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AI VIRTUAL MOUSE

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ABSTRACT

This paper presents an AI-driven virtual mouse system that leverages real-time hand gesture recognition to control mouse functions, eliminating the need for traditional input devices such as a physical mouse or touchpad. The system employs computer vision techniques to detect and track hand and fingertip movements using a standard webcam, enabling an intuitive and contactless human-computer interaction (HCI) experience.

The proposed model is developed using Python and integrates OpenCV for image processing and the MediaPipe framework for robust hand tracking. By recognizing various hand gestures, the system enables seamless control of essential mouse operations, including cursor movement, left-click, right- click, and scrolling. The system's ability to function using only a webcam enhances accessibility and usability, making it a practical alternative for individuals with mobility impairments and those seeking touchless interaction solutions.

I. INTRODUCTION

With advancements in augmented reality and the increasing integration of wireless and Bluetooth technologies into everyday devices, the need for compact and efficient input systems is growing. This paper presents an AI-based virtual mouse system that leverages hand gesture recognition and fingertip detection to perform computer mouse operations using computer vision. The primary goal of this system is to enable cursor control and scrolling functions through a built-in or external web camera, eliminating the need for a traditional physical mouse.

By utilizing hand gestures as a Human-Computer Interaction (HCI) mechanism, this approach allows users to navigate and control their computer with ease. The AI virtual mouse system captures hand movements through a camera, processes the visual data, and translates it into cursor movements and commands in real-time. Unlike conventional wireless or Bluetooth mice that require additional hardware such as a dongle, batteries, or charging, this system relies solely on a camera, making it a cost-effective and user-friendly alternative. The proposed system efficiently processes image frames without requiring GPU acceleration, ensuring smooth operation on standard CPUs.

This makes the solution lightweight and adaptable, delivering consistent performance based on camera clarity. As long as the computer is powered on, the system remains active, continuously detecting and responding to fingertip movements to execute the corresponding mouse functions.

1.1 Problem Description and Overview Traditional computer mice and touchpads require physical interaction, which can be inconvenient in certain scenarios, such as limited workspace, mobility impairments, or hygienesensitive environments like hospitals and shared offices. The AI Virtual Mouse aims to replace conventional input devices by enabling hands-free, gesture-based control using a webcam.

This system utilizes computer vision techniques, specifically OpenCV and MediaPipe, to track hand gestures in real time and map them to mouse functions like cursor movement, clicking, and scrolling. By eliminating physical contact, it enhances accessibility, hygiene, and ease of use.

1.2 Objective

The objective of the AI Virtual Mouse system is to develop a touchless, gesturebased alternative to traditional mouse devices using computer vision. By leveraging a webcam, OpenCV, and MediaPipe, the system detects hand gestures to perform cursor movement, clicking, and scrolling functions. This enhances accessibility, hygiene, and convenience making human- computer interaction more intuitive.

COMPONENTS

The components involved in this project cannot be specified in detail, as this work serves as a general example

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applicable to all computer systems. So, for positive The requirements are as follows:

Hardware requirement:

Webcam

To capture images, a webcam is essential. The accuracy of mouse control depends on the camera's resolution and clarity. Higher camera configurations ensure better user experience and responsiveness. The webcam continuously captures real-time images whenever the computer is active, enabling smooth interaction. The system intelligently detects and interprets finger and hand movements, translating them into corresponding mouse actions for precise and efficient control.

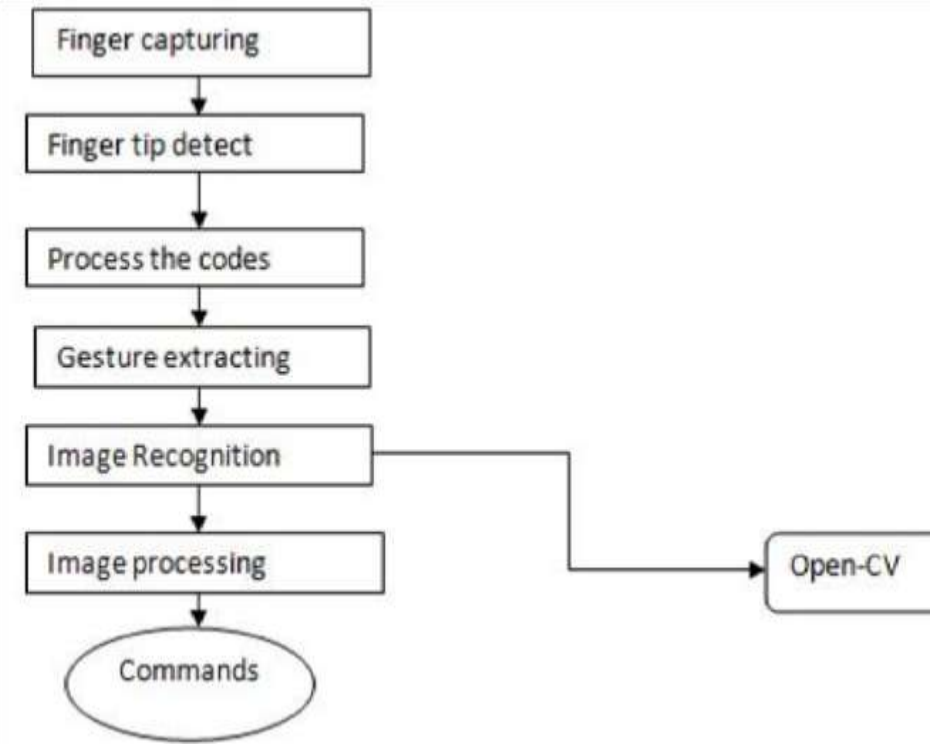
Software Requirement

OpenCV

OpenCV is a powerful open-source library for computer vision, image processing, and machine learning, playing a crucial role in modern systems. Its real-time performance capabilities are essential for processing images and videos efficiently. By utilizing OpenCV, the system can analyze and interpret visual data, such as objects, faces, and even handwritten text, making it a key tool for developing advanced computer vision applications.

II. METHODOLOGY

Within the methodology, the technique utilized in every issue of the system might be defined one at a time. They are the following subsections:



A. Camera Used in the Virtual Gesture Mouse project

OpenCV, a powerful Python library for computer vision, is essential for the AI virtual mouse system. It processes real-time images from a camera, handling both color (RGB) and grayscale formats, where pixel values range from 0 (black) to 255 (white). Additionally, binary images, consisting of only black and white (0 or 1), enhance object detection and gesture recognition. This enables accurate fingertip tracking, allowing seamless computer interaction without the need for a physical mouse..

B. Moving Hand through the Window using Rectangular Area

The AI virtual mouse system employs an algorithm to map the fingertip coordinates from the camera feed to the computer screen. When a hand is detected, the system analyzes which finger is raised to execute specific mouse functions. A designated rectangular region on the screen aligns with the camera's field of view, enabling users to control the cursor by adjusting hand movements. This approach ensures smooth and accurate pointer

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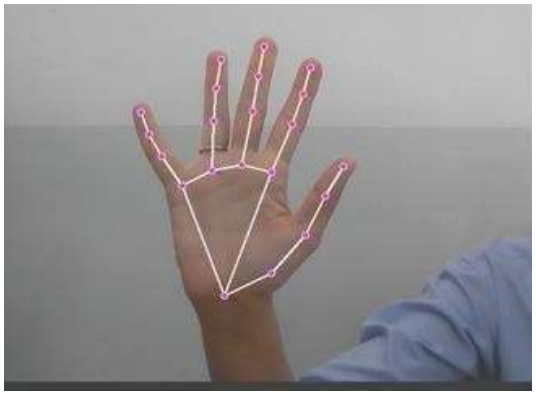
navigation, allowing seamless interaction without the need for a traditional mouse. as displayed fig.

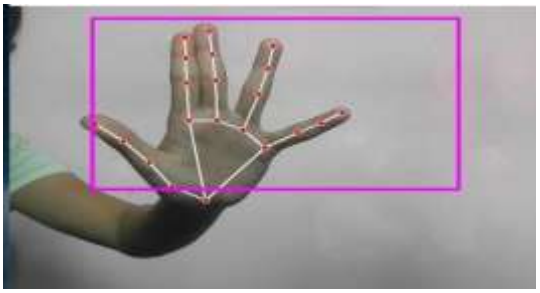


C. For the Mouse to Perform Left Button Click.

When both the index finger (tip ID = 1) and the thumb (tip ID = 0) are raised, and the distance between their tips is less than 30px, the system triggers a left mouse click. This simulates the action of pressing the left mouse button.

D. For the Mouse to Perform Double Click

If the When the index finger (tip ID = 1) and middle finger (tip ID = 2) are raised with a distance of less than 40px between them, while other fingers remain upward but with a distance greater than 40px, the system triggers a double-click action. This simulates the function of a double mouse click.



E. For the Mouse to Perform Right Button Click

When the index finger (tip ID = 1) and thumb (tip ID = 0) are raised with a distance greater than 40px between them, and the other fingers are pointed downward, the system triggers a right-click action, simulating the function of the right mouse button.

F. For the Mouse to Perform Scroll up Function

When both the index finger (tip ID = 1) and middle finger (tip ID = 2) are raised with a distance of less than

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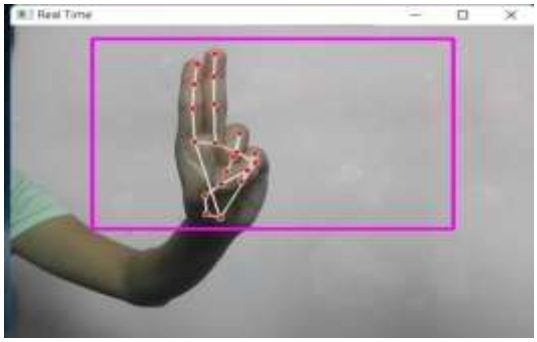
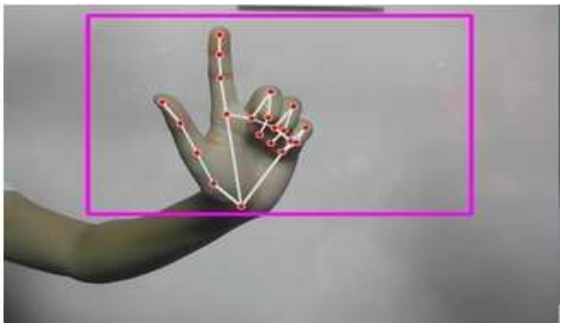
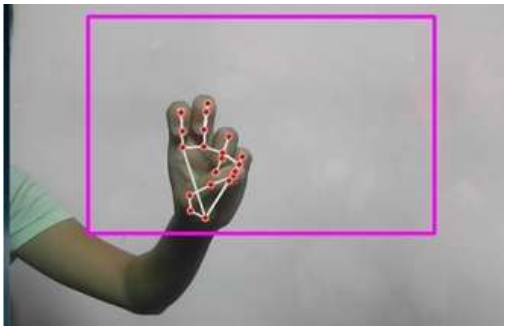
40px between them, and the fingers are moved upward, the system triggers the scroll-up function, simulating the action of scrolling up on the computer screen.



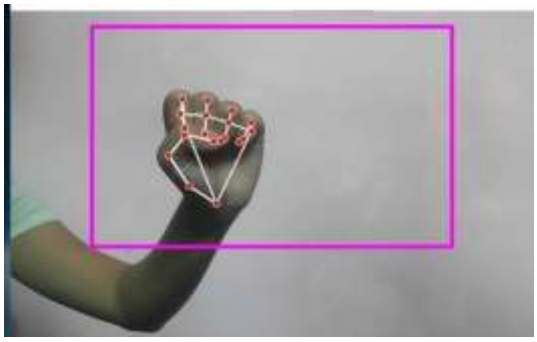
For the Mouse to Perform Scroll down Function When both the index finger (tip ID = 1) and middle finger (tip ID = 2) are pointing downward with a distance of less than 40px between them, and the fingers are moved downward, the system triggers the scroll-down function, simulating the action of scrolling down on the computer screen.





G. To Perform Refresh Function

When all fingers are pointed downward and the wrist movement is detected, with the fingers bending and then opening, this wrist gesture triggers the refresh function, simulating the action of refreshing the computer screen.



III. APPLICATIONS

The AI virtual mouse system has a wide range of applications. It helps reduce the need for physical mouse devices and can be used in situations where traditional mice are impractical or unavailable. By eliminating the reliance on physical input devices, the system enhances human computer interaction, offering a more flexible and efficient ways. Major applications:

1. **Hygiene-sensitive environments:** Enables hands-free computer interaction in hospitals and shared workspaces.
2. **Assistive technology:** Supports users with mobility impairments, allowing them to navigate a computer interface effortlessly.
3. **Touchless computing:** Enhances the overall user experience by providing an intuitive and interactive alternative to traditional mice.

IV. FUTURE SCOPE

The proposed AI virtual mouse system has some limitations, such as a slight reduction in accuracy for right-click functionality and challenges with clickand- drag operations for text selection. These limitations will be addressed through future enhancements. Additionally, the system can be expanded to support virtual keyboard functionalities alongside mouse controls, which would further improve the user experience. By incorporating both mouse and keyboard functionalities, the system would offer a more comprehensive and accessible solution for HumanComputer Interaction (HCI), providing greater flexibility and usability across a variety of applications and environments.

V. CONCLUSION

The primary goal of the AI virtual mouse system is to replace the traditional physical mouse with hand gestures, providing a more intuitive and touchless method of controlling mouse functions. The system utilizes a webcam or built-in camera to detect hand gestures and fingertip movements, processing these frames to execute specific mouse actions such as cursor movement, clicks, and scrolling. The model has demonstrated exceptional performance, achieving accuracy levels of 99%, surpassing existing virtual mouse systems in precision and reliability. This high accuracy makes the AI virtual mouse system an ideal solution for real-world applications, including environments where traditional input devices may not be practical or hygienic. For instance, it offers a touchless interaction method, contributing to reducing the risk of transmitting viruses like COVID-19, as users can control the mouse using gestures without physically touching any device.

While the system performs well overall, it does have some limitations. A slight decrease in accuracy for the right-click function and challenges with clicking and dragging to select text have been observed. These areas will be addressed in future work, where we aim to enhance the fingertip detection algorithm and improve the system's overall functionality. The goal is to refine the AI virtual mouse further, ensuring it meets the needs of diverse users and applications while providing a seamless, hands-free experience.

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