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# Drowsiness Detection based on Eye Movement, Yawn Detection and Head Rotation

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## ABSTRACT
Research shows that driver fatigue is one of the major reasons of road accidents. In this paper, we discuss our system which can be used to measure the level of alertness of the driver based on some critical physiological parameters. The system will analyze these parameters and accordingly issue an audio warning to the driver in case significant drowsiness is detected. The system is a software prototype of this system in vehicles, where images that are captured will be processed using image processing techniques and accordingly issue warning. The overall goal of the system is to reduce the number of accidents, and therefore improve the worsening road conditions.

## General Terms
Image Processing, algorithms

## Keywords
Drowsiness, face detection, eye blink rate, yawn detection, head rotation

## 1. INTRODUCTION
Most of the fatal road accidents occur at speeds greater than 70 kmph. The World Health Organization (WHO) has reported that India has the worst road conditions in the world in 2010 and 2011 with over two and a half lakh deaths [1]. Research shows that driver fatigue and drowsiness is one of the major reasons for these increasing accidents [2]. Drowsiness Detection is part of research under advanced safety vehicles, so as to minimize these accidents by continuously monitoring the state of the driver. Our system is development of a prototype of drowsiness detection system for vehicles.

The system will use a small security camera that helps to detect and track the drivers face, eyes and mouth. For the purpose of processing, four key measures will be used to help detect drowsiness, viz eye blink rate, eye closure duration, yawn detection and head rotation. Each of these algorithmic components will be integrated into the main system, and their collective outputs will be compared with standard levels studied by research and help decide the level of drowsiness in the driver. In case drowsiness is detected, an appropriate warning is issued to alert the driver through an appropriate audio signal.

Section 2 describes in brief the study on existing systems and also mentions the pitfalls of these systems. Section 3 provides the proposed solution, the proposed system architecture and how problems can be solved. Section 4 describes the software design and algorithms, along with one module explained. Section 5 shows results of the tests conducted on the system developed, also explains the same. Section 6 describes the benefits of the proposed systems.

## 2. EXISTING SYSTEM
The existing systems in this domain which have already been developed and used can be broadly classified into two types, intrusive and non-intrusive systems.

### 2.1 Intrusive Systems
These systems, while being the most accurate are annoying to the driver because electrodes have to be connected directly to the driver's body to measure his physiological characteristics, and accordingly detect drowsiness.

### 2.2 Non-intrusive Systems
This type of system is better suited for real world conditions, since it does not distract the driver. It measures the level of alertness of the driver by monitoring steering wheel movements, braking patterns, and also tracking road lane view[3]. The driver is alerted accordingly, through visual and audio signals. Some of the major automobile brands which use this kind of system are Mercedes Benz (Attention Assist [3]), Volvo (Driver Alert Control [4] ) and Ford (Driver Alert [5] ).

In intrusive systems, Because of electrodes that have to be connected to the driver's body at all times, it becomes a distraction. Also, after long hours, perspiration and other factors may not allow the system to function effectively.

Non-intrusive systems that have been developed are specific only to certain major automobile brands like Mercedes Benz and Volkswagen. Moreover, even in these brands, it has been implemented only in some of the models and not across the range, making it more of a luxury option. Also, the amount of research and investment in this technology is much higher.

## 3. PROPOSED SOLUTION
So, the aim of our system is to overcome these pitfalls, i.e. to develop a system which is non-intrusive, not specific to luxury brands and fairly cost efficient. The proposed solution will consist of a camera which will continuously capture video of the driver's face. The video will then be broken down into frames for processing. Algorithms such as face detection, eye detection and mouth detection will help track the drover's face, eyes and mouth respectively.
The four prominent measures of detecting drowsiness are as follows:

### *Duration of eye closure*
The first criterion is the duration of eyelid closure. It is used as a distinctive characteristic to judge whether a driver is drowsy or not. General Duration of closure is 0.15 to 0.25 seconds [6].

### *Frequency of eye blinks*
Low Eye blink frequency can help in drowsiness detection. [6]

### *Detection of yawning*
Yawning is detected by means of ratio between mouth height and width. [7]

### *Head rotation*
In case the eyes are not detected due to rotation of head or driver's face drooping down when he is completely asleep.

All the outputs from these four components will be computed and compared to accurately judge whether the driver is drowsy. The system will also have an audio signal generator which will be used to alert the driver in this case. The following diagram shows the proposed system architecture and the various stages. The first two stages, as shown, deal with capturing video input and then breaking into images for processing. The next stage is the drowsiness measuring module, which takes input from the sub-modules discussed above. The last stage is generation of an audio warning in case drowsiness is detected.

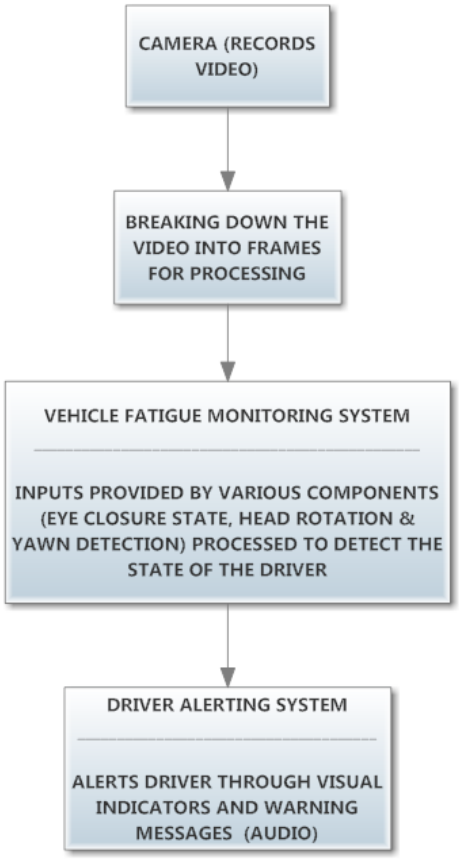


**Fig 1: Proposed System Architecture**

## 4. SOFTWARE DESIGN MODULES
Intel's Open Computer vision library (OpenCV) is a library of programming functions for real time computer vision.[9] It can be integrated completely with most of the integrated development environments (IDE) to work towards effective processing of images.

Through the OpenCV library, support provided for face detection, eye detection and mouth detection can be used, wherein the face, eyes and mouth of the driver can be tracked. A number of algorithms are available for these detections; the algorithm we have used is based on Haar classifiers. The core basis for Haar classifier object detection is the Haar-like features. These features, rather than using the intensity values of a pixel, use the change in contrast values between adjacent rectangular groups of pixels. [8]
The following figure shows detection of eyes as a subsequent step after face detection.


**Fig.2: Eye Identification**

After detection of face, eyes and mouth, techniques for measuring blinking, yawning and head rotation need to be implemented to compute the final result.

The steps for one of the modules of the system are shown in the diagram below. The module shows steps used in measuring duration of eye closure

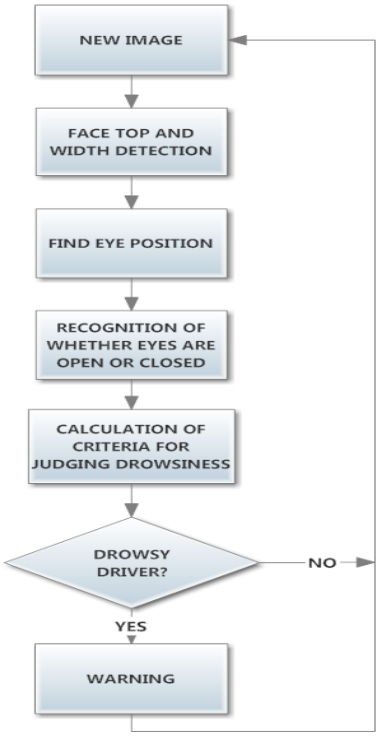


**Fig 3: Measuring eyes closure duration**

The steps shown in the figure above are specific only to the module measuring eye closure duration, though some of the steps shown above, such as face detection and warnings will remain the same for all the modules.

## 5. EXPERIMENTAL RESULTS

Results of our system developed have been added with snapshots of the person's features detected along with the warning messages that will be displayed for drowsiness.

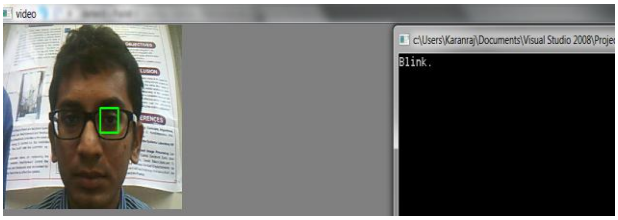


**Fig 4: Eye and blink detection**

As shown in the image above, the person's eye is detected, shown by the green rectangle drawn. Whenever he blinks, it detects and displays a message 'blink' on the screen. Although the person used for test has worn spectacles, our system detects eyes and blinks quite easily.

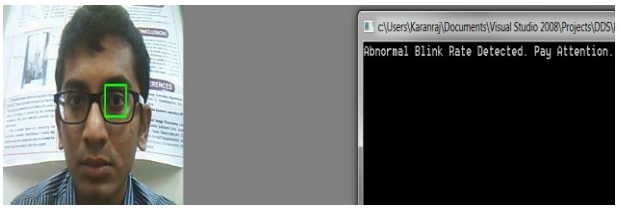


**Fig 5: Abnormal blink rate detection**

The figure above shows message of abnormal blink rate. Frequency of eye blinks is about 10 per minute [6]. In case of drowsy drivers, this normal rate reduces as they try to keep their eyes open without blinking. The system counts number of blinks, and computes the corresponding blink rate. Incase it is found abnormal, a message is shown and an audio warning is issued.


**Fig 6: Head rotation**

In case the driver rotates his head frequently or looks in another direction for a greater duration of time, his eyes are not detected and automatically the audio warning with the message is issued, as shown in the above figure.


**Fig 7: Sleeping driver**

If the driver doses off or closes his eyes for more than a few seconds, the system immediately issues a warning along with the message shown.

These system tests were conducted in conditions with reasonable illumination.

## 6. COMPARATIVE ANALYSIS

A major benefit of this system is that it can be expanded to every car model, since research isn't specific to any one brand, as compared to the present day systems in vehicles. Most of the big automobile brands carry out extensive research and heavy investment in development of their systems. The implementation of the system discussed is simple and hence does not require heavy investment in research, so it is more cost effective. The system is tested under various conditions and with diverse people with different skin tones and characteristics. Since number of test cases is adequate, the system is robust. The camera will track the drivers' face in a completely non intrusive manner, thereby ensuring maximum safety during driving and no potential threat due to disturbance. Also, the camera can be positioned such that it can easily detect the driver's facial features. The biggest advantage of this system is the fact that it is a software prototype. It can be used and modified to suit various other domains such as e learning, military systems, and surveillance systems. It could also be integrated with various hardware devices for certain specialized use.

## 7. CONCLUSION

Drowsiness is one of the measures of driver fatigue, which is the cause of most of the accidents on our roads. This system is a step in the direction of bringing about a positive change for better equipped vehicles, which will alert drivers in case drowsiness is detected and avoid a potential accident. Four parameters have been used to measure drowsiness, and their computed outputs together help to get the result. The system can also be extended once complete, to suit vehicle specific needs and integrate it with the other mechanical components to yield better results**.**

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**Aditya Shah** is pursuing engineering in Information Technology from D.J. Sanghvi College, University of Mumbai and is currently in the final year. His areas of interest are image processing, web technologies and Information Technology in Management.

**Neepa Shah** has more than ten years teaching experience in the field of Computer Engineering and Information Technology. She obtained B. E. (Computer) from SESCOE, Pune University in 2001. She obtained M.Tech.(Computer) Degree from NMIMS's MPSTME in 2008. Currently, she is working as Assistant Professor in the Department of Information Technology at D. J. Sanghvi College of Engineering. She is persuing Ph. D. from NMIMS's MPSTME. She has total of seven papers at National and International conferences. Her interest areas are Parallel processing, Data mining and semantic web.