DRIVER FATIGUE DETECTION

Aditya Chechani & Nidhi Tiwari

Abstract:

The risk, danger and sometimes tragic results of drowsy driving are alarming. The National Highway Traffic Safety Administration conservatively estimates that 100,000 police-reported crashes resulted in an estimated 1,550 deaths, 71,000 injuries, and $12.5 billion in monetary losses due to driver fatigue. Our project attempts to utilise the physical changes in the facial features of a driver with computer vision techniques to detect fatigue (or drowsiness) in the driver at an initial stage and give a warning so that the driver can take corrective steps. This project attempts to contribute towards the exercise of analysing driver behaviour in order to reduce preventable motor accidents.

1. Fatigue Detection Tech

The process of losing alertness at the wheel due to fatigue can be characterised by a gradual progression of facial features:

- Changes relating to the direction of the gaze of the driver
- Changes in the position of the eyelids or the size of the eye
- Rapid changes in rate of blinking and orientation and position of the head.

2. Possible methodologies

Due to the changes in the facial features and physical states, opportunities arise to solve our problem:

- Methods based on driver's current state, relating to the eye and eyelid movements.
    - Assessing changes in the driver's direction of gaze, blinking rate and actual eye closure.
- Measuring driver physiological state are also proposed in literature involving measuring driver fatigue. Examples: mouth shape, head position and EEG recording.
- However, for our project we will focus on application of computer vision techniques on Eye behaviours which provide significant information about a driver's alertness.

3. Methodologies demonstrated

The approach presented in this project can be saliently encapsulated as follows:

- Utilising face and eye detection using passive appearance based methods. These consist of two steps:
- Carrying out face detection utilising dlib frontal face detector.
- Extracting eye regions from the faces detected by detecting the key facial structures on the face ROI.
- Utilising computer vision techniques to check status of the eyes based on its shape assigning thresholds to give drowsiness alarms.

4. APPROACH

Step 1: Find the face and eye region

- We utilised a pre trained frontal face detector from Dlib's library which is based on a modification to the Histogram of Oriented Gradients in combination with Linear SVM for classification.
- This outputs a 68 Landmark model which excludes the pupils of the eyes. Therefore, we trained Dlib's Facial Landmark Detector on a 70 point facial landmarks dataset find the eye's pupil region.

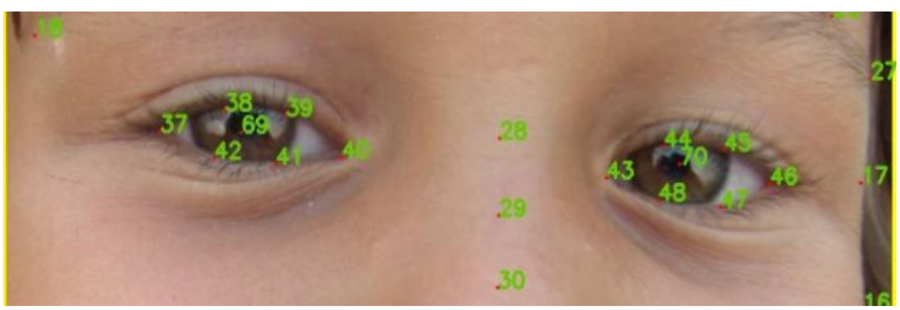

Figure1. Plotting of Dlib's facial landmarks

Understanding Dlib's Facial Landmark Detector

- Dlib's facial landmark detector is based on a paper by Vahid Kazemi and Josephine Sullivan, titled: **["One Millisecond Face Alignment with an Ensemble of Regression Trees"]**

- It uses an ensemble of regression trees trained on the training set of labeled facial landmarks on an image
- The pre-trained facial landmark detector inside the dlib library is used to estimate the location of 68 (x, y)-coordinates that map to facial structures on the face. The 68 landmark output is shown in the figure below. However, we utilised the 70 landmark model.

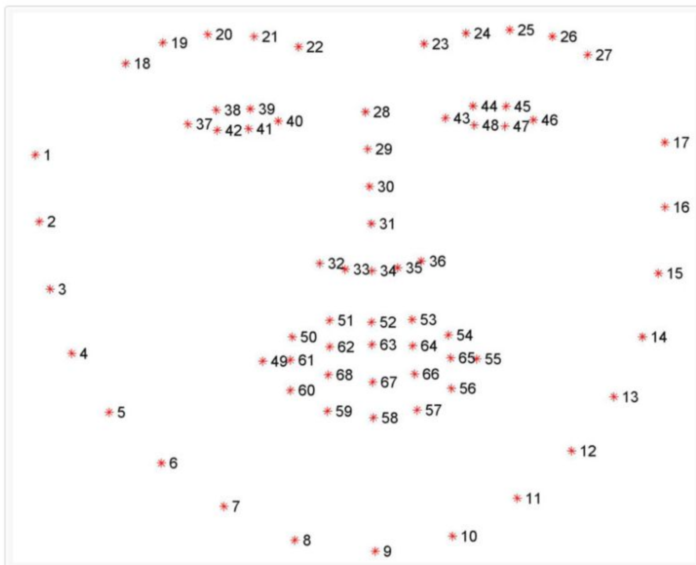

Figure2. Localisation of pre-trained Dlib's facial landmarks

Eliminate Effect of Lighting

We normalized the input to overcome the light variability using histogram equalization and Gamma Correction:

- Histogram Equalization:
    - It involves correcting image intensities to enhance contrast
- Gamma Correction:
    - This involves enhancing contrast by using a non-linear transformation between input and output mapped values.

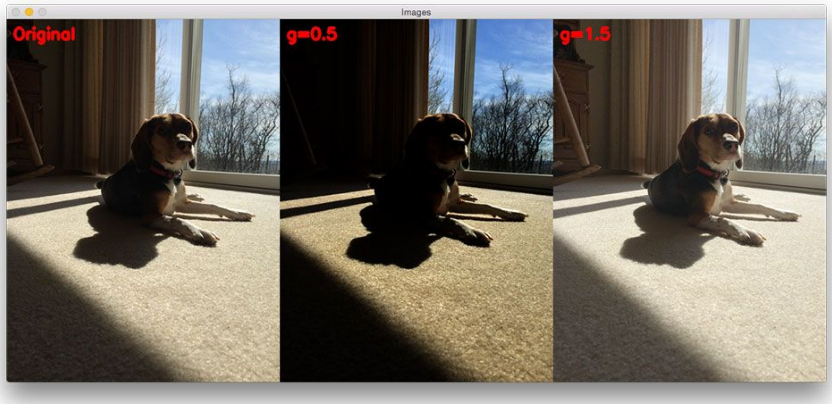

Figure3. Gamma Correction with different gamma values

Step 2: Find aspect ratio of eyes and check status

- We then calculate the aspect ratio to check whether eyes are opened or closed.
- The eye is open if Eye Aspect ratio is greater than threshold. (Around 0.3)

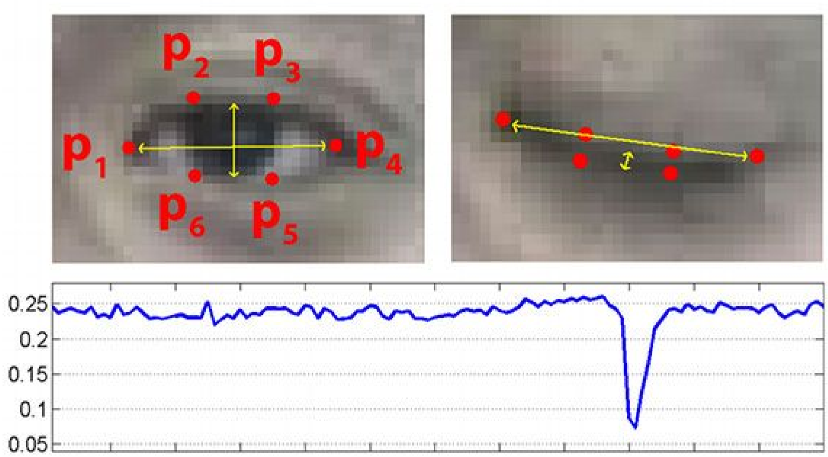

Figure 4: Calculating the eye aspect ratio

Step 3: Decision on blink and Drowsiness

- A blink is supposed to last 200-300 milliseconds. A drowsy blink would last for 800-900 ms.
- We use a finite state machine to keep track of the history of eye status and decide whether the blink should be valid or if the person is drowsy.

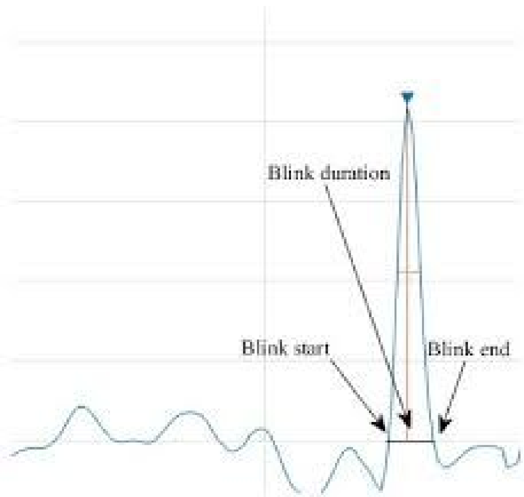

Figure 5: Changes in eye aspect ratio during blink

- Assume time between two frames is 100 ms (varies between computers)
- Blink will be valid if it lasts for 300 ms (3 frames). (Different for different people)
- Person is drowsy if eye remains closed for more than 900 ms (9 frames)

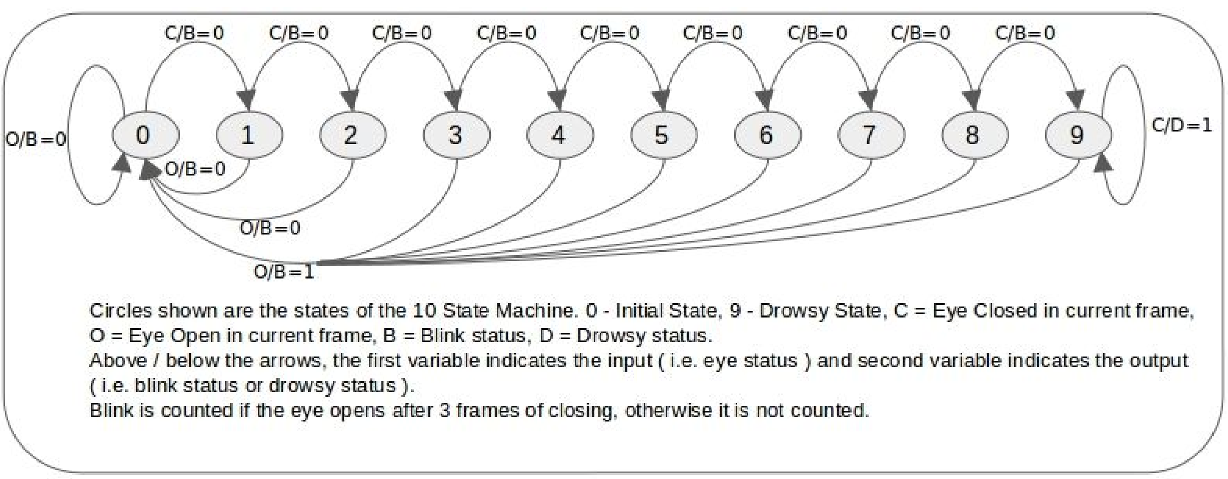

Figure 6: Finite state machine to differentiate between blink and drowsiness

Convert to frames based model instead of time

To make our model invariant to the frame rate of the system being used:

- Calculate frame rate of processor we're working on.
- Convert blink time and drowsy time to number of frames based on this frame rate

5. Obstacles

Some of the hurdles we faced along the progress of the project:

- Lighting conditions: Changing lighting conditions according to the time of day that causes changes in lighting of the face inside the car.
- Variable Frame Rate: Making our software adaptable to variable frame rate for different systems.
- Camera stability in the car
- Stability of landmark points on the face
- Driver wearing spectacles

6. Conclusions

Our drowsiness detector is hinged on the following important computer vision techniques:

- Face Detection
- Facial landmark detection
- Eye aspect ratio
- Histogram Equalization or Gamma Correction
- Facial Landmark prediction is an important technique in classifying the facial behaviours of the driver.
- Once we have our eye regions, we can apply the eye aspect ratio to determine if the eyes are closed. If the eyes have been closed for a sufficiently long enough period of time, we can assume the user is at risk of falling asleep and sound an alarm to grab their attention

7. Future work

- Next step is to detect driver’s gaze direction. We’d probably have to use two cameras for a robust detector.
- Stabilize the landmark points by using k previous frames.
- Attempt to utilise orientation of the head to add an additional layer of sophistication in the fatigue detection approach.