Enhancing Accessibility with Gesture Controlled Virtual Input

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Abstract: **This paper focuses on the development of a gesture-controlled virtual mouse and keyboard system that allows users to interact with a computer without using physical input devices. The system is designed using a standard webcam to capture real-time hand movements. These movements are processed with the help of computer vision techniques using MediaPipe and OpenCV to detect hand landmarks and recognize different gestures. The recognized gestures are then converted into mouse and keyboard actions such as cursor movement, clicking, scrolling, and text input using the PyAutoGUI library. The main aim of this work is to provide a simple and affordable solution that can improve accessibility, especially for users who face difficulty in using traditional mouse and keyboard devices. The system works in real time and does not require any special hardware or pre-trained datasets. Experimental results show that the proposed system performs well under normal lighting conditions and provides smooth and responsive control for basic computer operations. This project demonstrates that gesture-based virtual input can serve as a practical and low-cost alternative to conventional input devices.**

Keywords: Virtual Mouse and Keyboard, Hand Gestures, Human-Computer Interaction

I. INTRODUCTION

The human-computer interaction has been enhanced in the recent years, yet many individuals still rely on the same conventional tools such as a mouse and a keyboard to use a computer [1]. These devices work efficiently but they are not necessarily convenient to the user with limited mobility, injuries, and so on [2]. Inability to use physical inputs on the prolonged basis. It is due to this that researchers are trying to discover new methods of controlling computers without any physical touch to the hardware [3]. Gesture-based one of such solutions is through virtual input systems. The movements of hands can be monitored in real time and turned into action with the assistance of the machine learned and computer vision methods. such as scrolling the cursor, clicking or typing. It is made in libraries like MediaPipe and OpenCV. can be used to accurately locate hand landmarks with a regular webcam, and such tools as

The real mouse and keyboard activities in the screen are done through PyAutoGui. Using not only helps make the computer more accessible, hand gestures to control it also [2],[3]. offers a more natural interaction with digital material. This type of interface can be beneficial to physically disabled individuals, learners who are engaging in interaction projects, and even. customers who like to have a touch-free interface. The principle thought of this project is to develop a user-friendly, cheap, and simple virtual input system which functions without any. special hardware. This paper discusses a gestural mouse and keyboard which is controlled by a gesture. system that is oriented towards the ease of use and accessibility. The method proposed makes use of real-time. hand tracking, signal detection as well as gesture mapping to execute typical input functions. By integrating precision, inexpensive hardware, and customizable software packages, the system has a goal of offer an effective alternative to the conventional input devices

II. OBJECTIVES

The project will be based on creating a gesture-driven virtual input control system that will enable hands free interaction on a standard webcam.

- In order to enhance the digital accessibility of people with physical disabilities or motor impairments.
- To interpret and read hand gestures of users and to translate them into virtual inputs as typing and cursor control.
- To create a comfortable, straight forward interface which will be easy to use and comprehend without complicated calibration.
- To develop a low cost and standalone system with hardware that is easily available open-source technologies.

III. LITERATUR REVIEW

- Hand gesture recognition is a key area in human–computer interaction (HCI), enabling intuitive and touchless interfaces. Phursule (2023) proposed a virtual mouse and gesture-based keyboard using a webcam and computer vision, though scrolling and text selection remain challenging. Nazeer (2022) developed a similar system mapping gestures to mouse and keyboard functions using convex hull defects, allowing clicks, character selection, and navigation without external devices.
- Review studies have explored various techniques and challenges. Hassan and Hannan (2021) highlighted issues such as gesture variability, occlusion, and user adaptation. Elmezain and Hussain (2020) emphasized environmental challenges and the need for robust

multimodal systems. Park and Choi (2019) traced the evolution from vision-based methods to machine learning approaches, with applications in virtual mouse systems, interactive displays, and augmented reality. Kulkarni and Patil (2018) discussed environmental variability, gesture diversity, and adaptive system requirements.

- Cao, Gao, and Zhang (2017) demonstrated real-time hand gesture recognition using CNNs, achieving high accuracy for natural interaction. Overall, these studies show progress in gesture-based HCI systems while highlighting challenges in accuracy, lighting conditions, gesture variability, and real-time performance.

IV. METHODOLOGIES

The system proposed in the paper utilizes computer vision for the detection of hand movements, including the detection of hand tips, using the webcam [2]. This eliminates the restrictions of the Bluetooth mouse, which uses batteries for power supply, making the Bluetooth mouse less wireless [3]. The main idea behind the proposed system is to replace the physical mouse with the webcam or the camera attached to the computer [3],[4].

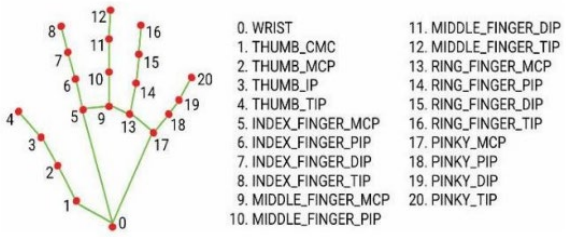

Fig. 1. Hand Landmark Points and Segmentation in Gesture Recognition System

The system proposed utilizes the machine learning algorithm [1]. The computer can be controlled virtually through hand movements, replacing the physical mouse for the computer, which can be used for left-click, right-click, scroll, computer cursor, etc [1]. The algorithm for the detection of hands utilizes the concept of deep learning. The proposed system eliminates the need for physical touch or the use of other equipment for the functioning of the computer, which may help in the prevention of the spread of COVID19[1]. Figure 1: Shows Landmark Points and Segmentation in Gesture Recognition System, which is used for the hand-tracking system, which helps in the detection of hand landmarks for the functioning of the virtual mouse and keyboard [2]. In addition to the virtual mouse, the proposed system also utilizes the gesture-based keyboard. This module helps the user to input text or commands using a set of pre-defined hand gestures, each associated with a character or a key press function. The combination of mouse and keyboard functionality makes it a comprehensive system of hands-free operation [3]. In the case of the virtual mouse, the system has been designed to accommodate basic mouse movement, left-click, right-click, scrolling, and even volume adjustment using intuitive hand gestures captured by the webcam [3],[4]. These hand gestures are recognized using Media Pipe's hand-tracking feature, along with a CNN model for better accuracy [3]. The gesture-based keyboard follows a similar principle, where a hand gesture is associated with a key press [4]. This enables the user to input text or key press commands without the need for a physical keyboard. This could prove to be a significant advantage in accessibility, touch-free computing, or hygienic and social distancing scenarios. Overall, this system makes the user experience more convenient with the combined functionality of mouse and keyboard, both being part of a single system using computer vision and machine learning techniques.

The system uses the webcam as the main input device, which captures the video frames in real time. These frames are then processed to identify the hand landmarks. Using the hand landmarks, the system is able to determine the distance and position, hence identifying the gesture.

To map the hand gesture to the screen coordinates, the system uses the following formula [1]:

$$X_{\{screen\}} = \left(\frac{X_{\{hand\}}}{W_{\{frame\}}}\right) * W_{\{screen\}}$$

$$Y_{\{screen\}} = \left(\frac{Y_{\{hand\}}}{H_{\{frame\}}}\right) * H_{\{screen\}}$$

For the detection of the gesture, the system uses the distance [2]:

$$d = \sqrt{\{(x_2 - x_1)^2 + (y_2 - y_1)^2\}}$$

V. RESULTS AND DISCUSSIONS

The system was tested using a standard webcam in normal room lighting. The MediaPipe model successfully detected all 21 hand landmarks in real time, and the cursor followed the movement of the index finger smoothly. The pinch gesture performed the click action, the hand triggered scrolling. The gesture recognition worked consistently when the user maintained a proper distance from the camera (30–50 cm).

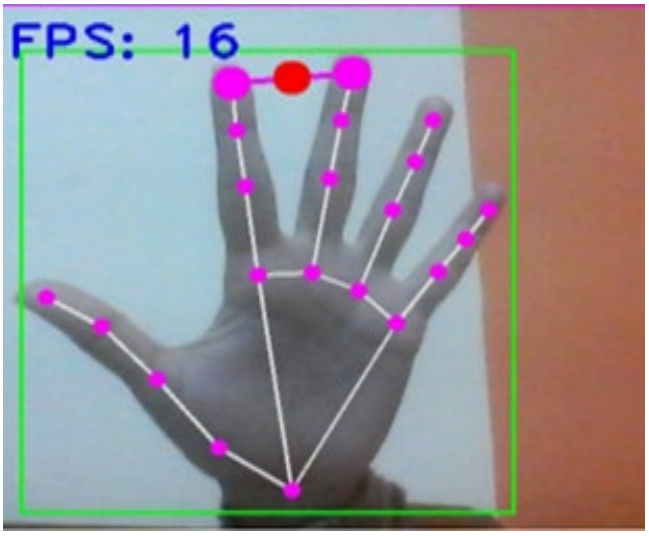

Fig. 2. Hand Land marks

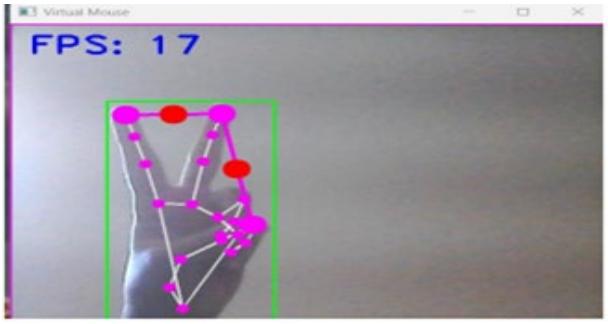

Fig. 3. Left click

Figure:3 illustrates the “Left Click” gesture, demonstrating how users can perform a mouse left-click using specific hand gesture.

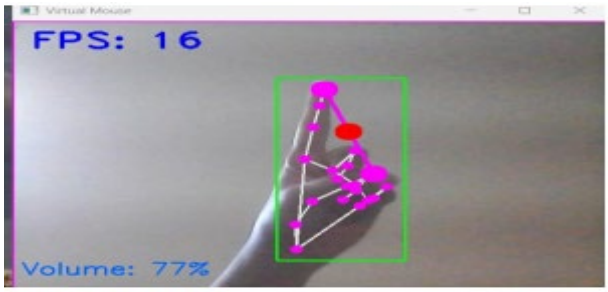

Fig. 4. Course movement

Figure:4 illustrates “Cursor Movement”, showing how users can move the mouse pointer across the screen through hand gestures. This allows for smooth, gesture-driven navigation in the virtual input system.

Fig. 5. Virtual Keyboard

Figure:5 illustrates when the thumb and index finger touch, that click gesture selects a key on the virtual keyboard, allowing the chosen character to appear in the notepad. This lets users enter letters, numbers and symbols using only simple pinch action. During testing, the system showed stable detection and responded quickly to gesture inputs. Cursor movement was smooth on plain backgrounds, and click gestures were detected correctly when the fingers were held clearly in front of the camera. The system performance decreased slightly in low-light conditions or when the hand moved too fast, which is expected in real-time computer vision setups. Overall, the results show that the system works reliably for basic mouse and keyboard actions using only live input. The results demonstrate that gesture-based virtual input can serve as a simple alternative to physical mouse and keyboard devices. The system is easy to use, cost-effective, and helpful for users who require touch-free interaction or have mobility limitations. However, the performance depends on lighting and background conditions, and complex gestures are not always detected accurately

VI. CONCLUSION

This project shows that basic mouse and keyboard actions can be controlled using simple hand gestures captured through a webcam. The system worked well for cursor movement, clicking, and showing a virtual keyboard in real time. Although it performs best in normal lighting and struggles with fast movements or poor backgrounds, it still provides a low-cost and touch-free alternative to physical input devices. With better gesture tracking and improved stability, the system can be made more accurate and useful for real-world applications.

FUTURE WORK

In the future, this system can be improved in several ways. One idea is to allow users to create their own custom gesture sets so the controls can match their personal needs and comfort. Another improvement would be to combine both the virtual mouse and keyboard functions into a single, unified platform for smoother and easier gesture-based interaction. The system can also be made better by increasing the accuracy of gesture recognition and reducing delay, so that the mouse and keyboard actions become more responsive and suitable for different applications.

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