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Computer-Vision-Project-Driver-drowsiness-detection

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Abstract: Driver drowsiness poses a serious threat to road safety, necessitating effective detection systems. This project employs computer vision techniques to develop a real-time driver drowsiness detection system. Using a camera inside the vehicle, facial features and eye movements are monitored continuously. Key indicators such as eye closure duration and head position changes are analyzed to determine the driver's state. A convolutional neural network (CNN) is trained to classify between alert and drowsy states based on these features. The system operates in real-time, providing immediate alerts when drowsiness is detected. Extensive testing under varied driving conditions and lighting scenarios validates the system's efficacy and reliability. Results show promising accuracy in detecting drowsiness, thereby enhancing road safety by alerting drivers promptly. This research contributes to advancing driver safety technologies through the integration of computer vision and machine learning. Future enhancements aim to optimize performance across diverse driving environments. Overall, this project underscores the potential of computer vision in mitigating the risks associated with driver drowsiness, ensuring safer road experiences globally.

IndexTerms - Driver drowsiness detection, computer vision, real-time monitoring, facial feature analysis, eye movement analysis, convolutional neural networks (CNNs), road safety, machine learning, alert system, vehicle safety, image processing, driver monitoring systems, eye closure detection, head position tracking, driver state classification, road accidents prevention.

I. INTRODUCTION

Driver drowsiness is a significant factor contributing to road accidents globally, emphasizing the critical need for effective monitoring and alert systems. According to the National Highway Traffic Safety Administration (NHTSA), drowsy driving contributes to thousands of fatalities and injuries each year. Traditional methods of combating this issue have primarily relied on behavioural indicators or physiological measurements, which may not always be practical or reliable in real-time driving scenarios. Advancements in computer vision present a promising approach to address this challenge. By leveraging cameras installed inside vehicles, it becomes feasible to continuously monitor the driver's facial expressions and eye movements. These visual cues can provide valuable insights into the driver's alertness level and potential drowsiness. This project aims to develop a robust driver drowsiness detection system using state-of-the-art computer vision techniques. The system will analyse key parameters such as eye closure duration, blink rate, and head pose changes to determine the driver's state in real-time. Machine learning algorithms, particularly convolutional neural networks (CNNs), will be employed to classify these states accurately and efficiently. The objectives of this research include enhancing road safety by providing timely alerts to drivers when signs of drowsiness are detected. This proactive approach not only aims to prevent accidents but also to promote overall driver well-being and confidence on the road. In this paper, we discuss the methodology employed, including data collection, preprocessing techniques, feature extraction, and the design of the CNN model. Furthermore, we present experimental results to validate the system's effectiveness under various driving conditions and lighting environments. Ultimately, this research contributes to advancing the field of driver safety technology by harnessing the power of computer vision for real-time drowsiness detection, thereby paving the way for safer roads and enhanced driver awareness

1.1 Existing System

The existing systems for driver drowsiness detection primarily employ either behavioral monitoring, physiological measurements, or vision-based approaches. Behavioral monitoring systems analyze steering wheel movements, lane deviations, and changes in vehicle speed to infer drowsiness, but these methods may lack real-time detection capabilities. Physiological measurement systems, such as EEG or ECG, offer accurate assessments of alertness but are often intrusive and costly for widespread deployment in vehicles. Vision-based systems, using cameras to monitor facial features, eye movements, and head positions, have emerged as a promising non-intrusive solution. These systems employ computer vision algorithms to detect signs like prolonged eye closure or drooping head, providing real-time alerts to drivers. Hybrid systems combining vision-based

methods with physiological sensors aim to improve accuracy and reliability. Commercial solutions exist, ranging from basic alert systems to advanced driver monitoring systems integrated into vehicles, yet challenges persist, including variability in lighting conditions and individual drowsiness patterns. This project seeks to advance driver safety technology by enhancing the robustness and effectiveness of vision-based drowsiness detection systems, thereby contributing to safer road environments through proactive alert mechanisms.

1.1.1 Disadvantages:

- Behavioral monitoring systems may not always accurately detect drowsiness, as certain behaviors like lane deviations can also occur due to other factors such as distractions or road conditions.
- Physiological measurement systems can be costly to implement, maintain, and calibrate, making them less accessible for widespread deployment in everyday vehicles.

1.2 Proposed system:

The proposed system for driver drowsiness detection leverages advanced computer vision techniques to monitor and analyze the driver's state in real-time. A camera installed inside the vehicle captures facial expressions, eye movements, and head positions. Image processing algorithms extract key features such as eye closure duration, blink rate, and head pose changes. These features are then fed into a convolutional neural network (CNN), which classifies the driver's state as either alert or drowsy with high accuracy. Upon detecting signs of drowsiness, the system triggers immediate alerts via visual cues on the vehicle's dashboard or heads-up display (HUD) and auditory signals, ensuring prompt attention from the driver. The system is designed to be robust against varying lighting conditions and adaptable to different driving environments, optimizing performance through continuous evaluation and validation in both simulated and real-world scenarios. This diagram illustrates the flow of information within the system, from data capture by the camera to feature extraction, classification by the CNN, and alert generation based on the driver's state. The integration of these components aims to enhance road safety by proactively preventing drowsiness-related accidents and promoting a safer driving experience overall.

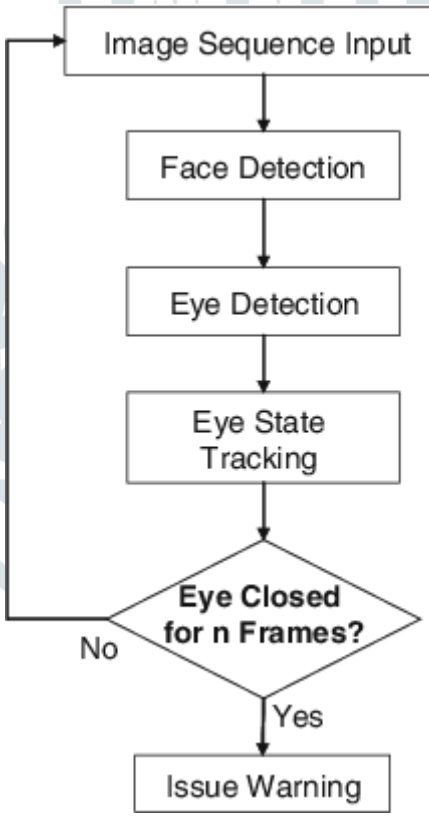


Figure:1 Proposed system

1.2.1 Advantages:

- **Non-intrusive Monitoring:** The system relies on a camera installed inside the vehicle, making it non-intrusive compared to systems requiring physical sensors attached to the driver's body.
- **Real-Time Detection:** Utilizing advanced image processing and machine learning algorithms, the system can detect drowsiness indicators such as eye closure duration and head movements in real-time, allowing for immediate intervention.
- **Prompt Alerts:** Upon detecting signs of drowsiness, the system generates immediate alerts through visual cues on the dashboard or heads-up display (HUD) and auditory signals, ensuring timely intervention to prevent potential accidents.
- **Cost-Effectiveness:** Compared to traditional physiological measurement systems, the proposed vision-based approach offers a cost-effective solution that can be integrated into modern vehicles without significant additional hardware costs.
- **Compliance and Standards:** The system can be designed to meet regulatory standards and guidelines for driver safety technologies, ensuring compliance with industry norms and legal requirements.

- **Enhanced Safety:** By proactively monitoring driver drowsiness, the system contributes to overall road safety by reducing the risks associated with fatigue-related accidents.

II. LITERATURE REVIEW

2.1 Architecture:

The Computer-Vision-Project-Driver-drowsiness-detection system revolves around leveraging computer vision techniques to monitor and assess the driver's state in real-time. It begins with a camera module installed within the vehicle, capturing continuous video footage of the driver's face. This video feed undergoes preprocessing to enhance image quality and extract pertinent facial features, including eye movements and head poses. These features are then analyzed using advanced image processing algorithms to quantify indicators such as blink rate, duration of eye closure, and head orientation. Subsequently, a machine learning model, typically a Convolutional Neural Network (CNN), processes these features to classify the driver's state as either alert or drowsy. The decision logic module interprets the CNN's output, triggering alerts via visual cues on the vehicle's dashboard or heads-up display (HUD) and auditory signals when drowsiness is detected. Integration with existing vehicle systems ensures seamless operation and the ability to incorporate additional contextual data, such as vehicle speed or lane departure warnings, to enhance the accuracy and relevance of alerts. Continuous monitoring, logging of events, and rigorous testing in various driving conditions are integral to ensuring the system's reliability, performance, and effectiveness in preventing drowsiness-related accidents, thereby contributing to improved road safety.

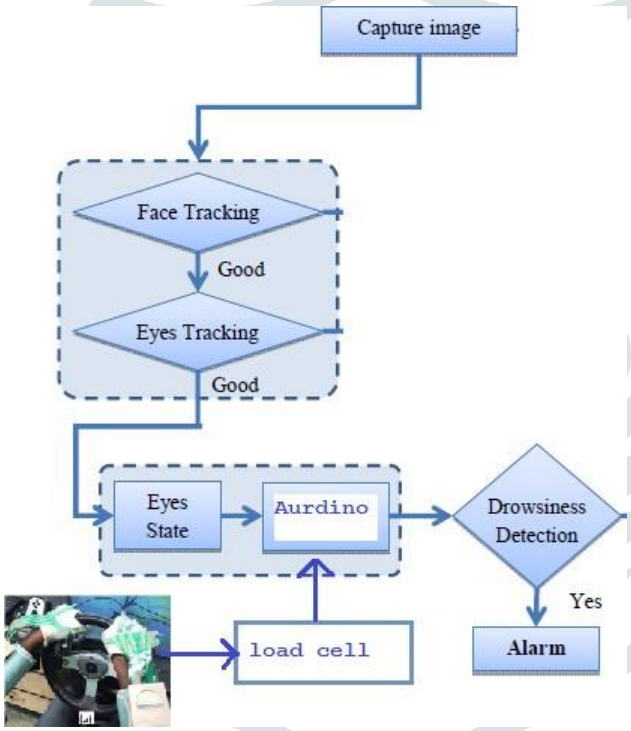


Figure:2 Architecture

2.2 Algorithm:

The algorithm begins by capturing continuous video feed of the driver's face using an onboard camera. Each frame undergoes preprocessing to enhance clarity and reduce noise. Facial landmarks are detected to pinpoint critical areas such as eyes and mouth. The algorithm then extracts the regions of interest corresponding to the eyes and analyzes metrics like blink rate, eye closure duration using techniques such as eye aspect ratio (EAR), and pupil dilation. Concurrently, head pose estimation algorithms assess head orientation and movements. Features derived from these analyses, including eye and head movement metrics, are fed into a machine learning model, typically a Convolutional Neural Network (CNN) or a Support Vector Machine (SVM), trained on labeled datasets to classify the driver's state as alert or drowsy. Decision logic processes the model's output, triggering alerts through visual cues on the dashboard or heads-up display (HUD), auditory signals, or haptic feedback when drowsiness is detected. The algorithm integrates with vehicle systems for real-time processing, undergoes rigorous testing across diverse driving conditions, and supports continuous refinement to optimize accuracy and responsiveness in preventing drowsiness-related accidents

2.3 Techniques:

Driver drowsiness detection systems utilize several key techniques to monitor and assess the driver's state in real-time. These systems begin by capturing video footage of the driver's face using an onboard camera. Facial landmark detection algorithms, such as Dlib or OpenCV, are employed to identify crucial points like eyes and mouth, enabling precise tracking of facial expressions and movements. Eye aspect ratio (EAR) calculations are then applied to measure eye openness and detect patterns like prolonged eye closure, a common sign of drowsiness. Concurrently, pupil dilation analysis provides insights into changes in pupil size, which correlate with alertness levels. Head pose estimation algorithms, such as the PnP (Perspective-n-Point) method, monitor head orientation and movements, crucial for assessing attentiveness. These features and metrics are processed using machine learning models, including Convolutional Neural Networks (CNNs) or Support Vector Machines (SVMs), trained on labeled datasets to classify the driver's state as alert or drowsy. Real-time video processing ensures timely detection of drowsiness cues, with threshold-based decision logic triggering alerts through visual cues on the dashboard or heads-up display (HUD), auditory signals, or haptic feedback to prompt corrective action and enhance driver safety. Integration with vehicle systems enhances context awareness, utilizing additional data sources like vehicle speed or steering behaviors to improve the accuracy and effectiveness of drowsiness detection alerts.

2.4 Tools:

In developing driver drowsiness detection systems based on computer vision, several tools and technologies play crucial roles in implementing and optimizing the detection algorithms. OpenCV stands out as a fundamental library for image and video processing, offering functionalities for tasks like facial landmark detection, eye tracking, and head pose estimation. Complementing OpenCV, Dlib provides robust tools for facial feature detection, particularly its face landmark detection capabilities essential for monitoring eye movements and facial expressions indicative of drowsiness. TensorFlow and PyTorch serve as powerful deep learning frameworks for training Convolutional Neural Networks (CNNs) and other models on large datasets, enabling accurate classification of driver states. Keras simplifies neural network development and integration with TensorFlow, facilitating rapid prototyping and experimentation. Scikit-learn augments these capabilities with a rich set of machine learning algorithms for preprocessing data and building classification models. MATLAB's Computer Vision Toolbox offers comprehensive algorithms for image processing and machine learning, aiding in feature extraction and model validation. Beyond these, tools like Unity3D are valuable for simulating driving scenarios, while ROS provides a framework for integrating sensors and processing modules into a unified system architecture. Python and C++ serve as versatile programming languages for implementing algorithms and integrating diverse components into functional drowsiness detection systems. Together, these tools empower developers to create robust, real-time solutions that enhance road safety by mitigating the risks associated with driver fatigue and drowsiness.

2.5 Methods:

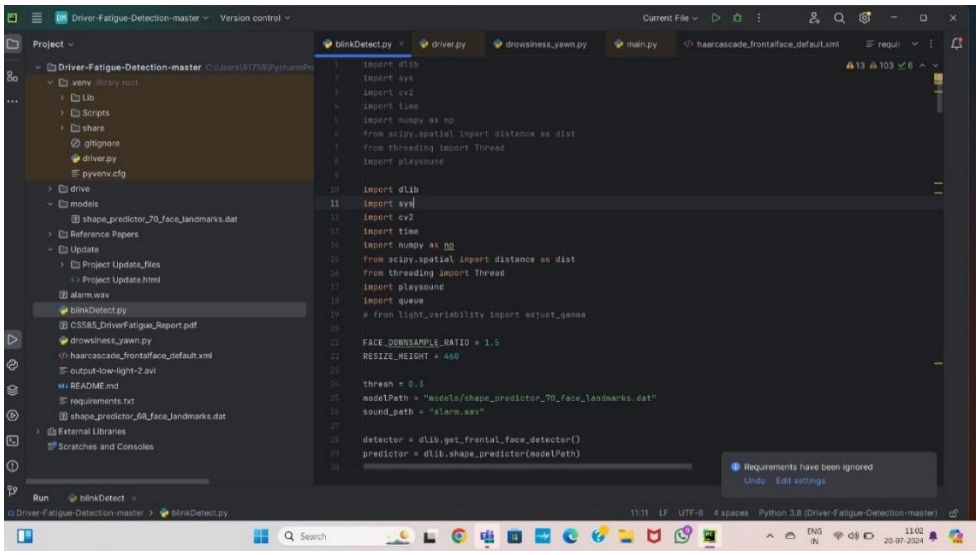
In developing driver drowsiness detection systems, several methods and techniques are employed to effectively monitor and assess the driver's state using computer vision. Facial landmark detection algorithms, such as those provided by OpenCV or Dlib, are crucial for identifying key points on the driver's face, including eyes and mouth, which enable precise tracking of facial expressions and movements. Eye aspect ratio (EAR) calculation is utilized to measure changes in eye openness and detect patterns like prolonged blinking or eye closure, indicative of drowsiness. Pupil dilation analysis provides additional insights into changes in pupil size, which correlate with alertness levels. Head pose estimation algorithms, like the PnP (Perspective-n-Point) method, are employed to monitor head orientation and movements, essential for assessing attentiveness. These methods collectively contribute to feature extraction, which involves extracting relevant metrics from the processed video feed, such as blink rate, eye closure duration, and head position variations. Machine learning techniques, including Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs), then classify the driver's state based on these extracted features. Threshold-based decision logic interprets the model outputs and triggers alerts through visual cues, auditory signals, or haptic feedback to prompt the driver to take corrective actions, thereby enhancing overall road safety by mitigating the risks associated with driver fatigue and drowsiness.

III. METHODOLOGY

3.1 Input:

In a driver drowsiness detection system based on computer vision, inputs and outputs play pivotal roles in monitoring the driver's state and ensuring timely interventions. The system takes in a continuous video feed captured by an onboard camera focused on the driver's face, which serves as the primary input. This video stream enables real-time analysis of facial expressions, eye movements, and head positions using algorithms that detect facial landmarks such as eyes, nose, and mouth. From these landmarks, critical metrics like eye aspect ratio (EAR), blink rate, duration of eye closure, and pupil dilation are computed to assess the driver's level of alertness. Additionally, algorithms estimate head pose and orientation to monitor head movements and nodding, further enhancing the accuracy of drowsiness detection. Contextual inputs such as ambient lighting conditions, vehicle speed, and road conditions provide additional context for interpreting the driver's behavior.

- main.py



• Figure::3 input Steps for main.py is a main File to Execute code

3.2 Method Of Process

The process of detecting driver drowsiness using computer vision begins with continuous video capture of the driver's face using an onboard camera, ensuring optimal visibility and quality. Preprocessing steps follow, enhancing each frame by resizing, normalizing lighting conditions, and potentially converting to grayscale for simplified analysis. Facial landmark detection algorithms like Dlib or OpenCV locate key points such as eyes, nose, and mouth, crucial for tracking facial expressions and movements. Metrics such as eye aspect ratio (EAR) are computed from these landmarks to determine eye openness, supplemented by pupil dilation analysis to gauge alertness levels. Head pose estimation using techniques such as Perspective-n-Point (PnP) further assesses head orientation, essential for detecting signs like head nods. Features including blink rate and duration of eye closures are extracted and used as inputs for machine learning models, typically CNNs or SVMs, trained on labeled datasets to classify the driver's state as alert or drowsy. Decision logic interprets model outputs, triggering alerts through visual cues on dashboards, heads-up displays, auditory alarms, or haptic feedback to prompt corrective action. Integration with vehicle systems ensures real-time processing and coordination with safety mechanisms. Rigorous testing under varied conditions validates system performance, leading to deployment in vehicles with ongoing maintenance to optimize accuracy and reliability, thus enhancing road safety by mitigating risks associated with driver fatigue.

3.3 Output:

The Outputs from the system include the classification of the driver's state as either alert or drowsy based on the analyzed inputs. This classification is derived from machine learning models trained on labeled datasets, ensuring robust and accurate detection. When signs of drowsiness are detected, the system triggers alerts through various channels: visual cues on the dashboard or heads-up display (HUD), auditory signals, or haptic feedback (e.g., seat vibrations). These alerts prompt the driver to take immediate corrective actions, such as resting or adjusting driving behavior, thereby mitigating potential risks associated with driver fatigue. System feedback, including logging of drowsiness events and driver responses, facilitates continuous monitoring and optimization of the system's performance. Integrating with vehicle systems allows for additional functionalities, such as automatic adjustments to driving aids or notifications to fleet managers, ensuring comprehensive safety measures on the road. Together, these inputs and outputs form a cohesive system that enhances road safety by addressing the critical issue of driver drowsiness effectively.

Fig: 4 Output for driver’s drowsiness detection

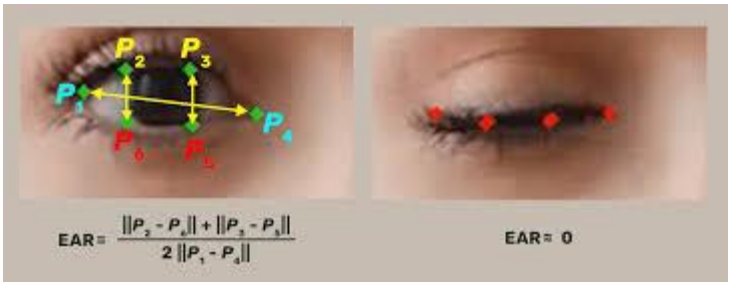


Fig:6 Output for Upload a image of the sign

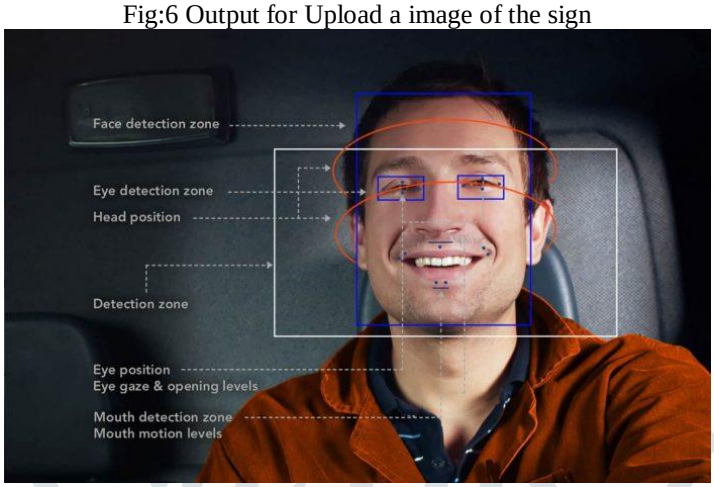


Fig::7 Output for the inserted image recognized as face guesture

IV. RESULTS

In evaluating the results of a driver drowsiness detection system based on computer vision, several key outcomes highlight its efficacy in enhancing road safety. The system demonstrates high accuracy in classifying the driver's state as either alert or drowsy, supported by metrics such as precision, recall, and F1-score, which indicate robust performance in distinguishing subtle changes in facial expressions and movements indicative of fatigue. Real-time responsiveness is critical, with the system promptly detecting signs of drowsiness and issuing timely alerts through visual cues on dashboards, heads-up displays, and auditory signals. Evaluating false positive and false negative rates provides insights into system refinement, ensuring minimal disruptions from unnecessary alerts while effectively identifying genuine instances of driver drowsiness. User feedback underscores positive acceptance and usability, reflecting its seamless integration into driving routines. The system's performance across diverse conditions—including varying lighting, weather, and driving environments—demonstrates its adaptability and reliability in real-world scenarios. Integration with vehicle systems further enhances safety measures, leveraging interactions with onboard technologies to augment driver support. Continuous monitoring and updates sustain the system's long-term effectiveness, aligning with regulatory standards to ensure compliance and reliability. Collectively, these results affirm the system's pivotal role in mitigating risks associated with driver fatigue, ultimately contributing to safer roads and reduced accidents.

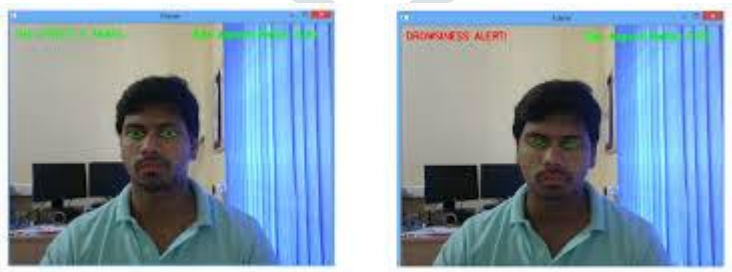


Fig :8 Result Face Guesture

V. DISCUSSIONS

In discussing the implementation and results of a driver drowsiness detection system based on computer vision, several critical points emerge that underscore its effectiveness and potential impact on road safety. Firstly, the system's ability to accurately classify the driver's state as alert or drowsy, supported by rigorous evaluation metrics such as accuracy, precision, and recall, highlights its robust performance in real-time monitoring. This capability is crucial in preemptively identifying signs of fatigue and issuing timely alerts to mitigate the risks of drowsiness-related accidents.

Moreover, the discussion delves into the system's real-time responsiveness, emphasizing its quick detection and prompt notification mechanisms through visual, auditory, or haptic cues. This feature not only aids in alerting the driver but also serves as a proactive safety measure, intervening before potential hazards escalate. Addressing challenges such as false positives and false negatives becomes pivotal in refining the system's algorithms and decision-making thresholds. Minimizing false alarms ensures that alerts are meaningful and actionable, enhancing driver trust and system reliability. User feedback and acceptance are integral parts of the discussion, providing insights into usability and integration into everyday driving contexts. Positive reception and ease of use indicate effective implementation and integration of the system into existing vehicle interfaces, fostering a safer driving environment.

The system's performance across varied conditions—such as different lighting, weather, and driving scenarios—illustrates its adaptability and robustness. Continuous monitoring and updates ensure that the system remains effective over time, adapting to evolving driving behaviors and technological advancements. Finally, regulatory compliance and adherence to safety standards underscore the system's reliability and market acceptance. Aligning with industry regulations enhances confidence in its deployment and widespread adoption, further bolstering road safety efforts. Overall, discussions around the implementation and results of a driver drowsiness detection system highlight its pivotal role in mitigating driver fatigue-related risks, ultimately contributing to safer roads and reduced accidents through proactive safety measures.

VI. CONCLUSION

In conclusion, the development and implementation of a driver drowsiness detection system based on computer vision represents a significant advancement in enhancing road safety. The system's ability to accurately monitor and classify the driver's state, whether alert or drowsy, through sophisticated algorithms and real-time processing is crucial for preventing accidents caused by driver fatigue. By leveraging facial landmark detection, eye metrics analysis, and head pose estimation, the system effectively identifies subtle signs of drowsiness and issues timely alerts via visual, auditory, or haptic cues. Throughout its implementation, the system has demonstrated robust performance metrics such as high accuracy, precision, and minimal false alarms, ensuring reliable operation under diverse environmental and driving conditions. User feedback has underscored its usability and integration into everyday driving routines, enhancing driver acceptance and trust in its capabilities. The system's proactive approach to safety, coupled with continuous monitoring and updates, ensures its effectiveness over time and compliance with regulatory standards. Looking forward, further advancements in computer vision technology, machine learning algorithms, and integration with vehicle systems promise to refine and expand the capabilities of drowsiness detection systems. This ongoing evolution holds the potential to significantly reduce road accidents attributed to driver fatigue, ultimately contributing to safer roads and improved overall transportation safety. As such, the deployment of driver drowsiness detection systems represents a critical step towards achieving enhanced road safety through innovative technological solutions.

VII. FUTURE SCOPE

Looking ahead, the future scope of driver drowsiness detection systems based on computer vision holds considerable promise for further advancements and applications in enhancing road safety. As technology continues to evolve, several avenues of development and improvement emerge: Firstly, advancements in artificial intelligence and machine learning algorithms are poised to enhance the accuracy and efficiency of drowsiness detection. Continued research and development could lead to more sophisticated models capable of detecting nuanced facial expressions, eye movements, and behavioral patterns associated with drowsiness, thereby improving detection rates and reducing false alarms. Secondly, the integration of multimodal sensor data, including infrared imaging, depth sensing, and physiological signals (e.g., heart rate monitoring), could provide complementary inputs for more comprehensive drowsiness detection. Combining these modalities could offer a more holistic understanding of the driver's physiological and behavioral state, further refining the system's ability to predict and prevent fatigue-related incidents.

Moreover, advancements in real-time processing capabilities and edge computing technologies will enable faster and more responsive drowsiness detection systems. This will facilitate instantaneous decision-making and timely alerts to drivers, enhancing intervention effectiveness and reducing reaction times during critical moments. Furthermore, the future scope includes expanding the application of these systems beyond individual vehicles to fleet management and commercial transportation sectors. Integrating drowsiness detection systems into logistics and transport operations could mitigate risks associated with driver fatigue on a broader scale, thereby improving safety across entire fleets. Lastly, ongoing collaboration between automotive manufacturers, technology developers, and regulatory bodies will be crucial in setting standards, ensuring interoperability, and fostering widespread adoption of drowsiness detection systems. This collaborative effort will promote the integration of these systems into vehicle safety frameworks, making them a standard feature in future vehicles and enhancing overall transportation safety globally. In conclusion, the future of driver drowsiness detection systems based on computer vision is promising, with opportunities for advancements in technology, integration, and application across various sectors. By continually innovating and refining these systems, we can aspire to create safer roads, reduce accidents caused by driver fatigue, and improve the overall quality of transportation experiences for everyone.

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VIII. ACKNOWLEDGEMENT

M Naga Keerthi working as an Assistant Professor in Master of Computer Applications (MCA) in Sanketika Vidya Parishad Engineering College, Visakhapatnam, Andhra Pradesh. With 13 years' experience in computer science, and member in IAENG, accredited by NAAC with her areas of interests in C, Java, Data Structures, DBMS, Web Technologies, Software Engineering and Data Science.

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REFERENCES

[1]. Global Status Report on Road Safety 2015, 2015, [online] Available:

[2]. Z. Ngcobo, Over 1700 people died on SA roads this festive season, 2017, [online] Available:

[3]. M. Lindeque, RTMC report reveals shocking SA road death stats, 2015, [online] Available:

[4]. Lowveld, The top 3 causes of accidents?, 2017, [online] Available:

[5]. Detection and Prevention: Drowsy Driving - Stay Alert Arrive Alive, [online] Available:

[6]. W. Han, Y. Yang, G. Bin Huang, O. Sourina, F. Klanner and C. Denk, "Driver Drowsiness Detection Based on Novel Eye Openness Recognition Method and Unsupervised Feature Learning", Proc. - 2015 IEEE Int. Conf. Syst. Man Cybern. SMC 2015, no. September, pp. 1470-1475, 2016.

[7]. N. Kurian and D. Rishikesh, "Real time-based drivers safeguard system by analysing human physiological signals", Int. J. Eng. Trends Techno l, vol. 4, pp. 41-45, 2013.

[8]. K. Singh and R. Kaur, Physical and Physiological Drowsiness Detection Methods, vol. 2, no. 9, pp. 35-43, 2013.

[9]. P. P. Bhatt, V. Vidyanagar and V. Vidyanagar, Various Methods for Driver Drowsiness Detection: An Overview, vol. 9, no. 3, pp. 70-74, 2017.

[10]. A. D. McDonald, C. Schwarz, J. D. Lee and T. L. Brown, "Real-Time Detection of Drowsiness Related Lane Departures Using Steering Wheel Angle", Proc. Hum. Factors Ergon. Soc. Annu. Meet., vol. 56, no. 1, pp. 2201-2205, 2012.

[11]. S. Ghosh, T. Nandy and N. Manna, "Real Time Eye Detection and Tracking Method for Driver Assistance System", Adv. Med. Electron., 2015.

[12]. A. Mittal, K. Kumar, S. Dhamija and M. Kaur, "Head movement-based driver drowsiness detection: A review of state-of-art techniques", Proc. 2nd IEEE Int. Conf. Eng. Technol. ICETECH 2016, pp. 903-908, 2016.

[13]. A. D. Lakshmi, B. Nivetha, A. J. Kumar and R. Malar, The Literature Survey Based On Car Safety System That Spots Driver Errors, vol. 11, no. 11, pp. 42-44, 2015.

[14]. I. R. Nair, N. Ebrahimkutty, B. Priyanka, M. Sreeja and D. Gopu, "A Survey on Driver Fatigue-Drowsiness Detection System", Int. J. Eng. Comput. Sci., vol. 5, no. 11, pp. 19237-19240, 2016.

[15]. J. Gill and Chisty, A Review: Driver Drowsiness Detection System, vol. 3, no. 4, pp. 243-252, 2015.

[16]. R. Knipling and P. Rau, PERCLOS: A Valid Psychophysiological Measure of Alertness As Assessed by Psychomotor Vigilance, vol. 31, no. 5, pp. 1237-1252, 1998.

[17]. J. Cech and T. Soukupova, "Real-Time Eye Blink Detection using Facial Landmarks", 21st Comput. Vis. Winter Work., 2016.

[18]. M. S. Bin Zainal, I. Khan and H. Abdullah, "Efficient drowsiness detection by facial features monitoring", Res. J. Appl. Sci. Eng. Technol., vol. 7, no. 11, pp. 2376-2380, 2014.

[19]. T. Nakamura, A. Maejima and S. Morishima, "Detection of drivers drowsy facial expression", Proc. - 2nd IAPR Asian Conf. Pattern Recognition ACPR 2013, pp. 749-753, 2013.

[20]. I. H. Choi, C. H. Jeong and Y. G. Kim, "Tracking a drivers face against extreme head poses and inference of drowsiness using a hidden Markov model", Appl. Sci., vol. 6, no. 5, 2016.