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GuardianDrive – Smart Drowsiness Detection and Safety System using OpenCV

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Abstract: The project addresses the crucial issue of drowsy driving, a significant contributor to road accidents. The proposed system employs cutting-edge technology to monitor the driver's level of drowsiness through computer vision. By analyzing facial cues and eye movements, the system can detect signs of fatigue and alertness in real-time. When drowsiness is detected, the system takes proactive measures to keep the driver awake and alert. It automatically plays an alarm to stimulate the driver's senses and mitigate drowsiness. The system also includes a hand detection module to determine whether the driver is active if the alert is activated a certain number of times. This function is essential since inactivity during a state of exhaustion might result in serious consequences. The technology alerts the driver and averts possible collisions when it detects a driver's condition of drowsiness. The technology reacts instantly in emergency scenarios if the driver's fatigue approaches a threshold and prolonged inactivity is noted. The driver's current position is shared with the chosen emergency contacts through an alert message. The overall goal of this project is to improve road safety through the efficient detection and mitigation of driver fatigue and the provision of prompt assistance in emergency situations.

Keywords: Computer Vision, Drowsy driving, Alarm, Alert message, Eye and hand detection.

I. INTRODUCTION

Drowsiness is a state of near sleep, where the person has a strong desire for sleep. It has two distinct meanings, referring both to the usual state preceding falling asleep and the chronic condition referring to being in that state independent of a daily rhythm. Sleepiness can be dangerous when performing tasks that require constant concentration, such as driving a vehicle. When a person is sufficiently fatigue while driving, they will experience drowsiness and this leads to increase the factor of road accident. We all pass through the drowsiness state on the way to sleep. It may not be a dangerous state if you are sitting watching television, but it certainly is a high risk if you're driving a car. Our thinking and reaction times slow down, and these changes inevitably make us a higher risk when on the road.

The development of technologies for detecting or preventing drowsiness while driving is a major challenge in the field of accident avoidance system. Because of the hazard that drowsiness presents on the road, methods need to be developed for counteracting its affects. Drowsy driving is a pervasive and deadly issue on roadways worldwide, responsible for a significant portion of accidents and fatalities. The consequences of drowsy driving are alarming, affecting not only the drivers themselves but also other road users and pedestrians.

The project's objectives encompass the creation of an all-encompassing drowsiness detection and alert system, employing state-of-the-art computer vision technology. This system is designed to actively monitor a driver's level of drowsiness by analysing various indicators such as facial cues and eye movements in real-time. When signs of fatigue are detected, the system will instantly trigger an alert mechanism, featuring auditory alarms designed to reinvigorate the driver's senses and counteract drowsiness. Furthermore, the project integrates a hand detection module to evaluate driver activity, ensuring that the driver remains actively engaged in the driving process. In emergency scenarios where drowsiness becomes severe and prolonged inactivity is observed, the system will rapidly dispatch an alert message to pre-selected emergency contacts, providing timely assistance.

While Computer Vision hold promise for drowsiness detection, it is essential to recognize their limitations. Understanding the limitations helps in building more effective systems. This section outlines some of the key limitations associated with using Computer Vision for this purpose:

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1. Environmental Factors: Adverse weather conditions, poor lighting, or other environmental factors may impact the system's performance, potentially leading to false positives or negatives in drowsiness detection.

2. Individual Variability: Driver behaviour and physiological responses to drowsiness can vary significantly among individuals. The system may not account for all personal variations, potentially leading to false alarms or overlooking signs of fatigue in certain users.

3. User Acceptance and Compliance: The success of the project relies on user acceptance and compliance. Drivers may disable or ignore the system's alerts, diminishing its overall effectiveness in preventing drowsy driving incidents.

4. Integration Challenges: Integrating the drowsiness detection system seamlessly into a diverse range of vehicle models may present technical challenges and compatibility issues, potentially limiting widespread adoption.

The rest of paper is organized as follows: Chapter 2 deals with the Literature survey conducted to know about the existing systems. The next chapter i.e., Chapter 3 deals with the proposed methodology. Chapter 4 deals with the implementation, proposed algorithm of the project. The Chapter 5 deals with the results the project has gained with the necessary screenshots. The report ends the conclusion and with a list of references that have been used.

Fig. 1. Driver drowsiness

II. RELATED WORK

In the past, there have been researches carried out by different groups, belonging to both, industry and academia that bear similar resemblance to or are based on a topic similar to what we are doing.

A. Driver drowsiness detection using Raspberry PI

The proposed drowsiness detection and prevention system [1] integrates both hardware and software components to effectively address the issue of drowsy driving. The hardware components include a Raspberry Pi, a camera, and a buzzer, while the software components involve the Raspberry Pi OS and Python programming.

The system operates through a systematic flow that comprises three essential stages: face detection, eye detection, and drowsiness detection. This process begins with the identification of the driver's face, followed by the precise tracking of the driver's eyes. Continuous monitoring of the driver's facial and eye movements is crucial in ensuring the system's effectiveness. When the system detects signs of drowsiness, it triggers an alarm, which is designed to alert the drowsy driver. Additionally, the system takes a proactive approach to prevent potential accidents caused by drowsy driving. It achieves this by activating a water pump, which serves as a stimulating mechanism to awaken the drowsy driver. The results obtained from this innovative system [1] demonstrate its capacity for successful drowsiness detection and prevention. These results underscore the significance of the system in addressing the critical issue of drowsy driving and its potential to significantly reduce accidents resulting from driver fatigue.

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B. Driver Drowsiness detection using OpenCV

The system is designed to identify signs of fatigue by closely monitoring the driver's eyes throughout their journey. This process involves several distinct steps, commencing with the capture of images via an onboard camera, followed by the critical stages of eye detection and yawning detection. To accomplish these tasks, the system [2] harnesses the capabilities of OpenCV, a powerful computer vision library renowned for its ability to handle various image processing tasks. The implementation of this system [2] encompasses rigorous testing and evaluation at each stage, yielding valuable insights and conclusive results. The initial phase involves the successful capture of video data, a fundamental element of the monitoring process. Subsequently, the system excels in its ability to extract and analyse features related to the driver's eyes and mouth.

By issuing timely warnings and notifications, the system [2] plays a pivotal role in keeping the driver vigilant and awake, mitigating the risks associated with drowsy driving. In conclusion, the system emerges as a robust and reliable solution to the critical issue of drowsiness-related problems during driving. The successful implementation of image capture, eye detection, and yawning detection, coupled with its capacity to issue audio alerts when necessary, underscores its effectiveness in achieving its objectives. The system's ability to proactively detect and address drowsiness-related concerns positions. it as a valuable tool in enhancing driver safety and reducing the potential for accidents caused by driver fatigue.

C. Drowsiness detection using machine learning

The study employs a multifaceted approach to tackle the critical issue of driver drowsiness, drawing upon various techniques and technologies. These techniques encompass eye blinking analysis, facial landmark detection, mouth movement tracking, pulse rate monitoring, and the utilization of machine learning algorithms. This diverse set of tools is harnessed to comprehensively detect and address the onset of driver drowsiness.

Machine learning algorithms play a pivotal role in this research, with a range of methods deployed, including Random Forest, Linear Regression, K-Nearest Neighbour, among others. These algorithms are tasked with the classification of eye and mouth states, enabling the system [3] to discern subtle cues that may indicate drowsiness. The results achieved through the use of these machine learning techniques are notable, showcasing high accuracy rates in effectively categorizing the states of the driver's eyes and mouth. In essence, the study [3] serves as a testament to the effectiveness of an integrated approach to driver drowsiness detection. By combining video processing, machine learning, and the monitoring of physiological parameters such as pulse rate, the research offers a comprehensive solution to enhance road safety. The positive outcomes and high accuracy rates achieved in the classification of eye and mouth states underscore the potential of these methods to significantly reduce the risks associated with drowsy driving, ultimately contributing to safer road conditions for all.

D. Drowsiness detection using CNN

The study introduces a novel drowsiness detection system designed specifically for drivers, merging the capabilities of OpenCV and deep learning techniques. This innovative approach [4] hinges on the analysis of webcam images to identify the presence of faces and eyes. The pivotal component of this system is a Convolutional Neural Network (CNN) model, which has the capacity to predict the status of eye closure in real-time.

The system [4] calculates a score, which serves as a crucial metric for monitoring the duration of closed-eye instances. When this score surpasses a predefined threshold, an alarm is promptly triggered. This alarm mechanism is a vital element of the system's functionality, intended to alert the driver when prolonged eye closure indicates drowsiness.

III. PROPOSED METHODOLOGY

The proposed system for addressing drowsy driving is a comprehensive solution that leverages cutting-edge technology to enhance road safety by monitoring driver fatigue in real-time and taking proactive measures to mitigate drowsiness. Here's an overview of the key components and functions of the system:

A. *Drowsiness Detection:*

Computer Vision: The system uses computer vision technology to analyse the driver's facial cues and eye movements continuously.

Real-time Monitoring: It constantly monitors the driver's behaviour to detect signs of drowsiness, such as drooping eyelids, slow or erratic eye movements, and changes in facial expressions. In the realm of drowsiness detection, the proposed system incorporates cutting-edge technology in the form of computer vision.

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This advanced approach involves the continuous analysis of the driver's facial cues and eye movements. By employing intricate algorithms and image processing techniques, the system can discern subtle changes in the driver's expressions, allowing for a comprehensive understanding of their alertness levels. A pivotal aspect of this system is its commitment to real-time monitoring. Through a continuous and high-frequency stream of data, the system vigilantly observes the driver's behaviour.

It remains attentive to key indicators of drowsiness, including the nuanced signs such as drooping eyelids, slow or erratic eye movements, and alterations in facial expressions. This continuous monitoring ensures that the system is not only responsive but also capable of early detection, thus enhancing its overall effectiveness in preventing potential accidents caused by drowsy driving.

The implementation of threshold-based detection adds a layer of sophistication to the system. By setting predefined thresholds for drowsiness, the system establishes a dynamic baseline for each driver. This approach recognizes that individual drivers may exhibit varying signs of drowsiness, and the system adapts accordingly. When the driver's behaviour surpasses this predetermined threshold, the system promptly identifies them as being in a state of drowsiness.

Threshold-Based Detection: The system sets a predefined threshold for drowsiness, and when the driver's behaviour crosses this threshold, it identifies them as drowsy.

B. *Proactive Measures:*

Alarm Activation: When drowsiness is detected, the system activates an alarm designed to stimulate the driver's senses and help them stay awake. In the domain of proactive measures, the proposed system employs a multi-faceted approach centered on alarm activation. When the system detects signs of drowsiness, it promptly initiates an alarm designed with precision to stimulate the driver's senses. It serves as a targeted mechanism to jolt the driver into a heightened state of awareness, counteracting the onset of fatigue.

The goal is not only to alert the driver to their drowsy state but also to elicit a response that ensures they remain actively engaged in the driving task. By employing a well- calibrated blend of auditory and visual alerts, the system seeks to create a proactive and user- centric solution that goes beyond conventional alarm systems.

C. *Hand Detection module:*

Active Driver Check: To ensure the driver remains actively engaged while the alert is activated, the system includes a hand detection module. Incorporating a critical dimension to driver engagement, the proposed system integrates a sophisticated hand detection module. This module serves as an active driver check, ensuring that the driver is not only aware of the alert but also actively engaged in the control of the vehicle. By incorporating this module, the system takes a proactive stance in addressing the potential challenges associated with driver inactivity during alert scenarios.

Continuity Checks: The system tracks the driver's hand movements to determine if they are actively controlling the vehicle. If the driver's hands are inactive for an extended period while the alert is active, the system takes further actions.

D. *Emergency Response:*

Collision Avoidance: In emergency scenarios where the driver's drowsiness approaches a critical level and prolonged inactivity is observed, the system takes immediate action to prevent collisions. In instances of emergency response, the proposed system unveils a robust strategy to avert potential accidents caused by severe driver drowsiness. This proactive approach involves collision avoidance mechanisms that are triggered when the system perceives the driver's drowsiness reaching a critical threshold and simultaneous prolonged inactivity. The system promptly intervenes to prevent collisions, leveraging a combination of advanced vehicle control systems such as automatic emergency braking and adaptive cruise control. This instantaneous response is calibrated to ensure swift and precise actions that align with the paramount objective of safeguarding lives and In the event of detected critical driver fatigue, the system diligently shares the driver's current position with pre-selected emergency contacts through an alert message. This strategic sharing of information empowers designated individuals, such as emergency responders or family members, with crucial details to provide swift and targeted assistance. This amalgamation of advanced technology and immediate emergency response mechanisms aligns with the core objective of the project: fostering safer road conditions through a holistic and proactive approach to drowsy driving prevention.

Position Sharing: The system shares the driver's current position with pre-selected emergency contacts through an alert message.

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Overall, the primary objective of this project is to enhance road safety by efficiently detecting and mitigating driver fatigue. It also aims to provide prompt assistance in emergency situations by sharing the driver's location with designated contacts. This comprehensive system combines advanced technology and real-time monitoring to reduce the risk of drowsy driving-related accidents and protect both the driver and others on the road..

IV. IMPLEMENTATION

A. *Dataset:*

The shape predictor 68 landmarks dataset refers to a collection of facial landmarks that are commonly used in computer vision and facial analysis tasks. Facial landmarks are used to localize and represent salient regions of the face, such as: Eyes, Eyebrows, Nose, Mouth, Jawline.

One popular dataset for this purpose is the 68-landmark model from the Dlib library, which includes a pre-trained shape predictor model. This model can predict the positions of these 68 landmarks on a given face image. 1. Face detection: Face detection is the first method that locates a human face and returns a value in x,y,w,h which is a rectangle. 2. Face landmark: After getting the location of a face in an image, then we have to through points inside of that rectangle.

The dataset is valuable for training and evaluating facial landmark detection algorithms. Researchers and developers leverage these annotated images to create and fine-tune models that can accurately locate facial landmarks.

Fig 2: Facial landmarks

B. *Implementation:*

Implementing a drowsiness detection and safety system using computer vision involves several steps, including model building, face, eye and hand detection, and EAR algorithm.

Step 1: Import libraries

Import the required libraries and their functions. In our program we used Dlib, a pre-trained program trained on the shape_predictor_68_landmarks dataset to detect human faces using the predefined 68 landmarks.

Step 2: Model Building

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a. Face detection:
Starting by the video capture, we will use OpenCV to capture the system's webcam in an "infinite" loop and thus give the impression of watching a video. It's a landmark's facial detector with pre- trained models, the dlib is used to estimate the location of 68 coordinates (x, y) that map the facial points on a driver's face.

b. Eye detection:
After passing our video feed to the dlib frame by frame, we are able to detect left eye and right eye features of the face. The Region of Interest (ROI) corresponding to the left and right eyes from facial landmark array.

c. Hand detection:
Hands are detected in a video frame using a Haar Cascade classifier and visualizes the detection by drawing green rectangles around the detected hand on the original frame.

Step 3: EAR Algorithm

Eye Aspect Ratio (EAR) calculates the level of eye openness based on the coordinates of facial landmarks representing the eyes. The Euclidean distances between specific pairs of landmarks are calculated. A lower EAR typically indicates closed eyes, while a higher EAR suggests open eyes.

$$EAR = (A + B) / (2 * C)$$

Step 4: Emergency alert

Once the system detects signs of drowsiness, it can activate an alarm to alert the driver or operator. The alarm can take various forms, such as audible alerts, visual warnings or haptic feedback. Here we are using audible alerts. The system designed to notify the driver of the potential danger.

The sound module in Pygame enables you to load and play sound files, making it possible to add background music, sound effects, and other audio elements to your games

Step 5: Location tracking

Location tracking using a geocoder involves the use of a geocoding service to convert addresses or place names into geographic coordinates (latitude and longitude), which can then be used to determine the location of a specific point on the Earth's surface.

Geocoding is essentially the process of transforming human-readable location information into a format that can be used for mapping and spatial analysis.

Step 6: Location sharing

Location sharing while driving can be important for various reasons, primarily related to safety, navigation, and communication.

Twilio primarily provides communication APIs for sending and receiving text messages, phone calls, and other forms of communication. Twilio's messaging capabilities in combination with other location-based services to implement location sharing in your application.

Step 7: Emergency contacts

Fetching emergency contacts before driving involves the process of accessing and organizing a list of contacts designated for emergencies.

This practice is particularly important for ensuring quick and efficient communication in case of unexpected situations while driving. By proactively fetching and organizing an emergency contacts list before driving, you enhance your preparedness for unforeseen circumstances.

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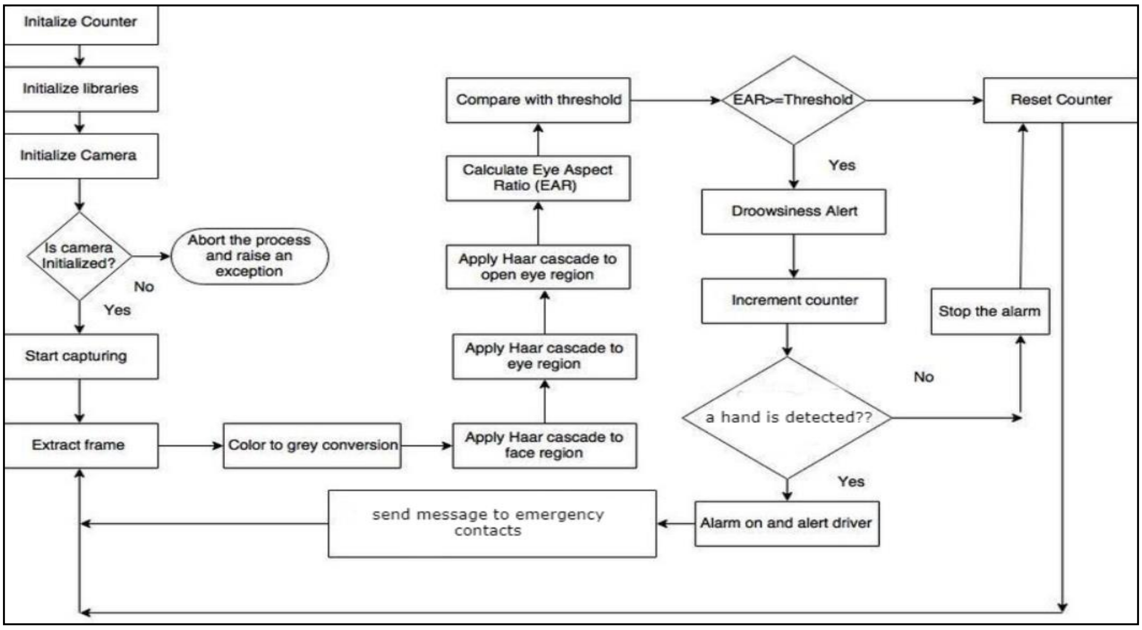

Fig 3: Flow of project

C. *Algorithm:*

Algorithm (Drowsiness detection)

Input:

Emergency contacts of the driver
Video frames

Output:

Enter emergency contacts and driver's name
Start video capture:
Get the frame
Convert the frame to grayscale
Draw the contours on the eyes
Compute the EAR for the left and right eye
Compute the average EAR
Detect the eye blink
If EAR_AVG > threshold:
Ring the alarm
Increment the counter
If counter > threshold_counter:
Detect hands in the frames
If detected: counter=0
Else: alert the emergency contacts
If long activity:
Get the last known location
Send alert messages to emergency contacts

EXIT

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V. RESULTS

After clicking on the run option in visual studio code, the program greets the "Hi! Driver." Then ask to enter the name of the driver. After entering your name, press Enter. Then the program asks the driver to enter three emergency contacts to which the emergency messages are to be sent. Then press Enter to start the webcam.

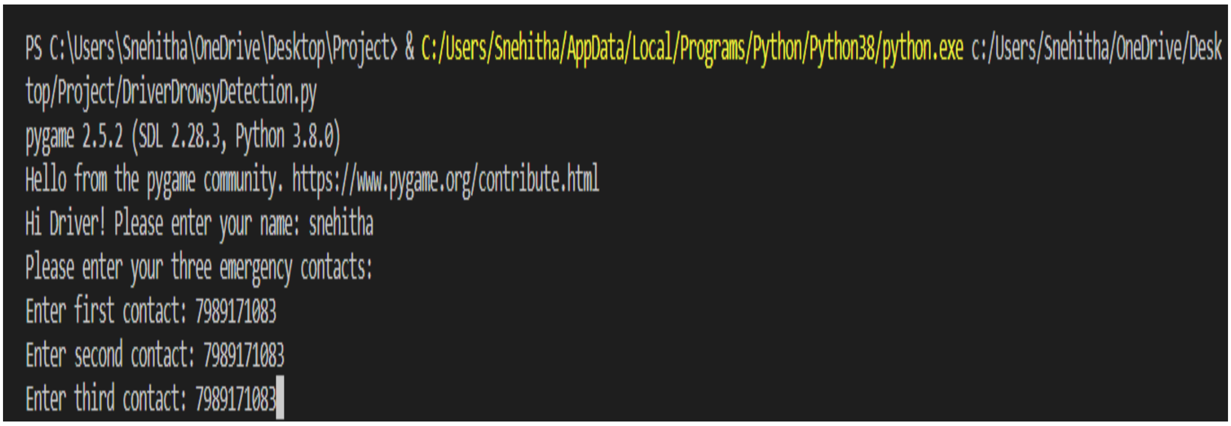

Fig 3: Listing Emergency contacts

After start of the webcam, a separate window gets opened with the title "Winks Found". Eye detection gets started and the green contour lines are drawn on both left and right eye. EAR value will be calculated and displayed on the screen. And also the seconds of eye closure will be displayed.

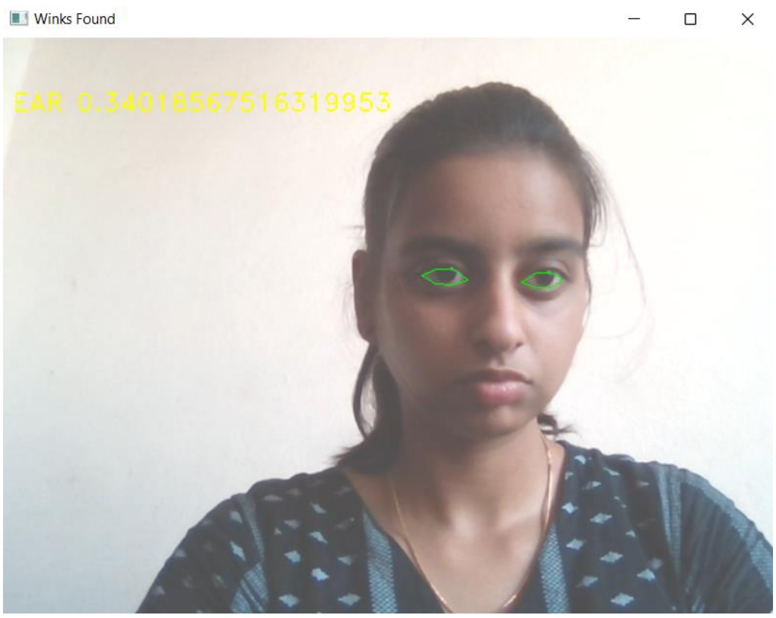

Fig 4: Drowsiness detection and EAR calculation

Frames will be captured and displayed continuously. The EAR value will also be calculated for each frame. As the time runs and drowsiness detected for more than 6 seconds then a red alert message will be displayed as "Drowsiness Alert". And an alarm sound will be played from the next four seconds of detection. This wakes up the driver. But the system will be running and video capture is on process

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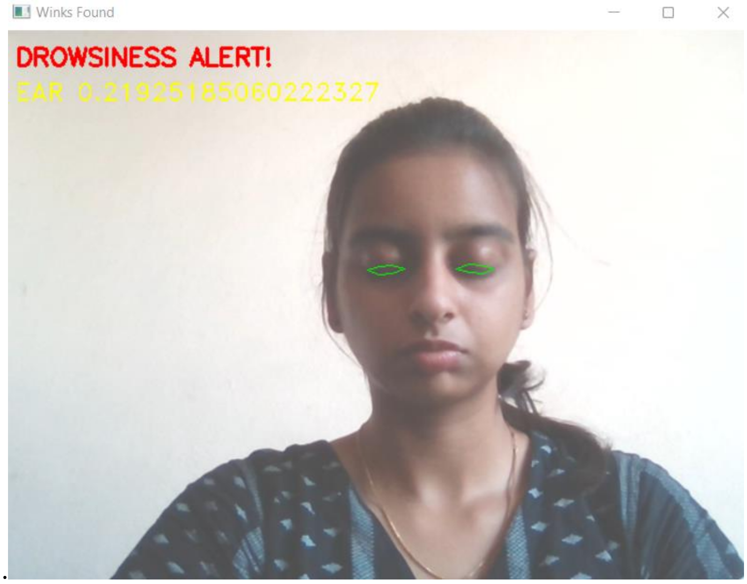

Fig 5: Drowsiness Alert message

The calculated EAR value will be displayed on the screen. If the drowsiness is detected and the Alarm is played, if the driver's EAR increases showing his activeness the timer will again reset back to 0. If the EAR value increases and the timer is set back to 0, then the counter value for hand detection is incremented by 1.

If drowsiness is detected continuously for five times and alarm keeps getting activated, this indicates that driver is in fatigue state. To make the senses of driver active and to know activeness of the driver hand detection module is built. When it gets activated, a separate video capture window is opened with the title "Hand detection". This asks the driver to show his palm to indicate that he is in his senses and is responding to the system. If the hand is not detected in the next 120 seconds this indicates that driver is not responding to the system and emergency alert message is send to the emergency contacts.

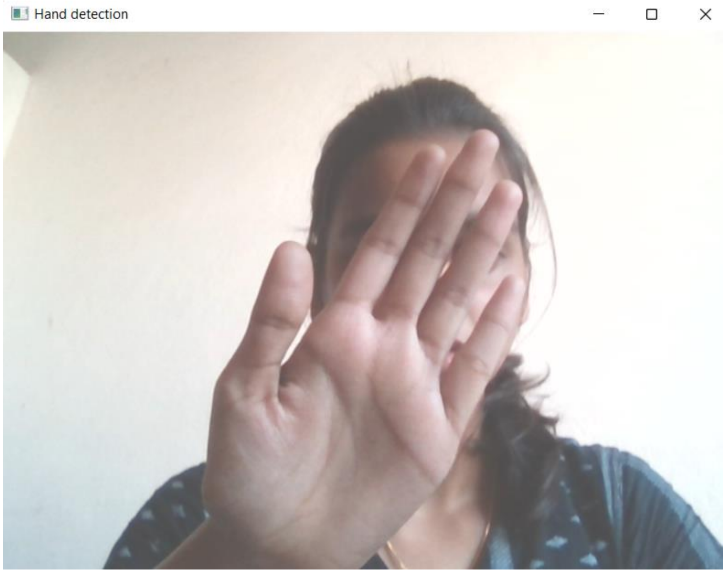

Fig 6: Hand detection module

If the driver reacts to the hand detection module, then no alert messages will be sent and hand detection module will be closed. This again reset the counter value to zero. Then after another alarm the counter will again be incremented. The palm detection module uses palm.xml, for a faster detection.

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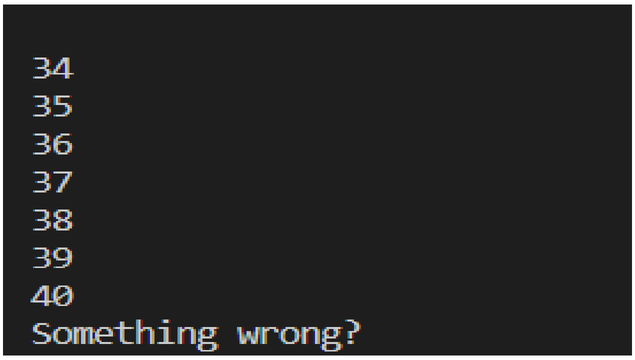

Fig 7: State of emergency

If in the previous video capture hand is detected within the threshold time, then hand detection module gets closed and drowsiness detection gets activated again. If the driver didn't respond to the alarms and continuously has his eyes closed for 40 time frames then this indicates that driver felt asleep and is a chance of accident. So geolocation is taken using geocoder and with help of twilio emergency alert messages along with the link to the location is sent to the emergency contacts fetched at the start.

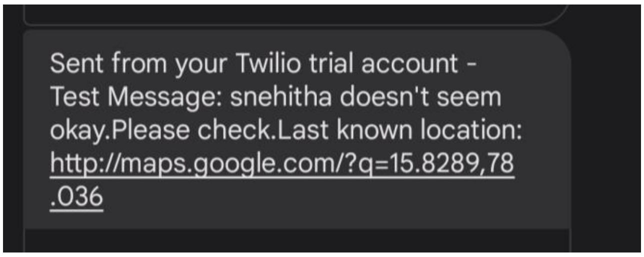

Fig 8: Emergency alert message

The figure shows the message sent by twilio as an alert message which says, Driver doesn't seem okay. Please check. Last known location: with a link to google maps along with the coordinates. As soon as the person receives the message he will understand that the driver is not okay and he need to respond by calling texting or checking for the person in the location. This way if any emergency has occurred then medical help will be fast and driver can be saved. To get the message from twilio we need to add the number to our twilio account at first otherwise the message will not be sent.

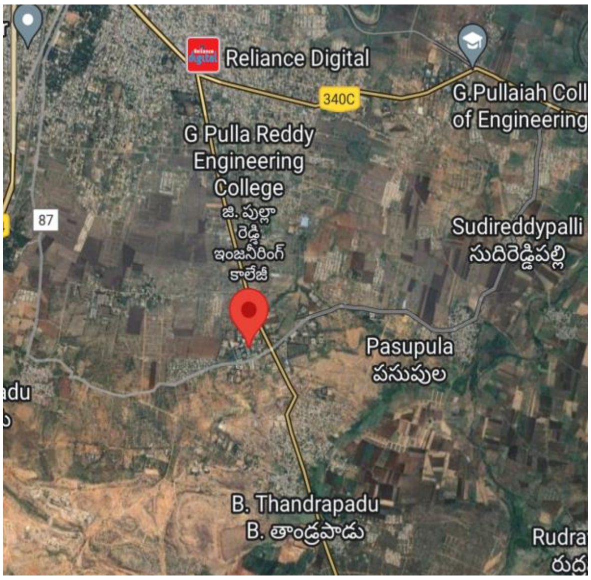

Fig 9: Google map location

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As the receiver clicks on the link sent along with the message the last known location of the driver can be seen.

VI. CONCLUSION

In conclusion, the proposed solution completely meets the objectives and requirements of the system. The framework has achieved an unfaltering state where all the bugs have been disposed of. It takes care of the issue of stressing out for individuals having fatigue-related issues to inform them about the drowsiness level while driving.

The ultimate goal of the system is to check the drowsiness condition of the driver. Based on the eye movements of the driver, the drowsiness is detected and according to eye blink, the alarm will be generated to alert the driver and if the driver does not respond to the alarm and drowsiness is still detected, then the system automatically sends the current location of the vehicle to the emergency contacts provided. To stop the alarm, the driver should raise their hand (palm). When the system detects the hand, then alarm automatically turns off. By doing this, many accidents will be reduced and provides safety to the driver and vehicle. A system that is driver safety and car security is presented only in luxurious costly cars. It completely meets the objectives and requirements of the system. The framework has achieved an unfaltering state where all the bugs have been disposed of. It takes care of the issue of stressing out for individuals having fatigue-related issues to inform them about the drowsiness level while driving.

For future work, the model can be improved incrementally by using other parameters like blink rate, yawning, state of the car, etc. If all these parameters are used it can improve the accuracy by a lot. We plan to further work on the project by adding a sensor to track the heart rate in order to prevent accidents caused due to sudden heart attacks to drivers. Same model and techniques can be used for various other uses like Netflix and other streaming services can detect when the user is asleep and stop the video accordingly. It can also be used in application that prevents user from sleeping.

User Customization: Allow users to customize the system based on their preferences and specific needs. This could include choosing different levels of alerts, setting personalized emergency protocols, or selecting preferred communication methods.

In-Car Voice Commands: Integrate in-car voice command systems to enable hands-free interaction with the emergency contact system. Users should be able to fetch emergency contacts, make calls, or send messages using voice commands. Machine Learning for Predictive Analysis: Utilize machine learning algorithms to analyse user behaviour and driving patterns. This could help predict potential risks or issues, allowing the system to proactively suggest safety measures or notify emergency contacts in advance.

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