The Fatigue Monitoring System using the EEG Signals

Worawut Yimyam
Department of Information Technology Management
King Mongkut's University of Technology North Bangkok, Thailand
Bangkok, Thailand
Worawut_yimyam@hotmail.com

Mahasak Ketcham
Department of Information Technology Management
King Mongkut's University of Technology North Bangkok, Thailand
Bangkok, Thailand
mahasak.k@it.kmutnb.ac.th

***Abstract*—there are many military missions such as the security of the border and the surveillance of Interception drug trafficking. These missions require a lot of military force and take several days to perform, so the soldiers were fatigue from the mission. Therefore, the fatigue effected to work performance and wrong decision making. This paper proposes to develop an algorithm used for monitoring fatigue of the soldiers while they perform their duty. Electroencephalography (EEG) signals are analyzed by an Artificial Neural Networks (ANN) technique and compared with other techniques. The experimental results show that the ANN provides more accurate results than Bayesnet, Support Vector Machines (SVM), and Naïve Bayes techniques. The result of the ANN technique provides the accuracy, recall and precision values at 83.77, 0.838 and 0.838 respectively.**

Keywords—Fatigue, EEG, ANN

I. Introduction

Nowadays, there are many important duties of solders in the mission of the military to perform against the law breaking such as the maintenance of the independence, sovereignty, national security, border security, and forest patrol. There are also the offenses that affect the national security such as drug and weapon trade, and deforestation. Each mission need lots of times to achieve on it. From that, soldiers may feel fatigued because of their mission. [1] When fatigue occurs, it causes accidents during the mission and also reduce work performance of the solders. For example, there was an accident occurred to US military called M985 in truck drive. The investigation found that the accident happened because of the driver's fatigue which leads him to death because of the lack of sleeping. [2] This type of problem has affected to the wrong decision, communication errors, and risk assessment. All these consequences have systematic relationships. [3]

Military's mission may face the risk any time. One mission needs many hours for working and uses a lot of military personnel. However, a number of soldiers are not enough in some military base. [6-7] Hence, these actions cause fatigue because the soldiers might work several tasks. For example, the mission of the military is to train the pilots to fly helicopter. In facts, the pilots should sleep appropriately because they have to work all day based on FFA rule. They have to wake up at 5.00 am, monitor the helicopter's engine before flying at 4 pm, take off at 5.30 pm, land at 10.30 pm, and store the helicopter at 12.30 am. Then, they move to another base to prepare helicopter at 2.30 am., recheck again at 6.00 am. until military mission is completed. As from their daily routine duties, it can be seen that the pilot's problem is the lack of sleep. Thus, the system is developed to monitor fatigue from the eyes [4-5]. There are many researches working in this area. However, the measurement of fatigue is not certainly accurate and effective.

This paper proposes the development of an algorithm used for monitoring fatigue of the soldiers while they perform their duty. Electroencephalography (EEG) signals are analyzed by an Artificial Neural Networks (ANN) technique and compared with other techniques.

II. System Design

This research focuses on the fatigue monitoring system of the military mission. The system is implemented by the EEG sensor in which it can send signal to smartphone via ZigBee and the frequency radio wave, and can collect EEG data via smartphone program. The system is able to analyze the soldier's fatigue conditions and sends the alert to the admin. The Fig. 1 shows the overview of system.

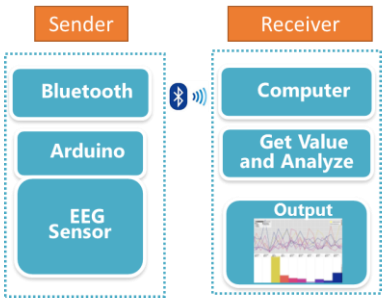

Fig. 1. Overview of system

A. EEG Sensor

This part is the analysis of the EEG signal received from EEG sensor. The fatigue from researcher's EEG signal is tested as shown in Fig.2.

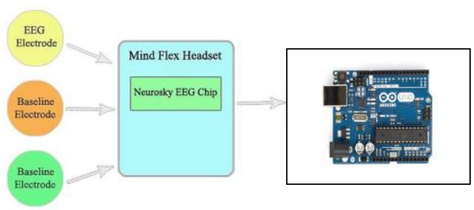

Fig. 2 Neurosky EEG Chip

978-616-368-065-5 ©2018 JSCI

B. Communication Link Arduino

EEG monitoring data is received from MindFlex Headset device. Arduino board is also used to convert value received from sensor to different types of signals which can be divided into 8 ranges: Delta 1-3 Hz, Theta 4-7 Hz, Low Alpha 8-9 Hz, High Beta 18-20 Hz, Low Gamma 31-40 Hz, and High Gamma 41-50 Hz. These frequency waves are transformed in ASCII coding.

C. Data reception

In data reception, the system connects to the Bluetooth module in order to send signal to computer for analyzing the fatigue in the next step.

D. Receive value and analyze with ANN

Artificial Neural Network technique (ANN) is used to nalyze data receiving from the EEG signals. The processing applies with neural network of the human brain. The EEG signal is an input of the ANN technique. The EEG data composes of Delta, Theta, Low Alpha, High Alpha, Low Beta, High Beta, Low Gamma, and High Gamma signals. All inputs are multiplied with weight which is represented as w1, w2, w3, w4, w5, w6, w7, and w8. Each neuron is a bias adjustment with the weighting. It has been sent to the transfer function in order to calculate the result as shown in Figure 3.

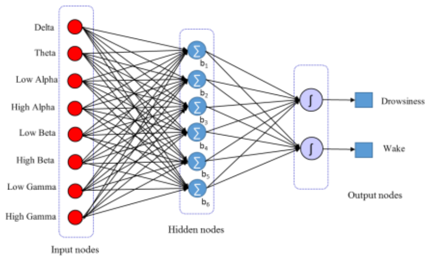

Fig.3 Example of Artificial Neural Network Technique

The Equation is shown as below:

$$a^m = f^{m+1}(w^{m+1}x^m + b^{m+1}) \quad (1)$$

Where

a^m means Output Node

f^m means Transfer Function

w^m= 0.2

b^m = 0.1

x^m =means Delta, Theta , Low Alpha, High Alpha, Low Beta ,High Beta ,Low Gamma , High Gamma

III. Experimental Results

The performance of classification is conducted by the ANN technique. It considers the accuracy of precision and recall as shown equation (2), (3), and (4). Table 1 shows the experimental results of the performance of predicted class. Table 2 shows the comparison of the performance of classification.

$$Precision(p) = \frac{TP}{TP+FP} \quad (2)$$

$$Recall(r) = \frac{TP}{TP+FN} \quad (3)$$

$$Accuracy(A) = \frac{TP+TN}{TP+TN+FP+FN} \quad (4)$$

TP = True Positive, FP = False Positive, FT = True Negative และ FN = False Negative

Table 1. The result of data experimental classification

		PREDICTED CLASS	
		Drowsiness	Wake
ACTUAL CLASS	Drowsiness	3546	595
	Wake	667	2993

Table 2. The comparison of the performance of classification

Model	*10-fold cross validation*		
	Accuracy	Recall	Precision
ANN	83.77	0.838	0.838
Bayesnet	77.07	0.771	0.777
SVM	75.40	0.754	0.759
NaiveBaye	62.10	0.621	0.712

IV. Conclusion

Researcher proposes the development of algorithm for monitoring fatigue in military mission based on brain signals. The ANN was applied to analyze the data. As a result, ANN performs higher performance than Bayesnet, Support Vector Machines (SVM), and Naïve Bayes. The experimental result of ANN technique showed the percentage of its accuracy, recall, and precision values at 83.77, 0.838, and 0.838, respectively.

References

[1] B. Sicard, E. Jouve, and O. Blin, “Risk propensity assessment in military special operations,” Military medicine, 166(10), 871-874, 2001.

[2] U. S. Army, “Leaders’ manual for combat stress control,” Field Manual 22 51 (1994).

[3] J. M. How, S. C. Foo, E. Low, T. M. Wong, A. Vijayan, M. G. Siew and R. Kanapathy, “Effects of sleep deprivation on performance of Naval seamen: I. Total sleep deprivation on performance,” Annals of the academy of medicine, Singapore, 23(5), 669-675, 1994.

[4] T. Brandt, R. Stemmer, and A. Rakotonirainy, “Affordable visual driver monitoring system for fatigue and monotony.” In Systems, Man and Cybernetics, 2004 IEEE International Conference on (Vol. 7, pp. 6451-6456). IEEE.

[5] T. Von Jan, T. Karnahl, K. Seifert, J. Hilgenstock, and R. Zobel, “Don't sleep and drive-VW's fatigue detection technology,” In Proceedings of 19th International Conference on Enhanced Safety of Vehicles, Washington, DC (Vol. 168). 2005.

[6] U.S. Army Safety Center. “Sustaining Performance in Combat,” Flight fax, (31)5:9-11. 2003.

[7] U.S. Army Safety Center. “Fatigue”, Countermeasure, (23)3:4-5. 2002.