Research Article

DROWSY DRIVER DETECTION WITH CNN AND RNN

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Abstract: This project is focused on drowsy driver detection and the objective of this project is to recognize driver's state with high performance. Drowsy driving is one of the main reasons of traffic accidents in which many people die or get injured. Drowsy driver detection methods are divided into two main groups: methods focusing on driver's performance and methods focusing on driver's state. Furthermore, methods focusing on driver's state are divided into two groups: methods using physiological signals and methods using computer vision. In this project, driver data are video segments captured by a camera and the method proposed belongs to the group that uses computer vision to detect driver's state. There are two main states of a driver, those are alert and drowsy states. Video segments captured are analysed by making use of image processing techniques. Face is localized in the image and key facial structures (Eye, Mouth) are detected on face ROI(region of interest). Then eye aspect ratio(EAR) and mouth aspect ratio(MAR) is calculated for horizontal and vertical distances. If EAR is less than some threshold value then eye is detected as closed and if MAR is greater is than some threshold value then yawning is detected. As closed eye and yawning are two most symptoms of drowsiness, we can easily predict the driver's state is alert or drowsy based on these two observations.
Key Words: Image processing, Neural networks,Gabor filter

1.0 INTRODUCTION

Humans have always invented machines and devised techniques to ease and protect their lives, for mundane activities like traveling to work, or for more interesting purposes like aircraft travel. With the advancement in technology, modes of transportation kept on advancing and our dependency on it started increasing exponentially. It has greatly affected our lives as we know it. Now, we can travel to places at a pace that even our grandparents wouldn't have thought possible. In modern times, almost everyone in this world uses some sort of transportation every day. Some people are rich enough to have their own vehicles while others use public transportation. However, there are some rules and codes of conduct for those who drive irrespective of their social status. One of them is staying alert and active while driving. Neglecting our duties towards safer travel has enabled hundreds of thousands of tragedies to get associated with this wonderful invention every year. It may seem like a trivial thing to most folks but following rules and regulations on the road is of utmost importance. While on road, an automobile wields the most power and in irresponsible hands, it can be destructive and sometimes, that carelessness can harm lives even of the people on the road. One kind of carelessness is not admitting when we are too tired to drive. In order to monitor and prevent a destructive outcome from such negligence, many researchers have written research papers on driver drowsiness detection systems. But at times, some of the points and observations made by the system are not accurate enough. Hence, to provide data and another perspective on the problem at hand, in order to improve their implementations and to further optimize the solution, this project has been done.

Related work

There are some significant previous studies about drowsiness detection and fatigue monitoring. Many computersvision-based schemes have been developed for non-intrusive, real-time detection of driver sleep states with the help of various visual cues and observed facial features. An observed pattern of movement of eyes, head and changes in facial expressions are known to reflect the person's fatigue and vigilance levels. Eye closure, head movement, jaw drop, eyebrow shape and eyelid movement are examples of some features typical of high fatigue and drowsy state of a person. To make use of these visual cues, a remote camera is usually mounted on the dashboard of the vehicle which, with the help of various extracted facial features, analyses driver's physical conditions and classifies the current state as drowsy/nondrowsy. It has been concluded that computer vision techniques are non-intrusive, practically acceptable and hence are most promising for determining the driver's physical conditions and monitoring driver fatigue.
The current study was designed to provide further information for traffic safety and others coulduse in their efforts to reduce the number of drowsy related crashes. The study had the followingprinciples:

- To verify message that need to be conveyed.
- Why are these people in drowsy-related crashes?
- Is itdue to long sleep or is minor sleep the bigger problem?
- What do person already know and practice with regard to drowsy driving?
- to examine potential under-reporting of drowsy-related crashes.

2.0 LITERATURE REVIEW

Singh et al. [1] developed a vision-based scheme based on eye blink durationusing the proposed mean sift algorithm. Saito et al. [2] uses driver's line of sight to detect the mental and physical conditionsHorng et al. [3] uses edge information for localizing eyes and dynamical template matching for eye tracking for driver fatigue detection. Smith et al. [4] describes an algorithm which relies on optical flow and color predicates to robustly track a person's head and facial features. Their study showed that the performance of their system is comparable with those of techniques using physiological signals. New techniques are based on machine learning algorithms to detect driver drowsiness levels. Vural et al. [5] creates Automatic classifiers for 30 facial actions from the Facial Action Coding system using machine learning on a separate database of spontaneous expressions to finally categorize driver drowsiness. Vural et al. [6] proposes a system that applies automated measurement of the face during actual drowsiness to discover new signals of drowsiness in facial expression and head motion. Ji et al. [7] demonstrates that 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 by using a Bayesian network.

3.0 Modules of The System

Recent years has seen many significant improvements in the area of representation feature learning by introduction of many models such as Deep Boltzman Machines(DBM) Deep Belief Networks(DBN) Convolutional neural networks (CNN) Restricted Boltzman Machine(RBM) Recurrent Neural Networks(RNN) and others. The underlying driving force behind the success of these models is the learning of feature representation which is capable of capturing more intelligent features from the unlabeled input data. Most of the models use multiple hidden layers to learn complex, non-linear, high dimensional representation which are fed to a classifier for high level of classification task.

Preparation of the driving simulator:

In this research, in order to detect the levels of drowsiness and recording images from the drivers, virtual-reality driving simulator was utilized in a room where levels of illumination, noise, and temperature were controlled., simulator model AKIA-BI 301BI 301 Full was used to conducting the test (Fig.1).

Fig.1: Driving simulator model AKIA-BI 301

Methods Focusing on Driver's Performance

In order to detect drowsiness, studies on driver's performance use lane tracking, distancebetween driver's vehicle and the vehicle in front of it; place sensors on components of thevehicle such as steering wheel, gas pedal and analyze the data taken by these sensors. Some of the previous studies make use of driver steering wheel movements and steering grips as an indicator to detect drowsiness. Since these systems are too dependent on the characteristics of theroad, they can only function well on motorways which make them work in limited situationsAnother disadvantage of these systems is that they cannot detect drowsiness that has not affectedvehicle's situation yet. When a driver is drowsy and the vehicle is in the appropriate lines, these systems cannot detect drowsiness.

Protocol of testing: For initiating the test, the driver starts the simulator. As the test begins, camera records images of driver's face. Meanwhile, observer interprets images to recognize the levels drowsiness. When simulator shows the road, crossing test finishes. (Four wheels should exit the road according to the researcher's assessment). For controlling, the light from the vehicles ahead that caused bright light shock leading to reduced subjective sleepiness the oncoming vehicles made use of low beam and the number of them was reduced.

Drowsiness detection model

In this part of the research, we developed software that could receive color frames from the camera placed in front of the driver and calculate coordination of facial details. Finally, by comparing and fissuring, the information obtained from interpreting assessment criterion about the alertness or sleepiness together with information resulted from image processing, the software for detection of the levels of drowsiness was developed and promoted. This method is conducted in several steps as follows:

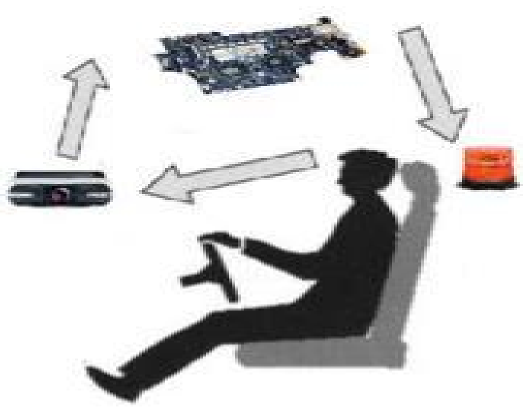


Fig. 2: Schematic view of driver, camera and image processor

System design:

Systems design is the mechanism used to decide the architecture, components, modules, interfaces, and data of a system to meet specified needs. It is similar to applying system theory toproduct development. Object-oriented methods of research and design are now the techniquesmost commonly used for the design of computer systems.

Output design

It provides the information to the user and is important as it is the only source of output to user.

The output that is efficient and correct improves the system relationship with the user which thenhelps in making decisions. An output is said to be a quality output, when it meets and serves theneeds of the end user and displays the information unambiguously. These results are discussedwith the user and the other system through outputs. The way displaying the information for theimmediate requirement is made in the output design.

The objectives are-

- Design the computer output to serve the user.
- Deliver appropriate output.
- Output is presented to the right user.
- Select methods for re-presenting information.
- Convey information about previous activities, present status.

Use Case diagram

A use case diagram at its simplest is a description of the interaction of a user with the device and adepiction of a use case requirement. A use case diagram will represent the various user styles of asystem and the different ways it communicates with the system. Usually, this type of diagram is used incombination with the case for textual use and is often also accompanied by other types of diagrams.

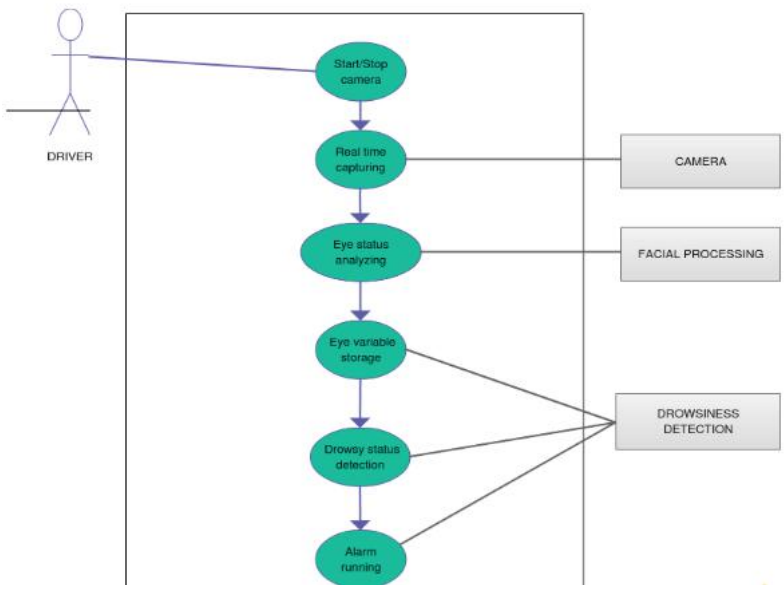


Figure: use case diagram

4.0 IMPLEMENTATION

Implementation is one of the most critical tasks in a project where one needs to be careful as allthe attempts made during the project have to be very interactive. Implementation is the mostcrucial stage in achieving an effective system and giving the users trust that the new system isworkable and efficient**.**

SYSTEM TESTING

Testing can be understood as the process of evaluating the software functionality with an

initiative that is intended to end up understanding and knowing whether the software that isdeveloped has lived up to the expectations and requirement specifications. This entire procedurewill help the developer know the pitfalls of the system before delivering it to the user. Once thedefects are known, the team will strive hard to make sure they are cleared as soon as possible andthe product is ready to be delivered. The software must be entirely reliable as expected by theclient and the quality check must take place thoroughly with the help of testing. It is simply analysing the software to detect differences between existing software and the developed software. The main aim of testing is to identify the errors and their spots so that they can berectified. Work product may contain several defects which are to be recognized with the processof testing. Testing provides tools to check the individual components functionality sub-assemblies, assemblies and the final product. The results of testing are put into action later onduring maintenance also. Testing is a method used to identify defects. By using Testing, it ispossible to detect any potential defect or flaw of the method in a work product.

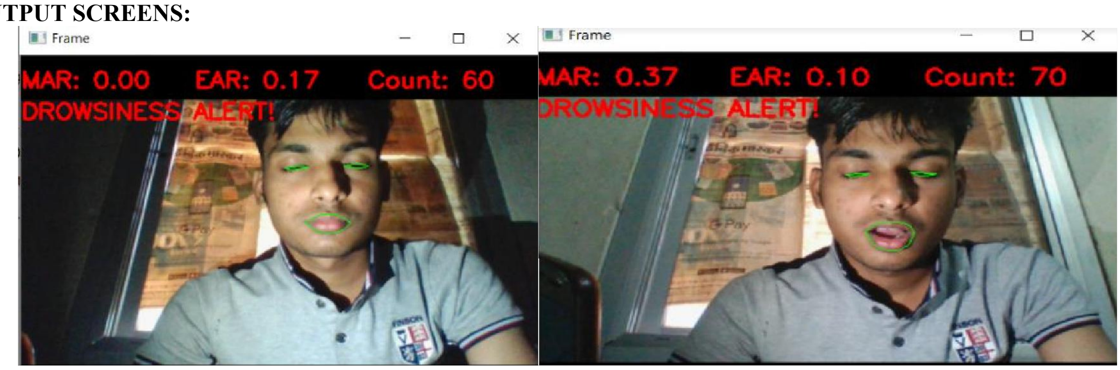
White Box Testing

It is the flow of working of the whole application. This is a kind of testingprocess which involves the tester who is expected to have the conscience of the overall structure,internal functioning knowledge and language of software. If not all, at least one of the aspectsmust be known by software testers. Code is being optimized. The developer performs white-box-testing. It requires a lot of knowledge on the coding part and other parts of the application. It canbe done in 2 steps:First, understanding the source codeCreating test cases and executing those test casesFew tools which help to perform white-box-testing are:

Black Box Testing:

It is a type of testing which is mostly based on software requirements andspecifications. All these testing reports/results will be mentioned in the document so called“SRS” (Software Requirement Specification) document. The working of software is leastbothered in the black box test. It is just concerned with the type of input given and responds tothe output. The tester performs black-box-testing.

OUTPUT SCREENS:



Results from neural network

To determine the levels of drowsiness by eyes signals, MLP neural network with three middle layers (with tansig function) and two inputs (first input: the averages of upper pixels and input: the averages of lower pixels) and one output (level of drowsiness) were utilized (Fig. 9). Full propagation and decreasing gradient methods were used. The number of training data was 9964 frames recorded from the five drivers' sleepiness. The network was taught by 1000 epoch. 70% of data and the rest of data (30% of data) for testing were transferred to the network for training. The mean of squares of errors for data trained and was tested by the network were 0.0623 and 0.0700, respectively. Then, the level of accuracy was estimated at 93%.

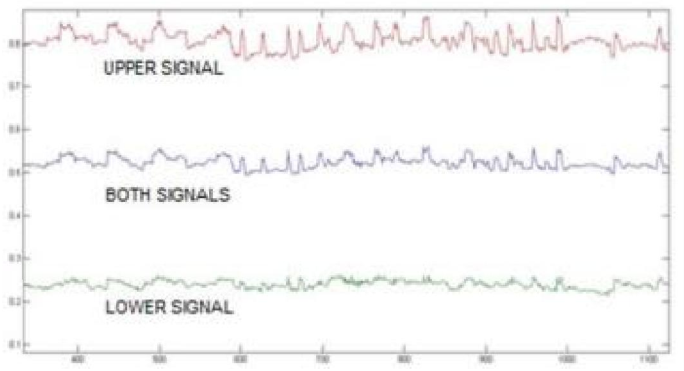


Fig. 3: Changes in black and white pixels in upper and lower parts of the image in a time interval

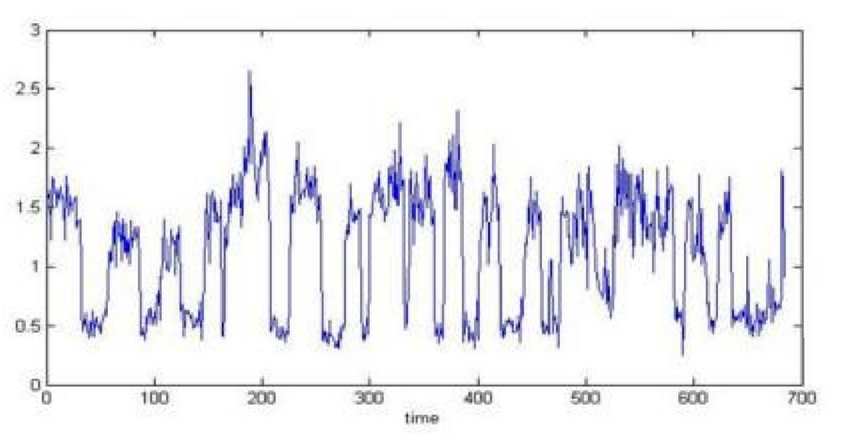


Fig. 4: Changes in black and white pixels in upper and lower parts of the image in a time interval

Discussions

Fatigue and drowsiness cause obvious changes in driver's facial features and expressions and the position of head and eyes. Most of the studies conducted on the effects of fatigue and sleepiness have focused on the dynamic changes of the eyes and their movements during the periods that an individual is fatigued and sleepy. In this research, the level of drivers' drowsiness was detected by employing an image-processing technique. In comparison with other techniques, this method detects the level drowsiness more accurately. For example, in the technique that employs a color video camera placed directly in front of the driver, eyes are targeted to recognize micro sleeps. In this research, we presented a method that in addition to the micro-sleeps, blinking (number and characteristics of blinks) is also monitored. While in another research hue and Gabor filter were utilized, we considered the blink duration and frequency, which are relatively more advantages.

CONCLUSION

Our drowsiness detector hinged on two important computer vision techniques:

- Facial landmark detection
- Eye and Mouth aspect ratio

Facial landmark prediction is the process of localizing key facial structures on a face, including the eyes, eyebrows, nose, mouth, and jawline.Specifically, in the context of drowsiness detection, we only needed the eye and mouth regionsOnce we have our eye regions, we can apply the eye aspect ratio to determine if the eyes areclosed. If the eyes have been closed for a sufficiently long enough period of time, we can assumethe user is at risk of falling asleep and sound an alarm to grab their attention.Thus, we have successfully designed a drowsiness detection system using OpenCV software. Thesystem so developed was successfully tested.

Future enhancement

- The model can be improved incrementally by using other parameters like blink rate,yawning, state of the car, etc. If all these parameters are used it can improve theaccuracy bya lot.
- We plan to further work on the project by adding a sensor to track the heart rate in order toprevent accidents caused due to sudden heart attacks to drivers.
- Same model and techniques can be used for various other uses like Netflix and otherstreaming services can detect when the user is asleep and stop the video accordingly. It canalso be used in application that prevents user from sleeping.
- Currently there is not adjustment in zoom or direction of the camera during operation. Futurework may be to automatically zoom in on the eyes once they are localized. This would avoidthe trade-off between having a wide field of view in order to locate the eyes, and a narrowview in order to detect fatigue.

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