TED UNIVERSITY

CMPE 492

Final Report

Project Name: Drive Safe-Off

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1. Introduction

Driver drowsy is one of the most important causes of traffic accidents. Every year, the amounts of deaths and fatal injuries worldwide are increasing. According to the National Sleep Foundation, nearly half of U.S. drivers report constantly getting behind the wheel on their way to work in the morning, despite feeling sleepy. About 20% of these drivers state that they fall asleep at the wheel during any of their driving. Another data indicates that more than 40% of them fall asleep at least once during their lifetime.

These numbers show how drowsy driving is common among drivers. What drivers don't realize when they drive drowsy is how much drowsy driving puts themselves and others at risk. In fact, an estimated 5,000 people died in accidents caused by drowsy driving in 2015, according to the Governors Highway Safety Association report.

Drowsy driving has not only health but also global, economic, environmental, and social impacts. The economic burden of drowsy driving includes the direct costs of accidents and the indirect costs of loss of life, disability, lost productivity, and occupational and civil accidents. It has been determined that the costs of sleepiness-related accidents can be between $139 billion and $152 billion in the United States, and between 43 billion V and 337 billion dollars for Europe. Based on 1.3 million sleepy drivers, 400,000 under the age of 25 and 400,000 over the age of 65, who die because of drivers who fall asleep while driving around the world each year, the indirect cost to society of drowsy driving has been estimated at $2,372 billion. Based on the 20 million to 50 million sleepy drivers who are injured or disabled, the cost of disability for insurance can be assumed to be between $2580 billion and $6450 billion each year. Even looking at these numbers, the economic damage of driving in a drowsy way was huge. Considering the material and moral destructive consequences of traffic accidents, there is a significant social impact due to deaths, injuries, loss of work force, family structures disintegrating due to loss of economic power, psychological deterioration and suicides.

Drowsy driving has many predictable and unpredictable consequences and affects all areas. A solution needs to be created in order to reduce the number of accidents caused by driver fatigue and thus increase transportation safety. That's why a system that detects drowsiness was created. There are many methods that can be used to detect drowsiness. Some of these methods are as follows: Physiological Methods, Vehicle-Based Methods, and Behavioral Methods.

Physiological Methods is based on the fact that a potential driver drowsiness detection system could allow slightly more time to alert a drowsy driver in a timely manner, so that during the early stages of drowsiness physiological signals begin to change. It can detect the human body by sending various electrophysiological signals such as electrocardiogram (EKG), electroencephalogram (EEG) and electrooculogram (EOG). But it can be uncomfortable for the driver to have something attached to his body during the ride. Therefore, the other two methods were examined. Vehicle-Based Methods, on the other hand, are related to the behavior of the vehicle, and can infer drowsiness by observing behaviors such as acceleration and lane tracking. but to detect this, a system that follows the whole path and detects all the vehicles is needed. Therefore, Behavioral Methods have been applied to detect drowsiness. By examining the driver's eye closure time and yawns, it is possible to comment on the drowsiness of the flock. In order for accidents and accidents to be preventable, the driver must react immediately. In a system that monitors the driver's behavior in real time, it is important to give instant warning when drowsiness is detected. This report will talk about how this system was developed, what was used and what results were obtained.

2. RELATED WORK

There are several different ways to detect and measure driver drowsiness. According to the Driver Drowsiness Detection Systems and Solutions[1] book, the methods are as follows:

They normally fall into four categories: subjective, physiological, vehicle-based and behavioral, this section provides a brief review of driver drowsiness detection methods in each of these categories.

- **Subjective Method**

  The Subjective method is to give an idea of how to more successfully predict which factors can lead to accidents and to provide tools for other groups of methods to focus on identifying and preventing some key factors associated with driver drowsiness. Some of the best-known subjective sleepiness tests include:

  - **Epworth Sleepiness Scale (ESS)[2]**: measures sleepiness according to individuals' propensity to fall asleep in static, non-stressful situations.
  - **Test of Maintaining Awake (MWT)[3]** [45]: A test in which individuals are instructed to try to stay awake.
  - **Stanford Sleepiness Scale (SSS)[4]**: a scale by which people evaluate their current level of wakefulness.

  Looking at the above subjective methods, there is no mechanism that can control the instantaneous behavior of the driver.

- **Physiological Method**

  Physiological measurements relate with driver drowsy. Following physiological signals to detect drowsiness:

  - electrocardiogram (ECG),
  - electroencephalogram (EEG),and
  - Electrooculogram (EOG).

  To detect drowsiness using EEG, EOG and ECG[5] alone, and combining their modalities to improve the performance of the drowsiness detection system. The challenging part is that providing and applying technologies of sensor devices are challenging. The devices to be connected to make the necessary measurements while

[1] (Aleksandar Colic, Oge Marques, Borko Furht, 2014)
[2] (Johns., 1991)
[3] (M. M. Mitler, K. S. Gujavarty, and C. P. Browman., 1982)
[4] (E. Hoddes, V. Zarcone, H. Smythe, R. Phillips, andW. C. Dement, 1973)
[5] (R. Khushaba, 2011)

driving may disturb the driver and this may actually cause an increase in accident values that are tried to be prevented or reduced throughout the project for a different reason.

- **Vehicle Method**

It is often based on subjective evidence such as police accident reports and the driver's own reports after the incident. Vehicle-related evidence gathered from reports of drowsiness crashes shows that the behavior of vehicles during these events often exhibits characteristics such as:

- Higher speed with little or no breaking[6]
    - delayed reaction because of drowsiness
- A sleep-deprived driver losing concentration and drifting off the road[7]
- The crash occurs on a high-speed road[8]

Compared with other types of crashes, drowsy driving accidents occur more frequently on highways and main roads with speed limits of 55 miles per hour and higher.

- **Behavioral Methods**

These methods rely on detecting certain behaviors exhibited by a driver while in a drowsy state. A typical focal point is facial expressions that can express features such as rapid, sustained blinking, nodding or nodding, or yawning frequently. These are all explanatory signs that a person may feel sleepy and/or sleepy. The following behaviors signals to detect drowsiness:

- **Head or eye position:**
    - When a driver is drowsy, some of the muscles in the body start to relax, causing her head to shake.[9]
- **Yawning:**
    - Frequent yawning may mean that the body is tired, but may not always occur before you fall asleep.[10]
- **Eye state:**
    - the amount of blink frequency
    - “eye conditions: wide open, partially open, or closed”, The last two can be used as an indicator that a driver is experiencing drowsiness. [11]

The methods mentioned so far outside of Behavioral can be considered either unreliable or too intrusive for real-world applications, so it was decided to use a different kind of methodology, the Behavioral Method, based on non-invasive

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[6] (J. A. Horne and L. A. Reyner, 1995)
[7] (R. Knipling, J. Wang, and M. J. Goodman)
[8] (R. Knipling, J. Wang, and M. J. Goodman)
[9] (E. Murphy-Chutorian and M. Trivedi, 2010)
[10] (M. Saradadevi and P. Bajaj. , 2008)
[11] (H. Wang, L. Zhou, and Y. Ying. , 2010)

observation of a driver to detect drowsiness. The system to be created interprets the driver's drowsiness based on the frequency of eye and mouth movements.

It was mentioned that drowsiness would be detected by monitoring the driver's eye and mouth behaviors. How to do this is based on the Real-Time Eye Blink Detection using Facial Landmarks[12] report. The most basic behavior in someone with drowsiness is the degree of clarity of the eye. Someone who goes to sleep exhibits a blindfolded behavior. In order to detect this, the Eye Aspect Ratio value was calculated. Robust real-time face landmark detectors are available today that capture most of the characteristic points in a human face image, including the eye corners and eyelids. It is possible to detect whether the eye is open or closed by using the points around the eye.

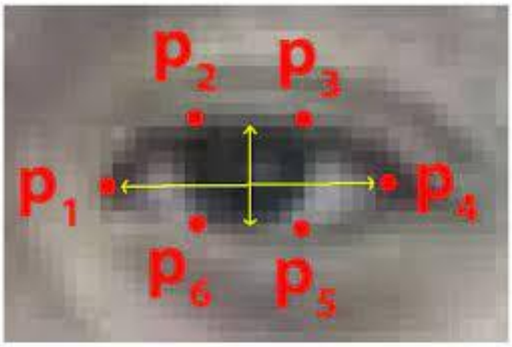

Figure 1: The positions of the landmarks to be used while calculating the EAR value.

After the eye points are determined as in Figure 1, the eye aspect ratio (EAR) between the height and width of the eye is calculated.

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

where p1 to p6 are landmark's location in Figure 1.

The EAR is mostly stable with one eye open and approaches zero when closing one eye.

The same logic was applied to the mouth. Yawning is evidence for the mouth, just as the closure of the eye is evidence for drowsiness. This threshold is easy to detect, as people will open their mouths more when yawning than when speaking. The EAR value was calculated to detect whether the eye was open or closed. For the mouth, the Mouth Aspect Ratio, that is, the MAR value will be calculated.

Based on the formula in the Driver Drowsiness Alert System with Effective Feature Extraction[13] study, the MAR value was found using landmarks around the mouth.

[12] (Lukaˇ Cehovin, Rok Mandeljc, Vitomirˇ Struc, 2016)
[13] (Ashlesha Singh, Chandrakant Chandewar, and Pranav Pattarkine, 2018)

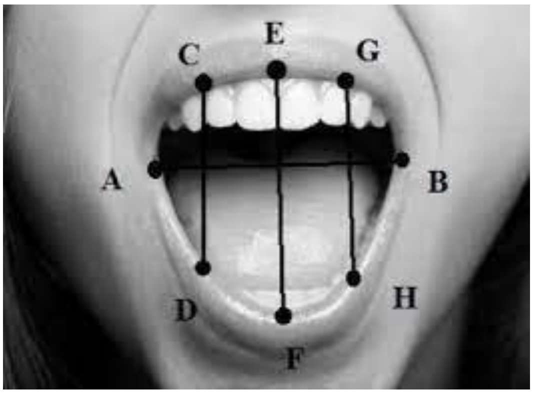

Figure 2: The positions of the landmarks to be used while calculating the MAR value.

For determining the yawning parameter the aspect ratio of the mouth is calculated based on Figure 2. It is calculated by the following formula,

$$MAR = \frac{|CD| + |EF| + |GF|}{3|AB|}$$

The behavior of the MAR value is as follows: when it approaches 0 in the mouth, like the eye, it is closed, in Figure 2, the value increases as the distance between mutual landmarks increases.

In short, the Behaviors Method to detect drowsiness and the eye and mouth between these behaviors will be examined. The open or closed state of the eye and mouth will be used in the formula in the two research reports mentioned above.

3. DESIGN OF SYSTEM

Our system generally tries to obtain results by processing the incoming image in real-time. After the face, eye and mouth are detected in the image that comes up after the system is started, face and eye are tracked for each frame, and mouth is detected for each frame for the mouth. The EAR for the tracked eye and the MAR for the detected mouth is calculated. It is predicted for eye and mouth conditions according to EAR and MAR values. According to their repetition, the driver is given an audible warning. In short, if what the system does is described stepwise:

1. *Track face and eye, and detect mouth*
2. *Find the EAR and MAR values*
3. *Predictions for eye and mouth status*
4. *Calculate the frequency*

How the above steps are implemented will be explained in detail in the following items.

1) Tracking Face, Mouth and Eye

Face detection is a computer technology being used in a variety of applications that identifies human faces in digital images. It can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of a specific object in an image. Face-detection algorithms focus on the detection of frontal human faces. In this task, OpenCV (Open-Source Computer Vision Library) which is an open-source computer vision and machine learning software library are used. OpenCV contains many pre-trained classifiers for face, eyes, mouth, etc. In this system, face and eye classifiers are used in order to detect human faces and eyes. We perform face detection for each frame of the videos in our data set. The first process of our system is to detect the face and the eyes of the driver by Haar feature-based Cascade Classifiers. Haar feature-based cascade classifiers are an effective object detection method proposed by Paul Viola and Michael Jones. It is a machine learning-based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

Furthermore, tracking algorithms are usually faster than detection algorithms. The reason for this is that while tracking an object detected in the previous frame, there is a lot of information about the appearance of the object. Also, thanks to the previous frame, the position, direction and speed of its movement are known. Thus, in the next frame, it can use all this information to predict the object's position in the next frame. To find the object accurately, a small search around the expected location of the object can easily find the object's new location. The initial bounding box supplied by the user is taken as a positive example for the object, and many image patches outside the bounding box are treated as the background. With a new frame applied, the classifier is run at the pixel facing a small neighborhood around the current location to generate a potential positive sample.

Secondly, after tracking the eye and face, we detected the mouth in order to observe the anomalies occurring in the driver's mouth. The SciPy package was used to calculate the aspect ratio of the mouth. In this way, it was possible to calculate the Euclidean distance between the required points in the mouth. Using this distance, the above-mentioned MAR formula is calculated. The output from the mar formula is used to detect anomalies in the mouth of the driver.

2) Find the EAR and MAR values

In the previous step, the position of the eye and mouth was found. As mentioned in the Related Work title, values were calculated in order to comment on the openness and closure of the eyes and mouth. This value is EAR for the eye and MAR for the mouth. Let's examine it in order:

- **EAR**

  After detecting and following the position of the eye, the system knows that position for each frame. But in order to find the status of being open or closed, the positions of the landmarks around the eyes must be found. Shape predictors were used to predict these landmarks. The shape predictor attempts to localize key points of interest along with the shape. The dataset, we used which name is Shape predictor 68 face landmarks file via dlib to predict these points on the face. The pre-trained face landmark detector in the dlib library is used to predict the position of the 68 (x,y) coordinate on the face that matches the face structures.

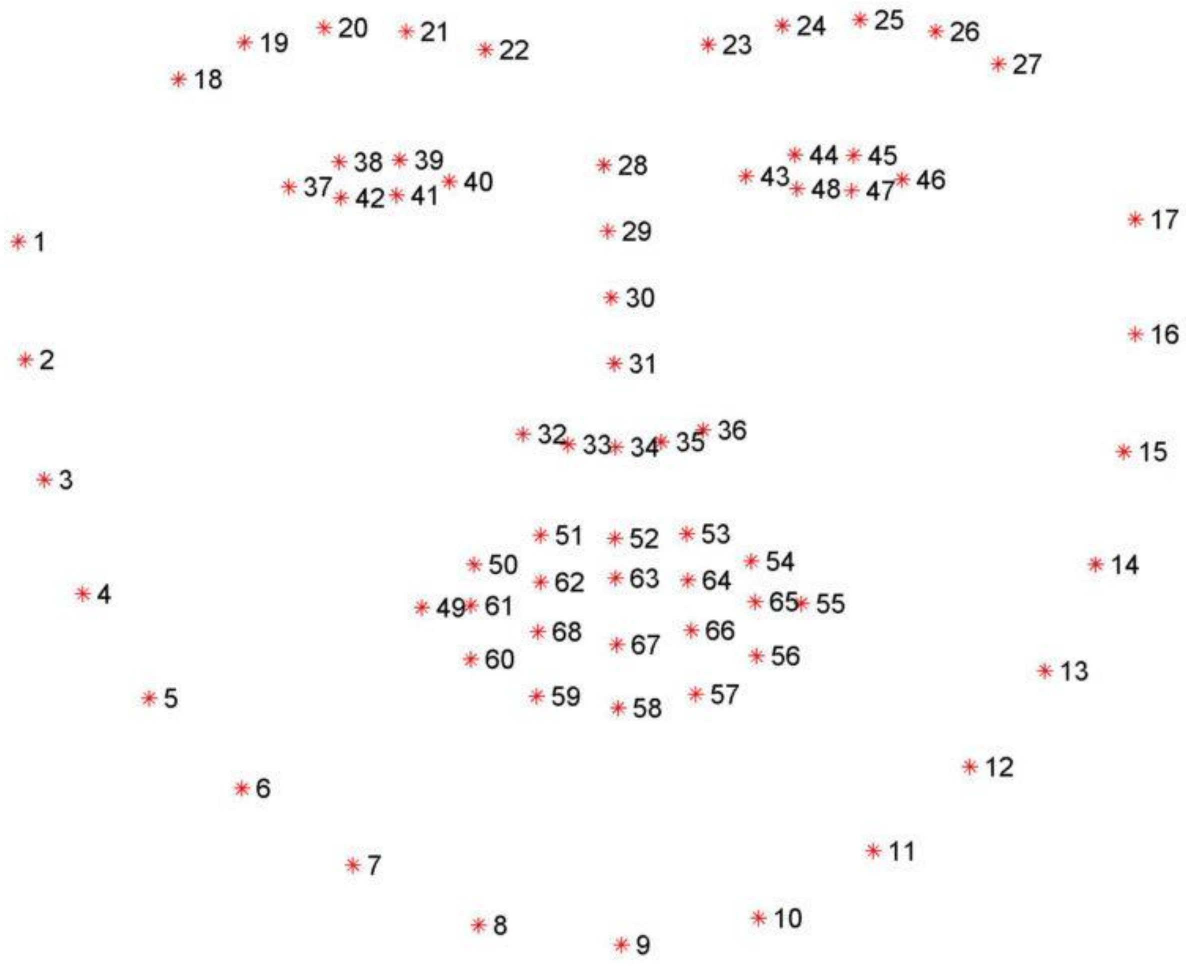

Figure 3: The visualization of 68 points in the shape predictor used.

The Figure 3 shows how these 68 points are visualized. By taking the positions of the points around the eyes and mouth in x,y coordination, the distance between these points can be calculated. It doesn't matter which dataset is used. The dlib framework is used to train a shape estimator on input training data. Using the dlib library, the system now knows where landmarks are for the eye. From now on, using these coordinates to create an EAR function and this value should be calculated for each frame. After obtaining the coordinates of the points in Figure 1, the aperture value of the eye is calculated with the EAR formula. This formula is valid for one eye. The system tracks both eyes per frame. Therefore, the EAR values obtained for both the right and left eyes are averaged. We know that the different behavior of the two eyes at the same time is not taken into account, that if the driver tries to drive with one eye open and one eye closed, the system will most likely give a warning because the average value will decrease (ear close to 0 when the eye is closed). A value system for the aperture of the eye is now obtained. The evaluation of this value, status or label will be examined in the next section.

- **MAR**

  The system will find landmarks for each frame with the help of mouth's dlib. The logic in the eye is the same in the mouth. In the researches, in order to find the opening value of the mouth, the distances between the points around the mouth should be found. In order to find the distances, the location of these landmarks in the coordinate plane must be known. For each frame, the location of the landmarks around the mouth is found with the help of the dataset file together with the dlib. The Euclidean distance is calculated for each corresponding point shown in the Figure 2, and the results obtained are written in the MAR formula and the aspect ratio value for the mouth is obtained. The evaluation of this value, status or label will be examined in the next section.

3) Predictions for eye and mouth status

So far, the system has: For each frame, it knows the position of the eye, mouth and face, to find the EAR and MAR values, the positions of the landmarks on the coordinates and the distance between these positions and a MAR and EAR aspect ratio values obtained by using the division and multiplication operations. So what do these values tell us?

EAR and MAR are ratio values between 0 and 1. This value does not give any information to the system about eyes closed or open or mouth closed or open. The aim of the system at this stage is to know the condition of the eyes and mouth. For this, thresholds must be determined. If the eye is below a certain ratio value, it can be said to be closed, and if it is at a certain ratio value, it can be said to be open. While determining these thresholds, the methods used are different for the eyes and mouth. Now let's examine it in order.

- **EYE**

  The EAR value of the eye is known in the incoming frame in real time. The model is used to indicate whether the incoming EAR value is closed or open. The SVM model was trained with the ear's value and the distance values obtained from the landmarks around the eye. The SVM model was trained with the ear's value and the distance values obtained from the landmarks around the eye. For this, labeled data was used. The labeled data used is as follows: data is video and consists of a tag file of the video that gives information about the eye of the person in the image for each frame. In this tag file, there is the frame number, the positions of the eye area, and most importantly, the label value that indicates whether the eye is open or closed. If the eye is open, label -1 is a different value than label -1 if the eye is closed. The reason for this is a data prepared to calculate the number of blinks of the person in the image in the data used. This value increases each time the person in the image blinks. In short, any number except label -1 if the eye is open, and label -1 if the eye is closed. In order to make it easier to predict the model according to the values, the data has been edited. If the eye is open, all labels with a value of -1 were set as label 0, and if the eye is closed, all labels indicating closed eye were set as 1. In this way, the model will have two classes, 0 and 1. Now we have data to train and tag files containing labels. Using these, the model was trained with SVM. The accuracy of the model will be discussed in the next sections. With the model obtained, predictions can be made using the EAR and distance values given to the model, and a clear situation can be said about whether the eye is open or closed.

- **MOUTH**

For the mouth, the situation is different. As in the eye, the dataset that we access was unlabeled. Therefore, MAR values were calculated for videos with images of yawning. When the yawning behavior is examined, the person opens his mouth up to a certain level of opening (the distance between to points in the Figure 2 increases), and the yawning behavior decreases close to the end. Since the values when the driver or the person in the video started to yawn and the mouth opening while yawning should have been repeated for a certain time and that value should have increased, both the initial and repetition frequencies of these values were examined. When the obtained values were examined, a threshold was determined by taking the average of the values. In short, the mouth opening of the driver will be determined according to the repetition of mouth opening after a certain threshold has passed.

4) Calculate the frequency

After the first three stages are completed, the system has the following: Now the system has information about the position of the eye and mouth, the EAR and MAR values, and the state of the eye and mouth. The next action will determine how many times it is repeated. The first goal was to detect the repetition of behaviors by anomaly detection, but no successful result was obtained. So a constant was set. In each frame, there is now information about whether your eyes are closed or open, your mouth is closed or open. If this information is repeated, the system increments the temporary variable by one, and if this temporary variable exceeds the constant, the system gives a warning. When the eye is closed for the first time after being open for a long time, the temporary value is equal to zero, for the mouth, if the MAR value is greater than the threshold, the temporary value increases by 1, and if it exceeds the constant after a certain frame, the yawning behavior is detected. It is reset when the MAR value falls below the threshold.

4. FINAL STATUS OF THE PROJECT

As in every project, priorities had to be made between the main element that made up the project. Since the main purpose of the project was to detect drowsiness according to mouth and eye behaviors, the operation of this part was emphasized. Therefore, most of the necessary actions could not be performed regarding the web interface, which we mentioned in previous reports as User Layer, where the supervisor enters the system and shares information that the user is drowsy. In the current system created, the driver's face, eyes and mouth can be detected, information about the eye and mouth conditions can be obtained, and an audible warning is given to the driver with the frequency of the behavior.

A classifier model was created that detects whether the eye is closed or open. In order to determine the accuracy and performance of this model, a test was performed with a certain part of the label data we have. The resulting confusion matrices are as follows:

Confusion Matrix	Positive (Actual)	Negative (Actual)
Positive (Actual)	85	31
Negative (Actual)	0	167

Table 1: Confusion Matrix obtained after testing the model.

A very small portion of the video was reserved for testing, because blindness is very rare in datasets. For the model to work better, more data was needed. As can be seen in the Confusion Matrix, 0, that is, the state of being open, has never been wrongly guessed. The reason for this is the intensity of the open state of the eye in the data. The model assigned a value of 0 for each case it thought would not be 1 while predicting. The general observation is that the points that the model predicts incorrectly are values that are very close to the threshold value or the borderline. Therefore, even if the driver does not close his eyes completely while driving, the system will detect it as blindfolded when he looks at the ground and will warn when repeated for a long time. It is important that the system gives a warning as it is an unexpected behavior by the driver that he does not look towards the road even if he does not close his eyes.

One value issue is tracking and detection. Why tracking is important is stated in Design of Systems. But there are situations that threaten the tracking or detection not working properly. The brightness of the environment is very important. If the environment is not bright enough, it is difficult to detect the eyes and mouth and calculate the landmarks around it. Therefore, the system will not perform well in a bright environment.

It will be difficult to show on the document that the system is giving a warning because the system gives a warning. In order to show that it is giving a warning, it is written on the frame why it gives a warning when it gives a sound warning.

Figure 4: When the system shows that the eyes are closed for a long time.

As seen in the Figure 4, the system gave a warning because the driver was blindfolded for a long time while driving. When your eyes are closed, the closeness of the EAR value to 0 can also be understood from the value in the frame.

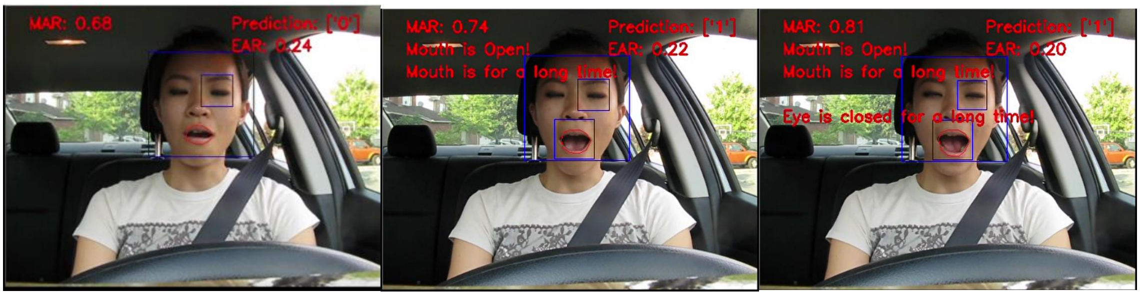

Figure 5: When the system shows that the mouth is closed for a long time.

In the Figure 5, this time the results of the system for stretching are examined. After the user's mouth gap exceeds a certain threshold, the system gave a "mouth opened" warning. When the mouth gap repeats a certain frame above the threshold, it also prints that the mouth is open for a long time. In this example, the user closed his eyes while yawning, so the system gave warnings for both when his eyes were closed for a long time and when he was yawning while his mouth was open for a long time. In this way, it can be said that the integration test to be made in the test plan has passed successfully.

5. ENGINEERING SOLUTIONS, CONTEMPORARY ISSUES and SOCIAL IMPACTS

The main purpose of the drive safe-off project is to reduce the worst possible and fatal accidents due to drowsiness, and it does this instantly. Therefore, when it detects momentary drowsiness in the driver, they should give an audible warning to the driver with long-term eyes closed. The engineering solution to be applied to reduce the accidents that may occur is the presence of a system that analyzes the image of the driver inside the car. The source of this system is the image of the driver that comes in real time. In order for these systems to run the project in real time, people must have this system in their vehicles. The project created has no meaning unless they buy this product and install it in their vehicle. When people install this system in their vehicles, it becomes a step towards the realization of the main purpose of the project. Traffic accidents caused by drowsiness. In this way, people will be protected socially and economically.

There is no such thing as threatening an occupational group in this system. Normally, there is no system in the vehicle that detects the drowsiness of people. However, with the developing technology, vehicles perform their own behaviors such as sudden braking or lane tracking in unexpected situations. This leads to the first stage before the project is developed, the vehicle-based method. Since our goal is behavioral detection, it doesn't matter if the tool can do these things. Considering the cost of vehicles with these features today, the Drive Safe-off system is cheaper and more convenient for everyone.

The Drive Safe-off project is a project that it will purchase and install on the vehicle with its own administration. The evaluation of the user's privacy is as follows: Since he bought the product himself, he is subject to permission and accepts all terms of use. The system detects the closed eyes and the opening of the mouth in the instant image, and the system does not record these data. Saving data is a burden for the system. But in the future, data recording can be a source for bad situations that may occur. The system will warn the driver when it detects drowsiness, it is up to the driver to detect and implement that warning. Despite everything, not responding to the warning given and continuing to exhibit drowsy behavior may cause an accident. The research to be conducted on the cause of the accident will also make an important contribution to the data in the system. But as mentioned before, saving data is a burden for the system.

Lastly, the project that integrates a novel approach to our daily lives and the professions. Firstly, daily habits in the driving sessions can be reshaped by this application. Drivers can be determined as to how much care, or the product enables monitors of the traffic to evaluate the safe commuting. Lastly, the professions depending on the driving can be also restructured according to this product. For example, the act of a truck driver changed after deploying this solution that monitors its attitude and evaluates its session. Consequently, social implications are inevitable. Also, various impacts will be investigated by the team after the release.

Overall, the solution involves low risk and high reward, but while maintaining low risk, we give up some potential in the system, namely revealing events that may occur by recording images. The system plays a critical role in important events by simply giving an alarm. The driver detects the alarm and can act accordingly. This will prevent any possible accident.

6. Tools & Technologies Used

In the project, Python and its libraries are used. Some important libraries that crucial for the project as follows:

OpenCV : It is an open-source library used in real-time computer vision applications.

CV2: It is the name that OpenCV developers chose when they created the binding generators,

NumPy: It is a Python library used for working with arrays.

Dlib: It is a modern C++ toolkit that contains machine learning algorithms. distance: It computes the euclidean distance between the two vertical eye landmarks (x and y coordinates)

Spyder: It is an open-source cross-platform integrated development environment for programming in the Python language.

ReactJS: It is an open-source JavaScript library for creating user interfaces.

DBeaver: It is a SQL client software application and also, a database administration tool.

7. Test Results

In the "Test Plan Report", a final system test was planned to test each subsystem separately and finally to see if all parts were working properly. The first test was to test whether the eye was open for a long time, but since there is no data on long-term closure in our data, we tested whether the eye was closed in this test. Since the tested video also has a label file, the accuracy of the result was calculated.

Confusion Matrix	Positive (Actual)	Negative (Actual)
Positive (Actual)	85	31
Negative (Actual)	0	167

Table 2: Confusion Matrix obtained after testing.

When the values in Table 2 are examined, the accuracy of the model is 0.89. It can be said that the model is successful in testing whether it is closed or not. When the image is watched, it also gives a warning when the eyes are closed for a long time. Therefore, it can be said that it passed the test.

The second part is about whether the mouth is open for a long time. It was very difficult to test it and calculate its accuracy since we did not have labeled again. Therefore, we evaluated the accuracy of the test with the comments of the users. In the video we have given to the system, if the mouth is open for a long time, the system should give a warning.

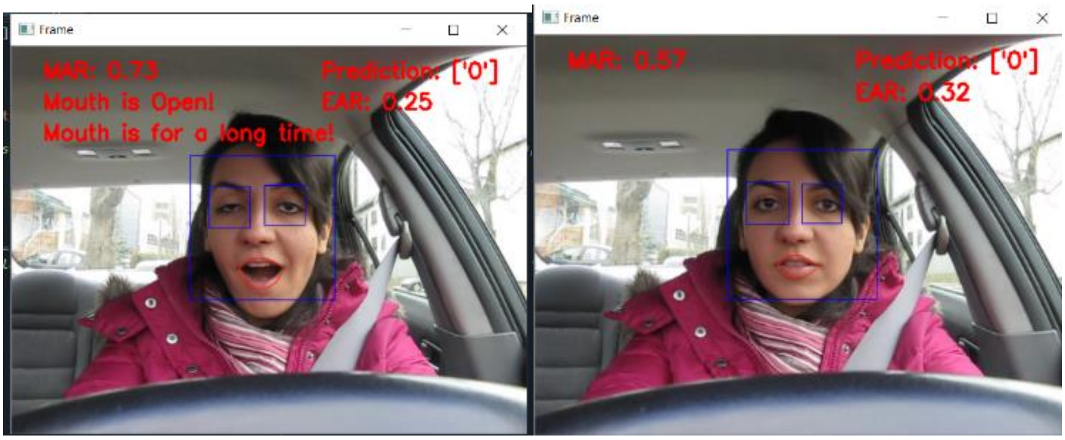

Figure 6: The testing result for mouth.

When the consecutive figures above are examined, the system does not give any warning when the driver exhibits a normal behavior, but when it starts to yawn, it starts to give a warning. Based on these images, it can be said that the tests passed. Because there is a driver showing yawning behavior in the video, the system has found that he exhibits yawning behavior.

Figure 7: The testing result of integration test.

For the third test, how these two systems work together will be tested. In the video, there is a person who has both eyes closed for a long time and exhibits yawning behavior. And the existence of these behaviors in the video is known. It has been checked by the user whether it detects these behaviors in the given input.

As it can be understood from the figures above, the warning given by the system about the long-term closed eye and the warning that it gives towards the end of the yawning moment are written on the screen and these images are taken from the tested video. The system gave a warning to the two expected behaviors in the video. That's why it passed the test.

In the system test, where all the parts come together, it can be said that the system passed the system test successfully, since it was observed that the eyes and mouth were followed in the video, their situations were predicted, and it was observed that they gave warnings under the necessary conditions.

8. User Manual

In order to download and run the project that we developed, it is sufficient for the user to have any programming language background and to have used any IDE. Since we used Python language while developing our project and based on our experiences throughout the project, Spyder IDE provided the best performance. Once the user extracts the required code from the compressed file, s/he will have everything s/he needs to run the code. The files in the compressed file are as follows: source code, dat file, datasets. When the user opens the main.py file in the source code files in the Spyder IDE, s/he will be able to see the packages that are not installed in her/him. S/he will be able to download these packages easily by writing the necessary codes to the Anaconda shell prompt. All library and package names that will be required in the project will be shared with the user in the file called requirements.txt. For the downloading these library in requirements, S/he need to run "pip install -r requirements.txt". Another important point when running the code is that the code will work with a computer camera, so the user must have a camera.

In addition, we will briefly touch on the classes in the project so that the user can better understand the function of each class in the project. The database.py file is the file that connects Spyder with the database.

The eye_tracker.py file is a file for tracking eyes. It is used to track eyes with the help of cv2 package and using haar cascade classifier files.

The EyeAspectRatioClass.py file is used to detect the aspect ratio of the eyes using the algorithm found in the .dat file.

The MouthAspectRatioClass.py file also uses the .dat file to detect the aspect ratio of the mouth. Aspect ratio is found by calculating the Euclidean distance of the points in the mouth.

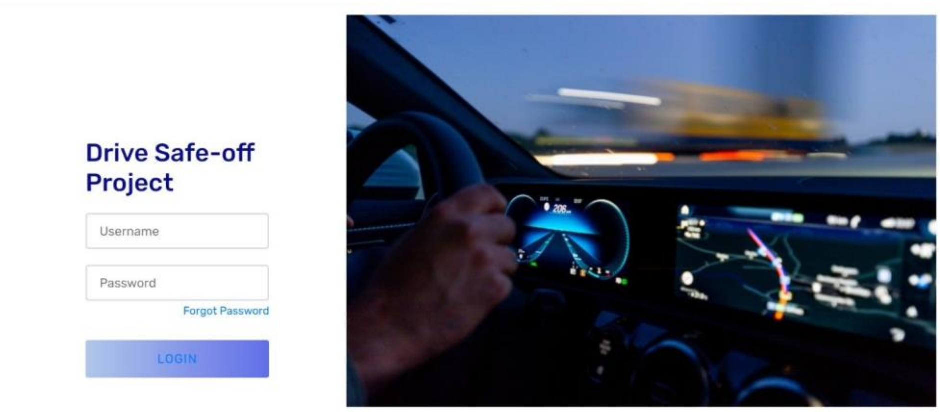

Figure 8: The home page of interface.

Secondly, in the Figure 8, there is the home page of the interface we developed for our project. Supervisors will be able to log into the system easily with their usernames and passwords.

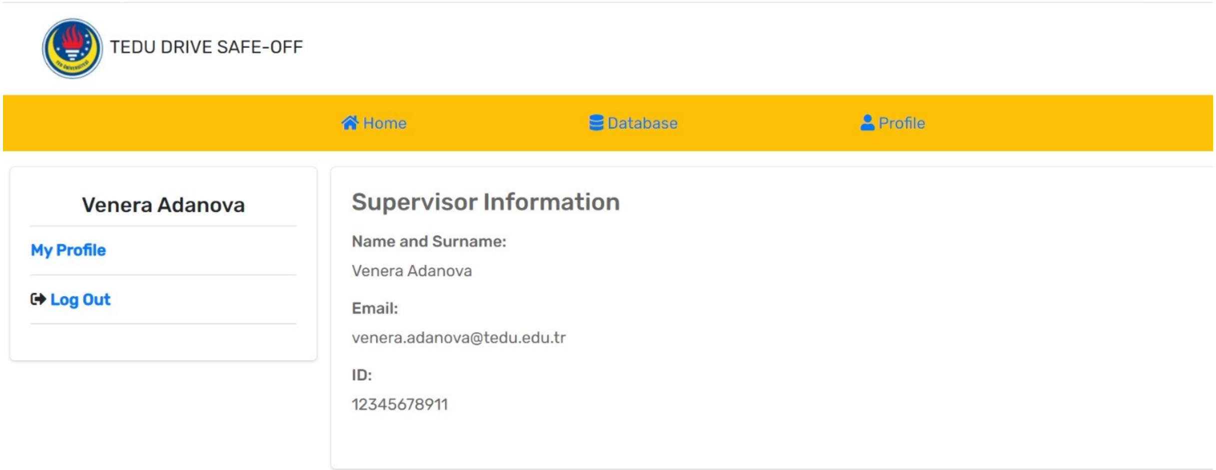

Figure 9: The profile page.

On the profile page in Figure 9, the user will be able to see their information.

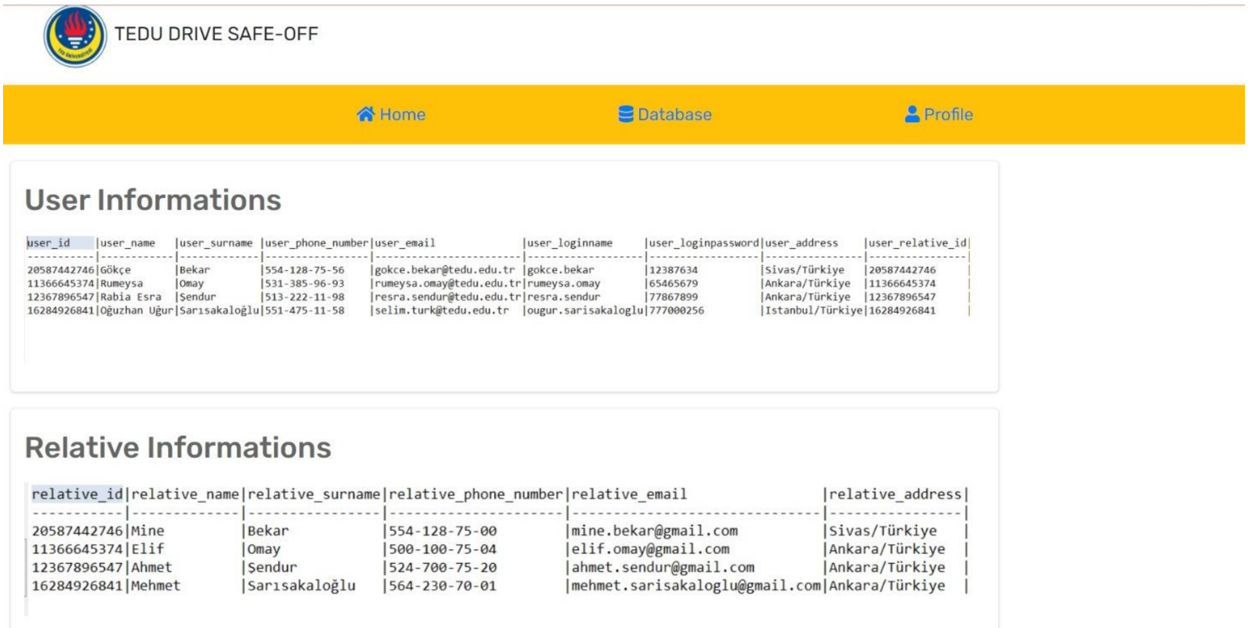

Figure 10: The database page.

On the database page, the user will be able to see information about the driver and their relatives in the database.

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