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Artificial Intelligence Based Virtual Mouse

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Abstract: The mouse is an indispensable input device that is used in all modern-day computer systems. Input devices are high-contact surfaces that we use daily and often all day. As such the mouse is laden with germs and bacteria. . Although, wireless mice have rid us of the need for a tangled mess of cables, there still exists the need to touch the device. In view of the pandemic, this proposed system uses the in-built camera or a peripheral web camera for capturing hand movements and finger-tip detection that can perform traditional mouse functions like left-clicking, right-clicking, scrolling and cursor functions. The algorithm is machine learning based. Using deep learning, the algorithm is trained so that hands can be detected using the camera. Hence, the proposed system will prevent the spread of Covid-19 by eliminating the need for human intervention and dependency on physical devices to control the computer system.

Keywords: virtual mouse, AI, MediaPipe, OpenCV

INTRODUCTION

There has been tremendous development in budding areas of AR (augmented reality) and other peripheral devices that we use on the daily and many of these devices are getting smaller and portable with the likes of Bluetooth and other wireless technologies. In this paper, the proposition is that we use an Artificial Intelligence based mouse system that can recognize gestures made by hands and detect finger tips for executing mouse functions on a computer using computer vision. The main objective of the proposed system is achieving conventional mouse functions such as clicking and scrolling using a built-in camera or a peripheral web camera in the place of a conventional mouse device. Hand gestures and detection of the finger tips helps communicate with the computer. With this system one can trail the fingertip to indicate cursor movement by making use of the computer's web camera and perform cursor functions and scrolling operations.

This paper focuses on the use of computer vision in place of Bluetooth or other wireless technologies like USB receiver technologies for achieving mouse operations using hand gestures and movements to move the mouse pointer on the computer

screen. The hand movements are tracked and the frames are processed by the built-in camera of the computer to detect functions of mouse like scrolling clicking, minimizing, maximizing, etc. by processing those gestures.

In this system, Python programming language which is very popular for Artificial Intelligence projects, OpenCV which is an open-source library for working with image processing and performing computer vision tasks like face-detection and object tracking and other python packages such as AutoPy, Mediapipe and PyAutoGUI are used to move the cursor around in the application and perform functions of pointing, clicking and scrolling. This proposed model can work extremely well in real production environment and does not need the rendering power of a GPU (Graphics Processing Unit). The accuracy of the model is quite high and functional.

RELATED WORK

Work related to virtual mouse have been performed where the user wears a glove for the system to recognize and collect data and also another system where colored pieces of paper are attached on hands for gesture recognition have been done, although such systems are not feasible for performing mouse operations explicitly. Recognizing gloves isn't always viable and many users don't want to wear gloves or the gloves may be ill-fitting. In the other case of using colored tips for detecting and gesture processing, may not always work with low levels of accuracy. Other have made contributions that led to this system such as Google's work with MediaPipe (an open source hand detection library).

[1] Sneha U. Dudhane ,Monika B. Gandhi, and Ashwini M. Patil in 2013 proposed a study on "Cursor Control System Using Hand Gesture Recognition." In this system, the disadvantage is that the framed have to be stored first and then processed for detection which is much slower than what is required in real-time.

[2] Dung-HuaLiou, ChenChiung Hsieh, and David Lee in 2010 proposed a study on "A Real-Time Hand Gesture Recognition System Using Motion History Image." The primary drawback of the proposed system is the use of complicated hand gestures.

[3] In 1990, Quam made possible a hardware-based system; in this model, the user is supposed to wear a data glove, Although Quam's model gives highly accurate results, many gestures are difficult to perform with a glove that restricts much of the free movement and speed and agility of the hand.

[4] Saurabh Singh, Vinay Kr. Pasi, and PoojaKumari in 2016 proposed "Cursor Control using Hand Gestures". The model advises the use of various bands of colors to perform a variety of mouse operations. Its limitation is owed to the fact of the requirement of different colors to perform required functions.

PROBLEM DESCRIPTION

This AI virtual mouse can be made use of in places where using a physical mouse is not feasible such as moist or wet conditions, to aid people who can't handle a device and where there isn't ample space for using a mouse and to eliminate the need of mouse and cable altogether. In view of the pandemic, there arises a need to avoid high-contact surfaces, out of which the mouse is one. In order to eliminate the need to avoid contact, the system provides an intuitive way to interact with the computer system with the use of hand-gestures and finger tips to emulate mouse-like functions such as scrolling, clicking, and pointing.

OBJECTIVE

The main objective of the proposed virtual AI mouse is to furnish an alternative to the conventional physical mouse that provides mouse functions with the help of computer vision enabled computer that houses a web camera which recognizes fingers and hand gestures and processes the captured frames and uses a machine learning algorithm to execute the defined mouse functions like moving the cursor, right click, left click and scrolling function. Also we are using multiple libraries to perform this project.

ALGORITHM USED FOR HAND DETECTION

For High-fidelity hand and finger tracking MediaPipe library (on open-source cross-platform framework) and OpenCV library for implementing computer vision are being used. [10] This algorithm utilizes machine learning concepts to track and detect hand gestures and finger tips.

MEDIAPIPE

The MediaPipe framework is used by the developer for building and analyzing the systems through graphs, and it also been used for developing the systems for the application purpose. MediaPipe library is used by developers for architecting and analyzing various models through graphs and many of these have been used for building applications. MediaPipe Hands utilizes an ML pipeline consisting of multiple models working together. The model that incorporated MediaPipe needs to work in a pipeline fashion. It consists of mainly graphs, nodes, streams and calculators.

The MediaPipe framework is based on three fundamental parts; they are performance evaluation, framework for retrieving sensor data, and a collection of components which are called calculators, and they are reusable.

A pipeline is a graph which consists of components called calculators, where each calculator is connected by streams in which the packets of data flow through. The pipeline is implemented as a MediaPipe graph that uses a hand landmark tracking subgraph from the hand landmark module, and renders using a dedicated hand renderer subgraph.

The hand landmark tracking subgraph internally uses a hand landmark subgraph from the same module and a palm detection subgraph from the palm detection module. The calculators and streams combined create a data-flow diagram; the graph (Figure 1) is created with MediaPipe where each node is a calculator and the nodes are connected by streams.

Mediapipe offers open source cross-platform, customizable ML solutions for live and streaming media. This is helpful in many cases such as:

1. Selfie segmentation.
2. Face mesh
3. Human pose detection and tracking
4. Holistic tracking
5. 3D object detection.

FIG 1. Hand recognition graph Mediapipe[12]

OPENCV

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. This library is written in the python language and it helps in the making of applications that used computer vision. In this model, OpenCV library is utilized for image and video processing and for detecting and analyzing faces and objects. [11]The developing of hand gesture recognition using Python and OpenCV can be implemented by applying the theories of hand segmentation and the hand detection system which use the Haar-cascade classifier.

FIG 2. Hand landmarks points used by MediaPipe

PROCEDURE AND FLOWCHART

The different functions and conditional statements used in the model are described in the given flowchart for the virtual mouse model that employs artificial intelligence which can be seen in figure 3.

CAPTURING VIDEO FRAMES USING CAMERA

For the proposed model, the system functions on the basis of frames that are captured by the in-built camera or a peripheral web camera. With the help of the Python library OpenCV, the camera window opens and starts capturing video. The web camera then sends these video frames to the AI mouse system.

FIG 3. Hand detection

FIG 4.Flowchart for hand detection and processing algorithm

PROCESSING THE COLLECTED FRAMES

The web camera keeps on collecting the frames until the underlying program is closed. The captured frames of video are collected in the BGR color format from the web camera. In order for OpenCV to process the frames, the BGR color format has to be converted to the RGB color format. Subsequently, OpenCV processes the frames to detect hand/s.

```
image = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
```

```
image = cv2.cvtColor(image, cv2.COLOR_RGB2BGR)
```

RECOGNIZING THE GESTURE

At this point, the hand is being tracked and if any finger is held pointed, MediaPipe recognizes the finger and the tip with the help of the 21 co-ordinates on the fingers and after processing the gesture, the appropriate mouse operation is handled.

FIG 5.Moving the mouse pointer

MOVING AROUND USING THE VIRTUAL MOUSE

OpenCV detects the hand and draws an rectangular window around the hand and uses a transformation algorithm that calculates the co-ordinates of the fingertips from the screen capture window to be able in the computer system and controls the pointer of the virtual mouse. When the finger tip is detected that is connected to a particular gesture the box is drawn around and allows it to act as a pointer to perform basic moving functionality as seen in figure 6.

Fig 6. Recognizing gesture for moving around

LEFT CLICK OPERATION

If the tip of the index finger and the tip of the middle finger are held up such that the distance calculated between them amounts to approximately 40px and then both the fingers' tips are made to come closer a left click is performed as shown in Figures 7 and 8.

FIG 7. Gesture for left click operation

FIG 8. Gesture for performing left click

RIGHT CLICK OPERATION

If the tip of the index finger and the tip of the middle finger are made to come together and the points of the handmarks align such that the distance between the tips is below 40px then a right click operation is performed as seen in figure 9.

FIG 9. Gesture for performing right click

SCROLLING OPERATION

Scrolling up

For scrolling up the tips of the index and the middle finger have to be brought close such that the distance is 40px or below and when the fingers gesture as to move from the bending position to straightening position as shown in figure 10.

Scrolling Down

Similarly for scrolling down, the tips of the index and the middle fingers are gestured to move down and then scroll down operation is performed by the computer.

FIG 10. Gesture for scrolling up/down

RESULTS AND INFERENCES

The proposed model of AI virtual mouse demonstrates the idea of computer vision technology and machine learning capabilities.

For verifying and testing of the proposed AI virtual mouse system only a certain quantity of datasets are attainable. The hand tracking, finger-tip detection and gestures recognition have been performed in various illuminated conditions and at diversified distances from the camera. The results of the testing are given below. The test was performed 25 times by 4 persons resulting in 600 gestures with manual labelling, and this test has been made in different light conditions and at different distances from the screen, and each person tested the AI 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, and the experimental results are tabulated in Table 1.

Mouse Function Performed	Correct Operation	Incorrect or failed operation	Accuracy
Pointer movement	100	0	100
Left click	98	2	98
Right click	94	6	94
Scrolling Up	98	2	98
Scrolling Down	99	1	99
Result	489	11	97.8

Table 1. Accuracy of mouse operations

The following bar graph shows the accuracy of operations that have been observed by testing the model under various illumination conditions and numerous operations. Table 1 shows the comparison between different functions and how they are accurate. Let's see the accuracy using bar graphs which is one of the most using statistical tool used to calculate the function parameters.

FIG 12. Accuracy of mouse operations (Bar Graph)

COMPARING WITH PREVIOUS MODELS

To see how well the proposed model works against previous systems we have compared them and the figure 13 shows the comparison of the AI virtual mouse model with models mentioned in the related models section.

FIG 13. Comparison graph with other models

FUTURE SCOPE

This AI virtual mouse has some drawbacks such as drop in accuracy of some functions like right click operation and inability to perform other mouse functions such as dragging and dropping, and selecting text. Another major limitation is that this model cannot function in the dark or low light settings. These drawbacks can be addressed in the future and can be overcome.

Apart from the above-mentioned, additionally key board capability can be incorporated to emulate keyboard functions along with the mouse operations which proves to be the scope for the future.

APPLICATIONS

The artificial-intelligence based virtual mouse has a plethora of application use cases. It could be used where there is restricted space for a conventional mouse and can be utilized in cases where the use of a traditional mouse device is not possible. This system rids of the need for a physical mouse and it can be used in its absence.

Some Applications:

- i. The proposed AI virtual mouse has an accuracy of approximately 98% which is larger than other systems that have been previously implemented.
- ii. It can be utilized in the areas of automation for robots and other systems without the need of a physical device.
- iii. The same system can be used for creating drawings both in two dimensions and three dimensions.
- iv. People who cannot use a physical mouse can make use of this system to perform mouse like functions.
- v. During this Covid-19 setting, it's advised to not touch high contact surfaces which can lead to the spread of the virus. Thus, the proposed model provides a viable solution that can be used to control personal computers and tablet computers which have a web camera attached to them and can perform almost all mouse operations.
- vi. In the areas of virtual reality and augmented reality, the current system can be extended to work with such upcoming technologies.

CONCLUSION

The main objective of the proposed virtual AI mouse is to furnish an alternative to the conventional physical mouse that provides mouse functions with the help of computer vision enabled computer that houses a web camera which recognizes fingers and hand gestures and processes the captured frames and uses a machine learning algorithm to execute the defined mouse functions like moving the cursor, right click, left click and scrolling function.

After testing we have come to the conclusion that the proposed virtual mouse system has worked exceedingly well and with greater accuracy when compared to previously proposed models mentioned in the related work and the current system has overcome the drawbacks of the other systems. As such, this proposed AI based virtual mouse system can be used in real-time and in real-world applications. Additionally, the system aids in reducing the spread of the Covid-19 virus by eliminating the need to contact high touch surfaces and devices by using hand gestures without using a conventional mouse device.

REFERENCES

- [1]. Google, MP, <https://ai.googleblog.com/2019/08/on-devicereal-time-hand-tracking-with.html>.
- [2]. S. U. Dudhane, "Cursor control system using hand gesture recognition," IJARCCCE, vol. 2, no. 5, 2013.
- [3]. Hsieh, Chen-Chiung, Dung-HuaLiou, and David Lee. "A real time hand gesture recognition system using motion history image." 2010 2nd international conference on signal processing systems, Vol. 2. IEEE, 2010.
- [4]. D. L. Quam, "Gesture recognition with a DataGlove," IEEE Conference on Aerospace and Electronics, vol. 2, pp. 755–760, 1990.
- [5]. Hsieh, C.C., Liou, D.H. and Lee, D., 2010, July. A real time hand gesture recognition system using motion history image. In 2010 2nd international conference on signal processing systems (Vol. 2, pp. V2-394). IEEE.
- [6]. K. P. Vinay, "Cursor control using hand gestures," International Journal of Critical Accounting, vol. 0975–8887, 2016.
- [7]. P. Nandhini, J. Jaya, and J. George, "Computer vision system for food quality evaluation—a review," in Proceedings of the 2013 International Conference on Current Trends in Engineering and Technology (ICCTET), pp. 85–87, Coimbatore, India, July 2013.
- [8]. D.-S. Tran, N.-H. Ho, H.-J. Yang, S.-H.Kim, and G. S. Lee, "Real-time virtual mouse system using RGB-D images and fingertip detection," Multimedia Tools and Applications Multimedia Tools and Applications, vol. 80, no. 7, pp. 10473–10490, 2021.
- [9]. <https://www.analyticsvidhya.com/blog/2021/07/building-a-hand-tracking-system-using-opencv/>
- [10]. https://docs.opencv.org/4.x/da/dd0/tutorial_table_of_content_video.html
- [11]. <https://www.javatpoint.com/opencv>
- [12]. <https://google.github.io/mediapipe/solutions/hands.html>