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VIRTUAL MOUSE

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Abstract:

Virtual mouse and gesture-recognition softwares have recently gained a lot of traction. This paper presents a model to detect different hand gestures and perform various actions according to them. Waving our hand in front of our computer/laptop allows us to manage certain of its functionalities. The concept is to use the camera instead of a standard mouse to control the mouse cursor functions. The Virtual Mouse provides an infrastructure between the user and the system using the camera. It allows users to interact with machines without the ant physical devices, and even control mouse functionalities. Virtual mouse became a more important tool after Covid-19 as direct contact with different objects could be dangerous and a reason for spreading coronavirus. The system uses OpenCV, Python and also some other tools.

Keyword: **Virtual mouse, Gesture-recognition, OpenCV, Python, Mouse cursor functions**

1. INTRODUCTION

As computer technology advances, the importance of Human-Computer Interaction is increasing rapidly. In today's world, gesture- recognition technology is applied in various fields for automation including medical applications, industry applications, IT hubs, banking sectors and so on. This concept is based on the common notions of using hand gestures for managing different actions in a laptop/computer. The touch-screen technology in mobile devices is very popular nowadays but this technology is not easily affordable & difficult in desktop systems. Computer Vision comes into the picture here and makes this technology easy to use. Virtual mouse gives us an alternative to the use of mouse. It uses a camera to detect the hand gestures and performs actions according to the movements.

Through gesture-recognition, it becomes possible for humans to interact with machines in a more natural manner. This technology has a wide range of applications in various fields such as augmented reality, computer graphics, computer games, & biomedical equipment as it works on the basis of Artificial intelligence. Using hand movement detection methods for instant camera access and user-friendly user interface makes it easily accessible. The hand movements are detected in real time with a very little amount of processing time and memory required. The usefulness of a webcam can also be greatly extended to other HCI applications such as a sign language database or motion controller. Over the past decades there have been significant advancements in HCI technologies for gaming purposes. These gaming technologies provide a more natural and interactive means of playing video games.

1.1. Problem Description

If we go back in time when people got to know about Covid-19 and it was announced as an epidemic in the world. In the days when Covid-19 cases were increasing rapidly in the world, it was extremely dangerous to get into physical contact with any of the things. During such days, it is very important to be careful about the things we were getting in touch with. All the physical works were shifted to virtual platforms. Virtual mouse became a great discovery in such a time when physical contact with any of the things could be a reason for getting infected with coronavirus.

1.2. Objective

The main objective of the Virtual mouse is to create an alternative to the common and traditional mouse system to perform all the mouse functions. This can be done with the help of a camera which will capture the hand gestures and then performs a particular mouse function.

2. LITERATURE SURVEY

As modern technology of human computer interactions are being important in our everyday lives, varieties of mouse with all kinds of shapes and sizes are being invented, from a casual office mouse to a hard-core gaming mouse. However, there are some limitations to these hardware as they are not as environment friendly as they seem. For example, the physical mouse requires a flat surface to operate, not to mention that it requires a certain area to fully utilize the functions offered. Furthermore, some of these hardware are completely useless when it comes to interaction with the computers remotely due to the cable length limitations, rendering it inaccessible. The current systems consist of a generic mouse and trackpad monitor control system, as well as the absence of a hand gesture control system. The use of hand gestures to access the monitor screen from a distance is not possible. Even though it is primarily attempting to implement, the scope is simply limited in the virtual mouse field. The existing virtual mouse control system consists of rag, and so on. The use of gesture-recognition in the future will be reduced. Even though there are a variety of systems for gesture-recognition, the system they use is a static hand recognition, which is simply a recognition of the shape made by the hand and the definition of action for each shape made, which is limited to a few defined actions and can cause a lot of confusion. As technology advances, there are more and more alternatives to using a mouse.
A special sensor (or built-in webcam) can track head movement to move the mouse pointer around on the screen. In the absence of a mouse button, the software's dwell delay feature is usually used. Clicking can also be accomplished with a well-placed switch.

3. RELATED WORK

There are some similar works carried out on virtual mouse which use gesture-recognition. These projects opted for detection of hand movements wearing gloves in hands and also using color tips in the hands. But they are no more accurate in mouse functions. The recognition was not so accurate because of the gloves or incorrect detection of color tips. Some efforts have been made for camera-based detection of the hand gesture interface.

In 1990, Quam introduced an early hardware-based system. In this system, the user should wear a DataGlove.*[1]* This system gives results of higher accuracy but there is difficulty in performing some of the functions using the system.

In 2010, Dung-HuaLiou, ChenChiung Hsieh and David Lee proposed a study on "A Real-Time Hand Gesture Recognition System Using Motion History Image."*[2]* The limitation of this system is more complicated hand gestures.

In 2013, Monika B. Gandhi, Sneha U. Dudhane and Ashwini M. Patil proposed a study on "Cursor Control using Hand Gesture Recognition."*[3]* The limitation is that the stored frames are needed to be processed for hand segmentation and skin pixel detection.

In 2016, Vinay Kr. Pasi, Saurabh Singh and PoojaKumari proposed "Cursor Control Using Hand Gestures" in the IJCA Journal.*[4]* The system proposes various bands to perform different functions of the mouse but it depends on many colors for performing mouse functions.

In 2018, Chaitanya C, Lisho Thomas, Naveen Wilson and Abhilash SS proposed "Virtual Mouse Using Hand Gestures"*[5]* The system is based on color detection but very few mouse functions are performed.

4. ALGORITHMS USED FOR HAND TRACKING

For the detection of hand gestures and hand tracking, we use the MediaPipe framework and OpenCV library is used for computer vision.*[6]* The algorithm also uses the machine learning concepts to track and recognize the hand gestures. The machine learning concepts along with artificial intelligence help in tracking the hand movements and recognize them to perform specific tasks.

4.1. MediaPipe

MediaPipe is an open source framework of Google. This framework is used for applications in a machine learning pipeline. The MediaPipe is useful for cross platform development as the framework is built with the time series data. The MediaPipe framework can be applied to various types of media such as audio, video, etc. as it is a multimodal. The developers use MediaPipe for building and analyzing the systems through graphs and figures and also for the development of systems for the application purpose. The systems that use AudioPipe follow some steps. These steps are carried out in the pipeline configuration. This pipeline can run on various platforms including mobile and desktops. The MediaPipe framework is based on three basic parts; which are (i) performance evaluation, (ii) framework for retrieving sensor data, and (iii) a collection of components which are called calculators. All these parts are reusable. A pipeline is a graph which consists of calculators. Each calculator is connected by streams in which the data packets flow through. The developers can replace or define custom calculators in the graph while creating their own application.*[7]*

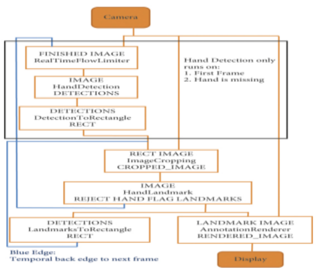

Figure 1.MediaPipe hand recognition graph [8]

Single-shot detector model is used by the MediaPipe to detect and recognize a hand movement in real time. In the hand detection module, it is first trained for a hand detection model. It is easy to train the hands for various movements rather than any other medium. A model of hand landmarks contains the locations of 21 knuckle co-ordinates in the hand region.*[9]*

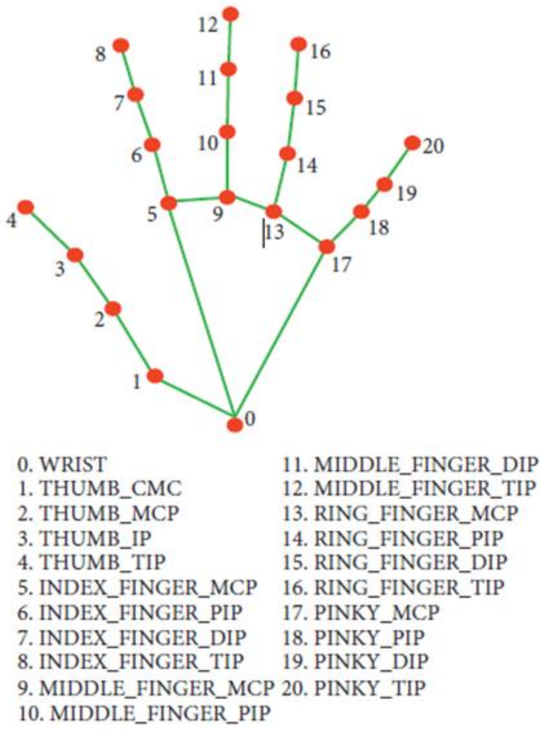

Figure 2. Co-ordinates or landmarks in the hand [8]

4.2. OpeCV

OpenCV is a computer vision library. It consists of image processing algorithms for object detection. OpenCV is a library of Python language. We can develop real time computer applications by using the computer vision library. We can use the OpenCV library in image and video processing. OpenCV can also be used for analysis such as face and object detection.*[10]*

The first OpenCV version was 1.0. OpenCV which was released under a BSD license. While designing OpenCV, the main focus was the development of real-time applications for computational efficiency. OpenCV has C, C++, Python and Java interfaces and it supports different operating systems including Windows, Linux, MacOS, iOS and Android.

Functionalities of OpenCV:

- Image/video I/O, processing, display
- Object/feature detection
- Geometry-based monocular or stereo computer vision
- Computational photography
- Machine learning and clustering
- CUDA acceleration

5. METHODOLOGY

The various functions and conditions which are used in the system can be explained in a flowchart of the real-time virtual mouse system.

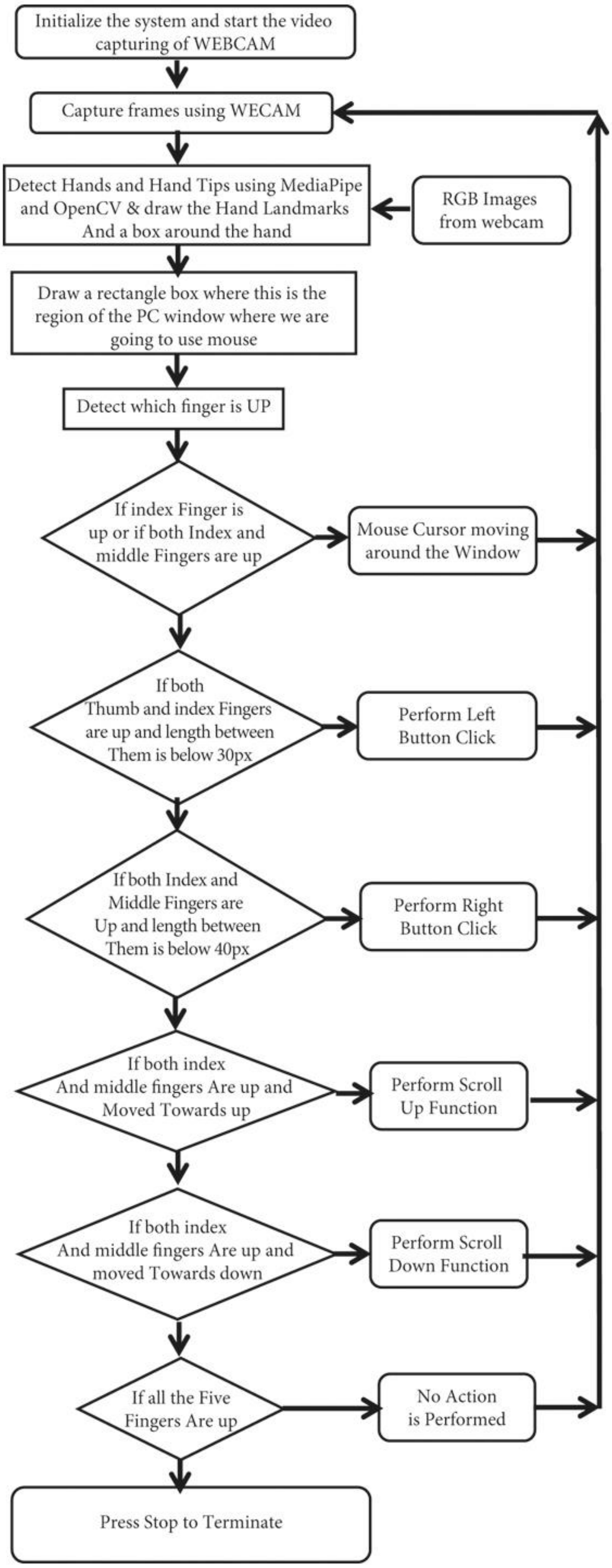

Figure 3. Flowchart of real-time virtual mouse system [11]

5.1. Camera used in the Virtual Mouse System

The Virtual Mouse System is based on the frames that are captured through the camera in a laptop or PC. With the use of OpenCV library, the video capture object is created and the camera will start to capture the video. The camera captures a video and passes the frames to the AI virtual system.

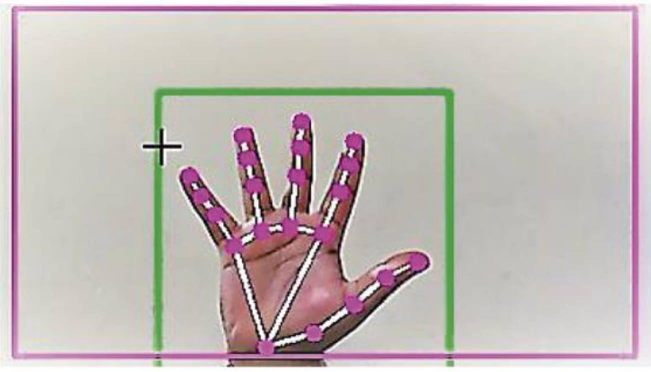

Figure 4. Capturing video using the webcam [11]

5.2. Capturing the Video and Processing

In the Virtual Mouse System, each frame is captured with the help of the camera till the termination of the program. The video frames are processed from BGR to RGB color space to detect the hand movements frame by frame in the video. The whole process is followed through the code given as under:

```
deffindHands(self, ing, draw = TRUE):
imgRGB = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
self.results = self.hands.process(imgRGB)
```

5.3. Virtual Screen Matching

The Virtual Mouse System uses the transformational algorithm. It converts the co-ordinates of the fingertip from the camera screen to the computer window screen to control the mouse. When the hand movements are detected and it finds the finger which is up for performing a particular mouse function, then a rectangular box is drawn with respect to the computer window in the webcam region where we move on the window with the use of the mouse cursor.

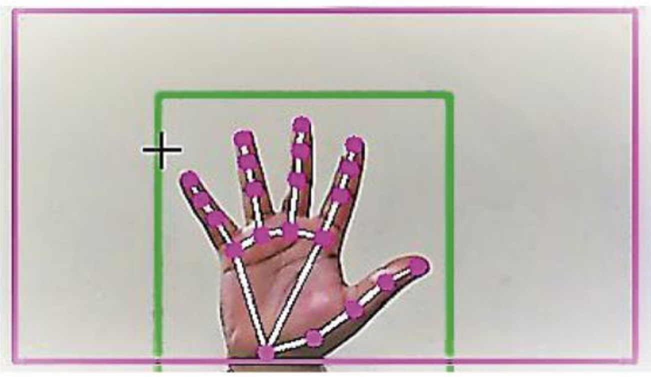

Figure 5. Rectangular box for the area of the computer screen where we can move the cursor [11]

5.4. Detecting which Finger is Up and Performing the Specific Mouse Function

In this step, we detect which finger is up with the help of tip Id of the respective finger using MediaPipe and the respective co-ordinates of the fingers that are up, the particular function is performed.

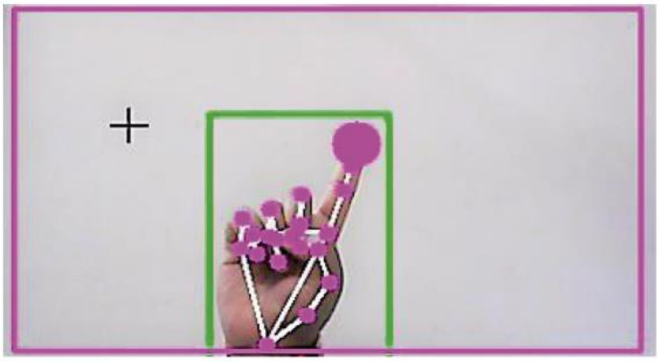

Figure 6. Detection of which finger is up [11]

5.5. Mouse Functions depending on the Hand Gestures and Hand Tip Detection Using Computer Vision

There are various functions that can be performed through different hand gestures. Each hand gesture performs a particular function. The description of the hand gestures and their functions is given below:

5.5.1. For the Mouse Cursor Moving around the Computer Window

If the index finger is up with tip Id = 1 or both the index finger and the middle finger with tip Id = 1 and tip Id = 2 respectively are up, then the mouse cursor will move around the computer window. It uses the AutoPy package of Python.

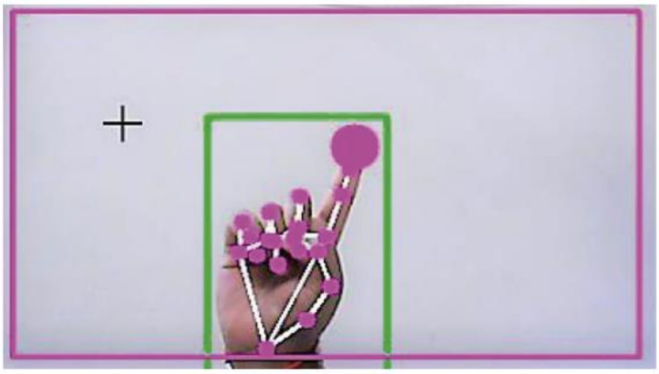

Figure7. Mouse cursor moving around the computer window[11]

5.5.2. To perform Left Button Click

If the index finger with tip Id = 1 and the thumb finger with tip Id = 0, both are up and the distance between the two is less than 30px, then the computer performs the left button click of the mouse. It uses pynput Python package.

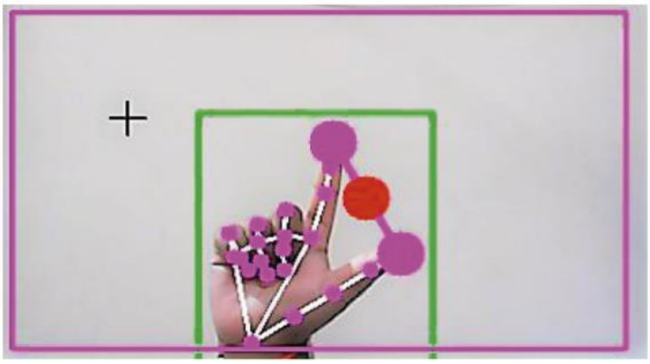

Figure 8. Gesture for the computer to perform left button click [11]

Figure 9. Gesture for the computer to perform left button click [11]

5.5.3. To Perform Right Button Click

If both the index finger with tip Id = 1 and the middle finger with tip Id = 0 are up and the distance between the two fingers is less than 40px, then the computer performs the right button click of the mouse with the use of pynput Python package.

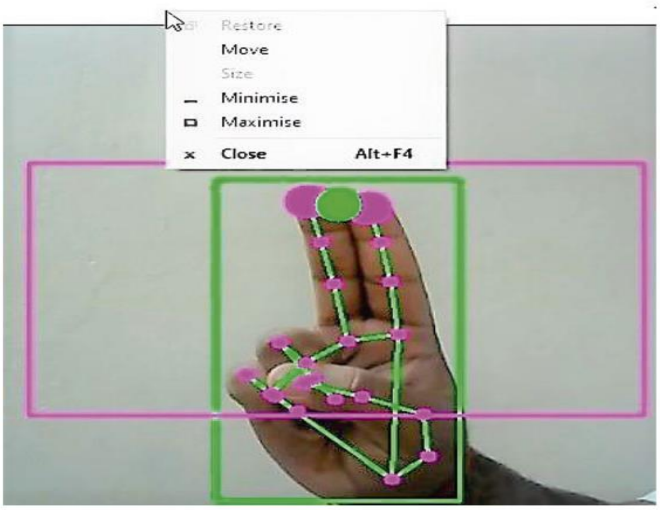

Figure 10. Gesture for the computer to perform right button click

5.5.4. To Perform Scroll Up Function

If the index finger and the middle finger with tip Id = 1 and tip Id = 2 respectively are up and the distance between the fingers is greater than 40px and both the fingers are moved upside the page, the computer performs scroll up mouse function with the use of PyAutoGUI Python package.

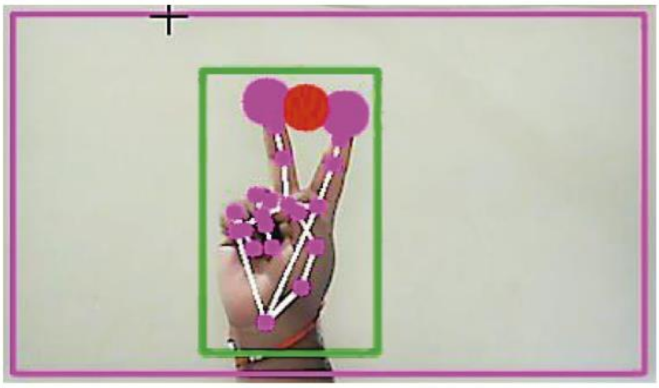

Figure 11. Gesture for computer to perform scroll up function [11]

5.5.5 To Perform Scroll Down Function

If the index finger and the middle finger with tip Id = 1 and tip Id = 2 respectively are up and the distance between the fingers is greater than 40px and both the fingers are moved down on the page, the computer performs scroll down mouse function with the use of PyAutoGUI Python package.

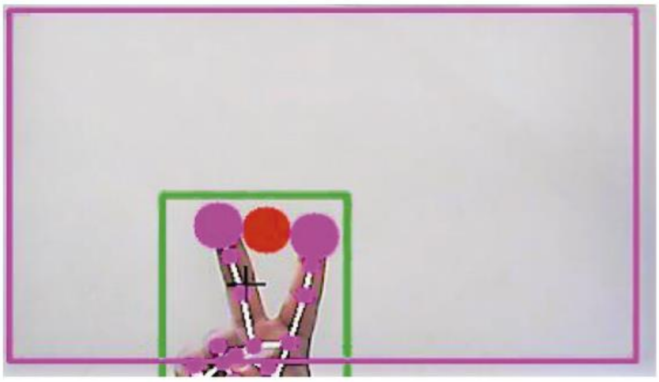

Figure 12. Gesture for computer to perform scroll down function [11]

5.5.6. For No Action to be Performed on the Screen

If all the fingers of the hand with tip Id = 0, 1, 2, 3, 4 are up, then the computer is made to not perform any mouse functions on the screen.

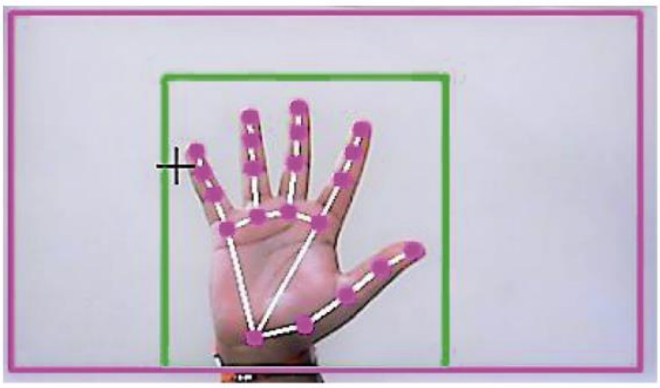

Figure 13. Gesture for the computer to perform no action [11]

6. PERFORMANCE ANALYSIS

In the proposed Virtual Mouse System, we've given the concept of advancing human-computer interaction using computer vision.
The comparison of the testing of the Virtual Mouse System is quite difficult due to availability of limited datasets. The hand gestures and fingertip detection is tested in various conditions and also with different distances from the webcam.

The test was performed 25 times by 4 persons resulting in 600 gestures with manual labeling, and this test is made in different light conditions and at different distances from the screen. Each person tested the Virtual Mouse System 10 times in normal light conditions, 5 times in faint light conditions, 5 times in close distance from the webcam and 5 times in long distance from the webcam. All the experimental results are represented in a table which is given below:

Mouse function performed	Success	Failure	Accuracy (%)
Mouse movement	100	0	100%
Left button click	98	2	98%
Right button click	99	1	99%
Scroll function	93	7	93%
Brightness control	95	5	95%
Volume control	96	4	96%
No action performed	100	0	100%
Result	681	19	97.28%

Experimental Results

From the given table, we can see that the Virtual Mouse System has achieved an accuracy of about 99% and it has performed well. The accuracy is high for most of the gestures. The graph of accuracy can be shown in the form of the following diagram:

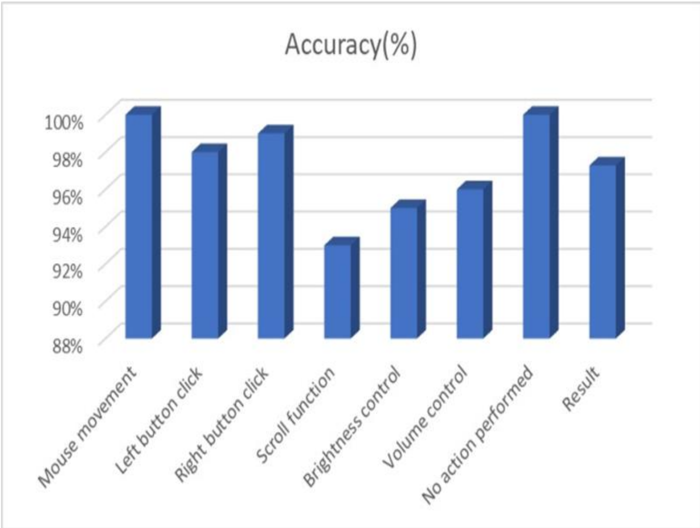

Figure 14. Graph of accuracy [11]

If we compare our system with other proposed systems, we can show the comparison results in the graph given below:

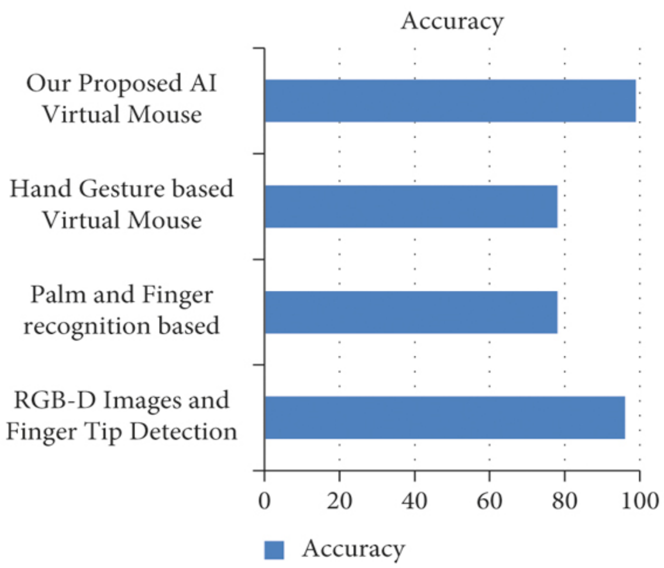

Figure 15. Graph for comparison between the models [11]

7. APPLICATIONS AND FUTURE SCOPE

The Virtual Mouse System is useful for many applications. Firstly, it almost reduces the physical contact of our hands with the mouse. The system almost eliminates the usage of devices and also improves the human-computer interaction. The major applications of the Virtual Mouse System are as follows:

- Amidst the COVID-19 situation, the physical contact with any of the devices became unsafe as it can cause spread of coronavirus. So the Virtual Mouse System can be used to control the mouse functions with even using the physical mouse.
- The Virtual Mouse System can be used to control robots and automation systems without using the physical mouse.
- It can be easy to draw 2D and 3D images using hand gestures with the Virtual Mouse System.
- The Virtual Mouse System can be used to play virtual reality and augmented reality based games without using wireless or wired mouse devices.
- The people having problems in their hands can have difficulty in controlling the mouse with their hands so the Virtual Mouse System can be helpful to them.

In the era where all things are moving towards automated systems, the Virtual Mouse System is a great discovery. This system can be helpful in reducing physical contact with the devices and can be time consuming as well.

8. CONCLUSION

The main objective of the Virtual Mouse System is to control the mouse functions using hand gestures instead of using the physical mouse. The proposed system can be developed with the use of a webcam or built-in camera. The webcam detects the hand gestures and movements and processes these frames to perform a specific mouse function.

From the results of the proposed model, we can conclude that the Virtual Mouse System has performed well and it has a very good accuracy. This model has overcome most of the limitations of the existing systems. The Virtual Mouse System can be used in real-world applications. It can be helpful in reducing the spread of COVID-19 as it can be used virtually using hand gestures without any physical contact with any device.

The model has a few limitations but we can work on the model to overcome these limitations by improving the gesture-recognition algorithms to get more accurate results.

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