QEEG Index for Early Detection of Imbalanced Conditions During Aerobatics

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Abstract—In this paper, the brain activity was studied and observed while person was in the loss of balance state due to the vestibular system disorder. The brain activity was recorded as QEEG data which was analyzed by the Z-scored FFT method. The experimental results showed brain activities in the positions O1, O2, P3, P5, P2, T5, and T6 in the forms of topographic map (Absolute Power) and brain connectivity (Amplitude Asymmetry). The analysis of results can be employed in the EEG-based alarm system of pilot during aerobatics.

I. METHOD

The five participants performed the head-down spinning which starts by standing on feet and bending downwards to the feet. Next, the subjects touched the floor with one hand as a rotation axis as shown in Fig. 1. Each participant rotated around themselves for 10-15 times, which affects their balance ability lost. Then, the quantitative electroencephalogram (QEEG) signal [1] was recorded for 2 minutes while the participants tried to stand and recover their balance.

Data were analyzed by using the Z-scored FFT method [2]. This method used for identifying the brain regions that were de-regulated and departed from the expected values as described in “equation (1)”.

\[ Z_{\text{FFT}} = \frac{X_i - \bar{X}}{SD_z} \]  

(1)

where \( SD_z \) is the standard deviation between subjects, \( X_i \) is the EEG feature, \( \bar{X} \) is the mean value of \( X_i \) from the normative database.

II. RESULTS

All subjects reveal similar QEEG results. The experimental results can be summarized and demonstrated in Fig. 2. The vestibular system disorder effects are clearly observed in the topographic map in the range of high beta band (25-40 Hz) at the occipital and parietal lobes.

The result from this study reveals that the subjects need more visual processing and exteroceptive perception in order to perform balanced maintaining. The red area represents the higher brain activity level, and the blue area represents the lower brain activity level referred to the normative database.

Furthermore, Fig. 2 shows the brain connectivity in the high beta band. There are strong connections (represented by red lines) among O1, O2 positions (occipital lobe) and Pz (parietal lobe), Fz (frontal lobe) and Cz (central lobe). The connections between O1, O2 and Pz indicate the strong relationship between the right and left visual processing and perception. The connection between O1, O2 and Fz referred to the strong relationship between the right and left visual processing and motor planning of lower extremities. The connection between O1, O2 and Cz showed the relationship between the right and left visual processing and sensorimotor integration of the lower extremities.

III. CONCLUSION

From this experiment, a specific EEG pattern can be detected during the loss of balance. Therefore, this observed brain activity from the results can be employed in an alarm system of pilot in aerobatics. If the higher brain activities in the occipital and parietal lobes start to be detected, the warning sound will be alarmed to indicate that the pilot is in the loss of balance state.

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REFERENCES