Intel-Eye: An Innovative System for Accident Detection, Warning and Prevention Using Image Processing (A Two – Way Approach in Eye Gaze Analysis)

B. Bhavya and R. Alice Josephine

***Abstract*—Driver in-alertness is an important cause for most accidents related to vehicle crashes. Drowsy driver detection methods can form the basis of a system to potentially reduce accidents related to driver doziness. Intel-Eye describes a real-time online driver in-alertness and shock related facial expression monitoring methods. Intel -Eye obtains visual cues such as eyelid movement; gaze movement, head movement, and facial expression 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. Intel-eye distinguishes itself by the Two-Way Approach in eye gaze analysis. Shock analysis is done to identify the driver's expression during a head on collision and signals are sent for automatic braking system. A probabilistic model is developed to model in Intel-Eye and it's used for predicting human in-alertness 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 and shock characterization than using a single visual cue. Percent eye closure (PERCLOS) [1] is also determined. Intel-Eye system is efficient under real-life fatigue conditions i.e. human subjects with/without glasses under different illumination conditions. Intel-Eye uses the two way approach when compared to other existing systems, it's main advantage is to analyse the shock expression and send signals to deviate the behind vehicles and avoid the collision directly by shifting movement. It is deemed to be reasonably robust, trustworthy, and precise in fatigue and shock characterization, detection and warning.**

***Index Terms*—Image processing, probabilistic model, shock analysis, PERCLOS.**

I. Introduction

The never ending saga of traffic accidents all over the world are due to deterioration of driver's vigilance level. Drivers with a depleting 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. Though advance safety features are provided such as advances in vehicle design, including the provision of seat belts and airbags and improvements in crashworthiness, have led to considerable casualty reductions in recent years. However, future increases in road traffic will make it difficult to meet future casualty reduction targets unless more advanced accident avoidance technologies can be introduced. Drowsiness [2] 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, the open/closed states of the eyes, trauma state expression in eyes seen through widening of gaze.

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 [3] by using image processing 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 [4] 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 is 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

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is. In order to detect fatigue and shock expressions probability the facial expression parameters must be extracted first.

II. Existing Systems for Detection

A. Electronic Stability Control

Electronic stability control (ESC) systems act on the braking or power systems of a vehicle to assist the driver in maintaining control of the vehicle in a critical situation(caused, for example, by poor road conditions or excessive speed during cornering). ESC usually acts by sensing wheel slip in individual wheels and reducing power or applying braking to one or more wheels to regain stability. ESC can reduce accidents by more than 20 percent in normal conditions and more than 30 percent in wet or icy conditions. It has been available on some cars for around 10 years, and costs have been reducing due to improved technology and increased volumes. A driver's state of vigilance can also be characterized by indirect vehicle behaviors like lateral position, steering wheel movements, and time to line crossing. There is an important Spanish system called TCD (Tech Co Driver) [5] based on steering wheel and lateral position sensors.

B. Advanced Emergency Braking Systems (AEBS)

Some vehicles are already fitted with systems which employ sensors to monitor the proximity of the vehicle in front and detect situations where the relative speed and distance between the two vehicles suggest that a collision is imminent. In such a situation, emergency braking can be automatically applied and the effects of the collision are either mitigated or avoided altogether. The capability of such systems could be expanded in the future to cover other types of accident (for example, pedestrian accidents or even head-on collisions). There are significant casualty savings to be obtained by equipping vehicle with these systems. The level of casualties saved depends on the type of vehicle and the level of capability of the system. Current systems do not always avoid collisions, but they ensure that the collision takes place at a slower speed thus mitigating injuries. Future systems should be able to avoid collisions altogether, including may collisions with pedestrians. That the highest benefit to cost ratios is likely to be achieved through fitting these systems to heavy vehicles due to the increased severity of front to rear collisions

III. Ideology

Doze 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. Typical paper articles describe 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. According to the U.S. National Highway Traffic Safety Administration (NHTSA), falling asleep while driving is responsible for major automobile crashes. Drowsy driving causes more than 100,000 crashes a year, resulting in 40,000 injuries and 1,550 deaths [6]. Distracted driving is another fiasco seen behind the wheel. Distracted driving is a dangerous epidemic on roadways. Reports say that, in 2010 alone, over 3,000 people were killed in distracted driving crashes in an industrialist nation like US. Department of Transportation in many countries is leading the effort to stop texting and cell phone use behind the wheel. Since 2009, UN has held two national distracted driving summits, banned texting and cell phone use for commercial drivers, encouraged states to adopt tough laws, and launched several campaigns to raise public awareness about the issue. In fact, about eight out of 10 crashes involve some sort of driver inattention within three seconds of that crash. 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 by analyzing the finer details of his eye expressions.

A. Keeping Tab on 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. Image processing techniques can also be incorporated. A representative project in this line is the MIT Smart Car [7], where several sensors (electrocardiogram, electromyogram, respiration, and skin conductance) are embedded in a car and visual information for sensor confirmation are used.

B. Two-Way Approach

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 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.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.

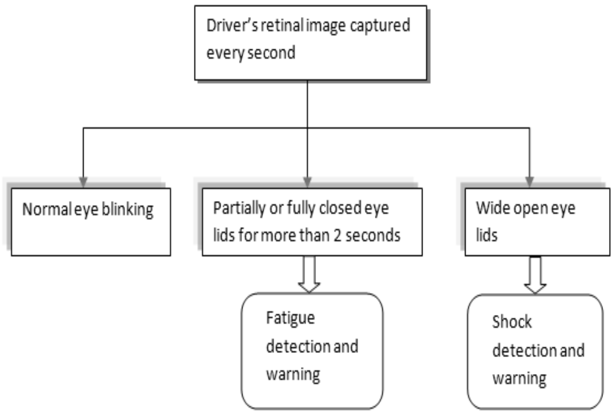


Fig. 1. Module for eye blinks detection.

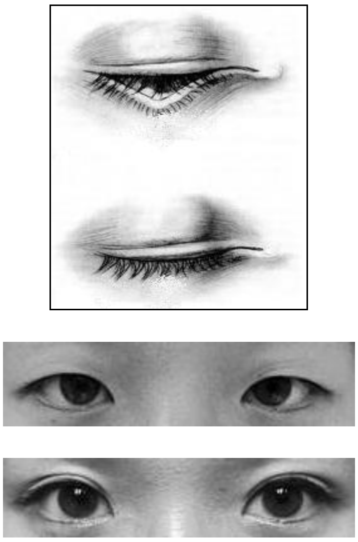
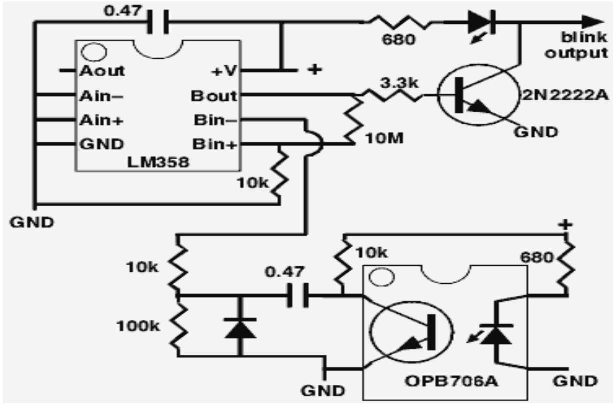


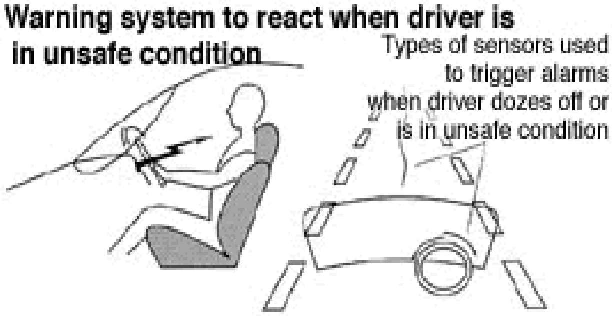
Fig. 2. Shows the different blinks.

IV. Eye-Blink and Motion Interface

The eye-blink and motion interface works by illuminating the eye and/or eyelid area with infrared light, then monitoring the changes in the reflected light using a phototransistor and differentiator circuit. The exact functionality depends greatly on the positioning and aiming of the emitter and detector with respect to the eye. For example, a relatively robust detection of blinking is easy to achieve by arranging the detector so that it is near the eyelid, mounting the detector to the rubber eyecup of an HMD has this effect. Detection of saccadic eye motion is more difficult but is still easier than detection of absolute position, due to the characteristically rapid change in the light reflected from the eye surface during the saccadic jumps. For saccadic detection the phototransistor and IR source are best separated, so that the corneal reflection is the main source of detected light. We have used the circuit of Fig. 5 with an assortment of emitter/detector pairs with good success. Although the OPB706A is specified in the schematic, we recommend experimentation with other components as they may better fit your application. For example, the Omron Electronics EE-SY124 is an emitter/detector pair in a 3 x 4 x 1.5mm package, which may better fit the available space in the eyecup of your HMD.



A. 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.

V. 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

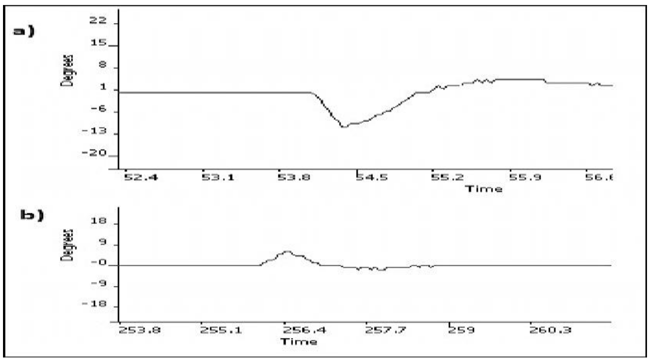
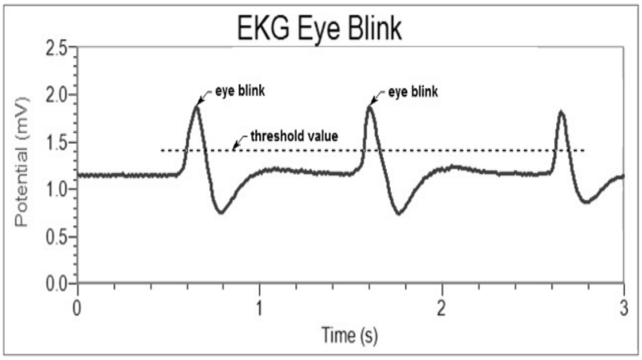


Fig. 3. Sample tilt angle versus time plots for (a) Left (b) Right turns.

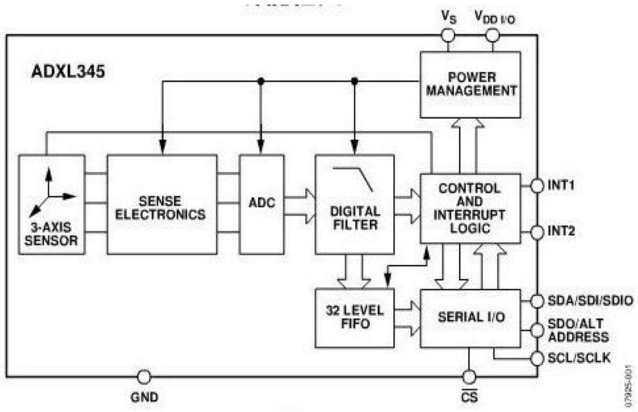
Fig. 3 Shows obtained test results for only one direction to smoothen the signal to avoid unwanted detection in movement other than effective movement.

A. Controlling a Circuit with the Blink of an Eye

LEDs (Light Emitting Diodes) are light sources made from a special semiconductor material that converts electrical current directly into light. You can turn an LED on and off by blinking your eye. An EKG sensor is normally used to record the muscle activity of the heart, but it can also record other electrical changes in your body, such as an eye blink. The retina of the eye maintains a charge across its surface giving the eyeball a small electrical dipole moment. The Vernier EKG Sensor is capable of detecting changes in this dipole moment as the eyes blink. When the eyes close a positive voltage pulse is produced in the EKG Sensor and as they reopen a pulse of opposite polarity is produced. As a STEM extension to the "Monitoring EKG" experiment, you will illuminate an LED in the Vernier Digital Control Unit (DCU) when you blink your eye.



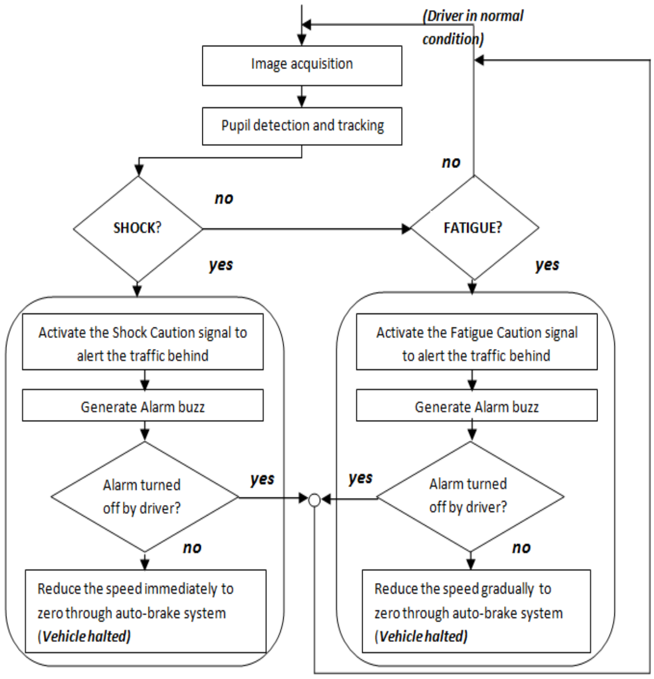
B. Accelerometer Adxl345



Advanced Automatic Collision Notification can be sent to cell phone using accelerometer ADXL345 which measures all accelerations, except those accelerations due to gravity.

VI. Proposed System

The general architecture of our system consists of four major modules: 1) image acquisition;2)pupil detection and tracking; 3) analyzing visual behaviors. The image acquisition is based on a low-cost charge-coupled device (CCD) micro-camera sensitive to near IR. The pupil detection and tracking stage is responsible for segmentation and image processing. The pupil detection stage is simplified by the "bright pupil" effect, similar to the red-eye effect in photography. We then use two Kalman filters in order to track the pupils robustly in real time. In the visual behavior stage, we calculate some parameters from the images in order to detect some visual behaviors easily observable in people experiencing fatigue: slow eyelid movement, smaller degree of eye opening, frequent nodding, blink frequency, and face pose. When the driver experiences a shock during a head on collision the widening of his eye gaze is measured i.e. a greater degree of eye widening is seen. The parameters obtained are sorted and correspondingly caution signals for fatigue and shock situations are sent. The shock caution signal is not only used to alert the driver it's also used to signal the vehicles behind. The fatigue caution signal generated an alarm to wake up the driver and it also slows down the vehicle as done in automatic braking systems. Despite all the warning signals if the driver continues to doze off, then the speed of the vehicle is graduated to zero. This is new breakthrough in accident avoidant systems proposed by Intel-Eye. Finally, in the driver vigilance evaluation stage, we fuse all individual parameters obtained in the previous stage using a two-way approach fuzzy system, yielding the driver inattentiveness level. An alarm is activated to signal other vehicles on road if the level of in-alertness exceeds a certain threshold.



Components Used

We have used following components:

- ARM processor.
- Pair of IR transmitter and receiver for eye blinks detection using image processing.
- An accelerometer ADXL330 for head movement detection (tilting and turning of head).
- EKG sensors for detection of eye blinks
- charged coupled device

Advantages

Component establishes interface with other drivers very easily.

Life of the driver can be saved by locking the ignition system of the car.

Driver entering stressed state can be identified by shock analyzers used in eye motion interfaces.

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.

AEBS are used to slow down the car when the system senses the driver's doze.

VII. 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.

VIII. Future Advancements

This system simply measures the eye gaze intensity and its physiological changes. So an interactive mobile app can be created instead of software which needs to be installed.

- 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.
- 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.
- By using wire-less technology such as Car Talk2000 If the driver gets a heart attack it will send signals to vehicles nearby about this so driver become alert.

IX. Conclusion

Intel-Eye based monitoring enabled through the use of image processing will be the future of all types of device control, thus making the operation so comfortable and much easier with less human presence, thus paving way for auto-driving in vehicles. Hence, Intel –Eye is developed to monitor fatigue and head on collision by detecting eye blink, eye gaze widening (when experiencing shock) & head movement was developed using self developed algorithms. Intel-eye is the need of the hour system which can be an inevitable part of our happy driving as it encourages getting distracted but with a stress on responsible driving.

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