Development of Drowsiness Detector System for Late Night Shift Worker Using Support Vector Machine Method with Neurosky Mindwave Mobile

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ABSTRACT

Drowsiness is the common thing that happens to every human. However, this could cause some problems. There have been many accidents happen in Indonesia, that worker must lose the part of his/her body, disability, and even life because of the drowsiness factor while doing work. In addition to solve this matter, an application is needed to give warning for workers when it detects the drowsiness. By using the brainwave receiver sensor, the application can give early warning in real-time based on worker condition.

This research involves 5 subjects were using Neurosky Mindwave Mobile for 3 hours from 21.00 to 24.00. Most people will begin to feel sleepy during this period of time. Each subject did twice experiments. The data gathered would be used to perform SVM training and testing. The data will be validated with β/α and $(\alpha+\theta)/\beta$ signal index. This research uses SVM as a mean to detect the level of drowsiness in brain waves.

The result of this research is the drowsiness detection application with accuracy for approximately 87.40% according to the results of the testing application of the 3 subjects who performed the valid training data.

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1. INTRODUCTION

Company's business processes may require the service for 24 hours a day. However, this could cause some problems. For example, in Situbondo, a worker lost his hand because of drowsiness while working in a wood cutting machine [1]. A young even lost his life because working in a sleepy condition [2].

Car driving is very prone to accident due to drowsiness. According to Directorate General of Land Transportation, Department of Transportation (http://www.dephub.go.id), accident that occurred in Indonesia is 93.52% caused by drowsiness.

Researches for early drowsiness detection have been done by previous researchers. Various methods have been used, such as CarSafe [3], a method based on eye's blink through Computer Vision technology. It utilized camera on a Smartphone. Its accuracy to detect drowsiness was up to 85%.

Yeo et al used SVM method to improve the drowsiness detection accuracy [4]. The results obtained in their study show that "SVM" was able to detect drowsiness as much as 99% in accuracy [4]. SVM is selected as drowsiness detecting method in this study because of the high accuracy.

The purpose of this research is to create an application which able to detect drowsiness by using a brain wave receiver called Neurosky Mindwave Mobile. The Electroencephalography (EEG) data will be processed using SVM method to determine whether the user is in a sleepy state or not. Alarm will ring when drowsiness is detected.

2. RESEARCH METHOD

Research methodology in this paper is described in Figure 1 below:

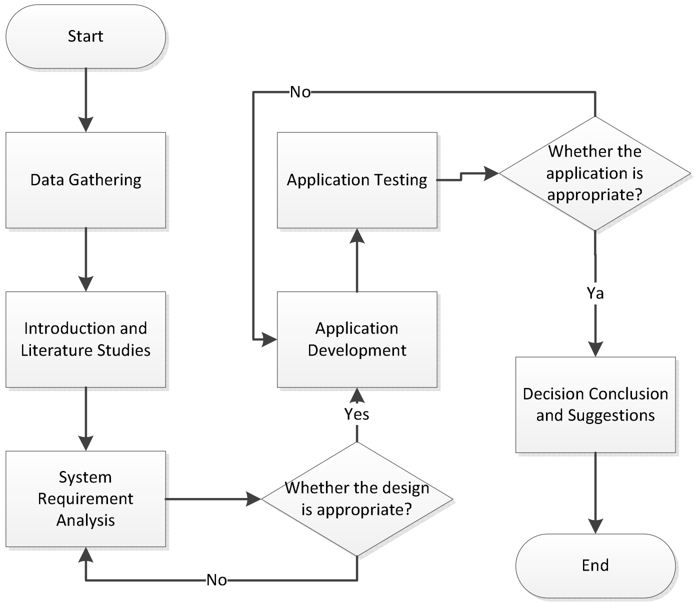

Figure 1. The flowchart of research methodology in this study

2. 1. Data Gathering

Data Gathering was the first stage, in order to get brain wave data from night workers. Night workers were examined while doing job in front of computer at night time. Students that do their job at night are included in this category. 5 subjects were using Neurosky Mindwave Mobile for 3 hours from 21.00 to 24.00. Most people will begin to feel sleepy during this period of time. Each subject did twice experiments.

The data gathered in this step would be used to perform SVM training and testing. Total EEG data obtained was 10 dataset. Each data set consisted of brain activity recording for 3 hours. Therefore, the total length was 30 hours of recording brain activity.

The authors of this paper were responsible for logging equipment, and also made a recording of subject's drowsiness level (Karolinska Sleepiness Scale/KSS). Subjects were asked about their KSS level every 5 minutes. KSS data would be used for SVM training and also measuring the accuracy from sleepiness identification methods which is applied

2. 2. Literature Studies

The literature study stages were done to learn how to capture brain wave signals with Neurosky Mindwave Mobile and detect drowsiness using SVM method. The authors conducted literature reference search through sources on the Internet, online journals and books. Outlook of EEG sensor is shown in Figure 2 below.

Figure 2. Outlook of EEG Sensor

2.2.1. Hardware Configuration

Major specifications of the proposed system including the EEG sensor used are as follows:

2.2.1.1. Measures

EEG Spectrums :

- Alpha
- Beta
- Theta

2.2.1.2. Signal and EEG:

- Maximum signal input range: 1 mV pk-pk
- Hardware filter range: 3Hz to 100Hz
- Sampling rate: 512Hz
- Class 2 Bluetooth Radio Range: 10 m 6dBm RF max power

2.2.1.3. Bluetooth Dongle:

- Bluetooth Standard: V2.0+EDR (backward compatible with V1.1/V1.2)
- Profiles support: Serial Port, Dial Up Networking, Fax, Headset, Printer, PIM Item Transfer, PIM Synchronization, File Transfer, LAN Access, Generic Object Exchange, Object Push, HCRP, HID, A2DP, AVRCP
- LED Indicator: Power On
- OS Support: Windows 2000 / XP / Vista / 7

2.2.2. Support Vector Machine (SVM)

Support Vector Machine (SVM) is a relatively new technique, used to make predictions in the case of classification and regression. Many scientists and practitioners applied this technique in solving real world problems. Such as in: gene expression analysis, financial, weather, up to the field of medicine. Generally, SVM gives better results than similar techniques such as Artificial Neural Network (ANN). [5]

In this research, Polynomial with Polyorder 4 is used in SVM. SVM serves as a tool to detect drowsiness of users who wear a Neurosky Mindwave Mobile headset. Signals obtained from Neurosky Mindwave Mobile will be received by the application. Then, the brain wave signal will be compiled into a table with a size of 7x40 columns. From the first column to the sixth column are the brain wave data and the seventh column is the KSS data.

93	31	33	93	24	54	0
42	17	34	58	88	361	0
21	55	51	67	45	83	0
340	54	96	41	195	76	0
69	43	95	25	105	47	0
42	75	123	120	72	87	0
175	44	72	80	169	15	0
67	78	122	40	100	78	0
61	109	475	156	28	30	0
20	38	18	194	22	30	0
131	69	124	358	214	101	1
26	73	50	69	44	79	1
18	20	45	85	52	56	1
49	18	80	36	63	125	1
267	317	62	86	19	81	1
118	75	55	34	47	202	1
129	115	256	138	76	73	1
42	58	140	47	91	39	1
58	199	89	34	44	48	1
40	70	112	56	37	91	1
342	400	247	18	273	89	1
191	79	8	134	172	93	1
77	74	16	45	149	363	1
278	13	43	163	60	86	1
58	113	47	238	76	65	1
38	53	243	37	141	111	1
24	66	140	91	242	45	1
143	14	175	61	102	202	1
57	202	80	110	183	132	1
59	129	41	51	118	71	1
11	61	60	104	41	205	1
775	84	203	568	100	109	1
112	62	125	31	335	363	1
211	1145	140	221	46	30	1
296	90	61	2258	106	266	1
52	38	102	78	323	167	1
168	109	24	415	146	48	1
52	19	418	164	50	62	1
76	132	169	86	111	34	1
146	43	51	376	189	88	1

Figure 3. Example of EEG and KSS data, which are represented

These are 40 data entered into the SVM. The first 20 data are the training dataset. These data were obtained from the collection of process. Which 10 brain wave data were collected from the fully awake user, and the other 10 were from brain wave data when the user is at the sleepy condition. Then, the another 20 were derived from real-time brain wave retrieval while the user uses the Neurosky Mindwave.

2.2.3. Karolinska Sleepiness Scale (KSS)

Karolinska Sleepiness Scale (KSS) is used as a subjective measure of sleepiness. KSS is a self-rating subjective scale, ranging from 1 to 9 [6]. The level 1 described when the subject is at the most watchful condition, level 5 is when the subject is neither watchful nor sleepy, and level 9 is very sleepy and try to resist to sleep.In this research, the KSS used is only between scale 1 and 0. Which is, 1 indicates that the subject is at the drowsy condition and 0 indicates the subject is at the unsleepy condition.

2. 3. System Requirement Analysis

System requirement analysis is used to determine the step that needs to be built. In this step, we conducted the analysis on data and also necessary technology . If the requirement for the development of the system has been found, then the process of developing application will be much easier to conduct.

The analysis conducted at this stage is the analysis from brain wave data and that has been obtained at the data collection process prior with index signal using β / α and index signal $\alpha + \theta / \beta$. If there is a significant difference for both index signals, then to subject that indeed in state of fatigue [7].

2. 4. Application Development

If the system requirements has been fulfilled, and so as the base of science and technology used in the system has been revealed, then the next step is designing the system. At this point, the SVM algorithm for drowsiness detection is developed. In addition to capturing the brain signals, alarm and the storing process of the data recorded is also developed.

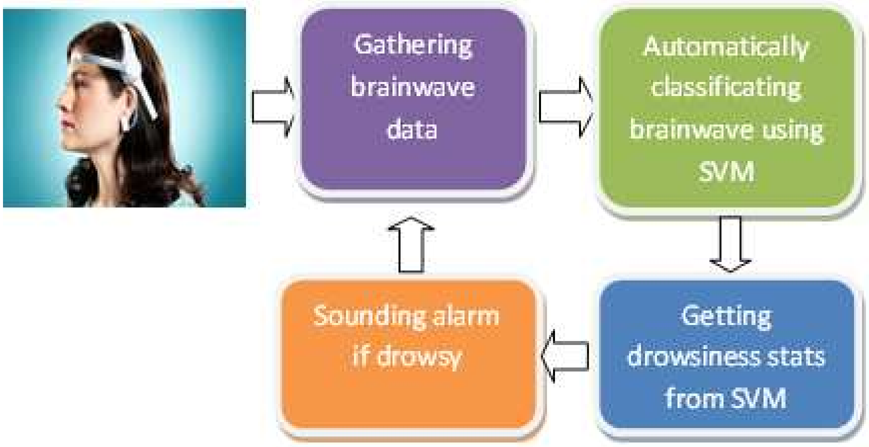

Figure 4. Application Work Flow Diagram

2. 5. Application Testing

This stage is performed to determine whether the application can run properly and in accordance detecting drowsiness on the subject of data taken. If there is any error in the application along this process, it will be advantages to correct the lack of the application. Process is done continuously until the application met the requirements that have been determined in the previous process.

3. RESULTS AND ANALYSIS

3.1. Analysis Data

On this stage, brainwave data that already obtained from the data collection phase is checked on drowsiness level condition to be validate. According to Hong J Eoh [7], research on traffic accidents caused by the drowsiness, states that drivers who crashed start from fatigue factors. This is because the extremely tired driver can lose their focus which mostly their vision and ultimately cannot see the state of the road clearly. In that study, it also concluded that the signal β / α and $\alpha + \theta / \beta$ can be used as a reference when the driver is tired or not. Due to the appearing signal, it will perform the significant difference between drowsy driver and another driver at the normal state.

Therefore, this study is also calculate the signal β / α and $(\alpha + \theta) / \beta$ to ensure the data which was already taken is valid and ready to be used for SVM training data. The condition of the subject's brain wave 5 minutes before and 5 minutes after the sleepy state is shown in figure 5 below.

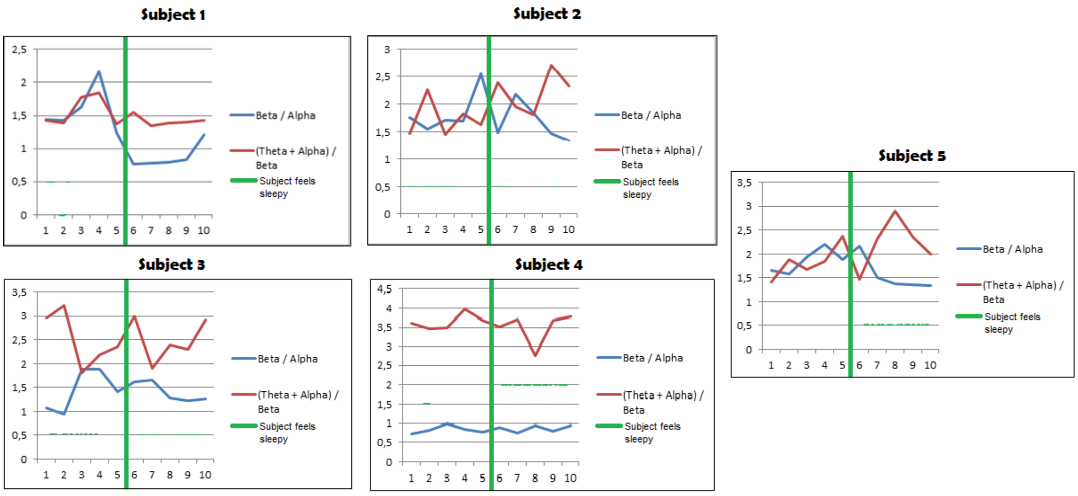

Figure 5. The Analysis of the Subject Data

From the analysis of the subject's data, there are 4 datas are declared to be valid because there is a difference between β / α and (α + θ) / β waves while the subject feels sleepy and 1 data is declared to be invalid because from initial wave data gathering β / α and (α + θ) / β waves was no different. That means the subject has already feel tired even before the data collection was conducted.

a. Application Testing

Drowsiness detection application testing will be done by involving subject's brain wave data that already taken from the data collection process. There are only 4 subjects from 5 that willing to participate in the trial system because the other one claimed he has another occupation to do. The procedure is exactly the same with the application testing phase. The difference is only by using the training data that has been obtained previously. Then the application will be assessed how many time the error detecting drowsiness of the subject.

Table 1. Application Testing Result

Subject	Total Application Detecting Right Stats	Total Application Detecting Wrong Stats	Accuracy
Subject 1	80	10	88,88%
Subject 2	80	10	88,88%
Subject 3	76	14	84,44%
Subject 4	62	28	68,88%

4. CONCLUSION

Based results obtained from the data analysis process, which was four subjects (first subject, second subject, third subject and the fifth subject), it concluded that reduction of Alpha waves occured in the sleepy condition, and the subjects are also feel tired in that condition.This is proven by the presence of the significant difference between the signal β / α and α + θ / β as shown in figure 4. 1 as Data of four subjects had a significant difference from initial data gathering to the end of data gathering. So the fourth subjects were already tired even before the data collection was done. And also, the testing process application, drowsiness detection application is able to detect drowsiness very well. This is proven by the test results, 88.88% for the first and second subject, 84.44% for the third subject.

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REFERENCES

[1] Ngantuk, Kedua Tangan Karyawan Putus. Kompas Megapolitan [newspaper on the Internet]. Jul 09, 2012 [cited 2013 Jun 30]; Available from: http://megapolitan.kompas.com/read/2012/09/07/19410277/Ngantuk.Kedua.Tangan.Karyawan.Putus.

[2] Pemuda Tewas Terjepit Mesin Cetak. Harian Jurnas [newspaper on the Internet]. Jul 09, 2012 [cited 2013 Jun 30]; Available from: http://www.jurnas.com/news/31273/Pemuda_Tewas_Terjepit_Mesin_Cetak/3/Ibu_Kota/Balai_Kota
[3] You, Chuang-Wen, et al. "CarSafe App: Alerting Drowsy and Distracted Drivers using Dual Cameras on Smartphones." *submitted to ACM Mobisys* (2013).
[4] Santosa, Budi. "DATA MINING: Teknik pemanfaatan Data untuk Keperluan bisnis." *Yogyakarta: Graha Ilmu* (2007).
[5] Santosa B, "Data Mining: Teknik Pemanfaatan Data untuk Keperluan Bisnis". *Graha Ilmu*, Yogyakarta.
[6] Reyner, L. A., and J. A. Horne. "Falling asleep whilst driving: are drivers aware of prior sleepiness?." *International Journal of Legal Medicine* 111.3 (1998): 120-123.
[7] Eoh, Hong J., Min K. Chung, and Seong-Han Kim. "Electroencephalographic study of drowsiness in simulated driving with sleep deprivation." *International Journal of Industrial Ergonomics* 35.4 (2005): 307-320.

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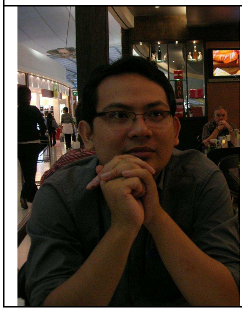	Radityo Prasetianto Wibowo, lecturer in system information department of Institut Teknologi Sepuluh November.