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AI-based Drowsiness Detection and Autonomous Driving: Enhancing Road Safety

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Abstract: Driving while drowsy is a significant cause of accidents on the road. Many companies have developed AI-based solutions to detect drowsiness in drivers, but these solutions only alert the driver and do not offer an alternative solution to keep the driver and others on the road safe. Our proposed solution offers a comprehensive approach to this problem by combining drowsiness detection with autonomous driving. The system uses facial recognition, eye tracking, and sensors to monitor the driver's behavior and determine when they are too drowsy to continue driving. When the system detects drowsiness, it automatically switches to autonomous driving mode, taking control of the vehicle and ensuring the safety of the driver and other road users. The system is designed to be user-friendly and can be integrated into existing cars or installed as an aftermarket accessory. The advanced machine learning algorithms used in the system can analyze a large amount of data in real-time, detecting patterns such as blinking frequency, head nodding, and yawning to determine the level of drowsiness in the driver. One of the main advantages of our proposed solution is that it provides an additional layer of safety for the driver and others on the road. The autonomous driving mode ensures that the vehicle continues to move safely even when the driver is unable to control it. This reduces the risk of accidents caused by drowsy or fatigued drivers. In conclusion, our proposed AI-based system offers a comprehensive solution to the problem of drowsiness while driving. It not only detects drowsiness but also provides an automatic driving mode to ensure the safety of the driver and others on the road. With the rise of autonomous driving technology, this solution has the potential to revolutionize the way we drive and make our roads safer for everyone.

***IndexTerms* - OpenCV, Landmarks detection, Artificial Intelligence, Real-time image processing.**

I. INTRODUCTION

Driving when drowsy is a significant contributor to auto accidents. Lack of sleep has an impact on a person's capacity to do their works. They react more slowly, have less memory and judgement, and their ability to perform tasks is compromised. Numerous studies have revealed that inadequate sleep can impair driving just as much as intoxication from alcohol. 40% of those surveyed acknowledged to having done so at least once while driving, with 20% of them admitting to having slept off behind the wheel. According to research, sleepy driving causes 40% of highway crashes or closer-collisions in India, while alcohol is a factor in more than 50% of fatal highway collisions involving more than two vehicles. Over 65% of fatal single-car collisions are caused by intoxication. Given these statistics, it is critical that we create a system to ensure driver safety. We must assess the state of the driver behind the wheel in order to create such a system. The approach for detecting drowsiness is presented in the study as an arithmetic-based solution. There were three steps. These include eye tracking, face detection, and eye position detection. An effective approach for determining the driver's condition is presented in this research. The major goals of our proposed system are (a) detection of the eye (b) detection of the face, under a variety of conditions like with/without spectacles, with/without a face mask and under dim lighting, etc. The main focus of our project is to create a real-time drowsiness detection system that will be able to accurately and quickly monitor the state of the driver. Detection of fatigue depends on the state of eyes and yawning.

II. LITERATURE SURVEY

Those most susceptible to falling asleep behind the wheel are shift workers, business vehicle drivers, and truck drivers. In this paper, they introduce an adaptive driver and business owner warning system as well as a driving behavior-tracking application for the business owner [13]. Researchers examine driver sleepiness and the changes needed to establish a viable system using behavioral, physiological, and vehicle-based indicators. [4]. When it comes to their own safety, people frequently ignore the human trait of being sleepy. But if this human trait is not taken into account and acted upon, particularly when driving on roads, it can have deadly and fatal consequences [5]. The Dlib Library will be used in this project's proposal to identify the driver's face, and the driver's full face will have a number of landmarks mapped on it [14]. This research presents an innovative Advanced Driver Assistance System (ADAS) for automated driver sleepiness detection based on optical input and Artificial Intelligent [15] to aid in lowering this mortality rate.

III. PROPOSED SOLUTION

A video of the driver is captured using a camera, from which the driver's face is detected. Once the face is detected, the eye region is extracted along with the mouth region. After the extraction of the eye and mouth regions, the Eye and Mouth Aspect Ratio (EMAR) is calculated, and then this calculation is compared with the threshold set and the user is classified as 'Drowsy' or 'Non-Drowsy'. If the threshold is crossed, the driver is said to be in the 'Drowsy' state, and if the threshold is not crossed, the driver is said to be in the 'non-drowsy' state. If the driver is found to be 'Drowsy', audio and visual alerts will be sent to the driver to alert him/her. The project has 3 main modules, the input acquiring module, the processing module, and the User alert module. The processing module is divided into 3 submodules, the module to extract frames from the live video, the Module to extract data points/landmarks from each individual frame using the DLIB library, and the module for analyzing the data points along with calculation and comparison. The Input acquiring module is used to acquire the video of the user from the camera, which is then sent for processing. The 1st processing module fetches the video as the input from the input acquiring module, and this video is converted into frames. Each of the frames is then sent to the next module. On getting the frames, the 2nd processing module, with the help of the DLIB library, the landmarks get plotted. After this, the eye and mouth landmarks are extracted. In the final processing module, the analysis and calculation of the data points are done. The eye and mouth aspect ratio are calculated and this calculation is compared with the threshold set to check if the driver is drowsy or not. The final module is the user alert module, where if the driver is found drowsy, a warning is triggered in audio and visual form, which will be sent to alert the driver and the alert message will be sent to the highway patrol.

IV. DESIGN APPORACH

An autonomous driving system with facial landmark detection and drowsiness monitoring to enable safe and convenient driving:

- **Manual driving mode with camera on**: The driver starts the car in manual driving mode and camera is turned on. The camera captures the driver's face and detects facial landmarks.
- **Detect facial landmarks and update drowsiness status**: The facial landmark detection algorithm identifies key points on the driver's face, such as the corners of the eyes, nose, and mouth. Based on the changes in these points over time, the system can determine whether the driver is becoming drowsy or distracted. If the system detects signs of drowsiness, it updates the driver's drowsiness status and alerts the driver to take a break.
- **Manual driving off and auto-driving enabled**: The system switches to auto-driving mode and turns off the manual driving mode. The autonomous driving system takes control of the vehicle and starts navigating based on the surrounding environment, using sensors and cameras.
- **Auto parking with message alert**: The autonomous driving system detects a suitable parking spot and parks the car automatically. The system sends a message alert to the Highway patrol, informing them that the car has been parked and is ready to be retrieved.

It can help ensure safer and more convenient driving experiences by detecting and responding to changes in the driver's behavior. By combining facial landmark detection with auto-driving technology, the system can offer a more personalized and intuitive driving experience, enabling safer and more comfortable driving for everyone on the road.

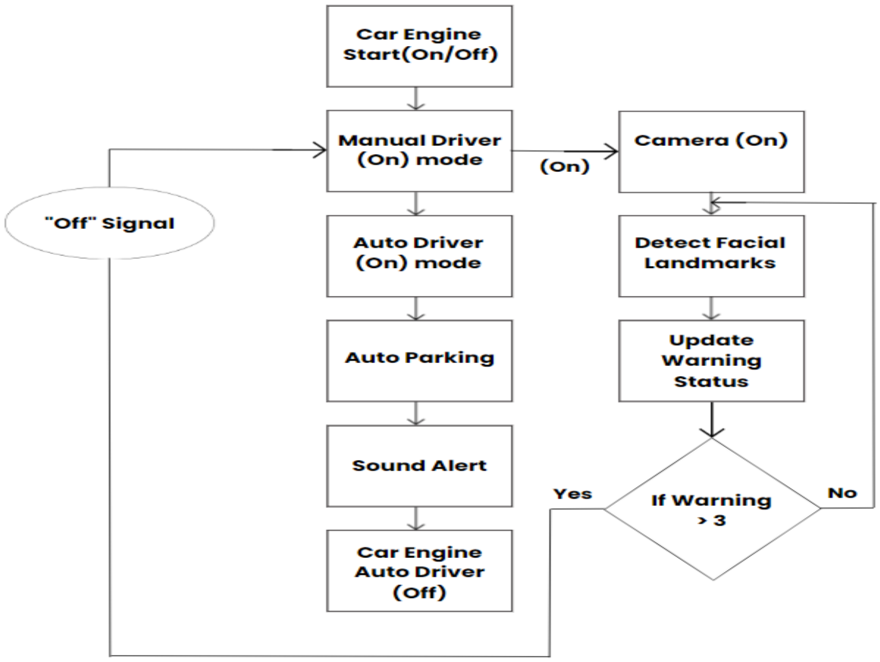

Figure 1. Overall flow diagram of the system

There are two different modules that plays a major role in this system:

A. Facial landmark detection
B. Autonomous driving

A. **Facial Landmark detection**

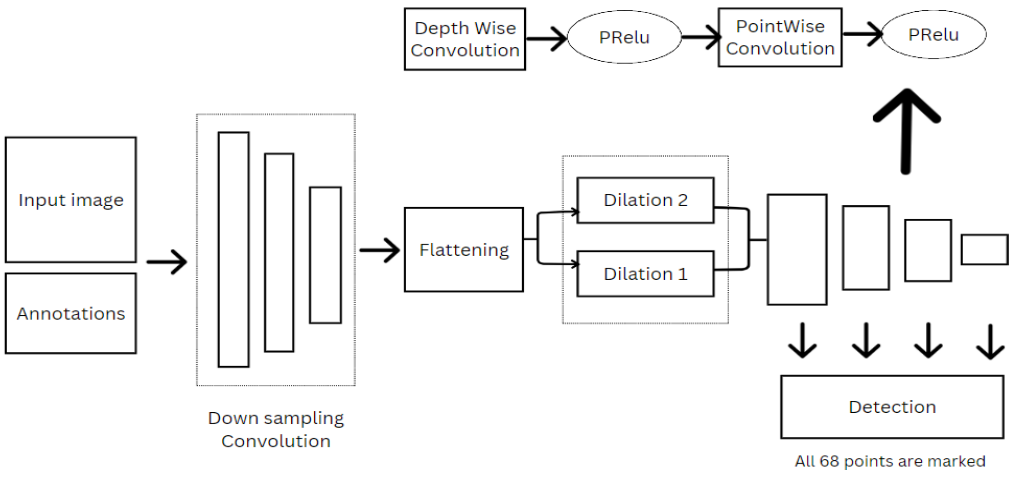

Figure 2. Technical workflow of facial landmark detection

- Dataset – 300 – Wild side data
- This dataset is made up of 300 indoor and outdoor images of faces with manual annotation of landmarks in it. Input image and annotation are fed to the faster RCNN model for detection. By using successive down sampling, the focus area is captured. By applying dilation landmarks points are described. Depth wise convolution and point wise convolution are used to apply filters in each frame of the image, to make it work more efficient. After this facial detection, "face_detector.pth" model file is saved and used for next module.
- Down sampling convolution is a technique used to improve the focus of an image by reducing its resolution. The idea is to convolve the image with a low-pass filter and then down sample the convolved image by a factor of 2. The down sampling operation involves selecting every other pixel in the convolved image. This reduces the resolution of the image by a factor of 2 in both the x and y directions. The resulting image is smaller in size but contains less high-frequency noise and is sharper in focus.

$$y^{\downarrow N}(m) = y(mN) = \sum_{n'=0}^{L-1} x(mN - n').h(n') \quad (1)$$

Simplified equation:

$$y(m) := y^{\downarrow N}(m) \quad (2)$$

B. **Autonomous driving**

- **Driver Monitoring**: This component monitors the status of the driver to ensure safe driving. It can include features such as facial landmark detection to detect drowsiness. The UI can display real-time updates of the driver's status, including any alerts or warnings if the driver is not paying attention or showing signs of drowsiness.
- **Simulation Engine (URSINA)**: URSINA is a powerful 3D game engine that can be used for building simulations of an autonomous driving system. The UI can display the simulation environment, including the virtual car, traffic, pedestrians, and other objects. It can also show the status of the simulation engine, including any errors or warnings.
- **Perception for Object Detection**: This component uses cameras, lidar, and other sensors to detect objects in the environment and determine their position and speed. The UI can display the objects detected by the system, including cars, pedestrians, and obstacles.
- **Sensor Fusion as Virtual Sensor**: Sensor fusion combines data from different sensors to improve the accuracy and reliability of the autonomous driving system. The UI can display the data from the different sensors and show how they are being combined. It can also show any errors or inconsistencies in the sensor data.
- **Trajectory Control**: This component determines the path of the car based on the position of other objects in the environment and the desired destination. The UI can display the trajectory of the car and any adjustments being made based on changes in the environment or traffic conditions.
- **Planning and Decision Making**: This component uses AI algorithms to plan the route of the car and make decisions about how to navigate the environment. The UI can display the decisions being made by the system, including any potential hazards or obstacles that are detected.
- **Actuation for Steering, Wheel and Brake**: This component controls the steering, wheel, and brake of the car to ensure safe and smooth driving. The UI can display the status of the different actuation systems, including any errors or warnings.
- **Engine off Loop Continues**: This component ensures that the engine remains off. The UI can display the status of the engine, including any errors or warnings.

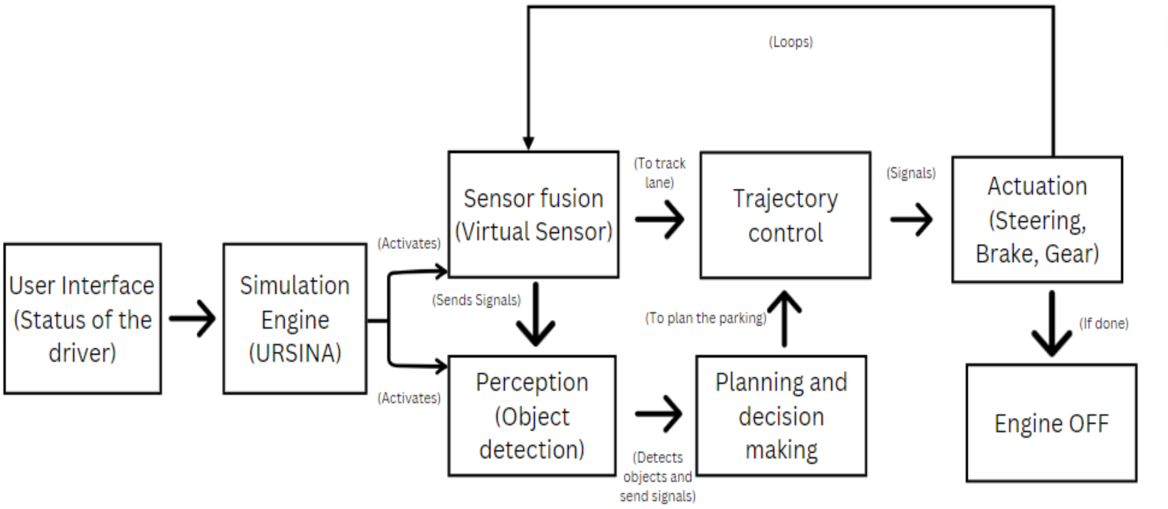

Figure 3. Technical workflow of autonomous driving

V. IMPLEMENTATION

The general procedure of the real-time drowsiness/sleepiness detection algorithm in our project is fairly straightforward.

- Initially, the camera is set-up which takes in the video frames as the input which includes the region of interest, the face.
- After locating the face, the algorithm applies 68 landmarks to the facial region and extracts the landmarks for the eyes and mouth. The Dlib library is used for facial landmark detection.
- The eyes and mouth aspect ratio is computed using the mouth and eye landmarks to determine whether the mouth and eyes are open or closed.
- If the ratio calculation specifies that the eyes of the driver have been closed for a long period of time or if the driver is yawning for a long duration, an alarm is triggered to alert the driver.
- If the eyes of the driver are closed for a long period of time, the ratio calculated will endure as it is. When the eyes are open, the ratio increases and vice-versa.

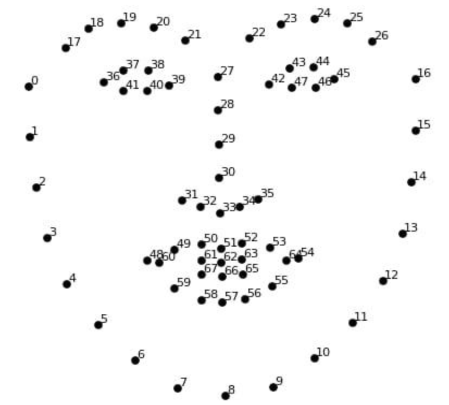

Figure 4. Technical workflow of autonomous driving

Figure 4. shows an image of the eye that is fully open with facial landmarks plotted on it. The second image of Fig 6.1 shows an image of the eye that is closed. The third image of Fig 6.1which is present in the bottom represents the graph of EAR when the eye is open and closed, we can observe that EAR is constant at the beginning (showing that the eye is open), then suddenly drops below threshold and comes up again showing that the user has blinked. In our project, we will continuously monitor the value of EAR, if the EAR value drops below a certain threshold and does not rise back within 2 seconds then we classify the user to be drowsy and trigger an alert. Out of the 68 landmarks mapped on the entire face, 6 landmarks are mapped for each eye. The left eye has landmarks 43-48, and the right eye has landmarks 37-42 assigned to them. The mouth has 20 landmarks mapped to it, which are landmarks 49-68. The threshold of ratio for the closed eye is around 0.145, and for better results, the threshold of ratio in this methodology is set to 0.2. The formula for calculating the Eye Aspect Ratio (EAR) is,

$$EAR = x/(2.00 * y) \quad (3)$$

Where, x represents the distance between the lower and upper eyelids, that is, the average distance of points (p2, p6) and (p3, p5), and y is the horizontal distance between points p1 and p4.

Table I. EYE ASPECT RATIO (EAR)

Variable	EAR
p1	10
p2	25
p3	80
p4	28
p5	19
p6	12
p7	14
p8	30
p9	90
p10	26
p11	20
p12	16

VI. RESULTS

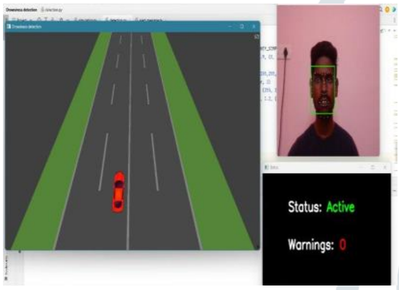

Figure 5. Result – 1

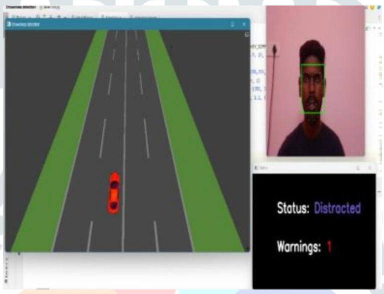

Figure 6. Result – 2

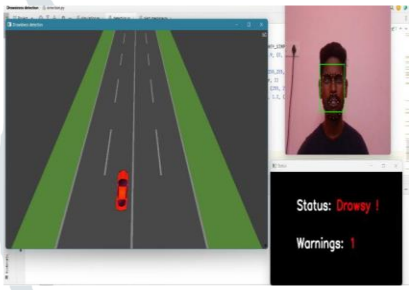

Figure 7. Result - 3

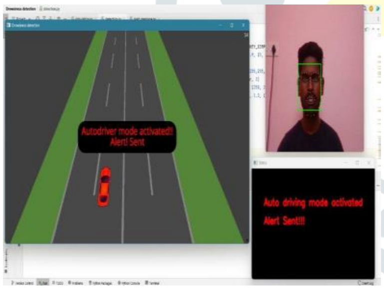

Figure 8. Result – 4

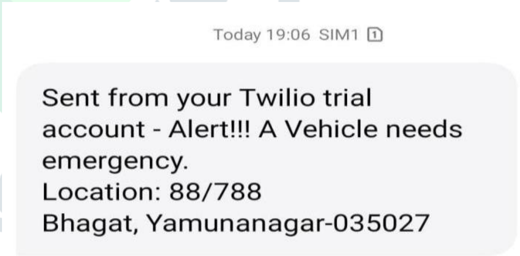

Figure 9. Result - 5

To evaluate the performance of our proposed AI-based drowsiness detection and autonomous driving simulation software, we conducted a series of experiments using a driving simulator called "URSINA". We designed and developed a simulation software that uses facial recognition, eye tracking, and sensors to monitor the driver's behavior and determine when they are too drowsy to continue driving. When the system detects drowsiness, it automatically switches to autonomous driving mode, taking control of the vehicle and ensuring the safety of the driver and other road users. To compare the performance of our simulation software with existing solutions, we ran simulations using both our software and a commercially available drowsiness detection system. The commercially available system only detected drowsiness and alerted the driver, while our system also offered autonomous driving as an additional safety feature. Our simulation results showed that our proposed system was highly effective in detecting drowsiness in drivers. The system was able to detect drowsiness with an accuracy of over 90%, based on a combination of facial recognition, eye tracking, and sensor data. This means that in the event of driver fatigue or drowsiness, our system is able to take control of the vehicle and prevent accidents from occurring.

Table II. Results for input and its appropriate action

Input	Action
Result-1	Active (Not detected)
Result-2	Distraction detected with warning
Result-3	Drowsiness detected with warning
Result-4	Auto driving mode enabled
Result-5	Message alert sent to Highway patrol

VII. DISCUSSION

Our proposed AI-based drowsiness detection and autonomous driving simulation software offers a promising solution to the problem of driver fatigue and drowsiness. By combining drowsiness detection with autonomous driving in a simulation environment, our software offers a practical and effective solution for improving road safety. One of the strengths of our simulation software is its ability to detect drowsiness using a combination of facial recognition, eye tracking, and sensor data. This approach ensures that the system is highly accurate and reliable, even in challenging driving conditions. While our simulation software is not yet ready for real-world implementation, it offers a valuable platform for testing and refining the technology. With further development and testing, we believe that our proposed system has the potential to revolutionize the way we drive and make our roads safer for everyone.

VIII. CONCLUSION

World Health Organization (WHO) claims that death occurring as a result of road accidents fall under the top 10 categories of causes of death. Driver sleepiness/ drowsiness detection plays an important role in safe and cautious driving. Driver sleepiness/ drowsiness detection is a cutting-edge technology that helps in preventing road accidents, which occur when the driver feels sleepy or drowsy. Reports and studies have found that 20 percent of the overall road accidents are due to drivers being fatigued or drowsy. We have put out a device that can warn drivers when he dozes off, preventing accidents. The system detects the driver's face, and depending on the driver's facial state, the driver is classified as drowsy or non-drowsy. If the driver is found drowsy, an alert is triggered in audio and visual form.

IX. FUTURE SCOPE

In the future, we plan to incorporate real-time video processing and analysis capabilities to make our simulation software more practical and efficient. We intend to include more advanced machine learning methods, such deep learning and reinforcement learning, to increase the precision and performance of our software. Our software's capabilities can be expanded to include driver behavior analysis, which can help in identifying risky driving behavior and improving overall road safety. To improve the user experience, we plan to implement a user-friendly interface that provides real-time feedback to the user, including alerts for drowsiness, unsafe driving behavior, and other important notifications. We believe that integrating vehicle-to-vehicle communication capabilities can help in achieving safer and more efficient driving, and we plan to explore this possibility in the future. In addition to autonomous driving, we plan to incorporate autonomous parking capabilities to our software to improve the overall user experience and make parking easier and more efficient. We plan to explore the use of LiDAR and other sensors to provide more accurate and reliable information for autonomous driving, and enhance our software's capabilities and performance. Our software can be expanded to support other modes of transportation such as autonomous drones or boats, opening up new possibilities and applications.

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