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Design and Implementation of Hand Gesture Based Virtual Mouse

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Abstract:

Since the invention of computers, there has been a dramatic shift in the method of creating contact between computers and people. The mouse is one example of a groundbreaking invention in HCI. The wireless or Bluetooth mouse is only one example of how these technologies continue to rely on supplementary hardware. For instance, a Bluetooth mouse may need a connecting dongle in addition to batteries. Such gadgets may be less user-friendly due to the need of these additional components. In this study, we provide a virtual mouse technology that solves these problems. Computer vision and hand gestures are the backbone of the proposed system, which is based on HCI concepts. Using methods such as color segmentation and detection, the onboard camera or webcam may pick up on gestures. Players control the cursor's movements—left click, right click, double click—and scroll up and down using precise hand motions by donning colorful caps on their fingers. The system uses the camera to record video frames, analyzes them for tracking, and then uses the user's motions to control the mouse. This virtual mouse system contributes to developments in HCI technology by offering a device-free alternative to actual gadgets, thereby reducing dependency on them.

Keywords: HCI (Human-Computer Interaction), HSV (Hue Saturation Value), Hand Gesture, Color Detection, Gesture Recognition.

Introduction

Devices are becoming smaller and smaller as technology advances daily. Some gadgets have gone wireless, while others have gone dormant. The future of human-computer interaction (HCI) is proposed in this study, which involves a technology that might cause some gadgets to lie dormant in the future. A virtual mouse that recognizes and responds to hand gestures is the proposed product. The goal is to eliminate the need for a conventional mouse by controlling the cursor functionalities using a basic camera. With only a camera, the Virtual Mouse can bridge the gap between user and computer. The user is able to operate mouse operations and communicate with a computer without the need for mechanical or physical devices thanks to this. By using a webcam or in-built camera with a colored cap or colored sticky note paper, this gesture recognition system can easily catch and follow the fingertip of a hand, allowing the system to follow the hand's movement and color as it moves the cursor. The majority of our interactions with computers take place via small peripherals like a mouse, keyboard, and the computer itself. In this study, the user's bare hand is the only input option utilizing a camera; nonetheless, the wireless devices do need a power supply and connection technology. This method of controlling the mouse pointer is, therefore, very interactive. The OpenCV library, which is based on computer vision, is used to construct this system in the Python programming language. Both the standard mouse and the remote control of machines might be supplanted by this method. The lighting situation is the only obstacle. Because most people use their computers in dimly lit rooms, the technology will never be enough to replace the conventional mouse. Section A. Problem Statement and Synopsis The camera has to be placed so that it can observe the user's hands in the correct locations in order to detect fingers as a moving object and use it for mouse functionalities. For patients without limb control, in tight quarters, or in similar circumstances, this may be a lifesaver. It's not a real mouse at all; rather, it's a virtual one that follows your colorful fingers and camera frames. The Importance in Practical Settings (B) Nowadays, video conferencing is all the rage. This is why the most majority of laptops come equipped with a camera, and why the vast majority of computer users use one. One possible benefit of the suggested webcam-based system is that it might reduce or do away with the requirement for a mouse altogether. A fascinating and successful method of human-computer interaction is the technique of interacting with a computer by hand gestures. This curiosity has been the subject of some excellent studies. Sign language recognition also makes use of hand gesture recognition technologies. Part C: Goal The goal is to come up with a different way to manipulate the mouse and put it into action. Another option is to use a camera and a color detection technology to recognize hand gestures. A system that can detect hand gestures and utilize them to control the mouse cursor using a color detection approach on any computer is the end goal of this article.

Related Work on This Theory

There are a lot of uses for hand gesture applications that control cursors, however a DataGlove is usually required. Because of this, the user-system performance is diminished. Additionally, the complexity of the system is a factor in this procedure. One approach to human-computer interaction (HCI) gesture detection might rely on hardware, while the other could use computer vision. Quam (1990) suggested a hardware-based solution that required the user to wear a cumbersome DataGlove [1]. While this technology provides precise control, it is not only impractical for daily usage by the masses but also rather difficult to master due to the fact that not everyone can utilize the same gestures. Both marker-based and non-marker based vision-based hand gesture recognition exist. As a rule, recognition that does not use markers is less accurate than recognition that does. Even if the user is limited to just a basic colored hat on their fingertip, maker-based recognition outperforms competing gesture recognition systems in terms of accuracy. However, as compared to the DataGlove of the hardware-based system, this method is much lighter and hardly noticeable. One possible future for computers to comprehend human gesture (Body Language) is gesture recognition. Rather of relying just on text, it will enable more complex interactions between humans and computers. For tracking, the majority of marker-based gesture recognition mice use a minimum of two colored markers. During performance, the system experiences slowdowns and lags caused by detecting different colors. Based on an adaptive skin color model and a motion history image (MHI), ChenChiung Hsieh and Dung-Hua Liou presented a paper titled "A Real-Time Hand Gesture Recognition System Using Motion History Image" [2] in 2010. They used a technique for detecting the direction of hand movements in motion history images and an adaptive skin color model in their study. An issue with working for more complex hand gesture recognition is the primary restriction of the article. An article titled "A Human-Machine Interaction Technique: Hand Gesture Recognition Based on Hidden Markov Models with Trajectory of Hand Motion" [3] was published in 2011 by Chang -Yi Kao and Chin-Shyurng Fahn. The work essentially discusses learning-based interaction between humans and machines. Though it was only compatible with high-end PCs, their work is spot-on. A viable gesture recognition framework for use in various real-time human-computer interaction applications was suggested in a 2013 article by Angel, Neethu. P.S., titled "Real Time Static and Dynamic Hand Gesture Recognition" [4]. On the other hand, it needed bright light to compute and failed miserably when used against complicated backgrounds. A machine-user interface that incorporates hand gesture recognition via the use of basic computer vision and multimedia methods was suggested in a 2013 work by Ashwini M. Patil, Sneha U. Dudhane, and Monika B. Gandhi, entitled "Cursor Control System Using Hand Gesture Recognition" [5]. However, a significant constraint is that skin pixel recognition and hand segmentation from stored frames must be accomplished prior to interacting with gesture comparison algorithms. Hand gestures were captured using a camera based on color detection technology in a 2014 work titled "Mouse Control using a Web Camera based on Color Detection" [6] by Abhik Banerjee and Abhirup Ghosh. One restriction of their work is that there can't be any brightly colored things or a very dark working backdrop. On certain high-configuration machines, it works well. By directly extracting fingers from prominent hand edges, Yimin Zhou, Guolai Jiang, and Yaorong Lin published "A novel finger and hand pose estimation technique for real-time hand gesture recognition" [7] in 2016. Segmenting and describing the hand posture based on the finger positions, palm center placement, and wrist position takes into account the geometrical properties of the hand. However, this strategy is incompatible with low-end computers. Based on several color bands where various colors do distinct operations, "Cursor Control using Hand Gestures" [8] was created by Pooja Kumari, Saurabh Singh, and Vinay Kr. Pasi in 2016. The key to performing mouse tasks is the quantity of colors. The system, however, was controlled by means of a variety of colors. Instead than using various movements, it relies on the amount of colors to accomplish a task. Based on a technique for detecting contours and extracting backgrounds, "Hand Gesture Recognition for Human Computer Interaction" [9] was created in 2017 by Aashni Haria, Archanasri Subramanian, Nivedhitha Asokkumar, Shristi Poddar, and Jyothi S Nayak. However, it is somewhat sluggish to manipulate. A study titled "Virtual Mouse Using Hand Gesture" [10] was published in 2018 by Abhilash SS, Lisho Thomas, Naveen Wilson, and Chaithanya C. The article was created to operate with a color detecting system and is based on the amount of colors detected. However, it is background-dependent and can only execute a limited set of mouse operations.

Methodology

Each component of the proposed system is detailed independently in this study.

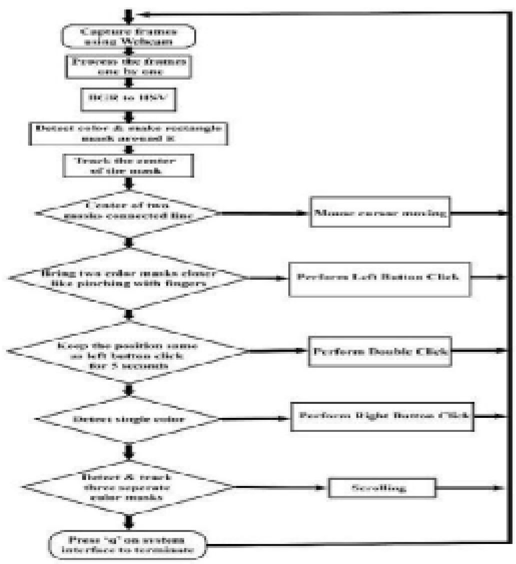


Fig. 1. Flowchart of The Methods of Gesture Based Mouse

Camera

Frames captured by a webcam or a laptop's integrated camera are used to run the system. A video capture object is initialized so that the system can handle webcam input in real-time. By setting the device index to "0," we may use a single camera in this configuration. You may progressively adjust the device indices to 1, 2, and so on to connect more cameras. The camera takes a series of pictures and sends them all to the computer for processing.

B. Capturing

The camera records every frame until the program ends by using an endless loop. The color space of the real-time video frames is converted from BGR to HSV.

C. Color Detection & Masking

According to the proposed method, color identification is accomplished by analyzing the webcam's recorded frames for the colored pixels of capped fingers. This is the first stage in constructing the suggested system. In the end, you get a grayscale picture where the color cap stands out from the background thanks to pixel intensity. The next step in monitoring the color cap is to construct rectangular bounding boxes (masks) around it. When the location of these color caps is tracked upwards, the motion is recognized and the scrolling action is performed. The color caps' location and coordinates are updated as the user moves up or down the screen with three fingers. Scrolls are executed once all three color caps get updated coordinates. It will scroll down if the values of their y coordinates go down and up if the values go up.

Gesture Recognition

Mouse Actions The first step is to determine the exact location of the intersection of two objects with matching colors using the coordinates of the detected rectangle's center. Utilizing the built-in OpenCV function, we can draw a line connecting two points, and the following equation may be used to get the midpoint:

$$M = \left(\frac{Xa+Xb}{2}, \frac{Ya+Yb}{2}\right) \quad (1)$$

To keep the mouse cursor on this midway, you may think of it as a tracker. This method converts the coordinates from the resolution of the camera-captured frames to the resolution of the screen. An open gesture occurs when the mouse cursor reaches a predetermined spot; the mouse then begins to operate at that area. The user may control the movement of the mouse cursor in this way. Part B: Clicking the Mouse Click events are handled by the proposed system using close gestures. The tracking bounding boxes form a new bounding box as two rectangles' edges approach each other. At 20% of its initial size, the system triggers a left-button click, allowing the user to click on the newly-created bounding box. To double-click, the user must keep their finger at this spot for at least five seconds. It also makes advantage of the open motion to click the right button again. Just one finger is all that's needed to click the proper button. After identifying the color of one fingertip cap, the system will click the correct button. Scrolling with a Mouse The user may scroll using this technique by making an open motion with three fingers and colored caps. Users may scroll down by bringing their three fingers together and moving it to a downward position. Similarly, it will scroll up if its position is adjusted to upwards. The color caps' location and coordinates are updated as the user moves up or down the screen with three fingers. Scrolls are executed once all three color caps get updated coordinates. It will scroll down if the values of their y coordinates go down and up if the values go up.

Result & Evaluation

We have used computer vision and Human Computer Interaction (HCI) in this study to make a contribution to future vision-based machine-human interaction. The topic of the proposed article is the use of hand gestures to control mouse functionalities. Up and down scrolling, left and right button clicks, double clicks, and mouse movement are the primary controls. With this method, consumers have the option to choose from a variety of colors. Based on the backdrops and lighting circumstances, users may choose any color from the established color ranges. In other contexts, this may look different. For instance, the system offers a color picker with options for Green, Yellow, Red, Blue, and two more when the user begins it. Either the user must choose a color that stands out against the backdrop or select a color that blends in with the existing backdrop.

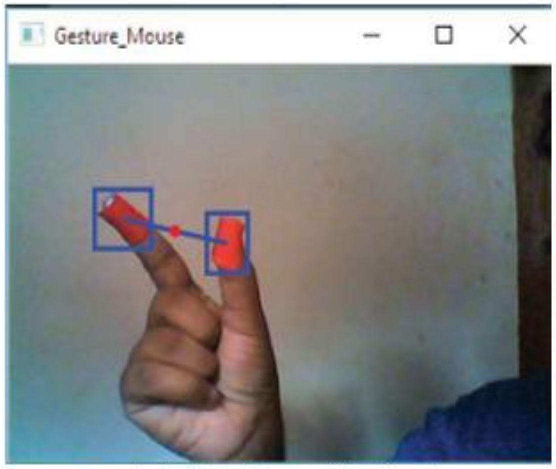


Fig. 2. Mouse Movement (Open Gesture)

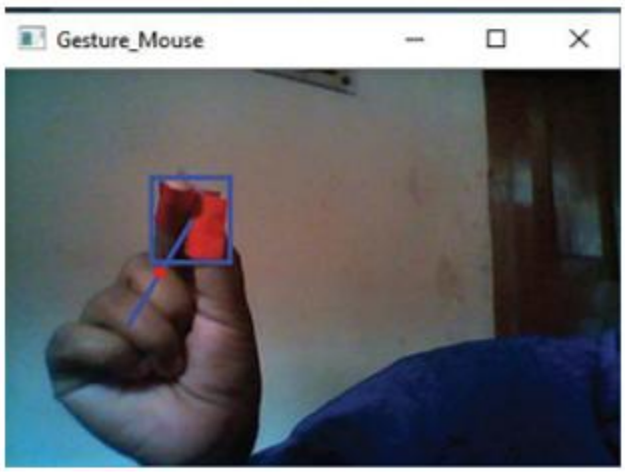
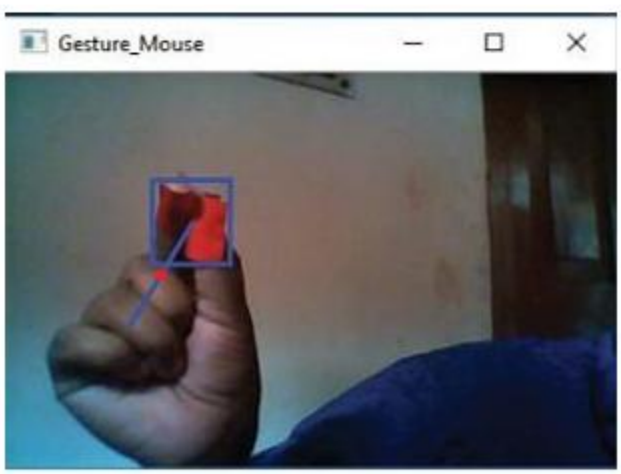


Fig. 3. Left Button Click (Close Gesture)



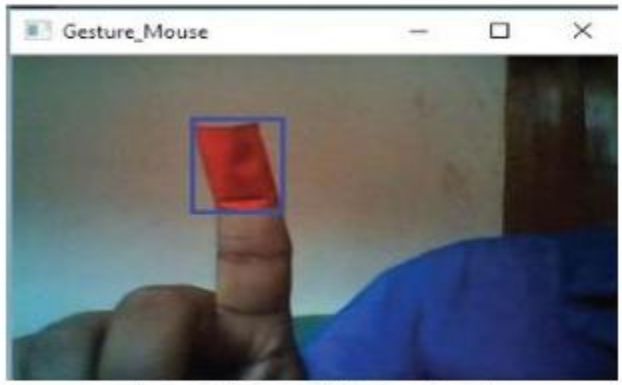


Fig. 5. Right Button Click (Open Gesture)

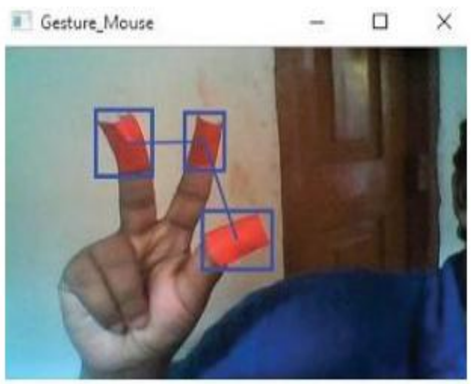


Fig. 6. Scrolling Up & Down (Open Gesture)

A simple backdrop is used for these tests. Both the speed and accuracy range from seventy-eight to ninety percent. Also included in the testing are a variety of complicated backdrops, such as checkered shirts, bright t-shirts, complex house backgrounds, indoor daylight settings, fluorescent lighting, etc. (although though the majority of people use computers while sitting at standard shirts or t-shirts), and so on. An accurate evaluation of these occurrences is shown in a table.

TABLE I. MOUSE EVENTS & EVALUATIONS

Gesture Input	Evaluation		
	Mouse events	*Accuracy with plain background (in %)*	*Accuracy with complex/ non-plain background (in %)*
Two color caps (Open Gesture)	Mouse Movement	91	41
Closer two color caps (Closed Gesture)	Left Button Click	88	40
Keep closer for 5 seconds (Closed Gesture)	Double Click	87	42
Single color cap (Open Gesture)	Right Button click	95	79
Three color caps (Swipe Up/Down)	Scrolling up or down	78	40

On such a complicated and uneven backdrop, the system's inefficiency becomes immediately apparent. However, as compared to other systems that employ gestures to operate the mouse, ours is noticeably quicker. Using a high-definition camera may improve this precision. The data in the table are derived from the Video Graphics Array (VGA) camera that is integrated inside the laptop. This system was built for Windows, but it's possible that Linux or Mac OS X could provide better results than Windows in some situations.

TABLE II. COMPARISON WITH EXISTING SYSTEMS

Existing methods	Comparison		
	Recognized Gestures	*Average Accuracy (in %)*	*Control Type (Static/Dynamic)*
Color tracking & counting[8]	Five (05) : Mouse Movement, Left Click, Right Click & Double Click etc.	Not Available	Dynamic
Finger & palm tracking[9]	Seven (07) : Opening Media Player, Web Page, Launching Powerpoint etc.	78	Static
Color masking & pinchflag [10]	Three (03) : Mouse Movement, Left Button Click, File Transfer	Not Available	Dynamic
Our proposed method	Five (05) : Mouse Movement, Left Click, Right Click, Double Click, Scrolling	78	Dynamic

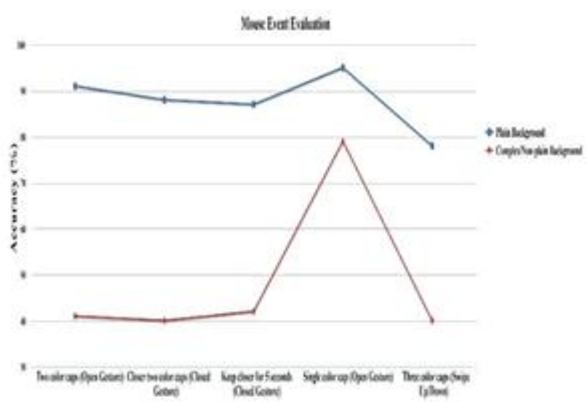


Fig. 7. Mouse Event Accuracy (%) Evaluation

Application

This project is useful for presentations and reduces the need for extra hardware devices and workspace. The technology is dependable and provides a more smooth experience than other current computer interaction systems, even in high-stakes circumstances like battlefields or operation theaters. An improved and more intimate relationship between the user and their workstation is achieved by doing away with the need for additional devices.

Major applications:

- One of the main uses for this technology is commanding robots. It may be a great complement to this technology to be able to control robots without machinery or other equipment.

- This gesture-based mouse allows digital artists to create 2D or 3D drawings on digital canvases. Artists will have greater room to move and more flexibility to express themselves. A battlefield, operating room, or mining field are all examples of crucial events that may be managed with a motion mouse.
- You can play VR/AR games more easily with only your bare hands, without the need for any additional accessories or wires.
- This technique may be quite helpful and successful for people who do not have control of their limbs.
- The deaf and dumb may use this mouse technology to communicate using sign language. They may use it to better communicate with computers.

Conclusion

A system that uses a webcam to control the mouse pointer and its actions is known as a virtual gesture control mouse. Included in our solution are the standard mouse actions—left click, right click, double click, and scrolling—as well as the ability to pick icons. The system utilizes image comparison and motion detection technology to facilitate cursor movements and icon selection. The results prove that the algorithms work well with sufficient illumination and a high-quality camera. Future improvements to the system will include support for multi-window interaction, window resizing, and shutting using palm and multiple finger gestures.

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