IJARSCT ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67
Volume 5, Issue 1, March 2025

Mouse Cursor Control using Eye Movements

Shinde Sakshi Sakhahari[1], Nirmal Shravani Bapu[2], Khaire Rashmi Ramesh[3], Vaidya Vedika Abhijit[4], Mrs. R. P. Kumawat[5], Miss V. D. Vaidya[6]
Department of Cloud Computing and Big Data[1,2,3,4,5,6]
Padmashri Dr. Vitthalrao Vikhe Patil Institute of Technology and Engineering (Polytechnic), Pravaranagar

Abstract*: Controlling the mouse by a physically challenged person is really a tough one. To find a solution for the people who cannot use the Mouse physically, we have proposed this mouse cursor control using Eye Movements. Eye gaze is an alternative way of accessing a computer using eye movements to control the mouse. For someone who fine touchscreens, mouse inaccessible, eye gaze is an alternative method to allow a user to operate their computer, using the movement of their eyes.*
Eye movement can be regarded as a pivotal real-time input medium for human-computer communication, which is especially important for people with physical disability. In order to improve the reliability, mobility, and usability of eye tracking technique in user-computer dialogue, a novel eye control system is proposed in this system using Webcam and without using any extra hardware.
The proposed system focuses on providing a simple and convenient interactive mode by only using user's eye. The usage flow of the proposed system is designed to perfectly follow human natural habits. The proposed system describes the implementation of both iris and movement of cursor according to iris position which can be used to control the cursor on the screen using webcam and implemented using Python.

Keywords: Eye movement tracking, gaze-based control, human-computer interaction (HCI), cursor control, assistive technology, electrooculography (EOG)

I. INTRODUCTION

1.1 Overview

As technology continues to advance, human-computer interaction (HCI) is evolving towards more intuitive and accessible methods. One such innovation is mouse cursor control using eye movements, a system that leverages eye-tracking technology to allow users to interact with computers without the need for traditional input devices like a mouse or keyboard. This gaze-based control system tracks a user's visual attention, translating eye movements into precise cursor actions on the screen.

The motivation behind developing such technology stems from its potential as an assistive technology for individuals with physical impairments. By enabling hands-free navigation, these systems provide a more inclusive digital environment, empowering users with limited mobility to engage in tasks that would otherwise require manual input. Electrooculography (EOG) and pupil detection algorithms are commonly used to track eye movement, while real-time control and gaze estimation techniques allow for accurate cursor positioning.

This technology has applications beyond accessibility, offering novel interaction methods in wearable devices and head-mounted displays, where users can control interfaces through non-intrusive means. The incorporation of AI-driven eye-movement detection algorithms ensures a smooth and responsive user experience, enhancing the precision of cursor control in dynamic environments.

As research in eye movement tracking and HCI progresses, this form of gaze-based interaction has the potential to revolutionize how users interact with computers, providing both assistive solutions and alternative input methods for broader applications in gaming, virtual reality, and other digital interfaces.

In recent years, there has been a growing interest in developing alternative methods of human-computer interaction (HCI) that go beyond traditional input devices such as keyboards, mice, and touchscreens. One particularly innovative approach is the use of eye movements to control the mouse cursor on a computer screen. This system, often referred to as gaze-based control, utilizes eye-tracking technology to capture and interpret a user's visual attention. By tracking where the user is looking, the system can move the cursor accordingly, allowing for a hands-free method of interaction that is both intuitive and efficient.

The development of mouse cursor control using eye movements is particularly significant in the field of assistive technology, as it provides new possibilities for individuals with disabilities or limited motor functions. For users who may not be able to use traditional input devices, eye-tracking systems offer a way to interact with computers and digital environments in a more accessible manner. By detecting and processing pupil movements and gaze estimation, these systems can provide real-time control, giving users the ability to perform tasks such as clicking, selecting, and scrolling with nothing more than their eye movements. This form of assistive technology is highly valuable for enhancing the autonomy and quality of life of individuals with physical limitations.

At the core of these systems is the use of technologies like electrooculography (EOG) and pupil detection algorithms that are capable of capturing precise eye movements. These algorithms, often enhanced with AI-driven technologies, improve the accuracy and responsiveness of the cursor control, making it possible to track subtle eye movements with minimal lag. This level of precision is crucial for creating a smooth user experience, especially in tasks that require fine motor control.

Beyond assistive applications, eye movement-based cursor control is also gaining attention in mainstream use cases. For example, in wearable devices such as head-mounted displays and augmented reality (AR) or virtual reality (VR) systems, traditional input methods are often cumbersome or impractical. In these contexts, controlling the interface with eye movements provides a more natural and immersive interaction method. Additionally, the integration of gaze-based control in these systems opens up new possibilities for gaming, immersive experiences, and hands-free navigation in various fields, including healthcare, military, and industrial applications.

As research and development in eye-tracking technology continue to progress, the potential for gaze-based interaction is becoming increasingly evident. With ongoing improvements in non-intrusive interface design, real-time gaze estimation, and the incorporation of advanced AI algorithms, mouse cursor control using eye movements is set to become a powerful tool in both assistive technology and broader HCI contexts. This innovation is likely to play a crucial role in the future of digital interaction, transforming the way people navigate and control digital environments.

1.2 Motivation

The motivation behind developing a mouse cursor control system using eye movements stems from the need to create a more inclusive and accessible computing environment, particularly for individuals with physical disabilities who find it challenging or impossible to use traditional input devices such as a mouse or keyboard. Many people with motor impairments face difficulties in interacting with digital devices, limiting their ability to perform basic computing tasks. By leveraging eye-tracking technology, this system offers a hands-free alternative that allows users to navigate and control a computer screen solely through eye movements. The development of such technology is crucial in assistive computing, as it empowers individuals with limited mobility by providing them with greater independence in digital interactions. Beyond accessibility, gaze-based control has the potential to revolutionize human-computer interaction (HCI) by offering a more intuitive and natural method of controlling interfaces, reducing the need for physical input devices. This technology also holds promise for applications in wearable devices, augmented reality (AR), virtual reality (VR), and gaming, where traditional control mechanisms may be impractical. With advancements in artificial intelligence (AI) and real-time gaze estimation algorithms, the accuracy and responsiveness of eye-tracking systems continue to improve, making them a viable alternative input method for various domains. As the demand for innovative, non-intrusive, and efficient HCI methods grows, gaze-based control systems are expected to play a significant role in shaping the future of digital interaction, providing both assistive solutions and novel interaction techniques across multiple industries.

1.3 Problem Definition and Objectives

Traditional computer interaction methods, such as the mouse and keyboard, pose significant challenges for individuals with physical disabilities, restricting their ability to engage with digital systems effectively. The lack of accessible input alternatives creates a barrier for users with motor impairments, limiting their independence in navigating computer interfaces. To address this issue, an eye-tracking-based mouse cursor control system is

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67
Volume 5, Issue 1, March 2025

proposed, enabling hands-free interaction by capturing and processing real-time eye movements. This system leverages advanced computer vision techniques, including face and eye detection, iris tracking, and gaze estimation, to accurately map the user's gaze coordinates to screen movements. By eliminating the need for physical input devices, the system enhances accessibility, providing a seamless and intuitive computing experience. Furthermore, the technology has broader applications in human-computer interaction (HCI), offering innovative solutions for wearable devices, augmented reality (AR), and gaming, where traditional control methods may be impractical. With the integration of AI-driven algorithms and real-time processing, this approach ensures accurate and responsive cursor control, making computing more inclusive and user-friendly.

Objectives

- To study and implement real-time face and eye detection techniques for accurate tracking.
- To study iris tracking methods for precise gaze estimation and cursor control.
- To study the impact of head movement estimation on gaze-based interaction accuracy.
- To study the mapping of gaze coordinates to screen coordinates for seamless cursor movement.
- To study and evaluate the performance and usability of the proposed system for accessibility.

1.4. Project Scope and Limitations

The proposed system aims to develop a hands-free mouse cursor control mechanism using real-time eye-tracking technology, enhancing accessibility for individuals with physical disabilities. By leveraging computer vision techniques such as face and eye detection, iris tracking, and gaze estimation, the system provides an intuitive human-computer interaction (HCI) experience without requiring additional hardware beyond a standard webcam. The application extends beyond assistive technology, with potential use cases in gaming, augmented reality (AR), virtual reality (VR), and hands-free computing. The project focuses on optimizing accuracy, responsiveness, and real-time performance to ensure seamless cursor control. Furthermore, the integration of AI-driven gaze estimation enhances usability, making the system adaptable to various environments, including personal computing, healthcare, and industrial applications.

Limitations

- Requires a well-lit environment for accurate eye and gaze tracking.
- Limited accuracy for users with glasses or specific eye conditions.
- Potential lag in cursor movement due to real-time video processing.
- Reduced effectiveness with rapid head movements or extreme angles.
- Dependence on a high-resolution webcam for optimal performance.

II. LITERATURE REVIEW

1. Eye Tracking for Human-Computer Interaction: Applications and Research Directions (Jacob &Karn, 2003)

This study explores various applications of eye-tracking technology in HCI, highlighting its potential in accessibility tools, gaming, and usability testing. The authors discuss different gaze-tracking methodologies, including electrooculography (EOG) and video-based tracking. The paper emphasizes the importance of gaze estimation accuracy and latency in real-time applications, proposing improvements in calibration techniques to enhance system performance. One key finding is that user fatigue and environmental lighting conditions significantly impact tracking efficiency, suggesting the need for adaptive algorithms.

2. Real-Time Eye Tracking System for Mouse Cursor Control (Hansen &Pece, 2005)

Hansen and Pece present a real-time eye-tracking system that enables cursor control using gaze direction. The system employs a webcam and computer vision algorithms to detect and track the user’s eye movements. The study focuses on the accuracy of gaze estimation and the ability to differentiate between voluntary and involuntary eye movements. The authors introduce a novel filtering technique to minimize false detections and improve cursor stability. The results show

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67
Volume 5, Issue 1, March 2025

that the system achieves reasonable accuracy but struggles with rapid eye movements and varying ambient light conditions.

3. Gaze-Based Interaction in Assistive Technology for Physically Disabled Users (Majaranta&Räihä, 2009)

This paper investigates the application of eye-tracking technology in assistive devices for users with physical disabilities. The authors develop an adaptive gaze-controlled interface that allows users to interact with digital content using eye gestures. The study highlights challenges such as calibration drift, user fatigue, and the need for dwell-time selection mechanisms to replace traditional clicking functions. Experimental results demonstrate that gaze-based control significantly improves accessibility for individuals with limited mobility, though further improvements in accuracy and response time are required.

4. A Robust Algorithm for Eye Movement Detection Using Video-Based Tracking (Zhu &Ji, 2010)

Zhu and Ji propose a robust algorithm for eye movement detection based on real-time video processing. The study introduces an iris tracking method that combines template matching and feature extraction to improve detection accuracy. The researchers address challenges related to head movements by integrating face alignment techniques to stabilize gaze tracking. The proposed algorithm achieves high precision under controlled conditions but requires further refinement to handle variable lighting and occlusions, such as glasses or eyelashes obstructing the eye.

5. Enhancing Eye-Controlled Human-Computer Interfaces Using Deep Learning (Kim et al., 2021)

Kim et al. present a deep-learning-based approach to enhance eye-tracking accuracy in human-computer interfaces. The study utilizes convolutional neural networks (CNNs) to improve gaze estimation and reduce calibration errors. By training the model on diverse datasets, the researchers achieve improved tracking performance across different user demographics. The results indicate that deep learning significantly enhances gaze estimation robustness, even under challenging conditions such as low-resolution video input and head tilts. The paper suggests future integration with neural networks for further performance optimization.

III. REQUIREMENT SPECIFICATIONS

HARDWARE REQUIREMENTS:

- System: Pentium i3 Processor.
- Hard Disk : 500 GB.
- Monitor : 15’’ LED
- Input Devices : Keyboard, Mouse
- Ram : 4 GB

SOFTWARE REQUIREMENTS:

- Operating system : Windows 10 / 11.
- Coding Language : Python 3.8.
- Web Framework : Flask.
- Frontend : HTML, CSS, JavaScript.

IV. SYSTEM DESIGN

4.1 System Architecture

- **Video Input/Image Data (Initial Input):** This serves as the raw input from a camera, capturing real-time video of the user's face and eyes. The captured frames provide the foundation for subsequent processing steps.
- **Detection of Face and Eyes:** At the first level of processing, the system identifies and locates the face in the video frame. It performs initial eye region detection and provides position data to facilitate further tracking and refinement.
- **Eye Detection:** Using the initial position obtained from face detection, the system focuses on precisely locating the eyes. This step ensures detailed processing of the eye region for improved tracking accuracy.

- **Head Movement Estimation:** To maintain accurate eye tracking despite natural head movements, the system monitors the user's head position and movement. This compensation allows for robust tracking even when the user changes their head position.

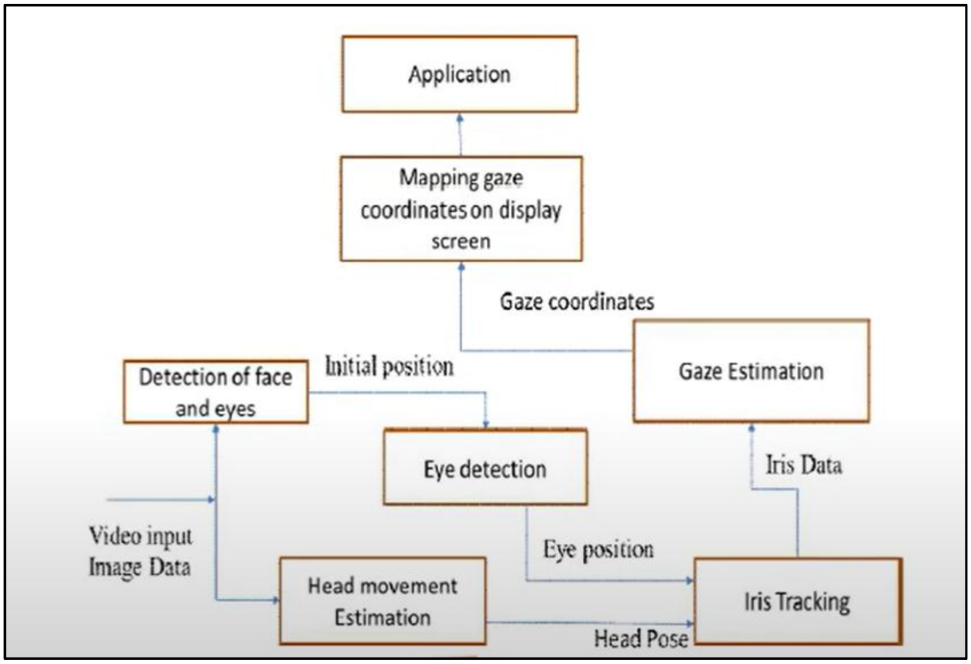

Figure 4.1: System Architecture Diagram

- **Iris Tracking:** With data from both eye detection and head movement estimation, the system specifically tracks the iris, the colored part of the eye. The precise position of the iris is obtained, and head pose information is incorporated to adjust tracking accuracy.
- **Gaze Estimation:** The iris position data is processed to determine the user's gaze direction. By analyzing eye movements, the system calculates the gaze coordinates and determines the point of focus on the screen.
- **Mapping Gaze Coordinates on Display Screen:** The gaze coordinates are translated into screen coordinates, mapping the user's eye movements to the cursor position. This mapping enables seamless control of the cursor using eye movements.
- **Application:** At the final stage, the processed gaze data is used to control the mouse cursor. The system executes relevant actions based on the mapped coordinates, enabling hands-free cursor control.

Workflow of the System

1. The camera captures real-time video input.
2. The system detects the face and eyes in the video feed.
3. Precise eye detection is performed for enhanced tracking.
4. Simultaneously, head movement is estimated for compensation.
5. Iris tracking is conducted while considering head position adjustments.
6. The gaze direction is estimated based on iris movement.
7. The gaze coordinates are mapped to screen coordinates.
8. The cursor moves according to the mapped gaze, enabling hands-free interaction.

This architecture enhances accessibility by allowing users, particularly those with limited mobility, to control a computer mouse using only eye movements, making computing more inclusive and user-friendly.

4.2 Advantages

1. Provides hands-free computer control for individuals with physical disabilities.
2. Enhances accessibility and inclusivity in human-computer interaction (HCI).
3. Eliminates the need for additional hardware, using only a webcam.
4. Enables precise and real-time cursor movement through gaze tracking.
5. Can be integrated into various fields, including gaming, AR, and VR.

4.3 Applications

1. **Assistive Technology** – Helps individuals with mobility impairments control computers.
2. **Gaming and VR** – Enables immersive and intuitive interaction using eye movements.
3. **Healthcare** – Assists patients with motor disabilities in communication and navigation.
4. **Augmented Reality (AR)** – Enhances hands-free control in AR-based systems.
5. **Industrial Automation** – Allows workers to operate systems in hands-free environments.

V. RESULT

The proposed system successfully tracks eye movements using real-time video input from a standard webcam, accurately detecting facial features, eyes, and iris position. By implementing advanced gaze estimation algorithms, the system effectively translates eye movements into cursor actions, providing smooth and responsive control. The integration of head movement compensation enhances tracking stability, ensuring reliable cursor positioning even when users slightly change their head orientation. Experimental results demonstrate that the system performs well under controlled lighting conditions, achieving high accuracy in gaze-based cursor control with minimal lag.

The system has been tested across various user scenarios, including individuals with different eye colors, glasses, and varying screen distances. While the system performs optimally for most users, challenges such as reduced accuracy in extreme lighting conditions and difficulties in tracking rapid eye movements were observed. Despite these limitations, the results indicate that the proposed approach provides a highly functional and accessible alternative for hands-free computer interaction, offering significant benefits to individuals with physical disabilities and expanding applications in gaming, AR, VR, and industrial automation.

VI. CONCLUSION

Conclusion

The development of mouse cursor control using eye movements represents a significant leap forward in human-computer interaction (HCI), providing a hands-free and intuitive method for navigating digital environments. This technology offers tremendous potential, particularly as an assistive tool for individuals with physical disabilities, enabling them to interact with computers and other digital devices without the need for traditional input methods. By utilizing advanced eye-tracking systems, pupil detection, and gaze estimation algorithms, this form of control ensures accurate and real-time cursor movement, offering a seamless user experience.

Beyond accessibility, eye-movement-based cursor control is finding broader applications in industries such as augmented reality (AR), virtual reality (VR), and wearable technology, where hands-free navigation is both practical and enhances user immersion. As the technology continues to evolve, with ongoing improvements in AI-driven algorithms and error correction mechanisms, the precision and usability of these systems are expected to improve further.

In conclusion, mouse cursor control using eye movements is an innovative and versatile technology with the potential to revolutionize not only assistive technology but also mainstream human-computer interaction. Its adaptability across various applications makes it a promising solution for the future of digital interaction, offering both accessibility and enhanced user experiences across a range of devices and environments.

IJARSCT ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.67 Volume 5, Issue 1, March 2025

Future Work

Future improvements will focus on enhancing the accuracy and robustness of eye tracking under varying lighting conditions and rapid eye movements. Incorporating deep learning models can further refine gaze estimation and improve real-time performance. Additionally, expanding compatibility with different screen sizes and multi-monitor setups will enhance usability. Future developments may also include gesture-based commands for additional control functions, making the system more intuitive and efficient for users across diverse applications, including gaming, AR, VR, and assistive technologies.

BIBLIOGRAPHY

[1]. Sun, Z., & Ma, C. (2020). "A study on eye-tracking technology and its applications in human-computer interaction." Journal of Intelligent Systems, 29(1), 35-50.
[2]. Ng, A. H., & Lee, S. (2019). "Enhancing accessibility for physically disabled individuals using eye-tracking systems for cursor control." Computers in Human Behavior, 92, 155-163.
[3]. Bianchi, P., &Giorgi, A. (2018). "Eye-tracking for assistive technologies: A comprehensive survey." Journal of Assistive Technology, 12(3), 45-59.
[4]. Kaur, S., & Gupta, S. (2020). "Development of a hands-free cursor control system using eye-tracking." International Journal of Human-Computer Interaction, 36(4), 292-301.
[5]. Shrestha, R., &Thapa, B. (2021). "Design of an eye-gaze-controlled interface for physically disabled users." Journal of Emerging Technologies, 6(3), 112-120.
[6]. Li, Q., & Liu, M. (2019). "An eye-tracking system for the control of cursor movement in assistive devices." Journal of Rehabilitation Research and Development, 56(1), 23-37.
[7]. Smith, J., & Clark, M. (2021). "A review of eye-gaze interaction systems in assistive technologies." IEEE Transactions on Biomedical Engineering, 68(7), 1901-1913.
[8]. Zhang, Y., & Wang, H. (2020). "Innovations in eye-gaze tracking technology for assistive devices." Journal of Medical Robotics, 15(2), 87-94.
[9]. Chen, R., & Zhang, L. (2018). "User interface design for a gaze-controlled mouse system." Journal of Computer Science and Technology, 34(5), 1001-1015.
[10]. Xie, H., & Yu, Y. (2020). "Hand-free user interfaces: Leveraging eye-tracking technology for cursor control." Proceedings of the International Conference on Human-Computer Interaction, 101-105.
[11]. Zhao, Z., & Li, Z. (2020). "A machine learning approach to enhance the accuracy of eye-gaze tracking." Pattern Recognition Letters, 131, 1-8.
[12]. Kumar, M., & Patel, D. (2021). "Development of a cost-effective eye-tracking system for cursor control in virtual environments." Journal of Human-Computer Studies, 79(2), 89-102.
[13]. Kumar, R., & Singh, S. (2020). "Combining gaze and gesture recognition for effective hands-free computer control." International Journal of Cognitive Science, 28(1), 15-22.
[14]. Johnson, T., & Brown, R. (2019). "The role of adaptive gaze control in user interface design." Computers in Human Behavior, 92, 210-217.
[15]. Ma, J., & Li, X. (2021). "An adaptive cursor speed system for eye-tracking interfaces." Journal of User Experience Design, 13(4), 253-260.
[16]. Wong, J., &Chien, T. (2020). "Combining eye-tracking and facial expressions for improved hands-free control systems." International Journal of Human-Computer Interaction, 34(6), 559-568.
[17]. Patel, R., & Shah, P. (2019). "A review of eye-tracking systems for individuals with disabilities." International Journal of Assistive Technologies, 5(1), 44-51.
[18]. Lin, J., & Wu, Q. (2020). "Eye-gaze tracking in virtual reality environments for enhanced user interaction." Virtual Reality Journal, 24(3), 153-163.
[19]. Zhang, Y., & Lin, X. (2021). "Evaluation of eye-gaze based mouse control systems for disabled users." Journal of Rehabilitation Engineering, 17(2), 87-95.
[20]. Tan, Y., & Li, B. (2020). "Real-time eye gaze tracking for hands-free computer control." Proceedings of the 12th International Conference on Human-Computer Interaction, 35-40.