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Eye Fatigue Detection in Vehicle Drivers Based on Facial Landmarks Features

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Abstract

Human factors are unavoidable in traffic accidents, so early detection is needed. Fatigue while driving can be interpreted as drowsiness or nervous breakdown. Therefore, vehicle drivers must be able to increase their vigilance. The occurrence's cause is mainly human negligence due to tired driving. When the body feels tired, it is difficult to stay awake and focus. For this reason, this study was undertaken to propose a comprehensive approach to explore parameters indicating eye fatigue or driver drowsiness.. Detection of eye fatigue in vehicle drivers uses a smartphone camera (droid cam) to acquire and detect the driver's eyes using face recognition. This application development uses OpenCV with the Python programming language. This research was conducted by detecting faces using the facial landmarks 68 algorithms and then looking for points around the eyes to calculate the eye aspect ratio. The results of the detection analysis on the eyes when open and closed indicate the rider's size is tired and buggy. The input from the program is the number of blinks of the rider's eyes every minute so that the quantity indicates the driver is tired, sleepy or fit. This figure indicates that motorists are sleepy and need to anticipate taking a short break to continue the journey later.

Keywords: Face recognition, landmarks, eye fatigue, drowsiness, blinking

INTRODUCTION

One of the problems of motorized transportation is that there are still many traffic accidents. According to Police data, in Indonesia, an average of 3 people die every hour due to road accidents. A large number of accidents was caused by 61% of accidents caused by human factors related to the ability and character of the driver, 9% due to vehicle factors (related to the fulfilment of roadworthy technical requirements) and 30% due to infrastructure and environmental factors.

Traffic accident cases continue to increase, as shown in 2017 up to 48 per cent (Health

Research and Development Agency, 2018). According to the World Health Organization (WHO), traffic accidents in Indonesia are considered the third biggest killer after coronary heart disease and tuberculosis. WHO states that traffic accident victims are in their productive age, 22-50 years.

The problem of accidents is driving, resulting in drivers improving their safety. Most of the accidents are caused by a sleepy driver. Investigated the effect of a driver sleep deprivation level on his performance during a driving job—the number of accidents and the consequences experienced by motorists. In 2017 s.d. 2019 is shown in Figure 1 Number of Accidents, Dead Victims, Serious Injury, Minor Injury, and Material Loss with increased data in 2019 on the number of accidents, minor injuries and material losses.

Humans' physiological and psychological exhaustion caused the human factor that resulted in the accident. Driver's facial image is mostly analyzed and conveyed various information from our brain (Dicarlo et al, 2012). Tired riders may result in impaired driving performance. The ability to control the vehicle is slightly lost. One of the most important approaches to reducing these accidents is by monitoring the driver's mental state and having plenty of reminders along the way when needed (Shanmugarajah et al., 2020). Therefore, an accurate and robust driver fatigue detection method is needed. It acts as one of the functions of the driver assistant system. The main issue of this method consists of data collected from the driver, vehicle and environment, an algorithm that quickly and precisely distinguishes the fatigue state from the non-fatigue state. Many methods have been proposed to improve the classification.

Blinking frequency can be affected by different factors such as conditions and commands. Under normal circumstances or stress-free, the average blink is 15 to 20 times per minute. It has also been researched that the average human blinks 20 minutes under normal conditions (when the focus is on reading) (Abusharha, 2017). Indicators to know someone is sleepy can be described when the normal condition (not sleepy) is the position of the eyelids opening wide before closing when closing has a fast time interval (less than one second). The model of a sleepy driver can be indicated that there are parameters decreasing interest in the environment and increasing drowsiness or a tendency to sleep (Sandberg et al., 2011), which is characterized by an increase in the duration of blinking to close.

Technology helps determine driver fatigue by using the sleepy eye detection method using facial landmarks in real-time via a droid cam or camera on a smartphone. Facial landmarks are used to localize and represent prominent parts of the face, such as eyes, eyebrows, nose, mouth, jaw. Facial Landmark Detection is part of the shape prediction problem. Given the input image and usually the Region of interest that determines the object, shape prediction tools localize the main points of interest along with the shape.

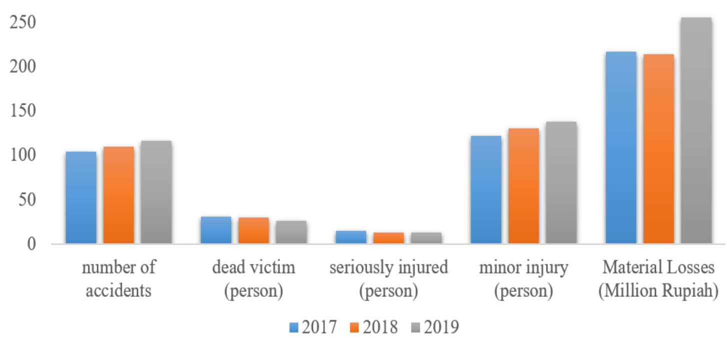

Figure 1. Condition of the number of traffic accidents and their consequences in 2017 to 2019

In the context of facial landmarks, we aim to detect critical facial structures on the face (driver) using shape prediction methods to determine the driver fatigue indicator through the drowsiness eye detection method using facial landmarks in real-time via a droid cam camera on a smartphone. Facial Landmark Detection trained in the library is used to estimate the location of the 68 (x,y) coordinates that map to facial structures on the face. Facial Landmark has been successfully applied to face alignment, head pose estimation, face swapping, blink detection, and more. Face recognition is done by applying the facial landmarks detection method. The model used in this study is facial landmarks 68

Based on the geometry of the face, the eyes are located in the upper half of the face. Because in general, when a person blinks, both eyes move simultaneously, then in this blink detection, the system identifies the blink of each eye, either the left eye or the right eye. The segmentation of the eye area obtained in the previous stage can be seen in the eye's position.

Computer Vision is the ability of a machine/computer to see until it can extract information from an image. One of the fields related to Computer Vision is Image Processing, commonly called Image Processing.

OpenCV (Open Source Computer Vision Library) is an open-source library developed by Intel that simplifies programming related to digital images. OpenCV already has many features, including face recognition, face tracking, face detection, Kalman filtering, and various methods of AI (Artificial Intelligence). The activity flow is made by a simple algorithm related to Computer Vision for low-level APIs.

METHOD

The following are the steps taken in the research, including tools and materials, system design, and face recognition application on eye fatigue detection in-vehicle users.

Tools and materials

The tools and materials used in this study include Laptop (Asus/ram 4Gb), iPhone X (droid cam), Anaconda3 2020.11, Python 3.8.5, Library OpenCV and Facial Landmarks 68

Participant

A total of 10 participants were sampled to accurately record driver fatigue-related behaviour and facial images and consider the impact of gender, age, physiological and psychological states. Participants were selected with the criteria of not having eye disease, having a valid driving license, free from orthopedic or neurological diseases.

The breakdown of environmental parameters indicated that fatigue is a multidimensional phenomenon. Fatigue and sleepiness often occur in sync. It is difficult for researchers to define fatigue precisely. Causative factors are classified into two types, namely factors related to sleep and factors related to tasks. Sleep-related factors are influenced by sleep rhythm, lack of sleep, and sleep disturbances. Task-related fatigue can be caused by active or passive fatigue. Active fatigue often occurs when the operator maintains a cognitive resource-consuming task for a period—passive fatigue results from highly repetitive monotonous stimulants. In our experiment, the driver's sleep rhythm was used as a factor causing fatigue. Fatigue detection is a key step for driver fatigue monitoring by building a system how to extract and select effective features from driver images (Niu & Wang, 2014).

Procedure

Sampling was used a smartphone droid cam in an indoor room. This paper's eye fatigue detection system uses real-time video using a webcam on a computer.

The video used pays attention to several conditions, such as the width of the eyes and the number of blinks. Eye Recognition will be easier to detect if the face is facing forward. When the face moves sideways, then the level of accuracy will decrease.

Open CV has many features that can be utilized. The following are the main features of OpenCV. Image and video I/O. This interface can read image data from files or live video feeds. Furthermore, it can also create image and video files—computer Vision in general and digital image processing (for low and mid-level API). We can conduct trials with various standard computer vision algorithms with this interface. It includes the line, edge, tip detection, elliptical projection, image pyramid for multi-scale image processing, template matching, and various transforms (Fourier, discrete cosine, distance transform) and more. High-level computer vision module. OpenCV also includes "high level" capabilities, such as additional capabilities for face detection, facial recognition, including optical flow methods for AI and machine learning. Computer vision applications often require machine learning or other AI methods, some of which are available in the OpenCV machine learning package. Image sampling and transformation. In OpenCV, there are already interfaces for subregion subtraction of images, random sampling, rotating, and others. Methods for creating and analyzing binary images. Methods to account for 3D modelling. This function is beneficial for mapping and localization, both for stereo cameras or one camera with various viewing angles.

The use of the facial landmarks 68 feature makes it easier to determine each object's correspondence point. There are 68 points stored in a 68 x 2 matrix containing the x and y coordinates of the points on the landmarks. The landmark points extracted from face detection will be transformed as features. It can be seen in the image of a person closing his eyes. Figure 2 shows a blindfolded image used for the video. The difference is found in the image of a person opening their eyes. Figure 3. shows an example of an open eye image used for a video.

Figure 2. An example of a closed eye image used for a video

Figure 3. Example of an open eye image used for a video

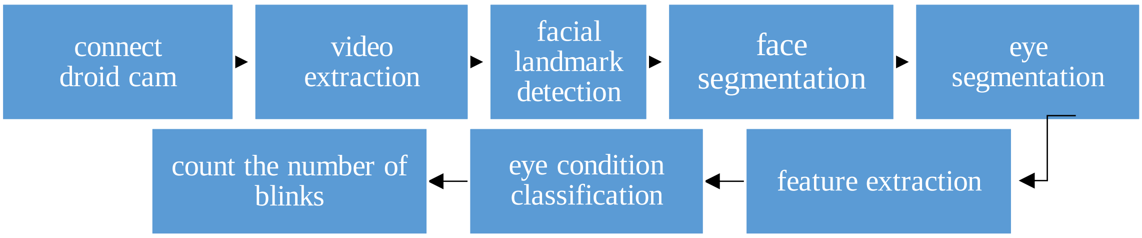

Figure 4. Program Design Flowchart

System planning

Detection begins with video capture using a web camera to detect the eye area using facial landmark detection. The output is the number of blinks and eye ratio if we detect sleepy eyes. The results of this eye detection will be obtained by concluding based on the number of blinks per minute. Under normal circumstances or stress-free, the average blink is 15 to 20 times per minute. If more than this amount, it can be concluded that the driver is sleepy. The flow of the program design can be shown in Figure 4. The flow starts from connecting to the droid cam. Then video extraction is carried out. Facial Landmark 68 detection is done by knowing the segmentation of the face, then on that part of the face, the target is the eye, so eye segmentation must be done. Extraction of features from the eye was performed to classify eye conditions. The driver prepares this by counting the number of blinks.

Driver's Mental Fatigue Assessment using Face Marker This machine learning-based detector is trained on a 'data set in the wild', which makes it robust for a wide range of illumination conditions on facial expressions and head rotation. The error between the eyes can reach under five per cent. The eye aspect ratio extracted from facial landmarks to detect the blink parameter effectively (Feng et al., 2020). Thus, we can derive some information about fatigue from the time series on the aspect ratio of the eye.

This study proposes a method to detect driver fatigue based on facial landmarks. This research can be interpreted as follows: facial landmarks' eye aspect ratio sequence can detect the driver's mental fatigue. If so, the answer is yes, then what effect can this be realized. A simulator-based experiment for riders was designed and carried out to explore the possibility of detecting mental fatigue by eye aspect ratio.

The person being tested participates in the experiment. The two raters' facial images and alertness assessments during the experiment were recorded. The eye aspect ratio and mouth aspect ratio of the facial landmarks indicated were extracted and used. Furthermore, participant requirements, devices, driving tasks and indicators will be explained to complete this procedure.

RESULT AND DISCUSSION

Facial landmarks detection is applied using a regression tree algorithm (Figure 5). This algorithm is used to detect the coordinates of the eye. After the eye coordinates are found, the eye coordinate values (x,y) will be processed using the eye aspect ratio formula to determine the blinking result. If the eye blinks more than 20 times per minute, the driver is considered sleepy.

The eye fatigue detection system for vehicle users using real-time video has a system display, as shown in Figure 6. The detection shows that the white dots form a more extensive area when the eyes are open. It is different from the condition of the eyes being closed, as shown in Figure 7. The area at the white point in focus appears to be narrower. The top and bottom points are closer together than the eye is open.

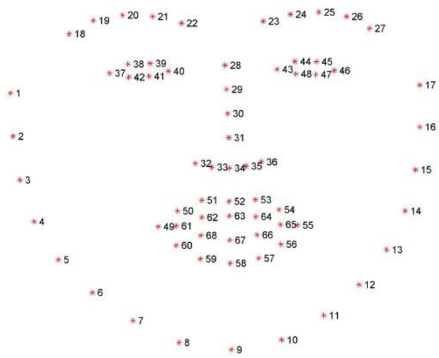

Figure 5. Dataset facial landmarks 68

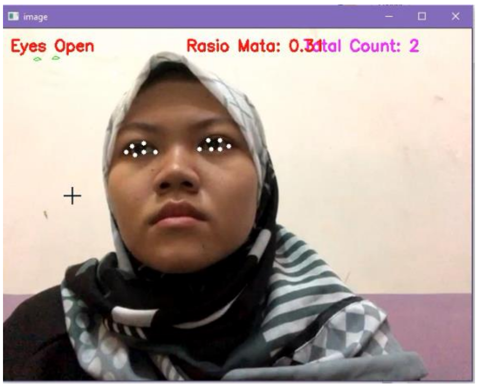

Figure 6. Detection of open eyes

Figure 7. Closed eye detection

This detection system uses an image in the form of a video. Detection is done by calculating the eye ratio to shrink at a predetermined limit. In a fit condition, the eye ratio reaches 0.28-0.34. The size is smaller in eye fatigue conditions, namely 0.18 -0.22 for measurements on ten samples shown in Figure 7. System alert driver because of the eye aspect ratio is detected depending on the approach of the tool and its effectiveness (Mehta et al., 2019). Detection of the face area also uses another method, namely the Haar Cascade Classifier, but has similarities to the regression stress algorithm on facial landmarks detection which is used to detect sleepy eyes with an output in the form of an alarm to give a reaction so that the driver is not sleepy (Maslikah et al., 2019).

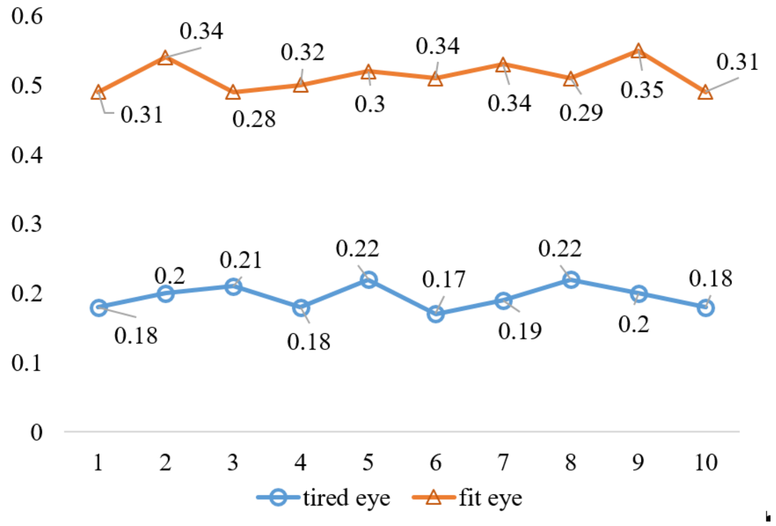

Figure 8. Comparison of eye ratio in conditions of tired or fit riders

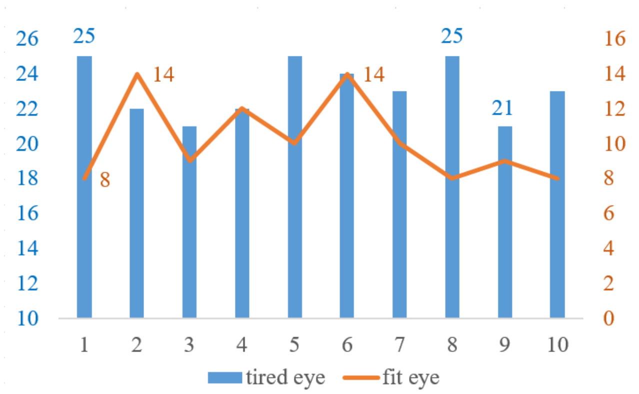

Figure 9. Comparison of the number of blinks in 1 minute for tired and fit eyes

Intelligent system technology on colouring changes the colour in the eye area into a grey image (grayscale), namely by calculating the grey value of each pixel (x, y) Where grey (x, y) is the value of the grey intensity on the pixel (x, y), while RGB is a colour image component. The next process is to equalize the histogram on the image, which aims to overcome the lighting problem. The next critical stage is morphological operation. In this study, morphological operations were used to remove the existing noise. Prior to the morphological operations, only certain areas (bounded areas) are processed, commonly called ROI (Region of Interest), to speed up the computational process. After determining the ROI area (in this study, ROI is the eye area), a thresholding process is carried out in that area, 35 in this study a threshold value of 5. if the grey intensity value is above 5, the detection result is marked in black. Region of Interest is applied to obtain a localized area with low computational costs and accurate features. There is a threshold that can be used as a single image classifier in the eyes aspect ratio method to detect eye condition for longer size (Maior et al., 2018).

Other detections can display that the number of eyes blinked at the driver. Then the blink of an eye will be counted by the system as the application's output. The system detects if eyes are open or closed based on the calculation of the eye ratio that has been done. The video was taken twice in a tired and fit condition for ten samples, as shown in Figure 8.

The analysis and detection of blinking is well researched, can use conventional cameras and the relationship between blinking pattern and driver sleepiness is also well established (Schmidt et al., 2018). The program can detect eye fatigue with indicators indicating tired or fit. The count of blinks is done every minute. The limit value to determine whether the driver is tired, sleepy or not, at fewer than 15 blinks in 1 minute, means that the driver is not sleepy—Vice versa. If the driver blinks more than 15 times in 1 minute, it can indicate that the driver is sleepy or experiencing eye fatigue. Eye fatigue, as well as sleepy eyes, need to be detected with developing technology. Many studies have been conducted in intelligent systems based on image processing and computer vision. Blinking behavior provides greater insight into the driver's level of fatigue or sleepiness. The blinks have a unique temporal signature that can be better captured by the event camera (Ryan et al., 2021). A system that detects the state of the eyes being closed or open (eye blinking detection) can be done by recognizing the condition of the driver yawning or not opening his mouth likewise, if this technology can detect fatigue by paying attention to the recognition of facial expressions as a whole. In addition, a fixed blink duration for all eyes is assumed, although everyone blinks differently (Benedetto et al., 2011). The proof of the simple detection algorithm, fast computing speed, and high detection and recognition accuracy of the system are indispensable as the real-time requirements of the driver fatigue detection system (Lin et al., 2015). This system can be used in real time and with high accuracy as long as the system can be embedded into a portable smart device to detect driving fatigue in everyday life (Kong et al., 2015). It is also supported that in particular the segmentation network using the lightweight U-Net structure performs pixel-level classification of eye images, which can accurately extract pupil and iris features from video images. Then, a feature map is extracted to estimate eye openness (Zhuang et al., 2020).

CONCLUSION

Detecting eye fatigue in motorized vehicle drivers can detect the eye ratio and the number of blinks according to eye conditions. The order of eye aspect ratio is calculated based on facial landmarks. These results will be obtained the results that the driver is sleepy or not. The parameter size used in the number of blinks is drowsiness. If the eye blinks more than 20 times for one minute, then the driver. This detection is done by performing landmarks with the facial landmarks 68 algorithms to detect with a good level of accuracy.

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