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Drowsy Driver Detection Using Viola-Jones Algorithm

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ABSTRACT

Drowsy driving is one of the factors that lead to road accidents which can cause dead. This is because driver does not able to give fully attention while driving. There are many factors that lead to driver drowsiness such as driving for a long time, do not have enough sleep and shift work. Thus, this research is proposed to develop a system to detect and alert drowsy driver by using Viola-Jones algorithm. Blinking rate is used as the indicator to determine either the driver is in drowsy or awake state. Viola-Jones algorithm is used to detect driver's face and eyes in real time. Haar cascade classifier for frontal face and glasses eyes are used to train the system to detect driver's face and eyes. In order to calculate eye blink, Eye Aspect Ratio (EAR) calculation is used to calculate and estimate of the eye-opening state in this system. The results of testing showed that the system with the Viola-Jones algorithm and Haar cascade classifier able to detect eyes blinking rate at the high accuracy percentages.

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1. Introduction

Majority of road accidents that occurred today is due to drowsy driving. According to the National Highway Traffic Safety Administration, police had reported about 100,000 crashes occurred every year due to drowsy driving which caused more than 1550 fatalities and 71,000 injuries in United State of America. This is because driver have difficulty to stay awake especially when driving for a long journey. In order to reduce road accidents, drivers need to have a drowsy driver detection system in their vehicle to alert them from drowsiness while driving [1]. This is because drivers who stayed awake for 24 hours are seven times in risk and tends to involve in accident which is similar to a person who has alcohol rate of 0.1/100ml in his blood system based on a study conducted by Adelaide Centre for Sleep Research [2].

However, current drowsy driver detection requires a complex computation and expensive hardware such as infrared cameras to implement it. In automotive industry, Bosch had developed

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driver drowsy detection system which can take decisions based on data derived from the sensor that is located at the steering, velocity of vehicle, use turn signal and lane assist [3]. Some of the system requires driver to wear equipment while driving which can make driver feels uncomfortable. For example, driver need to wear electroencephalography (EEG) cap that can measure impulses in the brain or electrocardiogram (ECG) to measure impulses in the heart. This technique is reliable to detect driver drowsiness but it can cause intrusive feeling to the drivers [4]. Besides, EEG have some drawbacks which are; expensive to be implemented, time consuming and its data consists of a mixture of stress and drowsiness [5].

Road accident due to drowsy driving can be reduced with the help of effective drowsy driver detection that used lower cost of implementation. This is because not all of the drivers are afforded to use this system for their vehicle. For instance, Lexus is one of the automakers that developed drowsy driver detection system cost nearly $20,000 that uses an infrared camera to detect driver's eye movement.

Therefore, this research aims to carry out a real-time drowsy driver detection using webcam. The webcam will point to the driver's face to detect drowsiness. Viola-Jones algorithm, is used to developed this project as it able to detect human face quickly in real-time. The driver's blinking rate is used to detect the level of drowsiness. The blinking rate is the repetition of where upper and lower eyelids are connected. This system will alert the driver whenever it detects driver in drowsy condition.

2. Literature Review

Transportation had become an important sector in Malaysia. Transportation is an action on moving people and goods from one location to another location safely. This sector helps to enhance the quality of life and provide competitive economy for the country. Currently, Malaysia has constructed over 200 000 km roads, 2900 km rails, 18 ports and 22 airports in nationwide [6].

There are four modes of transportation in Malaysia which are road transport, railway transport, water transport and air transport. Road transport is the major mode of transportation in Malaysia due to Malaysia's geographical characteristics. Malaysia has two noncontiguous regions which are Peninsular and East Malaysia that had been separated by South China Sea that makes the total land area in Malaysia is about 328 550 square kilometer [7] .

There are two types of transportation which are private vehicle and public vehicle transportation. Private vehicle is also known as personal transport commonly when people owned the car for personal uses. It provides flexibility to the users since they can use it whenever they want.

Today, most people have their own vehicle to live a hassle-free life whether they bought a new one or from the used-car dealer. However, it consume expensive affair since the owners need to deal with road tax, car's maintenance and many more [8].

Public transportation is a type of accommodation provided by the government to the citizen. Public transport in Malaysia covers numerous modes of transportation especially land and railway transportation. Bus, taxi and e-hailing are the examples of land transportation whereas Keretapi Tanah Melay (KTM) Commuter, monorail, Light Rail Transit (LRT) and MASS Rapid Transit (MRT) are the examples of railway transportation.

Public transportation provides lower cost compared to private transportation. However, public transportation is not flexible since it has its own schedule that need to be followed. Nevertheless, driver of public and private transportation tends to be involved with drowsy driving. This is because drivers need to stay focus when driving either for a short or long journey which lead them to experienced tired eyes. Drowsiness is a state of feeling abnormally sleepy when the person tend to fall asleep especially during the day [7]. Drowsiness can affect daily life activities since it causes difficulties to stay focus, less productivity and reaction time. Besides, fatigue is a state where the person feeling tired or exhausted after doing physical activities or illness. Fatigue can be relieved by rest and inactivity while enough sleeping is the best ways to relieve drowsiness. However, drowsiness is more dangerous compared to fatigue in term of safety perspective [7].

Drowsy and fatigue driving can lead to road accidents. This is because the driver has lack of attention during driving activities. There are some symptoms that shown someone is in drowsy driving which are yawning frequently, missing exit, drifting from lane and have difficulty to remember the past few miles driven [8]. Blinking rate also can be the indicator to identify the drossiness of the person since the number of blinks will be decreased when someone getting drowsy. Normal person will experienced average blink rate about 10 blinks per minute while blinking rate for a drowsy person is about four to six blinks per minute [8].

Driving hours is a key risk factors in road crashes. Human body is at lower levels of activity at night compared to the day. This is because hormone named melatonin is produce and release in human's brain getting increase during the night and decreasing during the day [9]. Therefore, there is higher possibility for road accident to be occurred during the night and early in the morning due to driver drowsiness. This situation may occur due to several factors such as length and timing of shift, mentally and physically demanding work and environmental condition.

3. Methodology

3.1 Image Processing

In this section, the technique of Viola-Jones in image processing is explained. Viola-Jones algorithm is an object-recognition framework that can detect images features in the real-time. It was developed by Paula Viola and Michael Jones in 2001. This algorithm can detect quickly and accurately object in images and it works well with human face [10]. However, this algorithm faced slow processing problem in the process of training data although it has fast detection [11].

There are two stages involved in Viola-Jones Algorithm namely training and detection. Training is a process where the machine is trained with the information given in order to identify features while detection is a process to detect features in images. This algorithm will detect the best at frontal faces position compare to sideway, upwards and downwards since it was designed for frontal faces [20].

The Viola-Jones algorithm is a combination of Haar-like feature, integral images, AdaBoost algorithm and cascade classifier [10]. Haar-like features shows how the machine detected the features in images. Viola-Jones algorithm used three types of Haar-like features which are edge features, line features and four-sided features. Then, finding a feature within an image can be easily detected with the help of integral images process since it makes the calculation much intensive and save time [20]. Next, Adaptive Boosting knowns as AdaBoost is used to select the best subset of features between all available features. Besides, cascade classifier can perform detection quickly and accurately since it is a multi-stage classifier [10].

The purpose of this research is to develop a system to detect and alert drowsy driver using Viola-Jones algorithm. This is because this algorithm is suitable to find features in image quickly and accurately in real time since detection can occurred at the rate one to two frames per second [10]. This algorithm also detects the best at frontal faces position which suitable to be implemented in this project. Besides, it also uses less data for training compared to other techniques. Viola-Jones algorithm provides better performance since there are three key innovations use in this algorithm which are integral image, AdaBoost and cascade. This is because integral image allows faster feature computation, AdaBoost helps to select simple and efficient classifiers while cascade is a method to combine successively complex classifier in a cascade structure by focusing on more promising areas of the images to increase the speed of detector.

Therefore, this project developed a system that can detect driver's eyes and trigger alert whenever the driver is detected in drowsy mode. Blinking rate is the indicator to identify the level of driver drowsiness. The drivers blinking rate will decrease as they become drowsy. Normal person usually has an average blinking rate ten blinks per minute while drowsy person experienced four to six blinks per minute [10].

3.2 System Architecture

Figure 1 shows the system architecture with Drowsy Driver Detection that used Viola-Jones algorithm. First of all, driver need to place the webcam at the angle where it can detect driver's face. The web cam will capture the driver's face in the real-time. Next, real-time classification process will take place. It will be dividing the video captured by the web cam into frames. Extraction of video key frame is an important process since it is the process where extracting set of frames that have a quality represent of shot occurred [8].The repeated frames will be removed in this process.

Face detection can be recognized from the extracting frames using Viola-Jones algorithm. Driver's eyes can be detecting from the driver face using Haar-like features. The algorithm uses concept of rectangle shape features where it uses the sums of pixels withing the rectangular area. Driver's eyes blink will be calculated using eye aspect ratio (EAR) in order to detect either drowsy is stay awake or drowsy. Calculation of EAR will be occurred as soon as the system detect driver's eyes. It refers on calculation aspect of the eye region. If the EAR value is less than predefined value, the process will be continuing to decision rule process else it will repeat to the initial step where it captures the driver's face.

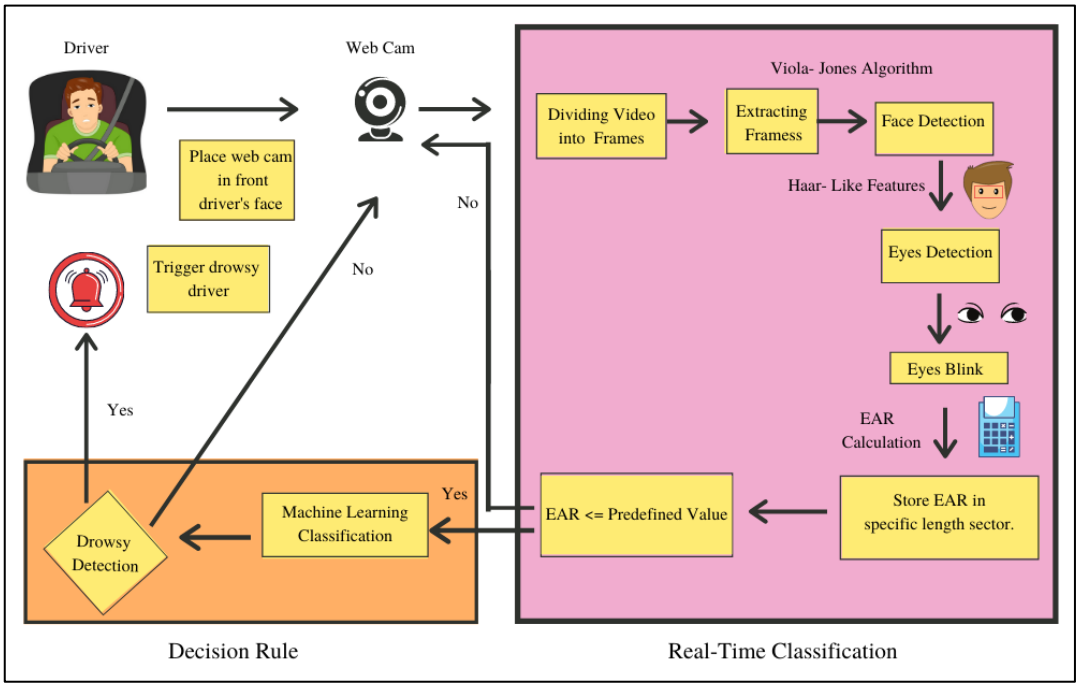

Figure 1. System Architecture

Machine learning classification can identify either the driver drowsy status based on the total blink in a minute and the eyes closure time. The system will trigger the driver when drowsy mode is detected and continue with the face capture monitoring.

4. Result and Discussion

In this section, the results of testing on face and eyes detection and testing on the ability of system to detect drowsiness in real-time are explained.

4.1 Testing on Face and Eyes Detection

The system has been tested with 30 samples from DrivFace dataset to check whether the system able to make detection on user's face and eyes [11]. This sample consist of three types of driver's position of head which are looking right, frontal and looking left. The accuracy of the system ability to detect on driver's face and eyes were recorded in Table 1. Furthermore, this system also able to detect driver eyes although the driver wear spectacles. This is because the Haar Cascade classifier will able to detect eyes whenever the driver's eyes is in opening state.

Table 1. Detection Accuracy for Different Type of Position Head

Position of Head	Type of Detection	Accuracy
Frontal	Face	100%
	Right Eye	100%
	Left Eye	100%
Looking- Right	Face	50%
	Right Eye	10%
	Left Eye	50%
Looking - Left	Face	50%
	Right Eye	30%
	Left Eye	10%

4.2 Testing on Ability of System to Detect Drowsiness

In order to test the ability of the system to detect drowsiness in real-time, the developer test the system functions for three times with different number of blinking. Table 2 shows the result from the testing.

Table 2. Result of System Ability to Detect Drowsiness

Test	NOB per Minute	NOBS per Minute	Alert Sound
1	2	2	Yes
2	4	4	Yes
3	6	6	No

NOB is the number of human blink while NOBS is the number of blink counted by the system. The NOBS is consistent with NOB to prove that the system is workable to detect the blinking of eyes accurately in real-time. Table 2 shows that the alert sound will only be appeared when the blink rate is less than five.

5. Conclusion

The goal of this project is to detect driver drowsiness in real time using Viola-Jones algorithm. Image processing technique has been used to develop this system. During the training process, trained Haar Classifiers were used in order to detect user's face and eyes using Viola-Jones algorithm. This system can be extended for future work to increase its benefit to reduce the road accidents. This system can be added with yawning detection in order to improve the efficiency in detecting driver drowsiness. This can be an advantage for the person who most likely to wear sunglasses during driving.

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References

[1] J. Gwak, A. Hirao, and M. Shino, "An investigation of early detection of driver drowsiness using ensemble machine learning based on hybrid sensing," *Appl. Sci.*, vol. 10, no. 8, 2020, doi: 10.3390/APP10082890.

[2] S. Puja and C. Anurag, "Drowsy Driver Detection Using Image Processing," vol. 9655, no. 6, pp. 135–143, 2017.

[3] V. Triyanti and H. Iridiastadi, "Challenges in detecting drowsiness based on driver's behavior," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 277, no. 1, 2017, doi: 10.1088/1757-899X/277/1/012042.

[4] Zahra Mardi, Seyedeh Naghmeh Miri Ashtiani, and Mohamad Mikail, "EEG-based Drowsiness Detection for Safe Driving Using Chaotic Features and Statistical Tests," *J Med Signals Sens*, 2011. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3342623/.

[5] Ministry of Transport Malaysia, "National Transport Policy 2019-2030," *Minist. Transp.*, p. 101, 2019.

[6] R. Jabbar, K. Al-Khalifa, M. Kharbeche, W. Alhajyaseen, M. Jafari, and S. Jiang, "Real-time Driver Drowsiness Detection for Android Application Using Deep Neural Networks Techniques," *Procedia Comput. Sci.*, vol. 130, pp. 400–407, 2018, doi: 10.1016/j.procs.2018.04.060.

[7] T. Vesselenyi, S. Moca, A. Rus, T. Mitran, and B. Tătaru, "Driver drowsiness detection using ANN image processing," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 252, no. 1, 2017, doi: 10.1088/1757-899X/252/1/012097.

[8] A. Islam, N. Rahaman, and M. Ahad, "A study on tiredness assessment by using eye blink detection," *J. Kejuruter.*, vol. 31, no. 2, pp. 209–214, 2019.

[9] İ. Umut, O. Aki, E. Uçar, and L. Öztürk, "Detection of Driver Sleepiness and Warning the Driver in Real-Time Using Image Processing and Machine Learning Techniques," *Adv. Sci. Technol. Res. J.*, vol. 11, no. 2, pp. 95–102, 2017, doi: 10.12913/22998624/69149.

[10] S. Z. Ouyang, L. Zhong, and R. Q. Luo, "The comparison and analysis of extracting video key

frame," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 359, no. 1, 2018, doi: 10.1088/1757-899X/359/1/012010.
[11] A. M. L. Katerine Diaz-Chito, Aura Hernández-Sabaté, *A reduced feature set for driver head pose estimation*. 2016.