**Virtual Mouse using ML**

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**ABSTRACT**

The mouse stands as a remarkable creation in the realm of Human-Computer Interaction (HCI) technology. While wireless or Bluetooth mice represent advancements, they still rely on devices such as batteries and dongles for connectivity to PCs. However, in the envisioned AI virtual mouse system, termed "1.5 Uuuation," this dependency on physical devices can be circumvented by leveraging webcams or built-in cameras for hand gesture recognition and detection, employing computer vision techniques. The system employs a machine learning algorithm to interpret these gestures, enabling virtual control of the computer, including left and right clicks, scrolling, and cursor movement, without the need for a physical mouse. Deep learning algorithms are utilized for hand detection within this framework.

By eliminating human interaction and device dependency, this proposed system offers a potential solution to curb the spread of COVID-19. The AI virtual mouse system is developed using the Python programming language, with the integration of OpenCV, a computer vision library. Additionally, the system incorporates the MediaPipe package for hand tracking and tip detection, along with Pyinput, Autopy, and PyAutoGUI packages for on-screen navigation and functions like left and right clicks and scrolling.

Experimental results demonstrate a notably high level of accuracy, suggesting the potential effectiveness of the model in real-world applications, even when deployed on a CPU without reliance on a GPU.

**INTRODUCTION**

Medical Advancements in augmented reality and compact wireless technologies are shaping our daily devices, such as Bluetooth and wireless gadgets. This paper introduces an AI-driven virtual mouse system that relies on hand gestures and tip detection for executing mouse functions on computers through computer vision. The primary goal of this proposed system is to emulate the cursor and scrolling functions of a conventional mouse using either a built-in or external webcam. Hand gestures and tip detection, facilitated by computer vision, serve as the human-computer interface (HCI). Through the AI virtual mouse system, users can control mouse operations by tracking fingertip movements captured by a camera, enabling cursor manipulation and scrolling.

Unlike traditional wireless or Bluetooth mice, which require various devices like the mouse itself, a dongle for PC connectivity, and batteries, this paper advocates for using built-in or external webcams alongside hand gestures to control computer mouse functions.

Project Objective:

The primary aim of the proposed AI virtual mouse system is to provide an alternative to conventional mouse setups by utilizing a webcam to capture hand gestures and tips. These captured frames are then processed to execute specific mouse functions such as left-click, right-click, and scrolling.

Problem Statement:

The envisioned AI virtual mouse, leveraging hand signals, addresses several challenges, including environments where space constraints make traditional mouse usage impractical and assisting individuals with grip issues who struggle with conventional mouse manipulation. Additionally, amid the COVID-19 pandemic, the avoidance of physical device contact is crucial in preventing virus transmission. The proposed AI virtual mouse system offers a solution by using hand signals and tip detection via a camera, such as a webcam, thereby mitigating the need for physical device interaction. Compared to wireless or Bluetooth mice, which entail multiple devices like the mouse itself and the connecting dongle, the AI virtual mouse system streamlines interaction with the PC.

**Literature Review for Problem Identification and Project Justification**

The current landscape features a conventional mouse and trackpad control system, alongside the emergence of hand gesture control. However, effectively accessing the screen from a distance using hand gestures remains challenging. While attempts have been made to implement such systems, their scope is primarily confined to the realm of virtual mouse operations. Existing virtual mouse control systems involve basic mouse functionalities facilitated by hand recognition systems, allowing for limited control over the mouse pointer, left click, right click, and dragging. However, reliance on hand recognition is expected to diminish in the future. Although various hand recognition techniques exist, most employ static hand recognition, which merely identifies hand shapes and associates predefined actions with them, resulting in limited functionality and usability.

With advancements in technology, alternatives to traditional mouse interfaces are increasingly viable. Some of the methods explored include:

Integration of Cameras in Virtual Gesture Mouse Projects: Leveraging OpenCV, a Python vision library, to facilitate an AI-driven virtual mouse structure dependent on data captured by cameras on a computer.

Input Provision: In computer vision, images are represented as arrays of numerical values denoting pixel intensities. Each image is treated as data that can be visualized in various forms, such as arrays of pixel values or complex plots illustrating pixel intensity distributions.

* **Hand Movement through the Window Using Rectangular Areas:**

The AI virtual mouse system utilizes algorithms to convert fingertip coordinates from the camera screen to full-screen coordinates on the computer window, enabling mouse control.

* **Finger Tip Detection and Cursor Manipulation:**

The AI mouse system identifies finger tips to execute mouse cursor operations. MediaPipe is employed for finger tracking, determining finger positions, and executing corresponding mouse actions. However, each method has its limitations, with potential issues related to user health, particularly when using head or eye-controlled cursor systems or touchscreens, which can lead to fatigue.

* **Project Justification:**

The PC mouse represents a significant advancement in Human-Computer Interaction (HCI). However, even modern wireless or touchless mice rely on power sources and pose potential health risks, particularly during the COVID-19 pandemic, where minimizing physical contact with shared devices is crucial. The proposed AI virtual mouse system aims to address these challenges by utilizing computer vision to recognize hand gestures and fingertips, enabling mouse functionalities without the need for physical mouse devices. By leveraging machine learning algorithms, the system can interpret hand gestures to perform tasks such as left-clicking, right-clicking, scrolling, and cursor movements.

* **Algorithm Utilization and Proposed Model:**

For hand gesture detection and tracking, the project utilizes the MediaPipe framework in conjunction with the OpenCV library for computer vision. MediaPipe offers multimodal capabilities, enabling developers to build and analyze systems through graphs. The pipeline configuration allows for scalability across various platforms, facilitating the creation of custom applications. OpenCV, on the other hand, serves as the backbone of computer vision applications, providing tools for image and video manipulation, storage, and retrieval across different platforms.

**METHODOLOGY**

O Pre-processing, a fundamental step in computer vision, aims to prepare images for further analysis by transforming them into a suitable format. Tasks such as exposure correction, color balancing, noise reduction, and image sharpening are crucial for achieving satisfactory results. This article proposes to introduce some commonly used image processing techniques using the popular Computer Vision library, OpenCV. I will briefly explain how each operation works and focus more on practical implementation, providing code examples for a hands-on learning experience.

* **Finger Identification in the AI Virtual Mouse System:**

The AI virtual mouse system relies on frames captured by the webcam of a laptop or PC. Utilizing the Python computer vision library OpenCV, a video capture object is created to commence video capture from the webcam.

* **Detecting Raised Fingers and Executing Mouse Functions:**

In this phase, the system identifies raised fingers using their respective tip IDs obtained through MediaPipe and their corresponding coordinates, as depicted in Figure 6. Based on this information, specific mouse functions are executed.

* **Right Mouse Button Click Execution:**

To trigger a right mouse button click, the system checks if both the index finger (tip ID = 1) and the middle finger (tip ID = 2) are raised, and if the distance between them is less than 40 pixels. If these conditions are met, the pynput Python package is employed to simulate a right mouse button click on the computer. PROPOSED SYSTEM

**PROPOSED SYSTEM**

For the analysis of hand signals and movements, the MediaPipe system is employed, with the OpenCV library utilized for general computer vision tasks, employing AI algorithms to interpret and recognize hand movements and fingertips.

Pre-processing, an initial step in computer vision, aims to prepare images for further analysis by converting them into a suitable format. Tasks such as exposure correction, color balancing, noise reduction, or enhancing image sharpness are crucial and demanding to achieve satisfactory results.

In this article, I propose to introduce some commonly used image processing techniques using the widely-known Computer Vision library, OpenCV. I'll briefly explain the workings of each operation and focus more on practical implementation, providing the necessary code for a hands-on learning experience.

The AI virtual mouse system holds numerous applications, such as reducing reliance on physical mice and enabling usage in environments where physical mice are impractical. By eliminating the need for additional devices, it enhances human-computer interaction. Key applications include:

1. High accuracy rate of 99%, surpassing other virtual mouse models, enhancing its versatility.
2. The system provides a safer alternative to touching devices, reducing the risk of virus transmission.
3. Control of robots and automation systems without the need for physical devices.
4. Drawing of 2D and 3D images using hand gestures.
5. Gaming in virtual reality and augmented reality environments without traditional mouse devices.
6. Accessibility for individuals with hand-related impairments.
7. Utilization in robotics for controlling robotic systems.
8. Application in designing and architecture for virtual prototyping and visualization.

**ANALYSIS**

In the proposed AI virtual mouse system, the concept of enhancing human-computer interaction through computer vision is introduced. However, comparing the testing outcomes of this system proves challenging due to the limited availability of datasets. Testing has been conducted under various illumination conditions and different distances from the webcam to assess hand gestures and fingertip detection. An experimental test, summarized in a table, was performed 25 times by 4 individuals, resulting in 600 gestures with manual labeling. This test encompassed different lighting conditions and distances from the screen, with each person testing the AI virtual mouse system 10 times under normal light, 5 times under low light, 5 times at close proximity to the webcam, and 5 times at a distance. The experimental results, including accuracy percentages, are tabulated.

**SYSTEM OVERVIEW**

The AI virtual mouse system employs computer vision to enhance human-computer interaction, facilitating mouse functions without physical devices. Testing under varied conditions ensures robust performance. Applications include high accuracy, robot control, drawing, gaming, accessibility, and design prototyping.

**CONCLUSION**

The primary aim of the AI virtual mouse system is to enable cursor control through hand gestures, replacing the need for a physical mouse. Utilizing webcam or built-in camera input, the system detects hand gestures and processes frames to execute mouse functions. With superior accuracy compared to existing models, it offers real-world application potential and addresses COVID-19 concerns. However, minor accuracy issues in right-click function and text selection highlight areas for algorithm refinement. Future efforts will focus on enhancing finger tip detection for improved precision.

**FUTURE WORK**

Many avenues for additional growth arise as Virtual Mouse grows, all oriented at enhancing the users's function and experience.

1. Enhanced Real-World Application: Further development could expand the AI virtual mouse system's usability across diverse contexts, such as in industrial settings, educational environments, and healthcare facilities, where minimizing physical contact with devices is paramount.
2. Gesture Customization: Introducing customizable gesture commands could optimize user experience and accessibility, allowing individuals to tailor hand movements to specific tasks or preferences, thereby enhancing efficiency and user satisfaction.
3. Integration with Assistive Technologies: Collaborating with assistive technology developers could facilitate integration of the AI virtual mouse system into assistive devices for individuals with disabilities, fostering greater inclusivity and accessibility in technology usage.
4. Advanced Gesture Recognition: Continued research and development in gesture recognition algorithms could improve the system's accuracy and responsiveness, enabling more nuanced and intuitive interaction with computers and other devices.
5. Interdisciplinary Collaboration: Engaging experts from fields such as psychology, human factors engineering, and ergonomics could provide valuable insights into user behavior and ergonomic considerations, informing the refinement of the AI virtual mouse system to better align with user needs and preferences.

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Haria, et al. "Hand Gesture Recognition for Human-Computer Interaction." Procedia Computer Science, vol. 115, pp. 367-374, 2017. Publisher Site: Scholar

**Additional Resources:**

OpenCV Tutorial: [Link]

Google. "On-Device Real-Time Hand Tracking with MediaPipe