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SMART VIRTUAL MOUSE USING HAND TRACKING & AI

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ABSTRACT:
This project presents an AI-based Virtual Mouse system that enables users to control a computer cursor through real-time hand gesture recognition without the need for a physical mouse. The system uses computer vision and machine learning techniques to detect and track hand landmarks via a webcam. The frontend is developed using a HTML, CSS, JS user friendly graphical interface that allows seamless interaction and displays real-time cursor movements, while the backend is implemented using PYTHON with libraries such as OpenCV and Media Pipe for hand tracking and gesture recognition. By analysing finger positions and movements, the system translates specific gestures into mouse operations including cursor movement, left click, right click, drag, and scrolling. The model processes video frames efficiently to ensure smooth and accurate performance. This touch free approach enhances accessibility, promotes hygienic interaction, and provides an innovative, cost-effective, and intuitive human-computer interaction method suitable for modern digital environments and assistive technology applications.

Keywords:
Smart Virtual Mouse, Hand Tracking, Artificial Intelligence (AI), Computer Vision, Gesture Recognition, Human–Computer Interaction (HCI), Touchless Mouse Control.

I.INTRODUCTION

In the modern digital era, human-computer interaction has become an essential part of everyday life. Traditional input devices such as the keyboard, mouse, and touchpad have long been used to control computer systems and execute commands. Among these devices, the mouse plays a major role in navigating interfaces, selecting objects, scrolling, dragging files, and performing numerous system operations. However, physical mouse devices have several limitations, including dependency on hardware, restricted mobility, wear and tear, hygiene concerns, and the inability to provide a seamless touchless experience. With the rapid development of Artificial Intelligence (AI), Computer Vision, and Machine Learning technologies, there is a growing demand for more intuitive, efficient, and contact-free interaction methods.

A Smart Virtual Mouse is an innovative technology that allows users to control the computer cursor and perform mouse operations using only hand gestures without physically touching any device. This system makes use of a webcam or camera sensor to capture real-time hand movements and processes themthrough hand tracking algorithms and artificial intelligence models. By identifying finger positions and interpreting specific gestures, the virtual mouse can simulate common mouse functionalities such as cursor movement, left click, right click, double click, scrolling, and drag-and-drop operations. This touchless control mechanism creates a more natural communication channel between humans and machines.

II.LITERATURE REVIEW

The rapid advancement of Artificial Intelligence, Computer Vision, and Human-Computer Interaction technologies has led to the development of intelligent systems that reduce dependency on conventional hardware devices. One such innovation is the virtual mouse, which allows users to interact with computer systems through hand gestures rather than using a physical mouse. Researchers across the world have explored gesture recognition, hand tracking, and image processing techniques to build touchless human-machine interfaces. The literatur
e related to smart virtual mousesystemshighlights various methodologies, tools, and performance improvements that have contributed to the development of this field.

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Early research in gesture-based interaction focused on the use of data gloves, infrared sensors, and specialized hardware to capture hand movements. Although these systems were effective, they were expensive, less portable, and uncomfortable for continuous use. Researchers such as Zimmerman et al.
orientation were measured using sensors. While these systems provided accurate tracking, they lacked practicality because users had to wear additional devices. This limitation encouraged further research into vision-based hand gesture recognition systems that use cameras instead of wearable hardware.

III.METHODOLOGY/PROPOSED METHOD

The proposed Smart Virtual Mouse Using Hand Tracking & Artificial Intelligence is designed to replace the conventional physical mouse with a touchless gesture-controlled system. The methodology of this project involves capturing hand movements through a webcam, detecting hand landmarks using artificial intelligence, interpreting finger gestures, and converting these gestures into mouse commands. The entire process is implemented through a combination of Computer Vision, Machine Learning, and automation libraries that work together to provide real-time human-computer interaction.

2. System Design Overview

The proposed system follows a vision-based gesture recognition model. A standard webcam connected to the computer continuously captures the live video stream of the user's hand movements. Each video frame is then processed using image processing techniques to identify the presence of a hand. Once the hand is detected, the AI-based hand tracking module extracts important landmark points such as fingertips, finger joints, and palm coordinates. These landmark points are used to understand finger positions and distances.
After identifying the coordinates, the system compares them with predefined gesture conditions. Each recognized gesture is mapped to a specific mouse operation such as cursor movement, left click, right click, double click, and scrolling. Finally, these interpreted commands are executed on the computer screen using mouse automation software.

2. Video Capture and Frame Processing

The first step of the methodology is acquiring real-time video input using the computer webcam. OpenCV library is used to access the webcam and capture continuous image frames. Since raw webcam images may contain unnecessary background information, each frame is flipped horizontally to provide mirror interaction and resized for efficient processing.
The captured frames are converted from BGR color format into RGB format because the AI hand detection framework works efficiently with RGB images. Frame-by-frame processing ensures that the system can detect hand motion in real time without significant delay. The image is then passed to the hand tracking model for landmark extraction.

IV.RESULT AND DISCSSION

The Smart Virtual Mouse Using Hand Tracking & Artificial Intelligence was successfully implemented and tested in a real-time computing environment using a webcam, Python programming language, OpenCV, MediaPipe, and PyAutoGUI libraries. The primary objective of the project was to create a touchless human-computer interaction system capable of replacing the traditional physical mouse with hand gestures. The obtained results show that the proposed system effectively recognizes hand movements, tracks finger landmarks accurately, and performs basic mouse operations with satisfactory speed and precision.

1. Successful Real-Time Hand Detection

During execution, the webcam continuously captured live video frames of the user's hand placed in front of the camera. The MediaPipe AI hand tracking framework successfully detected the hand in most testing conditions and generated 21 landmark points corresponding to fingertips, finger joints, and wrist positions. These landmarks were visible in real time on the processed video output, confirming that the hand detection module was functioning properly.
The system was able to identify the hand under normal indoor lighting conditions without requiring any gloves, colored markers, or external sensors. This demonstrates that the AI-based landmark detection approach is more flexible and user-friendly than traditional sensor-based systems. The tracking remained stable even when the hand moved at moderate speed, indicating that the selected framework is suitable for real-time applications.

2. Cursor Movement Performance

One of the most important outputs of the project was the movement of the computer cursor using the index finger. The fingertip coordinates detected from the webcam frame were successfully mapped to the monitor screen

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coordinates. As the user moved the index finger left, right, up, or down, the cursor responded accordingly on the screen.

The cursor movement was smooth after applying interpolation and motion smoothing techniques. Minor hand vibrations were reduced, which prevented unstable pointer behavior. The response time between finger motion and cursor displacement was very low, creating a natural user experience. Although slight delay was observed when the hand moved very quickly, the overall cursor control was efficient enough for performing regular tasks such as selecting icons, opening folders, and navigating menus.

V.CONCLUSION AND FUTURE WORK

The Smart Virtual Mouse Using Hand Tracking & Artificial Intelligence project successfully demonstrates an advanced touchless human-computer interaction system that can perform essential mouse operations without the need for a physical mouse device. By integrating webcam-based image capture, AI-powered hand landmark detection, gesture recognition, and cursor automation, the proposed system provides an efficient and low-cost solution for contactless computer control. The use of MediaPipe, OpenCV, and PyAutoGUI enabled real-satisfactory time hand tracking, smooth cursor movement, click actions, and scrolling with accuracy.

The project proves that natural hand gestures can be effectively translated into digital commands, thereby reducing dependency on traditional hardware peripherals. It offers several advantages such as improved hygiene, portability, accessibility, and modern user interaction. This system can be highly useful in public environments, smart classrooms, healthcare systems, and for users with limited access to physical input devices. Although minor limitations such as lighting sensitivity, background disturbances, and hand fatigue exist, the overall performance confirms the practical feasibility of AI-based virtual mouse technology.

VI.REFERENCE

[1] F. Zhang, V. Bazarevsky, A. Vakunov, A. Tkachenka, G. Sung, C. L. Chang, and M. Grundmann, “MediaPipe Hands: On-device Real-time Hand Tracking,” arXiv preprint arXiv:2006.10214, 2020.
[2] G. Sung, K. Sokal, E. Uboweja, V. Bazarevsky, J. Baccash, E. G. Bazavan, C. L. Chang, and M. Grundmann, “On-device Real-time Hand Gesture Recognition,” arXiv preprint arXiv:2111.00038, 2021.
[3] P. Uma Vignesh, M. Thaqib-ul-Rahman, S. Dheeraj, T. S. C. Reddy, and M. Ayaz Uddin, “AI Virtual Mouse Using Hand Gesture Recognition,” International Research Journal on Advanced Engineering Hub, vol. 3, no. 5, pp. 2259–2263, 2025.
[4] A. Paramarthalingam, A. Janarthanan, A. Amirthasaravanan, and S. S. Ariyangavu, “AI-Powered Virtual Mouse Control Through Hand Gestures With Computer Vision,” in Harnessing AI in Geospatial Technology for Environmental Monitoring and Management, IGI Global, 2025, pp. 61–76.
[5] R. B. N., G. Satish, S. Kundanagar, V. Shetty, and Y. R. Bhangigoudra, “Gesture Controlled Virtual Mouse using AI,” International Journal for Research in Applied Science and Engineering Technology, vol. 11, 2023.
[6] S. Patil, S. Chincholkar, D. Pawar, P. Munde, and A. Sheikh, “Hand Tracking-Based Virtual Mouse System,” International Journal for Research in Applied Science and Engineering Technology, vol. 13, 2025.
[7] C. Muthuramya, R. S. Ram, S. Ramkumar, C. Vasavi, B. Sri Latha, and V. Chennakesava Reddy, “Virtual Mouse Using Hand Gestures Using OpenCV,” in 2025 IEEE 4th International Conference on Data, Decision and Systems (ICDDS), pp. 95–99, 2025.
[8] R. D. T. Putri, L. Lasmadi, A. Kusumaningrum, R. Nurdin, and Y. Astuti, “Hand Gesture-Based Human-Computer Interaction using MediaPipe and OpenCV,” AVITEC Journal, vol. 7, no. 2, 2025.
[9] G. Bradski, “The OpenCV Library,” Dr. Dobb’s Journal of Software Tools, vol. 25, no. 11, pp. 120–126, 2000.
[10] A. Amprimo, G. Masi, G. Pettiti, G. Olmo, L. Priano, and C. Ferraris, “Hand Tracking for Clinical Applications: Validation of the Google MediaPipe Hand Framework,” arXiv preprint arXiv:2308.01088, 2023.
[11] R. Kumar, A. Bajpai, and A. Sinha, “Mediapipe and CNNs for Real-Time ASL Gesture Recognition,” arrive preprint arXiv:2305.05296, 2023.
[12] J. Y. Bouguet, “Pyramidal Implementation of the Lucas Kanade Feature Tracker,” Intel Corporation, Microprocessor Research Labs, 2001.
[13] R. C. Gonzalez and R. E. Woods, Digital Image Processing, 4th ed. Pearson Education, 2018.
[14] S. Mitra and T. Acharya, “Gesture Recognition: A Survey,” IEEE Transactions on Systems, Man, and Cybernetics, vol. 37, no. 3, pp. 311–324, 2007.
[15] V. I. Pavlovic, R. Sharma, and T. S. Huang, “Visual Interpretation of Hand Gestures for Human-Computer Interaction: A Review,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 19, no. 7, pp. 677–695, 1997.

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International Journal of Engineering Technology Research & Management (IJETRM)
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https://ijetrm.com/issue/

[16] M. Turk, "Computer Vision in Human-Computer Interaction," Communications of the ACM, vol. 47, no. 1, pp. 34–41, 2004.
[17] D. J. Sturman and D. Zeltzer, "A Survey of Glove-Based Input," IEEE Computer Graphics and Applications, vol. 14, no. 1, pp. 30–39, 1994.
[18] T. Starner, J. Weaver, and A. Pentland, "Real-Time American Sign Language Recognition Using Desk and Wearable Computer-Based Video," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 20, no. 12, pp. 1371–1375, 1998.
[19] R. Y. Wang and J. Popović, "Real-Time Hand-Tracking with a Color Glove," ACM Transactions on Graphics, vol. 28, no. 3, pp. 1–8, 2009.
[20] A. Jaimes and N. Sebe, "Multimodal Human-Computer Interaction: A Survey," Computer Vision and Image Understanding, vol. 108, no. 1–2, pp. 116–134, 2007.