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Virtual Mouse using MediaPipe

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ABSTRACT: The Virtual Mouse using MediaPipe is a gesture-based human-computer interaction system that replaces the traditional physical mouse with a contactless, intuitive interface. Leveraging the capabilities of Google's MediaPipe framework and a standard webcam, this system tracks hand gestures in real-time to control cursor movement and simulate mouse clicks. The project addresses the need for hygienic, accessible, and hardware-independent interaction, especially in post-pandemic scenarios and for individuals with physical disabilities. The system is designed to be low-cost, cross-platform, and scalable, utilizing open-source tools like OpenCV and PyAutoGUI. It provides real-time performance with minimal latency, requiring only basic hardware resources. This virtual mouse has significant applications in education, healthcare, public kiosks, and hands-free environments.

KEYWORDS: Virtual Mouse, Gesture Recognition, MediaPipe, Hand Tracking, Human- Computer Interaction (HCI), Contactless Control, OpenCV, PyAutoGUI, Real-Time Processing, Accessibility, Post-Pandemic Technology, Webcam-Based Interaction.

I. INTRODUCTION

A mouse is referred to as a pointing device in computer nomenclature, using two- dimensional movements in reference to a floor. This movement is converted into pointer motions on a display, making it possible to control the GUI of a computer platform. In the modern era, there have been several distinct types of mouses like mechanical mouse, which moves by using a sturdy rubber ball that rotates when the mouse is moved. After that, an LED sensor was developed to replace the rubber ball in the mouse with a hard exterior that could detect movement on the table and transfer data to a computer for processing. The laser mouse was subsequently launched in 2004 to solve the short comings of the optical mouse, which include challenges in tracking highly reflective surfaces and to improve motion accuracy with the tiniest hand motion. Despite its accuracy, the mouse nevertheless has limitations in terms of both its physical capabilities and its technical capabilities. For instance, a laptop mouse is a consumable piece of hardware since it eventually needs to be replaced either because the mouse buttons have worn out and now make worthless clicks or because the laptop no longer recognizes the mouse as a whole. Interactions between people and computers are crucial. Despite the limitations of laptop technology, it is expanding. Given the development of a touch- screen mobile device, the market is starting to demand the adoption of the same technology across all platforms, including desktop machines.

II. SYSTEM MODEL AND ASSUMPTIONS

System Model:

1. Utilizes a standard webcam to capture hand gestures.
2. Employs MediaPipe for real-time hand tracking, detecting 21 key landmarks per hand.
3. Maps hand landmarks to screen coordinates to control cursor movement.
4. Uses PyAutoGUI to simulate mouse events such as clicks and drags.
5. System designed to run on standard consumer hardware (minimum Intel Core i3, 4 GB RAM) across platforms (Windows, Linux, macOS).

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Assumptions:

1. User operates within a well-lit environment for accurate hand tracking.
2. Single-hand tracking is used for cursor control.
3. Users can maintain hand positions within the webcam's field of view.
4. Background should be reasonably uncluttered to ensure detection accuracy.
5. Users will calibrate the system to map hand gestures accurately to screen coordinates

III. PROPOSED METHODOLOGY

The proposed methodology for the Virtual Mouse system involves capturing real-time video frames using OpenCV. MediaPipe is used to detect the presence of the hand and extract 21 key hand landmarks for tracking. The system recognizes specific gestures such as an extended index finger for cursor movement and a pinch gesture for mouse clicks. Coordinate mapping techniques convert the webcam frame coordinates to screen coordinates with proper scaling and smoothing for accuracy. PyAutoGUI is used to simulate OS-level mouse actions based on the detected gestures. The system continuously loops in real-time, processing hand gestures until the program is terminated.

IV. SCOPE OF THE PROJECT

The project focuses on single-hand detection and tracking to control the cursor without the need for physical contact. It supports basic mouse functionalities like cursor movement and left- clicking through a simple pinch gesture. The system is compatible with standard webcams and does not require additional hardware calibration. Visual feedback is provided on-screen, displaying hand landmarks and recognized gestures for user reference. The project ensures cross-platform support and is fully developed using open-source Python libraries. This design makes the system accessible, low-cost, and easy to deploy across various devices.

V. ALGORITHM

The main steps of the algorithm:
Step 1: Start the webcam and begin frame capture.
Step 2: Preprocess frames (resize, mirror, color conversion).
Step 3: Detect hands using MediaPipe and extract hand landmarks. Step 4: Identify gestures - Index finger controls cursor position , pinch gesture (index and thumb tips close) triggers click.
Step 5: Map hand coordinates to screen coordinates.
Step 6: Use PyAutoGUI to move the cursor and simulate clicks.
Step 7: Provide visual feedback on the frame (landmarks and gesture status).
Step 8: Loop continuously for real-time operation.

VI. PERFORMANCE

The system consistently achieves frame rates between 30–60 frames per second (FPS) when running on standard consumer hardware. It operates efficiently on both laptops and desktops without requiring GPU acceleration, which keeps the system cost-effective. Real-time gesture recognition is handled smoothly, providing a responsive and natural user experience. However, performance may degrade in environments with poor lighting or when using low-quality webcams. Despite this, the system maintains low latency and high responsiveness under optimal conditions. Overall, the system is lightweight and capable of real-time processing for practical everyday use.

VII. RESULT AND DISCUSSION

The virtual mouse system successfully controls the cursor using hand gestures, with reliable performance for both movement and clicking through pinch gestures. Real-time responsiveness is maintained with minimal delays when appropriate lighting and hardware are available. Some challenges include reduced performance in low-light conditions, cluttered backgrounds, or when using lower-end cameras. Continuous use of hand gestures may also lead to user fatigue over time. The system is cross-platform compatible, successfully tested on Windows, Linux, and macOS operating systems. Although basic features work well, more advanced technique like application can be in updates.

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VIII. SCREENSHOTS

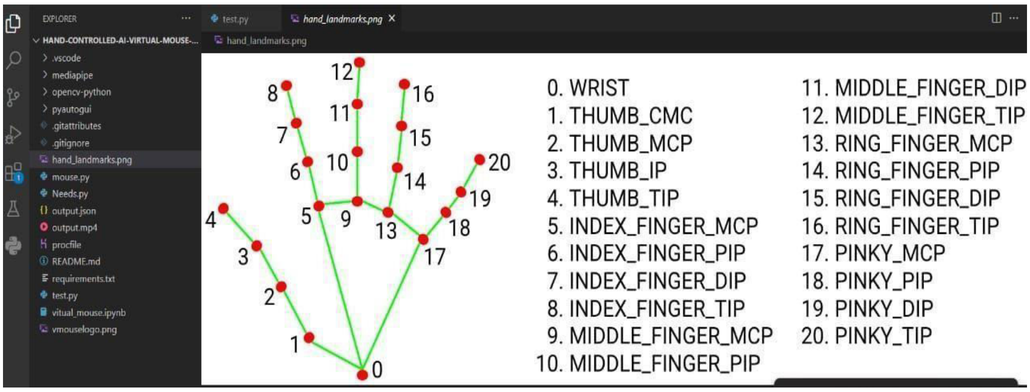

Figure 1: Mediapipe Hand Marks

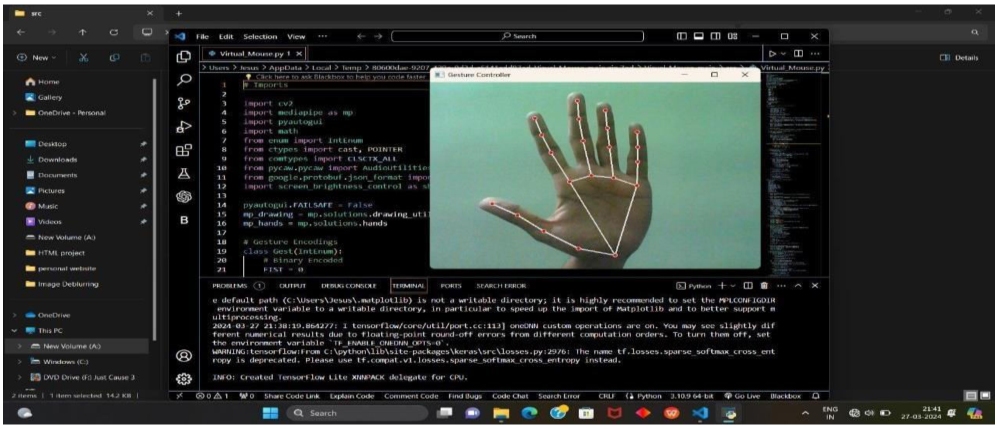

Figure 2: Capturing the hand

Figure 3: Left click

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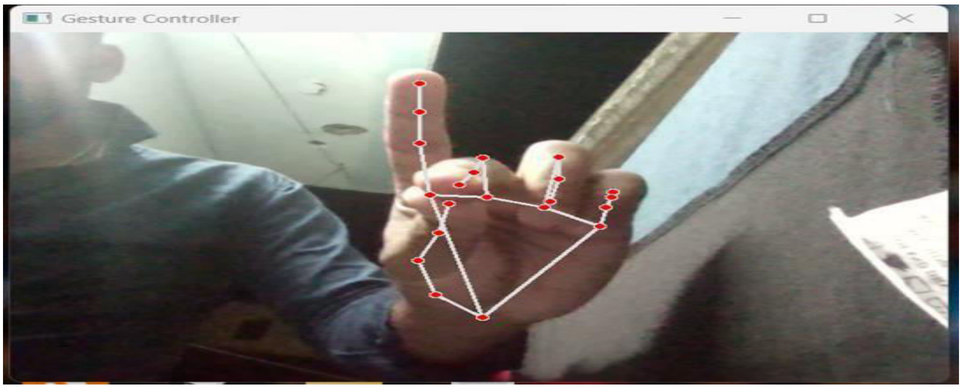

Figure 4: Right click

IX. CONCLUSION

The Virtual Mouse using MediaPipe project successfully demonstrates the feasibility and effectiveness of using hand gestures as a natural interface for controlling a computer cursor without physical contact. By integrating MediaPipe's state-of-the-art hand tracking capabilities with Python's OpenCV and PyAutoGUI libraries, the system provides real-time detection, interpretation, and execution of mouse control gestures such as cursor movement, left-click, and right-click. This touchless technology not only offers convenience but also presents important benefits in hygiene and accessibility, especially in environments where minimizing physical contact with devices is critical, such as hospitals and public kiosks.Throughout the development and testing phases, the project encountered challenges related to environmental conditions like varying lighting, background complexity, and differences in users' hand shapes and gestures. However, these were systematically addressed through careful calibration, optimized gesture recognition algorithms, and performance tuning to reduce latency. The modular design of the system also allowed for efficient debugging and incremental improvements. The Virtual Mouse using MediaPipe project has successfully showcased the ability to replace traditional physical mouse devices with an innovative, touchless interface controlled by natural hand gestures. By utilizing MediaPipe's robust hand tracking capabilities and integrating them with Python libraries such as OpenCV and PyAutoGUI, the system achieved real-time, accurate cursor control and mouse actions.

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