Drowsy Driver Detection System by Monitoring their Eye Movements

Prof. Prachi Kshirsagar[1], Apoorva Kambli[2], Ashlesha Deokar[3], Vedant Shinde[4]

[1]*Professor, Department of Information Technology Engineering, Vasantdada Patil Pratishthan's College of Engineering, Mumbai, Maharashtra, India*

[2-4]*Under Graduate Students, Department of Information Technology Engineering, Vasantdada Patil Pratishthan's College of Engineering, Mumbai, Maharashtra, India*

---***---

Abstract - *Living in today's competitive world is getting hectic and in order to keep up with the workload schedule there arises a need to compromise with napping time, due to which people are unable to take rest which indirectly contributes in increased fatigue level.*

There are many evidences recorded and studied that at least 1/3rd of the road accidents is related to fatigue. While this fatigue is seen as the driver dozing off unknowingly and losing control of the direction and steering which give rise to hazardous situations.

This paper aims to detect the drivers fatigue in real time by monitoring his eye movements and throw an alert if any kind of drowsiness is detected. Our system is developed in such a way that it uses camera for scanning the facial landmarks of the driver and detect whether the eyes are closed or open which determines the attention span of the driver in the crucial moment of driving. This technology can work on any automobiles hence providing the user a budget efficient technology.

Key Words: Drowsiness detection, driver-safety, alert system, image processing, Neural networks.

1. INTRODUCTION

Human population is prone to death and injury in which road crashes in the form of accidents serve as one of the major causes. According to data collected by World health organisation [9] in the year 2015 that there are approximately a total of 1.25 million deaths worldwide related to road traffic injuries which can be approximated almost every 25 second an individual may experience a road accident-related scenario.

According to the American National Highway Traffic Safety Administration (NHTSA) [8] it is reported that approximately 100,000 accidents per year in The United States are due to the drowsiness of the driver. It is seen that mainly shift workers face drowsiness while driving on a frequent basis which may be related to work related fatigue. Hence it becomes a priority to track down drowsiness and alert the driver in that instance itself to prevent fatal accident and loss of life.

Automotive industry has also started registering this issue and started to come up with different solutions. For instance, Volvo has developed Driver Alert Control which warns the drivers about their suspected drowsy driving by monitoring their sudden lane drifts using lane departure warning system (LDWS). Similarly, Mercedes-Benz has developed Attention Assist System that collects data on the driver's initial driving pattern and correlates with current movements and driving circumstances at the movements.

Some notable mentions also include automatic braking system when close to another vehicle which is detected by radars, ultrasonic sensors, automatic steering control if it is seen that the car is experiencing lot of drifts that to on a straight road. No doubt such driver safety assisting systems will be beneficial but such systems are implemented in luxury and high-end cars and such expensive cars are not affordable by the general audience and it may take a little more time to make such a system available in a normal car.

In order to cope up with this issue we have come up with method which is much cheaper and more efficient. It can be used by mass amount of audience. Since digitalization has led to people using devices like portable camera and taking advantage of this technology because they are easily available for the general public. Keeping this in consideration we have designed a system which can alert the driver about his upcoming drowsiness by analysing the eye moments through camera and will serve as a real time detection application for the driver.

1.1 Related Work

Drowsiness Detection Systems are a significantly well-known area of research numerous systems are developed which have shown remarkable results. There are many car models which have developed built-in models which would help to increase security of life and prevent damage of assets.

Bhowmick et al. [2] proposes to identify the individual's eye states with the help of infrared camera to detect drowsiness.

Researcher Federico Guede-Fernández of [3] the same field carried on drowsiness detection using respiratory signals. They used the method which uses real time algorithm for drowsiness detection by Thoracic Effort Derived Drowsiness index (TEDD). The respiratory signal is acquired with an inductive band around the driver's chest
while driving, which will analyse movements, coughing and speaking. They also used an algorithm based on the analysis

of the respiratory rate variability (RRV) in order to detect incoming sleep or drowsiness.

There has also been research done by Md Yousuf Hossain [4] where they proposed a system which makes use of IOT technologies like Pi camera needed to capture the images of the driver's eye and the entire system is incorporated using Raspberry-Pi.

There is another researcher A. Subbarao [5] In their project a spectacle with eye blink sensor is used to detect the driver drowsiness and alerts the driver with buzzer, if the driver is affected by drowsiness. They have also used various hardware components for this project which are mentioned as LPC2148 microcontroller, Eyeblink sensor, LCD and buzzer.

Sanya Gupta [6] proposed a system in which the software simulation is done through a MATLAB code to implement image processing methods for edge detection and determining the complexity value for the image. The hardware used in the system consists of FPGA Development Board, Camera, Vibration Motors and Speaker.

1.2. Existing System

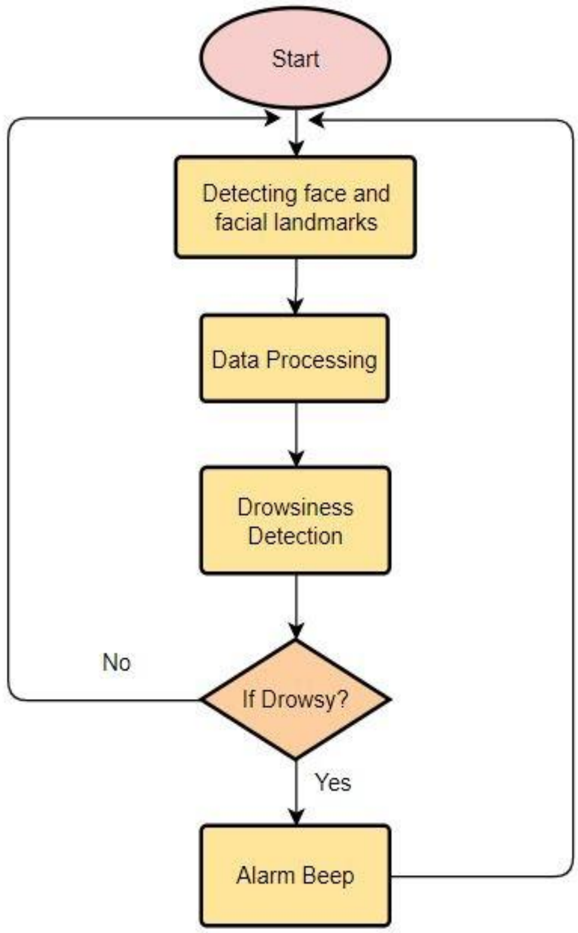
Talking about the existing system, the face detection was done through external cameras, Arduino, glasses, etc. There are a number of ways this functionality has been achieved. The key and challenging part here is to detect the face, the eyes of the driver and then to detect the eye movement of the driver which will tell us whether the driver is drowsy or not.

(i) One such approach we came across was using the Arduino board and external camera. Arduinos are electronic board which are able to detect input from different sensors like light sensors, IR sensors, etc. These sensors are connected to the Arduino board and they collaboratively function together to achieve desired output.

(ii) The drawback of this system is that too many hardware components are required in order to achieve our goal. Due to the hardware components the dashboard on the car looks muddled and chaotic. Moreover, if one of the components in this system fails to function properly, then our entire system is compromised and is of no use until that particular damaged part is replaced by another fresh part. Then only our entire system can run in coalition.

(iii) Another approach we came across was using the glasses to monitor the eye movements. This approach is not a bad one however, not all the drivers are comfortable with goggles. Moreover, there are also people who wear glasses for better vision. So, for those people it would be impossible to wear two glasses at a time.

2. Process of Implementation



Flowchart-1: Implementation flow of the proposed system

3. Proposed System:

We came up with two different approaches in order to tackle the problem.

(i) Eye Aspect Ratio (EAR)

This method makes use of the facial edges. This will help us to understand the presence of landmark on the facial structure of the driver. This data will be further processed and the program will plot the points on region of interests in other such areas if they exist.

This program predominantly uses Haar Cascade image classifier which will be responsible for estimation of probable distance between keys points we used. This will lead to generation of program that can determine if the driver's eyes are closed if the Eye Aspect ratio falls below a certain threshold point.

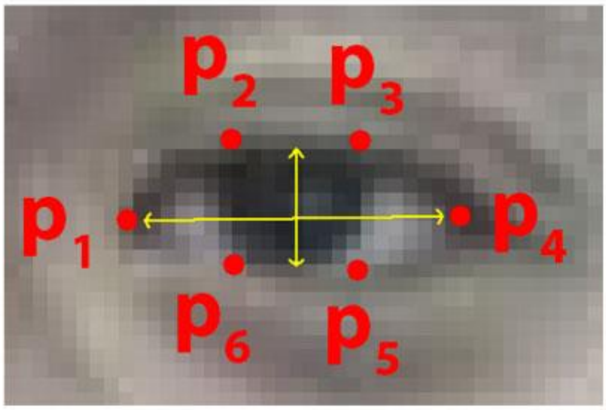


Fig -1: Representation of an eye with 6 coordinates

As shown in the figure we get to see that each eye is represented by 6 coordinates p1, p2, p3, p4, p5 lastly p6 starting from the left-hand side and then plotting in clockwise direction around the unmarked region.
Based on the reference work by Soukupová and Čech in their 2016 paper, Real-Time Eye Blink Detection using Facial Landmarks [1], we can then derive an equation called the Eye aspect ratio (EAR).

$$\text{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

The numerator in this equation will compute the distance between the vertical eye landmarks, and vice versa the denominator computes the distance between horizontal eye landmarks.

The eye aspect ratio is always constant while the eye is open, but will fall to zero when close eyes are detected.

Let us consider the figure from Soukupová and Čech [1]:

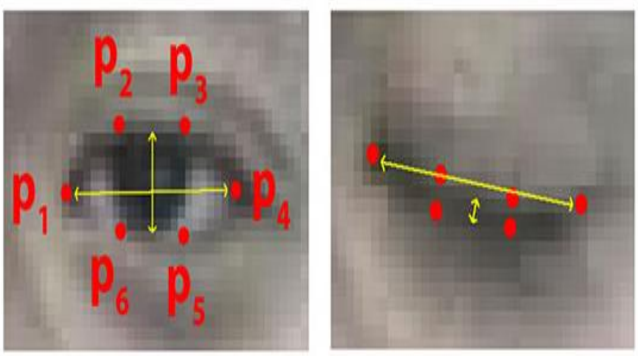


Fig -2: Visualization of eye landmarks when then the eye is open or closed

As we can see in the figure 2 on the left side there is an image of a completely open eye hence the eye aspect ratio is high and relatively constant. And on the other half we can see that when close eye is detected the eye aspect ratio will drastically go downhill approaching almost zero in no time. If the eye aspect ratio is low for a particular number of frames, then the alarm will beep.
The result of the EAR can be seen in the figure 3 given below:

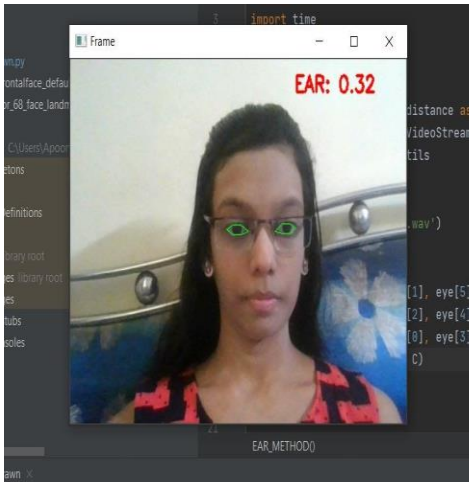


Fig -3: Result of EAR when eyes are open

We can see that near the region of interest which in our case are the eyes a presence of green outline which is the landmark detected by the Eye aspect ratio. Eye aspect ratio assists us to plot coordinates by identifying the facial landmarks.

While we can see that in the figure 4 the person has their eyes closed due to which the value of Eye aspect ratio continues to drop as compared to the value when the person has their eyes open. When the Eye aspect ratio falls under a certain threshold limit an alert is triggered which will cause the alarm to beep and alert the driver.

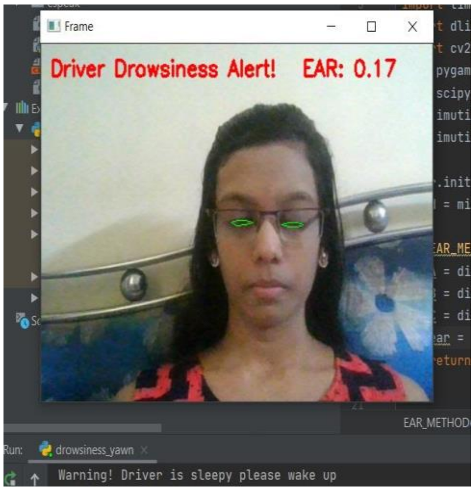


Fig -4: Result of EAR when eyes are closed

(ii) CNN Model

Let us consider the figure 5 given by Sumit Saha [11] in A Comprehensive Guide to Convolutional Neural Networks.

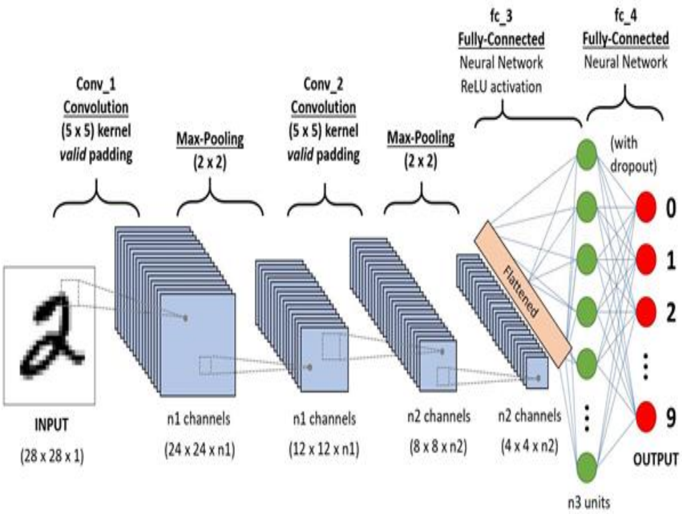


Fig -5: A CNN sequence to classify handwritten digits

There are a couple of ways this can be achieved. However, our one such approach is by building a CNN model which will capture the real time images of the driver's eyes and classify whether the driver is drowsy or not. In order to achieve this goal, we first have to detect the face of the driver. To detect the face, we have used the Haar Cascade dataset from the OpenCV library. This dataset contains XML files of facial images. With the help of this dataset, we were able to extract the face of the driver. After extracting the face, we also need to extract the eyes of that driver. The reason we extract the eyes is because we are developing a CNN model to classify those images. In order to train that model, we have used the eyes dataset from kaggle.com.

This dataset contains approx. 5000 to 7000 images of closed and open eyes. This is what we will train our CNN model on.Now let's dive into the details of our model. To build our CNN model we have used Keras sequential model. So, when the new data instance i.e., the eye image from the driver is fed to the classifier we first pre-process it by scaling it and normalising it. We also convert the image to grayscale in order to reduce the pixel size and complexity as we do not need coloured images. So, after this image is captured, we have augmented it. Data augmentation is one of the highly used techniques to help the model to see through images by zooming in/out, flipping it etc so that it our model will generalise properly.

The layers of the model will activate according to the hyperparameters. In order to avoid overfitting, we have added a dropout layer.

This will help our model to avoid overfitting. So, after the captured image has passed through all the layers, based on the output of the last layer, if the image is classified as closed then that means the driver might be drowsy.

Now we won't just yet beep the alarm. If this happens again and again or if the eyes of the driver are found to be closed for a particular number of frames continuously, then we can surely say that the driver is drowsy and accordingly beep the alarm. This is how the basic working of the model-based approach.

As you can see, we first trained our model on 20 epochs. The output of that is mentioned below in chart 1.

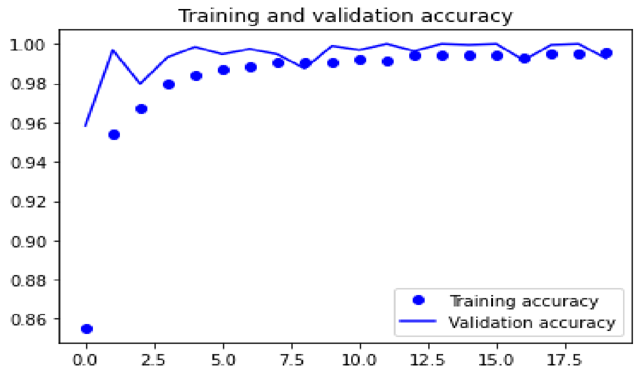


Chart -1: Accuracy achieved with 20 epochs

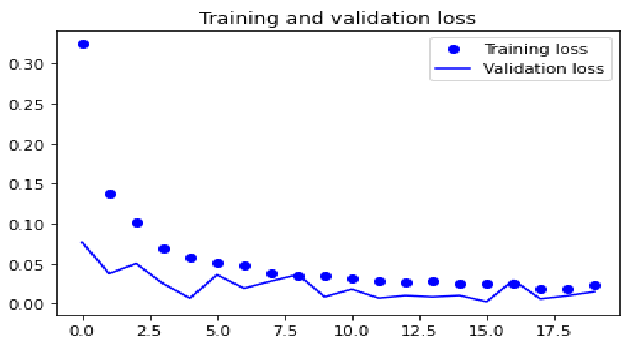


Chart -2: Loss occurred with 20 epochs

So, as you can see from the above charts, our model's accuracy is good, however it looks a little unstable. In order to train our model more accurately and make it more stable, we tried to reduce the number of epochs so that our accuracy and loss curve is smoother and more stable. In order to achieve this, we reduced the number of epochs from 20 to 15 and got a better output.

The graphs in Chart 3 shows the training and validation accuracy with the model trained with 15 epochs.

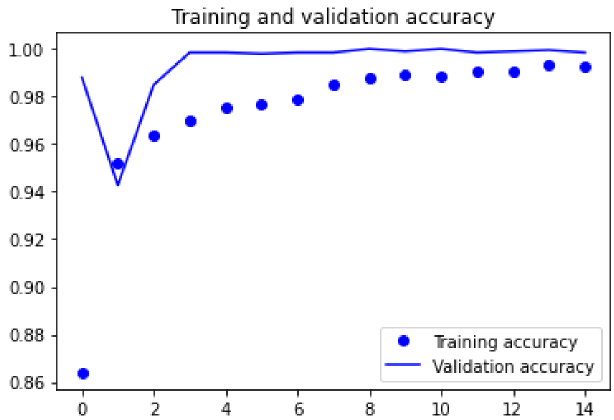


Chart -3: Accuracy achieved with 15 epochs

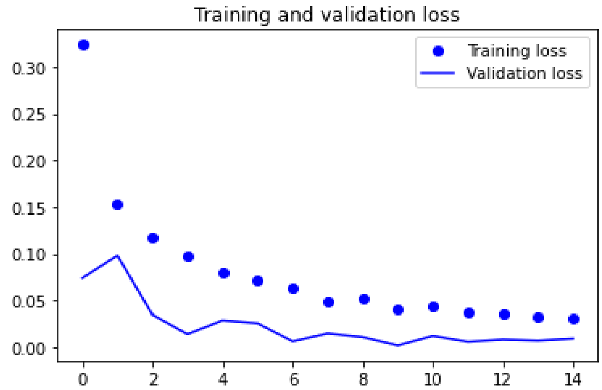


Chart -4: Loss occurred with 15 epochs

The output of our model is shown below:

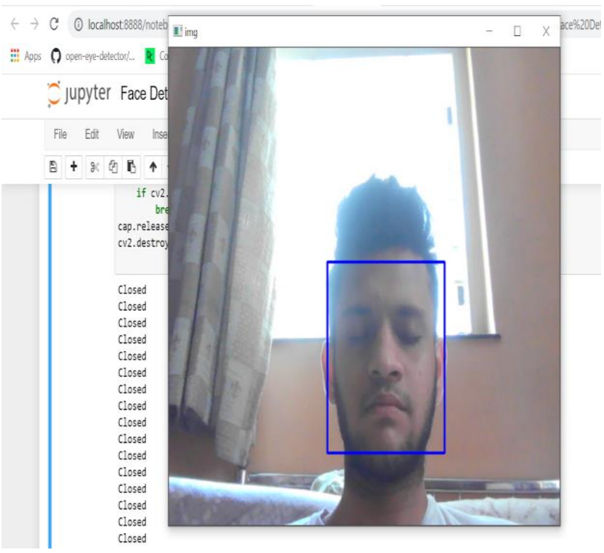


Fig -6: Result of CNN model when eyes are closed

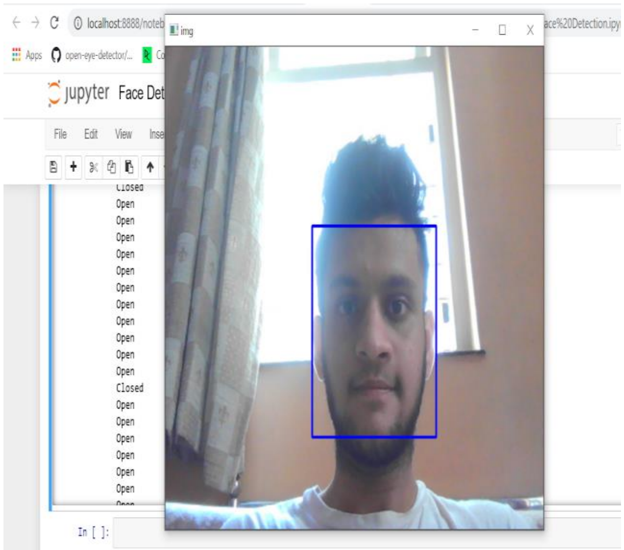


Fig -7: Result of CNN model when eyes are open

4. LIMITATIONS

As of now there are not much research done in this field using test subjects so there was difficult in finding dataset which limited the training of the mode to depend on single dataset instead of test on variety of datasets. We can also say that there are certain limitations to this technology which can include partial facial features are detected which may lead to inaccurate result. If the driver is wearing sunglasses in the car it would get difficult for the model to detect the eye landmarks. Improper lightning also plays a major role in such scenarios. Despite of this with rapid boost in the camera quality these problems can be tackled to much extent. To sum up everything that has been stated so far there is a room for improvement in the performance of this system.

5. FUTURE SCOPE

Further in future we can improve the quality of this drowsiness detection system project. As of now we are able to monitor the driver's eye movements in order to get the result. It can further be improved by analyzing the movements made by the steering wheel or monitor if the driver makes any sudden drifts out of nowhere, we can warn the driver accordingly. As yawning is also a trait of an incoming sleep, we would also further work on yawning analysis by collecting the landmarks of the mouth.

This project can also be used by Driver management companies like Uber or Ola who provide their services even during the night time which is the peak time where drowsiness is prominently seen. In order to cope up with this issue we can store the data of the driver and if the driver tends to get multiple warnings it can alert the driving agency and change the shift of the driver in the time where the driver is fully attentive.

6. CONCLUSION

The drowsiness plays a pivotal role in ensuring safe driving environment. This paper proposed a drowsiness detection system solely based on camera monitoring. The function of this project is to detect the facial landmarks of the driver and provide the obtained result from the trained model or EAR method to judge the driver's state whether the driver is attentive or not and throw alert by beeping an alarm to warn the driver accordingly. As of now this project is implemented on a small scale. With some enhancements this project can be used by the general public. Making the maximum use of its cost-efficient nature multiple drowsiness related accidents can be avoided. Henceforth we can conclude that this project will help to detect the indication of driver's distracted driving which may help us to avoid serious aftermaths at an early level where drowsiness is just emerging.

ACKNOWLEDGEMENT

The authors acknowledge the guidance by Prof. Prachi Kshirsagar, mentor from Department of Information Technology Engineering, VPPCOE, University of Mumbai for supporting and giving us a wonderful opportunity to work on this project. A lot of appreciation towards openly available learning resources that further enhanced our knowledge and learning in this field.

REFERENCES

[1] Tereza Soukupova and Jan ´ Cech ˇ. "Real-time eye blink detection using facial landmarks", 21st Computer Vision Winter Workshop,Corpus ID:21124316.

[2] B. Bhowmick and K. Chidanand Kumar. "Detection and classification of eye state in IR camera for driver drowsiness identification". In IEEE ICSIPA '09, Pages 340–345, 2009.

[3] Federico Guede-fernández. "Driver Drowsiness Detection Based on Respiratory Signal Analysis", In IEEE Access, pages 81826-81838.

[4] Md. Yousuf Hossain, IOT based real-time drowsy driving detection system for the prevention of road accidents, ICIIBMS 2018, Pages: 190-195.

[5] A. Subbarao, Driver Drowsiness Detection System for Vehicle Safety,(IJITEE) Pages:815-819 https://www.ijitee.org/wp-content/uploads/papers/v8i6s4/F11640486S419.pdf

[6] Sanya Gupta, Drowsy driver alerting system-Proceedings of the 2nd International conference on Electronics, Communication and Aerospace Technology (ICECA 2018) IEEE Conference Record Pages:1665-1670

[7] A Survey on Drowsy Driver Detection System -2017 International Conference on Big Data Analytics and computational Intelligence (ICBDACI) Pages:272-279

[8] Drowsy Driving NHTSA reports. (2018, January 08). Retrieved.from..https://www.nhtsa.gov/risky-driving/drowsy-driving.

[9] World Health Organization The top ten causes of death. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death

[10].Damian.Salapatek,.Driver.Drowsiness.Detection.System https://www.researchgate.net/publication/319464008 Pages:41-47

[11] Sumit Saha, A Comprehensive Guide to Convolutional Neural Networks - the ELI5 way. https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the-eli5-way-3bd2b1164a53

[12] Kavyan Shah, Eye-Dataset, Eyes seeing in that direction https://www.kaggle.com/kayvanshah/eye-dataset