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Driver Drowsiness Detection Techniques: A Survey

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Abstract: ***In today's world there are many driver assistance systems in existence. These systems include devices like GPS, music system, Bluetooth calling through car speakers, etc. Although these systems add up to the driver's satisfaction, they also are at times responsible for his / her distraction. These distractions cause major chunk of the road accidents. Also, driver drowsiness / sleepiness is also considered as one of the major reason for fatal road accidents. In this paper we try to address this issue by surveying various techniques / methods to detect the drowsy state of driver. We have compared the features of these methods depending on their cost effectiveness and accuracy.***

Keywords: Image processing, Computer Vision, Face detection, Region of Interest, Landmark detection, Eye-Aspect-ratio, Haar-Cascade classifier, PERCLOS

1. Introduction

The rapid growth in transportation industry recently has lead to more number of vehicles running on roads. And that has resulted in tremendous increase in number of road accidents. The Transport Research wing under Ministry of Road Transport & Highways, Government of India, published a report in 2016 which revealed that more people died on roads accidents as compared to the number of deaths in 2015.[11] There is a road accident every 4 minute in India. Drivers driving vehicles in drowsy or a sleepy state is one of the major reasons of road accidents. A driver can get drowsy for various reasons such as fatigue,less sleep, alcohol consumption, continuous driving for a long time, medical conditions or age. Accidents caused due to drowsiness of the driver have high fatality rate as driver's ability to recognise danger and control the vehicle is very less. Drowsy drivers tend to react slowly due to lack of attention. To prevent accidents caused by drowsiness of driver, we first need to detect the sleepiness in driver and then wake the driver up from sleepy state.

2. Types of measures for detecting drowsiness

2.1. Vehicular Measures

Vehicular measures can further be classified into following two categories:

2.1.1 Driver operating behavior
2.1.2 Vehicle operating behavior

The common vehicle motion parameters are Steering wheel, Accelerator, Brakes, Shift lever, Lateral position, Yaw rate, Speed, Lateral and longitudinal acceleration.

2.1.1. Driver operating behavior

i) Steering wheel
The Ideal frequency of rotation of the steering wheel is between 20-60 Hz and the ideal angle of rotation is +- 30 degrees.

A steering angle is the angle between the front wheels and steering of car.A steering ratio of p:q implies that for a turn of p degree(s) by the steering ,the wheel(s) turn q degree(s). In most of the passenger cars the ratio is between 12:1 and 20:1.A steering angle sensor (G85) can be used to detect angular variation of the steering wheel to generate signals at every pre-fixed angle of a steering angular variation. This indicates the direction toward which the steering angular variation occurs.

To detect frequency of steering operation, a detecting circuit that responds to the sensor signals can be used to detect signals within a given period of time hence to issue a warning signal when the detected frequency of steering operation exceeds a predetermined warning threshold value, and producing a warning in response to the warning signal.

ii) Lateral acceleration
Lateral acceleration acts on a car in the side direction to the direction of travel. It is a centrifugal force that pulls the car outwards while taking turns. Here we can make use of Lateral acceleration sensor(G200) to measure the lateral acceleration acting on car for calculating its actual position.

iii) Yaw rate acceleration
Yaw rate is angular velocity around vertical axis of the car.Yaw rate sensor measures rotational speed and is deployed at the same space as the lateral accelerator sensor. The Piezoelectric sensor is a type of yaw rate sensor. It has 4 piezo elements (two on top, two below)and has a shape of tuning fork.During rotation, the upper ones produce AC voltage.The sign of output signal is based on the left or right direction.

iv) Brakes
Brake pressure sensors can be used (G201) which converts pressure into analog signal.It is used in correspondence with distance sensor (in front of the vehicle).Calibrated amount of pressure is needed depending on which the proximity to vehicles is calculated and then, proper signals are generated. We have Automatic braking system which gradually decelerate the car after detection of driver drowsiness.The main component used is Servomotor (or Stepper Motor) which can be mounted on pedal of brake.The servo motor gets the input from microcontroller and with the required Pulse Width Modulation (PWM) signal the angle of the servomotor can be changed and variations can be done with respect to time and situation. When servo motor reaches 90 degree, the vehicle is in halt position.

2.1.2. Vehicle operating behavior

Lane deviation

The camera sensor is usually placed on the vehicles. The camera monitors the lane tracking by image processing algorithms to determine deviation which can be used to conclude as drowsiness or distraction. [8] In this system, lane crossing calculators and lane keeping detection system detect the lane boundaries. The lanes are always parallel but the marking size is very irregular. Also the slope of lanes is not constant. Hence, we use the warp perspective mapping, by which the original image with perspective view is rectified.

For detecting the lane deviation two types of sensors,active and passive. In active type we have the Radar based on Radio waves and Lidar(Light Detection and ranging).In passive type we have optical sensors.Vehicle's position in its lane can be monitored. When the function detects that the vehicle is about drift off the lane unintentionally,the driver is made alert by means signals (visual, audible or haptic signal)

2.2. Behavioural Measures

Behavioural measures include monitoring various behavioural changes in the driver while he is drowsy. It monitors the exterior changes in the driver. Exterior changes mainly constitute to the facial features. Facial features mainly include the eye-blink, yawning, head pose, etc. All these features can be monitored by a camera. The camera is kept in front of the driver monitoring his face. The frames extracted from the camera are then processed using image processing techniques. These techniques can be classified in following categories.

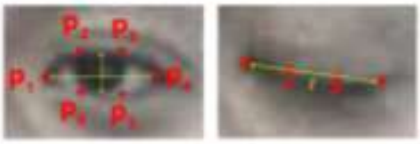
2.2.1. Template Matching based Technique:

This technique uses the templates of both open and close eyes. This technique first needs us to detect the face region, called as the region of interest (ROI). This ROI will then be given to the eye detection algorithm that will detect the eyes. Once the eye is detected it is matched with the template stored in the form of open eye and close eye. If the eye region matches the open eye template more than the close eye template, then the eye is detected to be open and vice versa as per [1].

2.2.2. Eye Blinking based Technique:

In this technique as well, the calculation of ROI is an essential step. Once the ROI is detected, it is given to the face landmark detection algorithm.[3] This algorithm detects 128 landmarks on the face region i.e. ROI. But, it's Dlib implementation detects 68 face landmarks, out of which 12 are eye landmarks. [2] Once we have these landmark points on the eye, we measure the vertical distance as per following formula.[2]

$$EAR = \frac{||p2 - p6|| + ||p3 - p5||}{2||p1 - p4||}$$



It the calculated EAR is found to be below a threshold then the driver is said to be have blinked.

2.2.3. Yawning based Technique:

A person often yawns when he is drowsy. Whenever a person has his mouth wide open vertically, we can he is yawning. This can be easily differentiated from speaking. To detect yawn we first need to apply face tracking followed by yawn tracking. In paper [4], they detect yawning based on the mouth opening rate and the mouth contour area changes.

2.3 Physiological Measures

One approach to detect sleepiness in driver is to measure physiological factors of driver such as pulse rate, heart rate, brain wave signals, etc.

Physiological changes can be measured by using following instruments:

i) EEG (electroencephalogram)
ii) EOG (electro oculogram)
iii) ECG (electrocardiogram)

i) EEG (Electroencephalogram) or brain-wave sensor

Our brain generates small electrical voltages which can be captured by EEG sensor[6]. This instrument tracks and records brain wave patterns. Small metal discs with thin wires (electrodes) are placed on the scalp, and the signals obtained from the instrument are sent to a processor after conversion into a control signal[6].

Normally a recognizable pattern can be observed in electrical activity of the brain. In a sleepy state different patterns in EEG signal are observed.

ii) EOG (Electro-oculogram)

EOG is a technique for measuring the corneo-retinal standing potential that exists between the front and the back of the human eye (Wikipedia).

EOG helps in detecting eye movements many eye related features can be extracted such as closeness of eye, blinking, blink rate, PERCLOS(percentage of eyelid closure) etc [6].These features give very accurate and fast measures regarding sleepy state of a person but the electrodes of this instrument need to be attached directly on the face i.e. one above the eye and one below the eye.This implementation is practically impossible in real world as it would be uncomfortable for the driver to wear such sensors.

iii) ECG (electrocardiogram): Heart rate and pulse rate
Heart rate is a high precision indicator of sleepiness. When a person is sleepy or drowsy heart rate of the person decreases and variability in heart rate increases. Also a person's respiration is flat and slow when he is drowsy.

Heart rate sensors can be installed in the steering wheel of car or electrodes need to be directly connected to the chest or back. Though this method is faster and precise, it cannot be completely relied upon, as heart rate of a person also depends on person's age and medical conditions.

Though this approach provides most accurate results of all methods, it needs the sensors to be in physical contact with driver's body. Hence this approach requires instruments which are costly, difficult to use and uncomfortable to the driver.

3. Conclusions

We have reviewed various techniques for detecting driver drowsiness and concluded that different techniques are suitable in different conditions. The EEG based technique is not suitable in real time applications as drivers often refuse to wear electrodes even though it is efficient. Also, vehicular based measures do not give accurate results. Hence image processing based methods are very famous among researchers. Although they are not as accurate as EEG, they are much simpler and user-friendly. Also, they give better results than vehicular measures. It's complexity increases if driver is wearing spectacles, but researchers are working on to remove this drawback. So, driver drowsiness detection using image processing is a very efficient way both in terms of cost factor as well as efficiency.

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