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A comparative analysis on driver drowsiness detection using CNN

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Abstract

The main objective of this project is to detect driver's drowsiness and alert the driver which is an important precautionary measure in order to avoid accidents. Here two different algorithms based on Convolution Neural Network (CNN) were applied and the results were compared respectively. "Highway Hypnosis" is a serious issue to be addressed while driving especially on highways. Drivers who travel on highways continuously for more than 3 hours must be aware of this serious problem. If there is proper knowledge of it, fatalities would be drastically reduced. In this project, a dedicated detection coupled with an alarm system is provided to alert the driver in case of drowsiness. CNN is used since it is very effective in analyzing images and videos. In this project, a live video feed is used to detect drowsiness by suitable algorithms.

Keywords: CNN, Drowsiness Detection, Viola-Jones, PERCLOS.

1. Introduction

Driving a car is a dynamic, multifaceted, and potentially dangerous task that necessitates the use of both physiological and cognitive resources in order to sustain performance over time. Reduced availability of all of these services may have disastrous effects, resulting in accidents.

The sensation of sleep lowers the driver's level of alert, culminating in extremely risky scenarios and increasing the chances of an accident. Drowsy driving and fatigue are two of the major causes of car accidents. Every year, they boost the level of fatalities and injuries around the world.

In this context, it's crucial to use modern technology to design and construct systems that can detect and quantify drivers' amounts of awareness during the entire driving period.

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Generally mental, emotional, or psychological state causes drowsiness. Drowsiness can be triggered by depression, as well as by high levels of stress or anxiety. Another known cause of drowsiness is boredom. Lack of sleep, extended periods of continuous driving, or some other medical problem, such as brain diseases, respiratory arrest, and so on, causes the driver's focus to deteriorate. The lack of oxygen, combined with the disturbance of sleep, causes daytime sleepiness, lethargy, and weariness. It's also linked to more significant problems including heart disease, diabetes, and obesity. Drowsiness can be caused by a variety of situations or events that disrupt sleep, including:

- Depression
- Irregular work schedule such as shift work (circadian rhythm sleep disorder)
- Stress & Boredom
- Travel across time zones
- Working Overtime
- Improper Sleep

To define tiredness, P. Viola and M. Jones devised a method that uses facial landmarks sensed by the camera and communicated to a Convolutional Neural Network (CNN). This work has proven the ability to provide a lightweight alternative to heavier classification models by increasing accuracy by more than 88 percent for the category without glasses and more than 85 percent for the category night without glasses in this study. The suggested CNN-based model may be used to create a high-accuracy and simple-to-use real-time driver drowsiness detection system for embedded systems and Android devices [3].

An algorithm was proposed by A. D. McDonald, J. D. Lee, C. Schwarz, and T. L. Brown. The purpose of this study is to create a contextual and temporal method for recognising drowsiness-related lanes. The algorithm considers steering angle, pedal input, vehicle speed, and acceleration as inputs. Speed and acceleration are used to provide a real-time measure of driving environment. These measures are integrated with a Dynamic Bayesian Network, which takes into account time dependencies in sleepiness and alertness transitions [1].

An algorithm was proposed by C. S. Wei, Y. T. Wang, C. T. Lin, and T. P. Jung. Many of the technical difficulties created by hair interacting with electrodes and the skin have been offered as an alternative to obtaining EEG from non-hair-bearing (NHB) scalp areas. Furthermore, the pilot study revealed that the NHB sections allow access to useful EEG functions associated to drowsiness [4].

S. Mehta, S. Dadhich, S. Gumber, and A. Jadhav Bhatt proposed an algorithm using an Android application to develop and implement a real- time driver drowsiness detection system. Using image recognition techniques, the device records the videos and determines the driver's face in-frame. Based on adaptive thresholding, the device can detect facial landmarks and compute the Eye Aspect Ratio and Eye Closure Ratio to detect driver drowsiness. To evaluate the effectiveness of the proposed solution, machine learning algorithms were used. Using a random forest classifier, empirical evidence show that the proposed model can achieve an accuracy of 84 percent [2].

1.1. Different Measures to Detect Drowsiness

There are three different measures to detect driver drowsiness. They are as follows:

1. Behavioural Measure:

- Yawning
- Amount of eye closure
- Head position

2. 2Vehicular Measure:
    - Ego Vehicle's lane position
    - Steering Wheel angle
    - Tyre position
3. Physiological Measure:
    - ECG
    - EEG
    - EMG

1.2. Statistics of Accidents

Road traffic continues to be a major a public health concern, and a leading cause of death and injury worldwide, killing over 1.35 million people each year. According to the Global Status Report on Road Safety 2018, 90 percent of these fatalities occur in developing nations, with India accounting for 11 percent of all fatalities (fig. 1). In 2018, 1,51,417 people died in road accidents in India, according to the 2018 Report on Road Accidents in India. Despite the government's constant attempts, this is a major source of concern. Around 85% of accident-related deaths occur in the 18-60 age range, which is the most productive. Road traffic tragedies not only cause considerable emotional distress to the relatives of the deceased, but they also cost the government a lot of money. In 2018, the number of accidents climbed by 0.46 percent, while the number of people died increased by 2.4 percent, with tiredness being the leading reason [5].

1.3. Highway Hypnosis

When a driver has been driving for a long period of time, he or she can encounter highway hypnosis, also identified as white line fever. Staring at the lines on the road has hypnotic properties. A driver under the impact of highway hypnosis can be able to drive and handle the vehicle normally and safely, but will have no memory of doing so later. Autopilot driving is a type of highway hypnosis. Allowing highway hypnosis to take over in Philadelphia can result in severe or fatal car accidents [6].

1. Causes: Drowsy driving or falling asleep at the wheel are also instances of highway hypnosis. The regions of the brain do not connect as easily or as often as they do in someone who is fully awake or conscious. This lessens the reaction time of the driver, significantly increasing the likelihood of a collision. In this event, the driver would have no recollection of the journey. Highway hypnosis and drowsiness can go hand in hand. Without his or her conscious mind's recognition, the driver will continue to drive the car. The outcomes could be fatal.
2. Preventive Measures: In certain situations, highway hypnosis is just as dangerous as driving while inebriated. Highway hypnosis can find it harder for a driver to adapt to changing road conditions in a timely manner. A red light, emerging traffic, or a pedestrian crossing the street can all generate hazards that a semi-conscious driver would be unable to avoid. Slow reaction times can lead to accidents that a driver would usually be able to avoid.
    - Some measures to prevent highway hypnosis-
    - Listen to engaging music

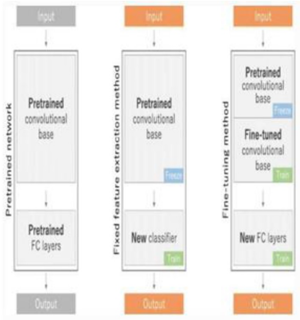

Figure 1: CNN Architecture

- Speak with passengers
- Take regular breaks
- Wash face regularly

1.4. Convolutional Neural Network

CNNs, a type of artificial neural network prominent in computer vision, are gaining interest in a variety of sectors, including radiology. Convolution layers, pooling layers, and fully connected back propagation are some of the basic elements used by CNN.

CNN is a type of deep learning model for automatically and adaptively processing data having a grid pattern, such as hierarchies of features, from low- to high-level patterns. Convolutional neural networks (CNNs) are made up of three different types of layers (or building blocks): convolutional, pooling, and fully connected. Convolution and pooling are the first two layers that extract features, whereas the third, a completely linked layer, translates those characteristics into final production, such as categorization.

A CNN's convolution layer is made up of a stack of mathematical operations such as convolution, which is a more advanced sort of linear operation. Because a feature can appear anywhere in a digital image, pixel values are stored in a two-dimensional (2D) grid, i.e., an array of numbers, and a small grid of parameters called kernel, an optimizable feature extractor, is applied at each image location, CNNs are highly effective for image processing. As one layer feeds its output onto the next layer, extracted features will grow more hierarchical and sophisticated.

Training is a method of parameter optimization that uses optimization methods such as back propagation and gradient descent to reduce the discrepancy between outputs and ground truth labels. As shown in Fig. 1, a convolution layer is a critical component of the CNN architecture that performs feature extraction utilising a combination of linear and nonlinear operations including convolution and activation functions. [7].

1.5. Viola-Jones Algorithm

The Viola–Jones object detection framework is an algorithm which is proposed in 2001 by Paul Viola and Michael Jones. Though it can be trained to identify a number of object classes, the problem of face detection is the motivating force behind it.

Object detection does not need to be implemented to each frame in a video of moving objects. Instead, tracking algorithms can be used to detect and track salient features within the detection bounding boxes as they move between frames. Not only does this increase tracking speed by removing the need to re-detect features in each frame, but it also strengthens robustness because the salient features are

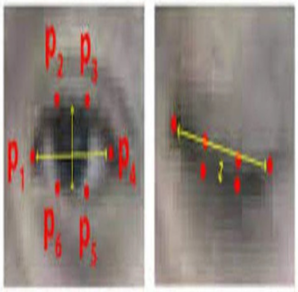

Figure 2: Eye aspect ratio

more immune to rotation and photometric changes than the Viola-Jones detection system as shown in Fig. 2 [8].

$$EAR = \frac{\|P2 - P6\| + \|P3 - P5\|}{2\|P1 - P4\|} \tag{1.1}$$

1.6. PERCLOS Algorithm

The condition of one's eyes is the most visible indicator of driver exhaustion. As a result, image processing infrastructure i.e., PERCLOS (Percentage of Eyelid Closure Over the Pupil Over Time) has become an effective way to detect fatigue. The human eye is the centre and focus in the process of detecting fatigue based on picture, precise and quick positioning.

$$P = \frac{N_m + N_a}{N_m} * 100 \tag{1.2}$$

where,
N_m- No. of eye frames per second
N_a- No. of attentive eye frames per second

2. System Description

As shown in Fig. 3, it depicts the 68 facial landmark points of humans [9]. The three points of interest are

- right eye (36-41)
- left eye (42-47)
- mouth (60-67)

These points are to be fed into the code so that they are detected in prior whenever necessary. Whenever the eyes are closed for some threshold period, the alarm message would pop-up in the multimedia screen. Likewise whenever the mouth is open for some threshold period, the alarm message would pop-up in the multimedia screen.

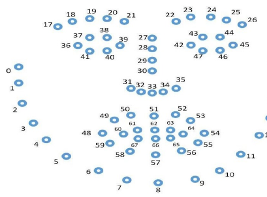

Figure 3: Facial Points

2.1. System Requirements

1. Hardware:
   - A PC with dedicated processor
   - Minimum of 1gb GPU
   - Web-Cam
2. Software:
   - Python IDLE 3.7
   - Visual Studio C++ 2017

3. Methodology

3.1. Viola-Jones Algorithm

The input videos are fed into the code so that the CNN gets trained and validated. After training is complete, live video feed is used to analyze the eyes and mouth frame-points by Viola-Jones algorithm. Then by using CNN the colour images are converted into gray scale and due to training, the points are detected accurately. Then finally, the driver is alerted by suitable alert messages as shown in Fig. 4.

3.2. PERCLOS Algorithm

The input videos are fed into the code so that the CNN gets trained and validated. After training is complete, live video feed is used to analyze the eyes and mouth frame-points by PERCLOS algorithm. Then by using CNN the colour images are converted into gray scale and due to training, the points are detected accurately. Then finally, the driver is alerted by suitable alert messages as shown in Fig.5.

4. Results

IV. RESULTS The output simulations were obtained from python coding used by the aid of Open cv, dlib and a few other library functions (open source) and thus implemented in Python idle application. Five input videos were fed initially into the code for training and validation purpose. The CNN is applied to these inputs and about 7000 frames were trained so that when live video is fed, they would be detected aptly.
After the training phase, live video is fed into the code and the output is obtained respectively. As shown in Fig. 6, the eyes region is detected as follows. Whenever the EAR went below 0.27, it is detected by the algorithm and finally an alert message is displayed in the infotainment screen to alert the driver. The threshold period is user-defined.

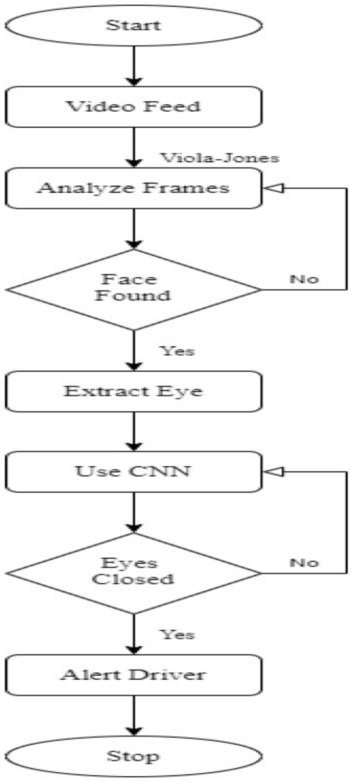

Figure 4: Viola-Jones Algorithm

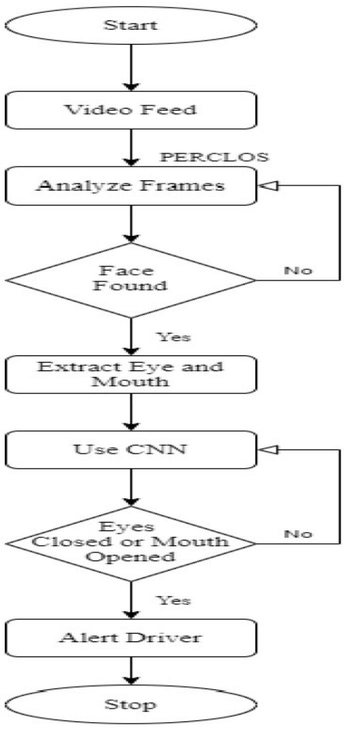

Figure 5: PERCLOS Algorithm

Figure 6: Result of Viola-Jones Algorithm

Table 1: ACCURACY CHART OF VIOLA-JONES ALGORITHM

I/P Video	Eye Detection Accuracy (%)	Drowsiness Accuracy (%)
Sample1	100	95
Sample2	95	100
Sample3	87.5	90
Sample4	100	95
Sample5	100	95

Total Accuracy=95.75% out of 7000 frames.

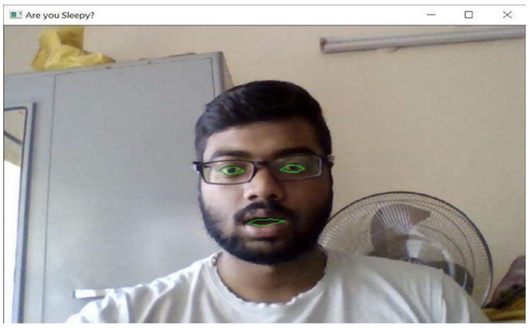

Figure 7: Result of PERCLOS algorithm

Table 2: ACCURACY CHART OF PERCLOS ALGORITHM

I/P Video	Eye Detection Accuracy (%)	Mouth Detection Accuracy (%)	Drowsiness Accuracy (%)
Sample1	100	100	100
Sample2	92	93	93
Sample3	87.5	87.5	90
Sample4	85	87.5	86.25
Sample5	80	83	81.5

Total Accuracy=90.15% out of 7000 frames

Table 3: COMPARATIVE ACCURACY CHART OF BOTH ALGORITHMS

I/P Video	Eye Detection Rate (sec)	Total Accuracy (%)
Viola-Jones	0.25	95.75
PERCLOS	1	90.15

After the training phase, live video is fed into the code and the output is obtained respectively. As shown in Fig. 7, the eyes region is detected as follows. Whenever the EAR went below 0.27 and the MAR went above 0.3, it is detected by the algorithm and finally an alert message is displayed in the infotainment screen to alert the driver. The threshold period is user-defined.

Technically, the Viola-Jones algorithm has a better accuracy than the PERCLOS algorithm. But, it doesn't necessarily be the best suit in all scenarios. For example, while testing the drowsiness detection in stations where the cars would be allowed to run for several days and lakhs of kilometres, PERCLOS algorithm would be the best match since it gives precise results. Yet, it has a limitation of one second Latency Time which is a small problem as accidents could occur even in a fraction of second. Hence, in testing phases it can be used whereas in real-time applications Viola-Jones algorithm shall be used. Both algorithms shall be used in real-time with suitable modifications.

5. Conclusion

Thus, the drowsiness detection based on Viola-Jones and PERCLOS algorithms using CNN were tested and satisfactory results were obtained. Based on accuracy aspect, Viola-Jones algorithm outnumbered the other. But, both algorithms have their own significance in different aspects. Ultimately these algorithms are used to alert the drivers in case of emergency situations so that accidents could be anticipated and avoided.

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