. Then lastly, section sic is the list of references.

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II. STUDY DESIGN

Specific EEG device system which is assembled and turn it into the term of mobility was used for data collection (Figure 1), namely EXG Brain Marker. This device is a high-quality device with a CE- certified. This device accomplished to measure up to 19 channels for EEG signal. The signal derived from this device in term of (signal-to-noise ratio) is extremely high, thus the system highly relevant for scientific research as well as standard applications in hospitals and practices. The weight of this device is under 500 grams. It is operated with power adapter with 12 volts with 2 to 4 amps (Ampere) The current produces by this device were with the medical grade of power supply. It protects the patient from any harm when using it with electrodes. This EXG device use the electrodes cap (Wave guard connect). The electrode cap consists of two universal size which is for kids and adults. The electrodes are connected accordingly to the EXG electrodes port based on the international standard positioning system (10-20 system). The electrode port at the EXG Brain Marker device with the universal size standard (DIN Standard) which allowing enabling the use of most available electrodes [11] This device was assembled for the purpose of dynamic data collection whereas the subjects or participant can move along together while completing the given task.

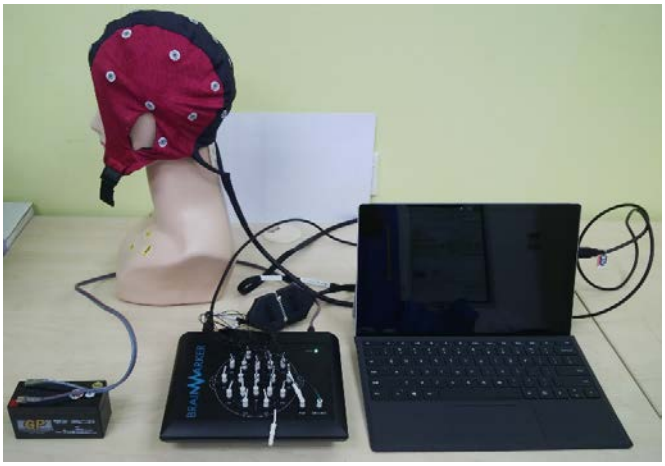

Figure 1. EXG Brain Marker Mobile EEG Device

Figure 2. EXG Brain Marker Mobile EEG Device in Bag pack.

In this study, combination and additional device were used. They are, Surface Pro 4 with specification of Intel Core i5 processor, GB RAM,128GB SSD for storage,12.3 Inch display and weight 800 Grams. Then the portable rechargeable battery with 12volt and 2.28 ampere. This battery can last for six hours with continues usage. Lastly the portable Wi-Fi with 4g connection speed, subscribed to local Malaysia telco company.

A. EXPERIMENTAL PROTOCOL

Data collection was performed at ALAM (Malacca Marine Academy), the subject is cargo ship pilot. The data were recorded during the simulation practice by the pilot. The pilot run the simulation practice based on the given and setup scenario.

The protocol or the paradigm of task sequence for the participant is divided into three main tasks (Figure3). While

performing all the tasks, the data are recorded using the EXG Brain Marker device. Formerly before performing the tasks, as a protocol for data collection, the participant will fill up the consent form and the answers the questionnaire for personality and stress test.

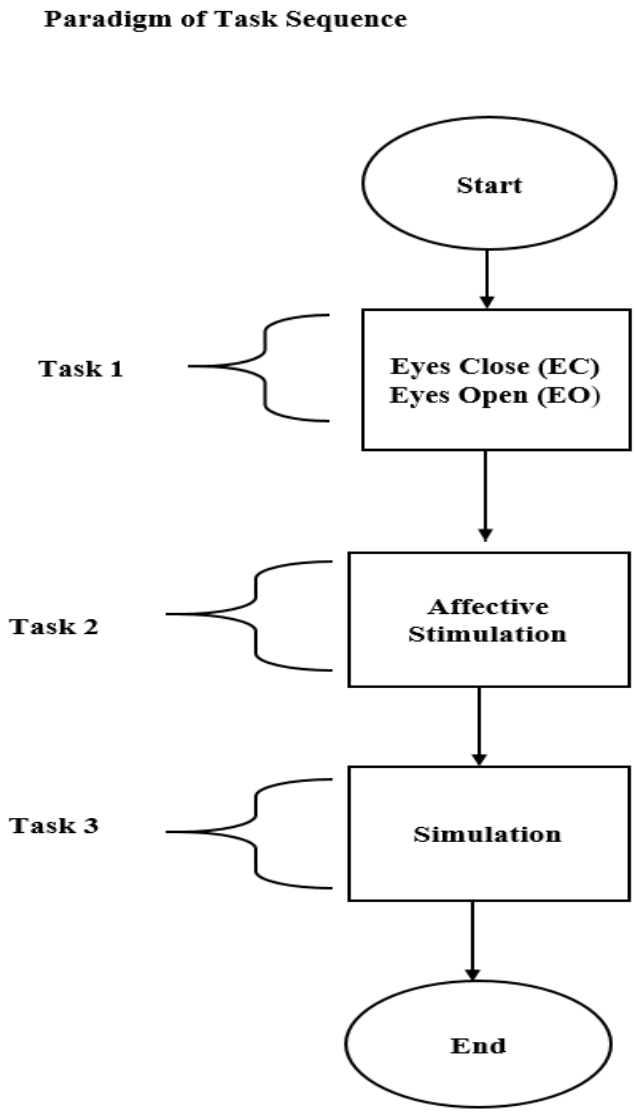

Figure 3. The Paradigm of Task Sequence

1) *EYES OPEN AND EYES CLOSE (RESTING STATES):* The figure 5 shown the task sequence involved. The first is eyes close and eyes open task (Resting States) [35]. The participant was asked to sit and closed their eyes for one minute. Later, open their eye looking at the blank white screen for 1 minute.

2) *AFFECTIVE STATE STIMULATION:* The second task is the affective stimulation. Participant was asked to watch the affective stimulation slide for four minutes. Participant would watch the IAPS slide for 4 minutes, the content of slide consists of images reflect to calm, happy, fear and sad. IAPS stand for International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1994) [22], [23].

In this study, the IAPS were selected from a set of static images based on a dimensional model of emotion. The image set comprises various pictures depicting mutilations, snakes, insects, attack scenes, accidents, contamination, illness, loss, pollution, puppies, babies, and landscape scenes, among others. According to [28], [36], [42] based on some dimensional model of emotion, it is generally shown that models including only two dimensions, valence and arousal, which are superior to models including more than these two dimensions. Consequently, the IAPS in this study select the images that will reproduce happy, calm, fear and sad. The selected images reflect to the valance and arousal in the categories of positive emotion (happy, calm) and negative emotion (sad, fear). Based on valence and arousal, the study can identify the subject for the stress detection level.

3) *Pilot Simulation:* The third task for experiment is the pilot simulation event at the Simulation Centre. The setup as a real marine ship complete with all control panel device and equipment at the cockpit deck (Figure 9). The scenario for simulation was projected through the surrounded screen glass in front of the cockpit. Participant will run the simulation where the scenario had been set up for the evaluation their action controlling the ship. The data recoding starts immediately when the simulation run. Common duration for a simulation is around 45 minutes. When the simulation stop, data recoding will be stop immediately to tally with the scenario time.

Figure 4. Simulation Layout

B. DATA

The data were attained and recorded from participants from three marine pilots at ALAM (Akademi Laut Malaysia) Simulation Centre. The pilot consists of novice, competent

and expert for their ranking. Participant from novice pilot had 1 years' experience and the competent pilot had 5 years' experience and the expert is 27 years' experience in marine pilot.

The subjects never been as subjects in any EEG experiments study and this is their first time participating. Thus, the data collection session setup took more times for the instruction and explanation about each protocol session going through.

C. *ANALYSIS*

In this section, the study will describe how each form of data was pre-processed and then analyzed.

1) *DATA PREPARATION:* The recorded EEG data from the EXG brain Marker device been classified as raw data. Data will be go through pre-processing method to get the clean data. As for recorded data during the simulation session, the data was processed through training process, which is consist of filtering, feature extraction and classification.

For filtering, the raw data from any noise and artefact to get a clean data base on it respected frequency band which is Delta, Theta, Alpha and Beta. By filtering, it removes most of the artifacts and remove all high frequency noise.

Then it went through feature extraction to extract the emotional state which is consist of happy, Calm, sad and fear. Then the classification process to classify the emotional state according to the Valence and Arousal. The trained data (emotional data) were test with the value of Valence and arousal to get the NET and it accuracy.

Then the resting state data (eyes open and eyes closed) were processed into two-part, filtering and feature extraction (spectrogram). After that the Resting state data been compared with the NET from emotional data to get the result of definite emotional state according to Valence and Arousal. Lastly, the study refers to the participant personality and stress test questionnaire result and keep it as a record for further study on it.

2) *STATISTICAL FEATURES:* EEG signals are the rich source of information about brain activity including affective state. It need to extract the valuable information from this large amount of data by reducing the amount of data available because normally, it is not possible to use these data for emotion recognition This process is known as feature extraction. This process extracts specified measures that are useful for the task. Features are characteristics of EEG signal that can distinguish between different emotions [14]. The signals were decomposed into the four commonly bands, Delta (0Hz, 4Hz), Theta (4Hz, 7.5Hz), Alpha (8Hz, 13Hz), Beta (13HZ, 30Hz). This study focuses on Frequency Domain for features extraction, through the PSD (Power Spectral Density) method to extract features for four affective state, happy, calm, sad and fear regarding to the Valence and Arousal. The features from the EEG signals been analyzed for each channel from 19 channels. This is to observe the statistical features from EEG signals for the maximum, minimum, mean and standard deviation and then compare it between three participants or subjects. This is to spot which channel is mostly correlated to the affective state that tend to lead to the stress.

III. RESULT AND DISCUSSION

The EEG data in this study were processed using MATLAB software. As for statistical features comparison, we use Microsoft Excel to analyse the value for maximum, minimum, mean and standard deviation for 19 channels from 3 participants. In this paper we only show the result from the resting state only from three participants because we already get the result of definite emotional state according to Valence and Arousal.

The following figure will show on maximum, minimum, mean and standard deviation for the resting state (eyes close and eyes open) for three different participants.

A. EYES CLOSED

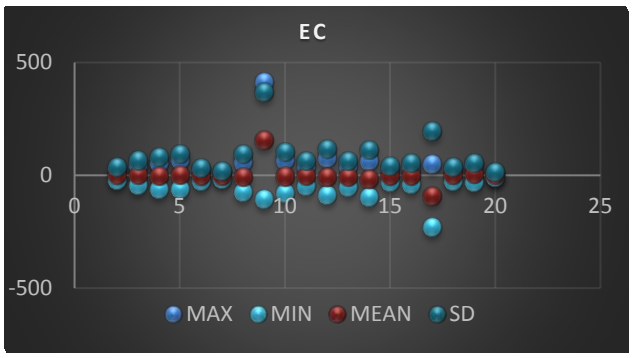

Figure 5. Participant 1

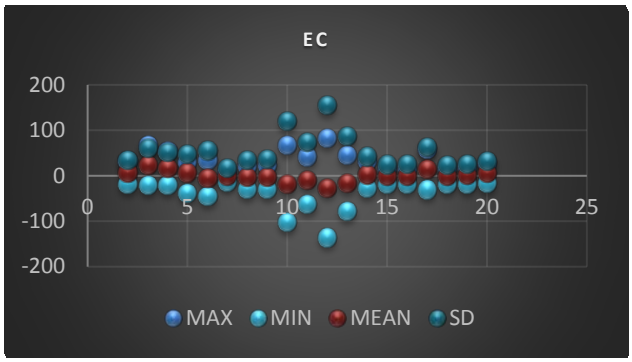

Figure 6. Participant 2

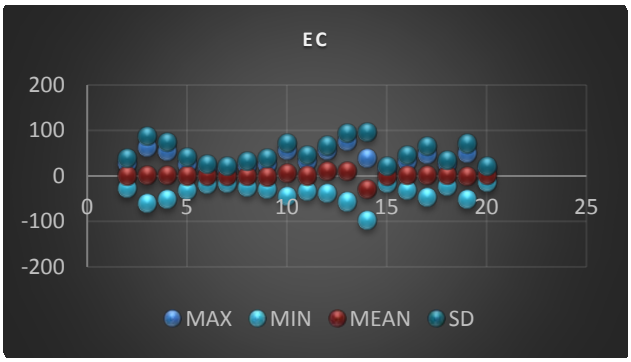

Figure 7. Participant 3

B. EYES OPEN

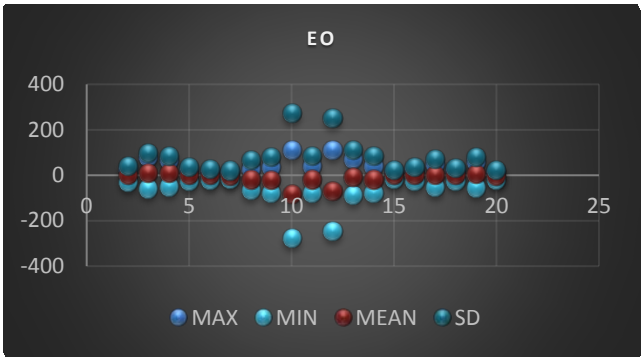

Figure 8. Participant 1

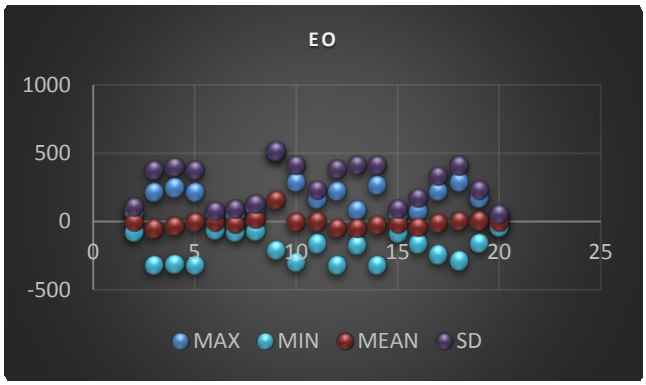

Figure 9. Participant 2

Figure 10. Participant 3

C. MAXIMUM AND MINIMUM CHANNEL FOR EYES CLOSE

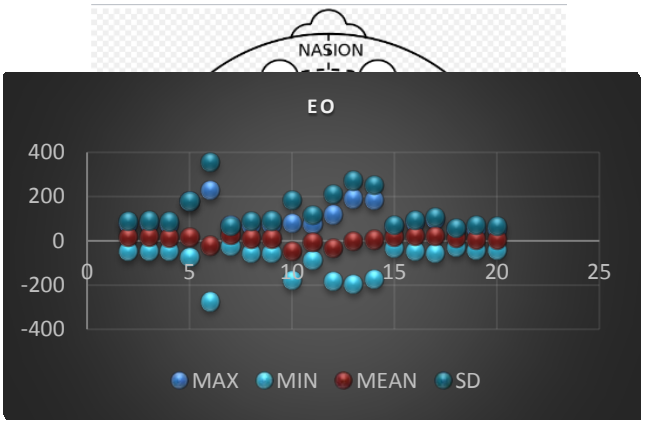

Figure 11. Participant 1

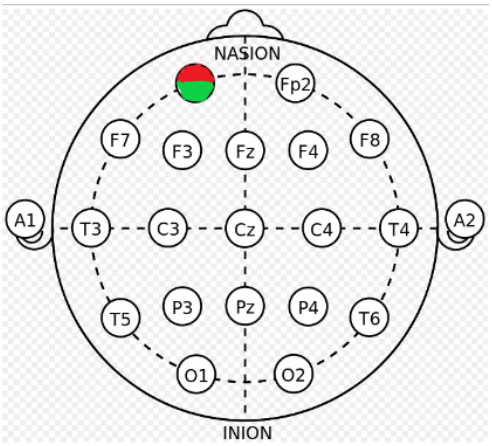

Figure 12. Participant 2

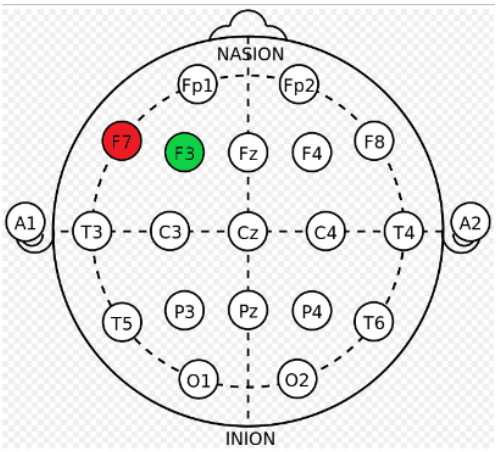

Figure 13. Participant 3

D. MAXIMUM AND MINIMUM CHANNEL FOR EYES OPEN

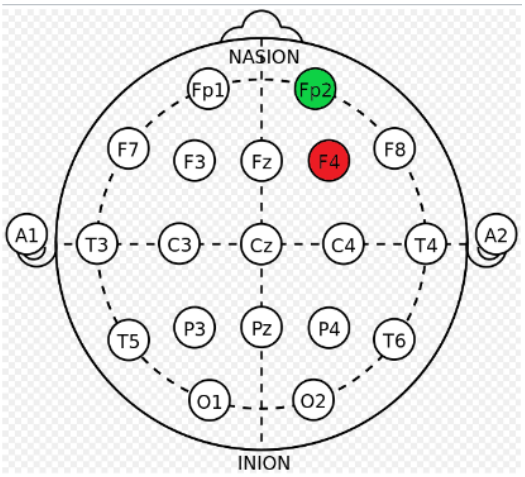

Figure 14. Participant 1

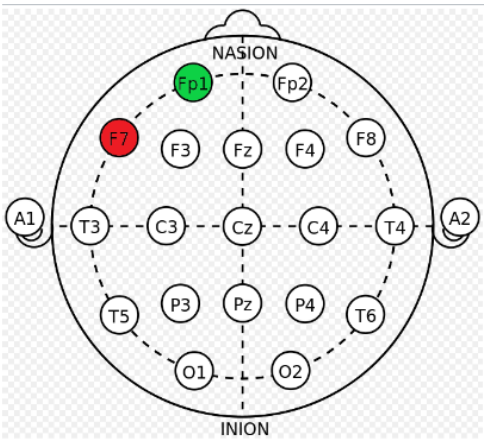

Figure 15. Participant 2

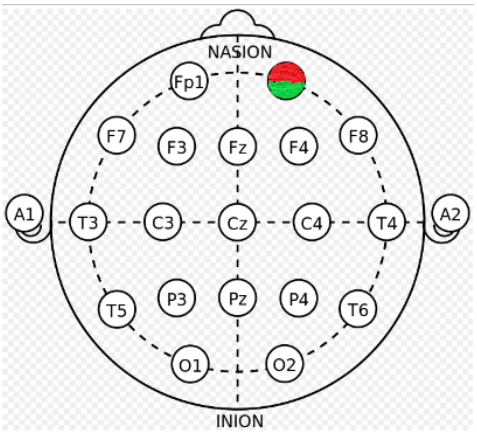

Figure 16. Participant 3

Figure 5,6 and 7 shows the plot based on features for maximum, minimum, mean and standard deviation for eyes close. X axis refer to the channel number where the Y axis is referred to the Value based on features. From the plot, we could observe only the pattern. It seems that identical pattern for participant 2 and participant 3 where the maximum range is not exceeded over 200.Compared to participant 1 which is almost reach to 500 in value. For the minimum value, all three participants share the same range of value which is below 200.The mean value for three participants show a linear value according to the plot. Nevertheless, for the standard deviation, the pattern seems scattered mostly for participant 2.

Whereas figure 8,9 and 10 shows the plot based on features for maximum, minimum, mean and standard deviation for eyes open. Also, it seems that identical pattern for participant 2 and participant 3 where the maximum range is not exceeded over 400.Compared to participant 1 which is exceeded over 500 in value. For the minimum value, all three participants share the same range of value which is

below 400.The mean value for three participants also show a linear value according to the plot. Nevertheless, for the standard deviation, the pattern seems scattered mostly for participant 1.

Figure 11,12 and 13 shows the maximum and minimum channel positioning for eyes close. All three participants did not share the similarity for the minimum and maximum positioning channel. Participant 1 show the maximum at channel F4 and minimum at T5 or P7. But for participant 2 shared the same channel for maximum and minimum, located at Fp1.Then the maximum and minimum channel for participant 3 located at F7 for maximum and F3 for minimum.

Figure 14,15 and 16 shows the maximum and minimum channel positioning for eyes open. For eyes open also all three participants did not share the similarity for the minimum and maximum positioning channel. Participant 1 show the maximum at channel Fp2 and minimum at F4. Then for participant 2, the maximum at channel Fp1 and minimum at F7. But for participant 3 shared the same channel for maximum and minimum, located at FP2.

IV. CONCLUSSIONS

From the observation, most of the maximum and minimum channel located at the frontal region when look at the channel positioning. For the shared value at the same channel for maximum and minimum also located at the frontal region of brain. The frontal area of the brain is where human affective state control, judgment, and insight comes from. This study expect that this type of pattern probably had a significant related to stress. Because the major areas of the brain most affected by stress is the prefrontal cortex, at the frontal region of brain [3]. This need to an extend of study to confirm the expectation.

To extend this study, future work could extend the emotion classification based on Valence and Arousal in detail to see which channel had the higher accuracy and then compare with the psychological stress measurement method (questionnaire) for example, probably with Dass21 questionnaire.

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