Technologies for Autonomous Vehicles

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Project 1

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1 Introduction

While driving is crucial that the driver maintains focus on the road, however many times we all get distracted by our phone or by the car instrumentation. Theese bad behaviours cause lots of car accidents that could be easily avoided. During the past years many tools were invented that can detect the concetration of the driver and notify him/her to regain attention.
The objective of this activity is to develop a Python code that manages to dentify the position of the driver's head and eyes in order to determine whether he is attentive to the road or not. Additionally we can compute the PERCLOS (PERcentage of eye CLOSure) to establish if the driver is drowsy.

2 Drowsiness detection

To detect if the driver is sleepy there are many papers and many theories. Our approach is to use the Eye Aspect Ratio (EAR) to figure out when the eye is opened and then the PERCLOS (PERcentage of eye CLOSure) formula to establish how much time they are opened.

The first thing to do is to perfom image processing with the python library MediaPipe FaceMesh, that provides 3D coordinates of 468 facial landmarks position on an RGB camera image.

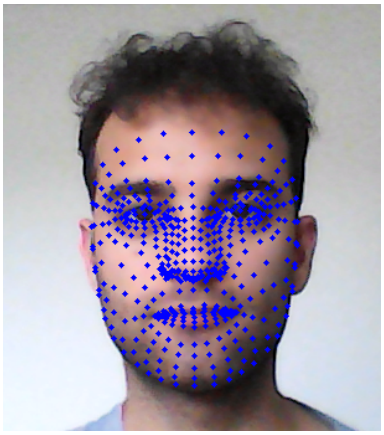


Figure 1

We use only 6 landmarks for each eye to compute the EAR, using the following formula:

$$EAR = \frac{\|Y_2 - Y_6\| + \|Y_3 - Y_5\|}{2 \cdot \|X_1 - X_4\|}$$

Where X_i and Y_i are the x and y axis respectively of the points P_i, for i=1-6.

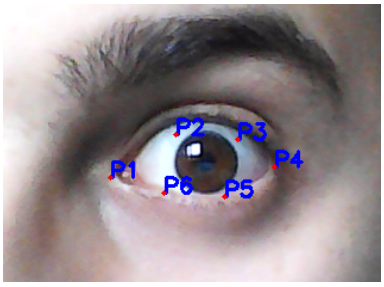


Figure 2

Furthermore, we can observe that wherever a person blinks or closes their eyes the distance between the points P_2, P_6 and P_3, P_5 decreases, while the horizontal distance remains the same. With the EAR value previously calculated we can establish that the driver is drowsy if the EAR is greater than 80% of its maximum for more than 10 seconds.
This rule is a bit counter intuitive but comes from multiple studies which found out that when a person is driving and is falling asleep, he stops blinking and his eyes slowly close until he's asleep.

Since the two eyes can behave independently, if only one of them satisfies the previous condition, then the person is considered drowsy and a message is printed on the screen. In a real case scenario, an alarm could sound to wake the driver.

3 Driver's Focus

While driving is important that the driver stays focused on the road, so his head and his eyes should be always oriented towards the front window (or in this case toward the camera).

3.1 Head orientation

To get the facial orientation we use significative points obtained as before from the MediaPipe library.

Figure 3

With those points we can solve perspective using the openCV library to get the rotational matrices, from which we can extract the orientation angles (*Roll-Pitch-Yaw*) of the head.

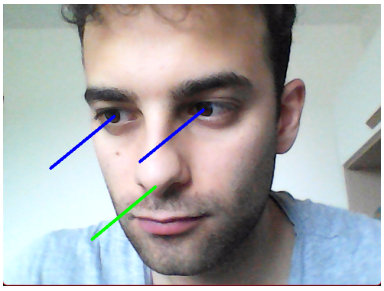
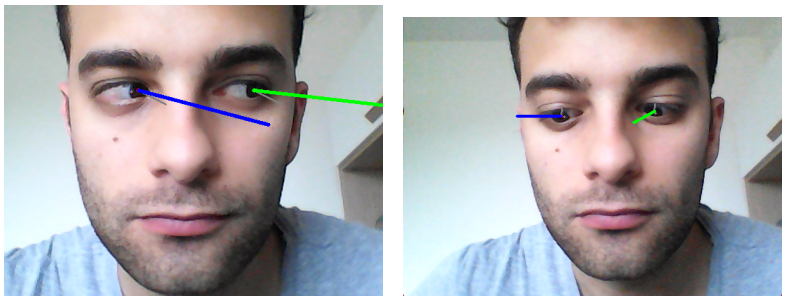


Figure 4

3.2 Eye gazing

For the eye gazing is a little different: the idea is to compute the gaze by looking at the distance of the pupil from the center of the eye.



(a) (b)

Figure 5

The formula we use is not complicated, we simply interpret the horizontal distance as the *yaw* angle and the vertical distance as the *pitch* angle. We can do this approximation because the distance and the relative angle are very small. When we tested the code it worked quite well for the horizontal orientation (Fig 5 (a)) while for the vertical orientation (Fig 5 (b)) the algorithm struggled to compute the exact difference between the two points due to the fact that the vertical length is shorter than the horizontal one. Probably with a better camera the results would improve.

4 Final Result

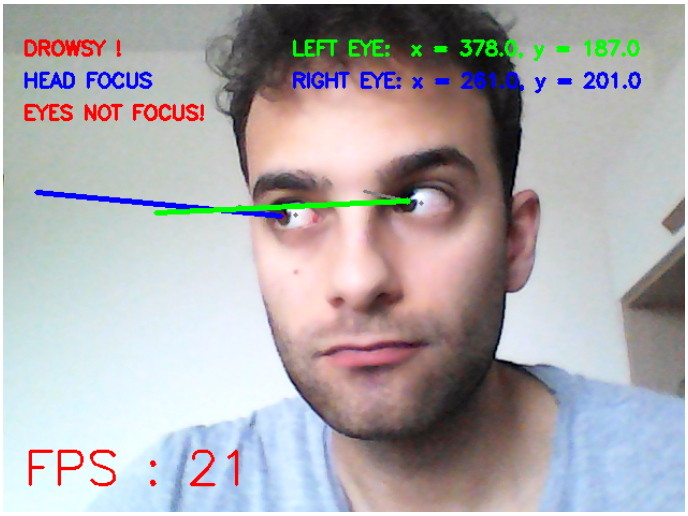


Figure 6