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Fatigue Detection from Facial Features Using AI to Prevent Accidents in Industrial and Transport Sectors

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ABSTRACT

Fatigue is one of the leading causes of accidents in transportation and industrial environments, often resulting from prolonged working hours, monotonous tasks, and reduced alertness. Continuous monitoring of human alertness is essential to prevent fatigue-related accidents and ensure operational safety. This paper presents a real-time fatigue detection system based on facial feature analysis using artificial intelligence and computer vision techniques. The proposed system analyzes eye behavior using facial landmark detection and Eye Aspect Ratio (EAR) computation to identify signs of drowsiness such as prolonged eye closure. The system operates in real time using a standard webcam and provides immediate visual and audio alerts when fatigue is detected. Experimental results demonstrate that the system achieves high detection accuracy with low latency, making it suitable for deployment in transportation and industrial environments.

Keywords: ***Fatigue Detection, Facial Landmarks, Eye Aspect Ratio (EAR), Computer Vision, Artificial Intelligence, Real-Time Monitoring***

INTRODUCTION

Fatigue significantly affects human performance and is a major contributor to accidents in transportation and industrial sectors. Drivers and machine operators often experience reduced alertness due to long working hours, night shifts, and repetitive tasks, leading to delayed reaction times and critical errors.

Traditional fatigue monitoring techniques rely on wearable physiological sensors or manual supervision, which are often intrusive, uncomfortable, and impractical for continuous use. Recent advancements in artificial intelligence and computer vision have enabled non-intrusive fatigue detection by analyzing facial features such as eye movements and blinking behavior. This paper proposes a real-time fatigue detection system using facial landmark analysis and Eye Aspect Ratio (EAR) computation. The system continuously monitors eye behavior through a live video stream and generates immediate alerts when fatigue is detected, thereby reducing the risk of accidents and improving safety.

LITERATURE SURVEY

Several studies have explored fatigue and drowsiness detection using physiological sensors such as EEG and ECG, which provide accurate results but suffer from discomfort and high cost. Behavioral approaches based on steering patterns and vehicle deviation have also been proposed, but their reliability decreases under varying driving conditions. Vision-based fatigue detection methods have gained popularity due to their non-intrusive nature. Research by Soukupová and Čech demonstrated the effectiveness of Eye Aspect Ratio (EAR) for real-time blink detection. Other studies employed facial landmark detection using Dlib and OpenCV to analyze eye closure duration and blinking frequency. Recent research highlights that facial-feature-based approaches provide a balance between accuracy, comfort, and real-time performance. These findings motivate the development of a lightweight, real-time fatigue detection system using facial landmarks.

RELATED WORK

Previous research has focused on fatigue detection using traditional image processing techniques and sensor-based systems. While sensor-based approaches offer high accuracy, they are intrusive and unsuitable for continuous monitoring. Vision-based methods using Haar cascades and classical classifiers showed limited robustness under varying lighting conditions.

Recent approaches integrate facial landmark detection with machine learning techniques to improve accuracy. EAR-based methods are computationally efficient and suitable for real-time applications, but many systems lack integrated alert mechanisms and web-based visualization. The proposed system addresses these limitations by combining facial landmark analysis with real-time alert generation in a web-enabled framework.

EXISTING SYSTEM

Existing fatigue detection systems rely on wearable sensors, vehicle behavior analysis, or manual observation.

These systems suffer from several limitations are Intrusive and uncomfortable sensor usage. High hardware and deployment costs. Lack of real-time performance.

Poor robustness under varying lighting conditions. Absence of automated alert mechanisms As a result, existing solutions are not well-suited for scalable deployment in real-world transportation and industrial environments.

PROPOSED SYSTEM

The proposed system introduces a real-time, vision-based fatigue detection framework using facial feature analysis. The system captures live video using a standard webcam and detects facial landmarks to monitor eye behavior continuously.

Eye Aspect Ratio (EAR) is computed from eye landmarks to determine eye openness. If the EAR value remains below a predefined threshold for a sustained duration, the system identifies the condition as fatigue and triggers both visual and audio alerts. The system is lightweight, non-intrusive, and operates efficiently on standard hardware without requiring GPUs or specialized sensors.

SYSTEM ARCHITECTURE

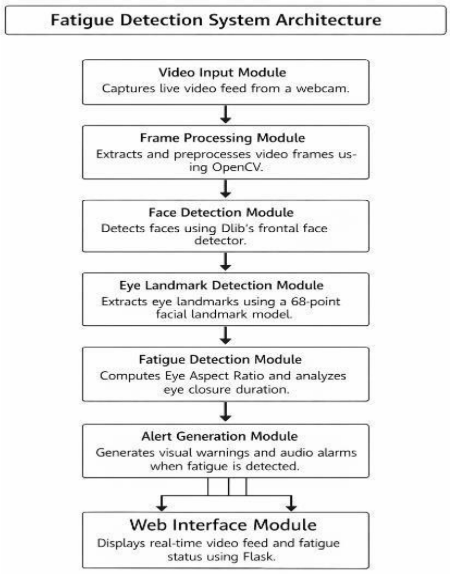

Fig 1: System Architecture

1.Video Input Module: This module captures live video from a standard webcam installed in a vehicle or industrial environment. The video stream serves as the primary data source for fatigue detection.

2.Frame Acquisition and Preprocessing Module: Using OpenCV, the live video stream is divided into individual frames. Each frame is resized and preprocessed to ensure uniform input quality and faster processing. . The system is lightweight, non-intrusive, and operates efficiently on standard hardware.

3.Face Detection Module: The system detects human faces in each video frame using Dlib's frontal face detector. This step ensures that further processing is applied only to relevant facial regions.

4. Facial Landmark Detection Module: A pre-trained 68-point facial landmark predictor is used to extract key facial features. The system primarily focuses on eye landmarks, which are critical indicators of fatigue.

5. Eye Region Extraction Module: From the detected facial landmarks, the eye regions are isolated. This allows accurate analysis of eye openness, blinking patterns, and eye closure duration.

6. Eye Aspect Ratio (EAR) Computation Module: The Eye Aspect Ratio (EAR) is calculated using Euclidean distances between eye landmarks. EAR values decrease significantly during eye closure, making them reliable indicators of fatigue.

7. Fatigue Detection Logic Module: The system compares the EAR value against a predefined threshold. If the EAR remains below the threshold for a continuous number of frames, the system classifies the condition as fatigue.

8. Alert Generation Module: Once fatigue is detected, the system triggers:Visual Alerts displayed on the video feed Audio Alerts using an alarm sound This ensures immediate attention and corrective action.

9. Web Interface Module: A Flask-based web interface displays the live video feed along with fatigue detection status. This enables real-time monitoring through a browser without additional software installation.

RESULTS AND DISCUSSION

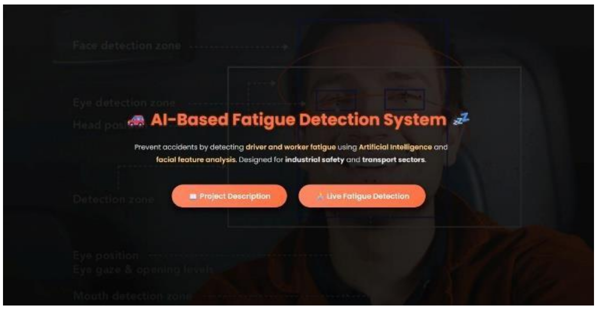

Fig 2: Home Page

Home Page: The home page introduces the AI-based fatigue detection system and provides access to live monitoring.

Fig 3: Project Description Page – Fatigue Detection in Driving

Project Description Page: This image shows the project description and theoretical analysis page titled Fatigue Detection in Driving: A Comprehensive Analysis.

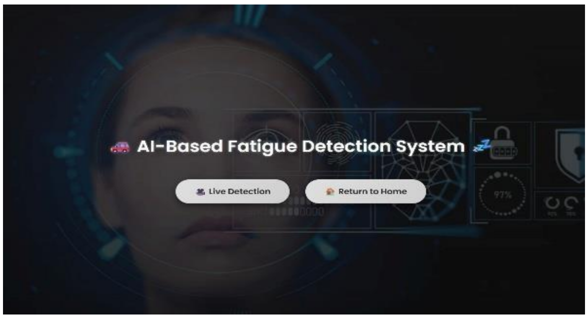

Fig 4: Navigation Interface

Navigation Interface: This interface allows users to initiate real-time fatigue detection.

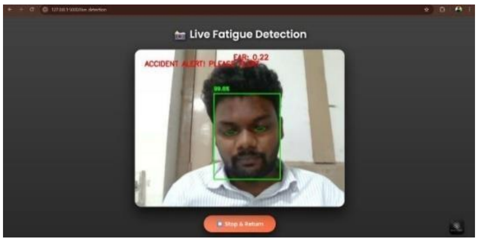

Fig 4: Live Fatigue Detection Output

Live Fatigue Detection Output: The live detection screen displays real-time video with eye landmarks, EAR values, and fatigue alerts. If the EAR remains below the threshold for a continuous number of frames, the system classifies the condition as fatigue. The system captures live video using a standard webcam and detects facial landmarks.

Fig 5: Backend Execution

Backend Execution: The backend execution window shows continuous processing of video frames using Python and Flask.

The system achieved an average processing speed of 20–25 frames per second and a detection accuracy of approximately 92–95% under normal lighting conditions.

CONCLUSION

This paper presented a real-time fatigue detection system based on facial feature analysis using artificial intelligence. By leveraging facial landmark detection and Eye Aspect Ratio computation, the system effectively identifies signs of fatigue and generates timely alerts to prevent accidents.

The proposed system is non-intrusive, cost-effective, and suitable for continuous monitoring in transportation and industrial environments. Experimental results demonstrate high accuracy, low latency, and stable real-time performance, making the system a practical solution for fatigue-related accident prevention.

FUTURE SCOPE

Future enhancements may include integrating deep learning models such as CNNs and LSTM networks for improved accuracy, incorporating yawning and head pose detection, and enabling night-time monitoring using infrared cameras. Deployment on embedded and edge devices can further expand real-world applicability.

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