Development of Drowsiness Detection System with Analyzing Attetion and Meditation Wave Using Support Vector Machine Method

Indoriko Shin, Bambang Setiawan, Febriliyan Samopa , Hatma Suryotrisongko, Faizal Johan Atletiko, Radityo P. Wibowo
Department of Information System, Faculty of Information Technology, Institut Teknologi Sepuluh Nopember

Keywords:
EEG
Detection
Drowsiness
eSense.

ABSTRACT

The purpose of this project is recording EEG data from user, and developing drowsiness detector system application as solution for accident problem caused by drowsiness. Hardware that used in this project is NeuroSky Mindwave, which is noninvasive EEG reader that available commercially in market. This device has a special function that called eSense. eSense are copyrighted special algorithm belong to NeuroSky that is used to classification certain brain wave. The wave that named Meditation and Attention, which is used in this project to detecting mental condition of user.

Drowsiness is the most concerned factor is safety especially for the driver who need high concentration and must stay focus in relative long time. Drowsiness in driving is the most contributed factor for on-road-accident. This problem can be prevented with using modern technology. Brain-computer interface (BCI) with input from electroencephalographic (EEG) can be used for measuring brain activity level. With EEG signal we can gather important information about mental condition of someone, like drowsiness and tiredness.

For that an application is needed to give an alarm or warning for driver when he/she feels drowsy to take a rest. With using brain wave censor hopefully this application can give an early warning and real time warning for driver.

Corresponding Author:

Indoriko Shin,
Department of Information System, Faculty of Information Technology,
Institut Teknologi Sepuluh Nopember,
Jalan Raya Kampus ITS, Gedung Sistem Informasi, Sukolilo, Surabaya, Indonesia.
Email: shin09@mhs.is.its.ac.id

1. INTRODUCTION

Our society has made progress where duty and service cycle is now no longer bound to the time, there is a term that saying 24/7. Where work and service operating throughout the day, especially sectors where shift work can be applied such as health services, manufacture, industrial, and transportation services.

With the emergence of shift work system also appears the impact on people's lives. With the existence of a long shift, or overtime work until late at night resulting in sleep deprivation, which affects the sleepiness. Sleepiness has been a concern in the medical and security fields. Someone who works on the ever-changing shifts or in incorrect hours of their sleep may experience disruption in sleep cycles. Disturbances in sleep cycle can result in decreased alertness, performance, and increasing the level of fatigue [1].

Sleepiness generally is a transition between the conscious and sleep condition, which in this condition all senses function is decreasing. This condition is a contributing factor to road accident happened [2]. Electroencephalography (EEG) is one of many ways to monitoring the brain condition which is reliable and noninvasive. Signals from EEG are psychological measure tool that reliably can predict and measure a person's level of alertness. This signal will be used as an input which is processed in the BCI.

Brain-Computer Interface (BCI) is a technology that uses brain waves to build an interface. This technology utilizes brain waves receiver, which then makes the brain waves that exist as input [3]. One of the brain wave receiver tools that are listed in market is MindWave, a market trading product of the NeuroSky Company.

Bioinformatics is a discipline that combines the study of molecular biology, mathematics and information technology (IT). This study is defined as the application of computational and analytical tools to capture and interpret molecular biology data. Molecular biology itself is also an interdisciplinary field, studying the lives in molecular level. One reliable method in bioinformatics is the Support Vector Machine (SVM). SVM has been used in several bioinformatics research. In the many studies conducted concluded that SVM is suitable to be applied in bioinformatics problems [4].

SVM is applied in many applications like EEG signal classification, cancer identification, bioinformatics, seizure prediction, and face recognition and speech disorder. SVM is used to construct the optimal hyperplane with largest margin for separating data between two groups. For two dimensional data, single hyperplane is enough to separate the data into two groups such as +1 or -1. Where in this research we use SVM to separate brainwave of sleepy and not sleepy condition. To obtain the hyperplane, we must insert some data of sleepy condition and not sleepy condition into SVM logarithm. Then SVM will compute the training data to obtain the hyperplane for actual use later.

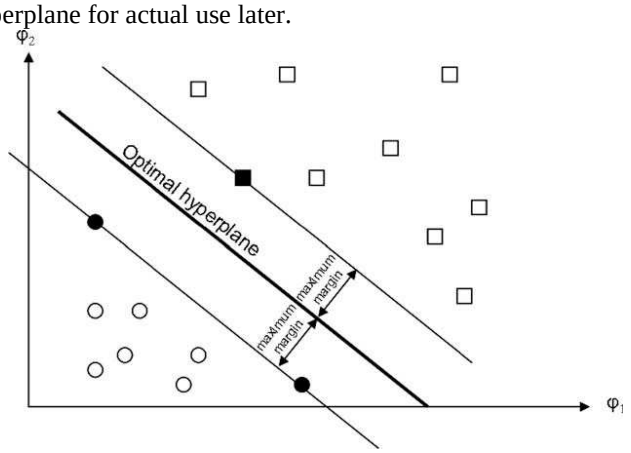


Figure 1. How SVM works

Research for early detection of drowsiness is already done by previous researchers. Various methods have been used, one of which is by using Computer Vision technology. Where drowsiness detection method is based on the subject's eyes blink.

In the study the subjects were given a kind of camera that is directed into the eye of the subject. Then the subjects were told to drive the vehicle from Bandung - Jakarta - Bandung (for 7 hours). Where every 5 minutes the subject will be asked how sleepy is her/his condition. From these studies showed, rapid eye blinking will increase about 20% if the subject in a state of drowsiness and micro sleep .Ranged from 0.5 per second [5]. Sleepiness with the Computer Vision Research is already at application development stage which called CarSafe [6]. Where the application is utilizing camera on Smartphone. Where the results of these studies show that Computer Vision can detect the state of drowsiness subject up to 85%.

On the other hand there is one study that makes writers prefer SVM than any other methods are a research conducted by Yeo et al. Where in the research, identify whether the SVM method can be used as a detector for drowsiness or not. SVM is able to detect a person's drowsiness by 99% [7]. Because that's accuracy, SVM selected as drowsiness detection method at this project.

After finding out the existing problems, where many accidents happened because of drowsiness. So, at this project will be create an application that will read and detect mental condition of vehicle drivers by using the eSense features that available on MindWave device, which is meditation, attention, delta, theta, and gamma wave which will then processed with SVM method to determine whether the driver drowsy or not. If the driver is detected being sleepy then this app will sound an alarm that reminds the driver to rest.

From this research will be obtained five brain wave data of each subject as long as 6 hours, so will be obtained raw data of EEG brain waves as many as 30 hours. This eventually can be used for further research. And also obtained result of analysis that shows whether the attention, meditation, theta, delta, and gamma wave can be used as a reference for detecting drowsiness condition on a person's.

This study aims to find innovative solutions to prevent accidents problems that caused by drowsiness (http://www.dephub.go.id). This study also opens new measures to using brain waves as solutions to everyday problems.

2. RESEARCH METHOD

In general, flowcharts methodology of research is as Figure 2 below:

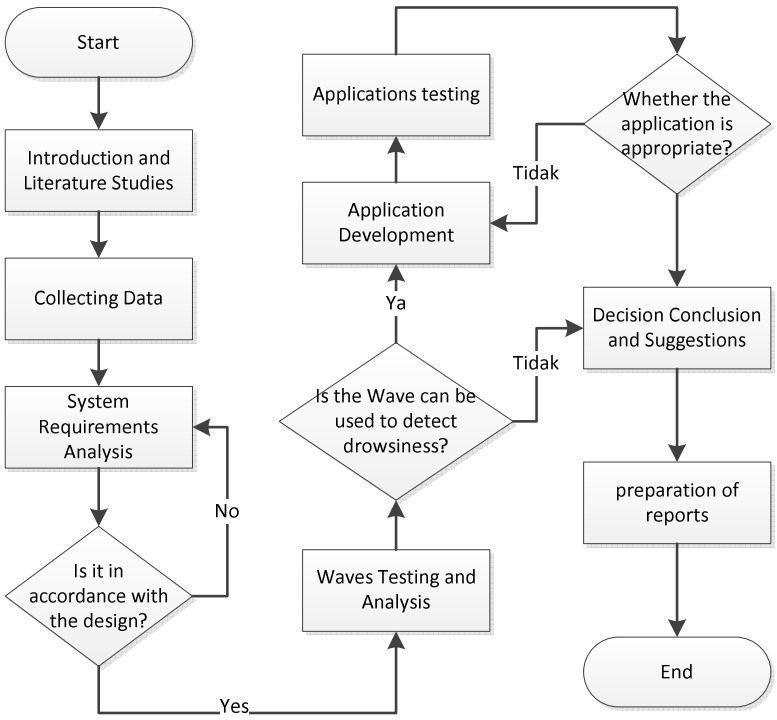


Figure 2. Research method

The study of literature is a stage of getting reference to get the information and data required in the execution of this research. This stage is done by looking for and learns how to capture the brain wave signal with NeuroSky Mindwave, recording brain wave signal from NeuroSky Mindwave with the application, and predict the state of drowsiness from the result of brain waves with SVM methods.

Data gathering is a step to get the data from driver's brain waves at night. For this data gathering, 5 subjects, will be applied NeuroSky Mindwave for 3 hours (21.00 to 00.00). The purpose of utilization at those hours is on that moment most people begin to feel sleepy and finally sleep. Each subject did twice data gathering. This data is used to perform SVM training and testing SVM. So overall the data obtained is 10set of data, each consisting of recorded brain activity for 3 hours. Total number of recorded brain waves is 30 hours.

In addition Subject, the authors also present in of the data gathering, responsible for logging equipment, and also makes the recording the level drowsiness Subject. Drowsiness level Subject will be asked to Subject every 5 minutes or so. The note of the drowsiness the level will be used for SVM training and also to measure the accuracy of the sleepiness identification method applied.

Analysis of system requirements is a step to determine the need for the system to be built. At this stage, we conducted the analysis on data and the necessary technology. If the requirement for the development of the system has been met, then the process of making the application will easier to create.

The first thing to do is analyze the waveform that will be used, that is attention, meditation, theta, delta, and gamma. Know how to get those waves. And that wave characteristics in certain circumstances. And observe whether the wave is influenced by the subject's behavior, such as whether is affected by the body movement or not. Then re-analyzed the wave obtained if need before used as processed input.

3. RESULTS AND ANALYSIS

From the retrieval Data of the the first subject we obtained the brain wave data and level of drowsiness as on Figure 3.

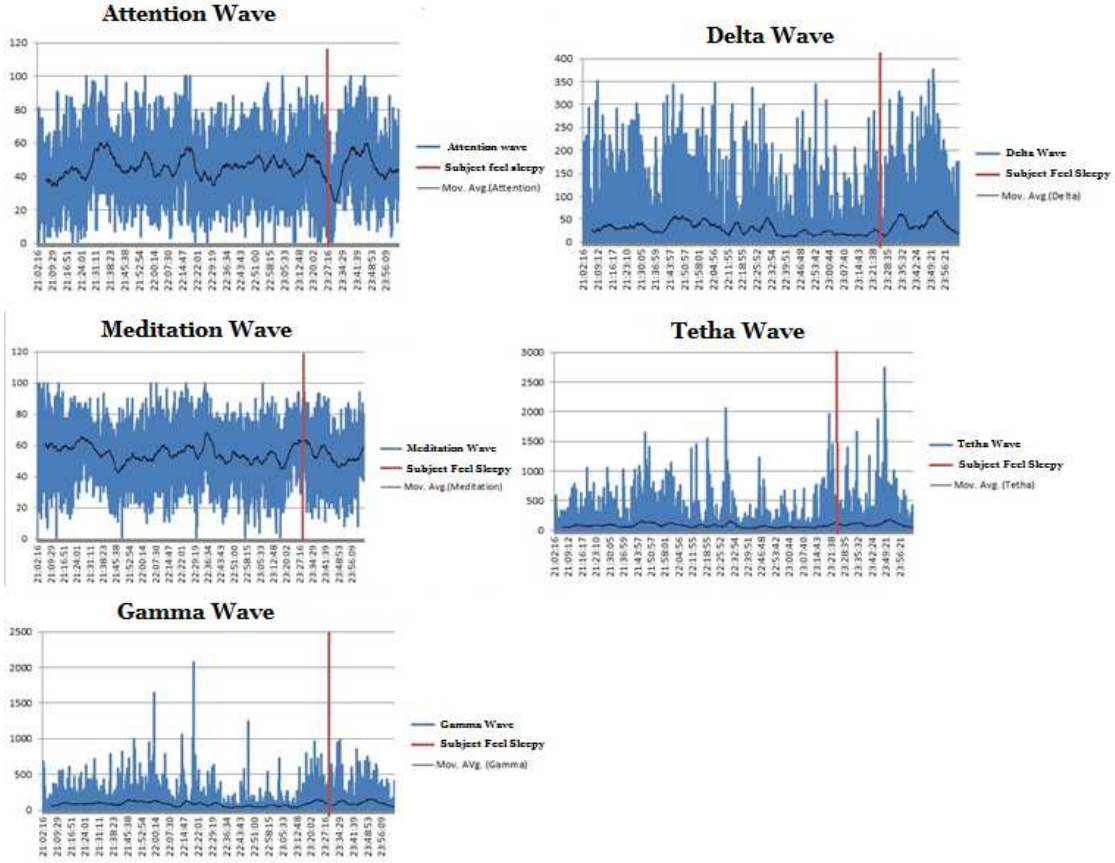


Figure 3. Subject recorded brain wave

From these data it appears that at the time the person feel sleepy, then the Attention decreased and Delta became stable. While Meditation, Tetha, and Gamma wave activity are not significant.

From the capture of RAW Data above can be concluded, Data indicate that visual observation is quite clear. Attention and delta Waves each has associated with drowsiness. It can be seen from the wave change in accordance with the status of Subject drowsiness.

To explore the relationship of the wave with drowsiness more than the raw Data is analyzed using regression correlation. To see the validity, several steps performed in regression analysis. The first analysis is analysis of ANOVA or F test. F test basically shows whether all the independent variables have an influence on the dependent variable.

Table 1. ANOVA analysis

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.170	5	3.434	22.089	.000[a]
	Residual	1595.025	10260	.155		
	Total	1612.195	10265			

From the F test or ANOVA test obtained value of F which is 22.089 with a probability 0.000. Because the probability is much smaller than 0.05, then regression model can be used to predict drowsiness or it can be said that the Attention, Meditation, Theta, Delta, and Gamma together affecting the sleepiness. The next step are regression coefficient or t test.

Table 2. Regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.155	.019		8.073	.000
	ATTENTION	.001	.000	.039	3.765	.000
	MEDITATION	.000	.000	-.020	-1.954	.051
	TETHA	.000	.000	.046	3.396	.001
	DELTA	.001	.000	.078	6.306	.000
	GAMMA	-5.849E-5	.000	-.015	-1.142	.254

From The five independent variables of, Meditation and Gamma regression variables of are not significant this can be seen from Meditation probability of 0.051 and 0.254 for Gamma. Both far above the 0.05 level. From here it can be concluded that the Attention, Theta, and Delta affecting sleepiness.

At this stage, the raw data that have been obtained from the previous stage then conducted validation checks for the relationships between drowsiness and the wave used. To validate compared with alpha of the wave that have been proven to be used to detect drowsiness [7]. Waves that has previously been tested by regression and correlation analysis and proved to have a strong relationship with drowsiness, that is attention and delta analyzed again by comparison with alpha wave. With the following results.

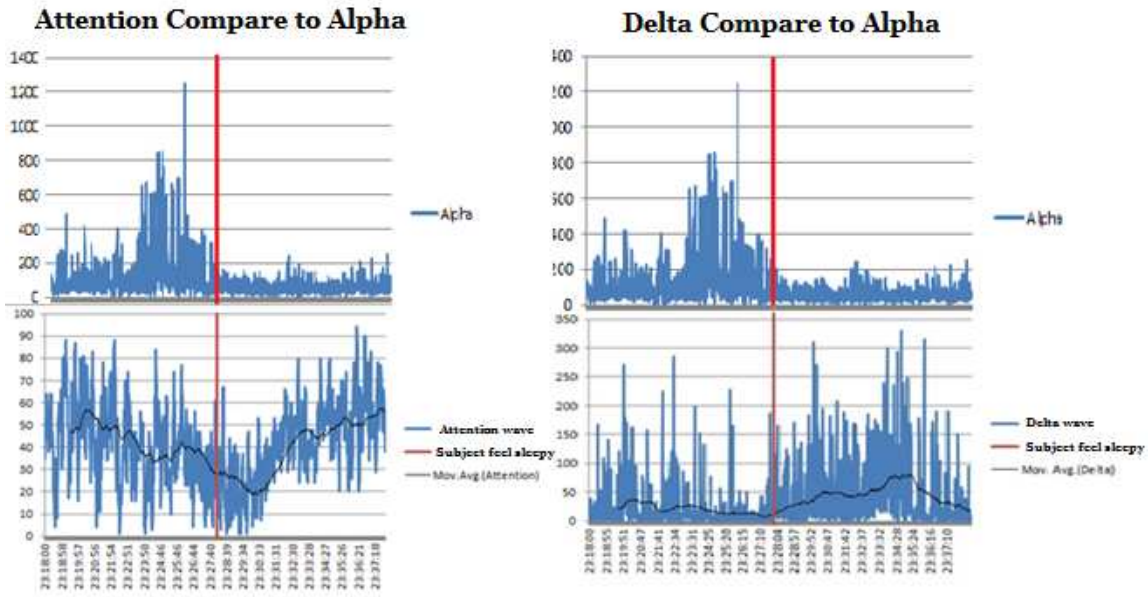


Figure 4. Attention and Delta compare to Alpha

After a comparison with alpha wave that have proven capable of detecting drowsiness. Attention and delta Waves on same time show a change which is indicating that the subject is being sleepy. And thus attention and delta can be used as a parameter to detecting drowsiness.

Once validated and declared can be used to detect drowsiness. Then we develop drowsiness detecting application by based attention and delta wave which is already valid. Applications executed and get the following results.

Table 2. Application testing

Time	Subject Conditions	Total Alarm ringing	Total Right stats	Total Wrong stats
21.20	Not Sleepy	0	10	0
21.40	Not Sleepy	0	10	0
22.00	Not Sleepy	0	10	0
22.20	Not Sleepy	0	10	0
22.40	Not Sleepy	1	9	1

Time	Subject Conditions	Total Alarm ringing	Total Right stats	Total Wrong stats
23.00	Not Sleepy	4	6	4
23.20	Sleepy	8	8	2
23.40	Sleepy	8	8	2
00.00	Sleepy	9	9	1
Total		30	80	10
Aaccuracy			88,88%	

From table 3 above, we can see that the application made mistake once at 22.21 – 22.40, the system assuming that the subject already sleepy even the subject is not. Then at 22.41 - 23.00, the system makes mistakes 4 times. Then at 23.01 – 23.20, the system made two mistakes by saying the subject is not sleepy even at the moment the subject is sleepy. The next mistakes are at 23.21 – 23.40, system made mistake once. And the last is at 23.41 – 00.00, system made mistake once. With the data above we can conclude that the application detecting drowsiness correctly 80 times, with total 90 total detection statuses. So the accuracy percentage is 88, 88%.

4. CONCLUSION

Based on the research that has been done, it can be concluded that, Attention Waves can detect early phases of drowsiness that is loss focus. Delta Waves can be used to detecting drowsiness condition. Meditation, Theta, and Gamma Waves cannot be used to detecting drowsiness. When compared to alpha wave that are tested, at the same time when alpha down, delta wave and attention wave also undergone significant changes which is can be used as a sign of drowsiness. So that attention and delta wave considered able detecting drowsiness. Drowsiness Detection applications can be implemented and this application has a feature to alert the user by alarm if being sleepy. Applications can detect drowsiness well enough; this proved from the test results of the first subject that has 88.88% accuracy.

ACKNOWLEDGEMENTS

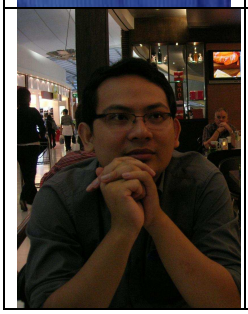
This work was supported by "Hibah Penelitian Laboratorium Dana BOPTN ITS 2013"

REFERENCES

[1] H.S. Choi, “Using Brain-Computer Interfaces to Analyze EEG Data for Safety Improvement”, 2008.
[2] R.R Knipling, and J.S. Wang, “Crashes and Fatalities Related to Driver Drowsiness/Fatigue”, *National Highway Traffic Safety Administration*, Washington, D.C., 1994.
[3] D.S. Tan and A. Nijholt, “Brain-Computer Interface: Applying Our Mind to Human-Computer Interaction”, *Springer*, 2010.
[4] E, M. Abdushshomad & A. D. Astuti, “BIOINFORMATIKA: Perkembangan, Disiplin Ilmu dan Penerapannya di Indonesia”, 2004.
[5] Y. I. M. Mahachandra, “Sleepiness Pattern of Indonesian Professional Driver Based on Subjective Scale and Eye Closure Activity”, *International Journal of Basic & Applied Sciences*, pp. 87-96, 2011.
[6] Chuang-Wen You, N. D.-d.-O., “CarSafe App: Alerting Drowsy and Distracted Drivers using Dual Cameras on Smartphones”, 2010.
[7] M. V. Yeo, X. Li, K. Shen, and E.P. Wilder-Smith, “Can SVM be used for automatic EEG detection of drowsiness during car driving?”, *Safety Science 47*, pp. 115-124, 2009.

BIBLIOGRAPHY OF AUTHORS

Indoriko Shin, student in information system department of Instut Teknologi Sepuluh November.

	Bambang Setiawan, lecturer and head of E-Business Laboratory in system information department of Institut Teknologi Sepuluh November.
	Febriliyan Samopa, lecturer and head of system information department of Institut Teknologi Sepuluh November.
	Hatma Suryotrisongko, lecturer in system information department of Institut Teknologi Sepuluh November.
	Faizal Johan atletiko, lecturer in system information department of Institut Teknologi Sepuluh November.
	Radityo Prasetianto Wibowo, lecturer in system information department of Institut Teknologi Sepuluh November.