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Virtual System Control Using Hand Gestures

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Abstract

As the technologies are developing day by day the devices are gradually becoming compact in size. Some devices have gone wireless, some of them gone latent. This project proposes a system that could make some of the devices go latent which is the future of HCI (Human-Computer Interaction). Our paper deals with controlling the cursor pointer with the bare hands using hand gestures without using any electronic device either wired or wireless. The operations of mouse like left click, right click, cursor pointer movement, scroll up and scroll down functions will be manipulated and processed using bare hands different gestures.This project advances a methodology for the next generation of Human Computer Interaction (HCI) in which the system can be taken into control by using mouse cursor movement which in turn will be controlled by making use of a live camera using hand gestures. The methodology we have presented is an advancement to the present strategy which includes wired mouse and wireless input devices like mouse and keyboard. Our system with the help of computer vision technology makes use of a camera to take control of the system using mouse events and is apt for performing tasks that a physical computer mouse can do. This system will get into control of the user with the help of their hand gestures by manipulating real-time images from the live stream, where the frames will be processed for gesture mapping in pattern finding. It's an immediate process and the cursor in the desktop will immediately move.

Key words: Human Computer Interaction, system control, mouse, camera control, covid, omicron.

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1. Introduction

A mouse in a computer system, is an input device that helps us to take control of the system. It is a pointer known as cursor that helps us in tracking the control pointer of the system in the Graphical User Interface (GUI). Since the evolution of the mouse there were different types starting from the rubber ball mouse to optical laser mouse and then from wired mouse to wireless mouse.

Even after the evolution of wireless mouse or bluetooth mouse, it still depends either on a battery to run or requires a bluetooth connection to stay connected. Next to it, there came the touch screen which was a boom in the fields of Human Computer Interaction. But the

prices of touch screen systems were very steep. Therefore a virtual interaction mode giving an alteration to the physical mouse or a very steep touch screen device is suitable for the upcoming era of the next generation Human Computer Interaction. This device which is the webcam will be constantly utilized by the software that monitors the hand gestures given by the user in order to process it and translate to cursor pointer, as similar to a physical mouse.

Objective

The main objective of the Virtual System Control is to develop a replacement for the wired and wireless mouse system to perform and control the mouse functions. This outcome can be accomplished by using a web camera that captures the live-stream of hand gestures and hand tips and then manipulate these frames to perform the distinct mouse function such as left click, right click, and scrolling functionalities.

Literature Review

Related works in the field of virtual mouse using hand gesture system was carried out by using color tips in the hands for recognition, but the accuracy of the system seems not be equal with the physical mouse, because of the failure in color tip detection. Efforts have been made for camera-based detection of the hand gesture for system control.

"A Real-Time Hand Gesture Recognition System Using Motion History Image" is a study proposed by Dung-Hua Liou, ChenChiung Hsieh, and David Lee in 2010[1]. The main limitation of this study is to handle more complex hand gestures.

A study proposed by Monika B. Gandhi, Sneha U. Dudhane, and Ashwini M. Patil in 2013 on "Cursor Control System Using Hand Gesture Recognition"[2] has the limitation of processing hand segmentation and skin pixel detection.

Vinay Kr. Pasi, Saurabh Singh, and Pooja Kumari in 2016 [3] made a study on "Cursor Control using Hand Gestures". The system proposes to process different mouse functions using various color bands.

Chaithanya C, Lisho Thomas, Naveen Wilson, and Abhilash SS in 2018 [4] proposed "Virtual Mouse Using Hand Gesture" where the model detection is based on colors. But, only few mouse functions are performed.

Algorithm used for Hand Tracking

To take control of the system we make use of hand gestures and for detecting such we go for a framework developed known as MediaPipe.[5-6] We also make use of OpenCV library which helps us in manipulating and processing computer vision techniques[7]. The developed algorithm is built with the help of machine learning and artificial intelligence tools to follow and identify the hand gestures and finger tips[8-9].

MediaPipe:

MediaPipe is an open source framework built by Google, that was specially developed only for Machine Learning techniques and implementation. Since the framework uses time series data it is probably preferred for cross platform development. Being multimodal, this framework can be extended to various audio and video application developments [5]. The

pipeline configuration below gives out a picture and a clarity on how the system uses MediaPipe, irrespective of mobile or desktop platform allowing scalability. There are three basic and fundamental units in the MediaPipe framework, they are performance evaluation, framework for retrieving data, and a collection of components known as called modules [6], which can be reused. A pipeline in mediapipe is usually a graph which contains basic units called modules, in which each module is in contact with other modules for data flow. We will be able to redefine or place custom and userdefined modules, in the pipeline for building our own product. The modules and streams combined will become a data-flow diagram; the graph (Figure 1) is built with MediaPipe where each node is a module and the modules are connected by streams [5-6].

MediaPipe Hands

MediaPipe Hands is a high performance hand and finger tracking solution. It makes use of machine learning (ML) and artificial intelligence (AI) to conclude 21 points of 3D landmarks in a hand by just using a single frame. The current state-of-the-art approaches depends upon high end system configurations for concluding an inference, where our developed method achieves real-time live performance on a mobile phone, and even processes numerous hands[10].

For detection and recognization of a hand palm in live stream we make use of single shot detector model. This model is used in MediaPipe Hands. Firstly we have the hand detection module, which is trained to identify and detect the palm[10]. In the below figure 2 we have a hand landmark which comprises 21 points of coordinates in the palm.

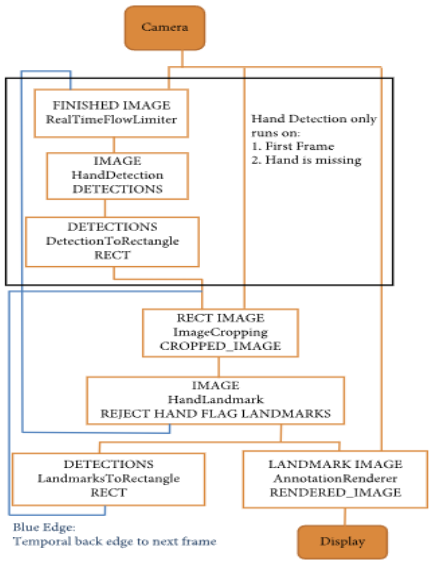

Figure 1 Data Flow Diagram

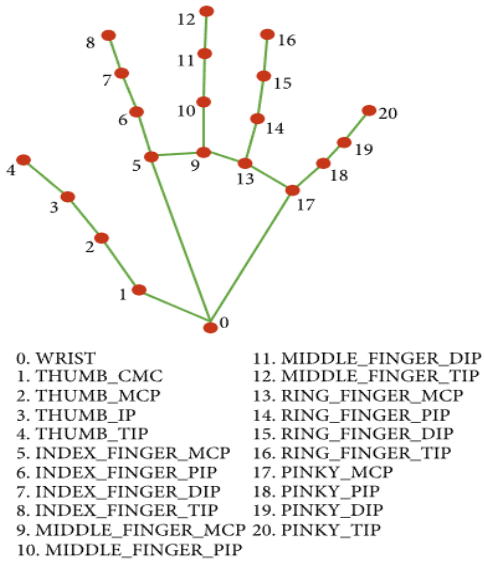

Figure 2 – Hand Landmarks

OpenCV

Opensource Computer Vision (OpenCV) is a computer vision package in python which has got image and video processing algorithms defined for various uses like object detection and so on. Using OpenCV, we can develop many computer vision applications by doing image processing techniques[10].

Methodology

The methods and their needs on function calls proposed in the module are given in the Figure 3.

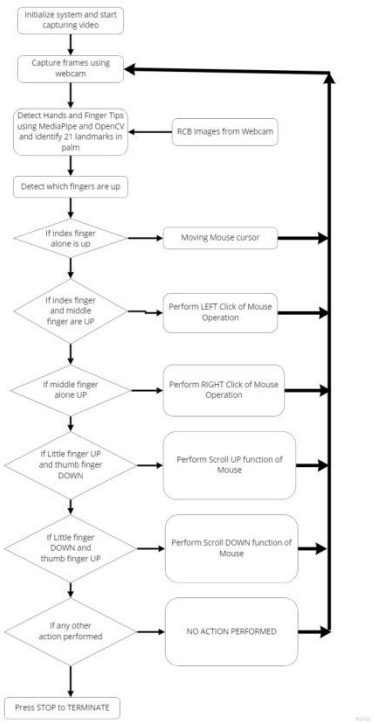

Figure 3 - Flow Chart

Stage I: The Camera Used for Virtual System Control

The proposed system can be implemented in an existing system by connecting it to an external camera either CCTV or webcam. It can also be implemented in a built in camera for a laptop. The frames are captured from a live-stream video. With the help of Python computer vision library - OpenCV, we utilize the methods available in it for capturing the video from the web camera and passes the frames captured to the respective modules for processing.

Stage II: Video Capturing and Manipulation

The model that we have proposed uses the webcam or any other external camera device in which frames are captured and processed till the application is terminated forcefully. The captured frames are converted into RGB from BGR color space to identify the hand gestures in the input frame.

Stage III: Virtual Screen Matching

The System proposed takes control of the mouse, using the transformational algorithm, and synchronizes the point of finger tips shown up in the webcam window to the Desktop screen window for taking control of the mouse. When the hands are detected then we find which finger is up and map the flow to the corresponding function. A rectangular box is drawn on the screen window mapping with the desktop size in the webcam region where we can move our hands for controlling the mouse.

Stage IV: Detection of the finger tips

Here, when the hand is up infront of the camera we detect which all fingers are up and seen clearly and we also find which fingers are down with the help of 21 land marks in the palm. According to the values we receive we map them to corresponding function for controlling the system.

Stage V: Mapping System Functions based on Hand Gestures

Module a: For moving the Mouse Cursor

To move the mouse cursor the index finger should be up. If the pattern matches then when u move your hand the mouse in the screen will also move accordingly with the help of autopy module developed in python.

Module b: Left Button Click in Mouse

To perform left click in mouse using hand gestures, the index finger and middle finger should be up and the distance between their finger tips should be very minimal like 20 pixels (negligible distance). If it is so left click will be processed for the cursor shown in the screen.

Module c: Right Button Click in Mouse

To perform right click in mouse using hand gestures, the middle finger alone must be up and the index finger must be down. When the system encounters as such then it will process the right click function for the cursor shown on the desktop screen.

Module d: Scroll UP Function in Mouse

To perform scroll up function as and how the mouse does, we need to point up our little finger up and have the thumb finger down, which will perform scroll up function on the page. You can immediately see the result on the desktop screen.

Module e: Scroll DOWN Function in Mouse

To perform scroll down function as and how the mouse does, we need to point up our thumb finger up and have the little finger down, which will perform scroll down function on the page. You can immediately see the result on the desktop screen.

Module f: No Action Performed on the Screen

If none of the actions said above are performed on the screen then there will be no effect of the mouse movement and hence there will be no control of the system.

Results and Discussion

The above said methodology gives an overview about the next generation of Human Computer Interaction of how to control the system without direct contact of the user with the system which can be implemented without using any wireless technologies and just by using machine learning models.

Testing the proposed system with other applications developed is tedious because of the limitedly available datasets. So we have tested the system with the hand gestures recognition and finger tips detection in a variety of illumination and dark conditions with different displacement from the camera for tracking the hand gesture and finger tips detection. To conclude the results a test was performed as tabulated in the below table. The test was taken by 4 persons in numerous ways in a variety of illumination conditions at variable distances from the camera.

Hand Tracking and Gesture Recognition	Result performed	Success	Failure	Accuracy (%)
Index finger UP	Mouse movement	100	0	100
Index finger UP and Middle finger UP distance between the fingers is <20	Left button click	98	2	98
Index finger DOWN and Middle finger UP	Right button click	94	6	94
Little finger UP and Thumb finger DOWN	Scroll up function	100	0	100
Little finger DOWN and Thumb finger UP	Scroll down function	100	0	100
None of the above actions performed	No action performed	100	0	100
Result		592	8	98.6

Table 1: Accuracy of the proposed system

As per the results tabulated in the Table 1, it shall be inferred that the methodology proposed has accomplished an accuracy of 98.6% in its overall performance. The right click function has got the least accuracy in the functions developed because of the gesture to be identified. With respect to previous approaches the system proposed seems to be the future of Human Computer Interaction and next generation technology. The graph of accuracy is shown in Figure 4.

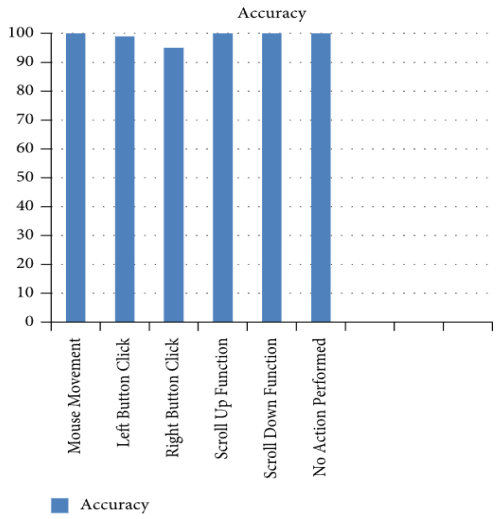

Figure 4 - Accuracy

Conclusion

The aim and objective of the proposed system is to take control of the system without using the devices for controlling either wired or wireless. This system makes use of hand gestures and lets us to take control of the mouse which in turn can take control of the system. This is achieved by allowing the user to interact with the camera connected with the system which

manipulates the hand gestures and performs corresponding function. From the results discussed above we can conclude that the system proposed has got 99% accuracy and seems to embark the journey of next generation Human Computer Interaction. This system can be useful in places where the spread of COVID-19 is uncontrollable in order to prevent the spread by the human contact.

Future Scope

The proposed system gives an over view of the next generation human computer interaction and seems to be in booming technology. In the spread of COVID-19, a widespread pandemic in the world this technology can be implemented in ATM's where people tend to touch the system and get themselves affected with the virus. This system can be made available and developed for Hospitals, Airports, Railway Stations, Malls, Schools, Colleges and public places where people management is tedious

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