RESEARCH ARTICLE

SAMRIDDHI Volume 15, Issue 1, 2023 Print ISSN: 2229-7111 Online ISSN: 2454-5767

An Approach to Detect Driver Drowsiness in Real Time using Facial Landmarks

Sushma Nagdeote*, Heenakausar Pendhari, Martina John, Shagun Agrawal

Department of Computer Engineering, Fr. Conceicao Rodrigues College of Engineering, Mumbai University, India.

Abstract

According to studies, 21% i.e., one-fourth of serious roadway accidents are caused due to the drowsiness of the drivers. Some of the most significant reasons that cause fatigueness in drivers are lack of sleep, heavy exertion and drunken driving. Heavy vehicle drivers who travel long distances despite their lack of sleep are more prone to road accidents. This research proposes a system that detects the drowsiness of the drivers like duration of eye closure and yawning. This system is built using Python and its libraries, such as OpenCV, dlib, pygame, etc. which would be integrated into a web application made with the help of flask in Python. This system in real-time determines if a person driving a car is drowsy or not, if the driver is drowsy, then the system alarms him by sound alerts.

Keywords: Eye aspect ratio, Mouth aspect ratio, Facial landmarks, PERCLOS, Drowsiness detection.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2023); DOI: 10.18090/samriddhi.v15i01.21

Introduction

A motor vehicle's operation while in a drowsy or fatigued state is more commonly referred to as 'drowsy driving'. This increases the risk of casualties significantly. When a person takes a microsleep i.e., dozes off for a few seconds while driving, there are chances that the vehicle could run off the road or collide with another vehicle. The damage increases from such crashes when the vehicles are at high speeds. Drowsiness can make a driver less attentive and easily distracted by the surroundings. The driver's reaction time decreases, making it harder to avoid accidents in the roadway. Insufficient sleep worsens the decision-making, which can increase the risk of accidents.

So to avoid accidents, a system is developed that helps in detecting driver drowsiness using dlib and OpenCV. The proposed system uses 68 facial landmarks to detect fatigues. When a driver is drowsy, the relative position of the facial landmarks varies. This system detects the drowsiness status of the drivers based on the duration of eye closure and yawning.

The operation of the proposed system as shown in Figure 1. can be split into three parts, firstly, detection or face localization and prediction critical points of dominant areas in the localized face is done. Next, drowsiness estimation is calculated, followed by producing sound alerts based on the symptoms of drowsiness. Once the landmarks are predicted, the eye and mouth landmarks are used to determine the Eye aspect ratio abbreviated as EAR and mouth aspect ratio i.e., MAR, respectively to check if a person is drowsy. Each eye is drawn using six points and mouth using 8 points that would help in determining the aspect ratios. In our drowsiness detection system, we will monitor the aspect ratios of the eyes and the mouth to detect various symptoms of drowsiness. This web application detects if a person is drowsy while driving and alerts that person by using a real-time audio alert. To run the system successfully, we would deploy it to a web application. This app would require access to the camera and audio. It aims to help drivers to be alert while driving, especially when they have a hectic schedule. This way, by creating a web application to detect driver drowsiness, we can contribute to the social welfare of the people.

Corresponding Author: Sushma Nagdeote, Department of Computer Engineering, Fr. Conceicao Rodrigues College of Engineering, Mumbai University, India, e-mail: sushman@fragnel.edu.in

How to cite this article: Nagdeote, S., Pendhari, H., John, M., Agrawal, S. (2023). An Approach to Detect Driver Drowsiness in Real Time using Facial Landmarks. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 15(1), 161-165.

Source of support: Nil

Conflict of interest: None

Related Work

Software to alert humans about their drowsy state has made life simpler as it helps to prevent accidents. This is done by detecting various facial expressions of humans. So Some of the papers that discuss various aspects that cause drowsiness in drivers, important factors that need to be taken under consideration for detecting drowsiness and different techniques that can be used for drowsiness detection are mentioned below.

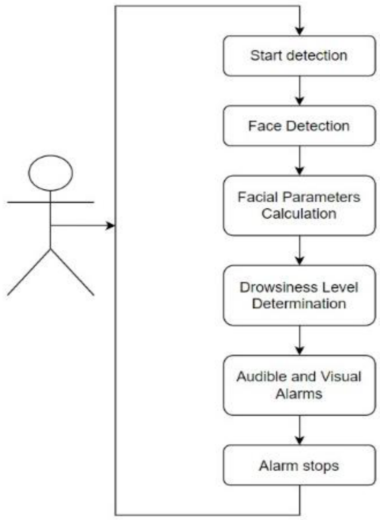

Figure 1: The proposed system

L Thulasimani, Poojeevan P and Prithashasni S P.[1] developed a prototype of a driver drowsiness detection system that detects initial signs of drowsiness and hence prevents critical situations from arising. Author further commented, "that one of the main causes of road accidents in the world is drowsiness". Therefore, in this paper, a study related to driver drowsiness detection is done. According to Major studies around 20% of vehicle accidents are fatigue-related. Some factors that indicates about driver drowsiness are eye ratio, head tilt and yawning. On detecting these we can alert the driver by using an alarm system.

V B Navya Kiran *et al.*[2] provided a comparative Study on driver drowsiness detection and alarm system. In this, a non-invasive system is built. This system uses an arithmetic method to detect drowsiness. A camera is used to detect eye movements in order to detect drowsiness. It can differentiate between eye blink and drowsiness. If drowsiness is detected then an alarm system is turned on.

H. Varun Chand and J. Karthikeyan[3] mentioned in their paper that many researchers are involved in developing a Driver Drowsiness Detection System system to reduce road accidents. Despite the development of more efficient models, traffic accidents continue to grow rapidly due to models' increased distraction detection time. Therefore, to increase the level of accuracy and reduce distraction time, the proposed model includes a two-level convolutional neural network that can classify driver behavior and emotions with reduced detection time.

R. Oyini Mbouna *et al.*[4] proposed to analyze visual features to monitor the drowsiness state of a vehicle driver. In this, a support vector machine i.e., SVM is used to classify set of video segments into alert and non-alert events. The video is used to extract critical information, from the visual features such as head posture, eye index and pupil activity, on the non-alertness of a vehicle driver.

Belal Alshaqaqi *et al.*[5] proposed an algorithm that finds, tracks, and analyzes both the driver's face and eyes to measure PERCLOS i.e., percentage of eyelid closure over the pupil over time and reflects slow eyelid closure rather than blinks. In this an automatic driver drowsiness detection system that is Advanced Driver Assistance System based on Artificial Intelligence and visual information is made.

Vandna Saini and Rekha Saini[6] proposed various factors used to cause drowsiness. Some techniques like Eye blinking, Optical detection, yawning, Steering wheel movement and head nodding are used to detect driver drowsiness.

S. Mohanty *et al.*[7] proposed a method to detect drowsiness by calculating the aspect ratios of eyes and mouth. They can be calculated using Dlib's shape predictor which maps the coordinates of facial landmarks. So the signs of driver drowsiness are determined by comparing aspect ratios to threshold values that are 0.15 for eye and 0.83 for mouth. The driver is said to be in a state of drowsiness if the average aspect ratio of the right and left eye is less than the threshold value.

Chisty and Jasmeen Gill[8] proposed using the computer vision technique for driver drowsiness detection. It can be detected by measuring PERCLOS. When drowsiness is successfully detected while driving, an alarm is turned on or a warning message is displayed to warn the driver to rest or concentrate on driving.

Wei Zhang *et al.*[9] proposed a discreet drowsiness detection method. It uses image processing and eye tracking. An algorithm is used as a solution to detect different driving postures and changes in illumination. After calculating, measures such as duration of maximum closure, average opening level of the eyes, percentage of eyelid closure, closing velocity of eyes, opening velocity of eyes and blink frequency are combined to extract an independent index and reduce correlations.

Pagar Surabhi and Antapurkar Harshala[10] proposed a comparatively more accurate warning system that can increase the rate of detection of drowsiness. Various drowsiness detection techniques are vehicle-based measures(Steering positioning and lane detection), behavioral measures(eye blink, eye closure, yawning and head position) and physiological measures (ECG: Electrocardiograph, EEG: Electroencephalograph, EOG: Electrooculography). Combining all these a Hybrid model that uses various modern technology such as machine learning, artificial neural network and IoT for drowsiness detection is made. It also tells about pattern recognition methods and various algorithms that can be used for detection.

Pratiksha Kolpe *et al.*[11] proposed a method to reduce road accidents caused due to driver drowsiness, which is around 30-40%. A shape predictor containing 68-face-landmarks is used for face analysis. A webcam is used for Eye position detection, Face and eye blinking pattern observation to detect drowsiness. It is done by using an image processing algorithm. An alarm system is turned on it is detected that driver is drowsy.

W. Deng and R. Wu[12] proposed a method to detect drivers' facial expressions such as yawning and eye closure duration from video images using a method based on 68-face-landmarks. Then driver's state is evaluated using these facial regions. In this, a new face-tracking algorithm combines Multiple Convolution Neural Networks (MTCNN) and KCF. It is combined to improve performance in Complex environments such as low light. MTCNN is used to mark the target in the first frame and CNN is also used to evaluate the state of the eye. When driver drowsiness is detected, the driver is warned by using an alert system

Proposed Methodology

The functioning of the system can be categorized into three parts

- Detection or face localization and predicting critical points of dominant areas in the localized face.
- Estimating drowsiness based on the relative position of the landmarks of specific facial regions.
- Different types of sound alerts are based on the symptoms of the drowsiness being detected.

Detection or Localization of the Face and Prediction of the Landmarks of Important Regions in the Detected Face

Face detection is one of the key aspects of image processing. Face can be detected by using some of the most prominent pre-trained models like Multi-task Cascaded Convolutional Networks (MTCNN), Haar cascades, dlib frontal face detector, Caffe model by using OpenCV's DNN module, etc. In this system, we have used dlib because it has a facial landmark predictor which predicts the location of 68 landmarks of a person's face. These facial landmarks help to locate the salient regions of a person's face.

Detection of the face is done by dlib's frontal face detector. The frontal face detector from dlib library is a pre-trained model based on the features of Histogram of Oriented Gradients i.e. HOG extracts. These features are passed through a linear Support Vector Machine i.e., SVM classifier. The landmarks of the face are detected by dlib's landmark predictor. The facial landmark predictor estimates the location of 68 points or f(x,y) coordinates on the face. The indexes of 68 coordinates can be clearly visualized as shown in Figure 2. These coordinates represent parts of the face such as the mouth, jaw, nose, left eye, right eye, left eyebrow and right eyebrow. The indexes of facial landmarks for certain parts of the face are as follows:

- Jaw - 1 to 17
- Left eyebrow - 18 to 22
- Right eyebrow - 23 to 27
- Nose - 28 to 36
- Right eye - 37 to 42
- Left eye - 43 to 48
- Mouth - 49 to 68.

A particular landmark or a part of the face can be accessed by mapping 1 to 68 facial landmarks to [0,67] (index 0 to index 67) in the code.

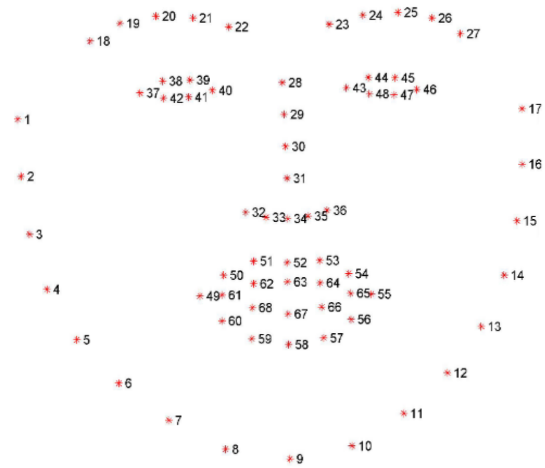

Figure 2: 68 facial landmarks representation

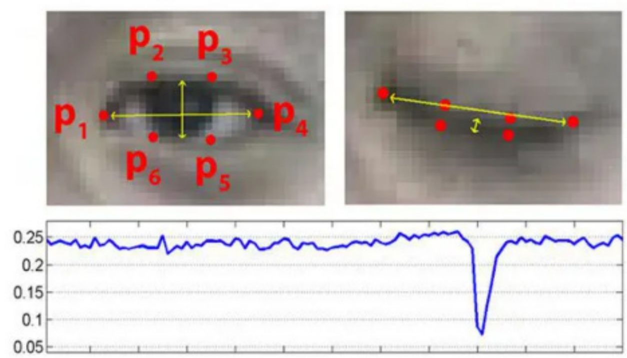

Figure 3: Representation of the position of the landmarks of eyes when open and closed. Plot of Eye aspect ratio with respect to time.

The movements of the eyes and the mouth mainly attribute to the detection of drowsiness. Hence in this system, we have extracted the regions of the eyes and the mouth using the facial landmark predictor by dlib. The change of position of the landmarks of the eyes and mouth, when a person closes his/her eyes or is yawning helps to estimate and detect drowsiness.

Estimation of Drowsiness Based on the Relative Position of the Landmarks of Specific Regions in the Face.

The landmarks of both eyes are marked by 6 coordinates. The right eye can be accessed using the points [36, 41]. The left eye can be accessed using the points [42, 47]. Using these points, the EAR is calculated. The EAR is a scalar value that is used to detect whether a person has opened or closed his/her eyes.

From the work of Tereza Soukupova and Jan Cech[13] named Real-Time Eye Blink Detection using Facial Landmarks, the formula of EAR is as follows:

$$EAR = \frac{||\, e_2 - e_6 \,|| + ||\, e_3 - e_5 \,||}{2||\, e_1 - e_4 \,||}$$

Let the position $P_1, P_2, P_3, P_4, P_5, P_6$, be denoted as e_1, e_2, e_3, e_4, e_5, and e_6, where e_1, e_2, e_3, e_4, e_5, and e_6, denotes the 6 facial landmarks of the eye. In this formula, the average of the vertical Euclidean distance between the points e_2 and e_6 and vertical Euclidean distance between the points e_3 and e_5 is divided by the horizontal Euclidean distance between the points e_1 and e_4 as shown in Figure 3.

The value of EAR remains constant as long as the eye remains open. Its value tends to zero when the person closes his/her eyes. The sudden decrease in the value of EAR as shown in Figure 3 is caused due to blinking of the eyes. Experimentally we have concluded that when the value of EAR remains greater than 0.25, the person is active i.e. fit for driving. When the value of EAR lies between 0.18 and 0.25, the person is in drowsy state and when the value of EAR is less than 0.18, it means that the person is dozing off or is sleeping. Active, drowsy or sleepy state is detected only when the value of EAR lies in any of the above-mentioned range for streak of at least 7 continuous frames.

The mouth is marked by 20 facial landmarks. For this system, we have used landmarks [60, 67] that mark the mouth's inner outline to calculate the MAR as shown in Figure 4. The MAR is a scalar value that is used to detect yawning. The calculation of MAR is similar to the calculation of EAR.

$$MAR = \frac{||e_2 - e_8|| + ||e_3 - e_7|| + ||e_4 - e_6||}{3||e_1 - e_5||}$$

where e_1 to e_8 denotes the 8 facial landmarks of the inner outline of the mouth. The MAR is calculated by taking the average of the three Euclidean vertical distances between e_2 and e_8, e_3 and e_7, e_4 and e_6 then dividing it by the Euclidean horizontal distance between e_1 and e_5 as shown in Figure 4. The value of MAR remains close zero as the mouth remains closed. The sudden increase in the value of MAR as shown in Figure 3 denotes the mouth being opened. If the MAR value is greater than 0.40 for a streak of at least 7 continuous frames, yawning is detected.

The plot in orange color denotes the value of MAR in Fig 5. The sudden sharp peaks in the plot of MAR indicate that the person can be talking, eating, etc or could have accidentally

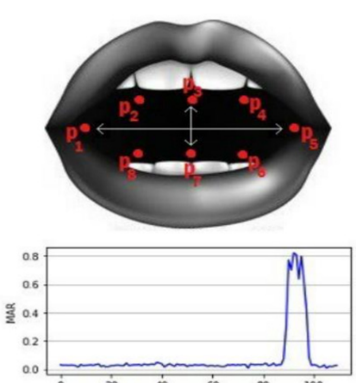

Figure 4: Representation of the position of the landmarks of mouth when opened. Plot of MAR with respect to time.

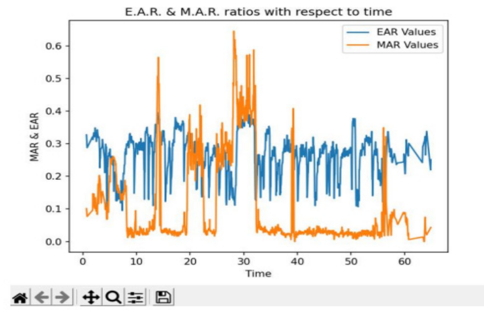

Figure 5: Graph of EAR and MAR with respect to time while running the system in real time

opened the mouth. The value of MAR being greater than zero for some considerable amount of time may indicate that the person is yawning. The plot in blue colour denotes the value of EAR in Figure 5. The periodic sudden decrease in the value of EAR denotes that the person is blinking his/her eyes. If the drop in the value remains constant for some time, it may indicate that the person is drowsy or sleepy.

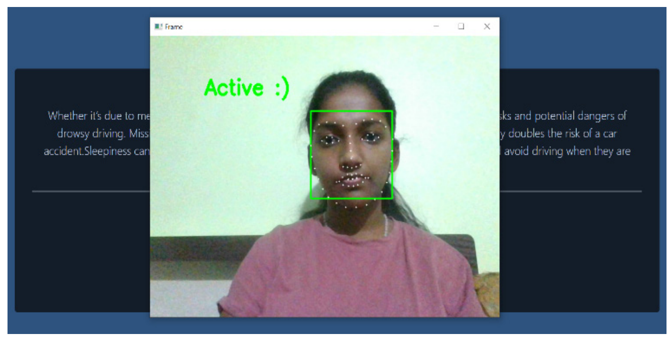

Figure 6: Active Behavior during driving

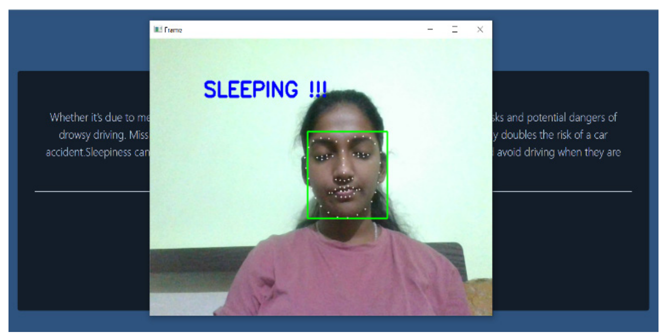

Figure 7: Sleeping Behavior during driving

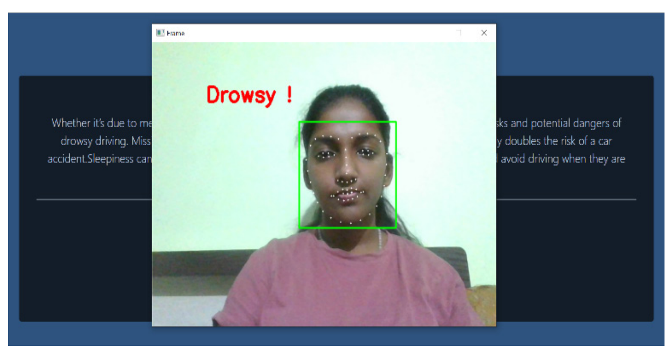

Figure 8: Drowsy Behavior during driving

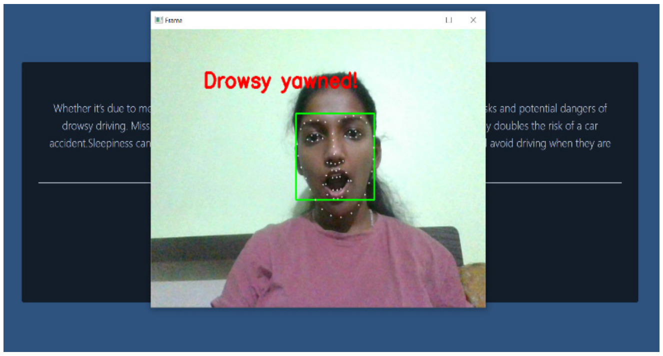

Figure 9: Drowsy Yawning Behavior during driving

Different Types of Sound Alerts Based on the Symptoms of the Drowsiness That is Being Detected.

If the driver is detected sleepy, a beep sound will be played until the person is completely awake. If the driver is detected as drowsy, specific sound alerts will be produced asking him/her to rest or stop yawning.

Now, we connect the Driver Drowsiness Detection System with our website using Flask.

Basic Syntax to connect flask with our webpage is

```
@APP.route('/')
def index():
""" Displays the home page accessible at '/'
"""
return flask.render_template('home.html')
```

render_template(imported from flask) is used to generate output from a template file.

So using this we have connected all our html pages to it. Then on running this flask code we get an address that when pasted in our browser, runs the website that is created.

Result

When both the eyes are fully open, the status is 'Active' as shown in Figure 6 which means the driver is not drowsy.

When the eyes are closed for a certain time period, the status is 'Sleeping' as shown in Figure 7. A sound alarm would be produced to waken up the driver.

When both the eyes are slightly shut, the status is 'Drowsy' as shown in Figure 8.

When the driver has drowsy eyes and is yawning, the status is 'Drowsy Yawned' as shown in Figure 9. A sound alert is produced to alert the driver.

Conclusion

Driver drowsiness detection System is basically a system designed to save the lives of drivers who constantly drive their vehicles without getting enough sleep. Nowadays, one of the main reasons of traffic accidents is driver drowsiness. This system helps to avoid casualties and save the lives of drivers. This system can detect driver drowsiness by calculating EAR and MAR. If the driver is drowsy, an alarm sound is produced to wake the driver and prevent accidents. This work can further be extended by making an android or ios application for this system so that it can be used more efficiently as using it through an application will be much easier. The proposed system is not restricted to driver drowsiness detection but it can be used in various sensitive fields where high concentration is needed like while working, studying etc. to prevent us from sleeping. In the future this system can be used as a switch or a controller by just using face movements.

References

[1] L Thulasimani, Poojeevan P, Prithashasni S P (2021). Real Time Driver Drowsiness Detection Using Opencv And Facial Landmarks. International Journal of Aquatic Science, 12(2), 4297-4314.

[2] V B Navya Kiran, Raksha R, Anisoor Rahman, Varsha K N, Dr. Nagamani N P (2020). Driver Drowsiness Detection. International Journal of Engineering Research & Technology (IJERT), 8(15).

[3] H. Varun Chand ,J. Karthikeyan (2022). Cnn based driver drowsiness detection system using emotion analysis. Intelligent Automation & Soft Computing, 31(2), 717–728.

[4] R. Oyini Mbouna, S. G. Kong, M. Geun Chun (2013). Visual Analysis of Eye State and Head Pose for Driver Alertness Monitoring. IEEE Transactions on Intelligent Transportation Systems, 14(3), 1462-1469.

[5] Belal Alshaqaqi, Abdullah Salem Baquhaizel, Mohamed El Amine Ouis, Meriem Boumehed, Abdelaziz Ouamri, Mokhtar Keche (2013). Driver drowsiness detection system. 8th International Workshop on Systems, Signal Processing and their Applications (WoSSPA), 151-155.

[6] Vandna Saini, Rekha Saini (2014). Driver Drowsiness Detection System and Techniques : A Review. International Journal of Computer Science and Information Technologies, 5(3), 4245-4249.

[7] S. Mohanty, S. V. Hegde, S. Prasad, J. Manikandan (2019). Design of Real-time Drowsiness Detection System using Dlib. IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), 1-4.

[8] Chisty, Jasmeen Gill (2015). A Review: Driver Drowsiness Detection System. International Journal of Computer Science Trends and Technology(IJCST), 3(4).

[9] W. Zhang, B. Cheng, Y. Lin (2012). Driver drowsiness recognition based on computer vision technology. Tsinghua Science and Technology, 17(3), 354-362.

[10] Pagar, Surabhi, Antapurkar, Harshala (2019). A Study on Driver Sleepiness Alert System. Journal of Advanced Research in Intelligence Systems and Robotics, 1(2), 30-34.

[11] Pratiksha Kolpe, Pratibha Kadam, Usama Mashayak (2020). Drowsiness Detection and Warning System Using Python. 2nd International Conference on Communication & Information Processing (ICCIP).

[12] W. Deng, R. Wu (2019). Real-Time Driver-Drowsiness Detection System Using Facial Features. EEE Access, 7, 118727-118738.

[13] Tereza Soukupova Jan Čech (2016). Real-Time Eye Blink Detection using Facial Landmarks. 21st Computer Vision Winter Workshop Luka Cehovin, Rok Mandeljc, Vitomir ˇ Struc (eds.) Rimske Toplice, Slovenia.