Accident Prevention Using Eye Blinking and Head Movement

Abhi R. Varma
B.E Electronics Engg.
Pravara Rural Engineering College, Loni

Seema V. Arote
Asst. prof Electronics Dept.
Pravara Rural Engineering College, Loni

Chetna Bharti
B.E Electronics Engg.
Pravara Rural Engineering College, Loni

Kuldeep Singh
B.E Electronics Engg.
Pravara Rural Engineering College, Loni

ABSTRACT
This paper describes a real-time online prototype driver-fatigue monitor. It uses remotely located charge-coupled-device cameras equipped with active infrared illuminators to acquire video images of the driver. Various visual cues that typically characterize the level of alertness of a person are extracted in real time and systematically combined to infer the fatigue level of the driver. The visual cues employed characterize eyelid movement, gaze movement, head movement, and facial expression. A probabilistic model is developed to model human fatigue and to predict fatigue based on the visual cues obtained. The simultaneous use of multiple visual cues and their systematic combination yields a much more robust and accurate fatigue characterization than using a single visual cue. This system was validated under real-life fatigue conditions with human subjects of different ethnic backgrounds, genders, and ages; with/without glasses; and under different illumination conditions. It was found to be reasonably robust, reliable, and accurate in fatigue characterization.

General Terms
Security, Artificial intelligence, Movement detection.

Keywords
Driver vigilance, Human fatigue, Probabilistic, Intelligence.

1. INTRODUCTION
The ever increasing numbers of traffic accidents all over the world are due to diminished driver's vigilance level. Drivers with a diminished vigilance level suffer from a marked decline in their perception; recognition and vehicle control abilities & therefore pose a serious danger to their own lives and the lives of the other people. For this reason, developing systems that actively monitors the driver's level of vigilance and alerting the driver of any insecure driving condition is essential for accident prevention. Many efforts have been reported in the literature for developing an active safety system for reducing the number of automobiles accidents due to reduced vigilance. Drowsiness in drivers can be generally divided into the following categories:

- Sensing of physiological characteristics.
- sensing of driver operation
- Sensing of vehicle response.
- Monitoring the response of driver.

Among these methods, the techniques based on human physiological phenomena are the most accurate. This technique is implemented in two ways:

- Measuring changes in physiological signals, such as brain waves, heart rate, and eye blinking.
- And measuring physical changes such as sagging posture, leaning of the driver's head and the open/closed states of the eyes.

The first technique, while most accurate, is not realistic, since sensing electrodes would have to be attached directly on to the driver's body, and hence be annoying and distracting to the driver. In addition, long time driving would result in perspiration on the sensors, diminishing their ability to monitor accurately. The second technique is well-suited for real world driving conditions since it can be non-intrusive by using video cameras to detect changes. Driver operation and vehicle behavior can be implemented by monitoring the steering wheel movement, accelerator or brake patterns, vehicle speed, lateral acceleration, and lateral displacement. These too are nonintrusive ways of detecting drowsiness, but are limited to vehicle type and driver condition. The final technique for detecting drowsiness is by monitoring the response of the driver. This involves periodically requesting the driver to send a response to the system to indicate alertness. The problem with this technique is that it will eventually become tiresome and annoying to the driver. The propose system based on eyes closer count & yawning count of the driver. By monitoring the eyes and mouth, it is believed that the symptoms of driver fatigue can be detected early enough to avoid a car accident. The eye blink frequency increases beyond the normal rate in the fatigued state. In addition, micro sleeps that are the short periods of sleep lasting 3 to 4 seconds are the good indicator of the fatigued state, but it is difficult to predict the driver fatigue accurately or reliably based only on single driver behavior. Additionally, the changes in a driver's performance are more complicated and not reliable so in this system second parameter is also considered which a yawning count is. In order to detect fatigue probability the facial expression parameters must be extracted first.

2. CONCEPT
Sleep related accidents tend to be more severe, possibly because of the higher speeds involved and because the driver is unable to take any avoiding action, or even brake, prior to the collision. Horne describes typical sleep related accidents as ones where the driver runs off the road or collides with another vehicle or an object, without any sign of hard braking before the impact. In 2002, the National Highway Traffic Safety Administration (NHTSA) estimated that 35 percent of

all traffic deaths occurred in crashes in which at least one driver or no occupant had a BAC(Blood Alcohol Content) of 0.08 percent or more and that any alcohol was present in 41 percent of all fatal crashes in 2002.Such statistics are sometimes cited as proof that a third to half of all fatal crashes are caused by "drunk driving" and that none of the crashes that involve alcohol would occur if the alcohol were not present. But this is incorrect and misleading because alcohol is only one of several factors that contribute to crashes involving drinking drivers. Furthermore, some fatally injured people in alcohol-related crashes are pedestrians with positive BACs, and these fatalities still would occur even if every driver were sober. Distracted driving is a top danger behind the wheel. In fact, about eight out of 10 crashes involve some sort of driver inattention within three seconds of that crash. We've all seen it and likely even done it, driving distracted includes anything from talking on the phone, to messing with your music, to attending to your children or even pets. All of these actions can lead to serious consequences. Martha Meade with AAA Mid-Atlantic says, "People are dying because of a simple missed phone call, a dropped toy or some other event that is completely not important." Possible techniques for detecting drowsiness in drivers can be generally divided into the following categories: sensing of physiological characteristics, sensing of driver operation, sensing of vehicle response, monitoring the response of driver:

2.1 Monitoring Physiological Characteristics:

Among these methods, the techniques that are best, based on accuracy are the ones based on human physiological phenomena. This technique is implemented in two ways: measuring changes in physiological signals, such as brain waves, heart rate, and eye blinking; and measuring physical changes such as sagging posture, leaning of the driver's head and the open/closed states of the eyes. The first technique, while most accurate, is not realistic, since sensing electrodes would have to be attached directly onto the driver's body, and hence be annoying and distracting to the driver. In addition, long time driving would result in perspiration on the sensors, diminishing their ability to monitor accurately. The second technique is well suited for real world driving conditions since it can be non-intrusive by using optical sensors of video cameras to detect changes.

2.2 Other Methods:

Driver operation and vehicle behaviour can be implemented by monitoring the steering wheel movement, accelerator or brake patterns, vehicle speed, lateral acceleration, and lateral displacement. These too are non-intrusive ways of detecting drowsiness, but are limited to vehicle type and driver conditions. The final technique for detecting drowsiness is by monitoring the response of the driver. This involves periodically requesting the driver to send a response to the system to indicate alertness. The problem with this technique is that it will eventually become tiresome and annoying to the driver.

3. EYE BLINK DETECTION

It is necessary in our working to find the blinking of eye, since it is used to drive the device and to operate events. So blink detection has to be done, for which we can avail readily available blink detectors in market *(Catalog No. 9008 of Enable devices)* or we can incorporate it with a special instruction written in image processing that, if there is no pupil found for the certain period of pre-determined i.e. time greater than the human eye blinking time then consider an event called "blink", for which the set of operations will be followed. Here, in this case we need to set time as 1 second or above it, as "blink event" is different from "normal eye blinking". We need to perform testing for only blink event estimation, and not to find normal eye blinking.

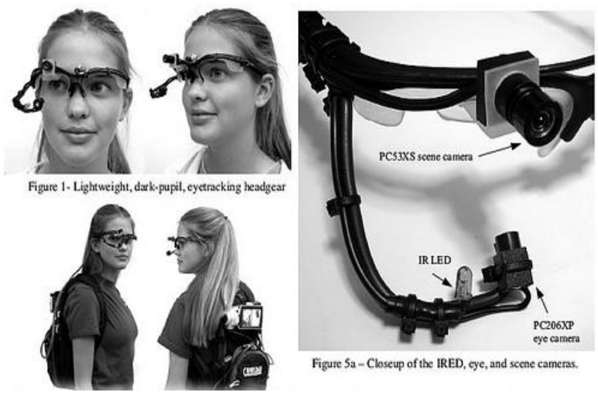

Fig. 1. Module for eye blinks detection

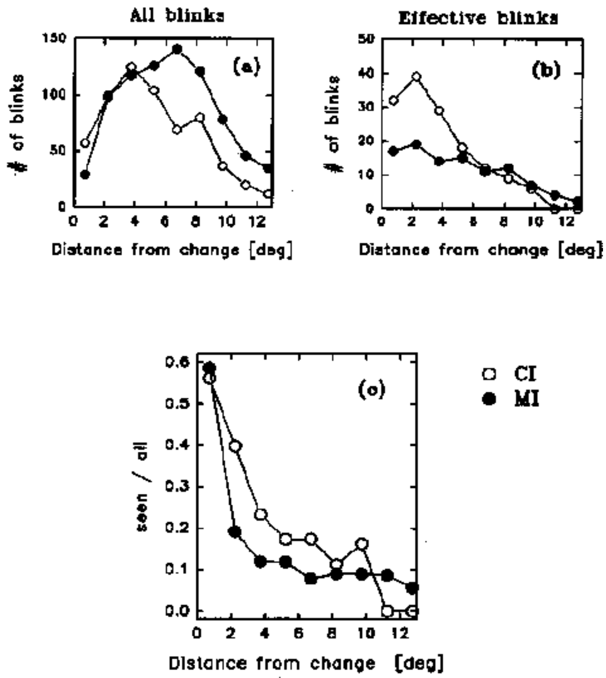

Fig. 2. Shows The Different Blinks

Fig 1 shows the setup of IR sensors & camera module that is to be used by the driver for Eye blink detection. Fig 2. Shows the different blink events which differ from normal blinking of eye using cumulative index (CI) & Mutual index(MI) which is obtained at receiver of IR sensor in terms of Current & voltage and plotted on graph. The signal can be smoothened using above graph to avoid unnecessary blinking event other than effective blinking event.

4. MOVEMENT DETECTION

Head movement detection is done through single step Accelerometer eg: ADXL330 which measures 3-axis detection. It consists of angle based accelerometer (ACC) input to simulate accurate head movement. Angle based approach does not require any pattern matching algorithms. ACC input signal is smoothened first to ignore any unwanted movement. Angle based model is believed to effective by researchers, which is debatable considering practical use of a single ACC sensor on head.

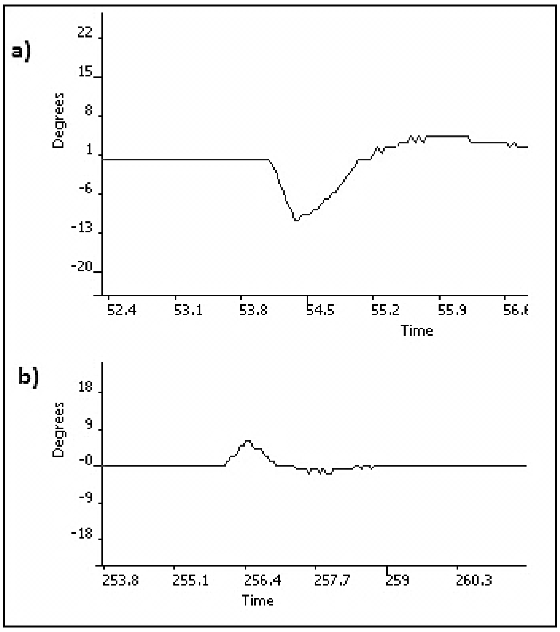

Fig. 3. Sample tilt angle versus time plots for (a) Left (b) Right turns

Fig 3. Shows the angle versus time plot for the movement detection in the two direction. The results obtained are test results for only one direction to smoothened the signal to avoid unwanted detection in movement other than effective movement.

4.1 Definition of Tilt Angle

This system uses head movements as the sole input method; more precisely head's tilt angles are used. Head tilt angles define how much the head is rotated along an axis. There are three possible head tilt movements, which are shown in Figure 4, and they are defined as:

- Pitch, the vertical head rotation movement (as in looking up or down)
- Roll, the head rotation that occurs when tilting head towards the shoulders

Yaw, the horizontal head rotation movement (as in looking to left or right).

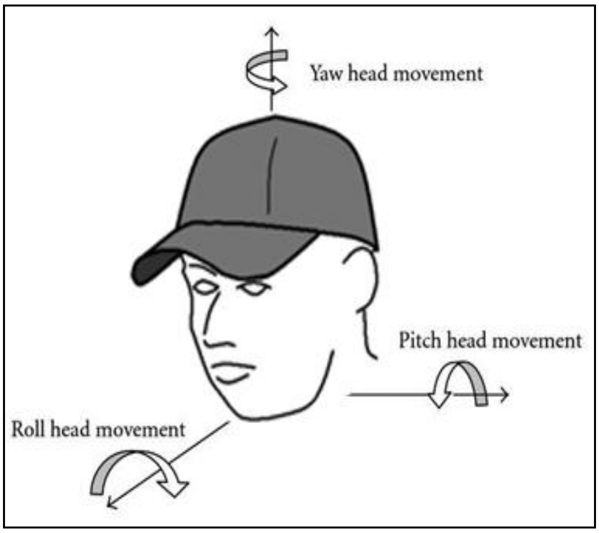

Fig. 4. Three possible head tilt movements

For the movement analysis, it is needed to somehow translate the tilt angle data to displacement of mouse cursor that is calculating new head position. There are two main methods when calculating the new head cursor position:

- Absolute mapping in which every tilt angle corresponds to a position on screen.
- Relative mapping in which every tilt angle corresponds to a head displacement amount (step size) and this amount is summed by the coordinates of the head's old position, to calculate new position.

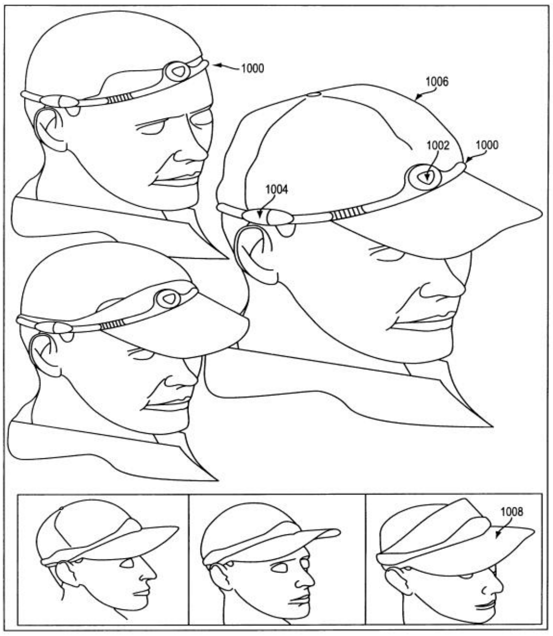

Fig. 5. Accelerometer Placement.

Fig. 5 shows the real time placement of the accelerometer on the driver head for the 3-axis detection of the head movement while driving to monitor fatigue by converting the angle based input to voltage output (in milivolts) for accurate detection.

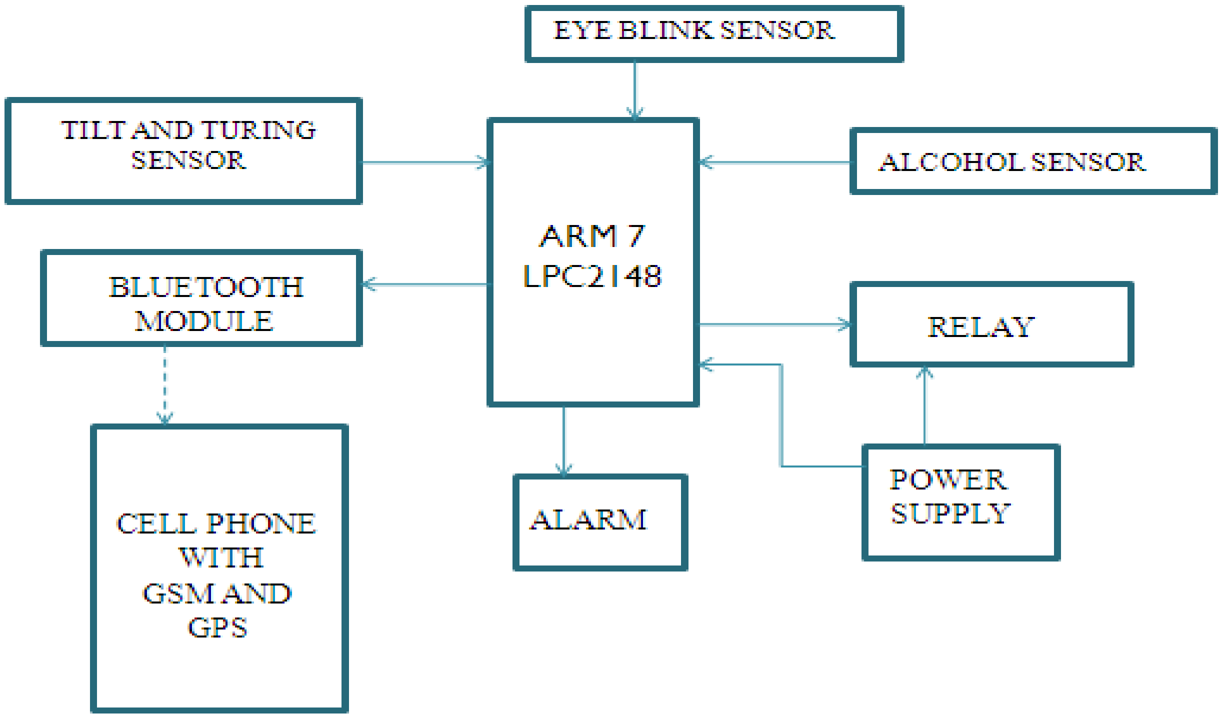

Fig 6: BLOCK DIAGRAM

5. COMPONENT DESCRIPTION

We have used following components:

1. ARM processor.
2. Pair of IR transmitter and receiver for eye blinks detection.
3. A sensor called MQ3 for the purpose of alcohol detection.
4. An accelerometer ADXL330 for head movement detection (tilting and turning of head).

5.1 Advantages

- Component establishes interface with other drivers very easily.
- Life of the driver can be saved by locking the ignition system of the car.
- Traffic management can be maintained by reducing accidents and traffic jams can be avoided.
- Using GPS & GSM exact location of the Car can be traced on MAP.

5.2 Application

- Automobiles.
- Security Guard Cabins.
- Operators at nuclear power plants where continuous monitoring is necessary.
- Pilots of airplane.
- Military application where high intensity monitoring of soldier is needed.

5.3 Future Scope

- This system only looks at the number of consecutive frames where the eyes are closed. At that point it may be too late to issue the warning. By studying eye movement patterns, it is possible to find a method to generate the warning sooner.
- Using 3D images is another possibility in finding the eyes. The eyes are the deepest part of a 3D image, and this maybe a more robust way of localizing the eyes.
- Instead of alarm we can use Automatic Braking System which will reduce the speed of the car.
- We can automatically park the car by first using Automatic braking system, which will slow down the car and simultaneously will turn on the parking lights of the car and will detect the parking space and will automatically park the car preventing from accident.
- Using Pressure sensor on the steering alarm or Automatic braking System can be set in case of drowsiness.
- By using wire-less technology such as Car Talk2000 If the driver gets a heart attack or he is drunk it will send signals to vehicles nearby about this so driver become alert.

6. RESULTS

Some of the results of eye blink detector through graph are given below:

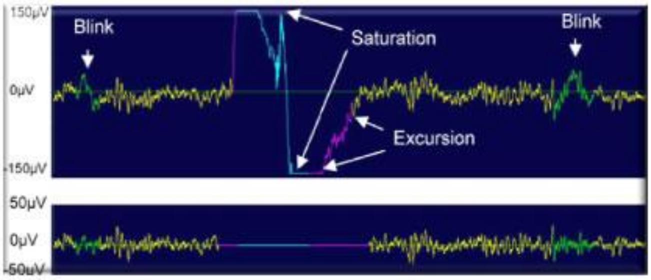

Fig. 7. Show Eye Blink

Fig. 7. shows the saturation & excursion effects occurred before and after the blinking of eye to smoothen the signal.

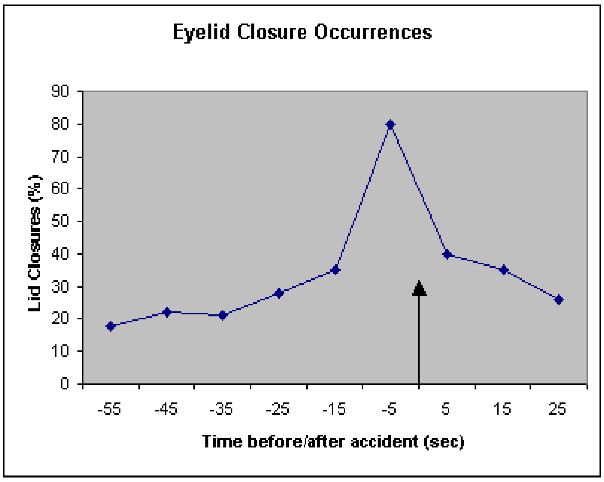

Fig. 8. Eyelid Closure Occurrences

Fig. 8. shows the "effective blinking event" for which lid closure is set 40% of closing of eye & above which if eye lid closes the event is occurred. Fig shows the lid closure % versus Time before/after accident meanwhile which the time is used to prevent the accident by using various techniques for eg: Buzzing the Alarm, Making Fake call on drivers mobile, etc using various self developed algorithms.

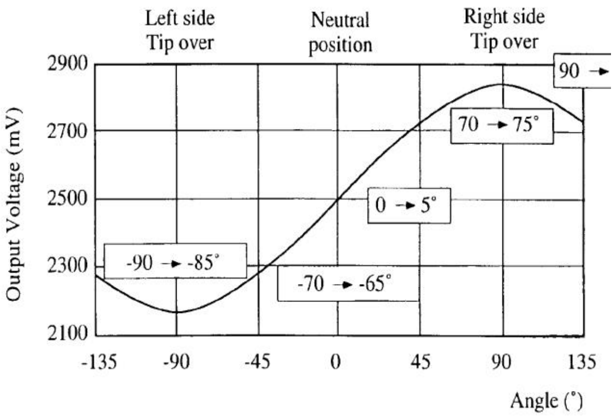

Fig. 9. Accelerometer detection using reference angle

Fig.9. shows the head movement detection in which the voltage changes w. r. t change in accelerometer angle. Initially 0V is set at 5° i.e. at neutral position. Change in head movement beyond certain specified limits changes the output voltage & hence head movement is detected.

7. CONCLUSION

Eye based control will be the future of all types of device control, thus making the operation so comfortable and much easier with less human presence. Several risk operations can be easily performed with this type of application and further research and study on these areas will create a new trend of interacting with machines. Hence, a system to monitor fatigue by detecting eye blink & head movement was developed using self developed algorithms.

8. ACKNOWLEDGMENTS

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