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AI Virtual Mouse And Keyboard

Radhika Ravikrindi, P.Kavya Reddy, A.Bhanu Priya, G.Harshitha
[1]Assistant Professor,ECE Department Bhoj Reddy Engineering College for Women
[2,3,4]B. Tech Students, Department Of ECE, Bhoj Reddy Engineering College For Women, India.

ABSTRACT

The AI Virtual Mouse and Keyboard project introduces a groundbreaking touchless interface that leverages real-time hand gesture recognition to control mouse and keyboard functions without the need for physical devices. Utilizing a standard webcam, the system captures hand movements and processes them using advanced computer vision techniques and artificial intelligence. Built with Python, OpenCV, and MediaPipe, it tracks 21 hand landmarks to interpret gestures with high accuracy. The virtual mouse component enables smooth cursor movement, clicks, scrolling, and drag-and-drop actions, while the virtual keyboard detects finger positions over an on-screen layout, allowing users to type by simply gesturing in the air. This system is designed with both convenience and hygiene in mind, offering a contactless alternative to traditional input devices. It is particularly useful in environments where physical touch is impractical or undesirable, such as hospitals, public kiosks, and cleanroom settings. Moreover, it significantly enhances accessibility for individuals with physical disabilities by reducing reliance on conventional hardware. With customizable features, the system allows users to adjust gesture sensitivity, feedback options, and keyboard behavior, ensuring a personalized and inclusive experience.

1-INTRODUCTION

The evolution of human-computer interaction has seen dramatic transformations from early punch cards to modern touchscreens and voice commands. In this rapidly progressing digital age, the demand for contactless, intuitive, and accessible technologies is greater than ever. The AI Virtual Mouse and Keyboard System represents a significant advancement in this domain by offering a hands-free alternative to traditional input devices, utilizing real-time hand gesture recognition. Through the integration of advanced computer vision tools like MediaPipe, OpenCV, and AutoPy, this system captures and interprets hand gestures to perform essential computer functions such as typing, cursor movement, clicking, dragging, and even scrolling and zooming. This approach not only enhances user convenience but also addresses accessibility challenges for individuals with physical disabilities or in environments where touching hardware is impractical such as healthcare settings, clean rooms, or during multitasking.

By unifying both virtual mouse and keyboard functionalities into a single gesture-controlled interface, the system provides a seamless user experience without requiring any external hardware beyond a standard webcam. The AI Virtual Mouse allows users to control the cursor, perform left and right clicks, drag and drop, and scroll through intuitive hand gestures, while the AI Virtual Keyboard overlays an on-screen keyboard for gesture-based typing, complete with text prediction and auto-correction features. This dual-module design is a step toward creating more inclusive, efficient, and hygienic interaction models, especially in public or shared environments. The system demonstrates not only the practical application of artificial intelligence in enhancing usability but also opens pathways for future innovations in touchless computing, including potential integrations with voice commands, augmented reality, and cross-platform applications.

2-LITERATURE SURVEY

Recent advancements in human-computer interaction have explored gesture-based control as a natural and intuitive alternative to traditional input devices like keyboards and mice. Studies in computer vision and artificial intelligence have enabled accurate tracking of hand movements using standard webcams. Many existing systems have demonstrated single-function capabilities such as gesture-controlled cursors or virtual keyboards. However, these systems often suffer from limitations including poor accuracy, slow response times, and the inability to perform both mouse and keyboard operations in an integrated manner. Additionally, reliance on external hardware like infrared sensors or gloves has restricted their practical usability.

To overcome these limitations, the AI Virtual Keyboard and Mouse project combines real-time hand gesture recognition into a unified platform using tools such as MediaPipe, OpenCV, and AutoPy. This integrated system enables users to perform mouse actions like movement, clicks, and drag-and-drop, along with keyboard typing via on-screen interfaces, all through hand gestures. Unlike previous systems, it provides seamless switching between functions, intuitive feedback mechanisms, and high adaptability to various environments and users. By offering a touchless, responsive, and inclusive control method, the project significantly improves accessibility, especially for users with physical challenges, and opens the door for hands-free interaction in diverse settings such as healthcare, presentations, and smart environments.

The integration of AI-powered hand gesture systems into computing marks a significant leap toward more accessible and hygienic technology use. Prior efforts largely focused on either cursor control or typing simulation, but rarely both. The proposed system fills this gap by enabling full functionality users can navigate, click, scroll, zoom, and type using only hand gestures. With built-in features like word suggestions, autocorrect, gesture-based clicks, and multi-finger recognition, the system improves usability and reduces reliance on physical hardware.

Traditional gesture-based systems have typically addressed only one aspect of user interaction such as cursor control or virtual typing but not both. Your proposed system bridges this gap by offering a comprehensive, touchless interface that combines both mouse and keyboard functionalities into a single, seamless user experience.

With this system, users can perform essential actions like navigating, clicking (left and right), scrolling, zooming, and typing through simple hand gestures, tracked in real time using computer vision libraries like MediaPipe and OpenCV. The inclusion of intelligent features such as word suggestions, auto-correction, and multi-finger recognition enhances the system's usability and makes it suitable for diverse user groups, including those with physical impairments. It eliminates the need for physical contact with devices, making it ideal for sterile environments, public kiosks, and situations where hygiene or accessibility is a concern.

Additionally, the system's adaptability allows it to function in varied lighting and background conditions, and its reliance on just a standard webcam and basic computing resources ensures it remains cost-effective. By combining gesture-based control with intelligent typing assistance, this project not only replaces the mouse and keyboard but redefines them, laying the groundwork for the future of human-computer interaction.

3-HAND TRACKING AND GESTURE-BASED CONTROL

This chapter explains how users interact with the computer using gesture-based control for both mouse and keyboard functions. It highlights the differences between the existing systems and the proposed integrated solution

Existing System

Traditional human-computer interaction relies heavily on physical input devices such as the mouse and keyboard. While effective, these devices require direct contact and manual dexterity, which can be limiting for users with physical disabilities or in environments where hands-free operation is preferred. Virtual input alternatives have been developed, including systems that use basic hand tracking for either cursor movement or gesture-based typing. However, most of these solutions are isolated focusing solely on either virtual mouse control or virtual keyboard input, rather than offering a combined, comprehensive interface.

Existing virtual mouse systems typically allow for basic operations like cursor movement and clicking, but often suffer from low accuracy, limited gesture support, and lag in real-time responsiveness. Similarly, virtual keyboard systems rely on gesture recognition for key selection, yet frequently face issues like gesture misinterpretation, lack of predictive input, and poor adaptability to different users or environments. Moreover, these systems may require additional hardware like specialized gloves or infrared sensors, making them less practical for everyday use. Many existing systems struggle to maintain consistent performance across different environments due to sensitivity to lighting conditions, background noise, or variations in hand size and position. They often lack customization options such as gesture sensitivity adjustment or cursor speed control, which limits their adaptability for diverse users. In addition, the absence of real-time feedback mechanisms in many solutions makes interaction less intuitive and increases the learning curve. These limitations reduce the practicality of gesture-based systems for daily use, especially in professional or assistive contexts.

Overall, the lack of integration between gesture-based mouse and keyboard functionalities reduces the usability and efficiency of such systems. This fragmentation necessitates separate applications and switching mechanisms, which can hinder seamless user interaction.

Proposed System

The proposed system introduces a unified, AI-powered solution that enables complete hands-free interaction with a computer by combining both virtual mouse and keyboard functionalities through real-time hand gesture recognition. Using a standard webcam, the system captures live video input and processes it using advanced computer vision techniques with libraries like MediaPipe for hand tracking and OpenCV for image processing. Gestures such as finger movements, pinches, and hand shapes are interpreted to perform mouse actions (like moving the cursor, left/right clicks, drag-and-drop, and scrolling) and keyboard actions (like selecting keys, typing text, and using special functions like backspace, space, and enter).

To enhance the user experience, the system also includes word suggestions, auto-correction, and sound feedback during typing, providing an intuitive and efficient virtual typing experience. For mouse control, the system leverages AutoPy, which translates recognized gestures into precise cursor movements and click actions on the screen. The cursor is controlled based on the position and distance between specific finger landmarks, while gestures such as pinching or forming a fist are used to simulate clicking or dragging.

By integrating both functionalities into a single platform, the proposed system eliminates the need to switch between separate applications or devices. It is designed to be adaptive, working effectively across various lighting conditions and backgrounds, and includes customization options like zoom control and gesture sensitivity. This makes the system particularly beneficial for users with physical limitations, as well as in environments where touchless operation is preferred such as during presentations, in sterile medical settings, or for public interfaces..

Block Diagram

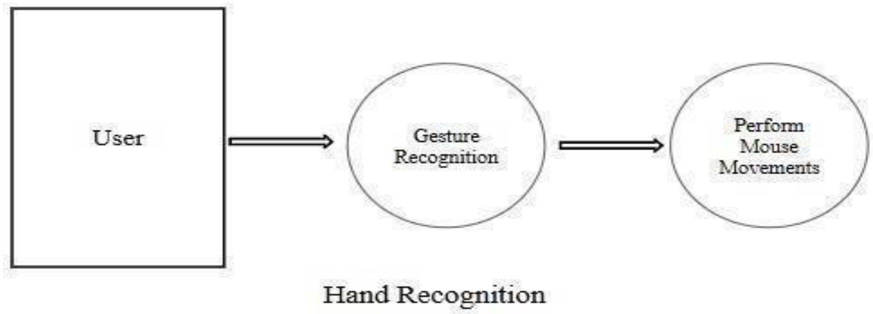


Fig 3.1: Hand Recognition of Mouse

4-SOFTWARE AND HARDWARE REQUIREMENTS

Software Requirements of Mouse and Keyboard

Software Components of Mouse:

The AI Virtual Keyboard and Mouse system requires several software tools for development and implementation. Key requirements include Python for coding the core logic, OpenCV for image processing and video capture, MediaPipe for accurate hand tracking, and AutoPy for executing mouse and keyboard commands. Additionally, a suitable IDE like PyCharm or VS Code is recommended for efficient code writing and debugging.

Programming Language: Python (for easy implementation of computer vision and AI libraries).

Libraries and Tools:

1. Mediapipe: For hand tracking and gesture recognition. Mediapipe is a cross platform framework developed by Google, designed for building pipelines to process multimodal media. Mediapipe is used for hand tracking and gesture recognition. It provides a pretrained hand tracking model that detects and tracks 21 hand landmarks, such as fingertips, knuckles, and wrists, with high precision. Mediapipe's hand tracking solution works efficiently by detecting the hand in real-time, even when the hand is partially obscured, and is robust to different hand poses and movement speeds. It provides both 2D and 3D hand landmark positions, which are critical for mapping hand gestures to corresponding actions like cursor movement and clicks.

2. OpenCV: For video frame processing and image handling. OpenCV (Open Source Computer Vision Library) is an open-source software library that provides a vast collection of computer vision algorithms. It enables the capturing, manipulation, and processing of video frames in real-time from a webcam .

3. Autopy: For performing mouse actions and screen control. Autopy is a Python automation library that allows you to simulate mouse actions and keyboard input on the screen. It is used in this

project to translate recognized hand gestures into real-time mouse and keyboard actions. Autopy allows the simulation of mouse movements, clicks, and keyboard presses, mimicking the functionality of a traditional mouse and keyboard. By integrating Autopy with gesture recognition, the system can respond to user hand gestures, like moving the hand to the left or right to move the cursor or making a fist to trigger a mouse click. It is highly useful for creating automated tasks or for hands-free control, making it an ideal choice for this virtual mouse system. Autopy also supports controlling the mouse position relative to the screen and simulating clicks at specific coordinates.

4. NumPy: For mathematical operations and coordinate mapping. NumPy is a powerful Python library used for mathematical operations and coordinate mapping. It provides efficient array handling and mathematical functions that are essential for performing operations on large datasets or arrays of data. In the context of the AI Virtual Mouse and Keyboard , NumPy is primarily used to handle and manipulate the coordinates of hand landmarks detected by Mediapipe.

5. IDE/Code Editor: Visual Studio Code, PyCharm, or Jupyter Notebook for writing and debugging code.For the development of the AI Virtual Keyboard and Mouse system, selecting an efficient IDE or code editor is crucial to ensure smooth coding, debugging, and project management. Visual Studio Code is a lightweight yet powerful code editor known for its extensive library of extensions, which support Python programming, code linting, debugging, and version control. PyCharm, a dedicated IDE for Python, provides advanced features like intelligent code completion, real-time error checking, and powerful debugging tools. It also supports virtual environments, making dependency management easier during the development process. Jupyter Notebook is an interactive web-based environment widely used in AI, data science, and computer vision projects. It offers a wide range of features that streamline the development process, including intelligent code completion, syntax highlighting, real-time error detection, and automatic code formatting.

Hardware Requirements

To effectively capture and interpret hand gestures, a combination of basic and recommended hardware specifications is required. The performance of the AI Virtual Mouse largely depends on the processing power, camera quality, and system memory.

1. **Webcam**

a. A standard webcam (either built-in or external) is essential for capturing hand gestures in real-time.

b. The camera should have at least a 720p resolution for clear and accurate gesture recognition.

c. Higher resolution cameras (e.g., 1080p or higher) can improve precision and tracking efficiency.

2. **Computer System Specifications**

The AI Virtual Mouse system requires a computer with the following minimum and recommended specifications:

a. Processor: A minimum Intel i3 or equivalent processor ensures basic functionality, while an Intel i5 or higher is recommended for better speed and performance.

b. RAM: Minimum 4GB RAM for standard performance; 8GB or higher recommended for smooth real-time gesture processing.

c. Storage: At least 500MB free space is required for installations, with additional storage needed for updates or expansions.

d. Monitor: A screen is needed to display cursor movements and virtual keyboard interactions, with higher refresh rates and resolutions enhancing the user experience.

e. **Input Devices** : A standard keyboard and mouse can be used as fallback input devices during testing or if gesture recognition fails.

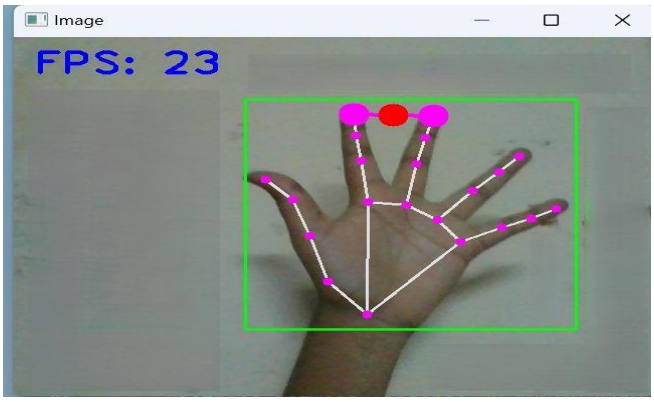
The AI Virtual Mouse system requires a combination of hardware and software components to ensure efficient and responsive operation. On the software side, it is developed using Python and relies on key libraries such as Mediapipe for hand tracking, OpenCV for image processing, Autopy for mouse actions, and NumPy for coordinate mapping. These libraries enable real-time gesture recognition and smooth cursor control. The system is compatible with Windows, macOS, and Linux, making it accessible across different platforms. For development, IDEs like Visual Studio Code or PyCharm are recommended due to their debugging tools and ease of use. On the hardware side, the system requires a standard webcam for capturing hand gestures and a computer with at least an Intel i3 processor, 4GB RAM (though 8GB is recommended for better performance), and minimal storage space of at least 500MB for software installations. A monitor is needed to display cursor movements

and virtual keyboard interactions, where higher refresh rates and resolutions can enhance user experience. Additionally, a standard keyboard and mouse serve as fallback input devices during testing or in cases where gesture recognition fails. These requirements collectively ensure smooth functionality, allowing users to interact with their systems through natural hand gestures without relying on traditional input devices.

5-RESULTS

The AI Virtual Mouse project leverages webcam input to capture live video, which serves as the foundation for recognizing gestures or objects. Using OpenCV, the system processes each video frame in real-time to identify specific hand movements, shapes, or objects that are mapped to corresponding mouse actions. This includes essential functions such as cursor movement, mouse clicks, and scrolling. By analyzing visual data through computer vision techniques, the system can

accurately interpret hand gestures and translate them into precise commands. This hands-free control method is particularly beneficial in scenarios where traditional input devices are inconvenient or inaccessible. Additionally, the system is designed to optimize performance by ensuring minimal delay during video processing, enabling smooth and responsive interaction. This innovative approach enhances accessibility, providing users with a seamless and intuitive way to interact with their computers.Using Autopy, the system triggers virtual mouse actions like movement



(autopy.mouse.move()) and clicks (autopy.mouse.click()), based on the recognized gestures or objects.

Fig 1 : Hand Detection

Using Autopy, the system triggers virtual mouse actions like movement (autopy.mouse.move()) and clicks (autopy.mouse.click()), based on the recognized gestures or objects. The project should be set up in PyCharm, with the correct Python interpreter and required libraries (OpenCV, Autopy) installed, allowing the system to process real-time video and simulate mouse behavior without noticeable lag. The final result is an interactive system where the user can control the mouse cursor and interact with applications via hand gestures or object tracking, providing a hands-free way to navigate the computer. Use OpenCV to capture video from the webcam and process each frame, enabling gesture or object tracking to control the mouse. At the core of this system is OpenCV, which is used to continuously capture video frames from the webcam.

Once the gesture is interpreted, the system maps it to a corresponding mouse function using libraries like AutoPy or PyAutoGUI. This integration of computer vision and gesture recognition results in a smooth and responsive user experience, transforming natural hand movements into virtual mouse commands. In addition to basic gesture recognition and object tracking, the AI Virtual Mouse system involves a well-defined gesture processing pipeline that ensures high accuracy and real-time responsiveness. After capturing frames through the webcam, each frame is preprocessed such as resizing or converting color spaces to enhance detection reliability before being passed to the landmark detection model. MediaPipe, for instance, detects 21 specific points on the hand, and these landmarks are used to identify key gestures. This enables the system to distinguish between movements like finger pinches, swipes, and holds, which can then be mapped to mouse functions such as click, drag, or scroll. The flexibility in recognizing dynamic finger positions makes the system highly versatile and adaptable.

Furthermore, to ensure smooth and natural cursor movement, the system translates hand positions from the video frame to screen coordinates using interpolation techniques. This mapping is fine-tuned with smoothing algorithms such as exponential moving averages to eliminate jitter caused by small unintentional hand movements. As a result, users experience fluid control that closely mimics traditional mouse behavior. The system also includes logic to identify and differentiate between single-clicks, long-clicks (for dragging), and other continuous gestures, enabling a wide range of interactive operations. These capabilities make the system not just functional but highly usable in real-world scenarios.

Beyond technical implementation, the virtual mouse system is designed with practical applications in mind. It proves especially useful in hygiene-sensitive environments like hospitals or laboratories, where touchless interaction is preferred. Additionally, it offers accessibility for users with mobility impairments by reducing the reliance on physical input devices. The system is further enhanced by allowing configuration of gesture sensitivity, screen boundaries, and recognition thresholds, making it adaptable to different user preferences, lighting conditions, and camera angles. This holistic approach combining computer vision, gesture control, and user-centered design marks a significant advancement in the field of human-computer interaction. For mouse movement, integrate Autopy to move the cursor or simulate clicks based on detected gestures. Performance optimization is crucial for real-time processing, so consider reducing the resolution of the video feed for faster computation. Finally, test the system by simulating gestures and ensuring smooth mouse control, adjusting the algorithm as needed to minimize lag and improve responsiveness.

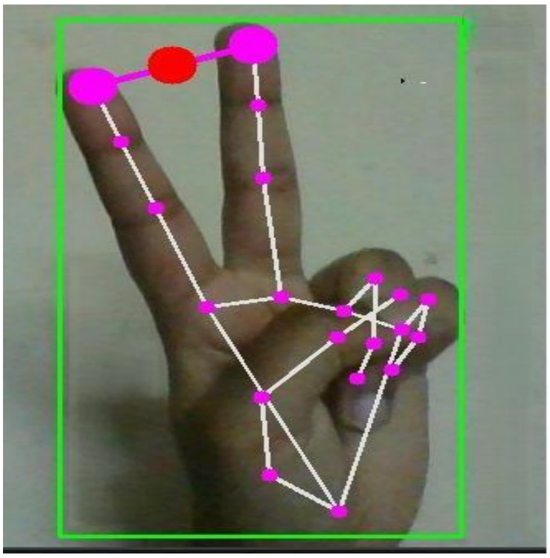


Fig 2 : Detection of Fingers

The project is designed to run in PyCharm, with the appropriate Python interpreter and essential libraries like OpenCV and AutoPy installed. This setup enables real-time video processing and smooth mouse control without noticeable delay. The system captures video from the webcam using OpenCV, processes each frame, and identifies gestures or object movements to manage mouse actions. For cursor movement and clicks, AutoPy is integrated to translate detected gestures into corresponding mouse commands. To ensure optimal performance, reducing the video feed resolution can improve processing speed. Thorough testing is essential to refine the system, ensuring accurate gesture recognition, minimal lag, and smooth cursor control for an enhanced user experience. By setting up the correct Python interpreter and installing essential libraries such as OpenCV for image processing and AutoPy for simulating mouse movements, the development environment is optimized for smooth execution. OpenCV continuously captures video frames from the webcam, enabling gesture or object recognition within each frame. AutoPy then takes the processed input and translates recognized gestures like finger movements or object positions into actionable mouse events such as cursor movement, left/right clicks, and drag operations. This seamless integration between gesture detection and system control creates a hands-free interface that is both functional and user-friendly.

To ensure efficient real-time performance, developers can reduce the resolution of the captured video feed, which decreases the computational load and accelerates frame processing. Lower resolution helps maintain responsiveness, especially on systems with limited hardware capabilities.

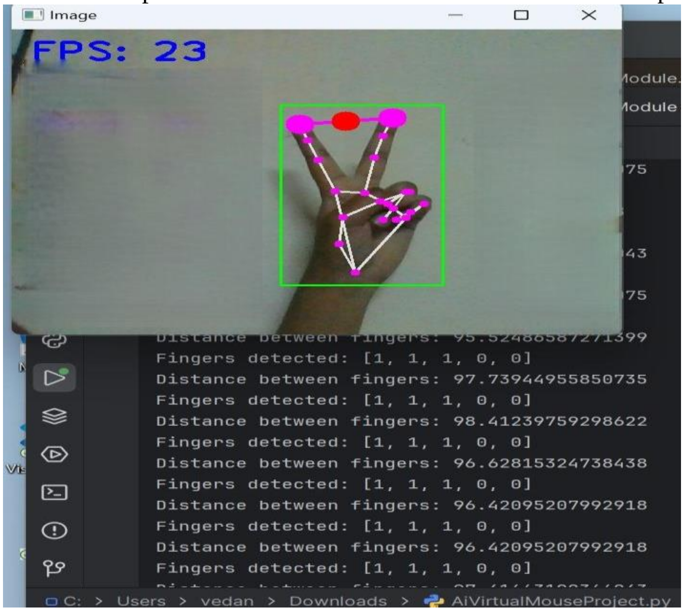


Fig 3 : Movement of Fingers

Additionally, consistent and thorough testing is vital to fine-tune gesture thresholds, detection sensitivity, and response timing. This iterative process helps eliminate lag, improve gesture accuracy, and ensure the cursor responds fluidly to user movements. Such refinement is critical to delivering an intuitive user experience, especially in environments where traditional input methods are impractical or undesirable. The final outcome of the system is a fully interactive, hands-free interface where users can control the mouse cursor and interact with various applications using only hand gestures or object tracking.

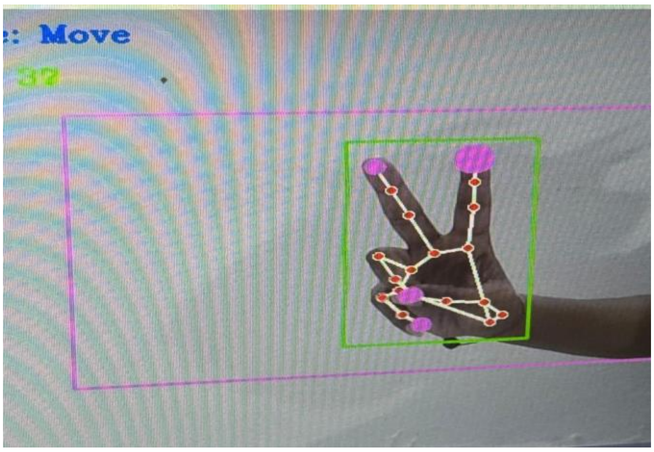


Fig 4 : Cursor Path Tracking

This image shows the "Move" mode of the Advanced Virtual Mouse system, where the user controls the cursor movement using a two-finger gesture (index and middle fingers raised). MediaPipe detects and tracks the hand landmarks in real time, highlighting the fingertips and connecting them with visual markers. The system calculates the midpoint between the two raised fingers to determine the cursor's position, allowing the cursor to move as the user moves their hand. The green box indicates active hand tracking, enabling smooth, hands-free navigation across the screen.

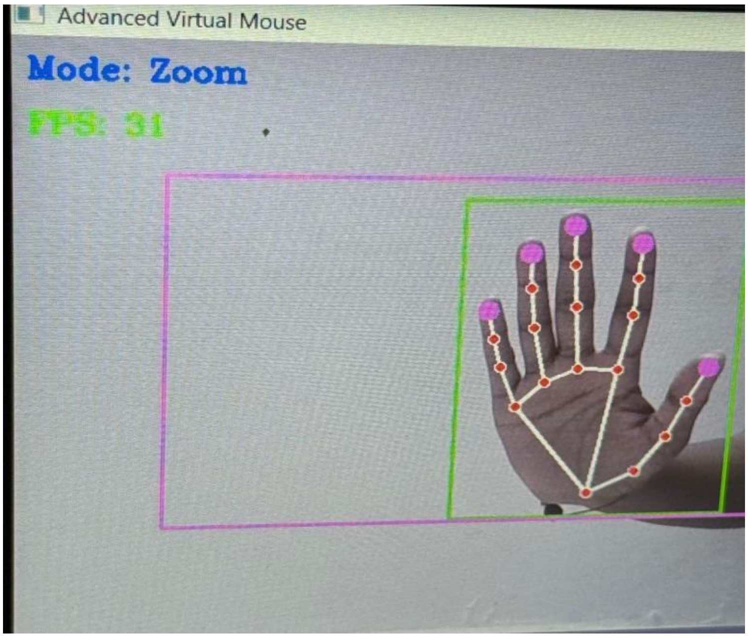


Fig 5 : Zoom Mode

This image shows the "Zoom" mode of the Advanced Virtual Mouse system, activated when all five fingers are extended. MediaPipe tracks the hand using landmarks, and vertical hand movement controls zooming upward for zoom-in (Ctrl +) and downward for zoom-out (Ctrl -). A cooldown mechanism ensures smooth, controlled operation, making this feature ideal for touch-free zooming in tasks like presentations or image editing.

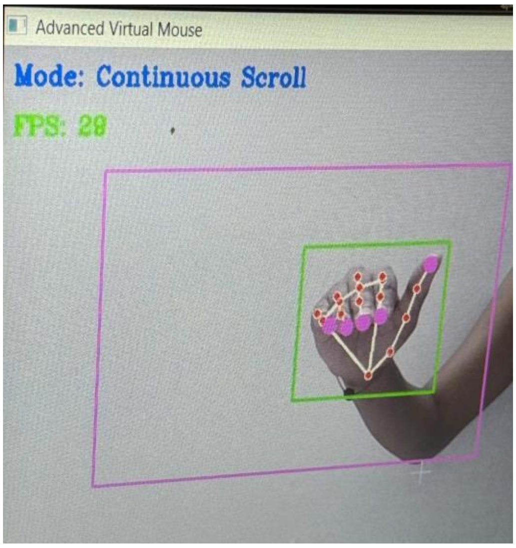


Fig 6 : Continuous Scroll

This image displays the "Continuous Scroll" mode of the Advanced Virtual Mouse system. In this mode, the system detects a gesture where four fingers are held up, which activates continuous scrolling. Using

MediaPipe, the hand landmarks are identified and tracked in real-time. The system calculates the vertical movement distance of the hand to determine the scrolling speed the greater the movement, the faster the scroll. This mode allows users to scroll through long pages smoothly and intuitively, without using a physical scroll wheel or touchpad.

In the continuous scroll mode, the system activates when four fingers are held up . The scroll direction and speed are controlled by the vertical movement of the hand upward motion scrolls up, and downward motion scrolls down. The scrolling speed adjusts dynamically based on how far the hand moves, providing smooth and responsive hands-free navigation.

6-CONCLUSION

The AI Virtual Mouse and Keyboard system represents a significant advancement in the field of human-computer interaction by replacing traditional input devices with a seamless, gesture-based interface. By utilizing powerful computer vision technologies such as MediaPipe, OpenCV, NumPy, and AutoPy, the system enables users to control both the mouse and keyboard through natural hand gestures in real time. This innovative solution not only mimics traditional input functions but also offers a touchless, intuitive, and accessible alternative that benefits users across a wide range of applications and environments.

The integration of gesture-based typing and mouse control opens up new possibilities, especially for individuals with physical disabilities or mobility challenges who may struggle with standard hardware. The AI Virtual Keyboard supports typing, special key functions, word suggestions, and audio feedback, while the AI Virtual Mouse enables pointer movement, clicks, scrolling, and zooming. These features provide a hands-free and hygienic experience, making the system ideal for use in healthcare, education, smart homes, public kiosks, and more. With a focus on accuracy, speed, and responsiveness, the system delivers a reliable and user-friendly experience.

Looking forward, the project holds enormous potential for growth and adaptation. Future enhancements such as multi-hand support, additional gestures, voice command integration, and cross-platform compatibility will further expand the system's versatility and usability. Integration with AR/VR technologies can make the system suitable for immersive applications in design, gaming, and remote collaboration. As the system continues to evolve, it aims to become an indispensable tool for inclusive, efficient, and modern digital interaction, transforming how people of all abilities engage with their devices and digital environments. The AI Virtual Mouse and Keyboard system not only promotes accessibility and innovation, but also aligns with growing global needs for touchless technology, particularly in the post-pandemic world where hygiene and minimal contact have become priorities. By eliminating the dependence on physical input devices, this system supports cleaner, safer interaction—especially in shared, public, or sterile environments such as hospitals, libraries, and educational institutions. Its customizable nature allows users to adapt gestures according to their comfort, making it highly versatile for diverse user groups.

Moreover, the system is designed to be lightweight and cost-effective, using only a standard webcam and basic computing hardware, making it suitable even in low-resource settings.

As machine learning and computer vision continue to advance, this project has the potential to integrate adaptive gesture learning, user-specific gesture profiles, and cloud-based gesture training, pushing the boundaries of personalized and intelligent interaction. With its strong foundation and expanding possibilities, the AI Virtual Mouse and Keyboard system stands as a forward-thinking solution for the future of digital communication and interaction.

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