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Eye Controlled Communication System for Motor Impaired Patients Using OpenCV

Dr. Nadiminti Venkata Ramana Murty[1], Gonapa Sivanvika[2], Malla Pranitham[3], Meka Venkata Neeraj[4], Munampaka Girish[5]

[1,2,3,4,5]*Department of Computer Science and Engineering (AI & ML), Gayatri Vidya Parishad College for Degree and PG Courses(A), Visakhapatnam, India*

***Abstract*—Computers have become an essential part of life for us in today's digital age when used for communicating, learning and conducting other daily activities. People with disabilities such as motor disabilities can find themselves in very difficult situations when it comes to using conventional input devices such as keyboards and mice. A solution to such problems would be an inexpensive human-computer interface based on eye movement and speech commands. A conventional webcam is used to record the face, after which computer vision algorithms detect the eye region. Computer vision algorithms are also used to determine the direction of eye movements. Blinking movements are converted into clicks. Another component of this interface is the speech recognition algorithm. The design for this solution uses Python with modules like OpenCV, Dlib, and speech recognition packages. Results from experiments show that the system works in real-time with reasonable accuracy in a normal environment. The inclusion of both video and voice input makes it more user-friendly. This strategy offers a low-cost solution for people with serious motor disabilities.**

***Index Terms*—Eye Tracking, Computer Vision, Assistive Technology, Human-Computer Interaction, Voice Commands, Speech Recognition.**

I. INTRODUCTION

As the technology advances rapidly, computers become an essential part of human life, enabling communication and health care operations. At the same time, individuals with motor impairments face some challenges when operating computers due to the fact that most of the computer operations require the usage of some external devices. There are some common approaches that address the needs of people with motor impairments, but they include purchasing new devices or taking some actions. In this connection, other techniques for communicating with computers need to be suggested. Among several approaches, eye tracking is identified as one of the potential solutions due to the ability to perform movements regardless of the physical abilities of the person involved. Moreover, voice control can add up to the control mechanism without involving any physical movement at all. Nevertheless, when only one form of control is used, problems such as low accuracy levels can occur.

To address these concerns, a combination of eye tracking and voice recognition is proposed. In this way, not only would a person be able to navigate with his eyes but also perform clicks by blinking and issuing verbal commands. The main achievements of this study are: Development of an eye-tracking-based real-time cursor control system Implementation of voice commands to improve user interface Low-cost implementation that is independent from hardware Evaluation of performance under realistic conditions

II. LITERATURE REVIEW

[1] Hand Gesture Controlled Virtual Mouse – 2024.This paper describes an innovative model in which hand gestures are employed to operate the virtual mouse. It enhances user interaction since it does not require any hardware input device. But repetitive hand motion may lead to exhaustion and needs a precise camera installation.[2] AI Virtual Mouse Based on Hand Gestures Recognition – 2025.This approach utilizes AI technology along with hand gesture recognition to simulate the mouse activities. It ensures non-contact interaction and increases accessibility. However, the performance of the hand gesture may deteriorate with varying

background conditions and lighting effects.[3] Virtual Mouse Through Media Pipe and OpenCV – 2024. This paper describes the development of a virtual mouse using the Media Pipe library and OpenCV library for tracking the hand movements. It is a cost-effective solution. However, the system relies on visibility which is a disadvantage as it cannot be used by individuals with motor disabilities.[4] Smart Hands-Free System Using Eye Tracking, Blinking and Voice Commands -2025 In this study, a hands-free system uses eye tracking, blinking and voice command functionalities. The system makes interaction more accessible as it includes several ways of interacting. However, performance may be affected by factors such as lighting and noise in the environment.[5] Voice Assistant Virtual Mouse using Hand Gestures - 2025 In this study, hand gestures and voice commands have been incorporated in the system in order to provide a flexible way of interacting with computers. Interaction using voice commands and hand gestures enables users to perform certain functions in different modes. However, it is still necessary to involve physical interaction by the user. Conclusion From the studies listed above, it can be stated that gesture-control-based systems allow users to interact effectively except for individuals with motor impairments. However, there are certain limitations regarding the accuracy of these two technologies as well as concerning the environments in which these interfaces can be used. To deal with the limitations of the current technologies, it was considered appropriate to create a new kind of eye-controlled communication system, incorporating both approaches described above. At the same time, it can be considered as one of the most promising ways of interaction between man and computer since using this technology it becomes possible to control the computer in real-time mode and monitor the attention of the user.

III. OVERVIEW OF THE CURRENT SYSTEM AND PROPOSED ENHANCEMENT

Current human computer interactions are highly dependent on traditional input methods such as mouse and keyboards. The said devices require physical actions; thus, not suitable for individuals who suffer from motor disabilities. Assistive technology based on head movements or specialized eye movements detection software/hardware can be expensive and complicated to install. Other technologies rely on voice commands which might experience difficulties in noisy environments. Therefore, current human computer interactions require physical actions, expensive equipment or unreliable technologies. This proposed project aims to create an Intelligent and efficient Eye Controlled Communication System that incorporates voice commands. In this case, the Eye Controlled Computer system will enable the user to operate the computer via eye movements and voice commands without having to exert any physical action. Below are the components involved in this project: Eye Movements Detection Module, Blink Movements Detection Module, Voice Commands Module, Cursor Movements Module, and Output Interactions Module.

3.1 Eye Tracking Module

The module captures images from a webcam and analyzes them in real-time using computer vision algorithms to detect the facial features. The software focuses on the eye area and tracks the direction and movement of the eye. The location of the eye may be utilized to move the cursor without having to use one's hands.

3.2. Blink Detection Module

The module detects eye blinks via the Eye Aspect Ratio (EAR). The Eye Aspect Ratio (EAR) is computed through the distance between eye landmarks. When the EAR is below a specific threshold value, this implies that there is a blink being performed. Blinking is then used to click the mouse button such as the left-click function

3.3. Voice Command Module

This particular module facilitates communication with the software through voice. The voice commands such as 'click', 'scroll up', 'scroll down' and 'open' are collected through the speech recognition technique. This helps in adding one more form of interaction with the system apart from eye movements.

3.4. Cursor Control Module

This particular module utilizes eye movement and blinking for performing cursor control. The cursor can be moved through eye movements while blinks can be used to click on buttons. Other tasks can be done using voice commands.

3.5. Output Interaction Module

This module helps in the interaction between the user and the computer system. It is with the help of this module that the output from the above-mentioned modules is used to facilitate user-computer interaction through application programs.

IV. MATERIALS AND METHODS

Methodology for the Eye Controlled Communication System for Motor-Impaired Patients is stated as follows:

Data Collection

The system captures the face data of the user using a camera. The frames obtained contain data on the user's face, with emphasis placed on the area around the eyes, whose movement needs to be tracked. Most of the data collected is based on live video feed, as opposed to already stored images since the entire process is performed in real time. Different aspects such as lighting, orientation of the face, as well as the position of the user are also taken into consideration.

4.1. Data Preprocessing

First, the face region is identified using computer vision methods. Then, the frames are scaled, normalized, and any noise contained within them is removed so that they have improved clarity. Various libraries including OpenCV and Dlib are used to pre-process the frame and obtain important information regarding eye coordinates.

4.2. Eye Tracking and Voice Command Processing

Facial landmark detection is employed to determine the location of the eyes and follow the path of their motion in real-time. The Eye Aspect Ratio (EAR) is computed to recognize blinks, which are used for performing clicks. The consistent monitoring of the orientation of the eyes allows cursor navigation around the screen. Besides eye tracking, voice commands are supported by the system as well. Speech recognition algorithms are utilized to determine voice commands like "click", "scroll up", "scroll down", and "open". The voice commands are recognized and translated into system actions.

4.3. Model Architecture

The proposed system involves the use of real time video processing and multimodal interaction as the basis. The first stage involves the inputting of the data through the use of the webcam. Data processing will involve the use of the Dlib function in detecting landmark features of the face and will particularly focus on the eyes. There are two main stages of operation involving Eye Tracking and Voice Commands. In Eye Tracking, eye movement will involve the manipulation of the mouse pointer while blinking produces the click command. Voice commands will involve the conversion of the voice inputs to actions such as scrolling and selecting objects. The output from both the modules is fed into the control module to decide the next course of action. When it comes to controlling the cursor, PyAutoGUI will be employed, making the manipulation of the computer system easier for the user.

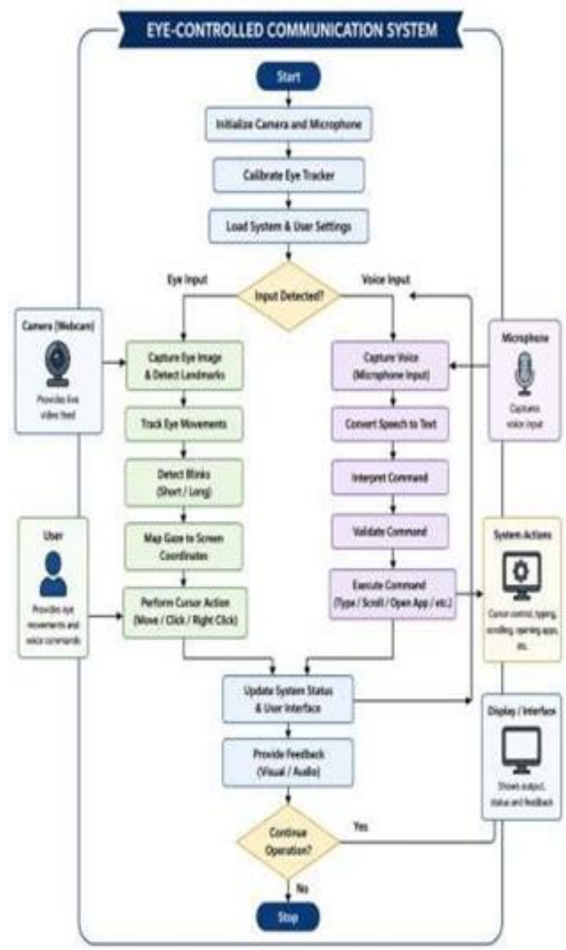

Fig 1: Block Diagram

Finally, there is immediate feedback, making it easy for users to communicate with the software. This is thanks to efficiency, speed, and friendliness without the need for any specific hardware.

V. RESULT AND DISCUSSION

Evaluation of the Eye Controlled Communication System was done under various circumstances so that its performance could be determined. The system managed to capture live videos through the webcam and identified the facial landmarks needed to track the eyes. Navigation of the cursor by eye movements was effective and enabled movement without any form of physical action.

The blinking of the eye, which triggered the clicks, was effective using the Eye Aspect Ratio (EAR) method. Most of the blinks were successful except when there was accidental blinking or moving of the head. This project managed to work efficiently under regular lighting, while there were minor differences in accuracy under dim lighting. Different commands like "click," "scroll up," and "scroll down" were also tried using the voice command module. The system proved quite effective in recognizing and implementing these commands in silent surroundings. But in cases of ambient noise, there could be some problem in recognizing them. The combination of eye tracking and voice commands helped make an efficient interaction system. There was no significant delay in recognizing the commands that made it practically applicable. With some shortcomings, the proposed system can offer an inexpensive solution to motor-impaired people to communicate with computers.

VI. USER INTERFACE RESULTS

Figure 2: System Calibration

The system calibration interface allows the user to initialize and adjust the eye tracking and voice modules before operation. It captures the user's face through the webcam and ensures proper alignment for accurate eye tracking. The calibration process improves detection accuracy and system responsiveness.

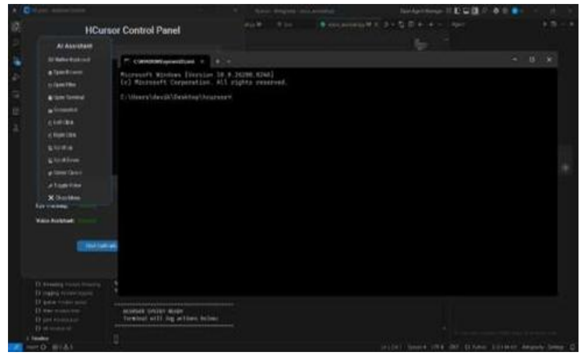

Figure 3: Eye Blink Controlled Terminal Access

The interface shows how eye blinking can be used for controlling operations in the computer system. It allows the users to control actions like launching the command prompt using eye blink actions.

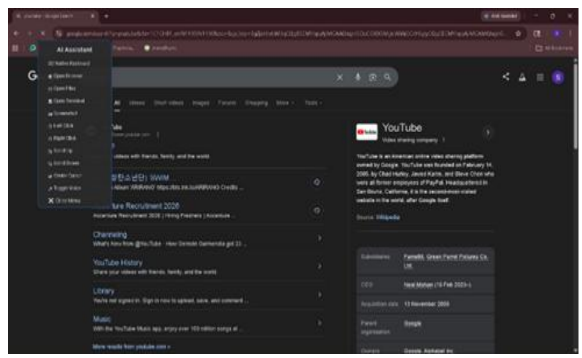

Figure4: Eye-Controlled Web Browser Navigation

The diagram below shows how eye tracking technology, alongside voice commands, has been utilized for operating a web browser. In this case, the user can maneuver the cursor and access different functions through the web browser without physical touch.

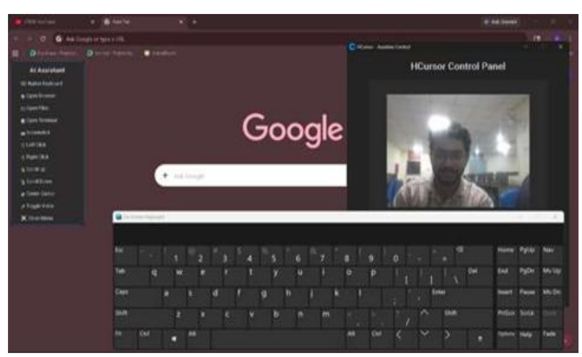

Figure 5: Eye controlled Native KeyBoard

The diagram above explains how eye-tracking technology can be used to control a virtual keyboard. The users can use the movements of the cursor and blinks to make selections and type out letters.

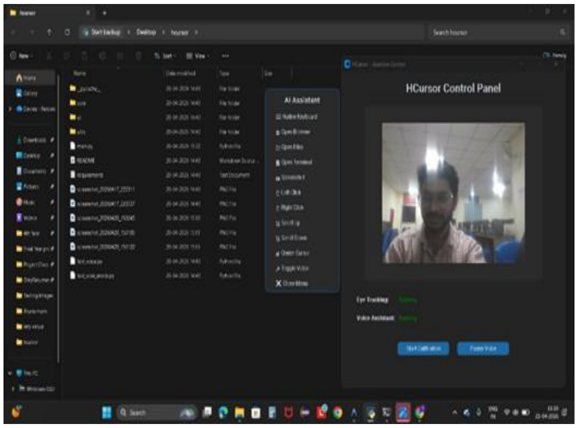

Figure 6: Eye-Controlled File Management

The diagram above illustrates how the system allows users to browse and manipulate files through their eyes and speech commands. Users can open directories, select files, and execute elementary file manipulation actions without having to use a tangible mouse or keyboard

VII. CONCLUSION

The Eye Controlled Communication System is an extremely efficient method of accomplishing the objectives of computer vision and speech recognition so that physically disabled people can communicate with the computer successfully. This will be accomplished with the help of the movements of the eyes for controlling the cursor movements and blinking for initiating mouse click events; hence, no input device will be required to interact with the computer. The design of the system is such that it can function at a lower cost without requiring any special hardware, which makes it practical for implementation in real life. Tests conducted on this system reveal that the system works efficiently during normal conditions without causing any delay. Despite having some drawbacks when it comes to dim light conditions and noise, the entire system is flexible. In summary, this research makes an important contribution to the development of accessibility and self-sufficiency of severely motor impaired people through the use of the human-computer interface system.

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