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AI VIRTUAL MOUSE

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Abstract - This project explores the development and implementation of an AI virtual mouse system. The system allows users to control their computers through hand gestures, enhancing the ease of human-computer interaction. The report outlines the journey from conceptualization to a fully functional application, emphasizing software development, library integration, hardware setup, rigorous testing, and optimization. The results are illustrated through gesture photos, showcasing the system's accuracy and effectiveness. This implementation introduces a novel approach to intuitive computer interaction, making it more accessible and user-friendly

1. INTRODUCTION

a. Introduction

A mouse, in computing terms, is a pointing device that detects two-dimensional movements relative to a surface. This movement is converted into the movement of a pointer on a display, allowing control of the Graphical User Interface (GUI) on a computer platform. Various types of mice have evolved over time. Initially, the mechanical mouse used a hard rubber ball to detect movement as it rolled around. Later, the optical mouse replaced the rubber ball with an LED sensor to detect tabletop movements and relay the information to the computer for processing. In 2004, the laser mouse was introduced, offering improved accuracy with minimal hand movement and overcoming the optical mouse's limitation of tracking high-gloss surfaces. Each advancement aimed to enhance precision and user experience, making interactions smoother and more intuitive.

Despite advancements, mice still face physical and technical limitations. They are consumable hardware devices that require replacement over time due to issues like degraded buttons causing inappropriate clicks or the mouse no longer being detected by the computer. The mechanical components can wear out, and even the most advanced mice are susceptible to damage from drops or spills. These factors highlight the need for more durable and reliable pointing devices in the long term.

An alternative to the physical mouse or keyboard is a virtual human-computer interaction device that uses a webcam or other image-capturing devices. This device, constantly utilized by software, monitors user gestures and translates them into pointer motion, similar to a physical mouse, providing a potential alternative to touchscreens. As technology continues to evolve, these virtual interfaces could become more prevalent, offering new ways to interact with computers and reducing the dependency on traditional hardware peripherals. The development of gesture recognition and augmented reality could further enhance the capabilities of these virtual devices, making them more accurate and responsive, thus opening up new possibilities for seamless and immersive user experiences.

b. Problem Statement

It's no surprised that all technological devices have its own limitations, especially when it comes to computer devices. After the review of various type of the physical mouse, the problems are identified and generalized. The following describes the general problem that the current physical mouse suffers:

- Physical mouse is subjected to mechanical wear and tear.
- Physical mouse requires special hardware and surface to operate.
- Physical mouse is not easily adaptable to different environments and its Performance varies depending on the environment.
- Mouse has limited functions even in present operational environments.
- All wired mouse and wireless mouse have its own lifespan.

c. Objective

1. To design to operate with the help of a webcam. The Virtual Mouse application will be operational with the help of a webcam, as the webcam is responsible for capturing images in real time. The application would not work if no webcam is detected.

2. To design a virtual input that can operate on all surfaces. The Virtual Mouse application will be operational on all surfaces and indoor environments, as long as users face the webcam while performing motion gestures.

3. To convert hand gestures/motions into mouse input that will be set to a particular screen position. The Virtual Mouse application will be programmed to detect the position of defined colors, which will be set as the position of the mouse pointer. Additionally, a combination of different colors may trigger various mouse events, such as right/left clicks and volume control.

2. METHODS AND MATERIAL

a. Architecture/Framework

The architecture and framework of our proposed AI virtual mouse system are the backbone of its functionality, defining how it operates and interacts with the user's computing environment. This section offers a comprehensive exploration of the structural components and the underlying framework that drive this innovative system

1. Core Components:
At the heart of our system lies a web camera, a computer equipped with Python and essential libraries, and the AI-based virtual mouse application. These components work in synergy to create a cohesive and effective system.

2. Data Flow:
The operation initiates with the web camera capturing real-time video frames. These frames undergo preprocessing, transitioning from the BGR colour space to the RGB colour space, which is a fundamental step for effective hand gesture recognition.

3. Hand Gesture Recognition:
A pivotal component of the system's framework involves recognizing and tracking hand gestures within the video feed. Utilizing sophisticated computer vision techniques and OpenCV, the system can accurately identify and interpret hand movements in real-time.

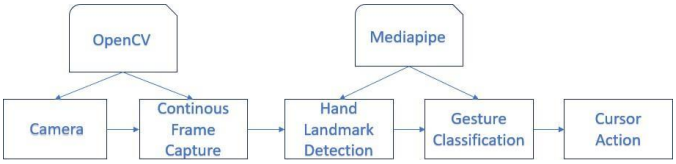


Figure 1 A: Framework

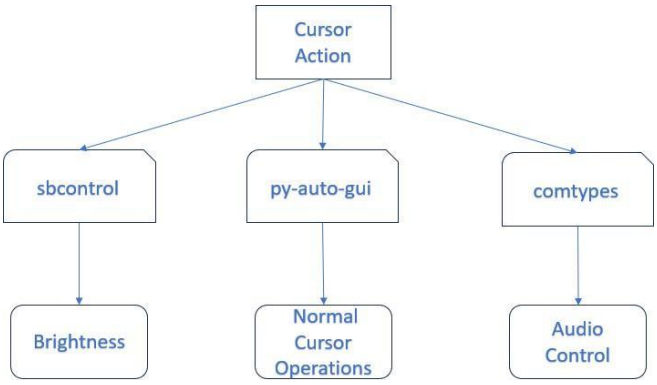


Figure 1 B: Framework

b. Architecture/Framework

System Initialization:
- The system starts by initializing the computer's webcam to capture video frames.

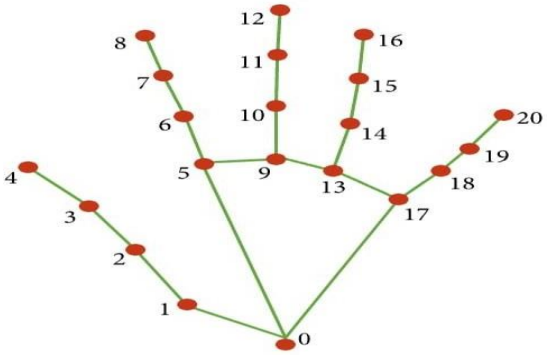
Continuous Frame Capture:
- It continuously captures video frames in real-time, akin to taking a series of photos.

Frame Preprocessing:
- Each frame undergoes preprocessing, converting its colour format from BGR to RGB to enhance gesture recognition.

Gesture Recognition:
- Hand Detection: Identifies and isolates hand regions in the frame.
- Feature Extraction: Extracts features such as finger positions and hand shape.
- Machine Learning Model: Processes features to interpret various gestures.
- Gesture Identification: Classifies gestures, such as open hand, fist, or spread fingers.

Visual Feedback:
- Displays the processed video frame on the screen, showing recognized gestures and the virtual mouse cursor's position.

Continuous Operation:
- The system runs in a loop, capturing frames, recognizing gestures, and executing actions in real-time for responsive user interaction.



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

Figure 2: Hand Landmarks

c. Hardware and Software components

Hardware Components:

Camera:

- The AI virtual mouse system utilizes a laptop camera, adaptable to standard webcams. The camera's specifications, including resolution and frame rate, are crucial for capturing video frames accurately.

Software Components:

Libraries and Frameworks:

- Media Pipe: Integral for hand gesture recognition and tracking.
- OpenCV: Essential for image processing and working with video frames.
- AutoPy: Facilitates system-level actions like mouse clicks and user-defined tasks.

Operating System:

- Designed to run primarily on Windows, with compatibility across different versions for flexible deployment.

Development Tools:

- PyCharm: Primary IDE used for coding and testing, offering essential features for Python development.

Additional Software:

- The system emphasizes a streamlined design without reliance on additional software components, ensuring self-contained functionality.

Efficiency Table:

For Testing of our system, we performed 20 iterations of all the functions with different hands here is the result of the testing:

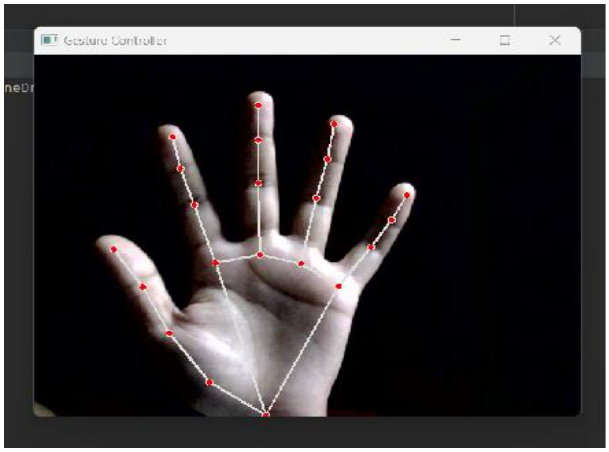
Table 2: Accuracy Data

3. RESULTS AND DISCUSSION

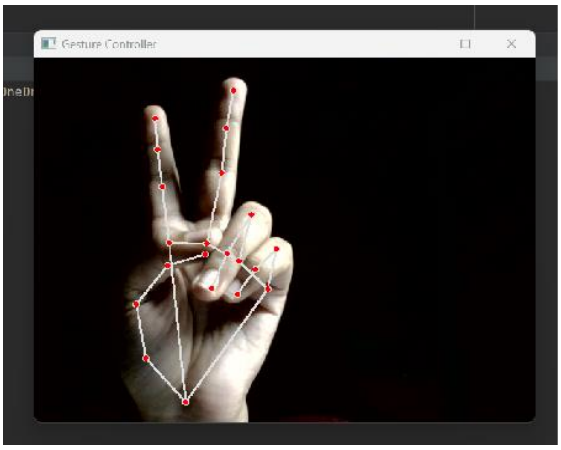
In the Results section, we present the outcomes of our AI virtual mouse system in action. This segment showcases the effectiveness of our system through visual aids in the form of gesture photos for various functions. These images offer a practical demonstration of how our system interprets hand gestures to control a computer. We'll highlight the system's accuracy and efficiency, emphasizing its ability to recognize and respond to different hand movements. Through the visual evidence provided, you'll gain a firsthand insight into the practical applications of our AI virtual mouse system. Below are the images of the Hand Gestures used for the given functions:

SR NO:	OPERATION PERFORMED	SUCCESS	FAILURE	ACCURACY
1	Cursor moving	19	1	95%
2	No movement	18	2	90%
3	Left click	19	1	95%
4	Right click	18	2	90%
5	Volume controller	17	3	85%
6	Brightness Control	18	2	90%
7	Scroll Control	16	4	80%
8	Double Click	19	1	95%
9	Drag and drop	18	2	90%

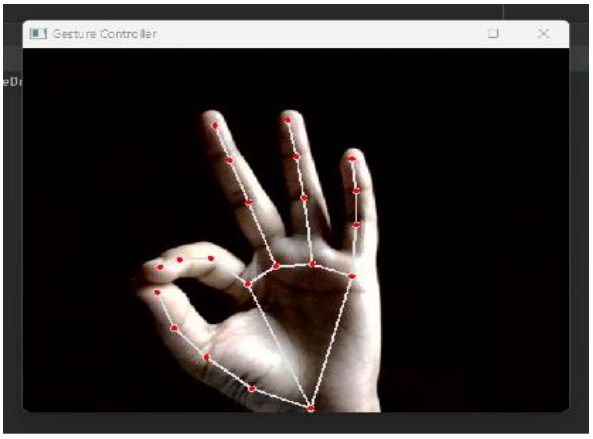
a. Figures:



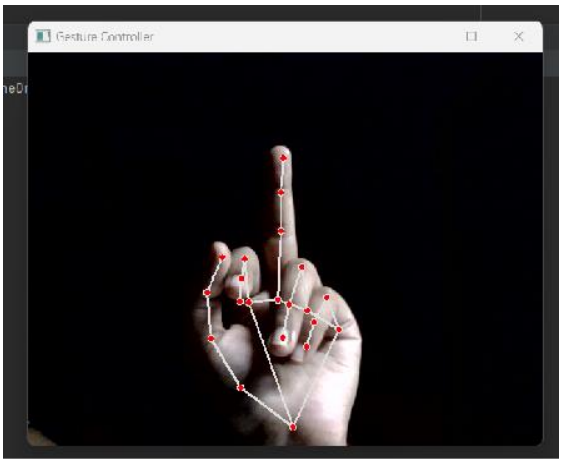
NO MOVEMENT



MOVE CURSOR

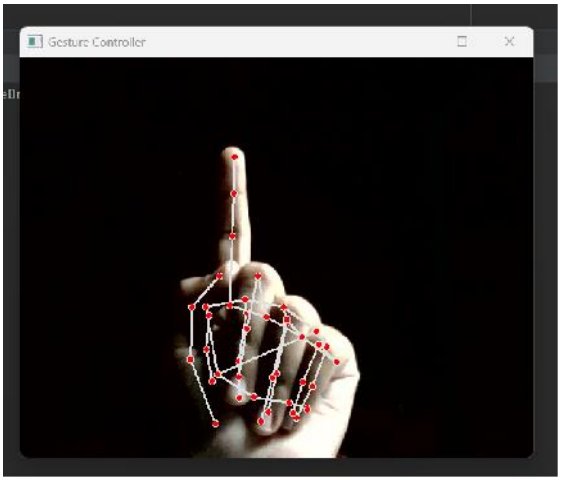


VOLUME CONTROLLER
(UP AND DOWN MOVEMENT)

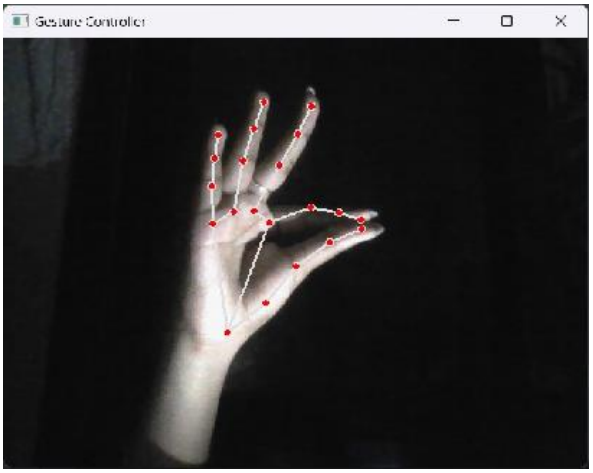


LEFT CLICK

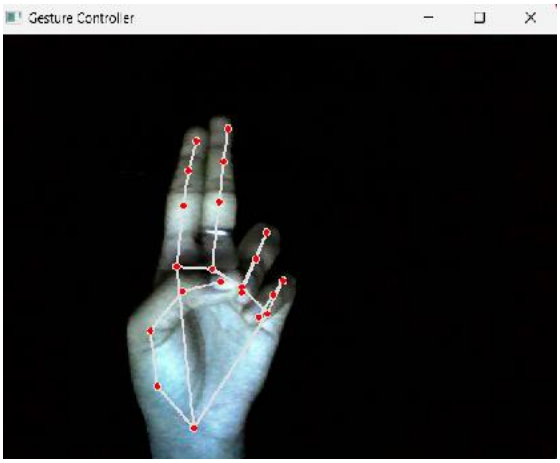
BRIGHTNESS CONTROLLER
(LEFT AND RIGHT MOVEMENT)



RIGHT CLICK



SCROLLING CONTROL



DOUBLE CLICK

DRAG AND DROP FILE

3. CONCLUSIONS

The main objective of the AI virtual mouse system is to control the mouse cursor functions by using the hand gestures instead of using a physical mouse. The proposed system can be achieved by using a webcam or a built-in camera which detects the handgestures and hand tip and processes these frames to perform the particular mouse functions. From the results of the model, we can come to a conclusion that the proposed AI virtual mouse system has performed very well and has a greater accuracy compared to the existing models and also the model overcomes most of the limitationsof the existing systems. Since the proposed model has greater accuracy, the AI virtualmouse can be used or real-world applications, and also, it can be used to reduce the spread of COVID-19, since the proposed mouse system can be used virtually using hand gestures without using the traditional physical mouse. The model has some limitations such as Limited functions. Hence, we will work next to overcome these limitations by improving the fingertip detection algorithm to produce more accurate results.

ACKNOWLEDGEMENT

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