A Comparability Study on Driver Fatigue Using C#, C++ and Python

K.J. Raman[1], A. Azman[2], S.Z. Ibrahim[3], S. Yogarayan[4], M.F.A. Abdullah[5], S.F. Abdul Razak[6], A.H. Muhamad Amin[7] and K. Sonai Muthu[8]

[1,2,3,4,5,6,7,8]*Faculty of Information Science and Technology, Multimedia University (MMU), Melaka, Malaysia*

[1]*kirbanajairaman@gmail.com*, [2]*afizan.azman.mmu.edu.my*, [3]*sitizainab.ibrahim@mmu.edu.my*, [4]*mastersumen@gmail.com*, [5]*mfikriazli.abdullah@mmu.edu.my*, [6]*fatimah.razak@mmu.edu.my*, [7]*anang.amin@mmu.edu.my*, [8]*kalaiarasi@mmu.edu.my*

Abstract—**Accidents on road are very common these days. Most of them are caused by driver fatigueness. Some common causes and symptoms have been identified. One of the main solution to detect driver fatigue is by analyzing the facial features of the drivers. This paper discusses about the facial features that can be used to detect driver fatigue. Further examples on existing vehicle safety technology is also discussed. Primarily, this work emphasizes on the study of three different programming languages and its compatibility which works best to be integrated with the proposed hardware. Based on the study, the result is discussed and the suitable programming language is suggested.**

Keywords—Accidents, Fatigue and Face Detection

I. INTRODUCTION

ONE of the main focus for car manufactures in safety falls is preventing the car from accident to occur. With the number of devices equipped in the modern cars, it is designed to protect the driver and passenger safety and accident prevention. These devices are generally categorized as active and passive driving safety. Active driving safety mainly points out to have a system which works to prevent the risk of collision or accident to occur. For instance, when a driver brakes, anti-lock brakes prevent the wheels from locking up thus, enabling the driver to control the car while braking. Traction control systems restrain the wheels from skidding when the car is being accelerated. Besides that, electronic stability control ensures the car is under control on the road regardless of the surrounding condition.

On the other hand, passive driving safety protects the drivers and passengers after the accident occurred. Air bags are equipped with a cushion as a safeguard to the occupants during a crash. Seat belts grips the passengers in place so that they don't flung forward or ejected from the car. Protecting the car occupant if the car is being rolled is the responsible of rollover bars. Moreover, in the occurrence read end collision, head restraints helps to prevent the vehicle occupant from getting whiplash.

II. FINDINGS

Fatigue can be described as a lack of energy, which results in a less active mode of an individual. Fatigue is the consequences of the 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 [1] [2].

Fatigue among drivers is distinguished into two categories; they are an acute fatigue and a chronic fatigue. In a simpler terms, an acute fatigue arises weariness while chronic fatigue typically arising from prior sleep deprivation. There are few causes for fatigue such as eating habit, amount of sleep, amount of exercise,

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anaemia, lack of nutrients, thyroid problems, diabetes, depression, sleeping problems and heart disease [3].

Fig. 1. Driver Fatigue Danger [4]

Fig. 1. shows a study conducted by the American National Sleep Foundation's, stated that more than half of the drivers admitted being fatigue while driving a vehicle. Another portion of the poll that is 37% of the drivers are reported falling asleep behind the wheel. The poll carried out by the America National Sleep Foundation, and found out that about 100000 of police reports over crashes each year due to fatigue problem among the drivers. An overall conclusion is that only one driver out five of them tend to pull over the side to take a rest as precautionary measures when they are feeling tired or drowsy [5]. It is advisable for the drivers to take breaks after a long journey because it is a common risk and even higher for the driver of falling asleep on wheel after every four to six hours of non-stop driving.

The National Highway Traffic Safety Administration (NHTSA) of America conservatively concluded that huge number of results in fatal accidents, serious and mild injuries, while billions in monetary losses [6]. On the other hand, Fig. 2. shows that fatigue can affect the individual mental and physical. The risk of crash is higher when the fatigue affects an individual physically rather than mentally. Most common symptoms of fatigue drivers are having trouble in focusing or having narrowing attention on roads, head nodding or inability to keep the eyes open and constant yawning or rubbing eyes. Besides that, slower reaction time and drifting out in lane are also considered as fatigue [7].

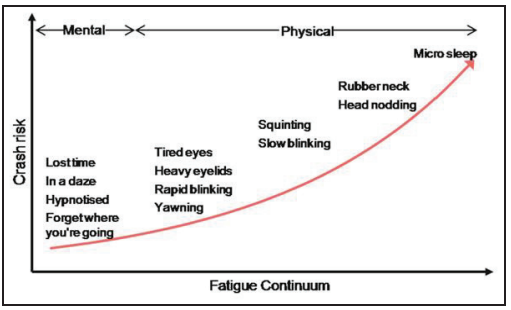

Fig. 2. Relationship between Fatigue Continuum and Crash Risk [8]

Many researches on fatigue detection have been carried out over the years. Eye closure is the simplest symptom to detect drowsiness. Despite the simplicity of this symptom, it provides very useful information about drowsiness and anesthesia even among the drivers. In order to detect drivers' drowsiness, eye closure can be used in two different forms which is a continuous eye closure and the eye closure percentage in a certain period of time.

The entire image of the face involves localization of the eyes and the eye-envelopes, which determines the areas around the eyes. In the subsequent frames, during the tracking, the search space is reduced to the area corresponding to the eye envelopes in the current frame. Besides, low computational effort can be used in this tracking, since the search space is significantly reduced. During the tracking, in order to detect the failure, the general constraints such as distance between eyes and horizontal alignment of the two eyes that can be used.

Apart from that, in fatigue, yawning is another symptom that occurs with mouth opening. However, some drivers while driving tend to speak which can be considered as a symptom of distraction. Therefore, mouth region is related to the symptoms can be used to detect driver drowsiness and as well distraction. According to research, there are lips reading when someone arches their lips. For example, arching lips upward is a mark of contempt, happy or satisfied, elongated lips is a mark of anger or grudge, while downward lips is a mark of frustration, sad or dissatisfaction. In this context, the mouth shape changes according

to different state it is engaged in. For example, the mouth is widely open when an individual is yawning and opens moderately when talking. In order to distinguish these two different states, training and testing method should be carried out so that it does not give a false positive result. Commonly, vehicle safety technology refers to an advanced driver assistance systems which is developed to secure the wellbeing of the vehicle occupants. The existing vehicle safety technology is discussed in Table I.

TABLE I. VEHICLE SAFETY TECHNOLOGY

Technology	How It Works
Steering Pattern Monitoring	Input by power steering system
Vehicle Position in Lane Monitoring	Usage of lane monitoring camera
Driver Face Monitoring	Usage of camera for driver face monitoring
Physiological Measurement	Requirement of body sensors to measure parameters such as brain activity, heart rate and muscle activity

Some of the examples of current existing technology for vehicles are Attention Assist of Mercedes Benz. Fig. 3. shows the functions that Attention Assists have. It creates an individual profile at the start of every trip. Basically, attention assists monitor and records steering movement and speed of car with a condition that the car is travelling at speeds between 80 and 180km/h. Attention Assists examine factors such as time behind wheel, driver activity, and weather and road surface. It releases an audible sound and frames on the instrument cluster in order to alert the drivers [9].

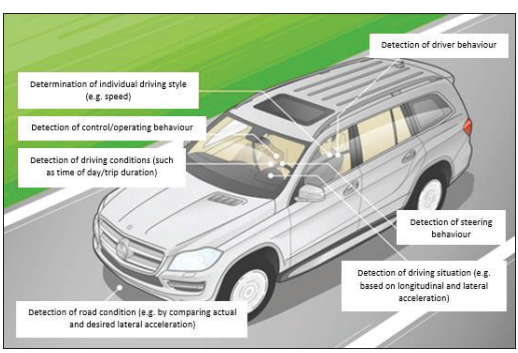

Fig. 3. Mercedes Benz Attention Assist [9]

Meanwhile, there is also a car safety technology from Volkswagen Das Auto as shown in Fig. 4., which is Fatigue Detection System. This system analyzes the driving characteristics and indicates possible fatigue [10]. Besides that, Fatigue Detection System assess steering movements along with other dashboard signals released inside the vehicle. Warning is prompted every 15 minutes if break not taken. Precisely, the system does not take control over the moving car into control as the drivers are rightfully in charge of the vehicle on their own. The system functions equally but has some restriction to winding roads, poor surface roads and a sporty driving style. Other existing car safety technology includes Driver Alert of Ford, Active Driving Assistant of BMW as shown in Fig. 5. and Lane Departure Warning of Mazda [11]. All these three-technology uses vehicle position in lane monitoring technology.

Fig. 4. Volkswagen Fatigue Detection [10]

Fig. 5. BMW Active Driving Assistant [11]

TABLE II. SUMMARY OF EXISITING VEHICLE SAFETY TECHNOLOGY

Automotive	System	Technology
Mercedes Benz [9]	Attention Assist	Steering Pattern Monitoring
Volkswagen Das Auto [10]	Fatigue Detection System	Steering Pattern Monitoring
BMW [11]	Active Driving Assistant	Vehicle Position in Lane Monitoring
Ford [12]	Driver Alert	Vehicle Position in Lane Monitoring
Mazda [13]	Lane Departure Warning System	Vehicle Position in Lane Monitoring

Table II summarizes the existing vehicle safety technology that are available in the market. It is seen that most car safety technology uses is vehicle position in lane monitoring.

III. PROPOSED WORK

The proposed system will be an active driving safety that will be placed in the car for real time fatigue detection. The proposed parameters is used to track fatigue in eyes and mouth. Beforehand, face will be detected firstly before detecting the facial features. As for this, OpenCV libraries and Haar Cascade Classifiers will be used. OpenCV is known as an open source computer vision and machine learning software library. OpenCV library has a huge number of optimized algorithms that can be used to identify objects, to detect faces and to track camera movements. It leans mostly towards real time applications.

Haar Cascade has already contains a pre-trained classifiers to detect and to extract features such as face, eyes, nose, lips and ears [14]. These cascade classifiers reduces the computational time taken to detect and to process the facial features. It is trained using many positive and negative images to ensure the accuracy of the classifiers [15]. Some examples of Haar feature based on line and edge features. Moreover, adaboost is also used to enhance further the training process. It reduces the rate of error and improves the detection.

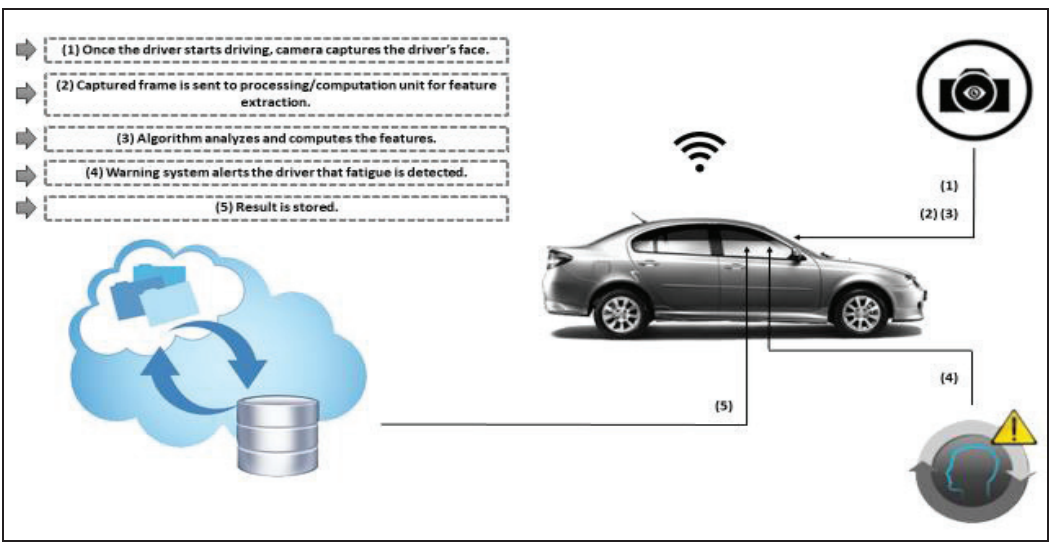

Fig. 6. Illustration Diagram of Driver Fatigue Alert System

Fig. 6. shows an illustration on how the system works. The system consists of driver fatigue detection. It starts right away when the driver starts driving and the camera will monitors the drivers face. Captured frame is sent to computation unit for facial feature extraction. Once the facial feature is analyzed, warning sound in the form of an audible sound will be triggered to alert the drivers. Detection result will be stored in the cloud for future usage. Fig. 7. illustrates the overall processes that takes place in Driver Fatigue Alert System.

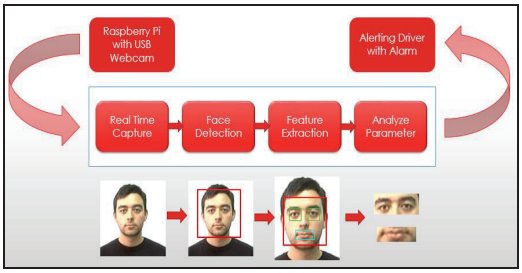

Fig. 7. Framework of Driver Fatigue

Raspberry Pi will be used to integrate the system into the car as it has low costing in terms of hardware. Meanwhile, the features' extraction involves eye closure and mouth open (yawning).

IV. COMPARISON

This system has been developed using three different programming languages and they are C#, C++ and Python. The ideology of the system is tested in different programming languages in order to observe the detection speed compatibility with Raspberry Pi.

A. C#

Being one of the prominent programming language, C# is prone to certain software such as systems, embedded and application with device drivers and high end quality server and client applications. It was designed to be simple, modern and an object-oriented language. The language is suitable for the development of software and the deployment in the distributed environments. EmguCV is a cross platform that is used to develop this system [16].

For the fatigue detection that has been developed using C#, the detection time is slower compared to C++ and Python. And due to portability in the development of C# programs by a large amount, it makes the system lags in a huge scale. It was developed using Visual Studio Community 2013. The main purpose is to develop a warning system through facial expression that deals to support the user by providing Graphical User Interface (GUI) which deals with utility, user ease and user friendly as well. Fig. 8. shows the code snippet from C#.

```
if (!detectedEyes.Any())
{
    _eyeBlinkCount++;
    _previousBlinkTime = _currentBlinkTime;
    _currentBlinkTime = DateTime.Now;
    TimeSpan interval = _currentBlinkTime - _pre

    label2.Text = "Blink count: " + _eyeBlinkCou
    Logger.Log(label2.Text);

    if (interval.Milliseconds < 500)
    {
        SoundPlayer player = new SoundPlayer("be
        player.Play();
    }

    if (interval.Milliseconds < 2000)
    {
        _rapidEyeBlinkCount++;
        if (_rapidEyeBlinkCount > 5)
        {
```

Fig. 8. Portion of C# Code

The flow of the system is divided into few steps, which are;

i. Face Detection

Under the face detection function, it takes one frame at a time. The frame grabber provides this framing and in every single frame, the detection tries to identify the face of the driver. This is accomplished by utilizing a set of predefined samples provided in Haarcascade.

ii. Eyes Detection

Once it function to detect the face of the driver, the next detection is focused on the driver's eyes. This is accomplished with the predefined set sample of Haarcascades. Moreover, the approach is known to be a machine learning based where the cascade function is trained with many positive and negative images that is used to detect objects.

iii. Fatigue Detection

In the process of detecting the position of the driver's eyes, fatigue detection system identifies if the driver is either fatigue or not fatigue. The detection function takes into consideration the state of the eyes, whether it is open or closed and the rate of the eyes blink. In the case, if the eyes of the driver is detected open, no action to be taken. However, if the eyes

of the driver is detected closed continuously for two seconds this indicates the driver is fatigue and automatically a warning sound is triggered.

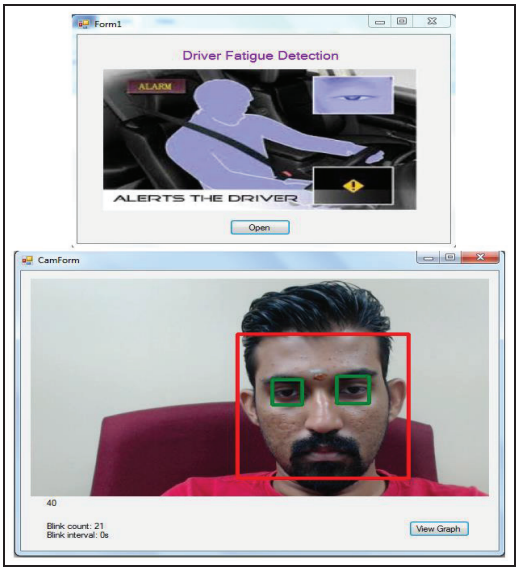

Fig. 9. C# Fatigue Detection

Fig. 9. shows the final output of fatigue detection that is programmed with C#.

B. C++

C++ is known to be a general purpose programming language that has essential, object oriented and basic and common programming feature. There are few different DLL's that are integrated together with OpenCV to enable the entire coding process to work smoothly. A missing in one of the DLL causes the system to completely fail to execute.

Detection level in C++ for fatigue is faster compared to that of C#. However, the entire development of a C++ project takes time and slow and at times faces debugging issues. Efficiency of program decreases along with the detection level as the system faces exception errors. It is less reliable due to the complexity of the operations.

For C++, nearly similar flow of process is involved as C#. Once the camera is activated, it searches for an individual's face. Once the face is identified, the region of interest is focused. Here, the region of interest is both the eyes and Fig. 10. shows the code snippet for C++ programming.

```
void detectface( IplImage* frame, IplImage * smallgrayscale,
                 CvHaarClassifierCascade *facecascade,
                 CvHaarClassifierCascade *eyecascade)
{
    int i, j;
    IplImage * Face, *FaceGray;
    int centerx, centery;
    CvPoint point1, point2;
    CvRect rect, rect1, rect2;
    CvSize size;
    CvPoint eye;
```

Fig. 10. Portion of C++ Code

Once the eyes are successfully detected, it is marked with a red cross spot indicating the eyes are being captured in the video feed. Later, computation process takes place focusing on the region of interest. The smaller the height and the larger the width, it is considered fatigue else, it is in a neutral state. There is no audible sound indicating a person is fatigue, however a fatigue alert message is displayed on the window as shown in Fig. 11.

Fig. 11. C++ Fatigue Detection

C. Python

Python is an object oriented script language and it contains certain modules that are used in order to run the system without error. Some of them are numpy, scipy and time. There are other modules 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 built a high level data types which is rich in polymorphic lists.

```
import numpy as np
import cv2
from array import array
import signal
import sys
import datetime
import time
import os
import pygame

pygame.init()
song = pygame.mixer.Sound('buzzer.ogg')
```

Fig. 12. Portion of Python Code

As shown in Fig. 12. above, python programming works with extensive support libraries that does not require lengthy coding. The development of fatigue detection in Python comes with computing the eye activity. Similarly, face detection is the first step to identify the eyes. Once the eyes is in the video feed, the eye activity is observed over frames.

PERCLOS method is used to detect fatigue. The percentage of the eye closure is calculated over the video feed with closeness of the eyes over 70% is considered fatigue. An audible sound is also prompted to alert the individual in case of fatigue. On the other hand, the eye activity record is stored in a log file for future retrieval purposes. Fig. 13. shows the results from the eye state detection.

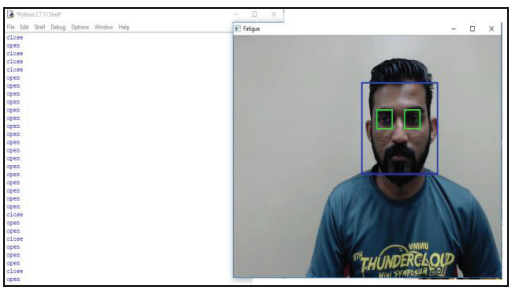

Fig. 13. Python Fatigue Detection

Fatigue detection level in Python works better compared to C#. Although the speed is almost similar with C++, it reduces the time taken for the development for the entire project due to simplified version of the coding hierarchy. Besides that, it has its modules that also reduces the computation time for fatigue detection.

D. *Compatibility with Raspberry Pi*

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 cost effective hardware that can be easily obtained and handled. Looking into the programming language compatibility for the Raspberry Pi, Python comes first. It is easy to read and to 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. If looking into having the system integrated in car using Raspberry Pi, Python is the best choice.

E. *DISCUSSION*

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.

TABLE III. COMPARISON OF THE PROGRAMMING LANGUAGES

Language / Criteria	C#	C++	Python
Speed	Moderate	Good	Good
Detection	Slow	Fairly Fast	Fast
Object Oriented	Yes	Yes	Yes
Development Time	Longer	Longer	Shorter
RPi Compatibility	Weak	Moderate	Good

A benchmark study as shown in Table III is carried out among the three programming languages, C#, C++ and Python and certain criteria have been looked into as well as the compatibility with Raspberry Pi. The speed is measured using the processor and memory usage and it is observed that Python and C++

has a good computational speed. Other than that, it is also noticed that all three languages is object oriented. Moreover, the development time taken for Python is shorter compared to the others since Python have its own predefined libraries which does not require much coding. It is seen that Python programming language have more of the advantages compared to C# and C++ in developing Fatigue Detection system.

V. CONCLUSION

In the research area of computer vision and image processing, face recognition is a challenging portion that has received a great deal of consideration and demands over the last few years because of its applications in various domains. With outgrowing technology and implementation of fatigue detection system using face recognition, it would lessen road accidents and simultaneously contribute to safety aspect of a driver's driving skill. Different facial features can also be used as parameters to detect and warn the drivers.

In the near future, this research can be expanded into a next level by using other features such as sensor motion in different aspects to reduce road accidents.

VI. FUTURE WORK

The future idea comprises of development of anger detection for drivers. Commonly, road rage is the term used to point the act of experiencing anger while behind the wheel of a car. The typical aggressive expressions while driving constitute of screaming at other drivers and blowing the horns frequently. Anger always causes driver to drive faster than normal, it make them to switch lane erratically and also tailgating another car too close. Study also shows that women drivers are angrier than men [17].

The objective of having an idea to come up with anger detector is to reduce road rages activities. Drivers tend to engage into aggressive driving if they are having anger stricken. According to The Star, Malaysia records the highest comparison of anger while driving [18]. Some reasonable factors can be taken into count while identifying driving anger includes weather and traffic. Moreover, when it comes discourtesy on the road, declining to give way, cutting queues, failure of using indicators before changing lanes and improper parking by the roadsides are the top reasons that causes driver anger. Another strongest trigger for road rage is traffic blockage or road construction or repair works along roads. Rude or hostile gestures, slow driving or road blocks by the police are some of the factors that contributes to road rage as shown in Fig. 14.

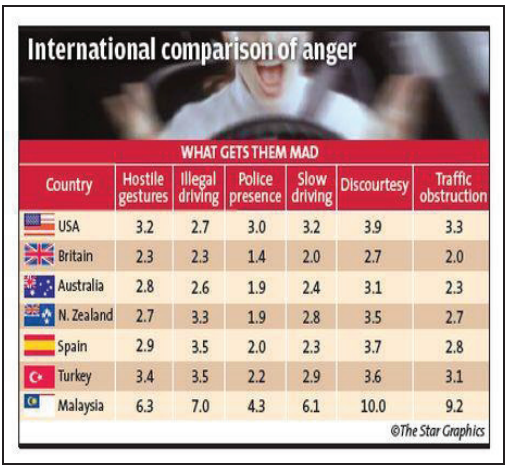

Fig. 14. International Comparison of Anger [18]

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