Developing an Image Processing Based Real-Time Driver Drowsiness Detection System

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Abstract- Road accidents in Bangladesh and all over the world have been a major problem for a very long time. Thousands lost their lives and millions of people lose a livelihood annually because of road accidents. Fatigue, which causes drowsiness among other factors, is a key contributor to road accidents; this study aimed at making use of the available technologies to detect drowsiness among drivers at an early stage in order to prevent or reduce the impact associated with accident, this is achieved by warning the driver of his or her state when driving. Agile development is adopted in the development of the final product that targeted embedded devices. The final product registered good system performance with up to 85% drowsy cases detected by the system. This system can detect drowsiness and it can output audio feedbacks as warning. This is a prototype and which can be used in any kind of vehicle. High level programming and developed advanced technologies has been used to build this real time detection system.

Index Terms- Accident, Drowsiness, EAR, Face Recognition, Image Processing, OpenCV.

I. Introduction

Driver in-alertness is an important cause for most accidents related to the vehicle's crashes. Driver fatigue resulting from sleep deprivation or sleep disorders is an important factor in the increasing number of the accidents on today's roads. Drowsy driver warning system can form the basis of the system to possibly reduce the accidents related to driver's drowsiness. The purpose of such a system is to perform detection of driver fatigue. By placing the camera inside the car, we can monitor the face of the driver and look for the eye-movements which indicate that the driver is no longer in condition to driver is no longer in condition to drive. In such a case, a warning signal should be issued. This paper describes how to find and track the eyes. We also describe a method that can determine if the eyes are open or closed. The main criterion of this system is that it must be highly non-intrusive and it should start when the ignition is turned on without having at the driver initiate the system. Nor should the driver be responsible for providing any feedback to the system. The system must also operate regardless of the texture and the color of the face. It must also be able to handle diverse conditions such as changes in light, shadows, reflections etc. In given paper a drowsy driver warning system using image processing as well as accelerometer is proposed.

The innovations in the automobile industry over the last hundred years have made our vehicles more powerful, easier to drive and control safer more energy efficient, and more environmentally friendly. Majority of the accidents caused today by cars are mainly due to the driver fatigue. Driving for a long period of time causes excessive fatigue and tiredness which in turn makes the driver sleepy or lose awareness. With the rapid increase in the number of accidents seems to be increasing day to day. Therefore, a need arises to design a system that keeps the driver focused on the road. Data on road accidents in India are collected by Transport Research Wing of Ministry of Road Transport & Highways.

The aim of this paper is to develop a prototype of drowsy driver warning system. Our whole focus and concentration will be placed on designing a system that will accurately monitor the open and closed state of the driver's eye in real time. By constantly monitoring the eyes, it can be seen that the symptoms of driver fatigue can be detected early enough to avoid an accident. This detection can be done using a sequence of images of eyes as well as face and head movement. The observation of eye movements and its edges for the detection will be used. Devices to detect when drivers are falling asleep and to provide warnings to alert them of the risk, or even control the vehicle's movement, have been the subject to much research and development. Driver fatigue is a serious problem resulting in many thousands of road accidents each year. It is not currently possible to calculate the exact number of sleep related accidents because of the difficulties in detecting whether fatigue was a factor and in assessing the level of fatigue. However, research suggests that up to 25% of accidents on monotonous roads in India are fatigue related. Research in other countries also indicates that driver fatigue is a serious problem [1].

Driver alert systems offer a way to reduce the likelihood that a drowsy or fatigued driver will cause an accident due to sluggish reactions or dozing off. These systems are designed to detect the telltale signs of a drowsy or impaired driver, and then provide an alert or take some type of corrective action. Each system uses different methods of detection and correction, but they all share that same general purpose, fatigued and drowsy drivers suffer

from slower reaction times and that a large number of both fatal and non-fatal crashes take place during the nighttime and early morning hours when drivers are less alert. With these two pieces of information, it's reasonable to assume that a general increase in driver alertness could potentially save lives.
Adequate sleep and proper education on the dangers of drowsy driving are the best solutions to the problem, the reality is that drowsy and impaired drivers get behind the wheel every day. For those drivers, an effective driver alert system can easily be the difference between an uneventful drive and a catastrophic accident.
Young male drivers, truck drivers, company car drivers and shift workers are most at risk of falling asleep while driving. However, any driver travelling long distances or when they are tired, it is at the risk of a sleep related accidents. The early hours of the morning and the middle of the afternoon are the peak times for fatigue accidents and long journeys on monotonous roads, particularly motor-ways, are the most likely to result in a driver falling asleep. In this paper the algorithms for face detection and eye tracking have been developed on frontal faces with no restrictions on the background the proposed method for eye tracking is built into five stages. Using frontal images obtained from a database, the probability maps for the eyes region are built etc.
Driver alert systems are closely related to lane departure warning systems, in that most of them function by keeping visual track of lane markings to identify any deviations from the lane. While lane departure warning systems are designed to prevent deviation under any and all circumstances, driver alert systems are specifically aimed at identifying signs of driver fatigue.
Rather than triggering only when a vehicle is in danger of straying from its lane, these systems look for the sort of erratic movement typically associated with an impaired driver. Other systems take it a step further by monitoring the driver's eyes and face for signs of drowsiness. If the system determines that the driver is having trouble staying awake, it may take corrective action.
The simplest driver alert systems are typically mounted to the driver's head, like an earpiece, and use a simple motion or tilt sensor. If the driver's head nods, the device will usually sound an alarm.
Face Images Analysis Is A Research Area with Many Applications Such as Face Recognition, Human Identification Security Systems and Virtual Tools . In This Project We Will Mainly Focus On The Extraction Of The Eye Region, This Involves Considering The Entire Image Of The Face, And Then To Determine The Eye Region By Using A Self-Developed Image-Processing Algorithm And Once The Position Of The Eyes Are Located, The System Will Determine Whether The Eyes Are Opened Or Closed Along With The Position Of The Head And Accordingly Detect Fatigue. While Developing A Driver Monitoring System, Two Issues Such as Driver Fatigue Measurement and Distraction Detection Should Be Solved. And Our Proposed System Solves Both by Monitoring the State of Eyes We Can Trigger Warning If Driver Has Fallen Asleep. By Monitoring The Head Region in Particular Area Algorithm Can Monitor If Driver Is Alert or Not.

II. Literature Review

Drowsiness detection can generally be divided into the following classes. According to reference, they include: sensing of physiological characteristics, sensing of driver operation, sensing of vehicle response and monitoring the driver response. To achieve the best result human physiological centered techniques are preferred. In this, both intrusive and non-intrusive techniques can be adopted. However, intrusive techniques such measuring of physiological change like brain wave, heart rate and body temperature may provide the most accurate results. They are however not realistic as they involve implanting of sensing electrodes on the drivers body an act that is annoying and destructive to the driver. Increased perspiration during long driving hours result in sweating which might also interfere with the performance of the implanted gadgets, hence reducing the accuracy of the data they obtain.
Non-intrusive techniques are most suited for real world driving conditions, through the use of 6 non-intrusive data collection techniques to obtain physical measures such as sagging posture, learning of the driver's head, open or closed state of the eyes, blink duration, blink frequency, saccade frequency has gained popularity among many researchers.
This is because of non-interference with normal state of the drives as they operate without even the knowledge of the driver.
Other non-intrusive techniques involve measuring driver operation and vehicle behavior; they can be achieved through measuring vehicles lateral displacement, braking and acceleration patterns, vehicle speed, steering wheel movements and lateral accelerations. In this drowsiness interferes with the driver alertness and vigilance leading to changes in both his driving behavior and the vehicle behavior. Being able to establish and measure this change one can be able to predict a drowsy driver. This system however may provide a very short time span to correct the situation before a crash occurs. However, they have been successful combined with other techniques by different manufacturers to develop drowsiness detection systems [3].
Finally, driver response can continually be monitored by frequently requesting the driver to send a response to the system to indicate his or her alertness. An audio or visual sign can be provided to driver periodically, to indicate his or her alertness the driver can respond to the sign, if the driver fails to respond within a specified time the frequency of the sign can be increased and later provide an alarm or alert of the driver's state. This method however is monotonous, boring and tiresome to the drivers; frequent false alarm may be annoying to drivers making them ignore even when the situation is genuine.

A. *Current Driver Drowsiness Detection and Warning Technologies*

- *Head- Nodding Technology*

When a driver is drowsy and gets sleepy hide muscles relax, hence he or she starts nodding. This symptom can be used to detect drowsiness. The approach however should be used to detect the onset of sleep as head-nodding phenomenon manifests as the last cue before micro-sleep or complete sleep occurs. Although this system appears to be efficient in detecting the onset of sleep the driver might as well drive unsafely leading to

accident before he even manifests the head-nodding to trigger an alert as the system warns the driver too late into the drowsiness curve [3].
The system may also trigger false alarms as the driver may make movements that are not indicators of drowsiness resulting in false alarms. This might be annoying to drivers hence they may ignore genuine warning.

- *Roadway Designs*

Roads can be designed to monitor weaving and alerting drivers when they drive off roads through use of rumble strips that produce a loud noise and vibrations within the car when a driver crosses or drives along the strip. This technology is advantageous as it is available to all drivers. These technologies highly reduce the amount of run off the road crashes

- *Lane Departure Warning Systems*

These systems depend on the feed from a camera that monitors the road ahead and establishes the lane boundaries; in the event that a driver veers of the lanes without using the turn signal an alarm sounds is produced. Lane departure has been can be implemented using different technologies such as sidetrack, Auto vie and many others being adopted by different automotive manufacturers. These systems however do not predict the drowsiness but senses the reputations of drowsiness.

Disadvantage

- ➢ The driver may experience false alert, which are annoying and may make him or her ignore future genuine alerts.
- ➢ When dealing with unmarked roads or rural road it will be difficult for the system to detect and warn the driver.

- *Collision Avoidance Warning*

These systems are commonly integrated in high end vehicles to provide warnings to drivers of eminent crushes; majorly these systems attempt to reduce the severity of a crash. These systems can measure the time of crush, sense when another vehicle or obstacle comes close to a vehicle reducing the collision velocity and minimizing to collision. The systems provide auditory tones and visual icon displays

- *Non-Intrusive ECG*

ECG measure can still be implemented in a non-intrusive manner contrary to the common practice of the electrode being in contact with the chest or the head. Intrusive approaches as earlier discussed bring discomfort to the driver.
For the non-intrusive ECG sensors, each half of the steering wheel is wrapped with electrically conductive fabric (ECF) and two ECG electrodes. To correct the heart rates from the hands of the driver.
The method can also be implemented using conductive fabrics fitted with ECG electrodes and placed on the driver seat's backrest.
In all these cases once the signal is obtained and amplified in is then digitized and transmitted to a computer that will analyze to detect any elements of change of heart rate which indicate drowsiness in the driver.

Disadvantages

- ➢ ECG signals from the electrodes are severely affected by the common mode noise (CMN) from the human body requiring a lot of filtering
- ➢ While using the driver seat, electrodes on the backrest are not in direct contact with the driver skin resulting to high impedance between the electrode and the skin possibly due to the poor permittivity of the commonly available clothes.
- ➢ In both cases, they can be affected by body physiological processes, e.g. sweat reducing their performance.

- *Hybrid Systems*

Each method used for detecting drowsiness has its own strengths and weaknesses, to overcome the weaknesses of different sensors can be combined to support each other in addressing drowsiness detection. Behavior based measures can be combined with vehicle-based measure and the results a significantly higher accuracy and reliability than using a single sensor
This approach however will require more system resources to perform to the expected levels. This aspect makes it difficult to implement in embedded environment where resources are constrained.

III. Methodology

Agile development was adopted. This approach combined both the extreme programming python and scrum methodologies to achieve the desired objectives. The researcher aimed at tapping into the strength from the python programming especially program refactoring and combining the scrum capabilities in order to overcome the different challenges found in embedded environment.

Practically, Physiological Based Approach Is Not Suitable for Drowsiness Detection as It Is an Intrusive Method Which Is Not User Friendly for Driver And For Drowsiness Detection. Vehicle Based Approach Is Based on Monitoring the Car Instead of Driver and Hence It Is Difficult to Determine Whether Driver Is Feeling Sleepy or Not. The Proposed System Consists of Three Major Components: -

A. Capturing Frames

Camera Mounted on The Dashboard Captures the Images of Driver's Face Including Eyes and Passes This Data to Processing Component.

B. Processing and Detecting Component

Captured Facial Image Is Used to Determine Whether Drivers' Eye Is Closed or Open. The Driver's Current Eye State Is Determined by Using Harr Classifier Which Is Use for Object and Face Detection. For Detecting Eyes, We First Create A Facial Landmark Detector File Which Is Implemented Inside Dlib Library. Dlib Produces 68 (X,Y) Coordinates That Map To A Specific Facial Structure. Once We Plot These Points, We Can Recognize Any Part of The Face Such as Nose, Ear Etc. Below We Can Visualize That What Each of These 68 Points Maps.

C. Signaling

After Processing the Eye Blink Frequency; Decision Will Be Made Whether to Give Alarm to Driver or Not. If Eyes Are Closed for More Than 22 Frames Then Alarm Will Be Given to Driver.

IV. Requirements Analysis

In order to develop the specific system that will operate in the target environment and meet the specific objectives requirement analysis was conducted. Through observation of the driver behaviors coupled with the research conducted by other researchers in the same and related area a lot of information was obtained.

A. System Requirements:

This defines how the user expectations will be met by the system, they are classified into:

- Functional Requirements

The system should be able to meet the following functionalities:

  - To detect drowsiness among drivers
  - Issue alert when drowsiness is detected

- Non- Functional Requirements

In order to meet the functional requirements while operating in constrained environment the system had to meet several non-functional requirements that are critical and core to its performance. The non-functional requirements mainly touch on the systems abilities in embedded environment

- Embedded Capabilities
  - The system is designed to operate under:
  - 1. Limited memory
  - 2. Constrained power supply
  - 3. Low processing power
  - 4. Meet real time capabilities

V. System Design

A. Data flowchart

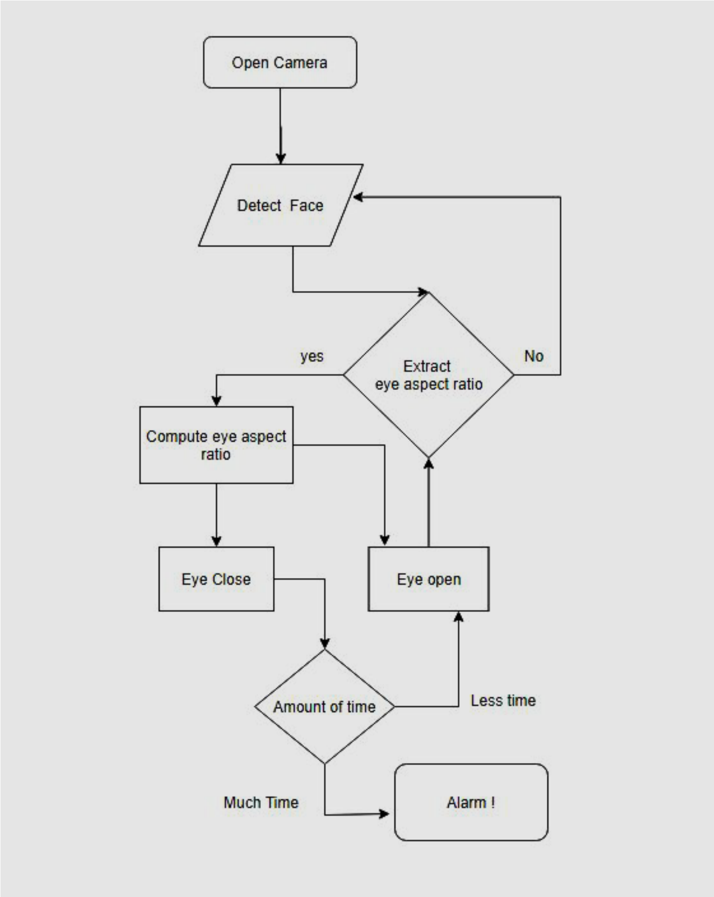

Figure 1: The System's data flowchart

B. *Face Detection and Eye Detection System*

Defining a function which is used to compute the ratio of distances between the vertical eye landmarks and the distances between the horizontal eye landmarks. The return value of the eye aspect ratio will be approximately constant when the eye is open. The values will then rapidly decrease towards zero during a blink. If the eye is closed, the eye aspect ratio will again remain approximately constant, but will be much smaller than the ratio when the eye is open. On the top-left we have an eye that is fully open with the eye facial landmarks plotted. Then on the top-right we have an eye that is closed. The bottom then plots the eye aspect ratio over time. As we can see, the eye aspect ratio is constant (indicating the eye is open), then rapidly drops to zero, then increases again, indicating a blink has taken place. In our drowsiness detector case, we'll be monitoring the eye aspect ratio to see if the value falls but does not increase again, thus implying that the person has closed their eyes.

Each eye is represented by 6 (x, y)-coordinates, starting at the left-corner of the eye (as if you were looking at the person), and then working clockwise around the remainder of the region. The points are P1…….P6 which are 2D facial landmark location .Driving an equation from it [6].

$$EAR = \frac{||P2 - P6|| + ||P3 - P5||}{2||P1 - P4||}$$

EAR=Eye Aspect Ratio. The following Equation is used in the figure 4 to have a clear understanding of our system.

On the top-left we have an eye that is fully open — the eye aspect ratio here would be large and relatively constant over time. However, once the person blinks (top-right) the eye aspect ratio decreases dramatically, approaching zero [2].

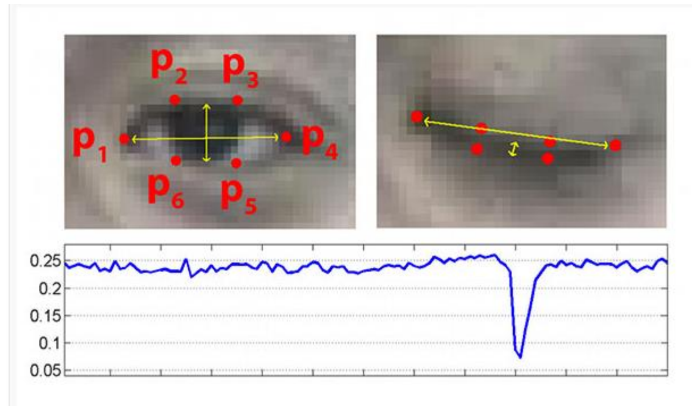

Figure 2: Eye aspect ratio

VI. Implementation

Software engineering includes all of the activities involved in software development from the initial requirements of the system through to maintenance and management of the deployed system. A critical stage of this process is, of course, system implementation, where this study proposed an executable version of the software. Implementation may involve developing programs in high-level or low-level programming languages or tailoring and adapting generic, off-the-shelf systems to meet the specific requirements of an organization.

A. *Code Run*

For Ubuntu there is no need any external IDE (Pycharm, Anaconda, Jupyter Etc.) for running proposed code. Run the code from the terminal by the following steps [15].

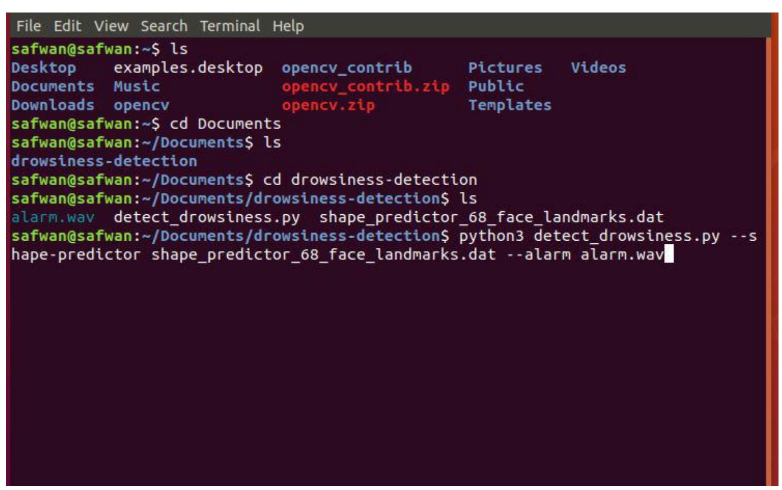

Figure 3: Ubuntu's Terminal

After Running the code our Drowsiness system will start running and the webcam will detect the face .EAR will be counted and the system will alert if the driver gets distracted or falls asleep.

VII. Testing

Software testing is an activity to check whether the actual result match the expected result and to ensure that the software system is defect free. It involves execution of a software component or system component to evaluate one or more properties of interest. Software testing also helps to identify errors, gaps or missing requirements in contrary to the actual requirements. It can be either done manually or using automated tools. Testing can be both manual and also automation.

The bellow Result Shows the Ellipse Shaped Marker Has Turned Out to Become a Flat Line and Ear Has Dropped Below 0.2. This Will Generate Alarm if Ear Stays Less Than 0.2 for 15 Consecutive Frames.

Proposed system Achieved 92% Accuracy by Testing the Prototype Using Different Video Input Streams. The Prototype Is Highly Capable of Determining Status of Eyes, Even If the Driver Wears Spectacles as Seen in The bellow Figure.

A. *Drowsiness Detection is on*

The bellow figure shows that the system is measuring the eye aspect ratio as mentioned before. When the EAR ratio is sufficient the system does not alert the driver as he needs to concentrate on driving.

Figure 4: Drowsiness Detection is on

B. *Drowsiness Alert*

Figure 5: Drowsiness Alert!

The system is tracing the eyes and measuring EAR (Eye aspect ratio) and in figure 5 it is alerting the driver for drowsiness [4].

VIII. Future Work

Coming to future scope this system can be further extended to have security like only certain people can access the vehicle. In case of theft, the vehicle does not start and an mms of the burglar could be sent to the owner of the vehicle

An Android application can be developed to record the whole drowsiness system. It can also be used to monitor the whole process

IX. Conclusion

The drowsiness detection proposed here is a minimum intrusive approach for monitoring driver drowsiness, based on computer vision techniques, installed on a real car, capable of dealing with real operation conditions. Results obtained with the system are similar or even better than other commercial ones being more flexible and open source. The commercial systems often require a non-trivial calibration procedure, to adjust the detection. This method is accurate up to 92%. This method of drowsiness detection takes less computational very less time. Hence, it is very advantages to use this technique in the real time applications.

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