OpenCV-Based Eye Movement Detection for Cursor Navigation

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***Abstract*— The Eye Gaze-Based Cursor Control System using OpenCV is developed to provide a hands-free method of controlling the computer cursor through eye movements. The main objective of this project is to assist individuals with physical disabilities who find it difficult to use a conventional mouse or keyboard. The system uses a standard webcam to capture real-time video and detect the user's face and eye region. By tracking the position of the pupil with the help of OpenCV, Dlib, and Python libraries, the cursor moves according to the direction of the user's eye movement. The implementation is simple, cost-effective, and does not require any specialized hardware or wearable sensors. This approach improves accessibility while offering a natural and convenient way of interacting with a computer. The project demonstrates that computer vision techniques can be effectively used to build user-friendly human-computer interaction systems, making digital technology more accessible to people with motor impairments and enhancing their independence.**

***Keywords* — Eye Tracking, OpenCV, Computer Vision, Pupil Detection, Cursor Control, Human-Computer Interaction (HCI), Gaze Tracking, Dlib, Python, Webcam-Based Interface.**

I. INTRODUCTION

Human-Computer Interaction (HCI) has become an important area of research due to the increasing demand for intelligent and accessible computing systems. Conventional input devices such as keyboards and mice are effective for most users, but they are difficult or impossible to use for individuals with severe physical disabilities. To address this challenge, researchers have explored alternative interaction methods that allow users to control computers through natural body movements, especially eye movements. Eye tracking provides an efficient and intuitive way of communicating with computers without requiring physical contact, making it highly suitable for people with limited motor abilities [1], [3].

Recent developments in computer vision and image processing have enabled real-time eye tracking using low-cost webcams and open-source software libraries such as OpenCV. These technologies eliminate the need for expensive eye-tracking hardware while maintaining acceptable accuracy and responsiveness. Face detection, eye localization, and pupil tracking algorithms can accurately determine the user's gaze direction and translate it into cursor movements on the computer screen [2], [5]. This approach offers a practical and affordable solution for developing hands-free human-computer interaction systems.

The proposed project, Eye Ball Cursor Movement Using OpenCV, is designed to control the computer cursor through the movement of the user's eyes. The system captures live video using a webcam, detects the face and eye regions, identifies the pupil position, and continuously tracks its movement. The detected eye coordinates are then mapped to cursor positions, allowing users to move the mouse pointer naturally without touching any physical device. OpenCV is used for image processing, while Python provides the implementation framework for real-time cursor control. This combination results in a lightweight, flexible, and cost-effective system that can be deployed on standard computers.

Several researchers have contributed to the development of eye-based interaction systems. Face tracking methods have demonstrated reliable cursor navigation using facial movements [1], while gaze estimation models have improved the precision of eye tracking through virtual eyeball modeling [2]. Symmetry-based gaze detection techniques have further enhanced communication systems for individuals with paralysis [3]. Other studies have explored webcam-based gaze estimation [5], video-based mouse replacement interfaces [6], electrooculogram (EOG)-based cursor control [7], and advanced eye motion control technologies [8], [9]. These contributions have significantly advanced the field of assistive computing.

Overall, this project aims to provide an accessible, low-cost, and user-friendly cursor control system that improves computer accessibility for individuals with physical impairments. By utilizing computer vision techniques and OpenCV, the proposed system demonstrates how eye movements can be effectively transformed into real-time cursor actions, thereby promoting independent computer usage and enhancing the overall user experience.

II. RELATED WORK

"Face as Mouse through Visual Face Tracking," Jilin Tu, Thomas Huang, and Hai Tao [1]
This study proposed a vision-based human-computer interaction system that enables users to control the mouse cursor using facial movements instead of a traditional mouse. The system employs a 3D face tracking technique to estimate facial position, rotation, and movement in real time. By detecting facial features such as the eyes and mouth, the proposed method translates head movements into cursor navigation and uses mouth gestures to perform mouse click operations. The researchers evaluated different cursor control strategies and demonstrated that the system provides smooth and reliable interaction without requiring specialized hardware. The proposed approach offers a practical solution for individuals with physical disabilities by enabling hands-free computer operation. This work laid the foundation for modern vision-based cursor control systems and inspired further research on eye tracking, face tracking, and computer vision techniques for developing accessible and cost-effective human-computer interaction applications.

"A Robust Eye Gaze Tracking Method Based on a Virtual Eyeball Model," Eni Chul Lee and Kang Ryoung Park [2]
This research introduced a robust eye gaze tracking technique based on a three-dimensional virtual eyeball model for accurate gaze estimation. The proposed system utilizes a camera and infrared light sources to determine the position of the eyeball and estimate the gaze direction with high precision. The authors developed a calibration method that compensates for individual eye characteristics, thereby improving tracking accuracy while reducing computational complexity. Experimental results demonstrated that the proposed method achieved lower gaze estimation error compared to earlier approaches and performed effectively even with moderate head movements. The study highlighted the importance of accurate eye modeling in gaze-based interaction systems and showed that eye tracking could be applied to various human-computer interaction applications. This work has significantly influenced the development of modern eye-controlled interfaces, cursor navigation systems, and assistive technologies designed for users with physical impairments.

"A Human-Computer Interface Using Symmetry Between Eyes to Detect Gaze Direction," John J. Magee, Margrit Betke, James Gips, Matthew R. Scott, and Benjamin N. Waber [3]
This paper presented a non-intrusive human-computer interface that detects eye gaze direction using the natural symmetry between the left and right eyes. Unlike systems that require expensive eye trackers or infrared illumination, the proposed solution works with a standard webcam and image processing algorithms to identify whether the user is looking left, right, or straight ahead. The detected gaze direction is then used to control applications such as virtual keyboards, communication tools, and computer games. The system was designed primarily for individuals with severe paralysis who rely on eye movement as their primary communication method. Experimental evaluation showed that the interface provides reliable gaze detection while maintaining user comfort and affordability. This research demonstrated that low-cost computer vision techniques could successfully replace specialized hardware, making eye-based interaction more accessible and practical for assistive computing applications.

"Real-Time Eye-Gaze Estimation Using a Low-Resolution Webcam," Yu-Tzu Lin, Ruei-Yan Lin, Yu-Chih Lin, and Greg C. Lee [5]
This study proposed a real-time eye-gaze estimation system that operates using an inexpensive low-resolution webcam instead of dedicated eye-tracking hardware. The researchers developed image processing algorithms capable of detecting eye regions, extracting gaze-related features, and estimating gaze direction under different lighting conditions. A hybrid detection model and Fourier Descriptor-based feature extraction technique were combined with Support Vector Machine (SVM) classification to improve gaze estimation accuracy while maintaining low computational cost. Experimental results demonstrated that the proposed system achieved

reliable real-time performance even with consumer-grade webcams. The research proved that affordable computer vision techniques could provide efficient eye tracking without sacrificing accuracy. This work has become an important reference for webcam-based gaze tracking applications and has contributed significantly to the development of low-cost eye-controlled cursor systems, virtual keyboards, and other human-computer interaction technologies.

"Hardware and Software Implementation of Real Time Electrooculogram (EOG) Acquisition System to Control Computer Cursor with Eyeball Movement," Hossain, Zakir, Md. Maruf Hossain Shuvo, and Prionjit Sarker [7]

This paper presented a real-time Electrooculogram (EOG)-based human-computer interaction system for controlling the computer cursor through eye movements. The proposed framework consists of EOG signal acquisition hardware, signal amplification, analog-to-digital conversion, and software modules for real-time cursor control. Electrodes placed around the eyes capture electrical signals generated during eye movement, while machine learning algorithms such as Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA) classify horizontal and vertical eye motions. The processed signals are then converted into corresponding cursor movements on the computer screen. Experimental evaluation demonstrated reliable cursor control with satisfactory response time and classification accuracy. The proposed system is particularly useful for individuals with severe physical disabilities, enabling them to interact with computers and assistive devices without using conventional input peripherals. The study highlighted the effectiveness of combining biomedical signal processing with intelligent classification techniques for assistive human-computer interaction.

III. DATASET DETAILS

The dataset used in this project consists of real-time video frames captured through a standard webcam to detect and track the user's eye movements for cursor control. Unlike conventional image datasets, the system processes live video input, where each frame contains facial and eye information required for gaze estimation. OpenCV and Dlib libraries are used to detect the face, identify facial landmarks, and locate the left and right pupils. The extracted pupil coordinates represent the user's gaze direction and are continuously updated to enable smooth cursor movement across the computer screen. Since webcam images may be affected by variations in lighting conditions, head movement, background clutter, and camera resolution, preprocessing techniques such as grayscale conversion, facial landmark detection, and pupil localization are applied to improve detection accuracy. The dataset generated from the live video stream includes eye position coordinates and gaze direction labels such as left, right, center, and blinking. These labeled eye movement patterns provide the necessary information for translating eye gestures into corresponding cursor actions. The use of a live webcam dataset makes the proposed system flexible, cost-effective, and suitable for real-time human-computer interaction without requiring specialized eye-tracking hardware.

Before cursor control is performed, each captured video frame undergoes several preprocessing stages to enhance image quality and improve gaze detection performance. The webcam continuously records video frames, which are resized and converted into grayscale images for faster processing. Face detection and facial landmark extraction are then performed to accurately identify the eye regions. The pupil positions are calculated using OpenCV image processing techniques and Dlib facial landmark detection, while unnecessary background information is ignored. The extracted eye coordinates are mapped to screen coordinates using cursor movement logic implemented in Python. The processed data are evaluated continuously in real time rather than being divided into fixed training and testing datasets, as the system performs live gaze estimation during execution. The generated eye movement information is used to detect gaze direction and blinking events, allowing the cursor to move naturally according to the user's eye position. This real-time processing framework enables accurate, responsive, and hands-free computer interaction, making the proposed system suitable for assistive applications and improving accessibility for users with physical disabilities.

IV. PROPOSED METHODOLOGY

The proposed methodology utilizes computer vision and eye gaze tracking to control the computer cursor using real-time eye movements. Initially, the webcam is activated to capture continuous video frames of the user's face. Each captured frame is processed using the OpenCV library to detect the face and locate the eye region. The Dlib facial landmark detector is then employed to identify the left and right eye positions accurately. After detecting the eyes, the pupil locations are extracted by the gaze tracking algorithm. The detected pupil coordinates represent the direction of the user's gaze and are continuously updated for every captured frame. These coordinates are used to determine whether the user is looking left, right, or center. The extracted eye movement information is then mapped to the computer screen coordinates, enabling real-time cursor movement without requiring a physical mouse. The proposed approach provides a low-cost and non-intrusive solution since it requires only a standard webcam and open-source software libraries.

Once the pupil coordinates are obtained, the system continuously tracks eye movement and updates the cursor position using the PyAutoGUI library. Whenever the user changes the gaze direction, the cursor automatically moves to the corresponding screen location. The system also detects eye blinking and displays the current gaze status, such as Looking Left, Looking Right, Looking Center, or Blinking, on the webcam interface. The detected left and right pupil coordinates are displayed in real time for monitoring the tracking accuracy. Since cursor movement is directly associated with the pupil coordinates, users can interact with the computer without touching a physical input device. This methodology improves accessibility for physically challenged individuals by providing an efficient hands-free human-computer interaction system based entirely on eye movements.

The system architecture shown in Figure 1 illustrates the complete workflow of the proposed eye-based cursor control system. It includes webcam video capture, face detection, eye region extraction, pupil detection using the GazeTracking algorithm, gaze direction estimation, cursor movement through PyAutoGUI, and real-time display of pupil coordinates and gaze status. The architecture enables smooth and accurate cursor navigation using only eye movements while eliminating the need for additional hardware.

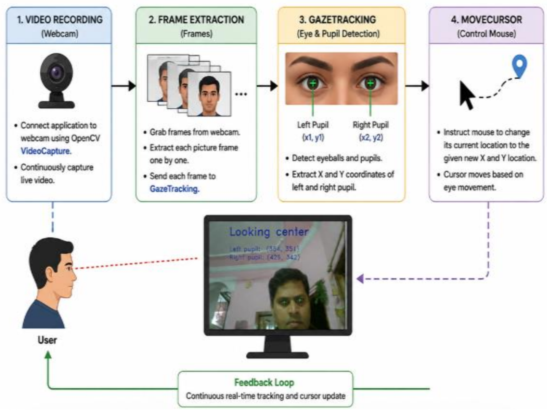

Figure 1. System Architecture for Eye Ball Cursor Movement Using OpenCV

The proposed methodology is designed to provide an accurate, real-time, and cost-effective eye-controlled cursor movement system. First, the webcam captures live video frames, and OpenCV performs image preprocessing to improve face and eye detection. The Dlib facial landmark detector extracts the eye regions, while the GazeTracking module identifies the pupil coordinates of both eyes. Based on these coordinates, the system estimates the user's gaze direction and maps it to the screen coordinates for cursor movement. Finally, the PyAutoGUI module controls the mouse pointer according to the detected eye position, while the application continuously displays gaze direction, pupil coordinates, and eye tracking results on the screen. The proposed system demonstrates an efficient and practical solution for hands-free computer interaction, particularly benefiting users with physical disabilities.

V. RESULT AND DISCUSSION

The experimental results demonstrate the effectiveness of the proposed Eye Ball Cursor Movement Using OpenCV system for hands-free computer interaction. The application utilizes a standard webcam to capture live video of the user's face and eye movements. Initially, the webcam records continuous video frames, which are processed using OpenCV to detect the face and eye regions. The extracted eye images are analyzed using the GazeTracking algorithm to identify the positions of the left and right pupils in real time. The detected pupil coordinates are continuously updated and mapped to the screen coordinates to control the mouse cursor. During experimentation, the system successfully detected gaze directions such as Looking Left, Looking Right, Looking Center, and Blinking while displaying the corresponding pupil coordinates on the screen. The integration of OpenCV, Dlib facial landmark detection, and PyAutoGUI enabled smooth cursor movement without requiring a physical mouse. Experimental observations showed that the system provided accurate eye tracking under normal lighting conditions and responded effectively to real-time eye movements. The proposed approach offers a simple, low-cost, and non-intrusive solution for cursor control, making it particularly useful for individuals with physical disabilities who cannot operate conventional input devices.

The developed application continuously monitored eye movements and updated the cursor position according to the detected pupil coordinates. The webcam interface displayed the current gaze direction along with the left and right pupil coordinates, allowing users to verify eye tracking performance visually. The system performed efficiently without requiring specialized eye-tracking hardware, relying only on a webcam and computer vision algorithms. However, slight variations in lighting conditions, rapid head movements, or moving the cursor to the extreme corners of the screen could occasionally affect tracking performance or generate application exceptions. Despite these limitations, the proposed system demonstrated stable real-time performance and reliable cursor navigation. Overall, the experimental results indicate that the developed eye-controlled cursor system provides an effective human-computer interaction mechanism that can significantly improve computer accessibility for physically challenged users while reducing dependence on traditional mouse devices.

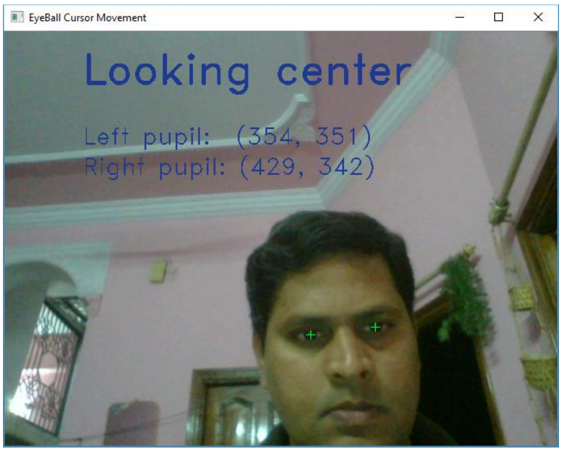

Figure [2] Dashboard of Eye Ball Cursor Movement Using OpenCV

The dashboard shown in Figure 2 represents the real-time execution screen of the proposed Eye Ball Cursor Movement system. After launching the application, the webcam captures the user's face and continuously tracks both eyes. The interface displays the detected gaze direction, such as Looking Center, together with the real-time coordinates of the left and right pupils. Green markers are drawn on both pupils to indicate successful eye detection. The detected pupil coordinates are used to control the mouse cursor automatically without requiring a physical mouse. This dashboard enables users to monitor eye tracking performance while interacting with the computer through eye movements.

DISCUSSION

The obtained results demonstrate that computer vision techniques can effectively be used for real-time cursor control using eye movements. The proposed system accurately detects the user's face and eye regions using OpenCV and Dlib, while the GazeTracking module successfully extracts the pupil coordinates required for gaze estimation. Based on the detected pupil positions, the system continuously updates the mouse cursor location, enabling smooth and hands-free computer interaction. The experimental observations confirmed that the application could reliably identify different gaze directions, including looking left, right, center, and blinking, while displaying the corresponding pupil coordinates on the screen.

The proposed system provides an inexpensive alternative to commercial eye-tracking devices because it requires only a standard webcam and open-source software libraries. The developed application is particularly beneficial for physically challenged users who are unable to operate conventional input devices such as a mouse or keyboard. Although the system performs effectively under normal lighting conditions, factors such as poor illumination, rapid head movement, low webcam resolution, or moving the cursor to the extreme screen corners may slightly reduce tracking accuracy. Nevertheless, the proposed OpenCV-based eye tracking system demonstrates reliable real-time performance and provides an efficient, user-friendly, and accessible solution for eye-controlled cursor movement. Future improvements may include click event recognition using eye blinks, smoother cursor mapping, and deep learning-based gaze estimation to further enhance tracking accuracy and usability.

VI. CONCLUSION

From the process implemented it is cleared that the cursor can be controlled by the eyeball movement i.e., without using hands on the computers. This will be helpful for the people having disability in using the physical parts of the computers to control the cursor points. Because the cursor points can be operated by moving the eyeballs. Without the help of others disabled people can use the computers. This technology can be enhanced in the future by inventing more techniques like clicking events as well as to do all the mouse movements and also for human interface systems using eye blinks. Technology also extended to the eyeball movement and eye blinking to get the efficient and accurate movement.

REFERENCES

[1] Jilin Tu, Thomas Huang, Elect and Comp EngrDept, Hai Tao, ElectEnggDept, “Face as Mouse through Visual Face Tracking”,IEEE,(2005).

[2] EniChul Lee Kang Ryoung Park “A robust eye gaze tracking methodbased on a virtual eyeball model”, Springer, pp.319-337, Apr (2008).

[3] John J. Magee, MargritBetke, James Gips, Matthew R. Scott, and Benjamin N.Waber“A Human-Computer Interface Using Symmetry Between Eyes to Detect Gaze Direction” IEEE Trans, Vol. 38, no.6,pp.1248-1259, Nov(2008).

[4] SunitaBarve, DhavalDholakiya, Shashank Gupta, DhananjayDhatrak, “Facial Feature Based Method For Real Time Face Detection and Tracking I-CURSOR”, International Journal of EnggResearchand App., Vol. 2, pp. 1406-1410, Apr (2012).

[5] Yu-Tzu Lin Ruei-Yan Lin Yu-Chih Lin Greg C Lee “Real-time eye-gaze estimation using a low-resolution webcam”, Springer, pp.543-568, Aug (2012).

[6] Samuel Epstein-Eric MissimerMargritBetke “Using Kernels for avideobased mouse-replacement interface”, Springer link, Nov (2012)

[7] Hossain, Zakir, Md Maruf Hossain Shuvo, and Prionjit Sarker. "Hardware and software implementation of real time electrooculogram (EOG) acquisition system to control computer cursor with eyeball movement." In 2017 4th International Conference on Advances in Electrical Engineering (ICAEE), pp. 132-137. IEEE, 2017.

[8] Lee, Jun-Seok, Kyung-hwa Yu, Sang-won Leigh, Jin-Yong Chung, and Sung-Goo Cho. "Method for controlling device on the basis of eyeball motion, and device therefor." U.S. Patent 9,864,429, issued January 9, 2018.

[9] Lee, Po-Lei, Jyun-Jie Sie, Yu-Ju Liu, Chi-Hsun Wu, Ming-Huan Lee, Chih- Hung Shu, Po-Hung Li, Chia-Wei Sun, and Kuo-Kai Shyu. "An SSVEPactuated brain computer interface using phase-tagged flickering sequences: a cursor system." Annals of biomedical engineering 38, no. 7 (2010): 2383-2397