ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
**Indian Journal of Science and Technology,** *Vol 11(20), DOI: 10.17485/ijst/2018/v11i20/123348, May 2018*

# Fatigue Alert System

**Kirbana Jai Raman*, Afizan Azman, Siti Zainab Ibrahim, Sumendra Yogarayan, Mohd Fikri Azli Abdullah, Siti Fatimah Abdul Razak, Anang Hudaya Muhamad Amin and Kalaiarasi Sonai Muthu**

Faculty of Information Science and Technology, Multimedia University, Malacca, Malaysia; jpk_kirbz@hotmail.com , afizan.azman@mmu.edu.my, sitizainab.ibrahim@mmu.edu.my, mastersumen@gmail.com, mfikriazli.abdullah@mmu.edu.my, fatimah.razak@mmu.edu.my, anang.amin@mmu.edu.my, kalaiarasi@mmu.edu.my

## Abstract

Accidents on road are very common these days with most of it are caused by driver behavioral pattern. Driver fatigue can also be categorized under driver behavioral as it comes from the driver itself. The idea behind the paper is to discuss the facial recognition and features used to detect and alert drivers in real time if fatigue is detected. Face monitoring technique is used to identify state of the driver. With the existence of such alert system, it would be helpful to reduce accidents on road.

**Keywords:** Alert, Eye Closure, Facial Recognition, Fatigue, Yawning

## 1. Introduction

These days, a continuous increase in automobile industry has brought dynamic, compatible and environmental friendly vehicle that also consumes lesser energy. Even then, more than half of accidents that occurs today are mostly because of driver fatigue. An uninterrupted driving activity that takes place for more than three hours results in fatigue and tired-ness, which eventually its consequences are making the driver sleepy and unaware of the surrounding. Therefore, there is need to develop a fatigue alert system that keeps the driver attentive on the road.

With the advancement of technology in automobile industry, there are number of devices that is equipped in modern cars for preventing accidents. The goal of such invention is to safeguard the driver and occupant of the car in the occurrence of an accident. Generally, these devices are categorized into two and they are active driving safety and passive driving safety.

Active driving safety points out to devices or appliance that keeps the car under control. It is normally automated to take care of human error, which is also classified as a substantial cause for car accidents according to Forbes. For example:

- Anti-lock brake maintains the tractive contact on the road surface while the driver brakes.
- Traction control systems prevents loss of friction when the car is accelerating.
- Electronic stability control is a technology that boost the stability of the car and keeps it under control

Meanwhile, passive driving safety indicates to systems in the car that shield the driver and passengers from injury in case of an accident. Some of the examples are:

- Air bag is an occupant restraint system, which safeguard the driver and passengers during collision.
- Seat belts is a device that is designed to protect the vehicle occupant from harmful movement.
- Rollover bars protect the car's occupants from injury if the vehicle rolls over during an accident.
- Head restraint prevents rearward movement of the head during a rear end collision.

*Author for correspondence

# 2. Findings

## 2.1 Fatigue

Fatigueness can be described as lack of energy which results in a less active mode of an individual. Fatigueness is consequences of exhausted state of an individual and it has a gradual onset that can have a physical or mental cause. Fatigue decreases efficiency in the performance of daily activities, Moreover, fatigue is the top most safety concern of many fields, mainly in transportation because fatigue can lead to catastrophic accidents.

Fatigueness among drivers is distinguished into two categories and they are acute fatigue and chronic fatigue. In simpler terms, acute fatigue arises weariness while chronic fatigue typically arising from prior sleep deprivation. There are few causes for fatigueness and they are eating habit, amount of sleep, amount of exercise, anemia, lack of nutrients, thyroid problems, diabetes, depression, sleeping problems and heart disease.

Approaches of fatigue and distraction are described from the perspective of psychology and physiology such as sensory fatigue, muscle fatigue and cognitive fatigue. The only countable ones are sensory fatigue and muscular fatigue while there is no any other method to count cognitive fatigue. Adding into that, it is also stated that there is no any affiliation between fatigue and body temperature, electrical skin resistance, and eye movement, rate of breathing and heart and also activity of brain.

A poll carried out in America in the year of 2005 by National Sleep Foundation classifies that 168 million of them which is about 60% of adult driver confess that they have continuously choose to drive even when they are feeling drowsy. Apart from that, there were some of them whom literally fell asleep while at the wheel. With the result of the overall poll, it can be said that 13% of them have nodded off at least once a month while roughly about 11 million drivers which is about 4% of them have met accident or close to it due to extreme tiredness while driving[1].

There are few techniques to predict circumstances of decrease in driver concentration on road using prediction on steering motion and driver face monitoring approaches. The approaches are compared and listed below in Table 1.

## 2.2 Face Detection

The primary portion of image processing has always been face detection because to detect any other facial features, one has to detect the face at first. Face detection can be classified into two common classes and they are feature based and learning based approaches. Usually, learning based approach are more reliable compared to feature based approach. However, they frequently consume extra computational resources. These approaches are able to obtain a detection rate reaching up to 80-90% or more in closed or room conditions, but they fail to perform in real condition at most cases more often due to poor lighting.

## 2.3 Eye Detection

With the number of existing driver face monitoring system for fatigue or drowsiness, most common symptom to be observed is the eye region. As for that, the eyes should be detected first before proceeding to process the eye region. There are research that studies about localization of eyes. On the other hand, height of the eyelid is also being researched on. The lesser the height of the eyelid, the higher the possibility of fatigue.

Even then, it is applicable for certain period of time in the fatigue context, eyes play important role to ease fatigue detection as the most common symptom of fatigue is eye closure. It can be detected by analyzing the eye activity over a period of time which is also known as PERCLOS. For example, the frames can be observed and analyzed in order to identify the condition of the eyes whether or not it is open. Some researchers develop the system such a way that seconds are measured to detect closure of the eyes. For instance, if the eyes are closed over about five to six seconds, it is alerted as fatigue. Apart from that, in a different method frames can also be used to detect fatigue.

**Table 1.** Comparison between Driver Fatigue and Distraction Detection[2]

| | Approaches based on Driver Face Monitoring | Approaches based on Steering Motion | Approaches based on Bioelectric Signals |
|---|---|---|---|
| **Driver Detection** | Yes | Yes | No |
| **Fatigue Detection** | Yes | Yes | Yes |
| **Detection Speed** | Fast | Slow | Very Fast |
| **Accuracy** | Easy | Relatively Easy | Very good |

Eye closure over a period of frames indicates fatigue. Similarly as stated, the research conducted in this paper uses eye closure over frames in the count of three. In the occurrence of eye closure over three frames or more, a warning is prompted to the driver as the sign that fatigue is detected. Frequently blinking eyes are symptom of fatigue as well.

## 2.4 Mouth Detection

Generally, yawning is also classified as a symptom that an individual is achieving the state of fatigue. The openness of mouth to a certain threshold can be classified as fatigue. There is also way to measure the height and width of the mouth for yawn detection. The condition is that, an increase in the height and decrease in the width. This is because, commonly the height of the mouth is smaller compared to the width which is longer. Thus, in any state of the increment in the height and decrement in the width of the mouth is classified as yawn.

With various other method actively being used to detect yawn of the driver, contour method is one of another. Contour method is an approach to detect the openness of the mouth of an individual. Few steps will be conducted for segmentation process and they are blur, erosion and dilation. It is later decided using certain threshold whether or not an individual is yawning. As of this paper, the threshold value is 75% which as of that, whenever the yawn percentage of 75% and above is detected, warning is activated. It is also suggested that a warning system in the form of an audible sound is much effective to alert to drivers in case of fatigue[3].

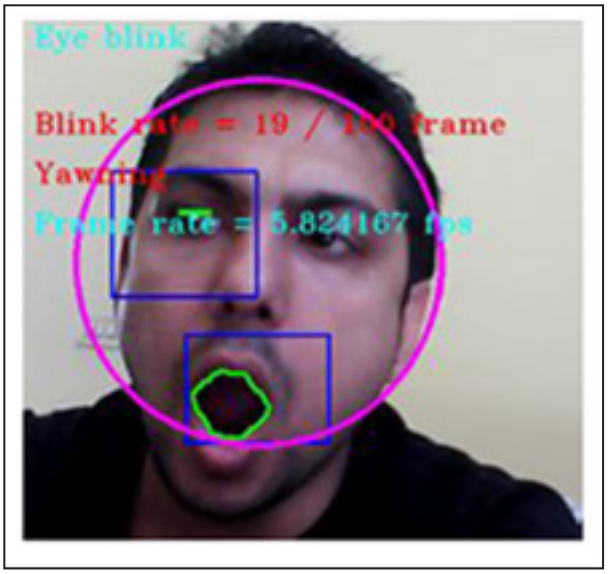


**Figure 1.** Face, Eyes and Mouth Detection[3].

**Table 2.** Summary of Previous Driver Fatigue Research

| Article | Authors | Parameter | Peripherals |
|---|---|---|---|
| Real Time Non-intrusive Monitoring and Prediction of Driver Fatigue[4] | Qiang Ji, Zhiwei Zhu, Peilin Lan | Eyelid Movement, Gaze Movement, Head Movement, Facial Expression. | CCD cameras equipped with Active IR Illuminators |
| Analysis of Real Time Driver Fatigue Detection Based on Eye and Yawning[3] | Narender Kumar, Dr. N.C. Barwar | Eyes and Mouth | iBall Face2Face C8, Viola Jones, Contour Detection Algorithm |
| Detecting Driver Fatigue Through the Use of Advanced Face Monitoring Techniques[5] | Harini Veeraraghavan, Nikolaos P. Papanikolopoulos | Face, Eye Tracking | Panasonic Camcorder. Pentium Pro 200 MHz PC with Matrix Genesis Imaging Board |
| Eye Tracking for Detection of Driver Fatigue[6] | Martin Eriksson, Nikolaos P. Papanikolopoulos | Eyes | Template-based Matching. Feature-based Matching |
| Automatic Fatigue Detection of Drivers through Yawning Analysis[7] | Tayyaba Azim, M. Arfan Jaffar, M. Ramzan, Anwar M. Mirza | Eyes and Mouth | Viola Jones Face Detection method, spatial Fuzzy C-Means (s-FCM) Clustering |
| Monitoring Mouth Movement for Driver Fatigue or Distraction with One Camera[8] | Wang Rongben, Guo Lie, Tong Bingliang, Jin Lisbeng | Mouth | Dashboard-Mounted CCD Camera |
| Yawning Detection for Monitoring Driver Fatigue[9] | Xiao Fan, Bao-Chai Yin, Yan-Feng Sun | Mouth | CCD Camera, Gravity-Center Template, Gabor Wavelet |

Table 2 summaries several driver fatigue research. Other concerns on fatigue or drowsiness attributes related to car crashes are of alcohol. Driver inattentiveness are classified due to the reason mentioned. Based on the summary of the table, it is seen that most of the researches used eyes and mouth for fatigue detection. That is the most commonly used parameters. There are many automotive brands that has such kinds of fatigue or drowsy detection system implemented or built in their brand cars. Those of existing car safety technologies are vehicle position in lane monitoring, steering pattern monitoring, physiological measurement and driver face monitoring.

**Table 3.** Car Safety Technology

| Technology | How It Works |
|---|---|
| Physiological Measurement | Require body sensors to measure parameters such as brain activity, heart rate and muscle activity |
| Driver Face Monitoring | Require a camera to monitor driver's face |
| Vehicle Position in Lane Monitoring | Uses lane monitoring camera |
| Steering Pattern Monitoring | Uses steering input from electric power steering system |

Table 3 shows some of existing car safety technology in the market and how it works. These existing technologies are inclusive of the automotive brands such as Mercedes Benz, Volkswagen Das Auto, Ford, BMW and Mazda. Attention Assist of Mercedes Benz Monitors the behavioral pattern of the driver from the beginning of the journey while creating a profile for an individual driver that is used to compare with existing sensor data constantly. This fixed pattern of observation is crucial for analyzing the transformation and progress of the driver from being awake to fatigue and alert the drivers in real time. Attention Assist is progressively active at the speed range between 80 and 180 km/h[10].

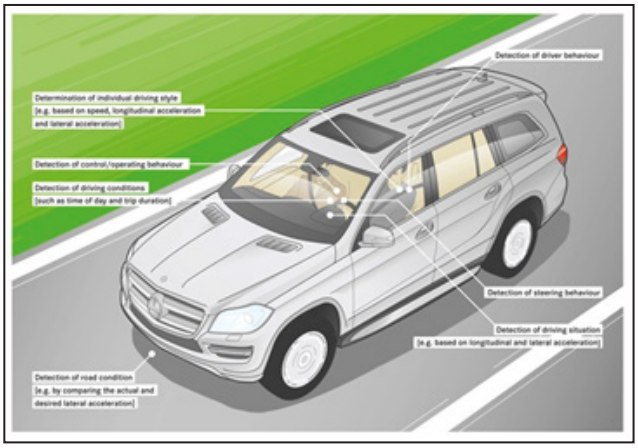


**Figure 2.** Mercedes Benz Attention Assist[4].

The advanced system which is available in the 2013 model year Mercedes Benz S and E class is currently active at a boosted speed range among 60 and 200 km/h. it has an extremely precise monitoring on the steering wheel movement and speed since the model is upgraded with highly sensitive sensor. Attention Assist computes the driver behavioural pattern based on the steering wheel movement and speed. With the aid of electronic control unit of the vehicle, current steering behaviour is continuously compared with previous steering behaviour. Based on the constant monitoring, drowsy indicator will be emitted through an audible signal and an absolute instruction will be displayed in the instrument cluster of Attention Assist if the driver is demanded drowsy[10].

**Table 4.** Summary of Automotive Brand and its Technology

| Automotive | System | Technology |
|---|---|---|
| Mercedes Benz[10] | Attention Assist | Steering Pattern Monitoring |
| Volkswagen Das Auto[11] | Fatigue Detection System | Steering Pattern Monitoring |
| Ford[12] | Driver Alert | Vehicle Position in Lane Monitoring |
| BMW[13] | Active Driving Assistant | Vehicle Position in Lane Monitoring |
| Mazda[14] | Lane Departure Warning System | Vehicle Position in Lane Monitoring |

## 3. Proposed Work

Development of the proposed system is based on Python programming language, which is an object oriented language that contains certain modules and libraries to run the program without errors. Some of them are numpy, scipy and time. There are other built in packages that comes together with python. Python is much simpler and leads to faster development. Moreover, it has a clean and straightforward syntax that ease the coding process besides having a huge standard library. Python has a built in high level data types, which is rich in polymorphic lists.

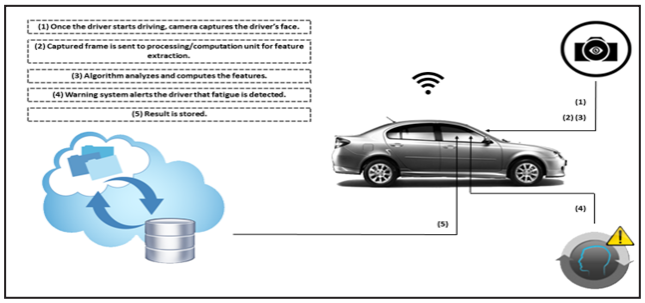


**Figure 3.** Overall Idea of Driver Alert System.

There have been many techniques and methods that can be used to detect fatigueness on drivers. But here on this research, face monitoring techniques have been used with facial parameters such as eyes and mouth are taken into count. The idea of Driver Alert System is to implement it in driving environment for a real time fatigue detection on the driver. As for that, an illustration diagram has been attached here for a clear understanding on how the system function in a car.

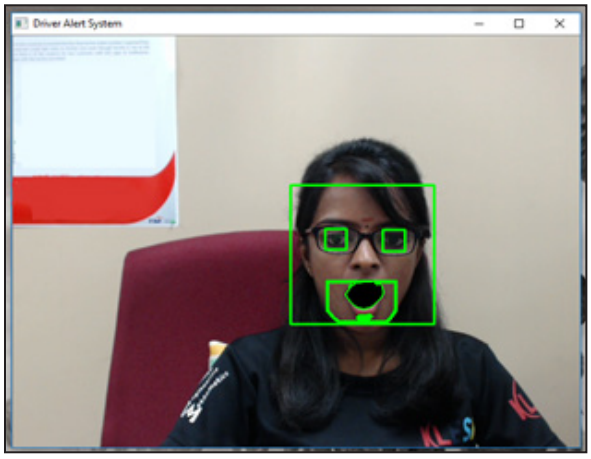


**Figure 4.** Eye Closure and Yawning Detection.

The system activates once the driver starts to drive. Later, camera activation occurs and it starts detecting the driver's face to capture and process the feature in real time. Captured frame is sent to computation unit for feature extraction. The algorithm then analyzes and computes the feature. In the occurrence of eye closure over certain number of frames and yawning, the alarm is triggered. The whole activity throughout the camera activation each neutral and fatigue state is written into a text file for future references.

Basically, the proposed system in this paper contains eye and mouth detection. These are two parameters are observed to detect fatigue for the driver in real time environment. As of that, eye closure and yawning are counted to identify the fatigue state of the driver. Since it is a real time detection, each and every frames are analyzed. As for eyes, the algorithm evaluate whether or not the eyes are closed over a period of frame. In this context, if the eyes are closed for consecutive 3 frames, alarm is triggered. It is more likely as PERCLOS method for eye closure detection. On the other hand, another obvious symptom of driver fatigue is yawning. As what the system does for the eye closure detection, it evaluates the openness of the mouth for yawning. In this system, contour method is used to detect yawning occurrence. Darkest region of the lower part of the face is focused to get the contour of the mouth accurately. The mouth zone is set to be the region of interest to point out yawning when opened mouth is detected.

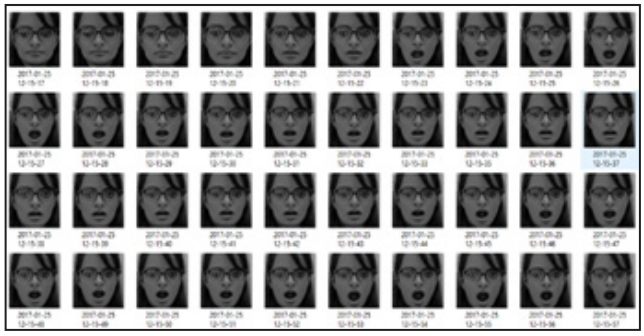

**Figure 5.** Storage of Captured Image.

Besides that, the percentage of mouth openness and the eye state is continuously being written into a log file, while gray scale converted images are stored into a folder. Apart from that, the main feature of the system would be the warning system. In case of eye closure over certain number of frames and yawning occurrence, an audible warning sound is triggered to alert the drivers.

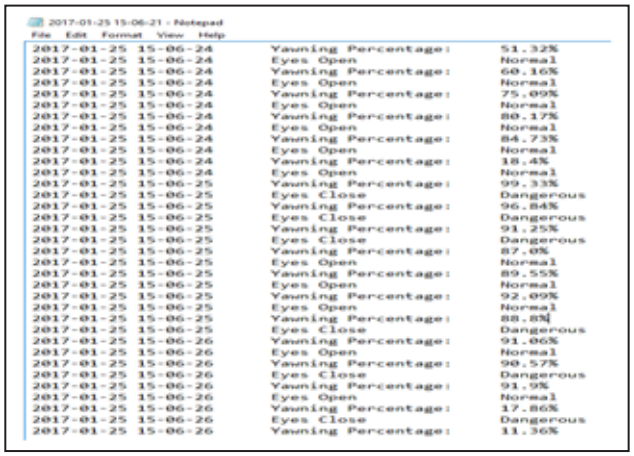


**Figure 6.** Output in Text File.

Figure 6 shows the written output into a text file. As seen here, it records the time, yawning percentage and eye state. The system that have been developed to detect fatigue will be integrated into Raspberry Pi. The purpose of using Raspberry Pi is mainly because to get the system integrated inside a car. It is a cost effective hardware that can be obtained easily and handled. Looking into the programming language compatibility for the Raspberry Pi, Python comes first. It is easy to read and write with Python on Raspberry Pi. Python syntax are clean at where Python development environment can be used through IDLE. Raspberry Pi supports Python version 2 and 3 at once. Python commands can be run using Raspberry Pi command line and it is directly executable.

## 4. Conclusion

Face recognition is a challenging problem in the field of image analysis and computer vision that has received a great deal of attention over the last few years because of its applications in various domains. The entire idea of developing fatigue detection system regardless of what is already in the global market is to provide a sight of it to Malaysian made cars. This is because local made cars does not have such system. Furthermore, considering other environmental factors such as weather and Malaysian road condition, it is crucial to have fatigue detection for Malaysian roads.

Driver Alert System detects real time fatigue using parameters such as eyes and mouth. Such alert system could reduce number of accidents on road caused by driver fatigue. One of the constraint faced was due to the various lighting environment. With outgrowing technology in the field of automotive, it would definitely contribute to safety aspects to be taken into consideration. Adding into it, the research can be expanded into next level in near future using sensor motion or lane keeping.

## 5. Acknowledgement

This research work was ostensibly supported and carried out within the framework of a project entitled Connected Car Services - Automatic Facial Recognition for Driver Satisfaction Detection and For Vehicle Data Analytics funded by TM R&D between Multimedia University (MMU), Melaka, Malaysia and Proton, Malaysia.

## 6. References

1. National Sleep Foundation. Available from: http://drowsydriving.org (n.d.).
2. Mohd Hoseyn Sigari. A Driver Face Monitoring System for Fatigue and Distraction Detection. International Journal of Vehicular Technology. 2013; 2013.
3. Narender K. Detection of Eye Blinking and Yawning for Monitoring Driver's Drowsiness in Real Time. International Journal of Computer Science and Information Technologies. 2014; p. 7821-6.
4. Ji Q. Real Time Non-intrusive Monitoring and Prediction of Driver Fatigue. IEEE Transactions on Vehicular Technology 2004 July; 53(4).
5. Veeraraghavan H. Detecting Driver Fatigue Through the Use of Advanced Face Monitoring Techniques. International Journal of Advanced Science and Technology. 2014; 64:73-100.
6. Eriksson M. Eye Tracking for Detection of Driver Fatigue. IEEE Transactions on Intelligent Transportation Systems. 1997. Crossref.
7. Azim T. Automatic Fatigue Detection of Drivers through Yawning Analysis. International Conference on Innovative Computing, Information and Control. 2009. Crossref.
8. Rongben W. Monitoring Mouth Movement for Driver Fatigue or Distraction with One Camera. IEEE Transactions on Intelligent Transportation Systems. 2004. Crossref.
9. Xiao Fan, B-C, Y-F. Yawning Detection for Monitoring Driver Fatigue. Sixth International Conference on Machine Learning and Cybernetics, 2007; p. 664-8. Crossref.

10. Daimler: Drowsiness Detection System Warns Drivers to Prevent Them Falling Asleep Momentarily. 2015. Available from:http://media.daimler.com/marsMediaSite/en/instance/ko/ATTENTION-ASSIST-Drowsiness-detection-system-warns-drivers-to-prevent-them-falling-asleep-momentarily.xhtml?oid=9361586.
11. Das Auto: Volkswagen Driver Alert System. 2016. Available from: http://www.volkswagen.co.uk/technology/car-saftey/driver-alert-system.
12. Ford: Ford Technology Newsbrief. Driver Alert. 2010. Available from: https://owner.ford.com/how-tos/vehicle-features/safety/driver-alert-system.html.
13. BMW: Group Driving Assistance Systems. Available from: https://www.press.bmwgroup.com/global/article/topic/5243 (n.d.).
14. Mazda: Lane Departure Waning System. Available from: http://www.mazda.com/en/innovation/technology/safety/active_safety/ldws/ (n.d.).
15. Mohsen Soryani. A Review on Driver Face Monitoring Systems for Fatigue and Distraction Detection. International Journal of Advanced Science and Technology. 2014.