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Smart Alarm System (Drowsiness Detection System Review Paper)

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Abstract: ***With the increase in automative population, accident rates are rising rapidly, one of the major reasons is the state of drowsiness or fatigue. Such fatal incidents can be prevented if the driver is warned in time. With time, several drowsiness alarm systems are been implemented, the system monitors driver's movements through various techniques, one of the most considerable one is face detection, Open Computer Vision is widely used to detect driver's movements for a long period of time. A comparative study on different types of approach is summarized in this paper. The main agenda is to help the society to understand more about the techniques and find the most convenient method for them.***
Keywords: Drowsiness, Face Detection, Mouth Yawn Detection, Open Computer Vision.

I. INTRODUCTION

A recent study stated that drowsy driving is one of the major reason for fatal road accidents, around 40% percent of road accidents are caused due to drowsy driving which is estimated around 1 out of 5 accidents. With the rise in cars, such accidents are increasing along with them and has become a major concern for the driver and the members moving along with in the vehicle. This in return led to development of Driver Assistance System. Implementation of Real time drowsiness detection can assist drivers and alert them in fatal conditions. There can be a bunch of reasons behind the drowsiness of the driver such as, heavy traffic, increase in automotive population, work load and tight commute time requirements. Considering all these factors, researchers started looking for a solution to avoid such incidents. Many of them came with a variety of solutions ranging from mobile based systems to desktop one's. The main concept behind all of these projects was driver's face recognition.

The primary intent of this paper is to review various drowsiness detection techniques in depth to make it easier for the readers to understand and learn about them and find the most convenient approach.

The paper is divided into various sections as follows: "Terminology" section will walk you through some unique terms used in the paper ahead. "Challenges and Limitations" section is all about the difficulties occurred while implementing the systems which is followed by "Types of Approach" section where we will discuss about the variety of methodology used. The section is divided into two major parts, "Software Based" and "Hardware Based", a comparative study will be discussed further. "Conclusion" section is about the overview of this paper and a comparative review on all the methodologies considered.

II. TERMINOLOGY

A. Drowsiness

Drowsiness is a state of abnormal sleeping, people suffering from drowsiness tend to sleep at inappropriate situations.

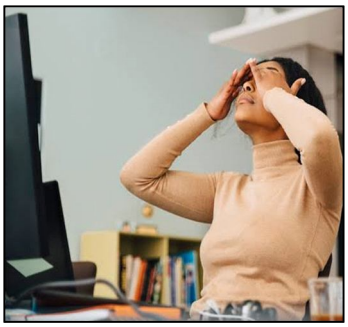


Image.1 State of drowsiness

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B. Face Detection

Face detection technique is divided into two parts, learning based and feature based detection. Learning base approach compares the face with training data samples, whereas feature based approach is based on various characteristics of the driver, like skin color, position etc.



Image.2 Face Detection

C. Eye Detection

The main purpose of eye detection is to consider driver's symptoms. It is divided into two methods such as (1) Feature based, (2) based on IR spectrum and other methods.

D. Mouth Detection

This method is applied to detect drivers mouth features such as lips, yawning is one of the main reasons to consider this in use. This generally works well in suitable light conditions.

E. Face Tracking

Face tracking is done to check the presence of face in the media. This is one of the widely used features in various technologies.

F. Decision Making

Extracted features is considered and the symptoms are compared to declare whether the driver is in the state of drowsiness. Accuracy rate is high when all the above processes give appropriate results.

III. CHALLENGES AND LIMITATIONS

With the rapid increase in road incidents in the world the challenges also come in hand, a minor distraction can lead to a fatal accident, so detecting all these detailed features can be a major challenge for researchers. Real time results with low error is also a major challenge. To get the desired accuracy is a limitation in this approach.

IV. TYPES OF APPROACH

In this paper we will discuss two major types of drowsiness detection; Smart phone based and Desktop based techniques.

V. SMARTPHONE BASED APPROACH

Nowadays, with the rise in smart phone technology, face monitoring techniques are developed in smart phone based applications. This in return favour the condition for implementing drowsiness alert systems. Smart phone based approach requires no extra tools and every process can be performed by itself. The monitoring sensors in smartphones include electrocardiography, photo plethysmography, temperature and three-axis accelerometer, that act as an input variable for an external framework.

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Table 1. Smartphone Based Approach

Ref.	Category	System	Accuracy	Detection Technique	Goal
[1]	Drowsy driving detection system	Samsung Galaxy S3	90%	Neural network, PERCLOS	Sober-Drive prototype.
[2]	Driver behavior information	Samsung Galaxy S3, Korean	Male-87.5% Female-70%	ECD, EEE, SVR	Driver Drowsiness Detection.
[3]	Driving maneuvers	Sense Fleet	90%	Fuzzy System	Detecting Risky driving events.
[4]	Real-time driver behavior information	Android Smartphone	93.7%	PERCLOS, Artificial Vision	Drowsiness alert.
[5]	Drowsiness detection during driving	Android phone with ALS gyro	93%	Haar-Cascade Classifier, LBPH algorithm	Sleep detection during driving.

VI. DESKTOP BASED APPROACH

We classify desktop based systems in two major categories; Software and Hardware approach.

A. Software

Software is the core part of any drowsiness detection system, its purpose is to run all the algorithms and calculations in real time, in this paper, we will discuss about some major software approach used in drowsiness detection systems, they are as follows; i) Image Processing Techniques, ii) Symptom extraction and iii) Decision Making.

1) *Image Processing Techniques:* Image processing is the major requirement in any drowsiness system, it tracks the driver's reaction in real-time and continuous evaluation is being done in the background. The main aim is to detect driver's facial characteristics such as eyes, mouth and movements. We will divide this into few sub topics to discuss more about the techniques used for drowsiness evaluation.
2) *Face Detection:* Face detection is the initial stage where driver's face is differentiated from the surrounding images. It is classified into two major techniques, Learning based and Feature based, the learning based is more robust, apart from that, low light situations can be challenging in both techniques. Let's discuss about few face detection techniques, A learning based method was used where Viola-Jones Method was implemented, the results were robust but it was limited to angles, tilted faces were hard to be processed. A feature based technique with RGB color space implementation removed the brightness from the RGB signal but the performance varied with different skin colors and the approach was lacking. Image 3. Displays how a face is recognized in an image.

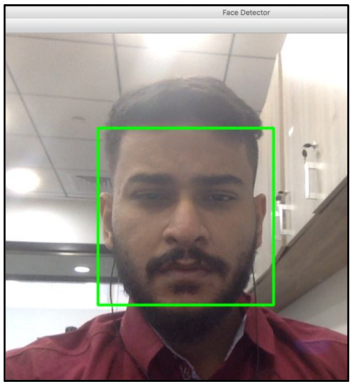


Image3. Face Detection

3) *Eye Detection:* Eye detection is the second stage after recognizing the facial features of the driver, it is also considered one of the vital information as drowsiness detection depends upon the eye and eyelid movements. There are a list of major eye detection techniques used for real time eye movement detection. Haar Classifiers is one of the most used technique which has a very high execution speed and the detection accuracy is robust, it comes with a de-merit where different lighting conditions affected the results. Vision based algorithms were considered were it was easier to train the dataset with a time complexity of O(n), but the limitation was to provide a bunch of quantitative and qualitative results.
4) *Mouth Yawn Detection:* A tabular representation of Mouth yawning detection is listed below, it consists of major techniques like Haar Features, Fuzzy C- Means clustering.

Ref.	Techniques	Merits	De-Merits
[6]	Haar Features	Quick Execution time and works well in different angles.	Depends on suitable lighting situation.
[7]	Fuzzy C-Means clustering.	Excellent results in night light due to presence of IR illuminator	Fails to perform well in bright days.

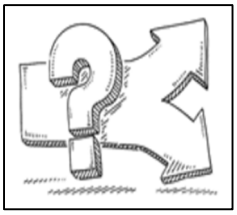
Table 2. Mouth Yawn Detection

5) *Symptom Parameter Extraction:* Extraction of facial features is one of the crucial stages in any drowsiness detection system, after this is done the symptoms are being recognized from the images, this is a major process as the system is responsible to judge the state of drowsiness from the input images in real time situations.

Table 3. Symptom Parameter

Ref.	Facial	Parameter	Decision
[8]	Eye	PERCLOS	Depends of the Blink rate, if higher then its drowsiness and if lower than its distraction.
[9]	Mouth	Ratio of height to width of the mouth	The ratio is significantly low when mouth is closed and is high when it is open.
[10]	Head	Head nodding	Bent head results in state

6) *Decision Making:* After comparing different kinds of algorithms, the last task of a system is to make an appropriate decision, decision making is the key factor of any drowsiness detection system.

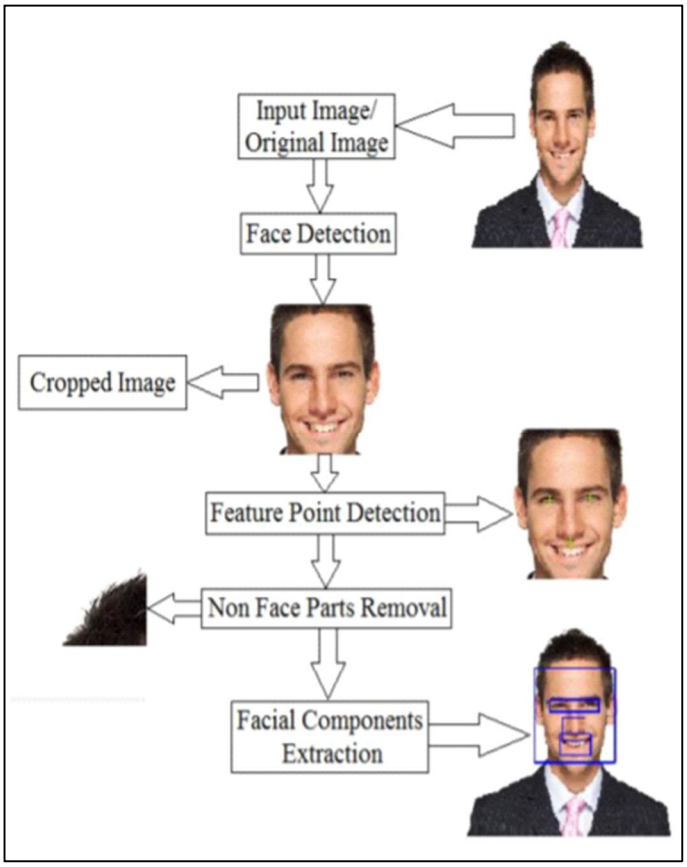


There are different kinds of approaches of how a decision is been made, they are as follows;

a) Knowledge-based Approach
b) Threshold-based Approach
c) Probability based theory
d) Statistical Methods

After detection and analyzing the facial features of the driver, particular method is applied for more accurate symptom results, all the different approach depends upon the system and algorithms chosen to test other data. Bayesian network is used as a probability method which can predict drivers future drowsiness state. Neural network is a statistical method which determines drowsiness level in two distinct sections, i) Unsupervised section and ii) Supervised section.

Image.4 Overview of face detection.



7) *Hardware:* Hardware components in a drowsiness detection system varies significantly. It can be a big desktop system or a small credit card sized computer running all the functions in it. The main criteria of the Hardware component is that it should be cheaper and easier to assemble and should also be an embedded system. Raspberry Pi is an incredible solution as a main hardware system as it has all the components to assemble everything in a single small sized computer, it is widely used in many drowsiness projects and has turned out to be an excellent and convenient choice for the researchers. Hardware components can vary accordingly, some of them are listed as follows:

a) Webcam
b) Raspberry Pi
c) VGA
d) OMAP
e) CCTV

Below is the tabular insight of hardware components used in a drowsiness detection system.

Table.4 Hardware Comparison

Ref.	Hardware Component	Merit	Limitations
[11]	Webcam	Can run videos at high frames and multi megapixel videos can be produced.	Connection to a web system for an infinite amount of time.
[12]	Raspberry Pi	Cheap and convenient system.	Compatibility issues with x86 Operating systems.
[13]	VGA	Can be used for video conferencing and can be applicable.	Resolution issues.
[14]	OMAP	Consists of a camera control panel on the board.	Resolution gets distorted in large image files.
[15]	CCTV	Resolution is upto the mark and capability of wide-angle recordings.	Frail security system.

VII. COMPARISION BETWEEN DESKTOP-BASED AND SMART PHONE BASED SYSTEMS

With the rapid increase in technology, a wide range of PC applications found their way to be operated on mobile phones, a lot of them work incredibly well and the results are up to the mark. Face monitoring systems are also implemented on these devices. But the main question is, are they well enough to used in such fragile conditions?

Considering both, Desktop and Smart phone based applications, the desktop one's are more reliable and the compatibility ratio is higher as compared to the mobile device. Complexity with computational tasks rises in smart phones, and due to the variety of smart phones existing, accuracy differs widely too. This all factors make smart phones a less reliable source for drowsiness alarm systems. A Tabular comparison of smart phone and desktop system is show below.

Table.5 Comparison between Desktop and Smartphone based systems.

Criteria	Desktop	SmartPhone
Processing	RaspberryPi	Variety of smartphone sensors.
Accuracy	Above 90%	Approximately 89%
Detection	Learning Based	Knowledge based.
Advantages	Highly robust and good real-time accuracy	Cheap and easier to assemble.
Disadvantages	Costly and accuracy varies due to different face complexity.	Accuracy varies significantly and low robustness with complex equations.

VIII. CONCLUSION

In this paper, we have discussed about different ways of drowsiness detection systems and their implementation. The methodology in the paper was divided into two main categories, Desktop Based and Phone Based drowsiness detection systems. Most of the algorithms discussed were highly robust and their compatibility range was significant too, but they did come with a range of limitations.
Desktop System was further divided into two categories; Software and Hardware. The software component consisted of Image processing techniques and list of algorithms used for accurate detection of Face, Eyes and Mouth Yawing features. Haar cascade is highly compatible with yawn features.
Furthermore, comparison between smart phone and Desktop based systems were done and it was clear that Desktop based applications were much robust and reliable for such fragile issues because smart phone was still lacking with compatibility issues and the accuracy range differed in different range of smartphones.
One of the major challenge behind this review is systems compatibility in night light situations, a bunch of night camera vision showed good results but they were still lacking accuracy in day light. In the end, all the problems can be overcome by researchers and a good drowsiness alarm system will be launched in every vehicle to prevent fatal accidents.

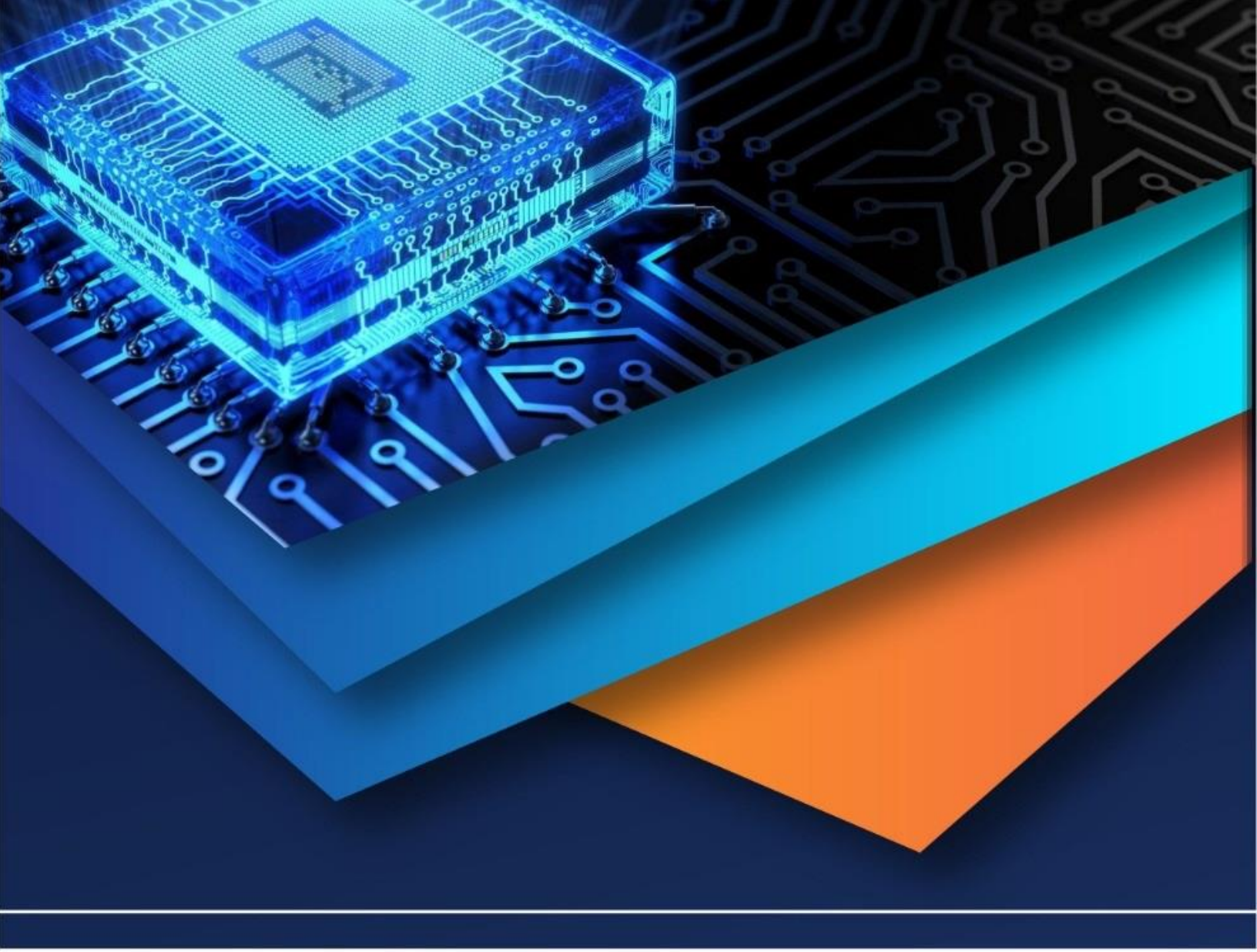
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