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Control Beyond Contact: Vision-Based Non-Verbal Communication

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Abstract: *Nowadays, computer vision has reached an advanced stage where computers can recognize their users with simple image-processing programs. This technology is widely applied in various aspects of daily life, including face recognition, color detection, and autonomous vehicles. In this project, computer vision and artificial intelligence (AI) are utilized to create an optical mouse and keyboard controlled by hand gestures. The camera of the computer reads the image of different gestures performed by a person's hand and eyes. Based on the movement and gesture, the mouse and keyboard perform actions, such as right and left swipes. Similarly, keyboard functions can be controlled through gestures, like using one finger for alphabet selection and four fingers to swipe. This system acts as a virtual mouse and keyboard, eliminating the need for wires or external devices. The only hardware required is a webcam, and the coding is done in Python using the Anaconda platform. AI enhances gesture recognition accuracy, improving response times and adaptability. The Haar Cascade algorithm is used for gesture recognition and eye-tracking, while AI-based models help refine gesture classification. The system generates convex hull defects from hand gestures, and these defect calculations are applied to create an algorithm that links gestures to specific mouse and keyboard functions. By mapping a few gestures to these functions, AI enables more precise user interactions. The goal of this research is to develop an AI-powered system that uses non-verbal cues to operate a computer's mouse and keyboard*

Keywords: Gesture, Hand, Eye, Mouse, Keyboard, Computer Vision, Non-Verbal, Swipe, Camera, Communication

I. INTRODUCTION

Traditional computer interaction depends on physical devices like mice and keyboards. However, with advancing technology, new ways of controlling computers using eye movements and hand gestures are emerging. This project aims to develop a system that replaces traditional input devices with natural, hands-free interactions. It is especially useful for people with physical disabilities or in situations where using a keyboard or mouse is difficult. The system mainly works by using eye movements to move the cursor on the screen. When a user looks to the left, the cursor moves left; when they look right, the cursor moves right. A simple blink can be used to click. This eliminates the need for a physical mouse, allowing users to control the computer just by looking at different areas on the screen. Additionally, hand gestures can be used for other functions, such as scrolling or selecting items. This combination of eye tracking and hand gestures provides an easy and natural way to interact with computers. It makes digital access more inclusive by removing physical barriers.

This hands-free approach is also useful in workplaces where multitasking is important, such as in medical fields where hygiene is a priority. By using AI and computer vision**,** this system enhances accessibility, efficiency, and convenience in human-computer interaction.

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II. PROBLEM STATEMENT

Traditional input devices can limit the user experience and accessibility, particularly for individual s with motor disabilities. Moreover, the current input methods lack the immersive qualities necessary for VR environments. This study proposes a gesture-based system that simulates mouse and keyboard functionality, offering seamless and accessible interactions.

III. PROPOSED SYSTEM

The proposed system will create a virtual mouse and keyboard that work using eye movements and hand gestures instead of physical devices. A webcam will capture the user's eye gaze to move the cursor, and a blink will be used for clicking. Had gestures will allow users to select alphabet using one finger and four finger use for swip. The system will use computer vision and AI to recognize these movements accurately. It will be developed using Python, OpenCV to process images and gestures in real time. This hands-free system will be helpful for people with disabilities and in workplaces where physical contact with a keyboard or mouse is not convenient. The goal is to make computer interaction easier, more accessible, and more efficient for everyone.

IV. RESULT

Figure 1: Home Page

Figure 2: Registration Page

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Figure 3: Login Page

Figure 4: Main Page

Figure 5: Mouse Control Using Eye Movement Page

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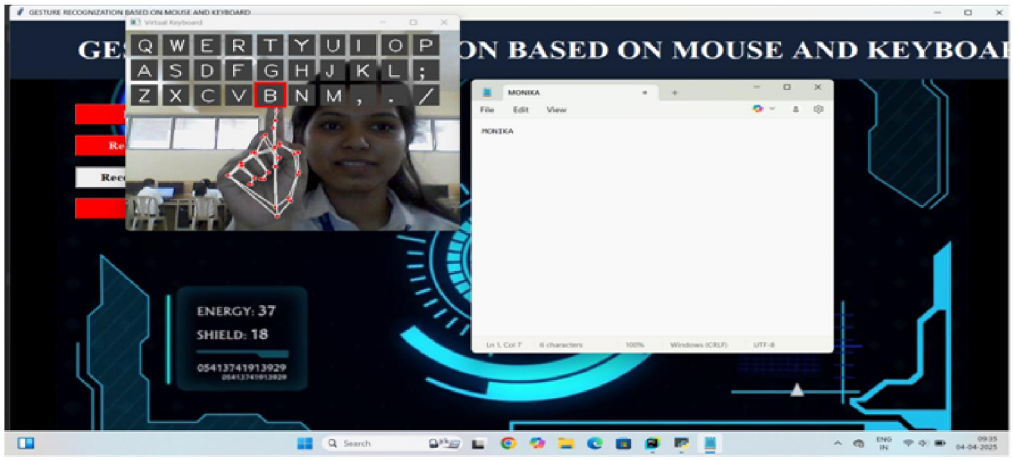

Figure 6: Keyboard Control Using Hand Gesture

V. SYSTEM ARCHITECTURE

In this project, convex hull and Haar cascade algorithm are employed for segmentation and classification, respectively. The process is divided into four stages: pre-processing, segmentation, feature extraction, and classification.

Pre-processing:

In this project, convex hull and Haar cascade algorithm are employed for segmentation and classification, respectively. The process is divided into four stages: pre-processing, segmentation, feature extraction, and classification. Pre-processing ensures that the input data, typically images or video streams, is optimized for further analysis. Techniques such as noise reduction and background subtraction are applied to improve the quality of the visual data. For hand gestures, background subtraction is used to isolate the hand from the scene, and lighting normalization is applied to maintain consistency across different conditions. Pre- processing enhances the distinction of key features that are critical for gesture and eye movement detection.

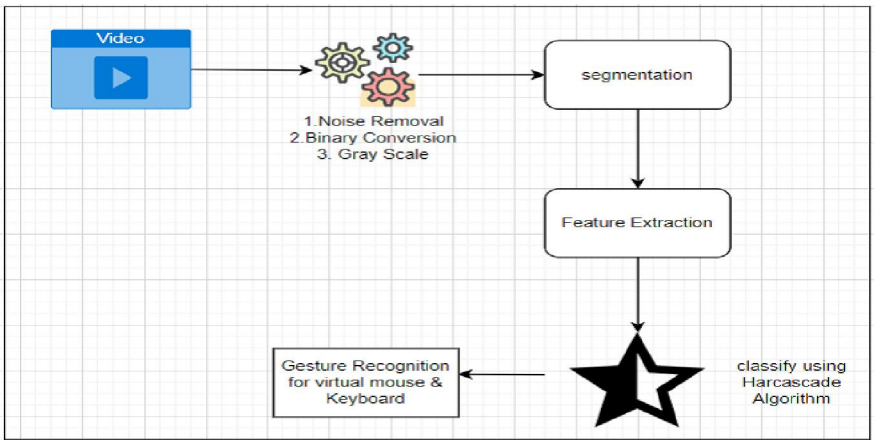

Figure 7: Architecture diagram

Segmentation:

Segmentation focuses on identifying and isolating regions of interest, particularly the hands and eyes, from the processed input. In this project, the convex hull algorithm is utilized to detect and segment the hand by generating a

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contour that encloses the hand shape. This approach enables precise segmentation of the hand, which is essential for recognizing gestures like finger pointing or swiping. For eye tracking, segmentation isolates the eye region for further feature extraction.

Feature Extraction:

Feature extraction is performed using the convex hull approach for hand gestures. The convex hull outlines the hand, making it easier to detect specific finger positions and shapes. The contour data is processed to identify gestures. For eye movements, relevant features such as pupil position and gaze orientation are extracted, which are crucial for interpreting gaze direction and blink patterns.

Classification:

The Haar Cascade algorithm is used to classify hand gestures and eye movements by detecting patterns in image features. For hand gestures, it identifies shapes from the convex hull to classify actions like pointing or swiping. For eye tracking, it detects eye movements and blinks to simulate mouse movements and clicks. This method offers a lightweight alternative to CNNs, ensuring real-time classification with lower computational demands.

VI. LITERATURE REVIEW

Prof. S. A. Nagtilak et.al. "Implementation of Gesture-Based Virtual Key board and Mouse" International Journal of Scientific Research in Engineering and Management,2024.

This study presents a novel approach that uses hand gestures and eye-tracking to create a virtual mouse and keyboard, enabling users to interact with computers without physical peripherals. The system tracks hand and eye movements to control the cursor and input commands, offering accurate and responsive interaction. It uses machine learning for gesture recognition and is customizable to user preferences. Testing has shown promising results, indicating potential for improved accessibility and productivity across various applications.

Sugnik Roy Chowdhury et.al." Gesture Recognition Based Virtual Mouse and Keyboard" , IEEE 2023.

This project uses computer vision to develop a virtual mouse and keyboard that responds to hand movements, with a webcam tracking gestures to control cursor movement, clicks, and typing. For example, moving your hand moves the cursor, and specific gestures trigger clicks or typing actions. The project, written in Python, processes the hand's shape (convex hull) to detect gestures, which are then mapped to mouse and keyboard functions. This system enables control of a computer using only hand movements, without the need for a physical mouse or keyboard.

Virendra Swaroop Sangtani et.al."Artificial Intelligence Virtual Mouse us ing Hand Gesture", International Journal of Modern Developments in Engi neering and Science,2023.

This study proposes a machine learning-based AI virtual mouse to enhance user productivity and accessibility. It focuses on the algorithm, scope, aims, applications, and benefits of the AI virtual mouse. Human-computer interaction often relies on hand gesture recognition, and recent advancements have improved this technology. Techniques like biometrics and hand gestures, commonly used on smartphones, allow users to control systems by simply showing their hand in front of a webcam, making such interfaces more user friendly and accessible.

Rupali Shinganjude et.al. "Virtual Mouse Using AI and Computer Vision, International Journal of Innovative Science and Research Technology,2023.

This paper presents a virtual mouse system controlled by hand ges tures, using AI algorithms to translate gestures into mouse movements. De signed as an alternative interface for users who struggle with traditional de vices, the system captures hand images via a camera andprocesses them torec ognize gestures. These gestures are then translated into corresponding mouse actions on a screen. Potential applications include hands-free device operation in hazardous environments and providing an alternative to a physical mouse, enhancing user experience and accessibility.

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Jonas Robin, Mehul Rajesh Soni, et.al."Computer Vision for Hand Ges tures",IEEE International Conference on Convergence to Digital World, 2022.

This project aims to detect specific objects, particularly hand ges tures, from the environment using computer vision. The computer captures an image of the environment that may include unnecessary objects. The image is then processed to focus only on the important information, such as the ges ture, while discarding the rest.

After processing, neural networks are utilized to improve the accuracy of gesture recognition. In particular, a Convolutional Neural Network (CNN) algorithm is employed to identify gestures in the im age. The result is then displayed on a screen or communicated through an audio device.

Noman Naseeb et.al. "RGB based EEG Controlled Virtual Keyboard for Physically Challenged People",3rd International Conference on Computing, Mathematics and Engineering Technologies,2022.

Many people take simple tasks like walking, eating, and talking for granted, but some individuals with disabilities or paralysis need help to do these activities. Around 1.9 percent of the population is affected by paralysis, which can lead to feelings of anxiety, depression, and isolation. As technology advances, Brain-Computer Interfaces (BCIs) help physically impaired people control devices like keyboards and mice using brain signals. This research aims to create a virtual keyboard with red, green, and blue sections. EEG electrodes on the scalp detect brain signals, which are amplified and analyzed with a Support Vector Machine. The goal is to build a system that is accurate and easy to use for spelling and typing**.**

VII. OBJECTIVE

To create computer programmers that can convert nonverbal cues into mouse and keyboard actions, improve the system's accuracy and dependability depending on user feedback, give people with impairments an alternate method of computer control, encouraging more freedom and self-reliance. To increase disabled people's inclusion and accessibility in the computing industry.

VIII. METHODOLOGY

Algorithm

The system's workflow is broken down into four key steps, as outlined below:

User Registration and Authentication:

The user initiates the system by registering and logging in with credentials, ensuring personalized interaction tracking and session management.

Eye-Based Mouse Control:

Eye Detection: The system utilizes a webcam to track the user's eye movements. Cursor Movement: The mouse cursor is controlled through the following eye movements:

Left eye movement → Cursor moves left.

Right eye movement → Cursor moves right

Blink → Execute a mouse click.

Hand Gesture-Based Keyboard Control:

Hand Detection: A webcam detects the user's hand and identifies gestures. Gesture Recognition: Recognized hand gestures are mapped to keyboard

Inputs: Complex gestures (e.g., pinch, finger extensions) simulate virtual key presses.

Action Execution:

Mouse Control: Based on eye movements and blink detection, cursor movements and clicks are performed.

Keyboard Input: Recognized hand gestures are translated into keyboard actions.

Continuous Operation: The system continually monitors user inputs and performs the corresponding actions until the session ends.

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IX. CONCLUSION

In conclusion, both the Haar Cascade algorithm and the hand gesture method can be used effectively for creating a virtual mouse and keyboard interface. The Haar Cascade algorithm uses a pre trained model to detect facial features and hand gestures, whereas the hand gesture method involves training a model to recognize specific hand movements. Both the methods have advantages and limitations. The Haar Cascade algorithm is faster and requires less computational power, but it may not be as accurate as the hand gesture detection method. On the other hand, the hand gesture method can be more accurate but requires more processing power and may take longer to train the model. Overall, both methods can be used to create an effective virtual mouse and keyboard interface depending on the specific requirements and constraints of the application.

X. FUTURE SCOPE

Future work will be focused on algorithm improvement by merging the models created and making an entire virtual system handler such that it has functionalities of virtual mouse and keyboard as well as it can control the volume, brightness and other functionalities. It also includes improvement in keyboard. We plan to add a caps-lock button. Also, a button that switches the keyboard characters to special characters so that they can be used when they are needed. The virtual keyboard and mouse can be used together in airport kiosk check-in machines for touch less check-in experience. The passengers can enter the PNR without touching the screen and get there boarding passes when such system is implemented.

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