Marmara University Faculty of Engineering

CSE4062 – Data Science, Spring2020

Group7

"DRIVER DROWSINESS DETECTION"

Delivery #1 - Report

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1. INTRODUCTION

Driver drowsines splays a significant role in road accidents, claiming the lives of thousands of people every year worldwide. If vehicles become equipped with technology capable of detecting signs of driver drowsiness in a timely manner, many potential accidents will be prevented and many lives will be spared as a result.

2. PROBLEM DEFINITON

When we consider the death rates of road accidents in last year of Turkey, 3704 people died and big majority of it (%92,65) was caused by driver defects [1]. Driver fatigue, more specifically drowsiness, is a major reason of traffic accidents [2]. Most of drivers who had an accident before due to the sleepiness (94%), mentioned themselves to be alone in the vehicle [3]. According to a survey between drivers, 24% of subjects were having a sleep attack regularly, during their driving experiences even if they don't cause any accidents [3]. Thus, some kind of an early warning mechanism for driver drowsiness gains importance.

3. GOALS

In the last decade, most of major car companies developed their own practical and robust drowsiness detection systems. But the recent quick rise of machine learning are require to be updated with newer technologies. So, for this project, we want to build our own visual drowsiness detection system and to find ways of implementing machine learning classifiers that we learned in the class lectures.

4. SCOPE

The main aim of this project is to build a system that detects the drowsiness of the driver and gives warning to the driver in real-time using image processing and machine learning techniques in order to minimize the traffic accidents due to fatigue. The project consists of three phases.

In the initial phase, processing video and detecting face landmark coordinates are included. In the second phase, development for frame-based feature extraction with normalization is residing. In the final phase, determining the appropriate classifier method which includes classical machine learning techniques like SVM, k-NN, Decision Trees or HMM.

Since this work is research-based project, developing any mobile/web application or commercial software is not taken into consideration.

5. DATASET SPECIFICATIONS

We are planning to use **NTHU-DDD** dataset which can be found on the link:

http://cv.cs.nthu.edu.tw/php/callforpaper/datasets/DDD/

This dataset is consisting 36 subjects of different ethnicities. It is included many variations of driving scenarios such as normal driving, yawning, show blink rate and falling asleep. The total time of videos almost 10 hours. There are 5 different scenarios; bare face, glasses, night bare face, night glasses and sunglasses. Each record is approximately 1 minute long. The participants are simulated the driving in lab environment. **The evaluation and testing datasets contain 90 driving videos** (from the other 18 subjects) with drowsy and non-drowsy status mixed under different scenarios. **Training set contains 360 videos** with 30 fps. If we accept video duration is approximately 1 min for each, we have 360*60*30 = **648000 frames for training set** and 90*60*30 = **162000 frames for evaluation set**. At the same time, these are the numbers of rows that we can use for classification.

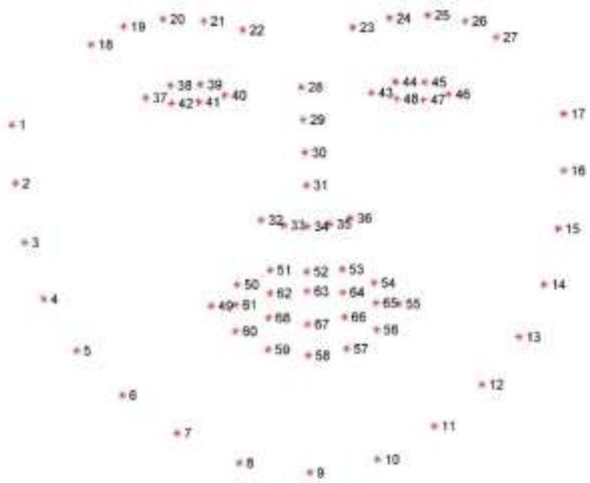

__Figure-1:__ 68 facial landmark coordinates of Dlib's shape_predictor method.

Since this dataset is basically bunch of videos and doesn't contain values as features, we need to read videos, process frames with **Dlib** library to predict **68 facial landmarks** (see **Figure-1**) for detected faces then based on coordinates of these landmarks, construct some hand-made features. All of these features will have **numeric type**. And we will use provided annotations of frames (**drowsy(1)/non-drowsy(0)**) as our **target attributes**.

Explanation of hand-made features can be found below:

1. **Eye aspect ratio (EAR):** A simple mathematical formula for eye closeness is called "Eye Aspect Ratio (EAR)" (5.1) and can be extracted from eye landmark coordinates in **Figure-1**.

$$EAR(i) = \frac{\|p_{38} - p_{42}\| + \|p_{39} - p_{41}\|}{2\|p_{37} - p_{40}\|}, \qquad (5.1)$$

   In the formula here, p_{37}, …, p_{42} are 2D landmark locations of the left eye depicted in **Figure-1 and Figure-2** and i is the frame index. $\|p_a - p_b\|$ represents the Euclidian distance between two landmark positions. The average of both eyes will be selected as a feature.

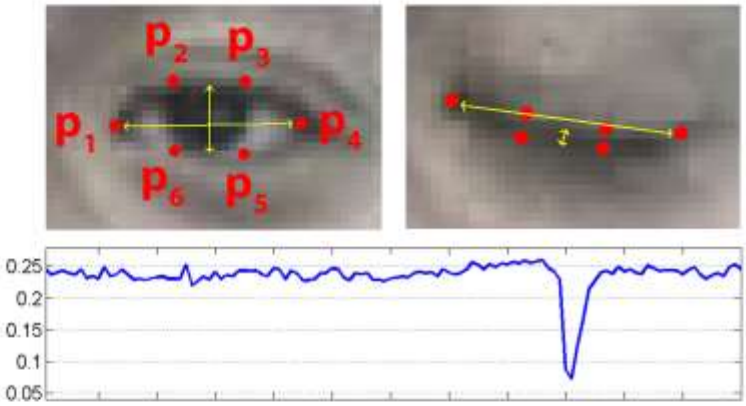

***Figure-2**: Eye landmarks are used in the calculation of EAR with open/closed eye scenarios.*

2. **Mouth aspect ratio (MAR):** This formula resembles to EAR (5.1), in the context of using 68 facial landmarks (see **Figure-1**). It uses inner landmarks of the mouth (61, ..., 68) and calculates a ratio just like EAR. Therefore, it can be useful for detecting yawning behavior.

$$MAR(i) = \frac{\|p_{63} - p_{67}\|}{\|p_{61} - p_{65}\|}, \qquad (5.2)$$

In the formula here (5.2), p_{61}, ..., p_{67} are 2D landmark locations of the inner points of the mouth shape depicted in **Figure-3** and i is the frame index. $\|p_a - p_b\|$ represents the Euclidian distance between two landmark positions.

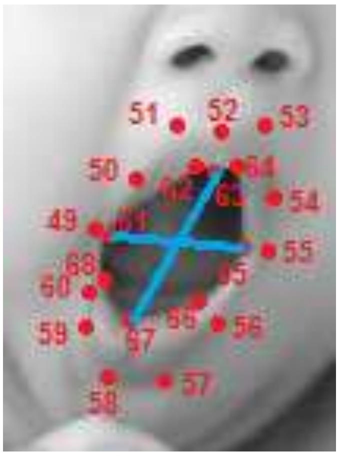

***Figure-3:** Ratio between [p63, p67] and [p61, p65] to measure Mouth Aspect Ratio (MAR).*

3. **Eye Circularity (EC):** It's a measure like EAR but it puts greater emphasis on the pupil area.

$$EC(i) = \frac{4 \times \pi \times Pupil\ Area}{(Eye\ Perimeter)^2}, \qquad (5.3)$$

$$Pupil\ Area = \left(\frac{\|p_{38} - p_{41}\|}{2}\right)^2 \times \pi, \qquad (5.4)$$

$$\begin{aligned} Eye\ Perimeter = \ & \|p_{37} - p_{38}\| + \|p_{38} - p_{39}\| + \|p_{39} - p_{40}\| + \\ & \|p_{40} - p_{41}\| + \|p_{41} - p_{42}\| + \|p_{42} - p_{37}\|, \quad (5.5) \end{aligned}$$

In the formulas above (5.3, 5.4, 5.5) p_{37}, …, p_{42} are 2D landmark locations of the left eye shape depicted in **Figure-4** and i is the frame index. $\|p_a - p_b\|$ represents the Euclidian distance between two landmark positions. The average of both eyes will be selected as a feature.

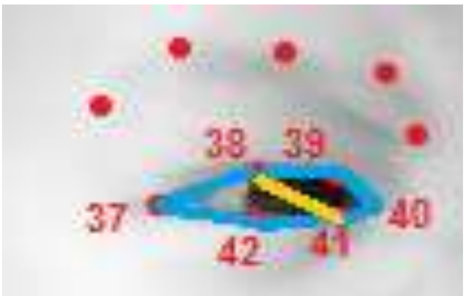

Figure-4: *Blue lines represent Eye Perimeter and the yellow line represents Pupil Diameter which is used in the calculation of Eye Circularity (EC).*

4. **Mouth over Eye (MOE):** Basically EAR (5.1) over MAR (5.2). It's an additional feature which can be interpreted as true drowsiness, since some facial actions like smiling and talking may produce some fake yawning MOE values.

$$EC(i) = \frac{MAR(i)}{EAR(i)}, \qquad (5.6)$$

5. **PERCLOS**: Indicates the frequency of closed eyes up until that moment. We are planning to use it with a small-time window like t = 30 seconds.

$$PERCLOS = \frac{count\ of\ frames\ when\ the\ eyes\ are\ closed}{total\ count\ of\ frames\ up\ until\ that\ moment} \times 100\%, \quad (5.7)$$

6. **Level of Eyebrows (LEB):** Level of eyebrows can be a good measure to drowsiness so another formula that calculates the average distance between first two of inner points of eyebrows and inner corner of an eye. Other points of eyes are ignored due to their moving nature. Other than two points of eyebrows are ignored also, since they are more stationary.

$$LEB(i) = \frac{\|p_{21} - p_{40}\| + \|p_{22} - p_{40}\|}{2}, \qquad (5.8)$$

In the formula above (5.8) p_{21} and p_{22} are most inner points of the left eyebrow, also p_{40} most inner point of the left eye and represents 2D locations as depicted in **Figure-5.** i is frame index and $\|p_a - p_b\|$ represents euclidian distance between two landmark positions. The average of both eyes will be selected as a feature.

Figure-5: *Blue lines represent distances [p21, p40] and [p22, p40]. Average of them is calculated to measure the Level of Eyebrows (LEB).*

7. **Size of Pupil (SOP):** Size of pupil can be a good measure of alertness. It's not a direct relation but fluctuations of size are related to the fatigue of a subject [65]. So defined formula below measures the ratio of pupil diameter and eye width.

$$SOP(i) = \frac{\|p_{38} - p_{41}\|}{\|p_{37} - p_{40}\|}, \qquad (5.9)$$

In the formula above (5.9), p_{37}, …, p_{40} are 2D landmark locations of the left eye depicted in **Figure-6** and i is the frame index. $\|p_a - p_b\|$ represents the Euclidian distance between two landmark positions. The average of both eyes will be selected as a feature.

Figure-6: *Blue line represent Eye Width [p37, p40] and orange line represents Pupil Diameter [p38, p41]. The ratio of them is called Size of Pupil (SOP).*

10. References

[1] Karayolları Genel Müdürlüğü, Trafik Kazaları Özeti. [Online]. Available: https://www.kgm.gov.tr/Sayfalar/KGM/SiteTr/Trafik/TrafikKazalariOzeti.aspx (Date of Access: 20 / 04 /2020)

[2] Abdulkerim Sönmez, "Ağır Vasıta Sürücüleri'nin Çalışma Koşulları ve Trafik Kazaları, Uzun Mesafe Yük ve Yolcu Taşımacılığı Yapan Sürücüler Üzerine Bir Çalışma", T.C. Emniyet Genel Müdürlüğü Trafik Hizmetleri Başkanlığı Trafik Araştırma Merkezi Müdürlüğü, 1999.

[3] Mahir Gökdağ, Fatih İrfan Baş, "The Effect of Fatigue and Sleepiness upon Driver Behaviors", Erzincan University Journal of Science and Technology, 2019.