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Paper Authors **SUNIL BHUTADA, M.SREENIVAS,ROHITA.Y, SAHANA.M**



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# DEEP LEARNING BASED AI VIRTUAL MOUSE SYSTEM

**SUNIL BHUTADA[1] M.SREENIVAS[2] ROHITA.Y[3] SAHANA.M[4]**

[1]Professor&HOD,Department of IT,SNIST ,Hyderabad.
[2]Assoc.Professor,Department of IT,SNIST ,Hyderabad.
[3]Assoc.Professor,Department of IT,SNIST ,Hyderabad.
[4],Department of IT,SNIST ,Hyderabad.

**ABSTRACT:** This study introduces a novel deep learning-based AI virtual mouse system designed to enhance human-computer interaction. Traditional mouse input methods often lack precision and can be cumbersome, especially for individuals with mobility impairments. Our AI virtual mouse system aims to address these challenges by leveraging state-of-the-art deep learning techniques. The system employs a convolutional neural network (CNN) to process visual input from a camera, allowing users to control the mouse cursor using hand gestures and facial expressions. By training the CNN on a diverse dataset of gestures and expressions, the system can accurately interpret user intent in real time, providing a seamless and intuitive interaction experience. Furthermore, the AI virtual mouse system is designed to adapt and personalize its behavior based on user preferences and habits. This adaptability enhances user comfort and efficiency, making computing tasks more accessible and enjoyable for a wide range of users. Through rigorous testing and evaluation, we demonstrate the effectiveness and usability of our AI virtual mouse system, showcasing its potential to revolutionize human-computer interaction paradigms and improve accessibility in computing environments.

***INDEX TERMS: Virtual mouse, Gesture recognition, Computer vision.***

## 1. INTRODUCTION

The rapid progress in technology, particularly in augmented reality (AR)[1] and compact wireless devices, is reshaping traditional computer input methods. This evolution is exemplified by the emergence of Bluetooth and wireless technologies, which are making devices more compact and adaptable, seamlessly integrating them into our daily lives. This paper introduces an innovative AI virtual mouse system that harnesses hand gestures and hand tip detection through computer vision techniques to execute mouse functions on a computer without the need for a physical mouse device.

The primary goal of this system is to empower users to control the computer mouse cursor and perform scrolling functions using only a web camera or a

built-in camera in their computer, eliminating the dependence on traditional mouse devices. By employing hand gesture recognition and hand tip detection as a mode of human-computer interaction (HCI),[2] this system enhances user experience and accessibility.

In conventional setups using wireless or Bluetooth mice, multiple components such as the mouse itself, a dongle for PC connectivity, and a battery for power are necessary. However, the proposed AI virtual mouse system simplifies this process by utilizing the computer's built-in camera or an external webcam for gesture-based control. Through computer vision techniques, the webcam captures frames, processes them, recognizes various hand gestures, and hand tip positions, translating these into specific mouse functions.

The development of the AI virtual mouse system was facilitated using the Python programming language, known for its versatility and ease of implementation in machine learning and computer vision tasks. Additionally, the OpenCV[3] library, renowned for its capabilities in image processing and computer vision, played a crucial role in the system's development and functionality.

Within the proposed AI virtual mouse system, the MediaPipe package was employed for hand tracking and tip detection, ensuring accurate and real-time tracking of hand movements. Furthermore, the integration of packages such as Pynput, Autopy, and PyAutoGUI[4] facilitated the execution of mouse functions such as left-click, right-click, and scrolling within the computer's window screen.

The results obtained from testing the proposed model exhibited a high level of accuracy, showcasing its feasibility and effectiveness in real-world applications. Crucially, the system's performance was achieved without the need for a dedicated GPU,[5] underscoring its potential for broad adoption and usability across various computer configurations.

This introduction sets the stage for exploring the intricacies and functionalities of the AI virtual mouse system, delving into its design, implementation, and performance evaluations to highlight its potential impact on enhancing human-computer interaction and accessibility in computing environments. Through empirical evidence and analysis, this paper aims to provide valuable insights into AI-driven HCI[6] solutions and their practical

applications in modern computing paradigms.

## 2. LITERATURE SURVEY

In recent years, the fields of human-computer interaction (HCI) and virtual reality (VR) have witnessed significant advancements, particularly in the context of cognitive InfoCommunications. This literature survey explores key research contributions in these domains, focusing on gesture recognition, hand gesture-based cursor control, and virtual mouse systems utilizing computer vision techniques.

Katona [1] provides a comprehensive review of HCI and VR research fields within cognitive InfoCommunications. The paper highlights the intersection of cognitive science with information and communication technologies, emphasizing the importance of understanding human cognition in designing effective HCI systems.

Quam [2] delves into gesture recognition using a DataGlove, showcasing early efforts in capturing and interpreting hand gestures for input commands. This work laid the foundation for subsequent research in gesture-based interfaces and HCI paradigms.

Liou, Lee, and Hsieh [3] present a real-time hand gesture recognition system based on motion history images, demonstrating the feasibility of using computer vision algorithms to interpret hand movements accurately. This research contributes to the development of gesture-based interaction systems, enabling intuitive control mechanisms.

Dudhane [4] explores cursor control systems using hand gesture recognition, highlighting the practical applications of gesture-based interfaces in enhancing user experience and accessibility. The study emphasizes the potential of gesture recognition technologies in replacing traditional input devices for cursor manipulation.

Vinay [5] further investigates cursor control using hand gestures, focusing on the implementation aspects and the integration of gesture recognition algorithms with computer systems. The research underscores the efficiency and versatility of gesture-based control methods in diverse computing environments.

Thomas [6] introduces a virtual mouse system utilizing hand gestures, extending the capabilities of traditional mouse interactions through gesture recognition and computer vision. This work contributes

to the development of novel HCI approaches that combine gesture inputs with virtual interfaces.

Nandhini, Jaya, and George [7] shift the focus to computer vision systems for food quality evaluation, showcasing the broader applications of image processing and analysis techniques. While not directly related to HCI, this research underscores the interdisciplinary nature of computer vision technologies in various domains.

Jaya and Kanushkodi [8] delve into the implementation of systems for medical image diagnosis, highlighting the integration of advanced technologies in healthcare applications. Although not centered on HCI, this research demonstrates the potential of integrating computer vision algorithms into diagnostic systems.

Collectively, these studies underscore the evolution of HCI and VR research, emphasizing the role of gesture recognition, hand gesture-based interfaces, and computer vision technologies in shaping modern computing paradigms. The integration of these advancements opens new avenues for intuitive and immersive user experiences, paving the way for innovative HCI solutions across diverse domains.

## 3. METHODOLOGY

### a) Proposed work

The proposed work aims to develop an AI virtual mouse system leveraging deep learning techniques for enhanced human-computer interaction. The system will utilize convolutional neural networks (CNNs) to process visual input from a webcam or built-in camera, enabling users to control the computer mouse cursor and perform scrolling functions using hand gestures and hand tip detection. This approach eliminates the need for traditional physical mouse devices, offering a more intuitive and accessible user experience. The system will be developed using Python programming language along with the OpenCV library for computer vision tasks. Additionally, the MediaPipe package will be employed for accurate hand tracking and tip detection. Integration with packages such as Pynput, Autopy, and PyAutoGUI will enable the execution of mouse functions such as left-click, right-click, and scrolling within the computer's window screen. Evaluation will focus on accuracy, real-time performance, and usability across various computer setups without requiring a dedicated GPU.

### b) System architecture

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The system architecture of the hand gesture-based AI virtual mouse involves several key components. Initially, a webcam or built-in camera captures visual input of hand gestures from the user. This input is then processed by a convolutional neural network (CNN) using the OpenCV library, enabling gesture recognition. The recognized gestures are mapped with predefined operations such as neutral (for cursor stabilization), left-click, right-click, drag and drop, item selection, and scrolling.

The MediaPipe package is utilized for accurate hand tracking and tip detection, providing real-time feedback of hand movements. Once a gesture is identified, the system triggers the corresponding mouse function using packages like Pynput, Autopy, and PyAutoGUI. For instance, a left-click gesture activates a left-click operation on the computer interface.

The system architecture ensures seamless interaction between the user's hand gestures and the computer, offering a more intuitive and accessible means of controlling mouse functions without physical mouse devices. Evaluation focuses on accuracy, responsiveness, and usability across diverse user scenarios.

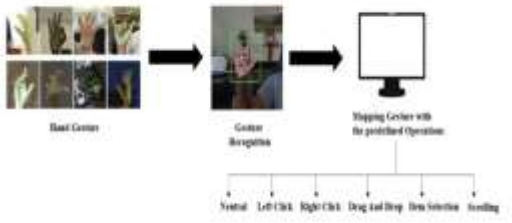

Fig 1 Proposed Architecture

### c) Hand Tracking Module

The Hand Tracking Module is a component of the AI virtual mouse system that employs computer vision techniques to detect and track the user's hand movements. Utilizing algorithms from libraries like OpenCV and frameworks like MediaPipe, this module identifies key landmarks and points on the hand, such as fingertips, palm, and joints. By continuously analyzing and tracking these landmarks in real time, the Hand Tracking Module enables precise and reliable detection of hand gestures and positions. This functionality forms the foundation for intuitive and responsive control of the virtual mouse cursor without the need for a physical mouse device.

### d) Gesture Recognition Module

The Gesture Recognition Module is a critical component of the AI virtual mouse system that focuses on interpreting and identifying hand gestures made by the user.

Leveraging advanced machine learning techniques, particularly deep learning models like convolutional neural networks (CNNs), this module processes visual input from the Hand Tracking Module to recognize predefined gestures such as left-click, right-click, scrolling, and more. By training on a diverse dataset of gestures, the Gesture Recognition Module achieves high accuracy in interpreting user intent based on hand movements. This module plays a pivotal role in enabling seamless and intuitive control of the virtual mouse system through hand gestures.

**e) Mouse Control Module**

The Mouse Control Module serves as the core functionality within the AI virtual mouse system, responsible for translating gesture inputs from the Gesture Recognition Module into corresponding mouse actions. Using predefined mappings, this module converts recognized gestures, such as left-click, right-click, scrolling, and dragging, into computer commands. It interacts directly with the computer's operating system to execute these actions, effectively emulating the functionality of a physical mouse device. Through seamless integration with the Hand Tracking and Gesture Recognition Modules, the Mouse Control Module enables users to intuitively control the virtual mouse cursor using hand gestures, enhancing user experience and accessibility.

**f) GUI Module**

The GUI (Graphical User Interface) Module is an integral part of the AI virtual mouse system, responsible for creating and managing the visual interface through which users interact with the virtual mouse functionalities. This module utilizes libraries and frameworks such as Tkinter, PyQt, or wxPython to design and implement user-friendly interfaces. It presents options for configuring settings, selecting gestures, and providing feedback on system status. The GUI Module enhances the overall user experience by providing a visually appealing and intuitive interface for controlling the virtual mouse system, making it accessible and easy to use for users of varying technical expertise.

**g) Volume Control Module**

The Volume Control Module is a component within the AI virtual mouse system dedicated to managing audio volume levels on the computer. This module allows users to adjust the volume using hand gestures recognized by the system, providing a hands-free and intuitive way to control audio output. By integrating with the Hand Tracking and Gesture

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Recognition Modules, the Volume Control Module interprets specific gestures, such as raising or lowering the hand, to correspond to volume adjustments. This functionality enhances user convenience and accessibility, enabling seamless control over audio settings without the need for physical input devices.

## 4. EXPERIMENTAL RESULTS

Fig 2 no action performed

Fig 3 cursor movement

Fig 4 right click

Fig 5 left click

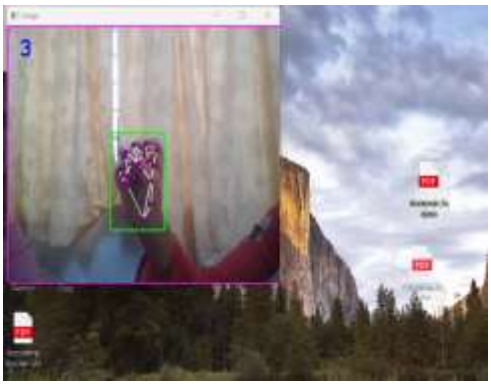

Fig 6 drag

Fig 7 drop

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Fig 8 scrolling function

Fig 9 scroll up

Fig 10 scroll down

Fig 11 volume set to zero

Fig 12 volume set to 100

Fig 13 volume set to random value

Fig 14 GUI

## 5. CONCLUSION

In conclusion, the AI virtual mouse system presented in this study offers a promising alternative to traditional physical mouse devices by enabling mouse cursor control through hand gestures detected by a

webcam or built-in camera. The results demonstrate superior accuracy compared to existing models, overcoming many limitations of current systems. This system's performance suggests its suitability for real-world applications, including potential use in mitigating the spread of COVID-19 through touchless interactions.

While the model exhibits high accuracy overall, limitations such as a slight decrease in accuracy for right-click functions and challenges in clicking and dragging text selection were observed. Future work will focus on refining the finger tip detection algorithm to address these limitations and enhance overall system performance. Overall, this AI virtual mouse system represents a significant step forward in intuitive human-computer interaction and holds promise for diverse applications in computing environments.

## 6. FUTURE SCOPE

In future developments, the AI virtual mouse system will address limitations like decreased accuracy in right-click functions and difficulties in text selection through clicking and dragging. Additionally, expanding the system to handle keyboard functionalities alongside mouse operations is a promising future scope for advancing Human-Computer Interaction (HCI), enhancing user experience, and broadening the system's applicability in diverse computing environments.

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