ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr827

AI-Based Virtual Mouse

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Publication Date: 2025/05/08

Abstract: An inventive device that enables hands-free computer interaction is the AI-Based Virtual Mouse, which uses generative AI and computer vision. Unlike traditional wireless or Bluetooth mice, which rely on physical components like batteries and dongles, this technology operates without the need for additional hardware. Instead, it recognizes hand gestures using an inbuilt camera or webcam, allowing users to move the cursor, scroll, and left- and right-click without actually touching a mouse.

The system was developed in Python and uses OpenCV for computer vision tasks and generative AI models for gesture detection and fingertip tracking. Additionally, MediaPipe and OpenCV provide machine-learning methods for tracking hand movements and translating them into screen cursor movements. The system uses real-time video data to recognize and interpret hand movements to deliver accurate and efficient computer navigation.

By eliminating the need for external input devices, our AI-powered virtual mouse enhances convenience and cleanliness while lowering hardware dependencies. Because of its effectiveness on a standard CPU, it is suitable for real-world applications and offers a creative, intuitive, and touch-free alternative to conventional computer interaction methods.

Keywords: *AI Virtual Mouse, Hands-Free Computer Interaction, Computer Vision, Fingertip tracking, OpenCV, Hand Tracking, Cursor Control with Gestures, Real-Time Video Processing, Webcam Mouse Control, Gesture-Based Navigation.*

How to Cite: Mr. N. V. Murali Krishna Raja; S. Swathi Rathnam; Ch. Sri Maha Lakshmi Aishwarya; Ch. Geetha Chandrika; M. Vyshnavi; T. Swathi Ratnam; K. Vedha Veekshita. (2025). AI-Based Virtual Mouse. *International Journal of Innovative Science and Research Technology*, 10 (4), 2880- 2885 . https://doi.org/10.38124/ijisrt/25apr827

I. INTRODUCTION

The way we engage with digital gadgets has changed dramatically in the age of rapid technological breakthroughs due to the considerable evolution of human-computer interaction. The AI-Based Virtual Mouse, a ground-breaking technology that combines computer vision and artificial intelligence to allow users to operate their digital gadgets with simple hand movements, is one of the most exciting developments in this field. This innovative technology has the potential to change millions of lives by doing away with the need for physical mouse devices, especially for those who are unable to use traditional mouse devices due to illnesses, accidents, or disabilities. Furthermore, by offering an unmatched degree of immersion, accessibility, and simplicity, the AI-Based Virtual Mouse has the potential to completely transform some sectors, including gaming, healthcare, education, and entertainment. The AI-Based Virtual Mouse is an invention that has the potential to forever alter the landscape of technology and beyond by redefining the limits of human-computer interaction.

The goal of the AI-Based Virtual Mouse project is to increase user experience and accessibility. The objective is to develop technology that makes it easier for persons with illnesses, accidents, or disabilities to connect with digital gadgets independently. Our goal is to improve the entire experience and the standard of living for millions of people worldwide by offering a more user-friendly and convenient method of interacting with digital gadgets. The potential to transform sectors including gaming, healthcare, education, and entertainment is another driving force behind this endeavor.

II. LITERATURE SURVEY

Title	Authors	Year	Journal
Artificial Intelligence Virtual Mouse	Alimul Rajee, Mohammad Likhan, Nurul Ahad Farhan, Israth Jahan	2023	Research Gate
Artificial Intelligence Based Virtual Mouse using hand Gestures	Neeraj Arora	2023	GLIMPSE
AI Virtual Mouse Using OpenCV	Shrinidhi Chintamani, Rutuja Bhad, Nikhil Deokar, Kalyani Kadam, Prof. Abhale B.A	2022	IRJMETS
Virtual Mouse Implementation Using OpenCV	Kollipara Sai varun, I. Puneeth, Prem Jacob	2019	Research Gate
Hand Gesture Recognition for Human-Computer Interaction	Aashni hariaa, Archanasri Subramaniana, Nivedhitha Asokkumara, Shristi Poddara, Jyothi S Nayak	2017	ICACC
Cursor Control Using Hand Gestures	Pooja Kumari, Saurabh Singh, Vinay Kr. Pasi	2016	IJCA

III. MATERIAL AND METHODS

The AI-Based Virtual Mouse system was created without the usage of external hardware, such as a real mouse or extra sensors, by utilizing a typical computing environment with an integrated webcam. Python 3.8 was used to implement the software components, with important libraries such as MediaPipe for hand landmark recognition, NumPy for mathematical calculations, PyAutoGUI for mouse motion simulation, and OpenCV for image processing. With a mid-range CPU (Intel Core i5, 2.5 GHz, 8GB RAM), the machine functioned well, showcasing its hardware-efficient and lightweight design.

An average frame rate of 30 frames per second (FPS) was used to record real-time video input, guaranteeing rapid and fluid interaction. The hand tracking solution from MediaPipe was used to process each frame. It was able to recognize 21 different hand landmarks with high precision (>95% in well-lit situations). To comply with MediaPipe's specifications, the incoming video frames were first converted from BGR to RGB format before being run through the model to determine the locations of the fingers and hands.

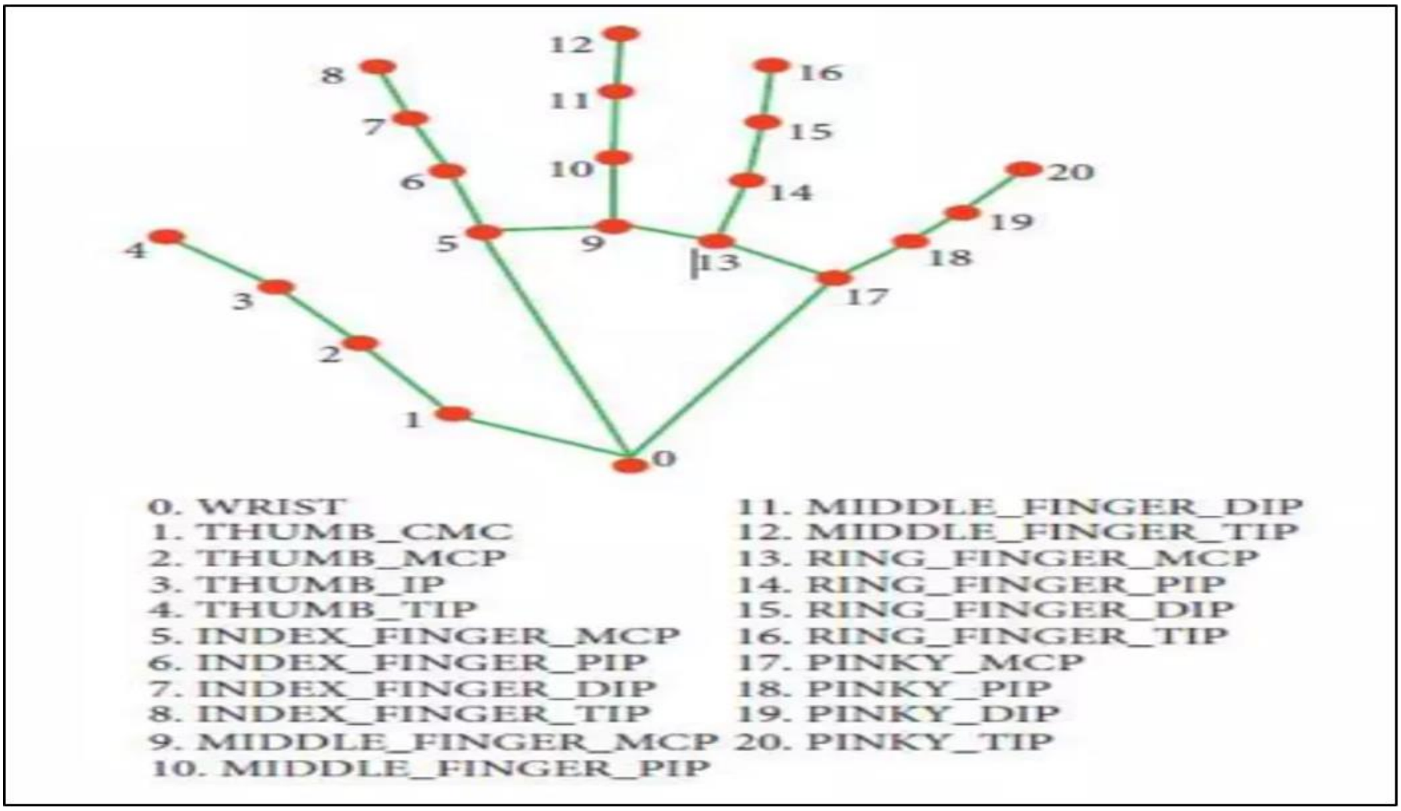

Fig 1 Landmarks

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25apr827

The relative locations of important sites served as the basis for defining gestures. For instance, a right-click was prompted by the thumb and index finger making a circle, a left-click was triggered by the index and middle fingers simultaneously extending, and a right-click was triggered by the index finger moving upward. Accurate mouse pointer control was made possible by normalizing and mapping the detected landmark coordinates to the 1920x1080 pixel screen resolution. Exponential moving averages were used as a smoothing function to guarantee fluid cursor movement, which improved user experience by minimizing abrupt jumps.

The system's viability for real-time applications was confirmed when testing was carried out in various lighting and background circumstances. It maintained over 90% accuracy in gesture detection with a latency of less than 100 milliseconds. As an alternative to conventional input devices, the solution is hygienic, user-friendly, and practical because it may operate completely without physical contact.

IV. PROPOSED METHODOLOGY

The goal of the suggested methodology is to employ computer vision and artificial intelligence techniques to create a frictionless virtual mouse device. The technology is made to recognize and decipher hand movements that are recorded by a webcam and translate them into real-time mouse motions.

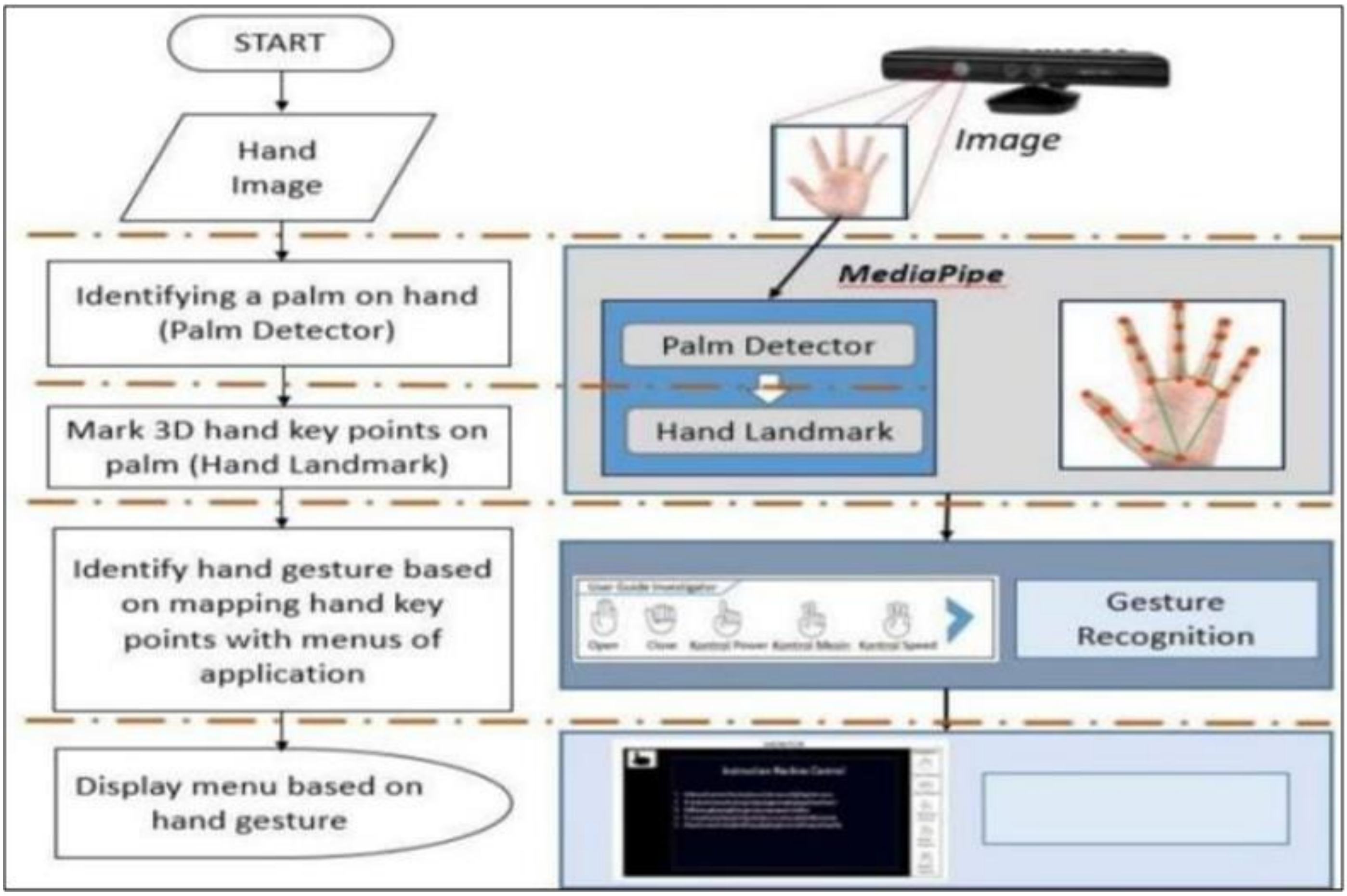

Fig 2 System Architecture

A. *The detailed procedure is as follows:*

➢ *Real-Time Video capture:*

Using an external webcam or the computer's built-in camera, the system first records a live video feed at about 30 frames per second (FPS).

➢ *Preprocessing of Frames:*

For MediaPipe's hand tracking model to work, every captured frame is translated from BGR to RGB format. Techniques for resizing and noise reduction are used to ensure reliable functioning.

➢ *Hand Landmark Detection:*

21 important landmarks on the user's hand are recognized by MediaPipe's hand detection technology. These landmarks which are crucial for gesture recognition include the fingertips, joints, and wrist points.

➢ *Gesture Recognition:*

Using the relative locations of landmarks, custom gesture logic is used to ascertain user intent:

- Index Finger extended: Move the cursor.
- Index and Middle Fingers extended: Perform a left-click.
- Thumb and Index Fingers joined: Perform a right-click.

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- Vertical Movement of Fingers: Control scrolling.

➢ *Mapping to Screen Coordinates:*

To precisely control the cursor position, the coordinates of the detected fingertip are mapped proportionately to the screen dimensions.

➢ *Execution of Mouse Events:*

Based on the identified gestures, the system executes mouse actions (click, scroll, and move) using the PyAutoGUI module. To prevent jitter and guarantee a realistic movement experience, smoothing algorithms are used.

➢ *Performance Optimization:*

The system can run smoothly on a regular CPU without the need for a specialized GPU because it is optimized for low-latency execution (<100 ms) and dependable gesture detection in a variety of illumination settings and backgrounds.

V. RESULTS AND DISCUSSION

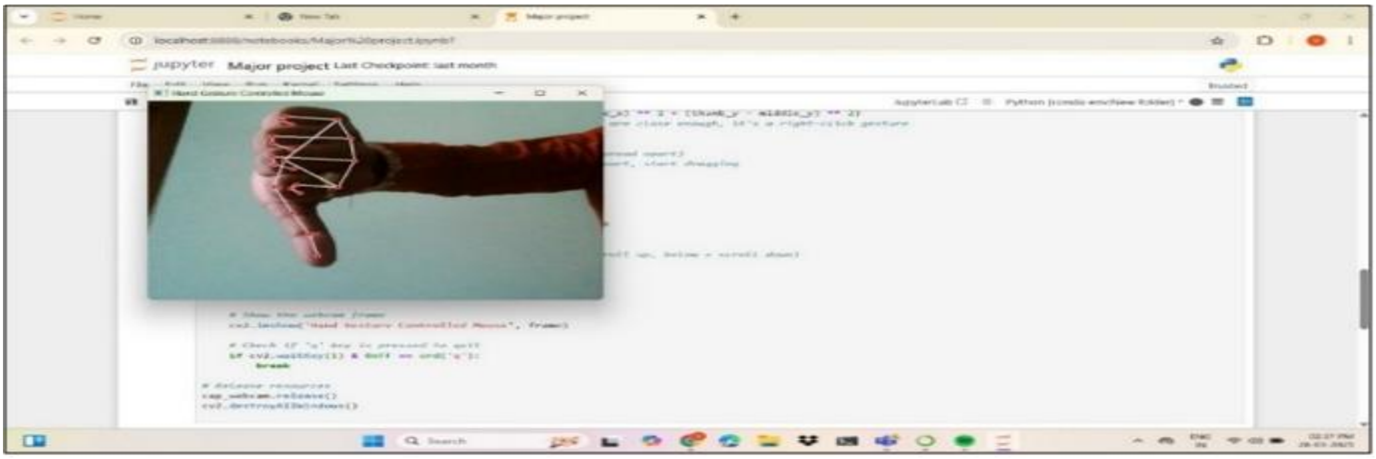

Fig 3 Thumb Below Index Finger – Scroll Down

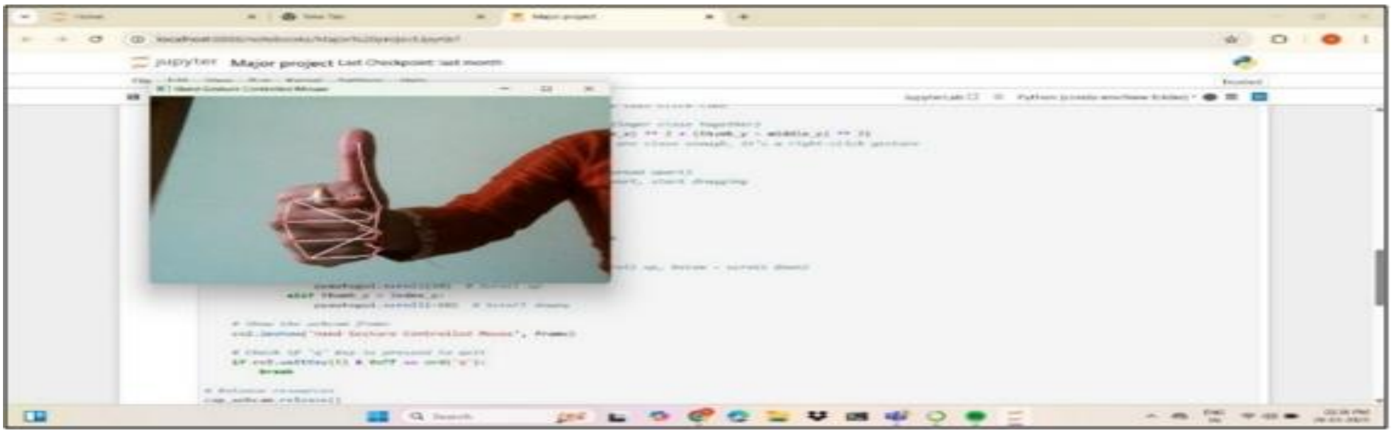

Fig 4 Thumb Above Index Finger – Scroll Up

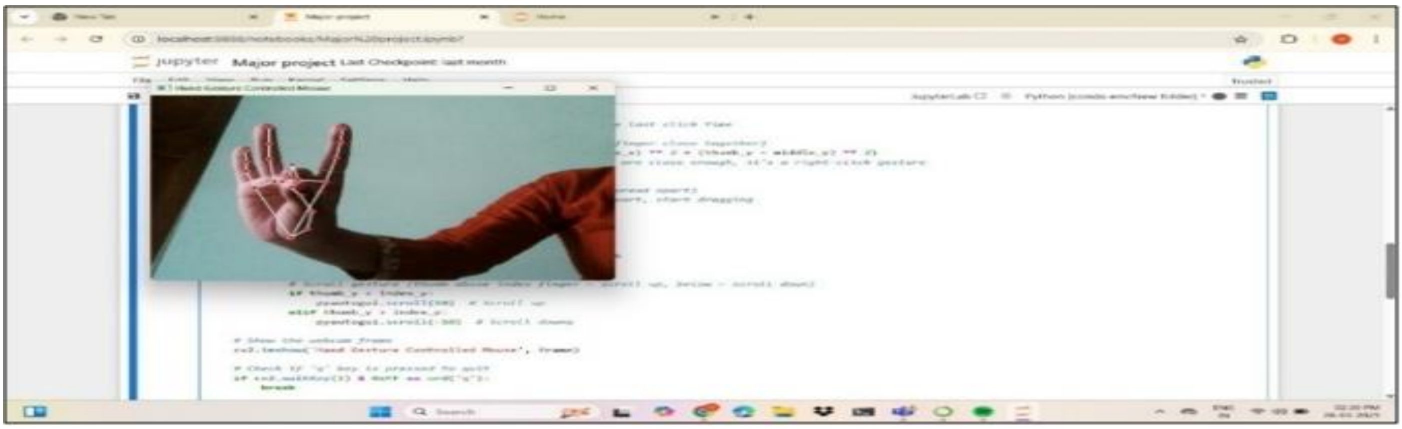

Fig 5 Pinch Middle Finger and Thumb - Right Click

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Fig 6 Index Finger and Thumb Far Apart – Dragging

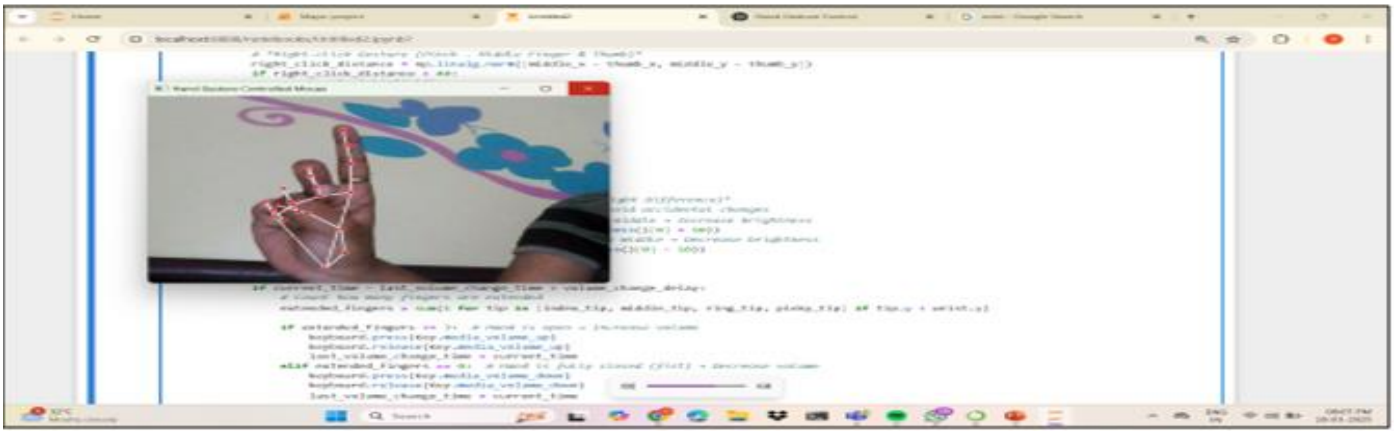

Fig 7 Index Finger higher than Middle Finger - Brightness Down

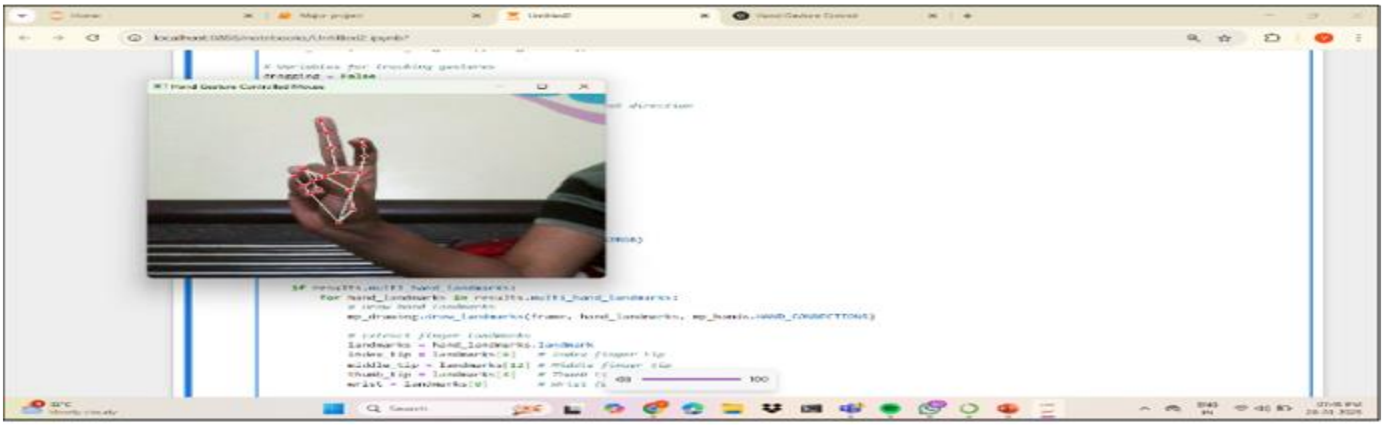

Fig 8 Middle Finger higher than Index Finger - Brightness Up

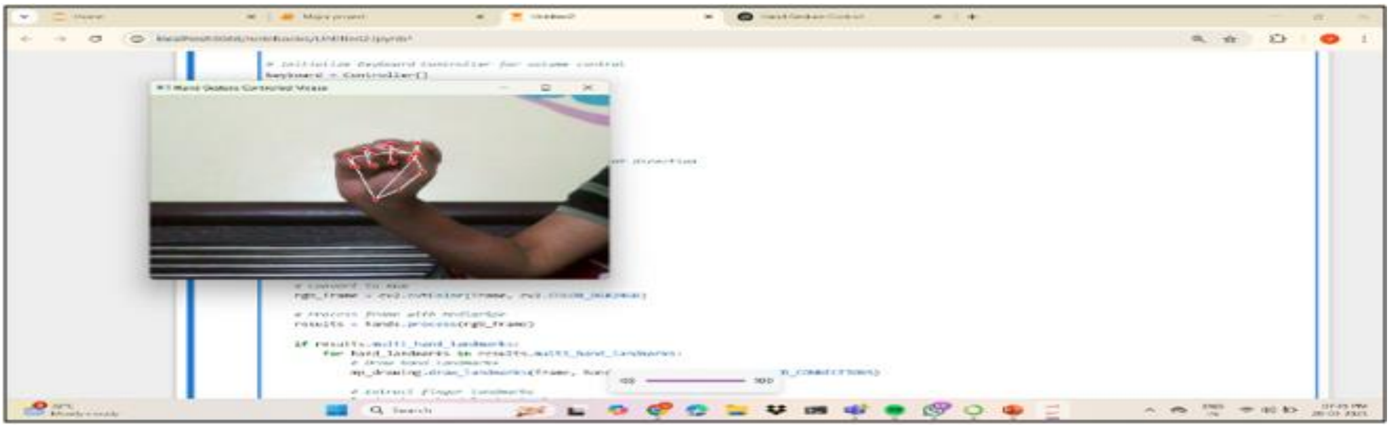

Fig 9 Thumb Above Wrist - Volume Up

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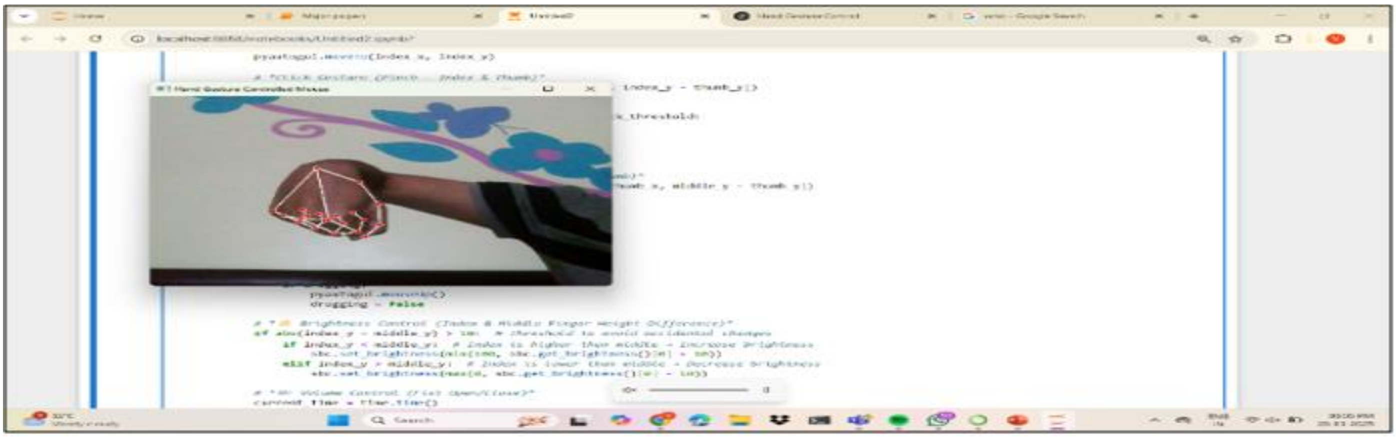

Fig 10 Thumb Below Wrist - Volume Down

VI. CONCLUSION

With the help of MediaPipe for hand tracking and PyAutoGUI for system control, this AI-powered virtual mouse enables users to interact with their computers using natural hand motions. The system eliminates the need for physical input devices like a mouse or keyboard by using computer vision and machine learning to provide more seamless and futuristic experiences.

A. Key takeaways:

- Effective Gesture Recognition: The system recognizes hand gestures with accuracy and converts them into shortcuts, media control, and mouse commands.
- Hands-Free Interaction: Users don't need to touch any device to zoom, drag, scroll, click, and adjust brightness.
- Real-Time Performance: To ensure minimal lag and seamless engagement, the system processes gestures in real-time.

B. Key features and functionalities:

- Use pinch motions to double-click and left-click.
- Use the thumb and middle finger to do a right-click.
- Using the thumb's relative position to guide the scroll.
- Zooming, adjusting brightness, playing media, and moving between apps are examples of system controls.

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