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Computer Vision Based Virtual Mouse Cursor Using Hand Gesture

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ABSTRACT: Human-Computer Interaction (HCI) is a field in which the developer makes a user-friendly system. The hand gesture is most frequently used as interaction in the digital environment and thus complexity and flexibility of the motion of the hand is a research topic. It is the most natural expression for communication between humans and computers in virtual systems. The technology is shifting towards gesture interface by capturing the motion of our hands and therefore controlling devices. In this study, we are trying to establish an innovative way to implement HCI using Python and Mediapipe. The hand gesture study divides the hand into 21 segments to identify gestures and control functionalities of the mouse cursor. We will be implementing some commands associated with each gesture.

KEYWORDS: Artificial Intelligence and Machine learning, Computer Vision, Python, OpenCV, MediaPipe, Numpy.

I. INTRODUCTION

Hand gesture controlled simulated mouse is a technology that enables users to control their computer cursor using hand gestures instead of a physical mouse or touchpad. The technology is based on computer vision algorithms that track the movement of a user's hand and interpret it as commands to move the cursor. There are several methods to achieve hand gesture control of a simulated mouse. One common approach is to use a camera to capture the movement of the user's hand. The camera then sends the captured video stream to a software application, which analyzes the data and translates the movements into commands for the simulated mouse.Another approach is to use sensors to detect the position and movement of the user's hand. For example, a glove with sensors on each finger can detect the bending of the fingers, which can be interpreted as commands to move the cursor in different directions. Hand gesture controlled simulated mouse technology has several advantages over traditional mouse or touchpad-based input methods. For example, it can be used by people with physical disabilities that make it difficult to use a traditional mouse or touchpad. It also allows for more natural and intuitive control of the cursor, as users can simply point to the location, they want the cursor to move to. However, hand gesture controlled simulated mouse technology also has some limitations. For example, it may require some training for users to learn how to use the gestures effectively. It may also be less precise than traditional input methods, particularly for tasks that require fine-grained control of the cursor. Overall, hand gesture controlled simulated mouse technology has the potential to be a useful input method for a variety of applications, particularly for users with physical disabilities or for tasks that require intuitive and natural control of the cursor.

II. MOTIVATION

This mode of interaction with machines is more natural as opposed to the traditional use of keyboards and mouse since it greatly reduces the complexity of operation. Mouse less computing is getting closer to being a reality. In recent times with the pandemic, there is a growing concern about maintaining hygiene standards while using common input devices such as computer mouse, keyboard, etc. Hand gesture controlled simulated mouse does not require physical contact, thus reducing the risk of transmitting germs

III. PROBLEM STATEMENT AND OBJECTIVES

Communication with an electronic device without using hands is an open problem. The existing virtual mouse techniques are mostly based on the hand tracking technique, which depend on the data gloves or other equipment, leading to high costs. The entire world will become virtualized as a generation develops, including hand and speech recognition. Hence, we are using a computer vision-based approach, Controlling devices based on wireless human movements interface, can ensure hygiene issues like we are currently facing in a pandemic.To simplify this, we will develop a prototype and use which will try to modify our day-to-day task on a laptop. Controls virtual mouse cursor with hand gesture, using webcam. Propose a methodology for controlling devices based on wireless human movements interface.

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IV. PROJECT SCOPE & LIMITATIONS

With the mentioned solution, the user will control the mouse pointer with the user's own hand depending on the user interface. To perform various mouse operations, the user will make various gestures. User's hand can be tracked by this technology and recognized. The technology will be able to understand hand gestures. System will perform processing of data to recognize and give accurate output.
System should need to have some basic specification to recognize gestures and the user's hand should be in proper light intensity.

V. METHODOLOGIES OF PROBLEM SOLVING

When designing and implementing hand gesture controlled simulated mouse technology, several problem-solving methodologies can be applied. Here are some of the methodologies that can be used:

1. Design Thinking: This methodology emphasizes empathy for the end-users, which is essential when designing technology for people with physical disabilities. By understanding the needs and pain points of the end-users, designers can create a technology that better meets their needs.

2. Agile Methodology: This methodology emphasizes flexibility and adaptability during the development process. It involves breaking down the development process into small, iterative stages, allowing developers to adjust and refine the technology as they go.

3. User-Centered Design: This methodology focuses on designing technology around the needs and preferences of end-users. It involves gathering user feedback and incorporating it into the design process to create a technology that is more user-friendly.

4. Human-Centered Design: This methodology places a strong emphasis on understanding the human factors that influence the design of technology. This includes factors such as ergonomics, cognitive load, and user behavior.

5. Six Sigma: This methodology is a data-driven approach to problem-solving that emphasizes process improvement and reducing defects. It involves measuring and analyzing data to identify areas for improvement in the development process.

6. Lean Startup: This methodology involves creating a minimum viable product (MVP) and testing it with users to gather feedback and iterate on the design. This allows developers to quickly test and refine the technology, minimizing the risk of investing resources in a technology that may not meet the needs of end-users.

VI. LITERATURE SURVEY

[1] "An Arduino Based Gesture Control System for Human-Computer Interface :-
In this paper, to control a computer using hand gesture recognition an Arduino based approach is explained. You can use hand gestures to manage a few browser features, such as opening and closing tabs, navigating between activities, pausing or playing videos and adjusting the volume. Using the proposed solution, some computer functions can be operated without need for a mouse or keyboard. It has some limitations like cost, and effectiveness of ultrasonic sensors is only for a short distance.

[2] Hand gesture sequence Recognition using inertial motion unit (IMU) :-
A data glove is a piece of technology containing sensors that can track the movements of the palm and fingers separately and transmit that information to a computer. A KNN classifier is used to recognize the gestures of the hand. various mouse functionalities like clicking, dragging, turning and pointing are performed. Because this model performs with great precision, gestures are designed in a way that they conflict with other gestures very seldom. Compared to computer vision, this method is more efficient, as you don't have to wave your hand and perform gestures in front of the camera all the time. Also, you can use this data glove for a longer time period. This way of doing HCI is very difficult, as you have to create sophisticated machine learning models, you have to create your own data set for training purposes. Once a model is created, changing even minor settings is also very difficult cumulative errors.

[3] Literature Survey on Hand Gesture Techniques for Sign Language Recognition :-
In the proposed paper, gesture recognition is done with the help of depth sensors and cameras. By using library packages, we can design a hand tracking system. We can design this system using GPU and depth sensor (computer integrated cameras)
This system design hand segmentation in 21 hand landmarks by using these 21 landmarks we can recognize hand gestures. Price is maintained because no external sensors/cameras are in use. Development of such applications is challenging; it may lack accuracy.

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[4] Gesture Recognition and fingertip detection for Human Computer Interaction:-
In this paper, a convex hull approach is used to find finger tips after computing the centroid of the palm region. After the fingertips can be detected, demonstrated movements can be recognized. Convex hull method is utilized for fingertip detection, whereas region growing segmentation is used for hands. Since the video camera records the hand's movements, it can be challenging to identify the hand section in each individual frame

[5] A Novel Design of an Intangible Hand Gesture Controlled Computer Mouse using Vision Based Image Processing :-
In this study controlling your computer using hand gestures is demonstrated. The method used in this research study to regulate mouse movement makes use of a cutting-edge skin color segmentation algorithm. With the help of this, various mouse actions have been carried out. The system operates with just your hands and an integrated webcam. No extra equipment required for recognition of hand gestures. No extra cost is involved. The system was tested indoors so if the system tested in outdoor accuracy reduces. It works only for a limited distance.

[6] The Simulated Mouse Method Based on Dynamic Hand Gesture Recognition :-
In this paper, hand gesture recognition is done in 2 ways, 1st is using kinect camera, and 2nd is Hidden Markov model. Users can use hand gestures to manage a few computer commands, such as opening and closing tabs, paging up and down on websites, switching between tasks (applications), playing or pausing videos, and adjusting the volume (in VLC Player). As kinect camera is very expensive, it put limitations on its usage.

[7] Virtual Mouse Using Object Tracking :-
In this study hand gestures are recognized using color taps.The user of this system can move the system cursor by holding coloured tapes or caps in their hand. HSV color detection technology is used in a vision-based mouse cursor control system that employs hand motions that are captured on a camera. The user can use the item to click, right-click, left-click, select, pause, and play any web video. People can now interact with many computer systems more easily thanks to it. This method is useful for limited distances.

[8] Virtual Mouse Implementation using OpenCV :-
In this paper, gesture recognition is done by using python, Opencv, MediaPipe. A CNN model is trained to recognize gestures. OpenCv's hand gesture tracker offers consumers a variety of readily usable models that will improve their quality of life. This can make systems and many other applications easier to use. As color detection is used it can give the best result in light conditions . Because of color detection it can't perform in dark conditions .

[9] Hand Gesture Real Time Paint Tool – Box: Machine Learning Approach:-
The recognition of hand gestures based on machine learning is discussed. Various gesture applications for computer vision have been developed. Machine Learning Based, accuracy will be of approximately 96%. There are six hand motions in this dataset, which includes those of roughly ten people. The background in this dataset is also complicated, light, and dark. It can be use-full for robot training , Virtual reality and augmented reality.

VII. ALGORITHM

An interdisciplinary scientific topic called computer vision studies how advanced knowledge may be extracted by computers from digital images or films. Artificial intelligence research in the area of computer vision teaches machines to comprehend and interpret visual data. Machines can properly recognise and classify items using digital images from cameras and videos, deep learning models, and then respond to what they "see."

Hand tracking uses 2 modules in back-end
Palm Detection : Works on Complete image and provides us hand's crop image.
Hand landmarks : Provides us 21segments hand landmarks as shown in Fig. 4.2

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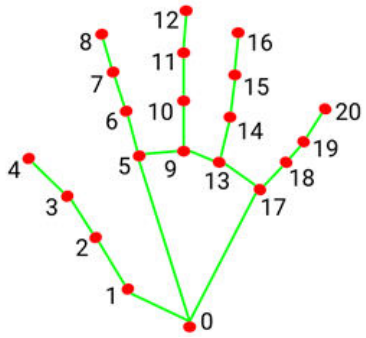

0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP

Fig. 6.3. Hand Landmarks(i)

a. SYSTEM DESIGN

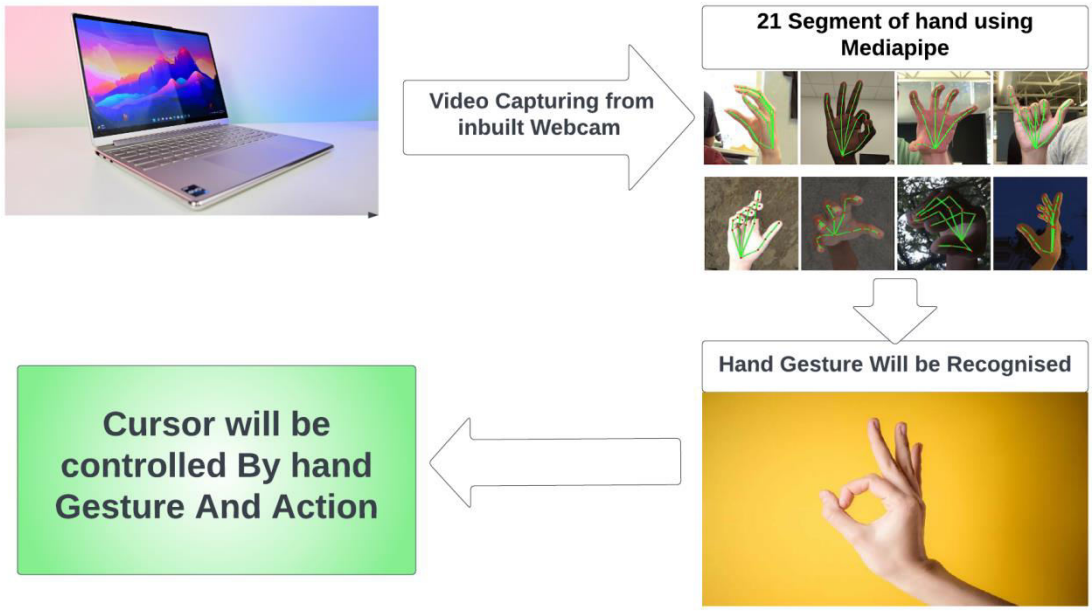

Fig. 4.1 System Architecture

The built-in webcam in the computer will be used by the HGBUI (Hand gesture based user -interface) system shown in Fig 5.1. The illustration demonstrates the webcam's function as a continuous image capture device that sends captured images to the computer for processing and gesture recognition. The computer will then complete the matching process so that the mouse pointer can be moved manually shown in Fig. 5.2.

MATHEMATICAL MODEL

The mathematical model for this system can be represented as a set of equations that relate the input (hand movements) to the output (cursor movements):

Cursor_X = f1(Hand_Position_X, Hand_Orientation_X, Gesture_Type)

Cursor_Y = f2(Hand_Position_Y, Hand_Orientation_Y, Gesture_Type)

Where:

Hand_Position_X and Hand_Position_Y are the x and y coordinates of the hand position.

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Hand_Orientation_X and Hand_Orientation_Y are the orientation angles of the hand.

Gesture_Type is the type of gesture recognized by the system.

Cursor_X and Cursor_Y are the x and y coordinates of the cursor position on the screen.

The functions f1 and f2 would implement the mapping between the hand movements and the cursor movements, based on the recognized gesture type. These functions could be trained using machine learning techniques, such as neural networks, or designed using rule-based systems.

DATA FLOW DIAGRAMS

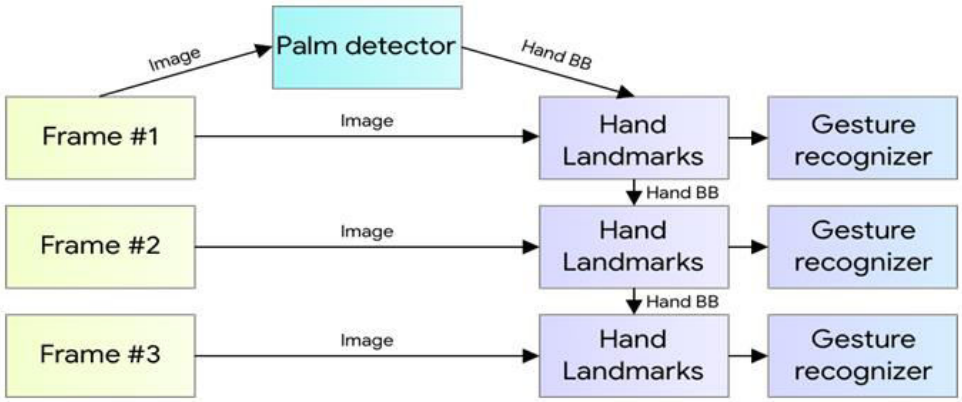

Fig. 4.3 Hand perception pipeline data flow diagram

VIII. CONCLUSION

The primary goal of the virtual AI mouse system is to replace the need for a portable mouse with gesture-based control. The suggested system can be used with a webcam or built-in camera. It interprets hand movements and the tips of hands to carry out specified mouse actions. Our strategy is to link mouse actions to various hand gestures using the MediaPipe libraries. This system uses NumPy, OpenCV, AutoPy and MediaPipe. Due to its substantially lower cost than hardware devices, many users prefer using vision control devices. This study has led us to conclude that this technology has a promising destiny in HCI based systems. Numerous sectors, such as robotics, biomedical instruments, computer gaming, and others can make substantial use of it.

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