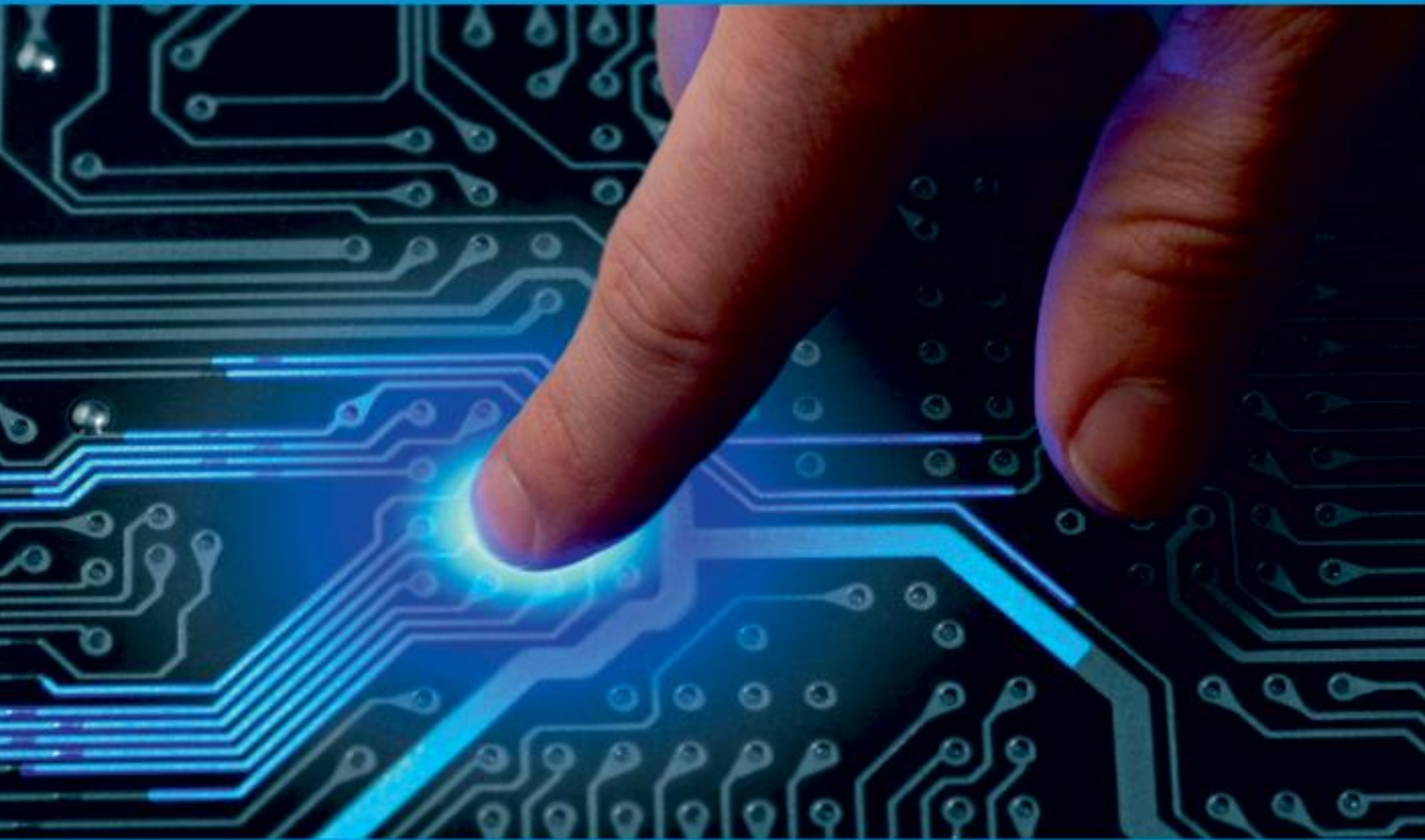
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 11, Issue 5, May 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 5, May 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1105213 |

Driver Drowsiness Detection System

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ABSTRACT: Detecting drowsiness in drivers is a crucial safety measure that can prevent accidents caused by drivers falling asleep while driving. Such a system would notify the driver when it detects signs of drowsiness, potentially reducing the number of fatigue-related car accidents. As a result, it is necessary to create systems that can detect and warn drivers of their physical and mental condition to help prevent such accidents. The development of technologies aimed at detecting or preventing drowsiness while driving is a significant challenge for accident-avoidance systems. In the event of detecting fatigue, the system will alert the driver and issue a warning.

KEYWORDS: Face detection, Eye Detection, Real-time system, Haar-cascade, Drowsy driver detection, Image Processing, Image Acquisition

I. INTRODUCTION

Driver drowsiness detection is a safety technology that can prevent accidents caused by fatigue, which is responsible for around 20% of road accidents and up to 50% on certain roads. To address this issue, new technologies have been developed to detect drowsiness and help avoid accidents. When drivers are drowsy or distracted, their lack of alertness can lead to inattention and distractions caused by objects or events during the driving task, leading to decreased driving performance, longer reaction times, and increased risk of crashes.

To address these challenges, a real-time monitoring system using image processing and face/eye detection techniques has been developed. The system employs a camera mounted in front of the driver to perform real-time processing and infer the driver's level of fatigue. If the driver is detected as drowsy, the system will sound an alert within seconds by sensing the eyes. This technology is particularly important in countries like India, where around half a million accidents occur each year, with driver fatigue accounting for around 60% of these accidents. The system uses Haar cascade samples to differentiate between an eye blink and drowsiness/fatigue detection, ensuring real-time computation. By implementing this technology, we can significantly reduce the number of accidents caused by driver fatigue and improve road safety.

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II. LITERATURE SURVEY

In [1] Advancements in computing technology and artificial intelligence have continuously progressed in the past decade, resulting in notable enhancements in driver monitoring systems. Numerous research studies have gathered real-world driver drowsiness data and applied various artificial intelligence algorithms and feature combinations to significantly improve the real-time performance of these systems. This paper provides an updated review of driver drowsiness detection systems developed in the past decade. The paper examines and evaluates recent systems that employ diverse measures to track and identify drowsiness. Each system is categorized based on the information

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utilized, and a comprehensive description of the features, classification algorithms, and datasets employed is provided. Additionally, the paper evaluates these systems in terms of their final classification accuracy, sensitivity, and precision. Moreover, the paper discusses the latest challenges in driver drowsiness detection, explores the practicality and reliability of each system type, and presents future trends in the field. In [2]This research paper presents an innovative system for detecting driver drowsiness using Convolutional Neural Networks (CNN). The system aims to achieve real-time application, high accuracy, and fast processing speed. Three potential models, including a Fully Designed Neural Network (FD-NN) and Transfer Learning with VGG16 and VGG19 architectures (TL-VGG), are introduced and evaluated using a comprehensive dataset. The experimental results demonstrate the system's effectiveness in accurately estimating eye closure and detecting drowsiness with low computational complexity. [3]This paper addresses the challenge of detecting driver drowsiness, which is influenced by distinct facial expressions caused by exhaustion. It explores different architectures for face and drowsiness detection, considering environmental factors such as lighting and camera positioning. The study proposes novel deep learning techniques and utilizes facial regions and modified LeNet architecture for effective detection. [4] this paper provides an up-to-date and comprehensive review of emerging technologies for monitoring driver drowsiness and alertness. It evaluates objective driver state monitoring technologies, including driving and driver behavioral analysis, as well as driver physiological signals measurement-based technologies. The study aims to enhance our understanding of driver sleepiness and contribute to the development of effective crash prevention technologies.

III. METHODOLOGY/APPROACH

A. *Design Considerations:*

Haar Cascade Classifier is one of the few object detection methods with the ability to detect faces. It offers high-speed computation depending on the number of pixels inside the rectangle feature and not depending on each pixel value of the image. Face Detection, a widely popular subject with a huge range of applications. Modern day Smartphones and Laptops come with in-built face detection softwares, which can authenticate the identity of the user. Haar Cascade is a machine learning-based approach where a lot of positive and negative images are used to train the classifier.

There are numerous apps that can capture, detect and process a face in real time, can identify the age and the gender of the user, and also can apply some really cool filters. The list is not limited to these mobile apps, as Face Detection also has a wide range of applications in Surveillance, Security and Biometrics as well. But the origin of its Success stories dates back to 2001, when Viola and Jones proposed the first ever Object Detection Framework for Real Time Face Detection in Video Footage.

The Viola-Jones object detection framework is a machine learning approach for object detection, proposed by Paul Viola and Micheal Jones in 2001. This framework can be trained to detect almost any object, but this primarily solves the problem of face detection in real- time. This algorithm has four steps.

Objects are classified on very simple features as a feature to encode ad-hoc domain knowledge and operate much faster than pixel system. The feature is similar to haar filters, hence the name ‘Haar’. An example of these features is a 2-rectangle feature, defined as the difference of the sum of pixels of area inside the rectangle, which can be any position and scale within the original image. 3-rectangle and 4- rectangle features are also used here.

The repository has the models stored in XML files, and can be read with the Open CV methods. These include models for face detection, eye detection, upper body and lower body detection, license plate detection etc. Below we see some of the concepts proposed by Viola and Jones in their research.

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Features

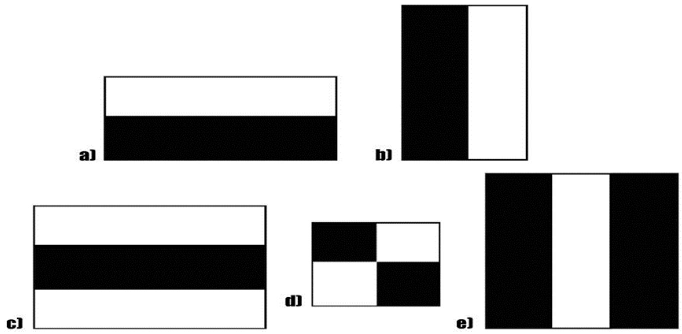

Fig.1 Haar Features.

The first contribution to the research was the introduction of the haar features shown above. These features on the image makes it easy to find out the edges or the lines in the image, or to pick areas where there is a sudden change in the intensities of the pixels.

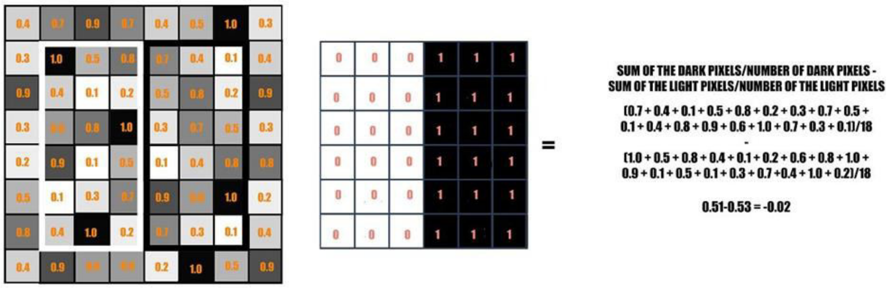

Fig.2 Image representation with pixel values 0.0 to 1.0.

The rectangle at the center is a haar kernel which has all the light pixels on the left and all the dark pixels on the right. The haar calculation is done by finding out the difference of the average of the pixel values at the darker region and the average of the pixel values at the lighter region. If the difference is close to 1, then there is an edge detected by the haar feature.

A sample calculation of Haar value from a rectangular image section has been shown here. The darker areas in the haar feature are pixels with values 1, and the lighter areas are pixels with values 0. Each of these is responsible for finding out one particular feature in the image. Such as an edge, a line or any structure in the image where there is a sudden change of intensities. For ex. in the image above, the haar feature can detect a vertical edge with darker pixels at its right and lighter pixels at its left.

The objective here is to find out the sum of all the image pixels lying in the darker area of the haar feature and the sum of all the image pixels lying in the lighter area of the haar feature. And then find out their difference. Now if the image has an edge separating dark pixels on the right and light pixels on the left, then the haar value will be closer to 1. That means, we say that there is an edge detected if the haar value is closer to 1. In the example above, there is no edge as the haar value is far from 1.

This is just one representation of a particular haar feature separating a vertical edge. Now there are other haar features as well, which will detect edges in other directions and any other image structures. To detect an edge anywhere in the image, the haar feature needs to traverse the whole image.

The haar feature continuously traverses from the top left of the image to the bottom right to search for the particular feature. This is just a representation of the whole concept of the haar feature traversal. In its actual work, the haar feature would traverse pixel by pixel in the image. Also all possible sizes of the haar features will be applied.

Depending on the feature each one is looking for, these are broadly classified into three categories. The first set of two rectangle features are responsible for finding out the edges in a horizontal or in a vertical direction (as shown

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above). The second set of three rectangle features are responsible for finding out if there is a lighter region surrounded by darker regions on either side or vice-versa. The third set of four rectangle features are responsible for finding out change of pixel intensities across diagonals.

Now, the haar features traversal on an image would involve a lot of mathematical calculations. As we can see for a single rectangle on either side, it involves 18 pixel value additions (for a rectangle enclosing 18 pixels). Imagine doing this for the whole image with all sizes of the haar features. This would be a hectic operation even for a high performance machine.

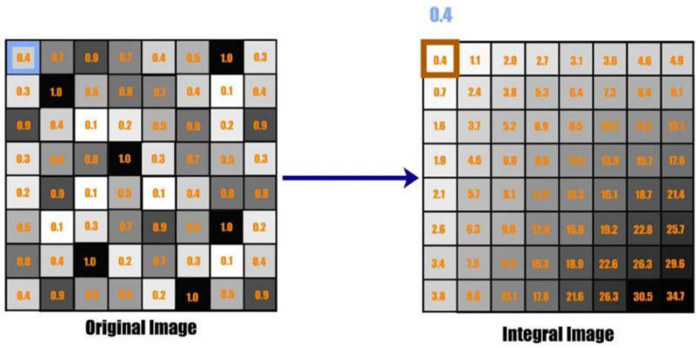

Fig.3 The making of an Integral Image.

To tackle this, they introduced another concept known as The Integral Image to perform the same operation. An Integral Image is calculated from the Original Image in such a way that each pixel in this is the sum of all the pixels lying in its left and above in the Original Image. The calculation of a pixel in the Integral Image can be seen in the above GIF. The last pixel at the bottom right corner of the Integral Image will be the sum of all the pixels in the Original Image.

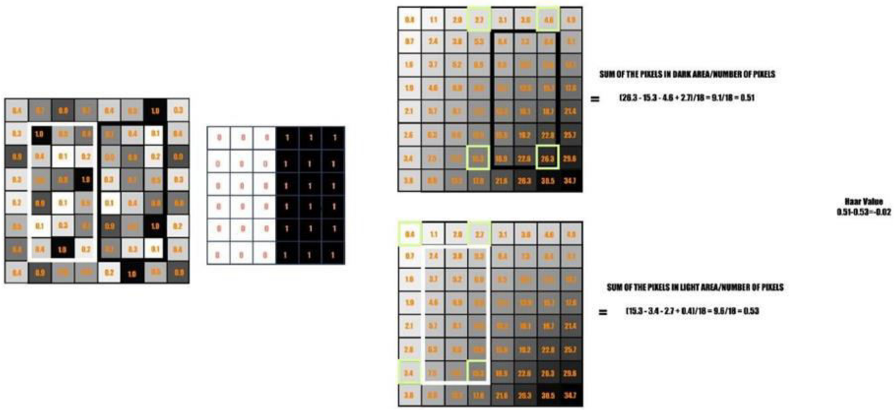

Fig.4 Calculating haar value using Integral Image

With the Integral Image, only 4 constant value additions are needed each time for any feature size (with respect to the 18 additions earlier). This reduces the time complexity of each addition gradually, as the number of additions does not depend on the number of pixels enclosed anymore.

In the above image, there is no edge in the vertical direction as the haar value is -0.02, which is very far from 1.

For a window of 24x24 pixels, there can be about 162,336 possible features that would be very expensive to evaluate. Hence AdaBoost algorithm is used to train the classifier with only the best features.

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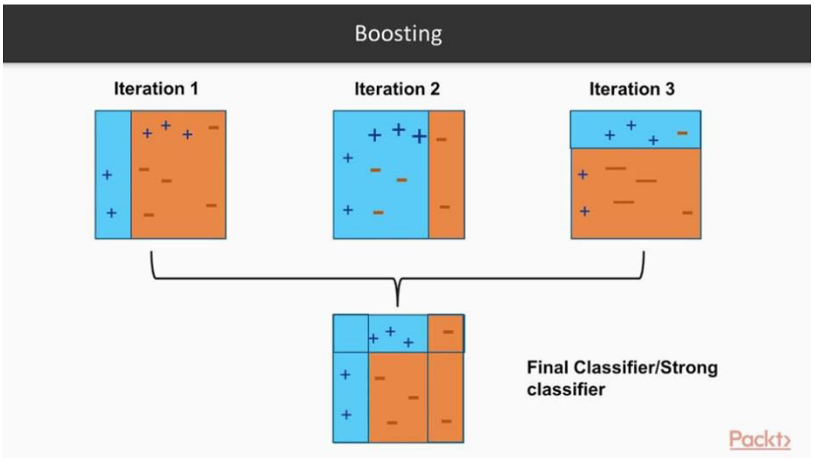

Fig.5 Final Classifier

A cascade classifier refers to the concatenation of several classifiers arranged in successive order. It makes large numbers of small decisions as to whether its the object or not. The structure of the cascade classifier is of a degenerate decision tree.

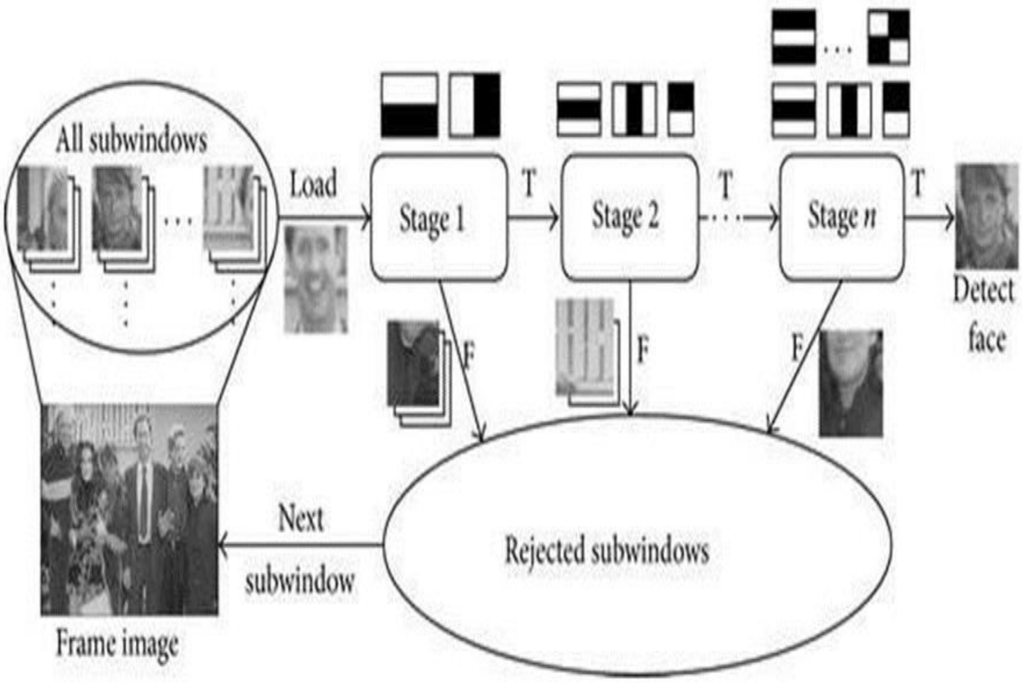

Fig.6 Architecture Diagram of Haar Cascade algorithm

Haar Cascade Detection is one of the oldest yet powerful face detection algorithms invented. It has been there since long, long before Deep Learning became famous. Haar Features were not only used to detect faces, but also for eyes, lips, license number plates etc. The models are stored on GitHub, and we can access them with OpenCV methods

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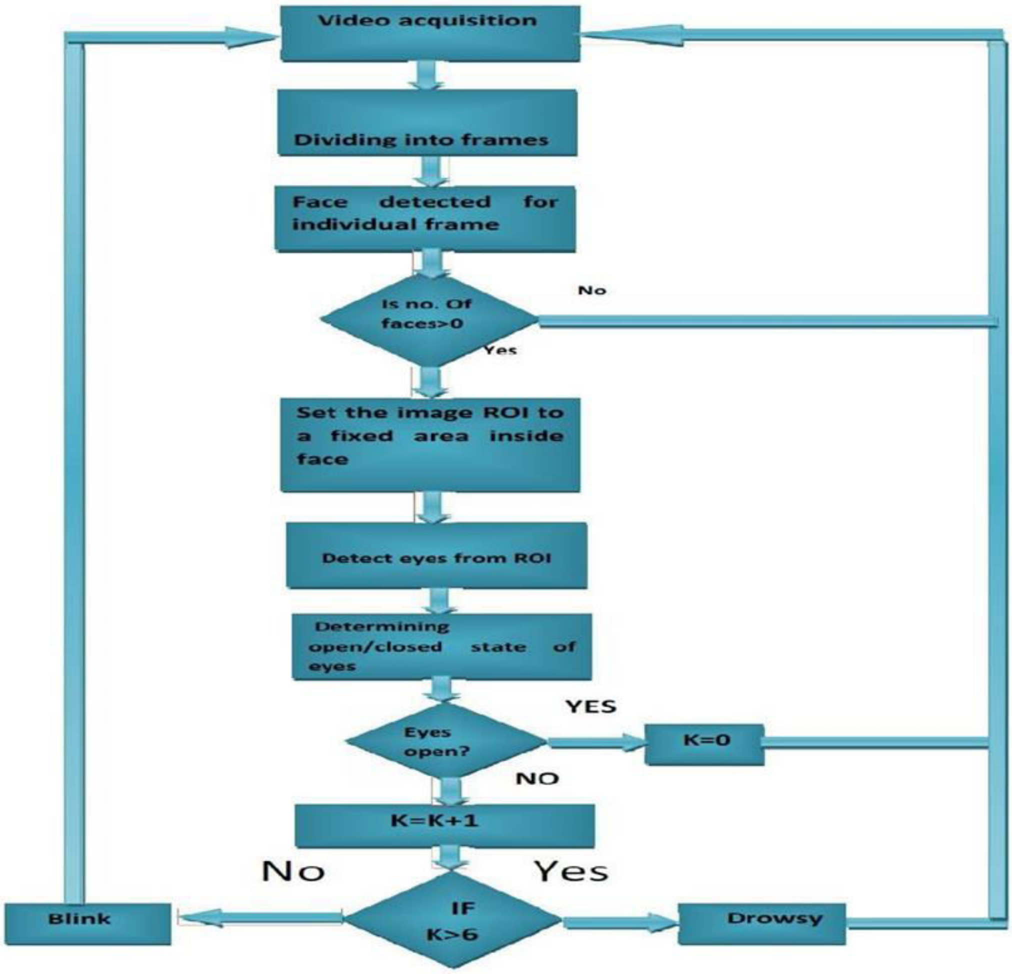

Fig.7 High Level System Flow

Is a particular number of frames depending on the frame rate, then it means that the automobile driver is feeling drowsy and a sound alarm is triggered. However, if the closed states of the eyes are not continuous, then it is declared as a blink

IV. RESULTS AND DISCUSSION

1. Driving Behavioral Analysis (Vehicle-based)

In this category, various technologies have been developed to analyze driving behaviors as indicators of driver drowsiness. Several studies have reported promising results using parameters such as steering wheel movement, lane deviation, and vehicle speed. These technologies have shown good accuracy in detecting drowsiness-related changes in driving behavior. However, further research is needed to validate their effectiveness in real-world driving scenarios and to address challenges such as different driving conditions and individual driving styles.

2. Driver Behavioral Analysis (Video-based)

Video-based technologies offer the advantage of directly monitoring the driver's facial expressions and eye movements. By analyzing facial features and changes in eye behavior, these systems can detect signs of drowsiness. Several algorithms, including deep learning approaches, have shown promising results in accurately detecting drowsiness-related facial expressions. However, challenges such as variations in lighting conditions and driver appearance need to be addressed to improve the robustness and real-time performance of these systems.

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3. Driver Physiological Signals Measurement-based Technologies

Technologies based on measuring driver physiological signals, such as heart rate, electroencephalography (EEG), and electrooculography (EOG), have also been explored for drowsiness detection. These systems can provide objective measurements of the driver's physiological state, which can be indicative of drowsiness. However, challenges remain in terms of sensor placement, signal processing techniques, and the impact of external factors on signal quality. Further advancements in wearable sensors and signal analysis algorithms are necessary to enhance the accuracy and usability of these technologies.

Overall, the reviewed technologies demonstrate significant potential in monitoring driver drowsiness and alertness. However, there are still challenges that need to be addressed, such as real-world validation, robustness to environmental factors, and user acceptance. Future research should focus on addressing these challenges to ensure the practical implementation and effectiveness of crash prevention technologies. By advancing our understanding of driver sleepiness and developing reliable detection systems, we can contribute to improving road safety and reducing the risk of accidents caused by drowsy driving.

V. CONCLUSION AND FUTURE WORK

Conclusion

In conclusion, this study has provided an overview and evaluation of emerging technologies for driver drowsiness detection and monitoring. The reviewed technologies, including driving behavioral analysis, driver behavioral analysis (video-based), and driver physiological signals measurement-based technologies, show great potential in detecting drowsiness and improving driver safety. Each technology has its strengths and limitations, and further research is needed to address challenges and enhance their effectiveness.

Through this research, it has been established that driver drowsiness is a critical issue that poses a significant risk to road safety. The development and implementation of drowsiness detection systems can play a vital role in preventing accidents caused by driver fatigue and improving overall driver alertness.

Future Work

There are several avenues for future research and development in the field of driver drowsiness detection. Some potential areas for future work include:

1. Integration of Multiple Technologies: Investigate the feasibility of combining multiple detection technologies, such as driving behavioral analysis, driver behavioral analysis (video-based), and driver physiological signals measurement-based technologies. Integration of these technologies may lead to more robust and accurate drowsiness detection systems.

2. Real-world Validation: Conduct extensive field studies and real-world validation of the developed systems to assess their performance and reliability under various driving conditions, including different road types, weather conditions, and traffic scenarios.

3. User Acceptance and Usability: Evaluate the user acceptance and usability of drowsiness detection systems. Consider factors such as user comfort, ease of use, and system integration in vehicles to ensure widespread adoption and practical implementation.

4. Long-term Monitoring: Explore the possibility of developing systems that can continuously monitor driver drowsiness over extended periods. This could involve the integration of wearable sensors or monitoring systems that can track drowsiness trends and provide timely alerts.

5. Incorporation of External Factors: Investigate the incorporation of external factors such as vehicle states, sleeping patterns, weather conditions, and mechanical data to enhance the accuracy and reliability of fatigue measurement.

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By addressing these areas of future research, we can further advance the field of driver drowsiness detection and contribute to the development of effective strategies for preventing accidents caused by drowsy driving. Ultimately, these efforts will improve road safety and save lives.

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