ISSN 2277-2685
IJESR/October-December 2024/ Volume-14/Issue-4/202-210
Mekala Srimanth Raj *et. al.*, / International Journal of Engineering & Science Research

# GAZE TRACKING CONTROL SYSTEM FOR WHEEL CHAIR AND HOME AUTOMATION

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***Abstract***

*In recent times, eye-controlled interfaces have revolutionized the lives of numerous individuals, particularly those with disabilities or severe motor impairments that hinder their use of alternative computer peripherals. The focus of this research paper is an eye tracking system that goes beyond enabling independent mobility—it empowers users to control various smart home devices in their surroundings. Additionally, the system incorporates an audio output feature to cater to the user's daily needs effectively.*

*Our research objective is to design an innovative eye tracking system with a user-friendly multi-screen interface. Each screen represents a smart home device, including the wheelchair, allowing users to effortlessly navigate and select devices using different eye-blinking patterns. This intuitive interface enhances user control and accessibility.*

*Moreover, the system prioritizes user safety by integrating various sensors. These sensors ensure a secure and reliable operation, providing peace of mind for individuals using the wheelchair.*

*Overall, the eye tracking system is equipped with advanced features, offering a reliable and safe solution for individuals with mobility limitations. it highlights the importance of user-centric design and personalized customization to ensure the system meets the specific needs and preferences of the wheelchair user.*

*keywords— Gaze tracking system, OpenCV, MediaPipe, Iris segmentation, Iris tracking, Image processing, Arduino, Home Automation, Euclidean distance.*

## I. INTRODUCTION

Individuals with mobility- limited disabilities find it difficult to navigate and perform day to day activities. It's important to note that the challenges faced by individuals with mobility-limited disabilities can vary depending on the specific disability, severity, and personal circumstances. However, advancements in assistive technology are gradually improving the overall quality of life for people with mobility limitations.

Various kinds of interfaces have been developed for wheelchair control such as joystick control, head control etc in order to accommodate various disabilities.

People who have quadriplegia, muscle dystrophy, spinal cord injury etc. or total four-branch paralysis find it difficult to navigate in this world which was not built with their needs in mind. Addressing these needs requires a multifaceted approach. Our cutting-edge Gaze tracking control system for wheel chair and home automation allows individuals with limited mobility to take control of their lives like never before.

This research paper focuses on the design and implementation of an eye tracking system that incorporates wheelchair control and home automation functionality. The system comprises two primary stages: iris segmentation and iris tracking. The objective of iris segmentation is to isolate the usable iris pattern from the rest of the eye. Through the utilization of Open CV and Media Pipe frameworks, facial landmarks are leveraged to extract specific points of interest within the eye region, facilitating accurate iris tracking. Iris tracking aims to determine the position of the iris by analyzing the ratio of distances between landmarks associated with the eye. Additionally, the system incorporates advanced features such as individual blink detection, enabling the identification of eye blinks and simultaneous blinks of both eyes. These features enhance the overall functionality of the system and enable the interpretation of various blinking patterns.

By accurately tracking the position of the user's iris, the system allows for intuitive control over the wheelchair's movements. The accompanying application features a user-friendly multi-screen interface, where each screen represents a different smart devices along with wheelchair. Through simple eye blinks, users can effortlessly navigate between screens and gain full control over the functionalities of their selected devices. This comprehensive system design offers individuals with limited mobility a newfound level of independence and empowerment in managing their environment and carrying out daily activities.

## II. MATERIALS AND METHOD

In this research, various hardware and software components were utilized to develop the project. The hardware requirements included an Arduino UNO, which served as the development board and was programmed using the Arduino IDE. A Bluetooth module, specifically the HC-05, was used to establish communication between the microcontroller and other devices. The motor driver shield, L293D, enabled the simultaneous control of multiple DC motors. Additionally, DC gear motors were employed to provide the necessary motion output. Power was supplied by 18650 Li-ion 5000mAh rechargeable batteries, known for their recharge ability and commonly used in portable electronic devices.

On the software side, Python 3.9 was the programming language of choice, known for its high-level capabilities and extensive libraries. OpenCV, a computer vision and machine learning software library, played a significant role in capturing the frames and image processing tasks. NumPy, another Python library utilized for faster calculations, is used in this project to denormalize the landmark values to obtain the pixel coordinates. Media Pipe, an open-source framework developed by Google, provided pre-built components for tasks such as face detection and object recognition. The Kivy framework, designed for developing multitouch applications with a natural user interface, facilitated mobile app development. Lastly, the Arduino IDE was instrumental in programming and communicating with the Arduino microcontrollers.

Overall, the combination of these hardware and software components enabled the implementation of the research project, providing the necessary tools for image processing, motor control, communication, and development of mobile applications.

## III. RESULTS

### *A. System Design:Eye Tracking System*

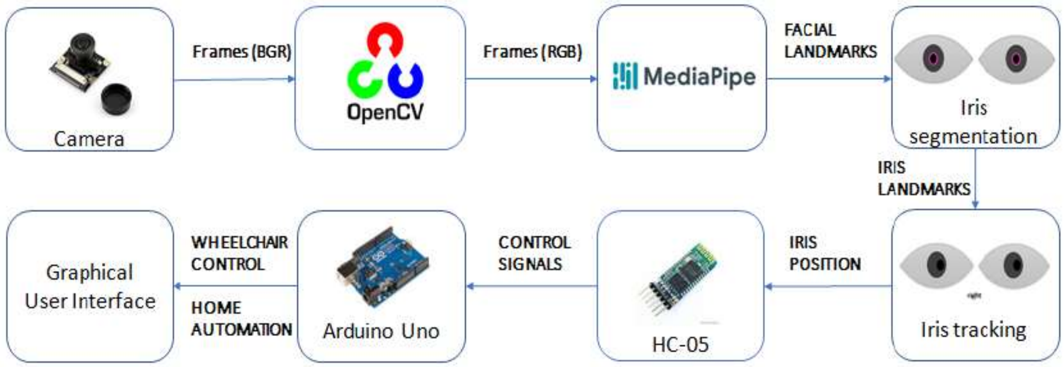


Fig.1 Block diagram

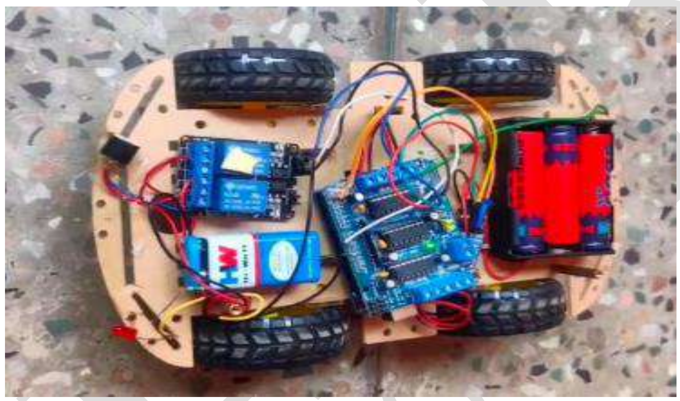

Fig.2.1 Wheel chair prototype

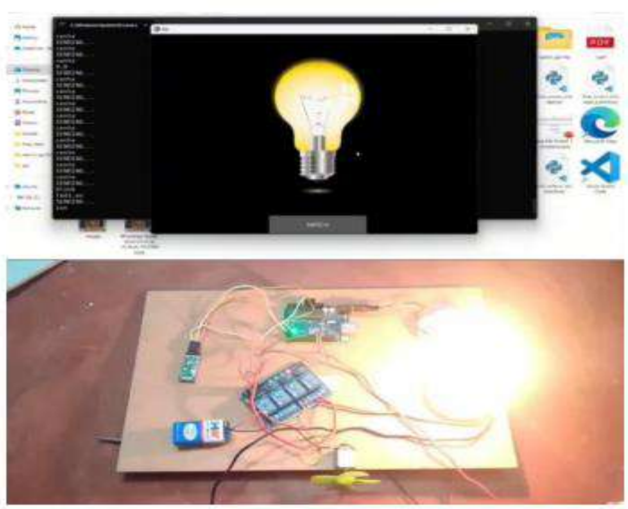

Fig.2.2 Home automation prototype

**Working methodology:**

The principle of the "Gaze Tracking Control System for Wheelchair and Home Automation" is to empower individuals with mobility impairments by offering an intuitive, safe, and customizable control system. The system works by tracking eye movements using advanced tools like OpenCV and MediaPipe. OpenCV captures and processes images of the eye, while Media Pipe identifies key facial landmarks to precisely track the position of the iris. The system uses Python for the coding framework and employs a Bluetooth module to send control signals to an Arduino-based microcontroller, which then operates the wheelchair or home automation devices. The eye tracking process involves two key steps: iris segmentation and iris tracking. By determining the position of the iris and detecting specific eye movements and blink patterns, the system allows users to navigate a multi-screen interface, where each screen controls different smart home devices. A double blink of the eyes shifts the interface between wheelchair control and home automation, enabling the user to seamlessly switch between navigating the wheelchair and controlling devices like lights, fans, or air conditioners. For example, once in the home automation mode, users can blink to select a device, turn it on or off, or adjust settings like fan speed or light brightness.

In order to develop a reliable eye tracking system, there are two primary stages that need to be followed: iris segmentation and iris tracking. The accuracy of these steps is essential as it greatly influences the effectiveness of the subsequent processing stages. Figure 1 illustrates the complete process involved in designing the eye tracking system.

**Iris Segmentation:**

The first step in the process is iris segmentation. Its objective is to isolate the usable iris pattern from the rest of the eye. For this, we utilize OpenCV to capture frames from the camera. OpenCV reads images in the BGR format, while MediaPipe assumes the order of colors to be RGB. Hence, we convert the BGR format to RGB.

By utilizing the MediaPipe framework, we can leverage facial landmarks to extract specific points of interest within the eye region. The provided figure 2 illustrates the relevant landmarks associated with the eye.

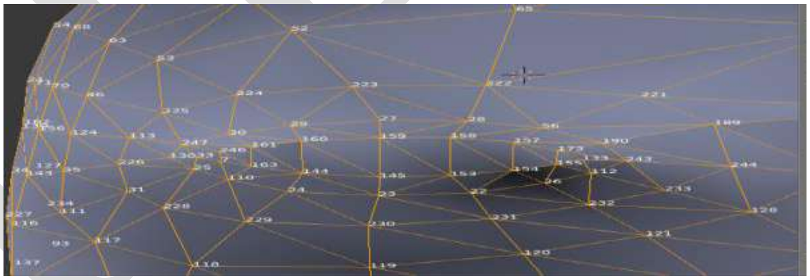

Fig.3 Media Pipe Landmarks

Analyzing these landmarks facilitates the ease of iris tracking, and the detection of the iris itself is accomplished by utilizing the iris landmarks. The Facial landmarks detection mode is initialized using the face_mesh method of Mediapipe's solutions class. Within the face_mesh method, we have our main function, FaceMesh(), which performs the landmark detectionThe normalized landmark values is obtained from results.multi_face_landmarks[0].landmark. To denormalize these values, we multiply the X-coordinate by the width and the Y-coordinate by the height of the frame using numpy. Through denormalization process we will get the pixerl coordinates which then converted into a numpy array for ease of use. Since we only obtain only four landmarks from the previous process, it is not sufficient to directly draw a circle. However, we pass these four landmarks to `cv2.minEnclosingCircle()`, which calculates the center coordinates and radius needed to draw a circle using `cv2.circle()`.We can see the circle drawn in the figure 3.This allows us to accurately represent the iris position on the frame.

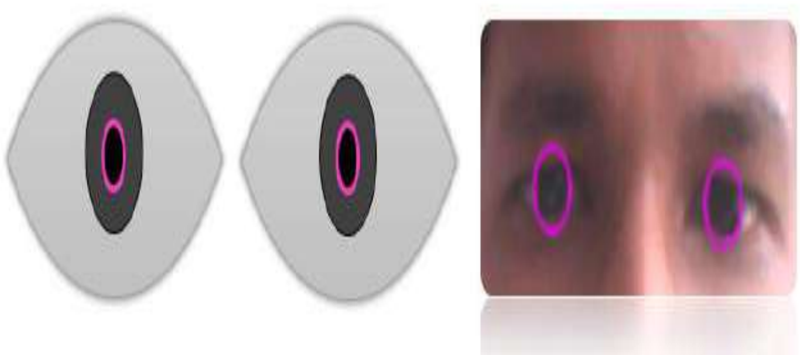

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Fig.4 Iris Tracking

**Iris tracking:**

In the second step, iris tracking, we aim to determine the position of the iris. This is accomplished by calculating the ratio of the Euclidean distance between the center and the right side of the eye to the distance between the right and left sides of the eye. The distances are depicted in Figure 4. If the ratio is greater than 0.57, the eye is looking to the right. If it falls between 0.42 and 0.57, the eye is centered, and if it is less than 0.42, the eye is looking to the left. The same principle applies to vertical movements(up and down).

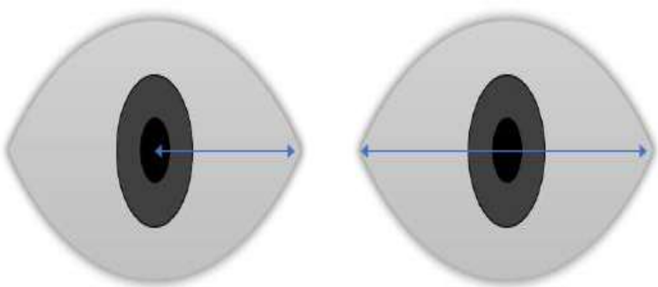

Fig.5 Euclidean distance

To detect whether the person's eyes are closed, we measure the Euclidean distance between the upper and lower points of the eye. If the distance is below a certain threshold, it indicates closed eyes. By utilizing the distance measurement for both eyes, we successfully identified individual eye blinks as well as simultaneous blinks of both eyes. Additionally, we were able to detect double blinks by analyzing the time interval between two consecutive instances of both-eye blinking. This comprehensive approach allowed us to accurately capture and interpret various blinking patterns, enhancing the overall functionality of the system.

The data on iris position is then sent to the bluetooth module, which connects to a microcontroller. Based on the iris position, the microcontroller is programmed to control movements of a wheelchair, enabling it to move forward, backward, and in other directions. Apart from wheelchair control, this gaze tracking system also incorporates home automation functionality.

The application we have developed goes beyond just controlling a wheelchair and includes a range of embedded features. The uniqueness of the application lies in its multi-screen interface, where each screen represents a distinct smart devices like light,fan,air-conditioner,wheelchair,etc as shown in figure 5. At any given time, Only one screen is presented at a time, ensuring a seamless user experience while interacting with and managing multiple smart devices. To navigate between screens, users can effortlessly blink both of their eyes and to select a particular screen, users can perform a double blink, allowing them to quickly access and have a full control over that particular smart device. Once the device is selected user can access various functionalities of that particular device,They can turn the device on or off by blinking his right eye or left eye respectively. Notably, user has precise control over fan speed and can adjust the set temperature of the air conditioner to achieve optimal room temperature conditions. Additionally, they have full control over the television, including precise volume adjustment and channel selection.This feature enables users to create a comfortable and personalized environment within their homes with just a few eye movements. Moreover, the application is equipped with an audio output screen that contains multiple screens for water, food, etc. When a specific need is selected, the system provides an audio output related to that particular requirement, enabling users to easily request their everyday necessities.

Fig.6 Home Automation Using Gaze Tracking Control System

Ultimately, the user gains complete control over all smart home devices through a single application. Furthermore, as the wheelchair is also integrated into the application, significant steps have been taken to enhance the quality of user mobility.The application's advanced capability to detect individual blinking has revolutionized the control of the wheelchair by implementing a secure password mechanism.This ensures that access to the wheelchair is protected and controlled. Once the user selects the wheelchair screen using double blink, they will gain access to the wheelchair only by performing a specific blinking sequence—twice with the right eye and once with the left eye. Similarly, this action can be repeated to revoke access to the wheelchair, providing a seamless and secure user experience by avoiding the random movement of eyes. Once the user has wheelchair access the user will come across the interface as shown in figure 6. Additionally, the system is integrated with a night vision camera, ensuring that users can control their wheelchair even in low light conditions.


Fig.7 Gaze Tracking System For Wheelchair

The application offers versatility and compatibility, supporting both laptops and mobile phones. This ensures flexibility and accessibility for users on various devices. Its meticulous design aims to empower users, granting them independence in mobility and the ability to carry out daily activities autonomously.

## IV. CONCLUSION

The primary objective of this study was to develop an assistive eye tracking device for individuals with mobility impairments, allowing them to control both their wheelchair and home devices. To achieve this, we designed a user-friendly multi-screen interface that enables users to navigate between screens and access various smart home devices using eye movements. The eye tracking process involved two crucial tasks: iris segmentation and iris tracking.

To control the wheelchair, we transmitted the iris position data to a Bluetooth module connected to a microcontroller. The microcontroller was programmed to execute wheelchair movements, enabling it to move in different directions such as forward, backward, and sideways. Furthermore, we addressed safety concerns by integrating ultrasound sensors, a gyrometer, GPS, and health sensors into the wheelchair design. In addition, to prevent unintended eye movements, we implemented a secure password mechanism for wheelchair access.

Moreover, we recognized the importance of user experience and personalization in the eye tracking system. Further improvements and developments can be made based on individual user preferences and feedback.

The integration of advanced safety features and the secure control mechanism contribute to the reliability and usability of the eye tracking system. By enhancing the mobility and independence of individuals with mobility impairments, this system has the potential to significantly improve their quality of life.

Overall, this research represents a significant advancement in assistive technology. The developed eye tracking system, along with its associated safety features, demonstrates promising potential for assisting individuals with mobility impairments in controlling their environment. As further research and user feedback are considered, the system can be refined and customized to better suit the specific needs and preferences of the users.

## V. SAFETY CONCERNS AND FUTURE SCOPES

While eye tracking systems offer exciting possibilities, there are also important safety concerns to consider. Additionally, integrating eye tracking with home automation holds promising future prospects. Let's explore these aspects in greaterdepth:

*A. Safety Concerns:*

• Attachment of ultrasound sensor to the wheelchair which stops the wheelchair whenever it is about to collide with

• GPS: for tracking the wheelchair.

• Health sensors can be incorporated into the system to provide real-time monitoring of vital signs, such as blood pressure and heart rate, for the individual seated in the wheelchair.

*B. Future Scopes:*

• Customization and Personalization: Offering customization options within the application would allow users to tailor the interface, gestures, and functionalities according to their specific preferences and requirements. This could involve enabling users to create personalized profiles, define shortcut commands, or adjust sensitivity settings for a more personalized and intuitive user experience.

• Integration of Machine Learning and AI: Implementing machine learning algorithms and artificial intelligence techniques can further enhance the performance and adaptability of the application. By continuously analyzing user interaction patterns and preferences, the system can learn and predict user behavior, making the control of smart devices and wheelchair navigation even more efficient and intuitive.

• Expansion of Device Integration: In the future, the application can be further expanded to support integration with a broader range of smart devices. This would enable users to control and manage additional appliances and systems within their homes, such as security systems, kitchen appliances, and healthcare devices, thereby offering a more comprehensive and integrated home automation experience.

• Enhanced Accessibility Features: To cater to a wider range of users with diverse needs, the application can be further developed to include additional accessibility features. This may involve incorporating voice control capabilities or integrating with assistive technologies, such as head movements or facial expressions recognition, to provide alternative control options for individuals with different abilities.

Overall, considering safety concerns and exploring future possibilities can lead to further advancements and improvements in eye tracking systems for wheelchairs and their integration with home automation.

## VI. ACKNOWLEDGEMENT

We would like to thank and gratefully acknowledge the sincere contributions of our mentor **Dr. K.E.Ch Vidyasagar** who has been our constant support during the entire span of our project and research. We sincerely thank him for his guidance and encouragement which helped us in carrying out this project so efficiently.

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