Vision-Shield AI -Based Eye Strain Detection System

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ABSTRACT

Vision Shield is an AI-based Eye Strain Detection System designed to reduce the negative effects of prolonged screen exposure. In today's digital world, students, office workers, and professionals spend long hours using computers and smartphones, which often leads to eye strain, dryness, blurred vision, headaches, and reduced productivity. The main objective of this project is to develop a real-time monitoring system that can detect early signs of visual fatigue and provide preventive suggestions. The system uses computer vision techniques through MediaPipe and OpenCV to analyze blink rate, Eye Aspect Ratio (EAR), sitting distance from the screen, ambient lighting conditions, and total screen time. A PyQt6-based graphical interface displays live monitoring results, warning alerts, and detailed usage reports in a simple and user-friendly manner. AI APIs are integrated to generate personalized recommendations and adaptive feedback based on user behavior. The system stores historical data for analysis and performance evaluation. Experimental testing shows accurate detection with smooth real-time performance on standard hardware. This project promotes digital wellness, improves awareness about healthy screen habits, and supports safer and more sustainable use of technology.

Key Words — Eye Strain Detection, Artificial Intelligence, Computer Vision, MediaPipe, OpenCV, Digital Wellness.

1.INTRODUCTION

The rapid growth of digital technology has changed the way people work, study, and communicate. Today, students, professionals, and even children spend many hours in front of computers, laptops, and mobile screens. Although digital devices make life easier and more productive, continuous screen usage has created serious health concerns. One of the most common problems is eye strain, also known as Computer Vision Syndrome (CVS). It causes symptoms such as dryness, irritation, blurred vision, headaches, and reduced concentration.Most existing solutions, such as simple reminder applications or blue light filters, are time-based and do not analyze the actual condition of the user's eyes. They lack intelligence and personalization. To overcome these limitations, this project proposes **Vision Shield – An AI-Based Eye Strain Detection System** that monitors eye strain in real time using computer vision and artificial intelligence techniques.The system uses MediaPipe and OpenCV to detect blink rate, Eye Aspect Ratio (EAR), sitting distance, and ambient lighting conditions. A PyQt6-based graphical interface displays live monitoring results, alerts, and usage reports.
The integration of AI APIs helps generate personalized recommendations to promote healthy screen habits.This project aims to improve digital wellness, increase productivity, and encourage safer and more sustainable use of technology.

2.LITERATURE SURVEY

Several studies have addressed eye strain detection using computer vision and machine learning techniques. Traditional methods relied on questionnaires and self-reported symptoms, which lacked real-time accuracy. Recent approaches use facial landmark detection to analyze parameters such as blink rate and Eye Aspect Ratio (EAR) for identifying eye fatigue. Machine learning models further improve detection accuracy by classifying eye strain based on extracted features. These systems are non-intrusive and enable continuous monitoring using standard cameras. However, challenges such as lighting variations and individual differences still remain.

3. BODY OF PAPER

3.1 System Overview-

VisionShield is an Artificial Intelligence (AI)-based Eye Strain Detection system developed to monitor visual fatigue caused by prolonged screen exposure. Computer Vision Syndrome (CVS) has become a common health issue due to increased use of digital devices. The proposed system detects early signs of eye strain using real-time webcam monitoring and computer vision techniques.The system captures live video frames and analyzes eye-related parameters such as blink rate, Eye Aspect Ratio (EAR), sitting distance, and screen exposure duration. Based on these parameters, the system determines whether the user is experiencing visual fatigue and provides preventive alerts

Figure-1 gives the overview of how system works

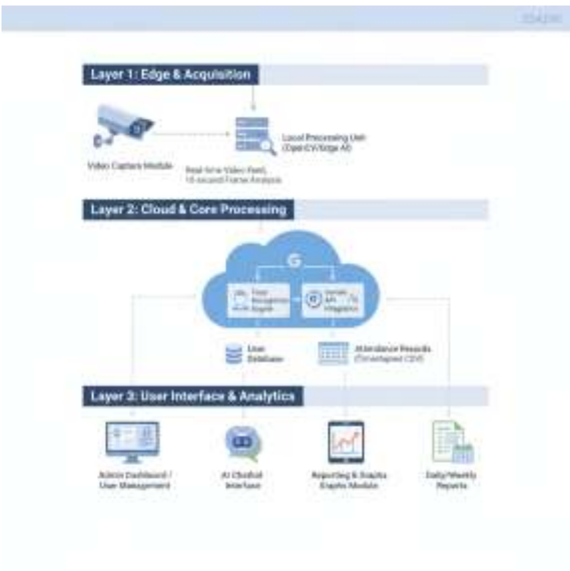

Fig.1:System Overview

Section 3.2 describes the system architecture, while Sec. 3.3 explains the algorithm used for detection.

3.2 System Architecture

The VisionShield system follows a layered architecture consisting of three major modules:

1. **Input Acquisition Module**
2. **Processing and Analysis Module**
3. **User Interaction Module**

In the Input Acquisition module, a standard 720p webcam captures real-time video of the user. The captured frames are passed to the Processing module, where facial landmarks are detected using MediaPipe and OpenCV. The Processing module calculates important eye metrics such as blink rate and Eye Aspect Ratio (EAR). These values are compared with predefined thresholds to detect abnormal eye behavior.The User Interaction module displays real-time monitoring data and provides alerts when eye strain is detected.

Figure 2 illustrates the overall system flow.

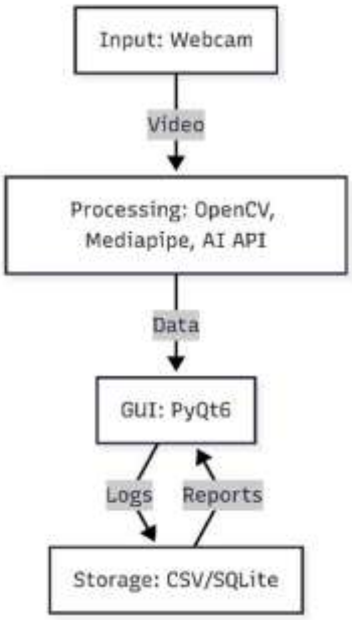

Fig. 2: System Architecture of VisionShield

3.3 Eye Strain Detection Methodology

The system primarily uses Eye Aspect Ratio (EAR) to detect blinking patterns. EAR is calculated using six eye landmark points detected by the MediaPipe Face Mesh model.

The mathematical representation of EAR is shown in Eq. (1):

$$EAR = (||p2 - p6|| + ||p3 - p5||) / (2\ ||p1 - p4||) \quad \cdots\cdots (1)$$

Where p1 to p6 represent specific eye landmark coordinates.

If the EAR value falls below a predefined threshold for a continuous period, it indicates eye closure or reduced blinking frequency. Reduced blinking is one of the major indicators of eye strain.

In addition to EAR, the system also monitors:

- Blink frequency per minute
- Continuous screen time
- Sitting distance from the screen
- Ambient lighting conditions

All parameters are combined to improve detection accuracy.

3.4 Implementation Details

The system is implemented using Python programming language. The following libraries are used:

- OpenCV (Open Source Computer Vision Library)
- MediaPipe
- NumPy
- Scikit-learn
- PyQt6 (Python Qt Framework)

OpenCV is used for real-time video capture and image processing. MediaPipe provides facial landmark detection. NumPy is used for numerical computations, while Scikit-learn is used for implementing the Machine Learning (ML) model.

The system processes video frames at approximately 25–30 frames per second (fps), ensuring smooth real-time performance.

3.5 Experimental Results

The system was tested on multiple users under different lighting conditions and screen exposure durations. The experiment aimed to evaluate detection accuracy and real-time performance.

The performance results are summarized in Table 1.

Table 1: Performance Analysis of Eye Strain Detection System

Sr .N o	Param eter Monit ore d	Normal Conditio n Range	Strain Condition Range	Observation
1.	Blink Rate (per minut e)	15 – 20 blinks	Less than 10 blinks	Reduced blinking observed during strain
2.	Eye Aspec t Ratio (EAR)	0.25 – 0.30	Below 0.20	Continuous low EAR indicates fatigue
3.	Contin uo us Screen Time	Less than 40 minutes	More than 60 minutes	Increased strain after long sessions
4.	Sitting Distan ce (cm)	50–70 cm	Less than 40 cm	Short distance increases strain
5.	Lightin g conditi on (lux)	300-500lux	Less than 200lux	Poor lighting affect eye format

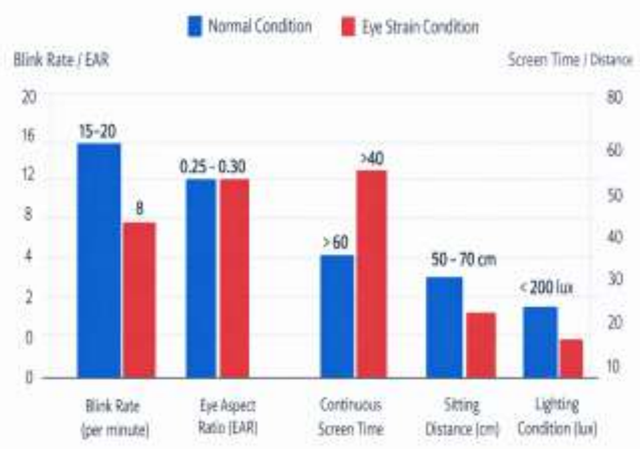

Fig. 2: Key Eye Strain Indicators in Normal vs Strain Conditions

Fig.3 Key eyestrain indicator in normal vs strain detection.

This barchart give quick idea about table-1.
The experimental results show that blink rate significantly decreases during prolonged screen usage. EAR values also drop below the normal threshold when the user experiences fatigue.
The system achieved an average detection accuracy of approximately 88–92% under controlled indoor conditions.

3.6 Discussion

The results presented in Sec. 3.5 demonstrate that the proposed system effectively detects early symptoms of eye strain. The combination of multiple parameters such as blink rate, EAR, and screen time improves reliability compared to single-parameter systems.
Unlike traditional reminder-based applications, VisionShield provides intelligent monitoring using real-time computer vision techniques. The system does not require additional wearable hardware, making it cost-effective and user-friendly.
However, the accuracy may slightly decrease in poor lighting conditions or when the user is not directly facing the webcam.

3.7 Advantages of the Proposed System

- Real-time monitoring of eye behavior
- Non-invasive and contactless system
- Cost-effective solution
- Easy integration with desktop systems
- Promotes digital wellness

3.8 Limitations

- Performance depends on webcam quality
- Requires stable lighting conditions
- Accuracy may vary for users wearing reflective glasses
- Internet dependency for advanced AI API features

4. CONCLUSIONS

In this paper, we presented Vision Shield, an AI-based Eye Strain Detection System developed to reduce the harmful effects of prolonged screen exposure. With the increasing use of digital devices in education and professional work, eye strain has become a common problem. The proposed system provides a smart and real-time solution to monitor visual fatigue and promote healthier screen habits.

The system uses computer vision and Artificial Intelligence (AI) techniques to detect blink rate, Eye Aspect Ratio (EAR), sitting distance, and ambient lighting conditions. Based on these parameters, it generates instant alerts and personalized recommendations. The graphical user interface makes the system easy to use and understand, even for non-technical users.
The experimental results show that the system performs efficiently on standard hardware and provides accurate real-time monitoring. By storing historical data, the system also helps users analyze their screen usage patterns over time.
Overall, Vision Shield contributes to digital wellness by encouraging responsible technology usage. In the future, the system can be enhanced with mobile application support, cloud data storage, and advanced AI models for improved accuracy and scalability.

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