ISSN No:-2456-2165

Virtual Mouse Using AI and Computer Vision

[1]Rupali Shinganjude, [2]Dipak Majrikar, [3]Atharva Bawiskar, [4]Sayali Bobhate, [5]Jatin Chaurawar, [6]Gaurav Ninawe

[1]Assistant Professor
[1]Department of Information Technology,
[1]Priyadarshini Bhagwati College of Engineering, Nagpur, India.

[2]Research Scholar, [3]Research Scholar, [4]Research Scholar, [5]Research Scholar, [6]Research Scholar

Abstract:- **A paper proposing a virtual mouse system controlled by hand gestures that use AI algorithms to recognize and translate them into mouse movements. In the human-computer interaction module, hand gestures played a significant role. The system is designed to provide an alternative interface for people who face difficulty using a traditional mouse or keyboard. This virtual mouse system uses a camera to capture images of the user's hand, which are processed by an AI algorithm to recognize the gestures made by the user. Once the gesture is recognized, it is translated to a corresponding mouse movement, which is then executed on the virtual screen. This model provides potential applications like enabling the hand-free operation of devices in hazardous environments and providing an alternative interface for hardware mouse. This hand gesture-controlled virtual mouse system offers a promising approach to enhance user experience and improve accessibility through human-computer interaction.**

Keywords:- *Virtual Mouse, Hand Gesture Recognition, Computer Vision, Media-Pipe.*

I. INTRODUCTION

In an era characterized by the relentless advancement of technology, the way we interact with computers and digital devices has undergone a significant transformation. The traditional computer mouse, a resolute way of human-computer interaction for decades, is now being challenged by innovative solutions that harness the power of Artificial Intelligence (AI) and Computer Vision. This paper delves into a groundbreaking frontier of HCI (Human-Computer Interaction) - the development and application of a "Virtual Mouse" empowered by AI and Computer Vision.

The computer mouse, a ubiquitous peripheral device, has long been the interface of choice for navigating the digital realm. However, it is limited in its capacity to provide a seamless and natural interaction between humans and machines. The emergence of AI and Computer Vision technologies has unlocked the potential for more intuitive, efficient, and versatile ways of interfacing with computers. The concept of a Virtual Mouse represents a paradigm shift in HCI, promising a future where users can interact with their devices using gestures and movements, eliminating the need for physical input devices.

This research paper is focused on various aspects of a Virtual Mouse system, spanning the underlying technologies, the development process, and its practical applications. We aimed to shed light on the possibilities and challenges associated with this innovative technology, as well as its potential to redefine the way we interact with digital interfaces in diverse domains, from gaming and healthcare to education and industry.

The foundation of the Virtual Mouse system lies in the fusion of AI and Computer Vision. AI algorithms enable the system to understand and interpret human gestures and movements, while Computer Vision technology provides the means to capture and process visual data. By dissecting these underlying technologies, we aimed to provide a comprehensive understanding of the principles that underpin this innovation. Creating a Virtual Mouse system involves a meticulous process. It encompasses the development of software algorithms for gesture recognition, hardware components such as cameras or sensors for data acquisition, and the integration of these elements to ensure a seamless user experience. We understood the technical aspects of building a Virtual Mouse prototype, and offered insights into potential challenges and solutions, from calibration to real-time tracking.

II. LITERATURE SURVEY

AI and Gesture Recognition have been fundamental to the development of Virtual Mouse systems. Gesture recognition is also important for developing alternative human-computer interaction models. It enables humans to interface with machines in a more natural way [1]. Furthermore, with additional voice assistant support, an AI virtual mouse using hand gestures can further enhance the experience of the user. The voice assistant that is integrated with the virtual mouse system will provide users with even more control over their devices [3]. These works establish a foundational understanding of the AI underpinning the Virtual Mouse system.

ISSN No:-2456-2165

The cornerstone of the Virtual Mouse technology is Computer Vision, particularly its ability to enable real-time tracking of hand movements. Computer vision concerns with the theories for building intelligent systems that could obtain information from images. The image data can be taken in many forms such as video sequences, views from multiple cameras, or multi-dimensional data from specific scanners [2]. This is a critical component in ensuring seamless user interactions and control over the digital environment.

For humans, it is very easy to detect and recognize objects as humans have a great capability to distinguish objects through their vision. But, for a machine object detection and recognition is a great issue. To overcome this problem 'Neural networks' have been introduced in the field of computer science [4]. In the human-computer interaction module, hand gesture has an important role. Obtaining accurate values in finger-pointing with 3-D space value is a difficult process [5]. These practical applications illustrate the versatile and potentially transformative nature of the Virtual Mouse. Convolutional layers of neural networks take a significant part of computer resources even if the target object (hand) is absent in the frame [6]. Furthermore, they delineate potential future directions, underlining the ongoing evolution of this technology and its growing impact in the realm of HCI.

III. PROPOSED METHODOLOGY

The proposed methodology outlines the steps involved in implementing the Virtual Mouse system and its integration with "Mediapipe," "OpenCV," and other Python libraries. This methodology emphasizes the integration of these tools into the project for hand tracking, gesture recognition, and real-time image processing.

A. Data Collection and Preprocessing:

- The project commences with the creation of a diverse dataset, crucial for training the Virtual Mouse system. This dataset encompasses various hand movements and gestures to ensure the system's versatility.
- OpenCV facilitates data collection through functions like Video Capture, allowing us to capture high-quality image frames from cameras. These frames serve as the foundation for training and testing the system.
- Data preprocessing includes noise reduction and image enhancement. OpenCV's image processing capabilities, such as Gaussian Blur and Histogram Equalization, are applied to ensure the collected data is clean and of high quality.
- "PyAutoGUI" streamlines the data labeling process, significantly expediting the annotation of the dataset, a critical step in supervised machine learning.

B. Hand Tracking and Pose Estimation using Mediapipe:

- Mediapipe plays a central role in enabling real-time hand tracking and pose estimation. The hand tracking module within Mediapipe detects and continuously track the user's hand throughout interactions.
- The module utilizes advanced techniques, including Convolutional Neural Networks (CNNs) and graph-based models, to precisely locate landmarks on the hand. These landmarks allow us to monitor the hand's position and orientation accurately.
- Additionally, Mediapipe is pivotal in finger tracking, estimating the positions and orientations of individual fingers, which is vital for recognizing intricate hand gestures and actions.

C. Gesture Recognition using Python Libraries:

- Python libraries develop custom gesture recognition algorithms. These algorithms utilize image analysis techniques, including feature extraction and pattern recognition.
- By developing custom algorithms, we ensure that the system accurately classifies a wide range of hand gestures. Python libraries such as NumPy and SciPy support various numerical and statistical operations, enabling us to fine-tune the recognition model.
- "PyAutoGUI" plays a pivotal role in the system's response to recognize gestures, enabling the translation of gestures into on-screen actions with precision.

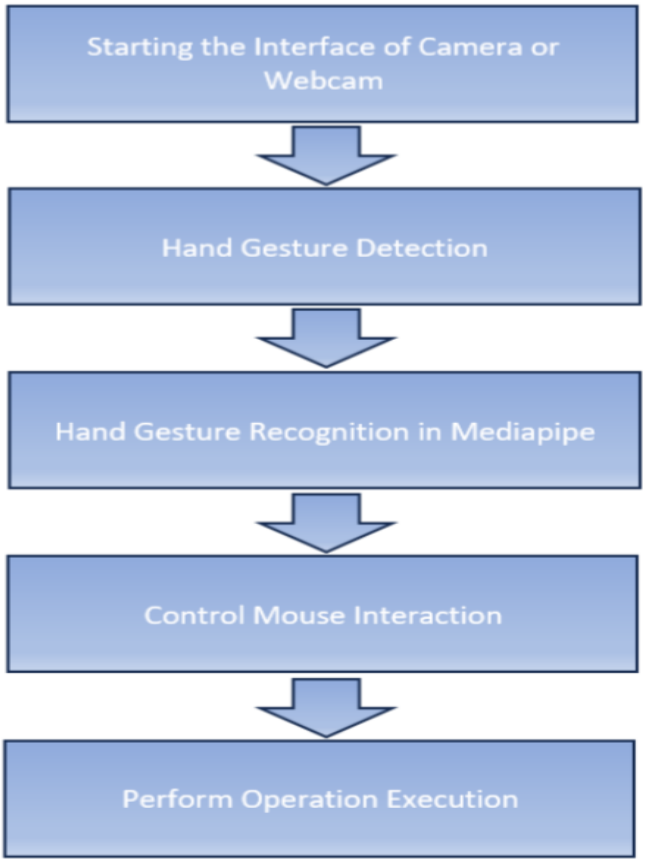

Fig. 1. Flow graph for Hand Gesture Recognition

IV. ALGORITHMS AND TOOLS USED

For the purpose of hand and finger detection, we used one of the effective open-source libraries Mediapipe, it is one type of framework based on the cross-platform features which was developed by Google and OpenCV to perform some Computer Vision related tasks. This algorithm uses machine learning related concepts for detecting hand gestures and tracking their movements.

A. *Mediapipe*

"Mediapipe" is a comprehensive open-source framework developed by Google that specializes in various aspects of computer vision, including real-time hand tracking and pose estimation. In the context of our project, "Mediapipe" played a central role in achieving precise hand tracking, a critical component of the Virtual Mouse system's functionality.

➢ *Hand Tracking Module:*

- "Mediapipe" offers a specialized hand tracking module capable of detecting and tracking hands in real-time from input images or video frames. This module leverages machine learning models trained on vast datasets to recognize and locate hands accurately. As a result, it provides the system with the capability to continuously track the user's hand throughout the interaction.
- "Mediapipe" hand tracking goes beyond merely detecting the presence of a hand. It identifies key landmarks and key points on the hand, enabling the system to precisely map and follow hand movements. This is particularly valuable for tracking gestures, as the system can monitor the relative positions of fingers and the palm, ensuring a detailed understanding of hand poses.

➢ *Finger Tracking and Pose Estimation:*

- One of the strengths of "Mediapipe" is its ability to perform finger tracking and hand pose estimation. The framework can accurately determine the positions and orientations of individual fingers, allowing the Virtual Mouse system to recognize complex hand gestures and gestures involving specific finger arrangements.
- The framework's pose estimation capabilities are particularly beneficial for understanding the orientation of the hand in 3D space. This information is vital for the system to interpret hand movements accurately and translate them into corresponding actions on the computer interface.

B. *OpenCV*

OpenCV, or Open Source Computer Vision Library, is a powerful open-source framework that is widely employed in computer vision and image processing tasks. In our project, OpenCV played a central role in various critical aspects of the Virtual Mouse system's development.

➢ *Data Collection and Preprocessing:*

- OpenCV is a foundational tool for data collection and preprocessing. It facilitates the capture of image frames from cameras, which is essential for building the dataset used to train the Virtual Mouse system. The library provides a straightforward and efficient way to gather visual data, ensuring that the training dataset is diverse and representative of real-world scenarios.
- Additionally, OpenCV offers a suite of functions for image preprocessing, such as noise reduction, contrast adjustment, and image enhancement. These preprocessing steps are crucial to ensure the collected data is of high quality, with minimal noise or interference.

➢ *Hand Detection:*

- OpenCV's Haar Cascade Classifier is used for the initial hand detection phase. This classifier is an effective machine learning object detection method, and it playes a pivotal role in identifying the presence of hands in image frames. By recognizing the hand's features, the Haar Cascade Classifier allows the system to extract the region of interest (ROI), namely the hand, for further analysis.
- The Haar Cascade Classifier is an important building block for the Virtual Mouse system's data collection process. It serves as the foundation for subsequent steps in hand tracking and gesture recognition.

➢ *Real-time Image Processing:*

- OpenCV excels in real-time image processing, making it a valuable tool for managing camera input and processing video frames in real-time. This capability is vital for the Virtual Mouse system, as it requires seamless and responsive interactions.
- The library's real-time image processing functions ensure that the system could keep up with hand movements and gestures as they occur. By providing a robust foundation for image analysis and manipulation, OpenCV supports the system in recognizing gestures and translating them into on-screen actions with minimal latency.

V. RESULTS

In our project, the virtual mouse system exhibited a moderate level of accuracy and precision in tracking hand gestures and translating them into cursor movements. While the system performed adequately, there is potential for further refinement to enhance its precision. The response time of the virtual mouse was found to be satisfactory, providing users with a responsive experience. However, there is room for optimization to reduce response times and enhance real-time performance.

Additionally, the gesture recognition rate was reasonable, accurately identifying a majority of hand gestures used for mouse control. Nonetheless, there is scope for improvement, especially in cases involving complex or rapid gestures. These results provide valuable insights into the performance of the

virtual mouse system, acknowledging its strengths and highlighting areas for future enhancements.

VI. CONCLUSION

We've seen how AI and computer vision can work together to create a digital tool that's easy to use. This combination not only brings the concept of the Virtual Mouse to life but also opens the door to more exciting innovations that can make how we use computers even better.

This research has also shown us that creating a Virtual Mouse is a complex task. It involves writing smart computer programs, using specialized hardware, and making sure everything happens in real time. Solving these challenges is essential for turning the Virtual Mouse from an idea into a real and common technology.

The Virtual Mouse has some really cool uses. It can help doctors and nurses use computers without touching them, which is important for keeping things clean and safe in healthcare. It can also make learning more fun and interactive in schools, and it can add more excitement to video games. Additionally, it can give people with physical challenges a way to use computers more easily, which is a big deal for inclusivity.

Looking ahead, the Virtual Mouse is like the first step toward a new way of working with computers. It won't replace our regular computer mice, but it will give us another way to get things done. This research has shown us the potential and challenges of this new technology. It's clear that the Virtual Mouse isn't just a fancy idea; it's a real step towards a future where we can work with computers in a smarter and more natural way.

REFERENCES

[1]. Shweta Yewale and Pankaj Bharne, "Hand Gesture Recognition Using Different Algorithms Based on Artificial Neural Network," *2011 International Conference on Emerging Trends in Networks and Computer Communications.*, 2011.

[2]. Kavitha R, Janasruthi U, Lokitha S, and Tharani G, "Hand Gesture Controlled Virtual Mouse Using Artificial Intelligence," 2023.

[3]. Chen-Chiung Hsieh, Dung-Hua Liou, and David Lee, "A Real Time Hand Gesture Recognition System Using Motion History Image," *2010 2nd International Conference on Signal Processing Systems.*, 2010.

[4]. Aishwarya Sarkale, Kaiwant shah, Anandji Chaudhary, and Tatwadarshi Nagarhalli, "An Innovative Machine Learning Approach for Object Detection and Recognition," *Proceedings of the International Conference on Inventive Communication and Computational Technologies : ICICCT 2018 : 20-21, April 2018*, 2018.

[5]. Preetha V H and Sherin Mohammed Sali Shajideen, "Hand Gestures - Virtual Mouse for Human Computer Interaction," *Proceedings of the International Conference on Smart Systems and Inventive Technology (ICSSIT 2018) : Francis Xavier Engineering College, Tirunelveli, India, date: December 13-14, 2018*, 2018.

[6]. R. Golovanov, D. Vorotnev, and D. Kalina, "Combining Hand Detection and Gesture Recognition Algorithms for Minimizing

[7]. Computational Cost," in *2020 22th International Conference on Digital Signal Processing and its Applications, DSPA 2020*, Institute of Electrical and Electronics Engineers Inc., Mar. 2020. doi: 10.1109/DSPA48919.2020.9213273.

[8]. N. Khade, M. S. Aswale, M. N. Kushwaha, M. Y. Bisen, M. R. Chaudhari, and M. T. Ramteke, "AI VIRTUAL MOUSE," 2023.

[9]. A. Voulodimos, N. Doulamis, A. Doulamis, and E. Protopapadakis, "Deep Learning for Computer Vision: A Brief Review," *Computational Intelligence and Neuroscience*, vol. 2018. Hindawi Limited, 2018.

[10]. W. Ouyang et al., "DeepID-Net: Object Detection with Deformable Part Based Convolutional Neural Networks," IEEE Trans Pattern Anal Mach Intell, vol. 39, no. 7, pp. 1320–1334, Jul. 2017.

[11]. X. Li and Y. Shi, "Computer vision imaging based on artificial intelligence," in Proceedings - 2018 International Conference on Virtual Reality and Intelligent Systems, ICVRIS 2018, Institute of Electrical and Electronics Engineers Inc., Nov. 2018.

[12]. E. Sankar, N. Bharadwaj, and A. Vignesh, "Virtual Mouse Using Hand Gesture," International Journal of Scientific Research in Engineering and Management, vol. 07, no. 05, May 2023, doi: 10.55041/IJSREM21501.

[13]. D. Singh, A. Singh, A. K. Singh, S. Chaudhary, and J. Kher, "Virtual Mouse using OpenCV," Int J Res Appl Sci Eng Technol, vol. 9, no. 12, pp. 1055–1058, Dec. 2021, doi: 10.22214/ijraset.2021.38160.

[14]. C. D. S. Nikhi, C. U. S. Rao, E. Brumancia, K. Indira, T. Anandhi, and P. Ajitha, "Finger Recognition and Gesture based Virtual Keyboard," International Conference on Communication and Electronics Systems, 2020.

[15]. F. Jabeen, L. Tao, and T. Linlin, "One Bit Mouse for Virtual Reality," in Proceedings - 2016 International Conference on Virtual Reality and Visualization, ICVRV 2016, Institute of Electrical and Electronics Engineers Inc., Jun. 2017, pp. 442–446. doi: 10.1109/ICVRV.2016.81.

[16]. D. S. Tran, N. H. Ho, H. J. Yang, S. H. Kim, and G. S. Lee, "Real-time virtual mouse system using RGB-D images and fingertip detection," Multimed Tools Appl, vol. 80, no. 7, pp. 10473–10490, Mar. 2021, doi: 10.1007/s11042-020-10156-5.

[17]. L. W. Heng, D. Chunjian, and L. Yi, "Implementation Of Virtual Mouse Based On Machine Vision," International Conference on Apperceiving Computing and Intelligence Analysis., 2010.