Detecting Alertness and Stability of a Driver

Shivansh Dadhwal
18BCE2119
Computer Science Engineering
VIT, Vellore

Suhaas Srungavarapu
18BCE2101
Computer Science Engineering
VIT, Vellore

Ayush Pilani
18BCB0010
BioInformatics
VIT, Vellore

***Abstract*—One of the major technical challenges in the automotive industry is the development of safety features to prevent drunk and drowsy driving. Driving while we are drowsy, especially in modern age, is a major reason behind road accidents. Driving when drowsy can result in a higher risk of crash than in alert condition. Therefore, by using assistive systems to monitor driver's level of alertness can be of significant help in prevention of accidents. This paper aims towards the detection of driver's drowsiness using the visual features.Driver drowsiness is based on real-time detection of the driver's head, face and mouth. Our system is much more efficient as we not only alert the driver by making alert sounds but we also send a text message to their closed ones , hence increasing the security of our customer.**

***Index Terms*—Drowsiness, Vehicles, Face, Feature extraction, Mouth, Visualization, Safety, Monitoring**

I. Introduction

Face Recognition is defined as the interpretation of faces. Nowadays Facial Recognition works in a number of applications, for security mechanisms, for Face ID's and in many more fields. Face detection and tracking systems have gained its importance as it is needed for video surveillance and providing higher security to the country. In the past years, automatic face detection and recognition has seen sudden growth in the field of military and other top-secret organizations. It is a very difficult task to train if examples are few and it's difficult to capture images for the dataset. The existing method is known as sensing of physiological characteristics. This technique will be implemented as -

1) Measuring changes in physiological signals, such as brain waves, heart rates and eye blinking.

2) Measuring physical changes such as sagging posture, leaning of the driver's head and open/closed state of the drivers.

The highlights of the contributions of paper in points are -

1)Measuring physical changes such as sagging posture, leaning of the driver's head and open/closed state of the drivers.

2)Our system not only alerts the driver by making alert sounds but we also sends a text message to their closed ones , hence increasing the security of our customer.

II. Literature Survey

The first developed algorithm for the face recognition used to extract features of the faces, for e.g. mouth, nose or eyes. These features were selected in a region form to perform identification. Classifiers based on the Set functionalities were used that turned out to give a response for the face and classifier-based datasets. This method was good but didn't showed great results because of less amount of information used. In Facial Detection we only capture the facial features ignoring the background. It is thus also called object-class recognition. Viola-James uses Haar like features because Haar features are high even for a very small image. The feature extraction is a topic of deep interest in the facial detection. The system should be good enough to represent the face in feature form. Features are captured in two forms Holistic features and Local features. Local features include eyes, nose and mouth with distance between them as a key factor. Holistic feature category includes taking the whole input image as a working set. Today there are a number of methods to extract features from a face. One of these is Principle Components Analysis (PCA). This method uses Eigen values to detect the features of different faces. Another method is Linear Discriminant Analysis (LDA). This method is often termed as Fisher Face Method. Both these methods fall under the holistic feature category. The feature extracted results in Template generation. Then this template is reduced to a data set that represents unique features of face. In the dataset each space represents a feature whereas each component of the dataset is visualized as a feature. Cascading is a multistage technique. Cascading uses all the relevant information from the output that is given by a classifier to the next classifier in a cascade. It forms a block chain where the output of others is used by the next classifier. It can also be defined as the join of many classifiers. The cascades are trained with hundreds of positive and negative images that are identical in terms of the size. After the training is completed, it can be used to detect an object, to search for an object. The search window is traversed across the entire frame of the image. The process is most commonly used in image processing. In many methods Fischer and Eschanger proposed one. In their method they compared features based on the size. This method was based on Local template matching. In Local features matching some proposed that face can be expressed as a set of geometric parameters and clubbing and distinguishing between these parameters. Kenade made the first fully developed face recognition system in 1973. In his program Kenade matched automated abstraction to manual abstraction. The identification rate was 45-75 percent. Results were better when we used unrelated features. Another enhancement to this was the contribution of Mark Nixon who presented a geometric measurement for eye spacing. The template matching style was improved with schemes such as “deformable templates”. In 2001 Viola and James introduced a face detection system that detected frontal-view faces. The algorithm is an implementation in OpenCV using Haar Features. Haar features are unique, but they have some of the properties similar. Haar Feature matching includes matching of local features. These include matching of different regions such as Region of the face near the eye is darker than the cheeks and Nose Bridge is brighter than the eyes. There are many recognizing tools LBP, Fisherman, Laplacian, etc. but the best is LBP because it can be used in all kinds of backgrounds and is suitable for different intensities of light. In Haar detection we use rectangular representations composing of 2D waves. Commonly visual representation is by black (for value, minus one) and white (for value, plus one) rectangles in Haar Cascade Algorithm. Study of different algorithms like PCA, LBP, Laplacian, Euclidean, Babacket al, SRC gave a detailed view of different ways in which we can store, recognize faces. There are major studies about drowsiness identification and fatigue monitoring done. Many deep learning-based techniques have been developed for non-intrusive, real-time detection of driver sleep states with the help of various visual cues and observed facial features. Alshaqaqi et al have presented a detection system based on edge detection and exploiting the symmetry of facial features for extracting the eyes. The state of the eyes is determined as open or closed by taking the Hough transform for circles and comparing the intersection of the Hough transform and the edge image with a threshold. The state of drowsiness is then determined by using Percentage of Eyelid Closure (PERCLOS)- a scientifically associated measure of drowsiness associated with infrared light at different frequencies. Two images of the driver’s face are taken at fixed wavelengths. The difference of these images is used to measure percentage eye closure. The second method although in its infancy uses a neural network to predict PERCLOS by finding the right combinations of driver performance variables. Malla et al have built a system for detecting microsleep. The system uses a remotely placed camera with near infra-red illumination to acquire the video. Haar object detection algorithm is used to detect a face. The eyes Region of interest is detected using anthropomorphic parameters. Eye closure is detected by taking the ratio of the closed portion of the eye to the average height of the open portion. Under the light of what has been mentioned above, methods for drowsy detection have involved detection of face, eyes and (or) facial features. Based on a comprehensive literature survey, a number of different methods that took varied inputs were found to detect if a driver is alert and attentive. Such as, a method for measuring the blinking of a driver in real time by motion picture processing has been developed. There are a number of methods to identify drowsiness of a person. They are broadly classified into Image Processing based, EEG based and Artificial neural network based. Further, the Image processing based can be divided into Template based, yawning based and eye blink measurement based. Moreover, a method for presuming consciousness degradation from the change in blink duration has been developed. The waveform of blinking differs for Individual people and differs over time for the same person. The method developed for processing blink waveforms is robust against the Influence of differences among Individuals. The Blink extraction rate obtained with ten subjects has considerably improved from 16 percent lo 95 percent, and we have the prospect of presuming degree of consciousness. Expression recognition has become quite popular and unlike conventional detection methods, which are based on the eye states alone, facial expressions are used to detect sleeplessness. There are many challenges involving detection systems. Among the important aspects are: change of intensity due to lighting conditions, the presence of glasses and beard on the face of the person. A hardware system which is based on infrared light and can be used in resolving these problems. Another method to recognize facial expressions, was found by extracting information of the expressive component through a de-expression learning procedure, called De-expression Residue Learning (DeRL). There were two approaches towards detecting sleeplessness or fatigue according to one research. They were:

1. Measuring changes in physiological signals, such as brain waves, heart rates and eye Blinking.

2. Measuring physical changes such as sagging posture, leaning of the driver’s head and open/closed state of the drivers. A symmetry-based approach was used to identify a face followed by a raster scan algorithm to detect the eyes. A system has been developed that uses image processing technology to analyze images of the driver’s face taken with a video camera. Diminished alertness is detected on the basis of the degree to which the driver’s eyes are open or closed. This detection system provides a noncontact technique for judging various levels of driver alertness and facilitates early detection of a decline in alertness during driving. An efficient method to solve these problems for eye state identification for fatigue detection, in embedded system, which is based on image processing techniques, was also proposed. This method goes against the traditional way of driver alertness detection to make it real time, it utilizes face detection and eye detection to initialize the location of driver’s eyes; after that an object tracking method is used to keep track of the eyes.Determining if the drivers’ eyes are red from lack of sleep is an emerging research. The sclera region (the white outer coat of the eye) comprises a unique and stable blood vessel structure which can be analyzed to identify humans. This work focuses on the accurate segmentation of the eye: the iris region and the external shape of the eye. Another method to detect iris-sclera pattern used three stages for identification of the eye. The first stage for face detection elliptical approximation and template matching techniques were used. During the second stage, the open eye was detected using the proposed iris–sclera pattern analysis method. In the third stage, the fatigued state of the driver was determined using Percentage of eye Closure (PERCLOS) measure.

A driver alertness detection system utilizing overhead capacitive sensors has been developed. The overhead capacitive sensor array is used to track head position over time. Initial tests indicate capability of advance detection of over 80 percent of driver errors attributable to extreme fatigue.[Citation: Kithil, P., Jones, R., and McCuish, J., "Driver Alertness Detection Research Using Capacitive Sensor Array," SAE Technical Paper 2001-01-3057, 2001]

The development of technologies for preventing drowsiness at the wheel is a major challenge in the field of accident avoidance systems. Preventing drowsiness during driving requires a method for accurately detecting a decline in driver alertness and a method for alerting and refreshing the driver. As a detection method, the authors have developed a system that uses image processing technology to analyze images of the driver's face taken with a video camera. Diminished alertness is detected on the basis of the degree to which the driver's eyes are open or closed. This detection system provides a noncontact technique for judging various levels of driver alertness and facilitates early detection of a decline in alertness during driving.[Taro Nakamura, Akinobu Maejima, Shigeo Morishima, "Detection of Driver's Drowsy Facial Expression", Pattern Recognition (ACPR) 2013 2nd IAPR Asian Conference on, pp. 749-753, 2013.]

We describe a system for analyzing human driver alertness. It relies on optical flow and color predicates to robustly track a person's head and facial features. Our system classifies rotation in all viewing directions, detects eye/mouth occlusion, detects eye blinking, and recovers the 3D gaze of the eyes. We show results and discuss how this system can be used for monitoring driver alertness.[S. Amarnag, R.S. Kumaran, J.N. Gowdy, "Real time eye tracking for human computer interfaces", Multimedia and Expo 2003. ICME '03. Proceedings. 2003 International Conference on, vol. 3, pp. III-557, 2003.]

This paper presents visual analysis of eye state and head pose (HP) for continuous monitoring of alertness of a vehicle driver. Most existing approaches to visual detection of nonalert driving patterns rely either on eye closure or head nodding angles to determine the driver drowsiness or distraction level. The proposed scheme uses visual features such as eye index (EI), pupil activity (PA), and HP to extract critical information on nonalertness of a vehicle driver. EI determines if the eye is open, half closed, or closed from the ratio of pupil height and eye height. PA measures the rate of deviation of the pupil center from the eye center over a time period. HP finds the amount of the driver's head movements by counting the number of video segments that involve a large deviation of three Euler angles of HP, i.e., nodding, shaking, and tilting, from its normal driving position. HP provides useful information on the lack of attention, particularly when the driver's eyes are not visible due to occlusion caused by large head movements. A support vector machine (SVM) classifies a sequence of video segments into alert or nonalert driving events. Experimental results show that the proposed scheme offers high classification accuracy with acceptably low errors and false alarms for people of various ethnicity and gender in real road driving conditions.[Lei Zhao, Zengcai Wang, Xiaojin Wang, Qing Liu, "Driver drowsiness detection using facial dynamic fusion information and a DBN", Intelligent Transport Systems IET, vol. 12, no. 2, pp. 127-133, 2018]

We describe a system for analyzing human driver alertness. It relies on optical flow and color predicates to robustly track a person's head and facial features. Our system classifies rotation in all viewing directions, detects eye/mouth occlusion, detects eye blinking, and recovers the 3D gaze of the eyes. We show results and discuss how this system can be used for monitoring driver alertness. [Published in: Proceedings 15th International Conference on Pattern Recognition. ICPR-2000 Date of Conference: 3-7 Sept. 2000 Date Added to IEEE Xplore: 06 August 2002 Print ISBN:0-7695-0750-6 Print ISSN: 1051-4651 INSPEC Accession Number: 6912378 DOI: 10.1109/ICPR.2000.902999 Publisher: IEEE Conference Location: Barcelona, Spain, Spain]

This paper describes a method to monitor driver safety by analyzing information related to fatigue using two distinct methods: eye movement monitoring and bio-signal processing. A monitoring system is designed in Android-based smartphone where it receives sensory data via wireless sensor network and further processes the data to indicate the current driving aptitude of the driver. It is critical that several sensors are integrated and synchronized for a more realistic evaluation of the driver behavior. The sensors applied include a video sensor to capture the driver image and a bio-signal sensor to gather the driver photoplethysmograph signal. A dynamic Bayesian network framework is used for the driver fatigue evaluation. A warning alarm is sounded if driver fatigue is believed to reach a defined threshold. The manifold testing of the system demonstrates the practical use of multiple features, particularly with discrete methods, and their fusion enables a more authentic and ample fatigue detection.[Malti Bansal, Bani Gandhi, "IoT based smart health care system using CNT electrodes (for continuous ECG monitoring)", Computing Communication and Automation (ICCCA) 2017 International Conference on, pp. 1324-1329, 2017.]

In this paper, we have reviewed a number of detection systems to monitor the concentration of a car driver and propose a portable Driver Alertness Detection System (DADS) to determine the level of concentration of the driver based on pixelated coloration detection technique using facial recognition. A portable camera will be placed at the front visor to capture facial expression and the eye activities. We evaluate DADS using 26 participants and have achieved 100 percent detection rate with good lighting condition and a low detection rate at night.[Hasibah Adenin, Rahimi Zahari, and Tiong Hoo Lim "Microcontroller based driver alertness detection systems to detect drowsiness", Proc. SPIE 10615, Ninth International Conference on Graphic and Image Processing (ICGIP 2017), 106150R (10 April 2018)]

The growing number of traffic accidents in recent years has become a serious concern to society. Accidents caused by driver's drowsiness behind the steering wheel have a high fatality rate because of the marked decline in the driver's abilities of perception, recognition, and vehicle control abilities while sleepy. Preventing such accidents caused by drowsiness is highly desirable but requires techniques for continuously detecting, estimating, and predicting the level of alertness of drivers and delivering effective feedbacks to maintain their maximum performance. This paper proposes an EEG-based drowsiness estimation system that combines electroencephalogram (EEG) log subband power spectrum, correlation analysis, principal component analysis, and linear regression models to indirectly estimate driver's drowsiness level in a virtual-reality-based driving simulator. Our results demonstrated that it is feasible to accurately estimate quantitatively driving performance, expressed as deviation between the center of the vehicle and the center of the cruising lane, in a realistic driving simulator.[Lin, C., Wu, R., Jung, T. et al. Estimating Driving Performance Based on EEG Spectrum Analysis. EURASIP J. Adv. Signal Process. 2005, 521368 (2005). https://doi.org/10.1155/ASP.2005.3165]

We developed a drowsiness detection mechanism based on an electroencephalogram (EEG) reading collected from the driver with an off-the-shelf mobile sensor. This sensor employs wireless transmission technology and is suitable for wear by the driver of a vehicle. The following classification techniques were incorporated: Artificial Neural Networks, Support Vector Machine, and k Nearest Neighbor. These classifiers were integrated with integration functions after a genetic algorithm was first used to adjust the weighting for each classifier in the integration function. In addition, since past studies have shown effects of music on a person's state-of-mind, we propose a personalized music recommendation mechanism as a part of our system. Through the in-car stereo system, this music recommendation mechanism can help prevent a driver from becoming drowsy due to monotonous road conditions.[Liu N-H, Chiang C-Y, Hsu H-M. Improving Driver Alertness through Music Selection Using a Mobile EEG to Detect Brainwaves. Sensors. 2013; 13(7):8199-8221.]

Some efforts have been reported in the literature on the development of the not-intrusive monitoring drowsiness systems based on the vision. Vitabile implemented a system based on an infrared camera to detect symptoms of driver drowsiness. An algorithm for detecting and tracking driver's eyes has been developed by exploiting the phenomenon of bright pupils. The device will alert the driver with a warning message when drowsiness is detected. Bhowmik used the Otsu threshold to extract the region around his face. Eye localization is done by locating facial landmarks such as eyebrows and possible center of the face. Morphological activity and K Means are used for precise segmentation of the brain. Then a set of shape functions are calculated and trained using non-linear SVM to obtain the eye status. To identify the driver's drowsiness state, Hong defined a system for detecting the eye states in real time. The face region is detected using Jones and Viola optimized systems. A horizontal projection is obtained to the eye area. Finally, a new complexity function with a dynamic threshold for the identification of the eye condition. Tian built a system that checks the state of the driver's eye. Their system uses the YCbCr color space components Cb and Cr. This method locates the face with function of vertical projection, and the eyes with function of horizontal projection. Once the eyes are located the system uses a complexity function to calculate the eye states. Under the light of what has been mentioned above, the identification of the driver drowsy state given with the help of OpenCV for gathering the images from a webcam and feeding them into a Deep Learning model which will classify whether the person's eyes are 'Open' or 'Closed'.

III. Methodology

Modules Used:

Vehicle based measures: A number of metrics, including deviations from lane position, movement of the steering wheel, pressure on the acceleration pedal, etc., are constantly monitored and any change in these that crosses a specified threshold indicates a significantly increased probability that the driver is drowsy.

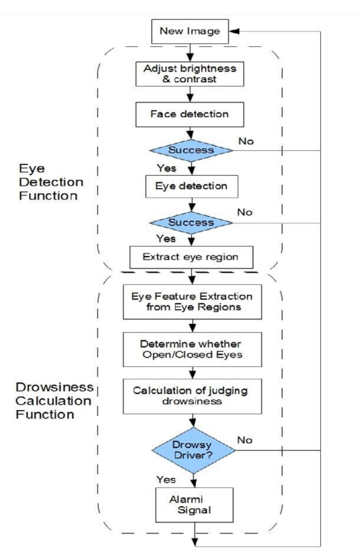
Behavioural based measures: The behaviour of the driver, including yawning, eye closure, eye blinking, head pose, etc. is monitored through a camera and the driver is alerted if any of these drowsiness symptoms are detected.

Physiological based measures: The correlation between physiological signals ECG (Electrocardiogram) and EOG (Electrooculogram). Drowsiness is detected through pulse rate, heart beat and brain information.

IV. Overall Architecture

The model we used is built with Keras using Convolutional Neural Networks (CNN). A convolutional neural network is a special type of deep neural network which performs extremely well for image classification purposes. A CNN basically consists of an input layer, an output layer and a hidden layer which can have multiple numbers of layers. A convolution operation is performed on these layers using a filter that performs 2D matrix multiplication on the layer and filter.

Architecture Diagram



Algorithm Used

1.OpenCV – OpenCV, a library of programming functions is used for detecting the face and facial features or in for this program, the eyes of the driver.

2. Haar Cascades – Haar Cascades is a Machine Learning (ML) based object detection algorithm. It is used to detect objects in an image or in a video.

3. Neural Networks – Neural Networks deals with developing a program based on real life simulation, based on how a human brain works.

4. Keras – Keras is a classification model that we will use to classify the eyes of the driver as either 'open' or 'closed'.

5. CNN – Convolutional Neural Network (CNN) is based on deep learning neural networks.

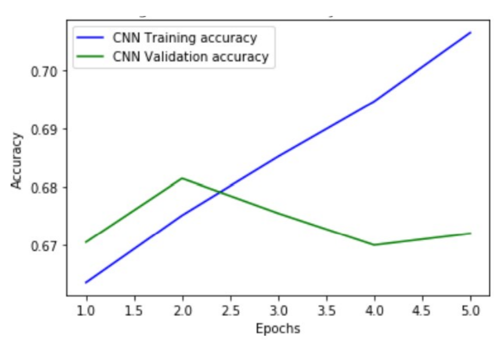
6. Max Pooling – Max Pooling acts as a filter that retrieves the maximum values from the image basically like a max-filter.

7. Tensorflow – Tensorflow is used as a backend and works with Keras.

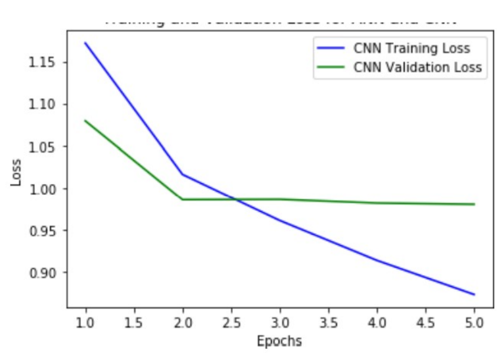
8. Pygame – Pygame is used to sound the alarm as soon as it is detected that the driver has fallen asleep.

V. Performance Evaluation

A. Accuracy



B. Loss

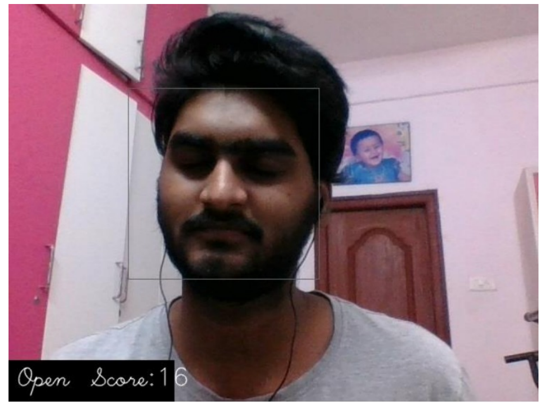


VI. Experimental Results and Discussion

Dataset Used

The dataset used for this model is created by us. To create the dataset, we wrote a script that captures eyes from a camera and stores in our local disk. We separated them into their respective labels 'Open' or 'Closed'. The data was manually cleaned by removing the unwanted images which were not necessary for building the model. The data comprises around 7000 images of people's eyes under different lighting conditions

Experimental Results



Explanation and Interpretation of results

The results of detecting a drowsy driver is a beeping noise that grows louder and louder until the user opens his eyes back up and the score on the meter goes below the specified limit,i.e, 16. We can also observe a red outline on the camera feed. A previously set phone number will also receive an sms informing them of the situation of the driver.

Conclusion

This project suggests an algorithm for person dizziness identification using representation learning. A new perspective towards person dizziness identification is presented as features responsible for decision making are produced by leveraging multi-layer convolutional neural networks. Described model warns drowsy drivers with an alarm, after successful eye-detection and tracking with computer vision and deep learning techniques (CNN and Keras) with an accuracy of 88.5 percent. A model has been implemented using a curated dataset to detect facial features. Then the eyes were extracted from the face as our region of interest. This was used to determine whether a driver's eyes were open or closed. If they were closed for more than 15 seconds an alarm was rung. If the alarm isn't stopped after 20 seconds, a message is sent to an emergency contact of the driver. This will help bring down the percentage of road accidents that are caused due to sleeplessness and fatigue.

This paper has proposed a system for assisting driver to avoid major accidents caused due to drowsiness of driver and alcohol consumption by assisting his/her state. State of driver is identified using algorithms related to image processing. [9]A buzzer is used to alert the driver if he/she is drowsy. With reference to the center of gravity the position of driver's head is determined and accordingly the current state of driver is identified. The movement of head is captured using a camera of appropriate resolution. A system gives extra feature of yawning detection. If a driver yawns more frequently than also an alarm is generated. A sensor is used to detect whether the driver is drunken or not. There should be proper distance between the sensor and the driver for accuracy. To inspire the driver to reach destination safely the alarm is generated which can be in the form of audio or vibration. Although there is need for more research, the proposed system can contribute effectively in detecting the driver's state and highly decrease the frequency of road accidents.

REFERENCES

[1] Makowiec-Dabrowska T. et al.: Zmeczenie praca u kierowców autobusów miejskich (Workfatigue in Urban bus driver", article of the Institute of Occupational Medicine im. Professor J. Nofer, Łódź 2015 (in Polish).

[2]Statistics related to fatique due to drivers Available – 2017.06.01: http://www.orlenbezpiecznedrogi.pl/downloads/material-backgroundowy.doc (in Polish).

[3]The fatique detection system implemented in cars Ford Available – 2017.06.01:http://www.technowinki.onet.pl/motoryzacja/system-monitorowaniakoncentracji-kierowcy-w-samochodzie-ford-focus/6f4kdg (in Polish).

[4]Algorytm Horn-Schunk Available – 2017.06.01: http://www.ee.pw.edu.pl/ jarek/Estymacja/hornSchunck.htm.

[5]Skoda brand fatique detection system Available – 2017.06.01: http://www.sklep.skoda.pl/upload/files/Fabia$_{3_a} kcesoria_2 015-01.pdf(inPolish)$.

[6]Bosch Drowsiness System Available – 2017.06.01: http://www.boschprasa.pl/informacja.php?idinformacji=1356.

[7]Pawelec J., Krawczyk Z.: Bezpieczeństwo w ruchu drogowym. Możliwości i przykłady zastosowań nowych technologii", Transcomp – XIV International Conference Computer Systems Aided Science, Industry and Transport.

[8] View at driver fatigue information (Ford Driver Assistant) Available – 2017.06.01: https://cbsdetroit.files.wordpress.com/2011/10/fordwarning.jpg?w=601.

[9]Information about the vision system for fatique detection Available – 2017.06.01: http://www.neuroblog.pl/video/kamera-monitorujace-emocjekierownica/ (in Polish). 47

[10] Information about the video fatique detection system Available – 2017.06.01: https://actu.epfl.ch/news/tracking-facial-features-to-make-driving-safer-and/ (in Polish).