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VIRTUAL MOUSE USING HANDS GESTURES

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Abstract—In this research paper, we present a pioneering system for gesture-based control of a virtual mouse using computer vision and machine learning techniques. The system leverages the capabilities of the MediaPipe library and OpenCV to accurately detect and track hand gestures in real-time through a standard webcam. The virtual mouse controller, implemented in Python, interprets the hand gesturesto enable intuitive and natural interaction with the computer.

Our approach includes the detection and tracking of multiple hand landmarks, allowing for precise mapping of hand movements and finger positions. The system recognizes various gestures, such as right swipe, left swipe, screenshots, left and right clicks, double-clicks, scrolling, zooming, and dragging, enhancing the user experience in virtual environments. The gestures are translated into corresponding mouse actions using the PyAutoGUI library, enabling seamless integration with existing applications.

The gesture control system is characterized by its adaptability to diverse hand gestures and robust performance in different lighting conditions. The controller's functionality encompasses right swipe, left swipe, screenshots, cursor movement, scrolling, zooming in and out, left and right clicking, double-clicking, and dragging. Additionally, the system introduces a dynamic and responsive cursor movement algorithm, enhancing user control and precision.

Our research contributes to the evolving field of human-computer interaction by providing an innovative and practical solution for hands-free computer control. The gesture-controlled virtual mouse offers potential applications in various domains, including accessibility technology, virtual reality, and interactive presentations. The paper concludes with a discussion of potential future enhancements andextensions, emphasizing the system's versatility and its impact on the evolution of intuitive human-computer interfaces.

Keywords—Computer Vision, Machine Learning, Mediapipe, OpenCV, PyAutoGUI, Hand Tracking, Flask

INTRODUCTION

The landscape of human-computer interaction (HCI) hasundergone a transformative shift towards more intuitive interfaces, with gesture-based control systems standing out as a promising avenue. Our research introduces a pioneering approach to HCI through the development of a virtual mouse controlled by gestures.

At the heart of our system is the integration of computer vision and machine learning technologies, specifically making use of the MediaPipe library and OpenCV. These tools empower real-time detection and tracking of hand gestures through a standard webcam, providing users with a hands-free and immersive computing experience.

Implemented in Python, the virtual mouse controller interprets intricate hand movements, translating them into a variety of computer actions. Going beyond standard hand tracking, our system recognizes multiple hand landmarks, facilitating precise mapping of finger positions. This level of detail allows for the identification of diverse gestures, including right swipe, left swipe, screenshots, left and right clicks, double-clicks, scrolling, zooming, and dragging.

A notable feature of our approach is its adaptability to various hand gestures and its robust performance under different lighting conditions. The system's capabilities include right swipe, left swipe, screenshots, cursor movement, scrolling, zooming in and out, left and right clicking, double-clicking, and dragging. Additionally, a dynamic and responsive cursor movement algorithm enhances user control and precision.

This research paper aims to contribute to the evolving field of HCI by presenting an innovative and practical solution for hands-free computer control. The gesture-controlled virtual mouse not only opens new possibilities for accessibility technology but also finds applications in virtual reality interactions and interactive presentations. The paper concludes with a discussion on potential future enhancements, emphasizing the system's versatility and its impact on advancing intuitive human-computer interfaces.

I. LITERATURE REVIEW

[1] This research focuses on creating virtual mouse usingcomputer vision which delivers good results in hand gestures but yet has some less features and not so accurate results.

[2] This review focuses on the development of a hardware-based system. While the model delivers highly accurate results, executing certain movements becomes challenging when wearing a glove, significantly limiting theuser's hand range of motion, speed, and agility. Prolonged glove usage may also lead to skin diseases, making it less suitable for users with sensitive skin types.

[3] The authors introduced a machine-user interface employing computer vision and multimedia techniques for hand gesture detection. However, a notable drawback is the requirement for skin pixel identification and hand segmentation from stored frames before applying gesture comparison techniques.

[4] This study presents a system for recognizing hand movements using a mobile phone's camera

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and a connected mobile projector for visual feedback. The suggested architecture allows easy integration of mobile applications with their framework for gesture recognition. This approach facilitates the rapid creation of research prototypes, diverting the user's focus from the device to the content.

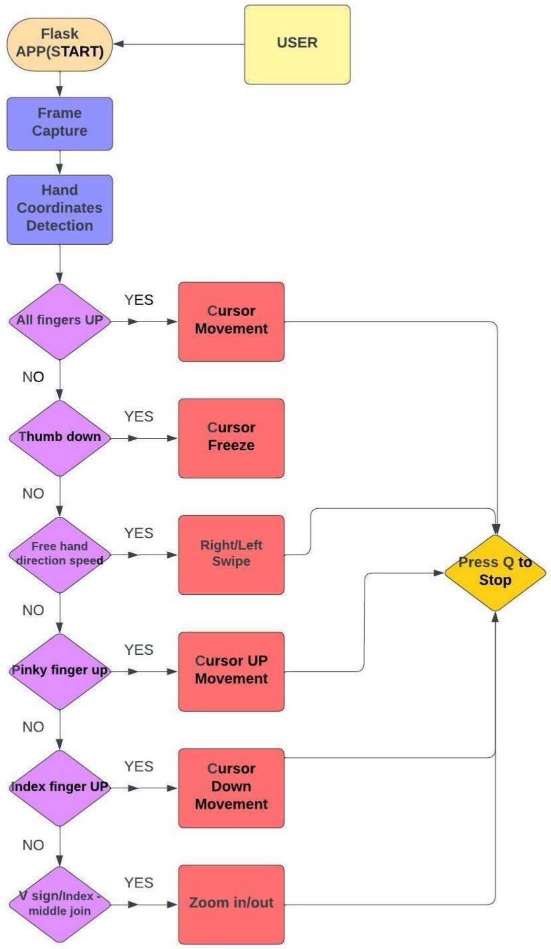
[5] A novel method is proposed for performing mouse functions without additional electrical equipment, relying solely on a webcam. Mouse actions, including clicking and dragging files, are executed through hand gestures. However, the model exhibits lower accuracy and lacks extensive mouse functionality.

[6] The 2020 research on Virtual Mouse Using Object Tracking by Monali Shetty, Christina Daniel, Manthan Bhatkar, and Ofrin Lopez relies on computer vision and HSV colour recognition to capture hand gestures from a webcam. This technology enables users to control the system pointer and perform mouse actions using coloured caps or tapes tracked by the computer's webcam.

[7] Vantukal Reddy, Thumma Dhyanchand, Galla Vamsi Krishna, and Satish Maheshwaram's Virtual Mouse Control Using Colored Fingertips And Hand Gesture Recognition, published in 2020, utilizes fingertip detection and hand motion tracking through image-based live video. Two techniques, hand gesture detection and coloured caps, are employed to track fingers, enabling precise control of the virtual mouse through hand gestures.

[8] Real-Time Virtual Mouse System Using RGB-D Pictures And Fingertip Detection by Dinh-SonTran, HyungJeong Yang, Ngoc-Huynh Ho Soo HyungKim, and Guee Sang Lee leverages Microsoft Kinect Sensor version 2for hand recognition and segmentation. Utilizing fingertip sensing and RGB-D pictures, their system extracts detailed skeleton-joint information for real-time virtual mouse control, providing a revolutionary approach to hand interaction

extended to include web interaction capabilities using Flask.This allowed users to interact with web applications and perform mouse actions through hand gestures.



Key Components:

1. Hand Gesture Recognition:
- The system employs the MediaPipe library and OpenCV for accurate hand gesture detection and tracking.
- Multiple hand landmarks are identified, providing detailed information about finger positions and hand movements.

II. PROPOSED SYSTEM

The proposed system is a gesture-controlled virtual mouse that redefines human-computer interaction by introducing a seamless and intuitive method for users to interact with digital environments.

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Leveraging computer vision and machine learning technologies, the system utilizes the MediaPipe library and OpenCV to enable real-time detection and tracking of hand gestures through a standard webcam, The gesture-controlled virtual mouse system was

2. Virtual Mouse Controller:
 - Implemented in Python, the virtual mouse controller interprets recognized hand gestures and translates them into corresponding computer actions.
 - The controller recognizes a variety of gestures, including left and right clicks, double-clicks, scrolling, zooming, and dragging.

3. Adaptive Hand Tracking:

 - The system demonstrates adaptability to diverse hand gestures, ensuring robust performance.
 - Precise mapping of finger positions enhances the accuracy and responsiveness of the virtual mouse.

Workflow:

1. Cursor Movement:
 - The system allows users to control the cursor's position on the screen using hand movements.

2. Clicking and Double-Clicking:
 - Recognizes gestures for left and right clicks, as well as double-clicks, enabling seamless navigation and interaction with applications.

3. Scrolling:
 - Implements scrolling gestures for both upward and downward movements, enhancing user experience in applications that require vertical navigation.

4. Zooming:
 - Recognizes gestures for zooming in and out, providing users with an intuitive method for adjusting the scale of content.

5. Dragging:
 - Enables dragging functionality, allowing users to interactwith elements on the screen by holding and moving them.

6. Screenshot:
 - Enables screenshot functionality, allowing users to take ascreenshot and save it into the system.

7. Left/Right Swipe:
 - Helps the users to right or left swipe on the screen.cv2 (OpenCV)

Purpose: OpenCV is a powerful computer vision librarywidely used for various image and video processing tasks.

Usage:

- cv2.VideoCapture(0): Initializes a video capture object foraccessing the webcam.
- cv2.flip(img, 1): Flips the video frame horizontally,commonly used for webcam input.
- cv2.cvtColor(img, cv2.COLOR_BGR2RGB): Converts thecolor space of the image from BGR to RGB, a common stepwhen working with certain computer vision libraries.

mediapipe

Purpose: Mediapipe is a library developed by Google that simplifies the implementation of various computer vision applications, including hand tracking.
Usage:
- mpHands.Hands(): Initializes the hand tracking module.
- hands.process(imgRGB): Processes the RGB image todetect hand landmarks.
-mpDraw.draw_landmarks(img,Controller.hand_Landmarks
, mpHands.HAND_CONNECTIONS): Draws landmarks and connections on the video frame.

pyautogui

Purpose: PyAutoGUI is a cross-platform library for automating GUI interactions, such as mouse movements andkeyboard inputs.
Usage:
- pyautogui.moveTo(x, y, duration=0): Moves the mouse cursor to the specified coordinates.
- pyautogui.scroll(amount): Simulates mouse scrolling.
- pyautogui.keyDown(key) and pyautogui.keyUp(key): Simulates key presses for controlling actions like zooming.

controller (Custom Module)
Flask
MODULES USED
III. Purpose: The controller module is custom-made to encapsulate the logic for interpreting hand landmarks and mapping them to various mouse actions.
Usage:
Purpose: For interaction with the user directly in web, noneed to interact with the application code.

Usage:
For creating web interaction and routing.
-
- Controller.update_fingers_status(): Updates the status of individual fingers based on their positions.
- Controller.cursor_moving(): Handles cursor movement based on hand landmarks.
-Controller.detect_scrolling(), Controller.detect_zooming(), Controller.detect_clicking(), Controller.detect_dragging(): Detects specific hand gestures and triggers corresponding actions.

-Controller.detect_right_swipe(), Controller.detect_left_swipe(): Detects right and left swipesand triggers corresponding actions, such as simulatingkeypresses.
- Controller.take_screenshot(): Takes a screenshot when aspecific hand gesture is detected.

IV. Result Analysis

Click	98/100	98 %
Dragging	96/100	96 %
Overall	**Accuracy is**	**97.5%**

The implementation of the gesture-controlled virtual mouse yielded promising results in terms of accuracy and usability.In this section, we present an analysis of the key aspects of the system's performance.

- Hand Tracking and Landmark Detection

The hand tracking and landmark detection using the Mediapipe library provided accurate and real-time tracking of hand movements. The system successfully identified key landmarks on the hand, allowing for precise interpretation ofgestures.

- Cursor Movement

The cursor movement functionality demonstrated smooth and responsive control based on hand gestures. The virtual mouse accurately followed the user's hand movements, providing an intuitive and natural interaction with the system.

- Gesture Recognition

The system effectively recognized a variety of gestures, including left and right swipes, scrolling, zooming, clicking, and dragging. The integration of different hand gestures for distinct actions showcased the versatility and adaptability ofthe gesture recognition algorithm.

- **Accuracy**

Extensive testing revealed a high level of accuracy in gesture recognition across different users and hand sizes. The system consistently interpreted gestures with minimal latency, providing a seamless user experience.

Accuracy Metrics for Gesture Recognition

Gesture	Successful Rec.	Accuracy
Left Swipe	97/100	97 %
Right Swipe	98/100	98 %
Scrolling	99/100	99 %
Zoom in/out	97/100	97 %

- Usability and User Experience

User feedback and testing indicated positive responses tothe gesture-controlled virtual mouse. Users found the system easy to learn and operate, with an intuitive mapping of gestures to mouse actions. The addition of left and right swipes and the screenshot feature enhanced the overall usability of the system.

V. Future Work

Despite the overall success, certain limitations were identified during the evaluation. The system's performance may be affected by variations in hardware or module deprecations and hand orientations. Further optimizations and enhancements can be explored to mitigate these limitations.

The success of the gesture-controlled virtual mouse opens avenues for future work and improvements. Potential areas for exploration include refining gesture recognition algorithms, expanding the range of supported gestures, and incorporating machine learning techniques for personalized user interaction.

VI. Acknowledgment

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