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Driver Drowsiness Detection Using Machine Learning Algorithm

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ABSTRACT: Drowsiness and fatigue are two of the main causes of road accidents. They can be prevented by making an effort to get enough sleep before driving, drinking coffee or energy drinks, or having a rest when the signs of drowsiness occur. The popular drowsiness detection method uses complex methods, such as EEG and ECG. This method has high accuracy for its measurement, but it needs contact measurement and has many limitations on driver fatigue and drowsiness monitoring. Thus, it is not comfortable to use in real-time driving. This paper proposes a way to detect drowsiness signs among drivers by measuring the eye closing rate and yawning. This work describes how to detect the eyes and mouth in a video recorded from the experiment conducted by MIROS (the Malaysian Institute of Road Safety). In the video, a participant will drive the driving simulation system, and a webcam will be placed in front of the simulator. The video will be recorded using the webcam to see the transition from awake to fatigued and finally to drowsy. The designed system deals with detecting the face area of the image captured from the video. The purpose of using the face area is so it can narrow down to detect eyes and mouths within the face area. Once the face is found, the eyes and mouth are found by creating the eye for left and right eye detection and also mouth detection. The parameters for eye and mouth detection are created within the face image. The video was converted into frames per second. From there, locating the eyes and mouth can be performed. Once the eyes are located, measuring the intensity changes in the eye area will determine whether the eyes are open or closed. If the eyes are found closed for four consecutive frames, it is confirmed that the driver is in a drowsy condition.

KEYWORDS: Driver, Drowsiness, Machine Learning

I.INTRODUCTION

Drowsiness is a state of near-sleep where the person has a strong desire for sleep. It has two distinct meanings, referring both to the usual state preceding falling asleep and to the chronic condition of being in that state independently of a daily rhythm. Sleepiness can be dangerous when performing tasks that require constant concentration, such as driving a vehicle. When a person is sufficiently fatigued while driving, they will experience drowsiness, which increases the risk of a road accident. Figure 1 shows the statistics of road accidents in Malaysia from 2005 to 2009, provided by MIROS (Malaysia Institute of Road Safety). The number of vehicles involved in road accidents keeps increasing each year. From Figure 1, car and taxi types of vehicles show that nearly 400,000 cases of road accidents have been recorded. It keeps increasing every year, and by 2009, the number of road accidents recorded by MIROS was nearly 500,000.

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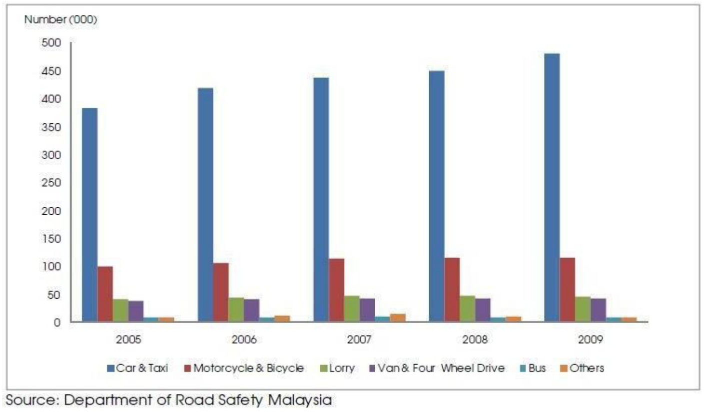

Figure 1: Statistic of Road Accident from 2005 to 2009

The development of technologies for detecting or preventing drowsiness while driving is a major challenge in the field of accident avoidance systems. Because of the hazard that drowsiness presents on the road, methods need to be developed for counteracting its effects. The main aim of this work is to develop a simulation of a drowsiness detection system. The focus will be placed on designing a system that will accurately monitor the open or closed state of the driver's eyes and mouth. By monitoring the eyes, it is believed that the symptoms of driver's drowsiness can be detected at a sufficiently early stage to avoid a car accident. Yawning detection is a method to assess the driver's fatigue. When a person is fatigued, they keep yawning to ensure that there is enough oxygen for the brain's consumption before going into a drowsy state. The detection of fatigue and drowsiness involves a sequence of images of a face and the observation of eyes and mouths open or closed. Another method to detect eye closure is PERCLOS. This detection method is based on the time of the eyes closed, which refers to a percentage of a specific time. The analysis of face images is a popular research area with applications such as face recognition, human identification, and tracking for security systems. This project is focused on the localization of the eyes and mouth, which involves looking at the entire image of the face and determining the position of the eyes and mouth by applying the existing methods in the image processing algorithm. Once the position of the eyes is located, the system is designed to determine whether the eyes and mouth are opened or closed and detect fatigue and drowsiness. In order to enhance the continuous SLR model, Mathieu De Coster's study investigated a number of neural network topologies, including hidden Markov models (HMM), long short-term memory (LSTM), and convolutional neural networks (CNN). OpenPose is a framework that collects the skeleton motion of gestures as a feature extractor. OpenPose is the only full-body pose estimation algorithm used to estimate gesture action because SLR depends on hand form, placement, orientation, and non-manual elements like mouth shape. Other pose estimation techniques exist; however, they only pinpoint specific critical spots, such as those on the body or hands (Fang et al., 2017). (2018) Mueller et al. Utilising the OpenPose Framework, he obtained the data, trained the model, and created the model. Bhushan Bhokse developed a gesture recognition programme in his study that enables a user to display his proposal that yawning and eye detection are the obvious signs of fatigue and drowsiness. Figure 2 shows the difference between fatigue and drowsiness.

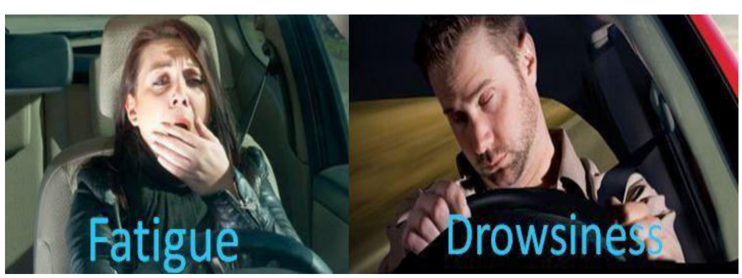

Figure 2: Examples of Fatigue & Drowsiness Condition

II. LITERATURE REVIEW

There are many previous studies regarding driver drowsiness detection systems that can be used as a reference to develop a real-time system for detecting drowsiness in drivers. There are also several methods that use different approaches to detect signs of drowsiness. According to MIROS (Malaysia Institute of Road Safety), from 2007 until 2010, 439 cases of road accidents have been investigated by the MIROS crash team.

2.1. Drowsiness and Fatigue

Antoine Picot et al. stated that drowsiness occurs when a person is in the middle of an awake and sleepy state. This situation leads the driver to not give full attention to their driving. Therefore, the vehicle can no longer be controlled due to the driver's being in a semi-conscious state. According to Gianluca Borghini et al., mental fatigue is a factor in drowsiness, and it causes the person who experiences it to not be able to perform because it decreases the efficiency of the brain to respond to sudden events.

2.2. Electroencephalography (EEG) for Drowsiness Detection

Electroencephalography (EEG) is a method that measures brain electrical activity. As shown in Figure 3, it can be used to measure the heartbeat, eye blinks, and even major physical movements such as head movement. It can be used on humans or animals as subjects to measure brain activity. It uses special hardware that places sensors around the top of the head to sense any electrical brain activity. The authors mentioned that, based on the method that has been implemented by the previous researcher to detect drowsiness signs, the EEG method is best suited for drowsiness and fatigue detection. In the method, EEG has four types of frequency components that can be analysed, i.e., alpha, beta, theta, and delta. When the power is increased in the alpha and delta frequency bands, it shows that the driver is facing fatigue and drowsiness. The disadvantages of this method are that it is very sensitive to noise around the sensors. For example, when the person is doing the EEG experiment, the surrounding area must be completely silent. The noise will interfere with the sensors that detect brain activity. Another disadvantage of this method is that, even if the result is accurate, it is not suitable for real-world driving applications. Imagine when a person is driving and he is wearing something on his head full of wires, and when the driver moves their head, the wire may strip off from their place. Even though it is not convenient to use for real-time driving, for experimentation purposes and data collection, it is one of the best methods so far.

Figure 3: Examples of EEG Data Collecting]

2.3. Drowsiness detection using face detection system

The algorithm processes the images captured using the grey-scale method, where the colour from the images is then transformed into black and white. Working with black-and-white images is easier because only two parameters have to be measured. The author then performs edge detection to detect the edges of the eyes so that the value of the eyelid area can be calculated. The problem with this method is that the size of the eye might vary from one person to another. Someone may have small eyes and look sleepy, but some are not. Other than that, if the person is wearing glasses, there is an obstacle to detecting the eye region. The images that are being captured must be in a certain range from the camera because when the distance is far from the camera, the images are blurred.

Figure 4: Examples of Eyelid Movement

2.4. PERCLOS (Percentage of Eye Closure)

Drowsiness can be captured by detecting eye blinks and the percentage of eye closure (PERCLOS). For eye blink detection, propose a method that learns the pattern of the duration of eyelid closure. According to, 'this proposed method measures the time for a person to close their eyes, and if they are closed longer than the normal eye blink time, it is possible that the person is falling asleep'. In, the author mentioned that 'nearly 310.3 ms are the average of a normal person's eye blink. The PERCLOS method proposes that drowsiness is measured by calculating the percentage of the eyelid that "droops." Sets of eye open and eye closed have been stored in the software library to be used as a parameter to differentiate whether the eyes are fully open or fully closed. For the eyelid to droop, it happened in much slower time as the person was slowly falling asleep. Hence, the transition of the driver's drowsiness can be recorded. Thus, the PERCLOS method puts a proportional value where, when the eyes are 80% closed, which is nearly fully closed, it assumes that the driver is drowsy.

2.5. Yawning Detection Method

The drowsiness of a person can be observed by looking at their face and behaviour. The author proposes a method where drowsiness can be detected by mouth positioning, and the images were processed using the cascade of classifiers that have been proposed by Viola-Jones for faces. The images were compared with the set of image data for mouth and yawning. Some people will close their mouths with their hands while yawning. It is an obstacle to getting good images if a person is closing their mouth while yawning, but yawning is definitely a sign of drowsiness and fatigue. Figure 5 shows examples of the yawning detection method used in the research.

Figure 5: Examples of Person in Normal and Yawning Condition.

After going through the research papers and the existing methods, this project proposed that the eyes and yawning detection method be used. Eye blink duration gives the data that the longer the person closes their eyes, the drowsier it will be considered. It is because when a person is in a drowsy state, their eyes will be closed longer than the normal eye blink.

Other than that, yawning is one of the symptoms of drowsiness, and it is a normal human response when yawning is a sign that they feel drowsy or fatigued.

III.DESIGN AND IMPLEMENTATION

A few algorithms and techniques have been used in the process of detecting the face, eyes, and mouth. The algorithm and technique used are cascade object detectors. The Cascade Object Detector uses the Viola-Jones algorithm to detect people's faces, noses, eyes, mouths, or upper bodies.

Viola-Jones Face Detection Algorithm

The Viola-Jones object detection framework can be used to detect a variety of object classes, but it is more focused on the detection of faces and facial features. This algorithm uses the concept of rectangle features, which involve the sums of pixels within the rectangular areas. In Figure 7, the sums of the pixels that lie within the white rectangles are subtracted from the sum of pixels in the grey rectangles.

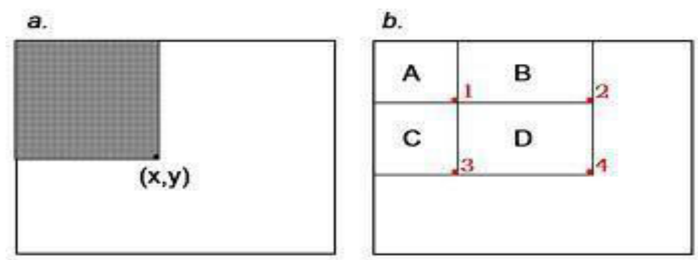

Figure 6: Viola-Jones Face Detection Algorithm

The value of a two-rectangle feature, which is represented by A and B, is the difference between the sum of pixels within two rectangular regions. The regions have the same size and shape. They are also horizontally or vertically oriented and adjacent to each other. A three-rectangle feature, which is represented as C, computes the sum within two outside rectangles subtracted from the sum in a center rectangle. Finally, a four-rectangle feature, which is represented as D, computes the difference between diagonal pairs of rectangles.

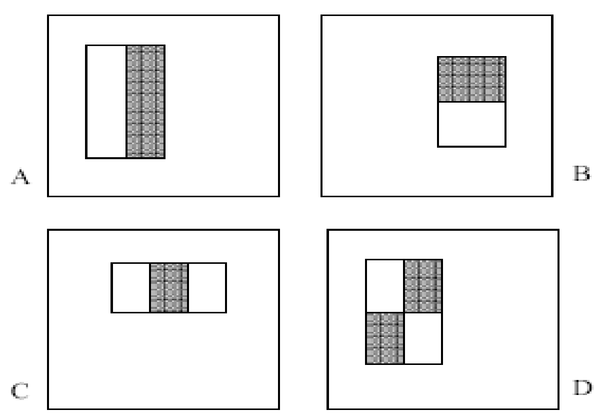

Figure 7: Feature Used in Viola-Jones

Rectangle features can be computed rapidly using a representation for the image called an integral image.

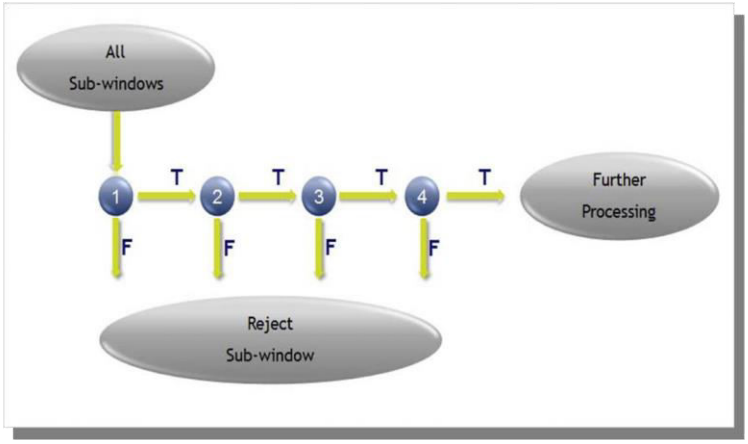

Figure 8: Integral Image

The value of the integral image at point (x, y) is the sum of all the pixels above and to the left. Based on the integral image, the sum of the pixels within rectangle D can be computed with four array references. The value of the integral image at location 1 is the sum of the pixels in rectangle A. The value at location 2 is A + B, at location 3 it is A + C, and at location 4 it is A + B + C + D.

For the task of face detection, the features that are selected to detect the location of the face are shown in Figure 9. The two features are shown in the top row and are overlayed on a typical training face in the bottom row. The first feature measures the difference in intensity between the region of the eyes and a region across the upper cheeks. This is because the region of the eyes is often darker than the region of the nose and upper cheeks. The second feature compares the intensities in the eye regions to the intensities across the bridge of the nose.

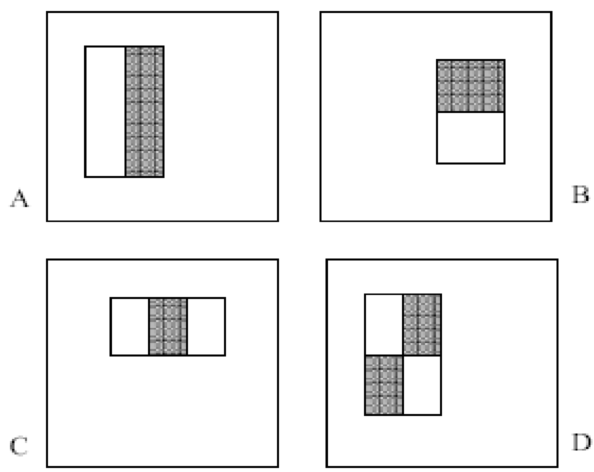

Figure 9: Feature for Face Detection

Cascade of Classifiers

In a standard 24x24 pixel sub-window, there are a total of 45,396 possible features that are detected. This is a number that is too large and prohibitively expensive to be evaluated. In order to improve detection performance, features need to be added to the classifiers. However, this step directly increases the computation time and making the detection process much

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slower. Therefore, a cascade of classifiers is constructed to increase detection performance while radically reducing computation time.

Figure 10: Cascade of Classifiers

The evaluation of the strong classifiers generated by the learning process can be done quickly but it is not fast enough to run in real-time. Therefore, the strong classifiers are arranged in a cascade in order of complexity. Each successive classifier is trained only on selected samples which pass through the preceding classifiers. If at any stage in the cascade a classifier rejects the sub- window under inspection, no further processing is performed and it continues to search the next sub-window.

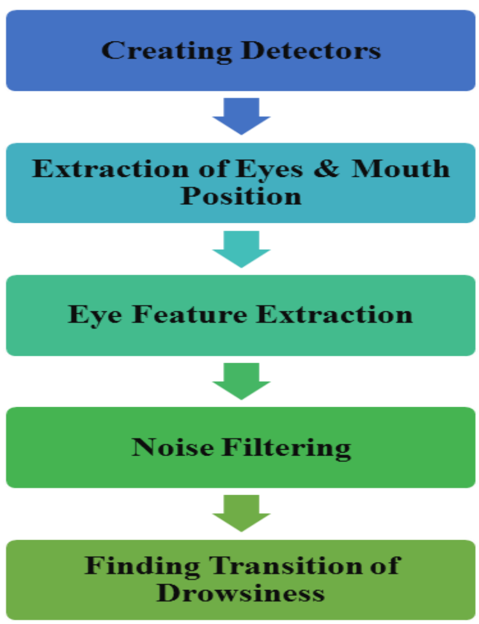

Figure 11: overall System Flowchart

The main goal of this work is to develop a simulation system that can detect drowsiness using a webcam. The system must meet certain requirement which is detecting drowsiness throughout the video frames. Thus, the driver can avoid accident. Secondly, it has to detect only drowsiness signs so that the system will not misinterpret any random signs that it received from the driver. Improvement on the algorithms to detect eyes and mouth need to be done for future implementation. Luminance changes have to be encounter to ensure the detection of the gradient of eyes is sufficient to improve the detection results. The quality of the video or images used in detecting drowsiness affects the result of the detection. Therefore, a good quality and high frame rate of images (number of pixel) is one of the factors to get better detection. Better techniques can be used to compare which technique is more reliable in detecting drowsiness. Implementing other method to detect drowsiness is also one of the improvements to the system so that it can ensure the system to be reliable to detect drowsiness. Besides that, a better internal specification of laptop or device can be used to In earlier stages of this final year project, it has been intended to use MATLAB® to develop the algorithm for the system. The remaining of FYP 1 time period and during the FYP 2 period has been scheduled for working on the coding for the system. Using MATLAB®, toolboxes of the software have been used to ease the process of writing the codes. In the experimentation result, detecting face, eyes and mouth has been done.

IV.RESULT

After completing the algorithm modeling, the simulation of algorithm was performed by using the video from the experiment conduct by MIROS. Due to the video length cannot be run in MATLAB® because the processor have not enough memory, the video were separated into 3 minutes each video. By doing that, each video contains not more than 400 images per video. There a 10 participants who complete the driving experiment but as to show in the result, we only take a participant. Total video that have been separate is 31 videos.

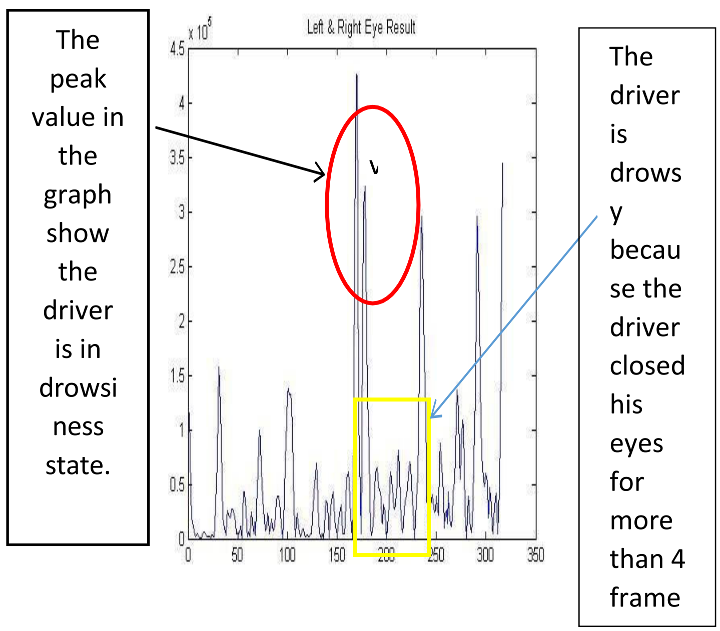

Figure 12: Drowsiness Detected in Graph

In the image above, the drowsiness state occur from frame number 168 to 179, where the driver closed it eyes for 11 seconds. The result of the driver yawns just after the drowsiness state occurs and it is shown in the graph in Figure 31.

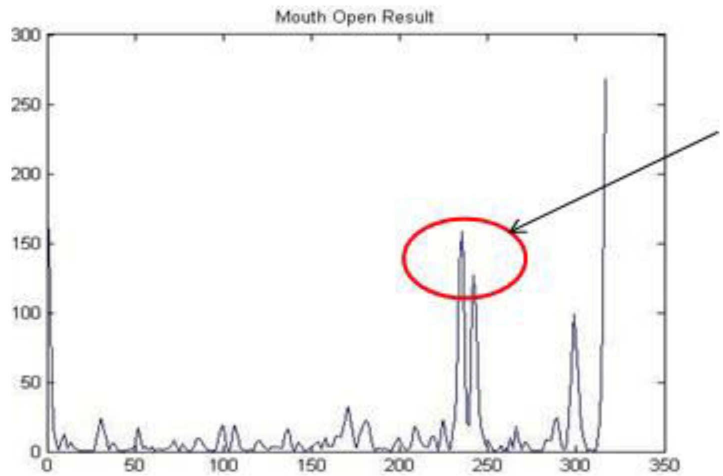

Figure 13: Driver Yawning Detected

From the experimentation and modelling, this work successfully detects each eyes and mouth for drowsiness detection system. This system is reliable because it detects the transition of the drowsiness state where the algorithms detects each eyes and mouth changes each frame per second. Therefore, the Drowsiness Detection System by using Webcam has successfully completed

IV.CONCLUSIONS

The K-Nearest Neighbour model provided accuracy comparable to the LSTM model in our scenario. But ultimately, it is better to employ the more sophisticated model with a lower false-negative rate than a simpler model that could be easier to implement since we do not want to mistakenly label those who are sleepy as awake. Second, normalisation was essential for our success. We noticed that everyone had a unique baseline for their eye and mouth aspect ratios, thus it was required to normalise for each participant. The majority of our effort was spent on data pre-processing and feature extraction/normalization outside of the runtime for our models. Updating our research and investigating ways to reduce the false-negative rate for KNN and other simpler models will be fascinating. There are a few things we can do going ahead to enhance our findings and hone the models. In order to account for any movement by the person in the video, we must first integrate the distance between the facial landmarks. We think quick movements by the participant may indicate tiredness or waking up from microsleep because in reality the participants won't be static on the screen. Second, in order to get better outcomes, we wish to update parameters using our more sophisticated models (NNs, ensembles, etc.). Third, and most importantly, we want to gather our own training data from a bigger sample of people (more data!) while integrating additional distinguishing sleepiness signs such abrupt head movement, hand movement, or even tracking eye movements.

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