TED UNIVERSITY

CMPE491

Senior Design Project I

SAFE AWAKE

-DROWSINESS DETECTION & ALERTING SYSTEM-

Project Analysis Report

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PROJECT URL: https://safeawake.github.io/

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1.Introduction

In this document, the main purpose is to formalize our system specifications produced during requirements elicitation and also examine in more detail boundary conditions and exceptional cases. Some of the general usage areas of this system, which will be developed to provide safer driving, are intercity buses, trucks, public transportation, taxis, and personal transportation. In today's world where technology is at the highest level, we aim to prevent many accidents and save many lives with such a system. When considering current efforts in this area, it appears to be predominantly concentrated among expensive car brands. In contrast, our aim is to design a system that not only contributes to the safety of the general public but is also economically accessible and applicable in broader contexts. We assert that this project addresses a significant gap in security that represents an underdeveloped area worldwide. For this reason, we are developing SafeAwake as the beginning of a new workspace. The overall goal of the project is to ensure driving safety by observing drivers' states such as sleep, awake, and yawning, and by warning drivers in case of emergency.

2. Current system (if any)

Since we do not have an established system, in this part we will mention the supply of materials required for our project.

Materials Supplied:

- Raspberry Pi 4 Model B.
- Raspberry Pi Camera and the necessary cables for the camera settings.
- MicroSD Card 32 GB.
- Raspberry Pi Power Supply.
- Raspberry Pi 4 Micro HDMI.

Picture 1: Raspberry Pi 4 Model B with Pi Camera

3. Proposed system

3.1 Overview

Nowadays, the number of traffic accidents due to drivers' carelessness and drowsiness is much higher than expected. With this project, we aim to minimize the number of traffic accidents caused by driver inattention and drowsy problems as much as possible. The difficulties we may encounter can be exemplified by some data-based security problems and decreased efficiency due to the angle of the camera. We plan to face these problems by preparing the necessary security protocols with companies, reaching companies and drivers with good marketing tactics, and setting the necessary start menu settings for the camera settings. Our system will consist of parts such as a camera, screen, alarm lights, and sound system. The screen will be used for situations such as adjusting camera settings and initializing the system. The alarm light and sound system will perform functions such as warning and waking the driver if the driver falls asleep or starts yawning. The camera will capture the facial expressions of the driver and provide data entry to the system. Thus, we aim to prevent traffic accidents caused by drivers' carelessness as much as possible. Since the project points to the safety of everyone using transportation vehicles, we believe that it will attract the attention of many public transportation or intercity bus companies, long-distance drivers, government organizations, and most importantly, everyone who is a passenger. We aim to develop this system using image processing techniques and machine learning algorithms. Once the system we have developed is set in vehicles, it will not only prevent traffic accidents but also give warnings regarding long-distance drivers. For example, noticing their fatigue and warning them: "Take a break!". In addition to these, we think that we can create a new business area to fulfill the functions required for the installation and maintenance of these systems. As outlined, SafeAwake cares about the safety of passengers and drivers. Considering that it is a subject that attracts the attention of many fields, it may not only lead to new development studies in the future, but also create a new working area, making it more useful to the public.

3.2 Functional Requirements

- The system must analyze facial expressions and eye movements to determine the driver's drowsiness.
- The system must warn the driver with an audible alarm when it notices symptoms of drowsiness.
- The system must provide a visual alert, such as flashing lights on the screen, simultaneously with the audible alarm. (These lights must turn red when detecting drowsiness and will turn yellow when detected by yawning.)
- The system must capture a photo of the driver when it detects drowsiness.

3.3 Nonfunctional Requirements

- The user interface of the system must be simple to use and intuitive, ensuring that drivers can easily understand and interact with the system.
- The system must detect signs of drowsiness with a minimum of 95% accuracy to minimize false alarms (false positives or false negatives).
- The system must respond to signs of drowsiness within 1 second.
- The device must sound an audible alarm with a minimum volume of 60 decibels when signs of drowsiness are detected.
- The camera must capture high-quality images with a minimum resolution of 720p.
- The system should use a camera that provides a clear view of the driver's entire face and eyes.
- The system must continuously analyze real-time video feed from the Raspberry Pi camera module for signs of driver drowsiness.
- The system must be resilient to vibrations and impacts commonly encountered in a vehicle.
- The system must be reliable in various lighting scenarios, on different types of roads, and with drivers of varying physical attributes.
- The system must operate within the specified temperature and humidity range for various vehicles without performance degradation.
- The system is required to comply with all applicable safety and traffic laws regulations in the regions where it is deployed.
- The system must not interfere with the proper operation of the vehicle or other safety systems.
- The system must permanently delete video streams within 3 days but keep the photo frames in the database.

3.4 Pseudo requirements

- The development language should be Python.
- The system should be compatible with a variety of platforms, including Windows and Linux, to ensure widespread usability.
- The system should employ a reliable and efficient method for yawn and drowsiness detection, leveraging technologies such as computer vision or machine learning, with a focus on features like **Mouth Aspect Ratio** (MAR) and **Eye Aspect Ratio** (EAR).
- The system should incorporate facial landmark detection using the OpenCV or Dlib library to identify key points on the face.
- The system should support integration with both TensorFlow and PyTorch frameworks for deep learning-based features.

- The system should incorporate pre-trained convolutional neural network models, such as those from OpenCV, MTCNN, or other suitable sources, for effective face detection within the input data.
- The system should integrate with alerting libraries, such as "playsound" in Python, to provide auditory alerts in response to detected signs of drowsiness or yawning.
- The system should provide performance evaluation metrics, including precision, recall, and F1-score, using Scikit-learn metrics, to assess the effectiveness of the yawn and drowsiness detection models.
- Data preprocessing techniques, including resizing, normalization, and augmentation, should be applied to improve model performance.

3.5 System models

3.5.1 Scenarios

Scenario 1: It is a situation where the system cannot detect drowsiness when the driver becomes drowsy.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- When the driver becomes drowsy, the system will not be able to warn the driver with an alarm because it cannot detect this situation.

Scenario 2: It is a situation where the system successfully detects drowsiness when the driver becomes drowsy.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- When the driver becomes drowsy, the system will be aware that this is a drowsy state, so it activates the audio warning system and aims to wake the driver with an alarm. It also gives a visual alarm with a flashing red light.

Scenario 3: While the driver is awake, the system misperceives and realizes that the driver is drowsy.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- Although the driver is awake, due to misleading situations such as environmental factors (such as head movement due to the roughness of the road), the system thinks that the driver is in a state of drowsiness and gives an audible and visual alarm.

Scenario 4: While the driver is awake, the system successfully detects that the driver is awake.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- The system recognizes that the driver is awake and therefore does not give any alarm.

Scenario 5: This is the situation where the camera cannot see the driver's face.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**" and gives an audible alarm.

Scenario 6: It is a situation where the system experiences a delay when tracking the driver's facial expressions and eye movements.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.

- Since the system responds late and cannot warn the driver in a drowsy state, it may cause possible accidents.

Scenario 7: It is the situation when the driver yawns, the system successfully activates the yellow light LED and the **"Take a Break!"** warning message.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- When the driver yawns, the yellow light LED and the **"Take a Break!"** warning message is displayed.

Scenario 8: It is a situation that if the driver yawns, the system activates the red light as if the driver is drowsy.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- The system detects the driver's yawning as if the driver is drowsy and turns on the red-light LED and gives an audible alarm.

Scenario 9: It is the situation where the system successfully activates the red-light LED while the driver is in drowsiness.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- When the driver is drowsy, the red LED works along with the audible alarm.

Scenario 10: It is a situation where the system incorrectly detects and turns on the yellow LED while the driver is in drowsiness.

- If the vehicle starts, the system will display the message "**Welcome to SafeAwake**". It becomes ready to work with the message.
- The driver must position the system in the correct position to see his/her face in the camera. If the device cannot see the driver's face clearly, it warns: "**Make sure that your face is clearly visible!**"
- The system starts tracking the driver's facial movements and eye movements.
- When the driver is drowsy, the system turns on the yellow LED that should be on when the driver is yawning.

Scenario 11: It is a situation where the device is disconnected from the vehicle.

- The system cannot work because the system is disconnected from the vehicle and cannot reach the power source.

3.5.2 Use case model

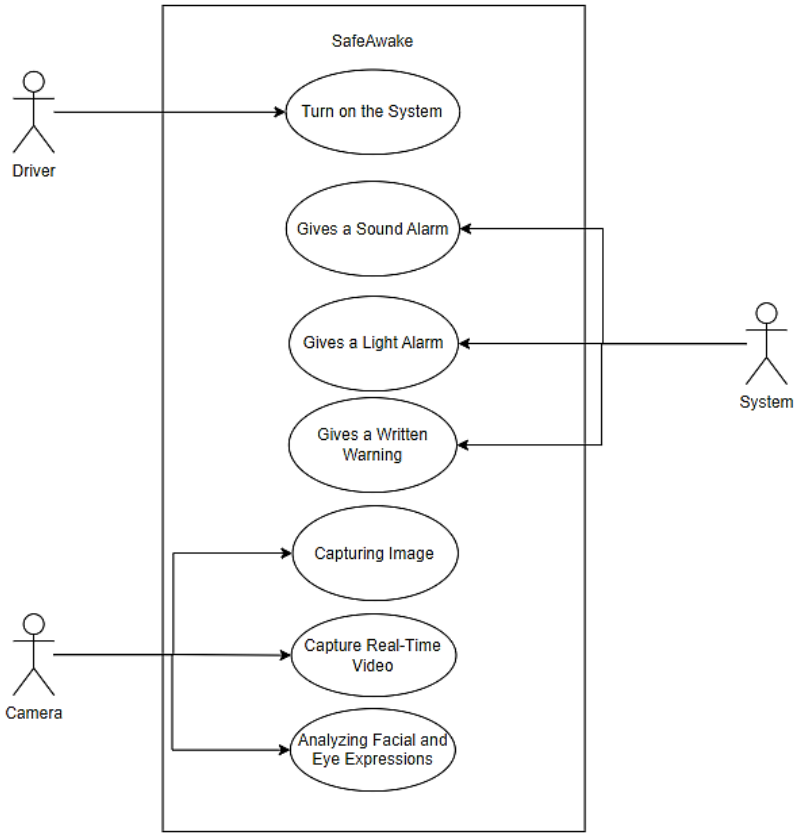


Figure 1: SafeAwake Use case Model

3.5.3 Object and class model

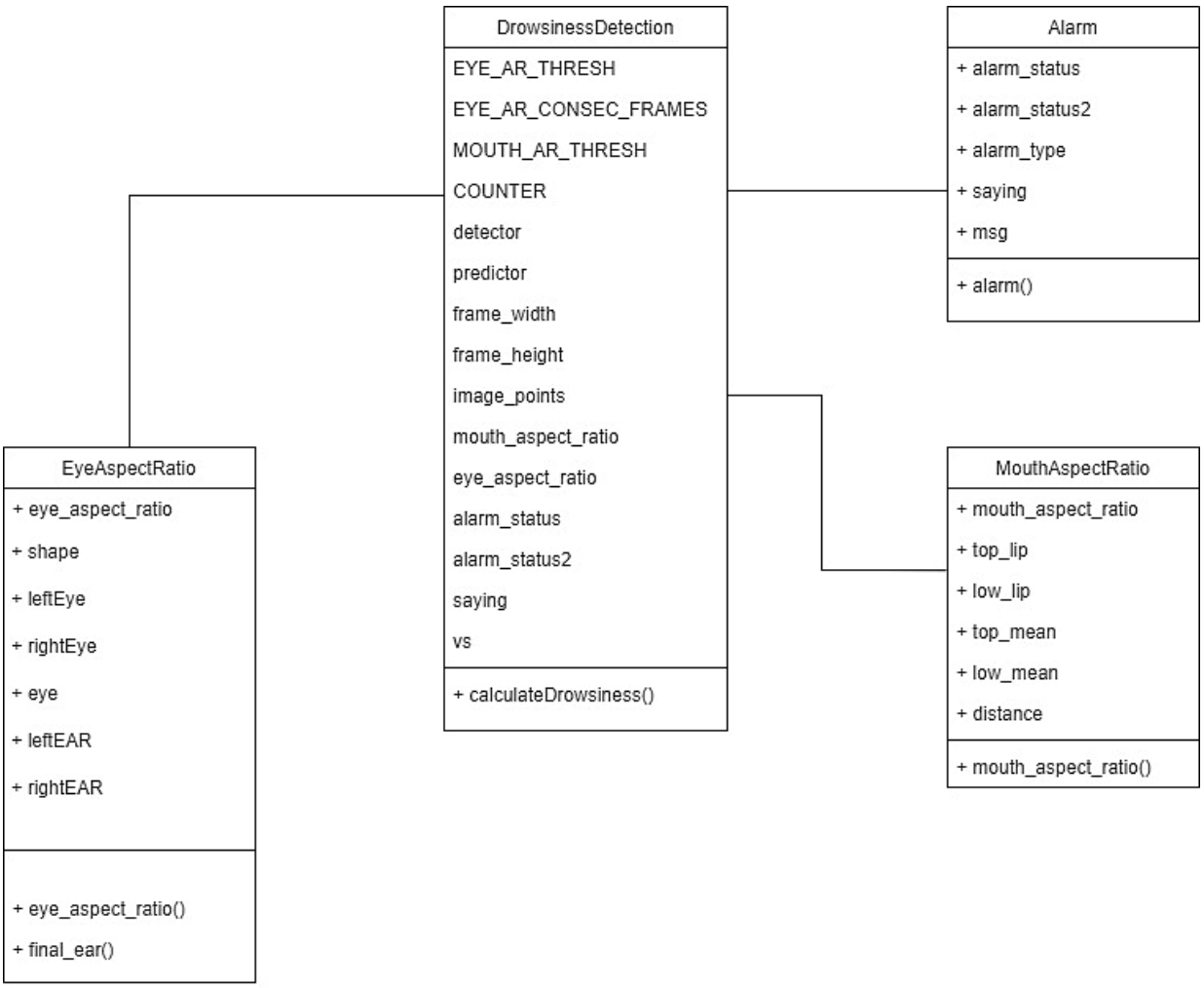


Figure 2: SafeAwake Object and Class Model

3.5.4 Dynamic models

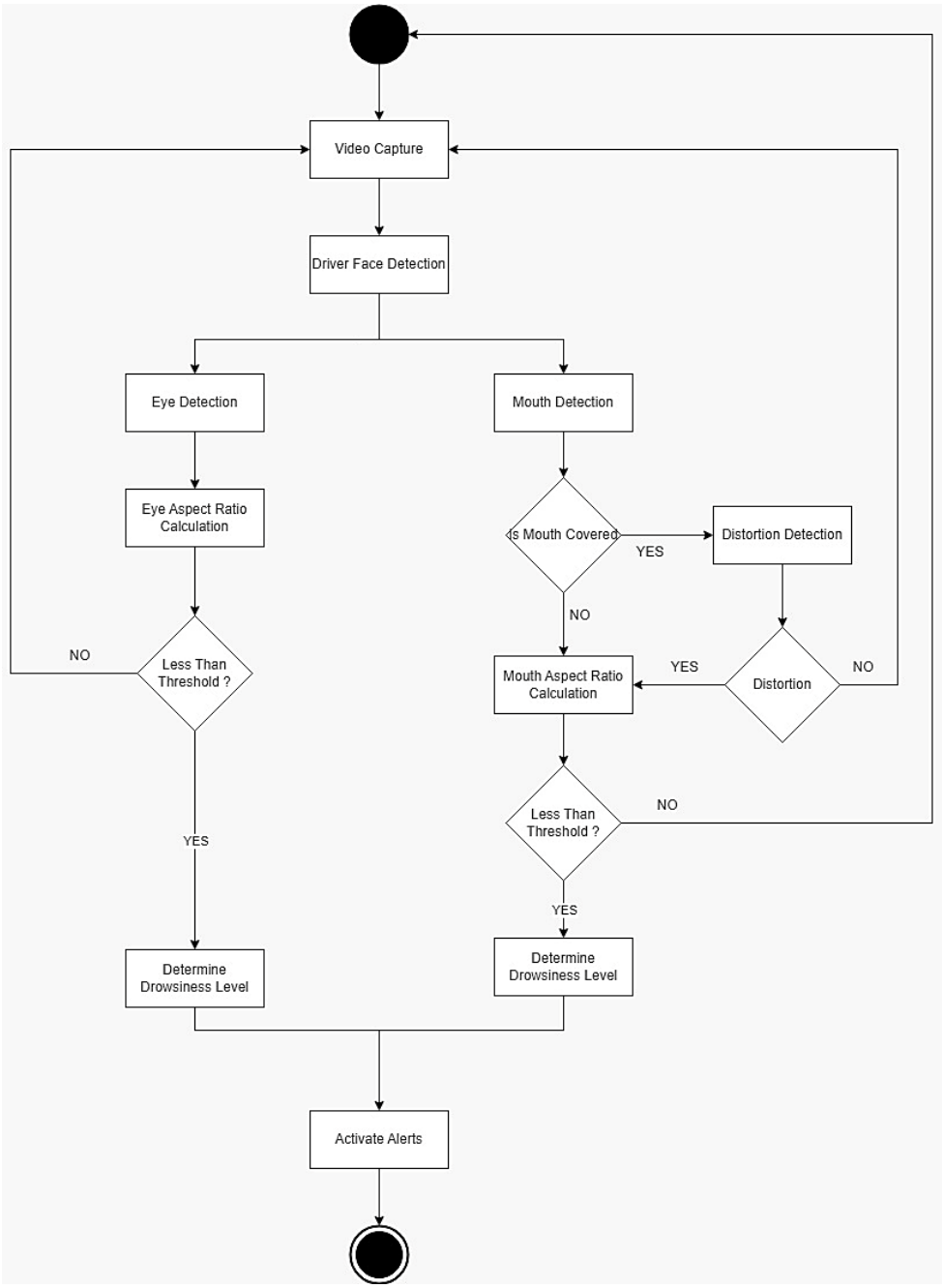
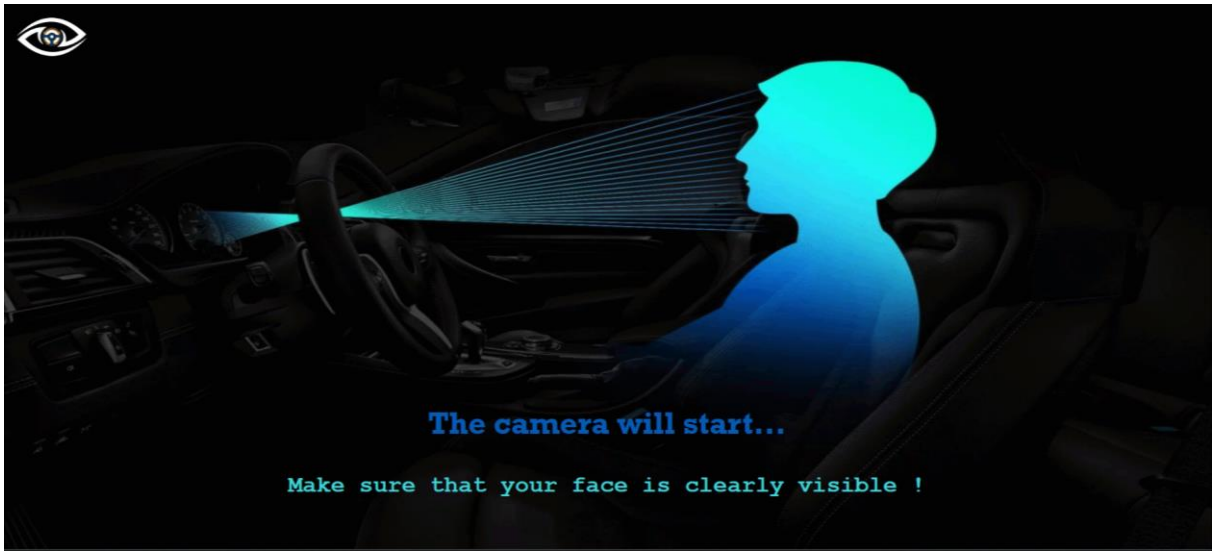


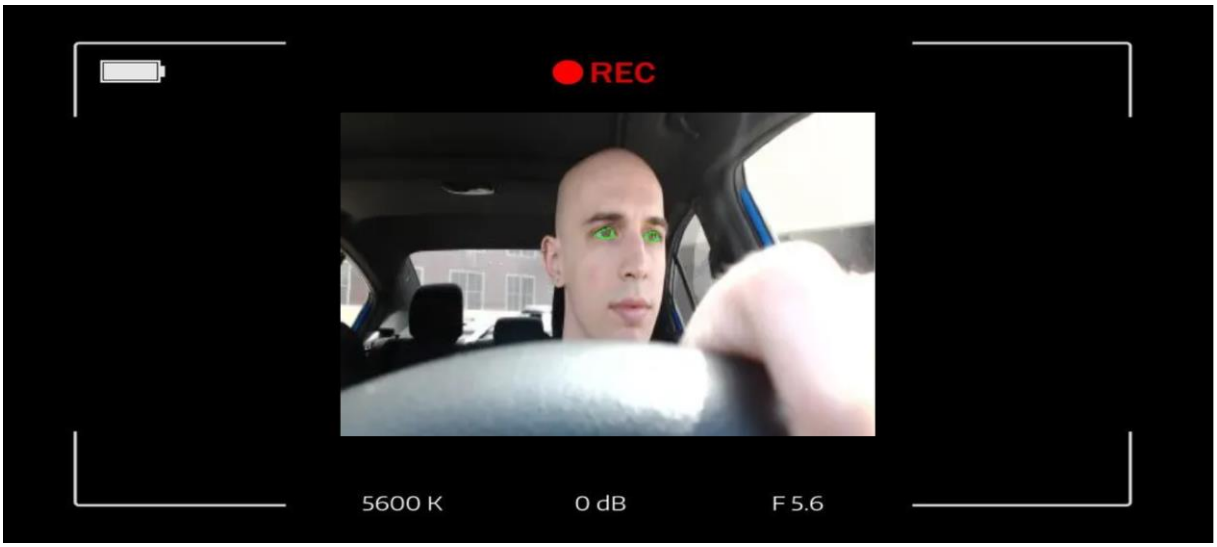
Figure 3: SafeAwake Activity Diagram

3.5.5 User interface - navigational paths and screen mock-ups

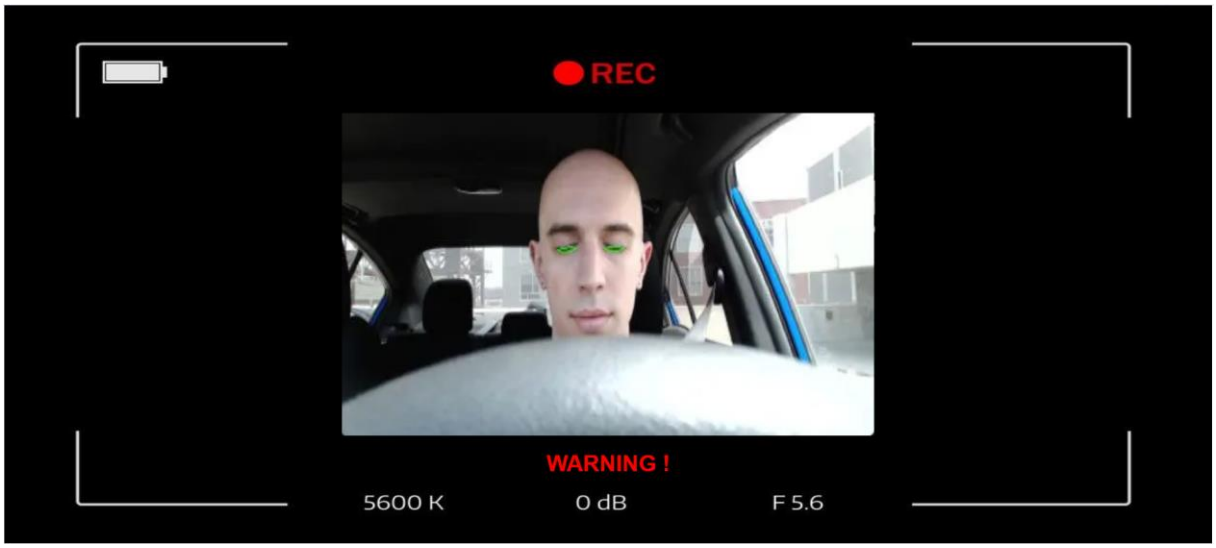
Picture 2: Main Screen



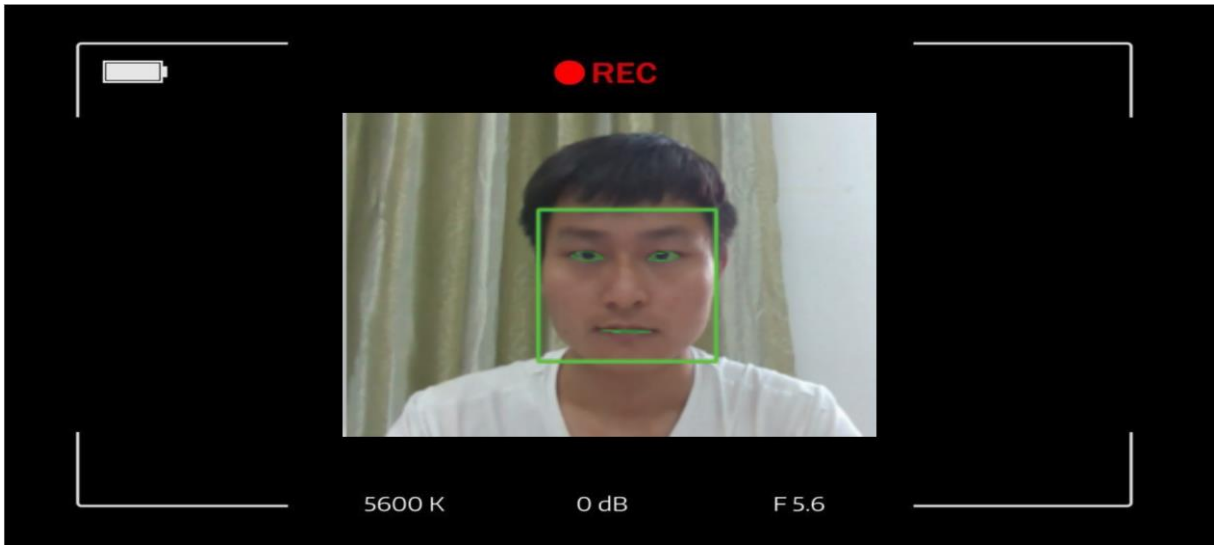
Picture 3: Camera Start Screen



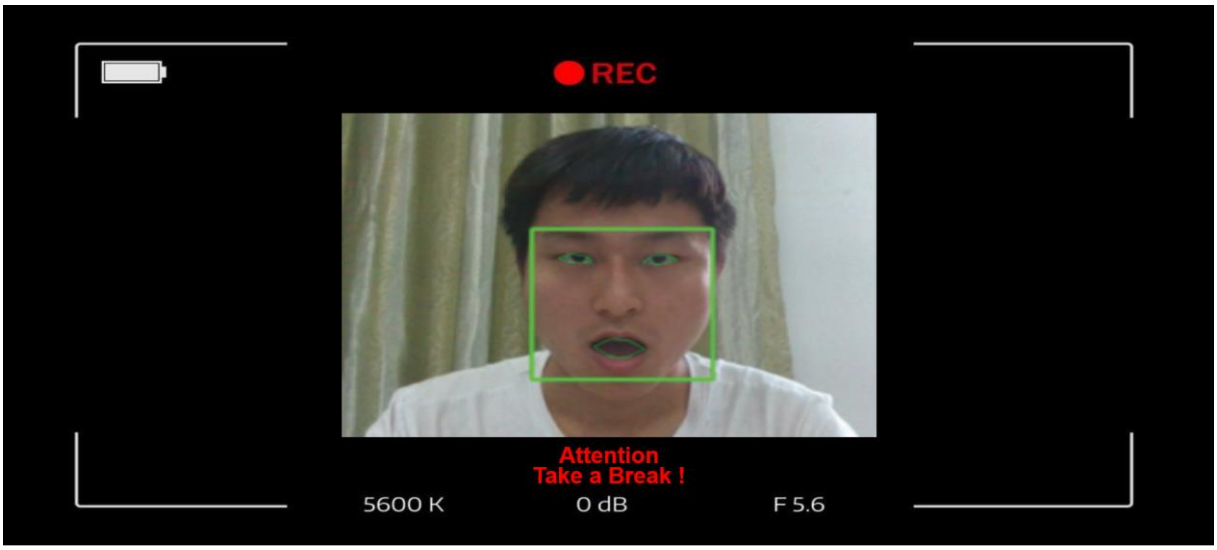
Picture 4: Awake Driver



Picture 5: Drowsy Driver



Picture 6: Awake Driver



Picture 7: Yawn Driver

The interface of our planned system is shown in the images above. When the system starts working, the user will see the screen in **picture 2**. Afterward, the interface in **picture 3** will be seen on the device. This screen warns that the camera position must be adjusted correctly. If the driver's eyes are closed, the system gives a "**Warning**" message as in **picture 5**. When the driver goes into a yawning, as in the image in **picture 7**, the system displays the message "**Take a break!**".

4. Glossary

- **EAR:** Eye Aspect Ratio.
- **MAR:** Mouth Aspect Ratio.
- **MTCNN:** Multi-Task Cascaded Convolutional Neural Networks.

5. References

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