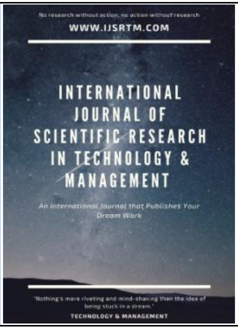
https://www.ijsrtm.com
Vol.2 Issue 1 March 2022: 01-07
Published online 11 March 2022

E-ISSN: 2583-7141

International Journal of Scientific Research in Technology & Management



Real Time Driver Drowsiness Detection using Landmark Predicator in Deep Neural Network

Hemant Ahirwar
Electronics & Communication Engineering
Sagar Intitute of Research & Technology
Bhopal, Madhya Pradesh, India
hemanthemant093@gmail.com

Minal Saxena
Electronics & Communication Engineering
Sagar Intitute of Research & Technology
Bhopal, Madhya Pradesh, India
drmeenalsgi@gmail.com

Abstract— ***In the modern era, road accident is very common and there are lots of casualties happen. The major reason is drowsiness of drivers which should be rectified at real time. One of these is drowsiness in drivers. A little tiredness could cause a catastrophic accident with many fatalities. Many lives could be saved if a device could instantly detect a driver's alertness and tiredness. Different behaviours, such as expanding the mouth wide, closing both eyelids and a combination of the two, can be used to identify drowsiness. It may be suggested not to drive while fatigued. Drowsiness can be identified in real time using a variety of techniques, but accuracy is important. The proposed system is based on Landmark Predicator algorithm in Deep Neural Network. A computer vision task called "facial landmark detection" identifies and tracks significant points on a person's face. Dlib is a library for using computer vision and machine learning techniques. Because the model will predict continuous values, ensemble regression trees are the foundation of the model. The iBUG-300 W dataset, which includes photos and their accompanying 68 face landmark points, served as the basis for training this model. The nose, the eyes, the mouth, and the edge of a face are often those landmarks.***

Keywords— ***Landmark Predicator, Deep Neural Network, Machine Learning, Drowsiness Detection, Face Detection, Eye Detection, Computer Vision.***

I. Introduction

A vehicle safety device called driver sleepiness detection aids in preventing incidents that could have been avoided. According to numerous studies, weariness may be a factor in up to 50% of certain types of roads and up to 20% of all accidents involving vehicles. Some of the devices in use today can recognise drowsy driving by studying the patterns of the driver. Driving while fatigued increases the risk of collisions and accidents. Driving while fatigued increases the risk of collisions and accidents. Every year, many people lose their lives in car accidents as a result of drowsy driving brought on by lack of sleep, intoxication, drug and alcohol misuse, heat exposure, or drinking. Various technologies for driving assistance are available from automakers like Tesla, Mercedes-Benz, and others, including lane departure warning, emergency braking systems, variable cruise control, and steering assistance. These developments have helped drivers reduce the likelihood of crashes. By detecting face traits and trends, Samsung has looked at how attentive a driver is. However, the majority of these technologies are exclusive and only available in expensive vehicles. These procedures for identifying tiredness can be broken down based on several criteria, including the vehicle context, behavioural patterns, and physiological factors. Drowsiness can be detected using a variety of techniques that have been established in the past. Based on vehicle-based sleepiness identification methods, lane changes, steering wheel rotation, speed, and pedal compressions are observed [1].

Fig. 1. Drowsiness while Driving [2]

The number of safety systems in cars and other vehicles has increased, and many of them are now required, yet none of them can prevent a driver from falling asleep at the wheel, even for a little period of time. We will therefore construct a Driver Drowsiness Detection System today. The problem of shape prediction includes the subset of recognising facial landmarks. A shape predictor aims to identify important points of interest along the shape given an input image (and typically a ROI that identifies the object of interest). The actual algorithm that was employed to find the face in the image is irrelevant in either scenario. Instead, what matters is that we discover the face bounding box—that is, the (x, y)-coordinates of the face in the picture—by some means [2]. The dlib data and mathematical functions are handled using Numpy. We can collect webcam frames with the aid of Opencv, edit them, and then display the edited frames. The open source Dlib toolkit was created in C++ and includes a number of machine learning models that have been optimised. Dlib is preferred over other libraries and building your own model because it is somewhat accurate, quick, thoroughly explained, and accessible for academic, research, and even commercial use. Because the goal of this project is not to train a neural network, we will use the dlib python wrapper even if Dlib's accuracy and performance are equivalent to those of the most cutting-edge neural networks [3].

II. RELATED WORKS

A. Related Works

Zuopeng Zhao et al. [4] proposed driver fatigue detection using EM-CNN. It is anticipated that the method for detecting driver fatigue based on cascaded MTCNN and EM-CNN will be crucial in preventing car accidents brought on by driver drowsiness. We apply the MTCNN architecture of a hierarchical convolutional network for face detection and feature point localization, which generates the facial bounding box and the five feature points of the left and right eyes, nose, and left and right mouth corners. The feature points are used to extract the ROI from the driver image. This research suggests the use of an EM-CNN-based detection approach to assess the condition of the lips and eyes. The proposed technique showed good accuracy and robustness to real driving environments in an experimental evaluation.

Elena Magán et al. [5] proposed a framework which is based on deep learning. Deep learning is a key component of both of the proposed implementations for a driver drowsiness detection system in this paper. In this work, a full sequence of 60 s is used to determine if a driver is weary or not throughout the past minute. These systems employ photographs of the driver to identify fatigue symptoms rather than predicting whether a driver is fatigued or not from a single image. A convolutional neural network and a recurrent neural network are combined in the first suggested approach to estimate the driver's level of tiredness using a deep learning model. The second method uses deep learning and artificial intelligence to preprocess the data before employing the fuzzy inference system to calculate the amount of weariness.

Rajamohana S.P. et al. [6] proposed driver drowsiness detection system using CNN and BILSTM. The suggested project involves identifying facial landmarks from pictures taken while a person is operating a vehicle using a camera mounted on the vehicle and giving the information to a competent model to determine the driver's condition. The driver would be alerted to halt the car to avoid accidents if the data collected was found to reveal indicators of intoxication. The hybrid CNN BiLSTM technique is suggested for open eye driver drowsiness detection. The performance of the suggested approach is satisfactory, while nighttime web camera use may be made more effective. It has been demonstrated that the CNN BiLSTM method performs well in low-resolution images for a variety of eye positions. Data collection for all stages of eye openings and eyeglass samples was divided into 70% for preparation and 30% for testing. A shape predictor using Euclidean algorithms can be used to determine the driver's head and eye positions. When applied to photographs with different backgrounds and lighting, this technique produces amazing results. Therefore, the suggested system can determine whether your eyes are open or closed. An alert call may be made to the driver if the eyes are closed for an extended period of time. When the system notices drowsiness, it immediately calls the driver to warn them. When this technology detects tiredness, it will alert the driver almost immediately.

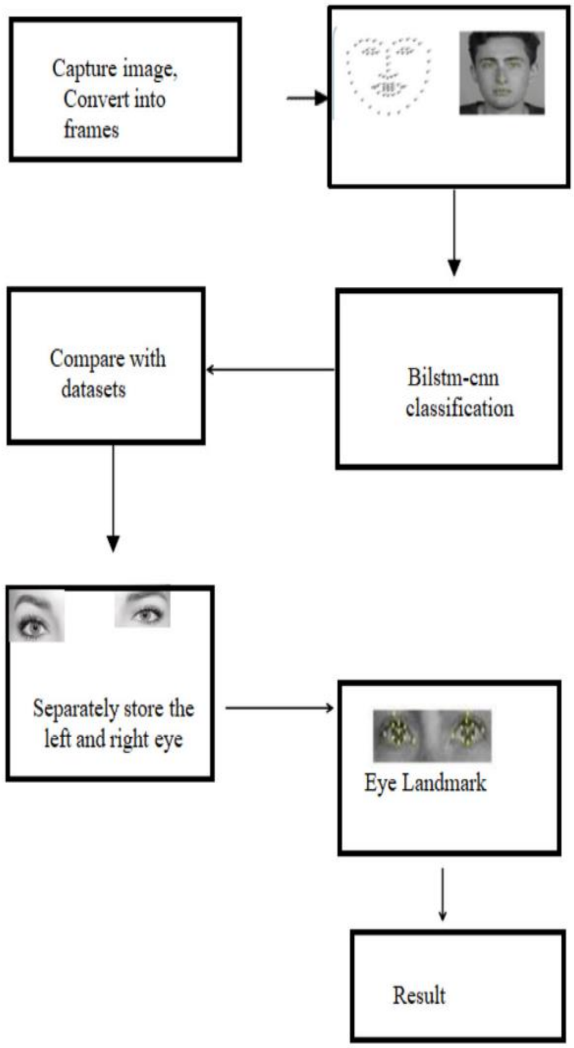


Fig. 2. Work Flow of the System [6]

Jagendra Singh et al. [7] proposed a driver drowsiness detection using deep learning. The motorist is alerted by the framework caution. As the framework is used, an infrared camera will be added to capture the video stream, making it less intrusive, and a modified signal will be added to alert the driver. The device can accommodate many users at various distances from the webcam and under varying lighting conditions. The decade's spotlight is on driver assistance systems, where many innovative ideas are being combined to create the safest product. These systems should be able to detect when a motorist needs some assistance in order to focus on driving again rather than becoming tired, drowsy, or distracted when using a cell phone. Yuvraj Suryawanshi et al. [8] proposed a system which is based on LBP and Haar algorithm. The suggested solution provides us with a real-time analysis of drowsiness detection when outdoors with effective brightness toward the face. This technology achieves the main objective of identifying driver inattentiveness while driving to prevent traffic accidents. The LBP method was used to identify the face region, the Haar algorithm to identify the eye region, and the AdaBoost algorithm in conjunction with the specially designed Haar cascade to identify eye blinking. The system immediately provides us with the output in real-time as it recognises the face, eye location, and eye blinking. The technology is unable to detect driver tiredness under low light conditions, low brightness, or in the dark.

III. Proposed Work & Implementation

Proposed work is able to detect driver drowsiness at real time by using Landmark Predicator in Deep Neural Network. System is also able to recognize facial features and classify them for drowsiness detection. System is also monitoring motions at real time for current transition and alert when drowsiness has been detected. System is able to sense whether the eyes are open or not for certain limit of time. It is helpful for getting prior notification if drowsiness has been detected or in a simple word it may helpful for monitoring against road accidents related to the drowsiness. Proposed system is intelligent enough to identify the facial features. If the ratio satisfy the threshold value then it will be correctly considered as drowsiness. System can work at real time with less processing time and respond immediately when transition occurred. Co-ordinates have been updated as per the face appeared at real time. Only contouring area can detect the density and rest area is not considered as region of interest but motion can be detected in entire frame. The proposed technology aims to identify drowsy driving in order to prevent casualties from accidents. The system can detect real-time facial expressions and determine if drowsiness is present or not. The system is also capable of classifying facial features for tiredness detection.

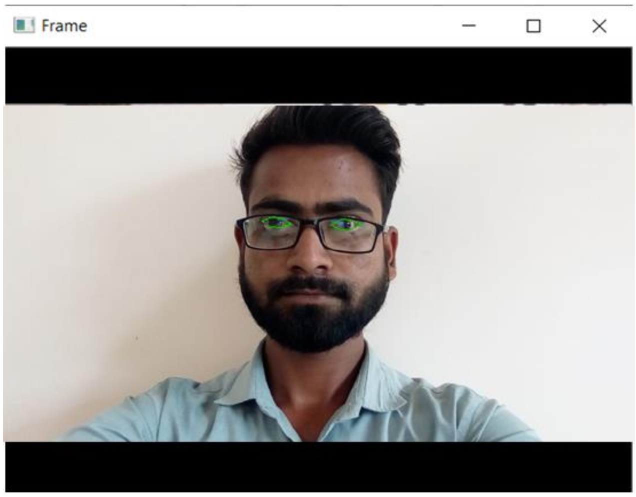


Fig. 3. Proposed Work API

The system also continuously monitors motions for current transitions and alerts when drowsiness is found. The system is able to detect whether or not the eyes are open. In other words, it may be helpful for monitoring against vehicle accidents connected to drowsiness. It is useful for receiving advance information if drowsiness has been discovered. This project's goal is to identify and warn users when they are feeling sleepy or drowsy, which can significantly reduce the number of accidents that are caused by driving while fatigued or sleep-deprived. Highways around the world are used by millions of people every day and night. This includes persons who frequently labour for very long stretches of time and are susceptible to accidents because they are sleepy or drowsy, such as taxi, cab, bus, and truck drivers. The plan is to develop a visual system that will assess the driver's level of attentiveness or drowsiness using tools like Deep Neural Networks and other image analysis techniques. Here, in order to detect whether the driver is drowsy or not, we are considering the eye aspect ratio and yawn characteristics. The eye aspect ratio and lip-distance are calculated when the eye coordinates and mouth coordinates are taken from the frame using the Dlib Python package. The driver is alerted to whether or not they are drowsy if either the eye aspect ratio falls below a predetermined critical value or the yawn surpasses a crucial threshold.

A. Landmark Predicator

In the computer vision problem of "facial landmark recognition," a model must forecast key points that correspond to areas or landmarks on a human face, such as the eyes, nose, mouth, and other features. Other computer vision tasks, such as head pose estimation, determining gaze direction, recognising facial movements, and switching faces, can be carried out using facial landmark identification as a basis job. This is a unique shape predictor model that has been trained to recognise 81 landmarks for facial features in any image. It is trained using 68 face landmark shape predictor from dlib. I added an additional 13 landmarks to the original 68 facial features to cover the area around the forehead. This makes it possible to accurately detect heads and perform picture operations that call for points along the top of the head, like putting a hat on someone's head. Many auto accidents are the result of fatigued drivers, and smart cars' emergency stopping systems don't always work. It's helpful to keep an eye out for indicators of driver drowsiness to prevent accidents. For instance, a computer vision model might analyse video feeds from a car camera that recognises indicators of fatigue or inattention in the driver's face. If the driver isn't paying enough attention to the road, the model may send a warning. While wearable ECG tracking devices and built-in movement tracking systems can serve a similar purpose, a computer vision solution is easier and less obtrusive. Using facial landmark inputs, neural networks can learn to recognise tiredness in drivers' faces. As an alternative, although training takes longer, a MobileNetV2 architecture can identify driver weariness in video streams without landmark detection. Dataset labelling for training can be made simpler with the aid of CNN-based landmark detection. Driver monitoring systems, however, may be impacted by the neural network's inference speed and the calibre of mobile devices. Consequently, landmark detection algorithms provide a superior answer.

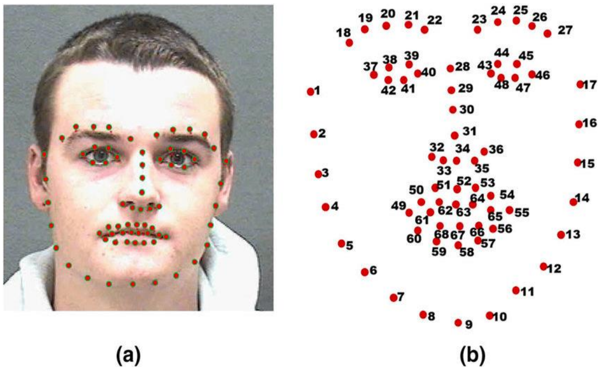


Fig. 4. a) Facial Landmarks, b) Landmark points [9]

Based on a small number of photos with annotated facial landmarks, face animation algorithms use facial landmark identification to create animated figures. These algorithms can create additional frames for video games and cinema. Another use is to change the audio track in dubbed movies to match the face movements. The area around the mouth can be replaced with a modified 3D model using a facial landmark detection method. For lip-syncing jobs, the Pix2PixHD neural network is helpful, while the DeFA algorithm may create a complete 3D face mesh. Face representations can be created utilising borders and facial landmarks by using the Dlib package. When training, FReeNet can generate reenactments between several people utilising a Unified Landmark Converter module. From source and target photos, the PFLD algorithm may extract facial landmarks, which a GAN can then use to create new images with richer facial information. In this use case, algorithms are used to verify, recognise, and cluster faces (grouping similar faces). The best algorithms enhance facial recognition by using face preprocessing and face alignment. These techniques frequently locate landmarks and recognise faces using multi-task cascaded convolutional networks (MTCNN).

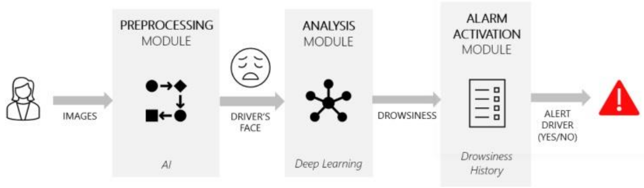


Fig. 5. Block Diagram of Proposed System [5]

B. Landmark Predicator Algorithm

Input: 3-D Image Matrix

Output: Face geometry

Step 1: Initialize input matrix *I*

Step 2: Define data points of image *I*

$x = (x_1, x_2, x_3 \cdots x_n)$

$y = (y_1, y_2, y_3 .. y_n)$

$z = (z_1, z_2, z_3 .. z_n)$

Step 3: Apply histogram equalization

$$P_n = \frac{number\ of\ Pixel\ Intensity\ n}{Total\ number\ of\ pixels} \quad n = 0,1 \ldots . L-1$$

P_n is the affected pixel values after histogram equalization

Step 4: Extract facial features to locate face from image

Step 5: Predicator detects key points from face

Step 6: Extract geometric shape and create bounding box

Step 7: if left eye = close || right eye = close then
Drowsiness Predicted;
elseif mouth = open || left eye = close || right eye = close then
Drowsiness Predicted;
else
No Drowsiness Predicted;
end else
end if

Step 8: End

First of all initialize the input image matrix and then collect the data points to localize the target area. Then histogram equalization has been applied to enhance the visibility of image. Then facial features have been extracted to locate face from image. Then predicator detects the data points and face geometry has been extracted to create bounding box around the features. Then predictions are based on drowsiness symptoms.

C. Flow Chart

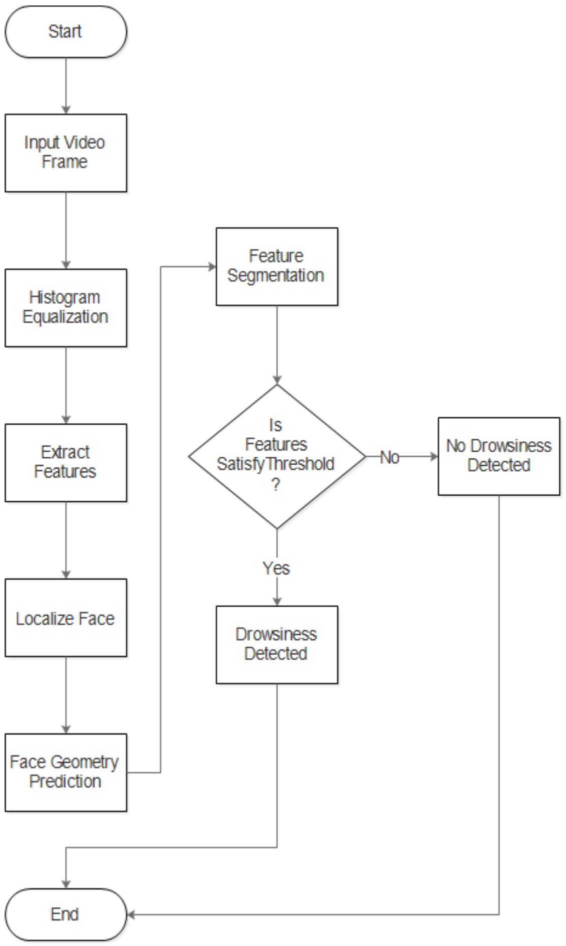


Fig. 6. Flow Chart

In flow chart, first of all video sequence frame will be acquired for feature extraction. Then it will rectify whether frame is about to end or not, if it becomes end then the process will get expired otherwise process get accessed till frames acquisition. Then histogram equalization has been applied once the frame is acquired. Then feature extraction has been done. Then system localize the face to extract the face geometry and then feature will be segmented and it will further check the value with threshold and if it satisfy the threshold vale then drowsiness is detected otherwise no drowsiness will be detected. If 7 frames are continuously monitor the drowsiness then it declares the drowsiness otherwise it can be considered as the normal condition.

IV. RESULT ANALYSIS

A. Result Simulation

Result is based on True Positive, True Negative, False Positive and False Negative. True positive means; if a frame contains drowsiness and system detected it correctly with drowsiness. True negative means; if a frame does not contain drowsiness and system detected it correctly with no drowsiness. False positive means; if a frame does not contain drowsiness and system detected it incorrectly as drowsiness. False negative means; if a frame contains drowsiness and system detected it incorrectly as no drowsiness. The result will be computed through confusion matrix.

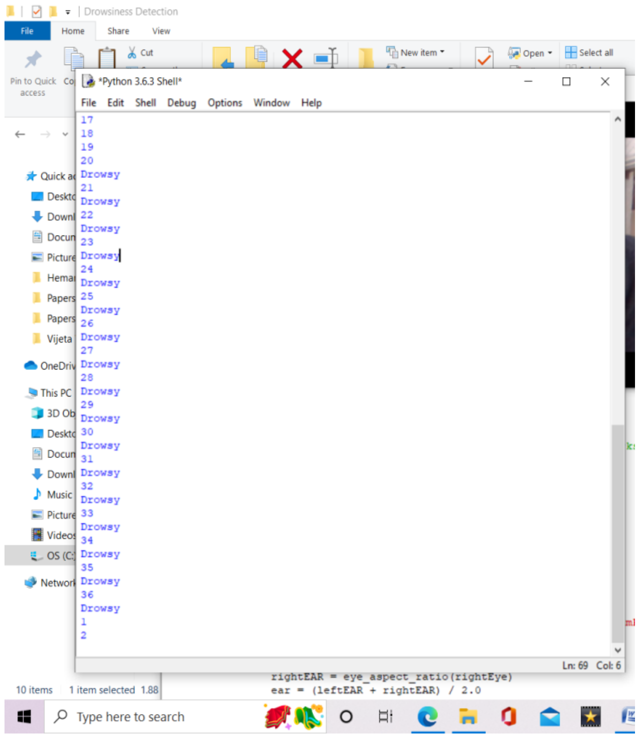


Fig. 7. Result Console

$$\text{Specificity} = \frac{TN}{FP + TN} * 100\ \%$$

$$\text{Precision} = \frac{TP}{TP + FP} * 100\ \%$$

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN} * 100\ \%$$

$$F1 = \frac{2TP}{2TP + FP + FN} * 100\ \%$$

$$\text{Recall} = \frac{TP}{FN + TP} * 100\ \%$$

Table No. I Result Analysis

Terms	**Proposed**
True Positive	36
True Negative	283
False Positive	2
False Negative	3
Total Frames	324
Accuracy in %	98.46
Precision in %	94.74
Recall in %	92.30

F1 in %	93.51
Specificity in %	99.30

Table No. II Result Comparison

	Rajamohana S.P. [6]	**Proposed**
Method	CNN_BiLSTM	DNN_LP
Accuracy in %	94	**98.46**
Precision in %	90.67	**94.74**
Recall in %	**96**	92.30

Table II shows the result comparison with previous result where 94.00 % of accuracy has been obtained which is better lesser than the proposed system which is 98.46. The precision of the previous system is 90.67 % which is also bit lesser than the proposed system which is 94.74 %. The recall value of previous system is 96 % which is higher than the proposed system which is 92.30 % because it has bit higher flase negative rate as compare to the previous system. So, the overall accuracy has been recorded as 98.46 % after experiments. In proposed system, 324 frames have been tested that resulted 36 as drowsiness, 283 as non drowsiness.

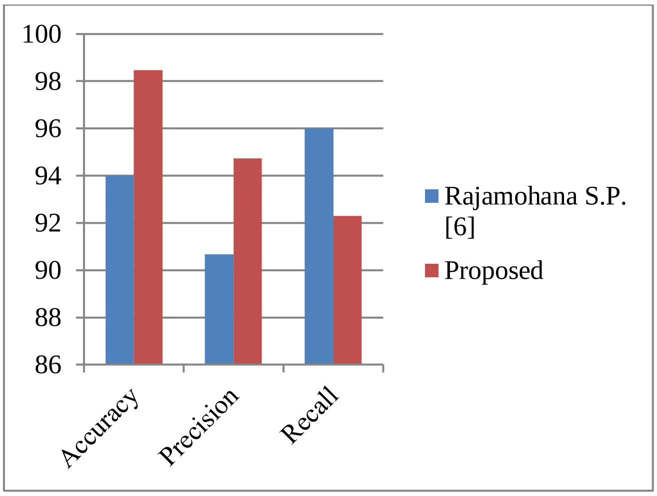


Fig. 8. Result Comparison

V. Conclusion & Future Scope

The proposed system enhanced the accuracy of detecting the facial features even at the real time. Landmark predicator has been modified with certain libraries that enhances the recognition. Automatic Drivers Drowsiness Detection is a useful concept for implementing safe driving that may aware drivers for any type of accidental casualties. The aim of this study is to address a solution to one of the major causes of the road accident. System achieved high level of accuracy as compare to the earlier proposed systems. In future the accuracy can be enhanced and ability of drowsiness detection can be more precise by adapting more recent technologies or methods.

References

[1] Md. Tanvir Ahammed Dipu, Syeda Sumbul Hossain, Yeasir Arafat and Fatama Binta Rafiq, “Real-time Driver Drowsiness Detection using Deep Learning” International Journal of Advanced Computer Science and Applications(IJACSA), 12(7), 2021. http://dx.doi.org/10.14569/IJACSA.2021.0120794

[2] Irfan Alghani Khalid, Face Landmark Detection using Python. https://towardsdatascience.com/face-landmark-detection-using-python-1964cb620837. Accessed- 15 September 2022.

[3] Py Image Search, Facial landmarks with dlib, OpenCV, and Python, https://pyimagesearch.com/2017/04/03/facial-landmarks-dlib-opencv-python/. Accessed- 15 September 2022.

[4] Zhao Z, Zhou N, Zhang L, Yan H, Xu Y, Zhang Z. Driver Fatigue Detection Based on Convolutional Neural Networks Using EM-CNN. Comput Intell Neurosci. 2020 Nov 18;2020:7251280. doi: 10.1155/2020/7251280. PMID: 33293943; PMCID: PMC7688374.

[5] Magán López, Elena & Sesmero Lorente, M. Paz & Alonso-Weber, Juan & Sanchis de Miguel, Araceli. (2022). Driver Drowsiness Detection by Applying Deep Learning Techniques to Sequences of Images. Applied Sciences. 12. 1145. 10.3390/app12031145.

[6] S.P. Rajamohana, E.G. Radhika, S. Priya, S. Sangeetha, Driver drowsiness detection system using hybrid approach of convolutional neural network and bidirectional long short term memory (CNN_BILSTM), Materials Today: Proceedings, Volume 45, Part 2, 2021, Pages 2897-2901.

[7] J. Singh, "Learning based Driver Drowsiness Detection Model," 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS), 2020, pp. 698-701, doi: 10.1109/ICISS49785.2020.9316131.

[8] Y. Suryawanshi and S. Agrawal, "Driver Drowsiness Detection System based on LBP and Haar Algorithm," 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2020, pp. 778-783, doi: 10.1109/I-SMAC49090.2020.9243347.

[9] Elmahmudi, Ali & Ugail, Hassan. (2021). A framework for facial age progression and regression using exemplar face templates. The Visual Computer. 37. 10.1007/s00371-020-01960-z.

[10] Jaeik Jo Sung Joo Lee, Ho Gi Jung, Ryoung Park, Jaihie Kim " vision based method for detecting driver drowsiness and distraction monitoring system" Optical Engineering Vol 50(12) December 2011

[11] Linkedin, Driver Drowsiness Detection Alert System with Open-CV & Keras Using IP-webCam For Camera Connection, Available: Sep 2020, https://www.linkedin.com/pulse/driver-drowsiness-detection-alert-system-open-cv-keras-khandave/. Accessed: 29 June 2021.

[12] Fouzia, R. Roopalakshmi, J. A. Rathod, A. S. Shetty and K. Supriya, "Driver Drowsiness Detection System Based on Visual Features," 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), 2018, pp. 1344-1347, doi: 10.1109/ICICCT.2018.8473203.

[13] F. Guede-Fernández, M. Fernández-Chimeno, J. Ramos-Castro and M. A. García-González, "Driver Drowsiness Detection Based on Respiratory Signal Analysis," in IEEE Access, vol. 7, pp. 81826-81838, 2019, doi: 10.1109/ACCESS.2019.2924481.

[14] A. Bhaskar, "EyeAwake: A cost effective drowsy driver alert and vehicle correction system," 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, India, 2017, pp. 1-6, doi: 10.1109/ICIIECS.2017.8276114.

[15] X. Ma, L. Chau and K. Yap, "Depth video-based two-stream convolutional neural networks for driver fatigue detection," 2017 International Conference on Orange Technologies (ICOT), Singapore, 2017, pp. 155-158, doi: 10.1109/ICOT.2017.8336111.

[16] A. Riztiane, D. H. Hareva, D. Stefani and S. Lukas, "Driver Drowsiness Detection Using Visual Information On Android Device," 2017 International Conference on Soft Computing, Intelligent System and Information Technology (ICSIIT), Denpasar, Indonesia, 2017, pp. 283-287, doi: 10.1109/ICSIIT.2017.20.

[17] S. Gupta, P. Jain and E. Rufus, "Drowsy Driver Alerting System," 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2018, pp. 1665-1670, doi: 10.1109/ICECA.2018.8474931.

[18] S.P. Rajamohana, E.G. Radhika, S. Priya, S. Sangeetha,

[19] Driver drowsiness detection system using hybrid approach of convolutional neural network and bidirectional long short term memory (CNN_BILSTM), Materials Today: Proceedings, Volume 45, Part 2, 2021, Pages 2897-2901,

[20] F. You, X. Li, Y. Gong, H. Wang and H. Li, "A Real-time Driving Drowsiness Detection Algorithm With Individual Differences Consideration," in IEEE Access, vol. 7, pp. 179396-179408, 2019, doi: 10.1109/ACCESS.2019.2958667.

[21] B. M. K. Kumari and P. R. Kumar, "A survey on drowsy driver detection system," 2017 International Conference on Big Data Analytics and Computational Intelligence (ICBDAC), Chirala, Andhra Pradesh, India, 2017, pp. 272-279, doi: 10.1109/ICBDACI.2017.8070847.

[22] A. Pinto, M. Bhasi, D. Bhalekar, P. Hegde and S. G. Koolagudi, "A Deep Learning Approach to Detect Drowsy Drivers in Real Time," 2019 IEEE 16th India Council International Conference (INDICON), Rajkot, India, 2019, pp. 1-4, doi: 10.1109/INDICON47234.2019.9030305.

[23] M. Miranda, A. Villanueva, M. J. Buo, R. Merabite, S. P. Perez and J. M. Rodriguez, "Portable Prevention and Monitoring of Driver's Drowsiness Focuses to Eyelid Movement Using Internet of Things," 2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology,Communication and Control, Environment and Management (HNICEM), Baguio City, Philippines, 2018, pp. 1-5, doi: 10.1109/HNICEM.2018.8666334.

[24] Z. Jie, M. Mahmoud, Q. Stafford-Fraser, P. Robinson, E. Dias and L. Skrypchuk, "Analysis of Yawning Behaviour in Spontaneous Expressions of Drowsy Drivers," 2018 13th IEEE International Conference on Automatic Face & Gesture Recognition (FG 2018), Xi'an, China, 2018, pp. 571-576, doi: 10.1109/FG.2018.00091.

[25] J. Yu, S. Park, S. Lee and M. Jeon, "Driver Drowsiness Detection Using Condition-Adaptive Representation Learning Framework," in IEEE Transactions on Intelligent Transportation Systems, vol. 20, no. 11, pp. 4206-4218, Nov. 2019, doi: 10.1109/TITS.2018.2883823.

[26] S. Kusuma, J. Divya Udayan and A. Sachdeva, "Driver Distraction Detection using Deep Learning and Computer Vision," 2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), Kannur, India, 2019, pp. 289-292, doi: 10.1109/ICICICT46008.2019.8993260.

[27] Y. Wang, L. Jin, K. Li, B. Guo, Y. Zheng and J. Shi, "Drowsy Driving Detection Based on Fused Data and Information Granulation," in IEEE Access, vol. 7, pp. 183739-183750, 2019, doi: 10.1109/ACCESS.2019.2960157.

[28] C. Yang, X. Wang and S. Mao, "Unsupervised Drowsy Driving Detection With RFID," in IEEE Transactions on Vehicular Technology, vol. 69, no. 8, pp. 8151-8163, Aug. 2020, doi: 10.1109/TVT.2020.2995835.

[29] M. M. Islam, I. Kowsar, M. S. Zaman, M. F. Rahman Sakib and N. Saquib, "An Algorithmic Approach to Driver Drowsiness Detection for Ensuring Safety in an Autonomous Car," 2020 IEEE Region 10 Symposium (TENSYMP), Dhaka, Bangladesh, 2020, pp. 328-333, doi: 10.1109/TENSYMP50017.2020.9230766.