International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Implementation of Virtual Mouse Control System Using Hand Gestures for Web Service Discovery

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Submitted: 28/11/2023 **Revised**: 09/01/2024 **Accepted**: 20/01/2024

Abstract: There are important web services SOAP, UDDU and WSDL. These web services are designed and integrated in suitable website after discovery. The research work focuses on design of Virtual Mouse Control System Using Hand Gestures for the discovery among several web services. This research article suggests a real-time virtual mouse controller based on hand movements and computer vision. Traditional physical mouse have drawbacks, such as requiring additional hardware and being challenging to use. Gesture-based interaction is made feasible with the use of this technology while overcoming practical difficulties, logistical problems, mobility issues, and accessibility issues. The system records hand motions using a built-in camera or webcam and processes them using colour segmentation and detection methods. By using a variety of hand gestures to control mouse actions including left clicks, right clicks, and scrolling, which can be constructed using MediaPipe, Python, and OpenCV, users can interact with computers in a more intuitive and natural way. The problem that this research aims to answer is the need for a more user-friendly and accessible manner of connecting with a computer that does not rely on physical mouse devices. A virtual mouse controller based on computer vision and hand gestures can benefit anyone with physical restrictions or discomfort from using a normal mouse by resolving this issue.The method also has the potential to limit the spread of infections by eliminating the requirement for physical touch with shared computer equipment.

Keywords: *Virtual mouse control, hand gesture, Web service Discovery, computer vision, Image processing, user experience, and human-computer interface (HCI).*

1. Introduction

In Traditional mouse control techniques are no longer viable in today's technologically advanced environment. Instead, users can use virtual mouse systems to control their computers without a hardware mouse or touchpad. The goal of this project is to create a dynamic hand gesture-based interactive virtual mouse control system that uses more effective working algorithms to deliver gesture control with greater accuracy. Users using virtual mouse systems can control their devices while engaging in activities like yoga or physical exercise without the need for a surface.

To reach a high degree of accuracy and usefulness, the system discussed in this work combines numerous technologies, including Human-Computer Interaction (HCI), computer vision, and hand gesture detection. People with physical limitations who find it challenging to travel from one location to another can perform activities from their current position by employing hand gestures, which is processed by this system's hand gesture identification.

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By removing the need for physical contact, which has the potential to spread infections, a virtual mouse can be useful in the context of reducing infection , by providing a way to encourage remote usage of the computing device like mouse during circumstances like Covid.

Researchers have investigated several methods for comprehending gestures, including the use of depth pictures and skin color segmentation[1][2]. Md. Manik has assessed and examined the effectiveness of several hand gesture recognition techniques which include Template Matching PCA and KNN [5]. Grzejszczak has suggested a dynamic technique like image processing, feature detection and optical flow for following the position of a fingertip[3]. A. Haria has used techniques like Skin color segmentation, contour analysis along with the use of template matching to enhance the efficiency of the algorithms[1].

The focus of this research project will be on developing a virtual mouse control system that processes the dynamic hand gestures with greater efficiency. The study goes into considerable depth regarding the tools used to build a virtual mouse and boost the model's efficiency and accuracy, including Media Pipe, Open CV, and AutoPy. The article also contains multiple references to past studies on virtual mouse systems, demonstrating the rising interest that scientists have in these systems.

The first section concentrates on prior research on virtual mouse technology in the examination of the literature in

order to pinpoint gaps and provide prospects for progress.The second section of the research deals with the comparative research section where we examine current virtual mouse systems and assess their functionalities, efficacy, and user interface in various scenarios. The third section is entitled a "Methodology," where we describe our approach to develop a superior virtual mouse system by utilizing hand gesture technology for a variety of non-traditional mouse usage scenarios.

2. Literature Review:

Varun Sharma et al. and Aashni Hariaa et al.[1][2] mentioned several gesture recognition methods. Aashni Hariaa investigates the use of hand gestures for computer interaction in his study [1], while Varun Sharma presents an overview of the most cutting-edge techniques for gesture detection, including deep learning and convolutional neural networks (CNNs), in his paper [2]. It also covers a variety of approaches and procedures for hand gesture identification that include noise reduction, edge detection, smoothening, segmentation, and contour extraction algorithms and procedures.

Tomasz Grzejszczak et al. provide a novel way for monitoring fingertip locations during dynamic motions in video segments through the use of hand landmark identification and localization techniques [3].The author evaluates the capacity, repeatability, and accuracy of the approach using the various movements recorded on a USB camera.

S. Shriram et al. presented a deep learning-based real-time AI virtual mouse system that employs Deep learning, convolutional neural networks and Open Cv which contributed to prevent the spread of COVID[4]. The device offered a contactless method of mouse control by detecting hand movements and converting them into cursor movements using a hand gesture recognition model. The Python computer vision package OpenCV was used to construct a video capture object for the system, which is based on frames taken by a camera in a laptop or PC.

Md. Manik Ahmed et al presented a comparison of several hand gesture recognition approaches, encompassing the extraction and classification of algorithms in their article [5]. According to their study's findings, feature extraction and machine learning techniques may be used to increase identification accuracy and offer a reliable solution for HCI applications. It stated the difficulties in identifying hand gestures because of different things including orientation, illumination, complicated backdrops, and scale of gesture images. The report also discusses several approaches that have been created to solve these difficulties and evaluate their effectiveness.

Ranjeet Saroj et al. in their study on a virtual mouse employing color detection, employed color detection as a technique[6] which detected the user's hand via color filtering, and then followed that hand's motion to control the mouse cursor. It emphasized Human-Computer Interaction (HCI) by leveraging hand movements captured by a camera based on the color detection approach to control mouse cursor movement and click events. The project's goal was to offer a practical method for creating a virtual device for human-computer interaction.

Munir Oudah et al. reviewed many methods such as template matching, neural networks, and deep learning that helped in the identification of hand gestures using computer vision [7]. Their research also mentioned the drawbacks and restrictions of these techniques and presented a comprehensive review of computer vision-based hand gesture detection technologies that included skin tone, motion, skeleton, depth, 3D module, and deep learning.

Javeria Farooq and Muhaddisa Barat Ali have researched real-time hand gesture detection to identify motions and move the mouse cursor, they combined form analysis and skin color segmentation [8] . Convex hull, k-curvature, and perimeter curvature are three alternative methods for hand gesture detection that were examined in this work and the results of the experiments indicate that the perimeter's curvature is the most reliable strategy.

Siddharth S. Rautaray in a study proposed a real-time hand gesture identification system using computer vision algorithms and gesture recognition techniques [9].A central computing module that used the cam shift method to track hands and their actions made up the system. Using a Haar-like technique as a classifier, the positions of the hands were identified, and the gestures were categorised. Additionally, the number of defects that the prescribed motions caused in the hands was charted to determine how the gestures were classified.. The OpenGL library was used to create virtual objects.

The researchers created the hand gesture-based virtual mouse using computer vision and HCI (Human Computer Interaction) approaches for the implementation phase of the virtual mouse. OpenCV, an open-source computer vision framework was used to record photos from the camera and recognise hand motions then the hand motions were allocated to specific mouse actions, such as movement, left- and right-button clicks, double-clicks, and up- and down-scrolling. This method was tested on several users with a range of hand sizes and shapes to ensure its effectiveness and evaluation was done on the basis of precision and speed of their technology in comparison to a conventional mouse device. Vijay Kumar Sharma included a virtual mouse in the research [11] in which the system recognises hand gestures and converts them into mouse movements using machine learning techniques. It uses a camera as an input device. The author also mentions that

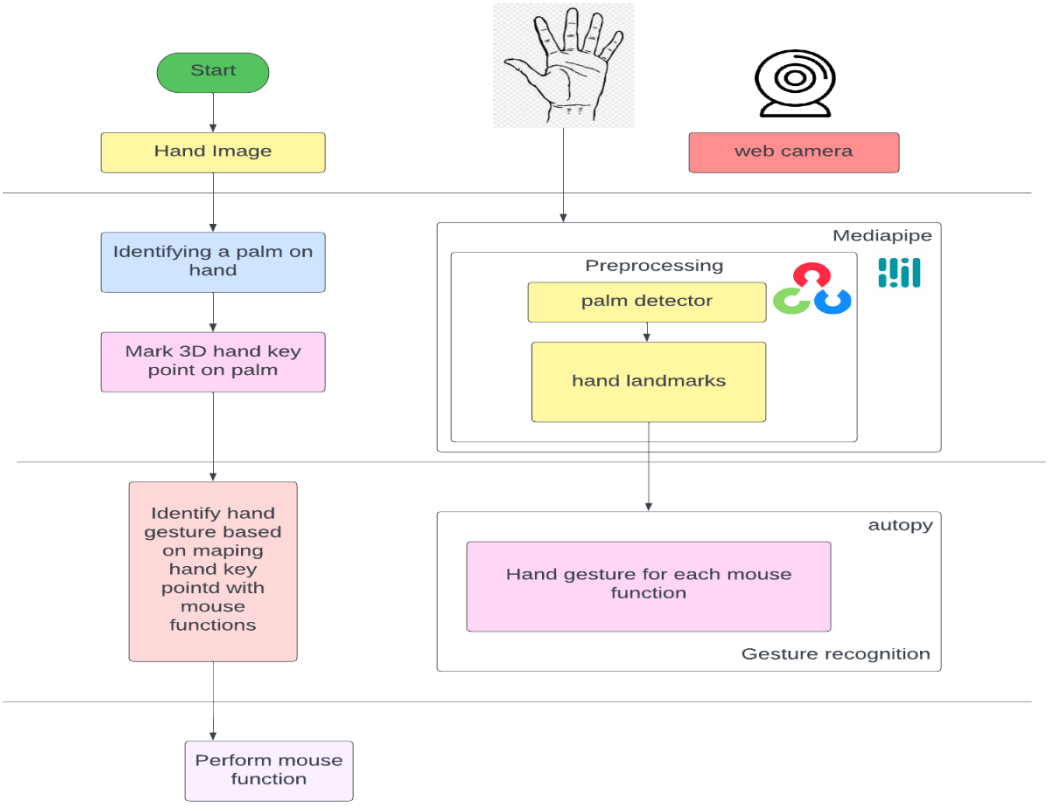
they constructed the system using Python and OpenCV and makes references to other related research articles that used various software platforms and libraries for similar purposes.

Other researchers, Kabid Hassan Shibly et al.[10], G N Srinivas et al.[12], and Dinh-Son Tran et al.[13] also investigated the use of hand gesture detection for virtual mouse control by tracking and detecting the hand motions using methods including fingertip detection and RGB-D picture processing.

Virtual mouse systems that can recognise and track hand motions in real-time have been designed using methodologies such as deep learning and computer vision-based technologies. These technologies are might prove to be helpful when cleanliness is a problem since they can provide a frictionless and affordable mouse control option. Orientation, illumination, and complicated backdrops are to be addressed so as to increase the precision and durability of these systems.

3. System Design :

The term "System Design", refers to a systematic approach or a set of actions, strategies, and tools used to carry out research, deal with problems, or achieve certain objectives. It covers the steps or methods used to gather, analyse, and utilise data, along with the steps taken to make decisions or take action based on that data. The methodology is commonly used in academic research, scientific experimentation, business analysis, and other fields where a structured and exacting approach is needed to get reliable findings.



Architecture design

3.1. Research Design for the virtual mouse implementation

A crucial element in the development of a virtual mouse is the processing and interpretation of data acquired by technology tools like MediaPipe, OpenCV, and Autopy. The steps of the data analysis process include data preparation, data exploration, user behaviour analysis, error analysis, and effectiveness evaluation. The organisation, cleansing, and formatting of the obtained data constitute the initial stage of the data analysis process, sometimes referred to as data preparation. With the help of this process, the data is presented in a form that makes it easy to analyse and understand. In the second step, known as data exploration, the collected data is examined to discover trends, patterns, and insights. This step may be finished using methods including data mining, statistical analysis, and visualisation.

The virtual mouse controller method employs Python, Autopy, and Mediapipe together with OpenCV to capture and analyse live video frames from a camera. The hand is identified and tracked using Mediapipe's hand tracking model. The hand landmarks are then used to identify the hand's position and motion. The mouse cursor on the screen is moved using Autopy in accordance with the user's hand gestures. To avoid unintentional cursor movements caused

by hand tremors, a moving average filter is used to smooth the cursor's motion. Numerous technologies must be incorporated into the approach in order to provide hand gesture-based control of the mouse cursor on the screen. The virtual mouse is implemented using Mediapipe, OpenCV, and Autopy software tools. Mediapipe provides pre-trained models for the purposes of recognising hand landmarks and tracking a user's hand location. Use the computer vision library OpenCV for real-time tracking and hand detection.

3.2. Data Collection Methods for the Implementation of virtual mouse

Data collection is a crucial initial step in the creation of a precise and reliable system. A range of data-collection methods, including human annotation, image segmentation, and tracking, may be used to create a virtual mouse. Manual annotation is the technique of manually annotating screenshots or videos of mouse and hand gestures. This approach requires a lot of time and expertise to appropriately identify the data. The process of segmenting a picture or video involves eliminating the hand and mouse from the background. This method can be fully automatic, using computational techniques to segment the image, or semi-automatic, allowing the user to select the region of interest. During tracking, the hand and mouse gestures in the videos are observed. For this approach to correctly monitor the hand and mouse movements, tracking algorithms must be used.

3.3. Image Processing using OpenCV

Real-time hand gesture recognition may be accomplished using the tools and methods provided by OpenCV[14]. To do this, video frames are preprocessed after being shot to identify and separate the hand from the backdrop. To identify certain hand motions, the region of interest is then excised and subjected to several analyses, including contour, convex hull, and convexity defects. Due to their precision and speed, Haar cascades are widely utilised for real-time hand gesture identification, however deep learning-based techniques provide even better accuracy at the expense of additional processing power. Once the hand motion has been identified, the user may view the outcome in real time by using OpenCV to create a bounding box, overlay a message, or initiate an action after the result has been determined. Real-time hand gesture recognition has applications in gaming, virtual reality, assistive technology, and robotics. It calls for effective algorithms and techniques that can process video frames quickly and accurately in real time, as well as a balance between accuracy, speed, and latency.

3.4. Hand Tracking and Gesture Recognition using MediaPipe

A cross-platform framework called MediaPipe was developed by Google. It provides pre-built pipelines and building blocks for developing various computer vision and artificial intelligence applications, including the installation of a virtual mouse. MediaPipe's Hand Tracking solution is highly beneficial in the installation of a virtual mouse since it provides a trustworthy and accurate hand-tracking model that can recognise and track the actions of the hand in real time[15]. Using a mix of deep learning and computer vision techniques, the hand is located in the image or video, and in this method, its motions are monitored together with gesture identification. In addition, MediaPipe provides other building blocks for the development of virtual mouse, such as object identification and location estimation. By utilising MediaPipe's built-in solutions and building blocks, developers may save time and effort when developing their own hand tracking and other computer vision models, which can be challenging and time-consuming to implement. Moreover, this framework enables a high degree of accuracy and robustness even in challenging lighting and background circumstances. MediaPipe's modular design makes it possible for programmers to change and combine its component parts to create a complete virtual mouse system that meets specific user requirements and use cases. Overall, MediaPipe provides a robust and flexible framework for developing virtual mouse systems with pre-made solutions and foundational components that speed up development and improve hand tracking and gesture recognition reliability and accuracy.

3.5. Controlling Mouse movements and mapping them with gestures using AutoPy

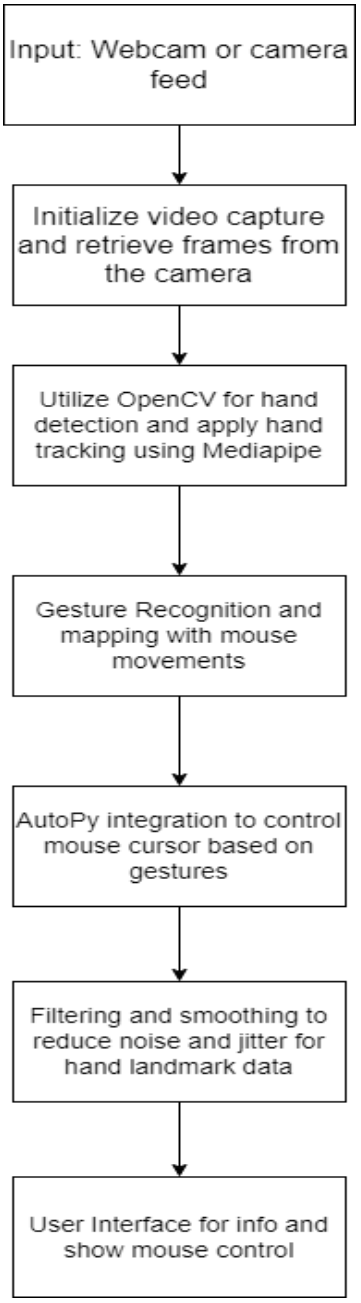
The Python module provides AutoPy, a simple and user-friendly interface for controlling a computer's mouse and keyboard.[17] It is widely used in virtual mouse implementation to simulate mouse movements and clicks based on hand-tracking data obtained from a camera or other input devices. To control mouse movements and clicks, the library may use a hand-tracking model. Since the hand's position in a photo or video corresponds to the mouse's placement on the screen, the user may move the mouse pointer by moving their hand. Hand gestures can be used to mimic mouse clicks. The virtual mouse solution's use of AutoPy delivers simplicity, convenience, and adaptability. The library's mouse and keyboard control interface makes it simple and easy to develop virtual mouse capabilities, and it does so without the use of complicated code. It is possible to create virtual mouse programmes that work on a variety of hardware and platforms thanks to the cross-platform functionality of the AutoPy library, which is compatible with many different operating systems. The Autopy functionality enables the modelling of mouse gestures and clicks. With the use of hand motions, users will be able to control the mouse cursor using a virtual mouse created with the help of this library. This can be especially useful for people who have impairments or for applications that need hands-free computer use. The virtual cursor is a graphic that

displays the current location of the mouse on the screen. It alters in response to input from the user and choices made by the control logic.

3.6 Data Analysis Methods for the virtual mouse control System

Data analysis enables programmers to use hand-tracking data to drive the virtual mouse, hence it is crucial to the creation of the virtual mouse. Some of the often employed techniques in data analysis for the virtual mouse include statistical analysis, signal processing, image processing, machine learning, and statistical analysis. For virtual mouse data analysis, processing and analysis of hand-tracking data from the camera or other input devices are needed. This information may include the hand's position in the image or video, its motions, and other relevant details. A broad spectrum of data processing and analysis techniques are employed to extract useful information from the data and use it to control the virtual mouse during analysis. Three different data analysis methods are used in the creation of the virtual mouse: statistical analysis, signal processing, and image processing. Using statistical analysis, the pattern of distribution of the hand tracking data may be studied, and patterns and trends in the data can be discovered. Signal processing techniques can be used to filter and alter the raw hand-tracking data in order to extract information that is useful. Using image processing techniques to enhance the quality of the hand-tracking data can raise the accuracy of the hand-tracking model. Error analysis is a vital step in the data analysis process. The objective at hand at this point is to analyse the user errors that happened when utilising the virtual mouse programmes. Developers may improve the usability and functionality of the virtual mouse software by pinpointing the most common errors, their root causes, and viable solutions. Finally, performance evaluation involves using the collected data to assess the operation of the virtual mouse software. Evaluation of the efficacy of multiple software versions or the outcomes of software change assessments may be required at this point.

Algorithm



4. Comparative Analysis:

Paper	Technologies Used	Limitations	Accuracy
[1] Haria et al. (2017)	Skin color segmentation, contour analysis, template matching	Limited gesture recognition, sensitivity to lighting conditions	90% accuracy
[2] Sharma et al. (2023)	Deep learning, convolutional neural networks, OpenCV	Requires large amounts of training data, high computational complexity	96.5% accuracy
[3] Grzejszczak et al. (2020)	Image processing, feature detection, optical flow	Limited to static gestures, sensitive to lighting conditions	87.2% accuracy

[4] Shriram et al. (2021)	Deep learning, convolutional neural networks, OpenCV	Limited to mouse emulation, requires a stable background	95.6% accuracy
[5] Ahmed et al. (2019)	Template matching, PCA, KNN	Limited to static gestures, sensitivity to lighting conditions	83% accuracy
[6] Saroj et al. (2018)	Color detection, image processing, contour analysis	Limited to basic gestures, sensitivity to lighting conditions	78.6% accuracy
[7] Oudah et al. (2020)	Deep learning, convolutional neural networks, OpenCV	Requires large amounts of training data, high computational complexity	97.5% accuracy
[8] Farooq & Ali (2014)	Image processing, feature detection, PCA, KNN	Limited to static gestures, sensitivity to lighting conditions	82.7% accuracy
[9] Rautaray & Agrawal (2012)	Image processing, feature detection, template matching	Limited to basic gestures, sensitivity to lighting conditions	75% accuracy

In summary, different technologies were used in these papers to recognize hand gestures, including depth sensors, RGB cameras, deep learning, and computer vision techniques. Each technology has its advantages and disadvantages, and the choice of technology depends on the application's requirements. Overall, the results show that these technologies can achieve high accuracy in recognizing hand gestures in real-time or real-world scenarios.

5. Results and Future Scope:

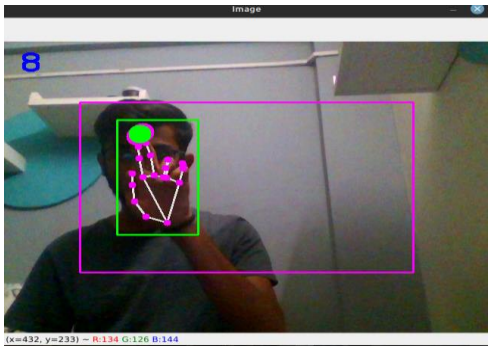
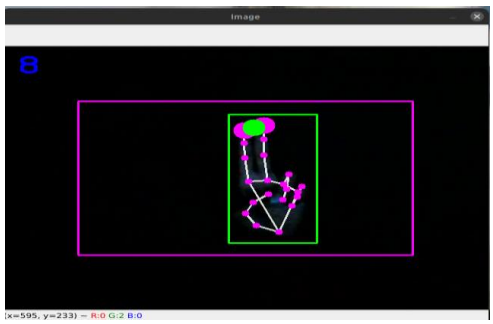
Results

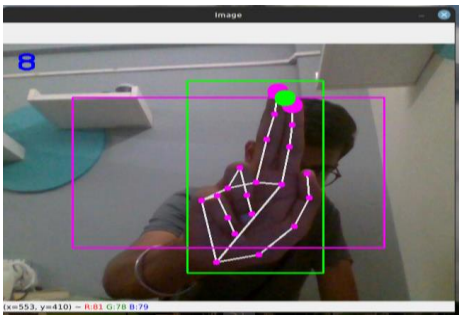
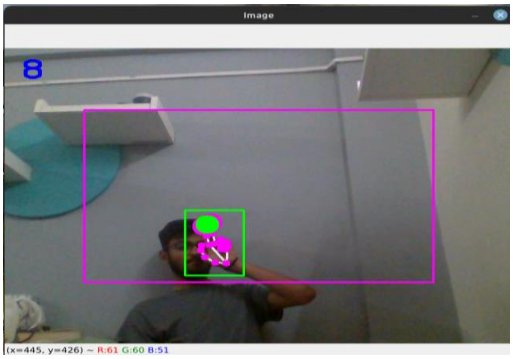
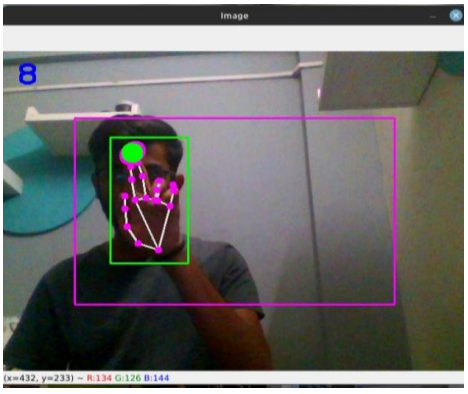
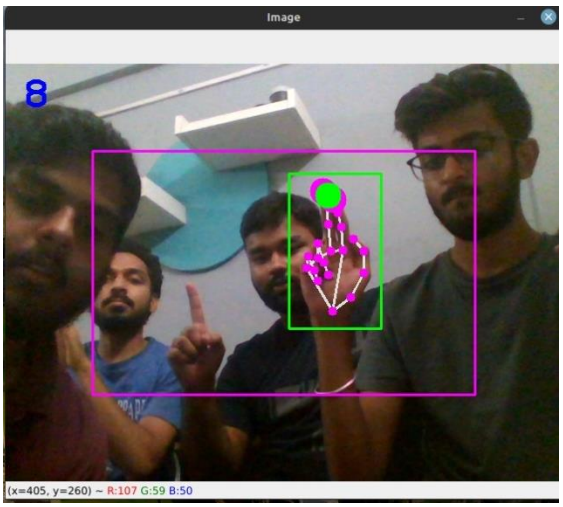
Sample Input	Fingertip Captured	Action Performed
	One Fingertip	Navigation of the cursor on the screen is performed.
	Two Fingertips	Right clicking operation is performed when both the fingertip touch.

	Three Fingertip	Left click function is stimulated using this gesture.
	Zero Fingertip	Drag operations are performed using this action in the screen.

Performance in different environment

There were different observations when our virtual mouse system was tested on different working environments like varying brightness or intensity of surrounding lighting, distance between the user and the computer screen, and the multiple users in present in front of the computers screen.

Different Environment	**Observation in the fingertip detection**
 **Normal Lighting Intensity**	Under the normal light intensity fingertip were detected correctly for all the time. (almost 92%).
 **Low lighting intensity**	During the darker or low light conditions, the fingertip detection efficiency reduced to 70%.

 **Normal Distance between camera and fingertip**	The fingertip detection was correctly processed by the system when the user's hand were at an optimal distance from the camera.
 **Distance more than 15 cm from the camera**	The finger tips were still correctly captured by the camera for the user's hand beyond 15 cm from the camera.
 **Single user in front of the camera**	In case of a single user, our system captured the fingertips accurately and was providing better efficiency(>90%).
 **Multiple users in front of the camera**	When multiple users were present in front of the camera, the virtual mouse system was not able to focus on a single user's fingertip i.e. the system switching its focus from one user's fingertip to another.

Experimental Results:

Gesture	Fingertip Involved	Fingertip Detected	operations performed	Successful Operations	Accuracy(%)
Cursor Movements	1	1	500	470	94
Right Click	2	2	500	405	81
Left Click	3	3	500	423	84.6
Drag	0	0	500	447	89.4

Total Accuracy= 87.25%

Future Scope

The virtual mouse we created has a very broad future potential. The incorporation of more sophisticated gesture detection methods might be one of the primary areas for improvement and might make it possible for even more accurate and effective mouse control. Additionally, incorporating machine learning techniques may improve gesture identification precision and decrease false positives. Incorporating the usage of other input devices, such as voice or eye-tracking, might be another avenue for research to provide users even more accessibility and flexibility.

A virtual mouse system may offer certain advantages and breakthroughs, but it also has some drawbacks. The requirement for a camera or other sensing device to follow hand motions, which may only occasionally be practicable or accessible, is one of the key restrictions. Lighting circumstances, hand position, and movement might all have an impact on the system's accuracy and consistency. Additionally, certain users, including those with physical limitations, may find it challenging to make particular movements. The virtual mouse system's overall usability and efficacy may be enhanced by addressing these drawbacks.

Now for the application part, many come to mind, some of them are listed below:

1. Accessibility: For those with impairments who are unable to operate a physical mouse, a virtual mouse may be a fantastic tool. They may use simple hand motions to operate a computer or other technological equipment.
2. In order to provide customers a more realistic and participatory gaming experience, virtual mice can be utilised in place of conventional gaming controllers.
3. Users can engage with the virtual world in virtual reality by making hand motions. In order to manage the user's interactions, a virtual mouse might be a helpful tool.
4. Medical Industry: By removing the need for direct physical touch with the computer or device, utilising a virtual mouse in surgical procedures can assist maintain a clean atmosphere.
5. Education: A virtual mouse may be utilised in classrooms to improve hands-on learning activities like virtual laboratories and simulations.
6. Design and Creative Industries: To enable accurate command and control of digital art and graphics, virtual mice can be employed in the design and creative industries.

6. Conclusion

An effective and user-friendly technology that enables numerous mouse activities including clicking, dragging, and scrolling by simple hand movements is a virtual mouse operated by hand gestures. Because it eliminates the need for a real mouse and allows for a hands-free experience, this technology is both convenient and accessible. People with mobility or disability may find it helpful. However, there are several restrictions that must be taken into account, such as the requirement for appropriate backdrop and lighting circumstances and the system's sensitivity to hand motion recognition, which can result in mistakes. These restrictions imply that virtual mouse solutions might not be appropriate for all users and settings. However, with more study and development, computer vision techniques may be used to enhance the system's accuracy[1]–[19] and resilience, making it a useful supplement to already-existing computer input devices. Thus, Virtual Mouse Control System is discovered through web services.

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