Controlling laptop working with hand gestures(like a mouse)

A Project Work Synopsis

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ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

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Abstract

In Human Computer Interaction (HCI), the mouse is a remarkable invention in Computer Technology, faces limitations in contemporary Bluetooth and wireless models due to battery reliance and PC connectivity via dongles. These challenges are addressed by the proposed AI gesture-based virtual mouse. By capturing hand motions through a camera, this innovation utilizes gestures as a potent communication mode. The computer can replicate functions like right and left-click, scrolling, and cursor control without a physical mouse, thus aiding COVID-19 prevention and minimizing bias in computer control. The popularity of hand gesture recognition in AI advancement drives the creation of a system that translates hand gestures into mouse actions. This camera-based system accommodates users struggling with traditional input methods, recognizing gestures through AI algorithms trained on a diverse dataset. Recognized gestures prompt corresponding virtual mouse actions, scalable across environments and devices. This system, integrated with voice commands, employs ML and Computer Vision algorithms like CNN and mediapipe, eliminating extra hardware requirements. With applications in hazard-prone environments and as an alternate hardware mouse interface, the hand gesture-controlled virtual mouse substantially enhances accessibility and user interaction.

Keywords: Human Computer Interaction (HCI), Webcam, OpenCV, Mediapipe , CNN, Virtual Mouse.

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1. INTRODUCTION

Computers have seamlessly integrated into our daily routines, simplifying human-computer interaction (HCI). However, individuals with disabilities face distinct challenges in utilizing these devices effectively. This study introduces a gesture-based AI virtual mouse system, leveraging computer vision to execute mouse tasks using hand movements and fingertip detection. The system's core objective is to replace the conventional mouse with a web or built-in camera, enabling cursor control and scrolling through hand gestures.

Python, along with the OpenCV computer vision library, forms the foundation of the gesture-based AI virtual mouse framework. MediaPipe aids in tracking hand and fingertip positions, while Autopy facilitates window navigation, left and right clicking, and scrolling actions. Notably, the model demonstrates exceptional accuracy and efficacy, particularly on CPU-based systems, extending its practicality to real-world scenarios.

Hand gestures are universally recognized as a potent form of human expression. This project taps into this natural mode of communication, proposing a low-cost USB web camera setup for input. The paper introduces a real-time hand gesture system, incorporating techniques such as preprocessing, background subtraction, and edge detection to achieve effective gesture segmentation. By employing the Python language and OpenCV, the AI virtual mouse system is crafted, further enhanced by MediaPipe, Pynput, Autopy, and PyAutoGUI packages for precise hand tracking, cursor movement, and diverse operations.

This project presents a comprehensive approach to bridging accessibility gaps through a gesture-driven AI virtual mouse, ushering in a new era of intuitive human-computer interaction.

1.1 Problem Definition

This project aims to develop a system enabling users, especially those with disabilities, to control a laptop's mouse functions through hand gestures. The main goal is to create an intuitive interface translating specific hand movements into accurate mouse actions—such as cursor movement, clicking, and scrolling. Challenges involve accurate gesture recognition, real-time processing, robustness under varying conditions, user-friendliness, compatibility, diverse actions, reduced user strain, error prevention, and adaptability to individual preferences. The ultimate purpose is to enhance accessibility and user experience in human-computer interaction by utilizing AI and computer vision. This empowers users to navigate laptop tasks seamlessly using natural hand gestures, ensuring precision, responsiveness, and ease of use across various scenarios.

1.2 Problem Overview

The problem revolves around developing a system that employs artificial intelligence to control a virtual mouse using hand gestures. The objective is to create a user-friendly and accessible method for interacting with computers. By enabling users to navigate and control computer functions through hand gestures, the system aims to provide an alternative input approach, particularly

beneficial for people with disabilities or those seeking a more intuitive means of interaction. Key considerations encompass accurate gesture recognition, real-time responsiveness, adaptability to different hand shapes, user-friendliness, and seamless integration of AI algorithms. The project's aim is to enhance human-computer interaction by utilizing AI and hand gestures to control a virtual mouse, thus enhancing accessibility and expanding the ways users can engage with technology.

1.3 Hardware Specification

A Webcam

1.4 Software Specification

- 64-bit Operating System: Windows 8 or Higher
- Python
- Any IDE (PyCharm or Visual Studio)
- OpenCV needs to be installed.
- MediaPipe needs to be installed.
- Windows Administrator permissions are needed for some parts of the program to function properly.

2. LITERATURE SURVEY

2.1 Existing System

The Virtual Mouse Control System, employing colored fingertip detection and hand gesture recognition [1], enables cursor manipulation without requiring direct physical contact or sensors. This approach involves identifying vibrant fingertip colors and tracking their movements, with the potential to substitute different hand gestures for colored caps. The system facilitates a range of mouse functions, including scrolling, single and double-clicking on the left side, and more. Diverse arrangements of colored caps cater to various tasks, adapting to different users and lighting conditions.

The system's adaptability is demonstrated by adjusting skin tone detection based on the user and environment. By analyzing program output during hand motions, the unused area within the hand's convex hull is approximated. In well-lit settings like offices, where brightness ranges from 500 to 600 lux, colors like Red, Green, and Blue exhibit around 90% detection accuracy. The system overcomes these challenges by incorporating hand gesture recognition technology that detects hand contours, effectively enabling mouse operations through colored fingertips.

This system comprises two main methods: finger detection via colored fingertips and gesture recognition. It employs video processing and background subtraction, leveraging colored finger caps for detection, followed by color and circle identification [2]. The recognized gestures trigger various mouse actions.

In essence, the Virtual Mouse Control System revolutionizes hands-free cursor manipulation through colored fingertip tracking and hand gesture interpretation, significantly enhancing user interaction and accessibility.

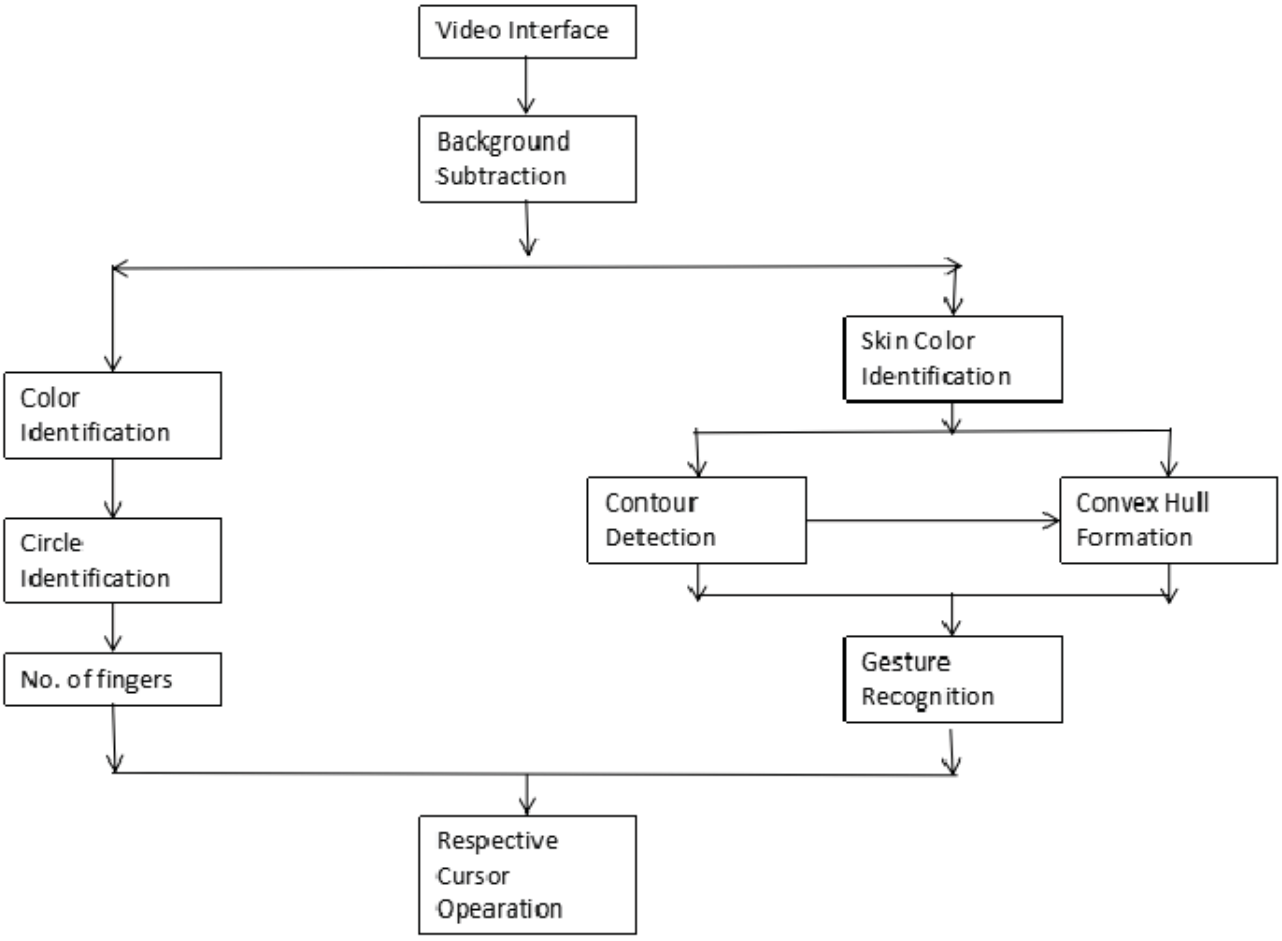

Fig : - Virtual Mouse Control using Colored Fingertips and Hand Gestures Recognition

2.2 Proposed System

Creating a hardware-independent virtual mouse eliminates the need for additional equipment and colored fingertip markers. Instead, our approach utilizes the existing web camera on the user's device to capture real-time feeds. The system's workflow commences by initiating the video interface through the device's web camera. Subsequently, the system detects hand gestures, facilitating mouse interaction and executing diverse cursor operations. This virtual mouse solution is characterized by its portability, user-friendliness, and affordability.

The system incorporates "Mediapipe" technology, specifically its hand landmark detection functionality. Mediapipe, developed by Google, is a versatile toolkit that empowers applications with AI-driven features such as hand tracking and gesture recognition. This integration enhances the virtual mouse's capabilities and precision, contributing to an improved user experience [3][4].

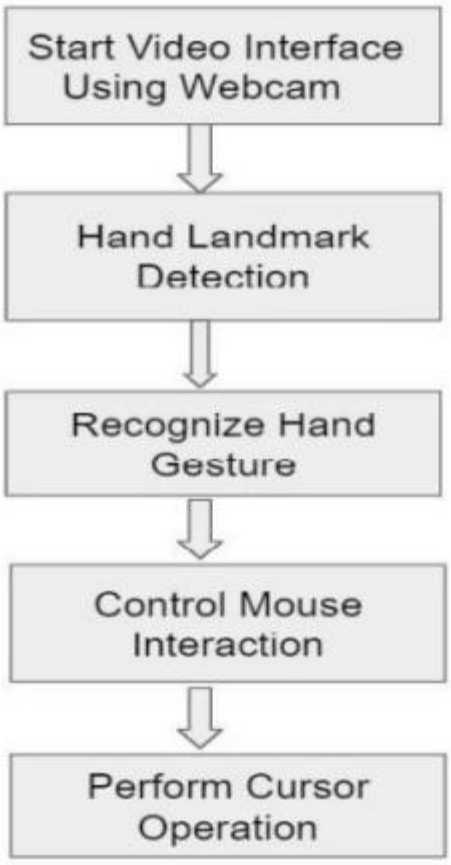

Fig : - Virtual mouse using hand gesture recognition

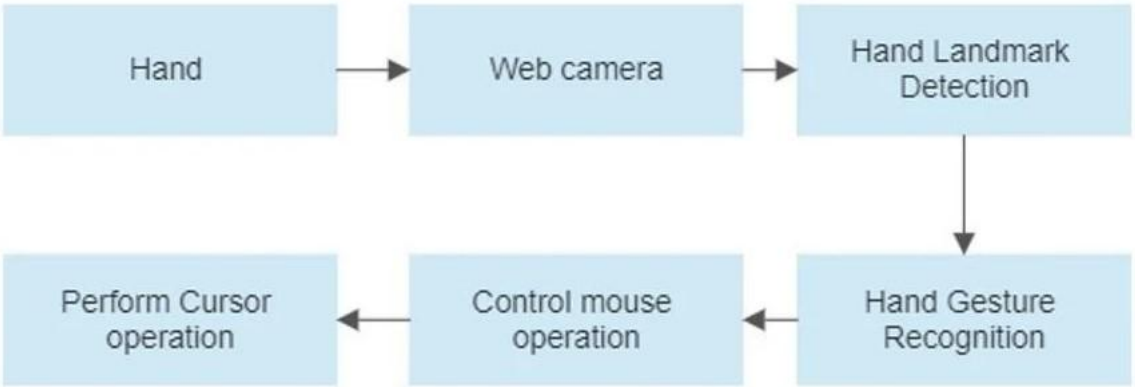

Fig : - : Block Diagram of Virtual mouse using hand gesture recognition

2.3 Literature Review Summary **(Minimum 7 articles should refer)**

Year and Citation	Article/ Author	Tools/ Software	Source	Findings	Evaluation Parameter
2020	Virtual Mouse Control Using Colored Finger Tips and Hand Gesture Recognition	Python, OpenCV, Mediapipe, Neural Networks	IEEE	Using colored finger caps, the system detects fingers, identifies colors, forms circles on fingers, and interprets gestures for mouse operations.	
2023	VIRTUAL MOUSE USING OPENCV	Python, OpenCV, Hand Gesture	IRJET	Utilizing computer vision and OpenCV for easier mouse movement and system usage.	

2020	Virtual Mouse Using Object Tracking	Python, OpenCV, HSV technique	IEEE	A webcam-based hand gesture system controls the cursor using computer vision.	
2022	Virtual Mouse Using Hand Gesture Recognition (Volume 9)	Python, Mediapipe, Hand Gesture	IRJET	Initiating with video interface, the system recognizes gestures, controlling mouse.	
2022	Gesture Recognition-based AI Virtual Mouse (Volume 10)	OpenCV, Mediapipe, AI	IJRASET	MediaPipe detects hand motion, OpenCV enables computer vision. Machine learning identifies gestures.	

2023	HAND GESTURE CONTROLLED VIRTUAL MOUSE USING ARTIFICAL INTELLIGENCE (Volume 9)	Mediapipe, Computer Vision, Hand Gesture Recognition, AI	IJARIIE	Revolutionizing computer interaction through AI-based hand gesture-controlled virtual mouse.	
2023	Control Mouse using Hand Gesture and Voice (Volume 11)	Mediapipe, OpenCV, CNN, Voice assistant	IJRASET	Gesture recognition enhances human-machine interaction, enabling diverse HCI modalities.	

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3. PROBLEM FORMULATION

The problem at hand involves devising a virtual mouse system that utilizes hand gesture recognition to redefine the way users interact with computers. The aim is to establish an intuitive and efficient means of controlling mouse actions through hand gestures, transcending traditional input methods and enhancing the human-computer interaction experience.

The key components of this problem formulation are as follows:

Gesture Recognition Accuracy: The primary challenge is to design a robust algorithm that can accurately identify and interpret a wide range of hand gestures. This involves mapping specific gestures to corresponding mouse actions like cursor movement, clicking, scrolling, and potentially more complex tasks.

Real-Time Responsiveness: The system needs to provide instant feedback and execute mouse actions in real time, ensuring a seamless and responsive user experience. Delays in gesture recognition and response could hinder usability.

Adaptability to Varied Gestures: The system must be capable of recognizing diverse hand gestures, accommodating variations in speed, orientation, and complexity to cater to different users' preferences and needs.

User-Friendly Interface: The design should prioritize ease of use, allowing users to learn and perform gestures without a steep learning curve. Intuitive gestures and smooth execution are essential for effective human-computer interaction.

Integration with Existing Systems: The virtual mouse system needs to be compatible with various devices, operating systems, and applications, ensuring its widespread usability and accessibility.

Reducing Physical Strain: The system should aim to reduce user fatigue caused by prolonged mouse usage. This could be achieved by creating ergonomic and intuitive gestures that minimize physical effort.

Error Handling and Correction: Mechanisms for preventing accidental gestures triggering unintended actions and providing options to rectify or cancel actions are vital for a reliable and frustration-free interaction.

Future Scope in HCI: The proposed method holds potential for expanding beyond mouse control to encompass keyboard functionalities through hand gestures, enriching the realm of Human-Computer Interaction.

The problem of designing a virtual mouse system using hand gesture recognition focuses on enhancing user interaction with computers by leveraging intuitive gestures. Addressing challenges related to accuracy, real-time response, adaptability, and usability, the solution aims to revolutionize the way individuals navigate and engage with digital interfaces, opening doors to more intuitive and accessible human-computer interaction paradigms.

4. OBJECTIVES

The objective of the Virtual Mouse Using Hand Gesture Recognition is to create an innovative and intuitive human-computer interaction paradigm that empowers users to control and navigate digital interfaces through natural hand gestures. This novel approach seeks to enhance user experience, accessibility, and efficiency by eliminating the need for traditional physical input devices like mouse and touchpads. The primary objectives of this system can be summarized as follows:

Accurate Gesture Recognition: Develop a sophisticated gesture recognition algorithm that can accurately interpret a wide array of hand gestures. The system should be capable of distinguishing between gestures for cursor movement, clicking, scrolling, and potentially other commands.

Real-Time Responsiveness: Ensure that the system recognizes and responds to hand gestures in real time, providing users with an immediate and seamless interaction experience. Minimize any perceptible delays between gesture execution and system response.

Intuitive User Interface: Design a user-friendly interface that allows users to learn and perform hand gestures effortlessly. The system should provide clear visual feedback to users as they execute gestures, enhancing the overall user experience.

Compatibility and Adaptability: Create a system that can be easily integrated into various devices, operating systems, and applications. The

solution should adapt to different hardware configurations and accommodate a wide range of user preferences.

Reduced Physical Strain: Address the issue of user fatigue caused by extended use of traditional input devices. The virtual mouse should offer a more ergonomic and comfortable way of interacting with computers, minimizing strain on users' hands and wrists.

Error Handling and Flexibility: Implement mechanisms to prevent unintended actions triggered by accidental gestures. Additionally, provide users with options to correct or cancel actions to ensure a frustration-free experience.

Enhancing Accessibility: Improve accessibility for users with physical disabilities or mobility limitations, enabling them to interact with computers more effectively and independently.

Potential for Expansion: Explore the possibility of expanding the system's capabilities beyond basic mouse control, such as incorporating keyboard functions or supporting complex interactions.

The objective of the Virtual Mouse Using Hand Gesture Recognition is to revolutionize the way individuals interact with computers by offering a more natural, efficient, and accessible method of input.

5. METHODOLOGY

Hand tracking and gesture recognition leverage the MediaPipe framework, while computer vision tasks are facilitated by the OpenCV library. The approach employs machine learning to track hand gestures and fingertip positions effectively.

OpenCV :

OpenCV, a Python-based computer vision library, encompasses object detection and image processing algorithms. It's integral for real-time computer vision applications, image/video processing, and tasks like face and object detection.

Mediapipe :

MediaPipe, an open-source Google framework, serves as a versatile tool for machine learning pipelines, particularly for cross-platform development due to its time series data compatibility and multimodal capabilities.

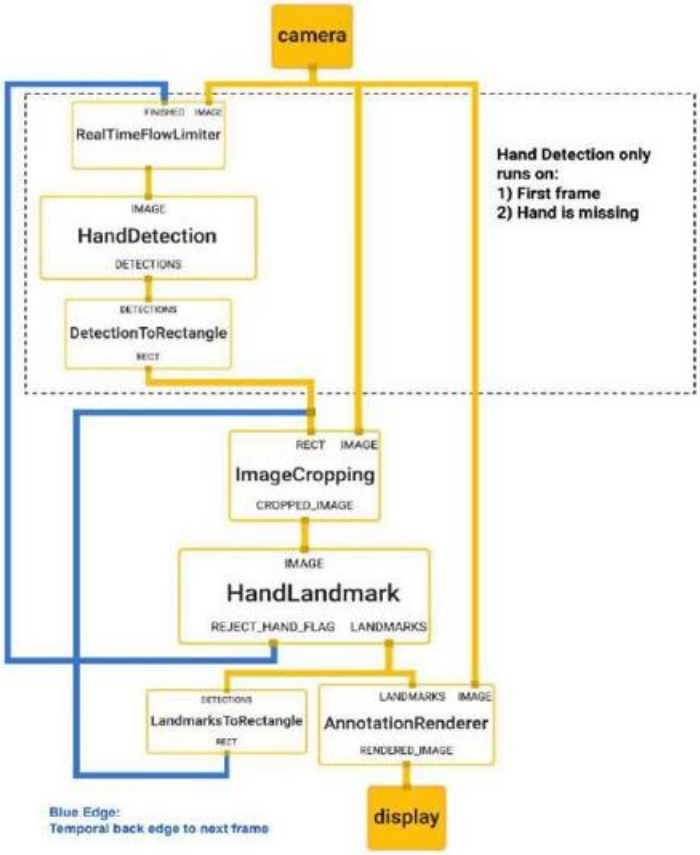


Fig : - MediaPipe Hand Recognition Graph

Capturing the video :-

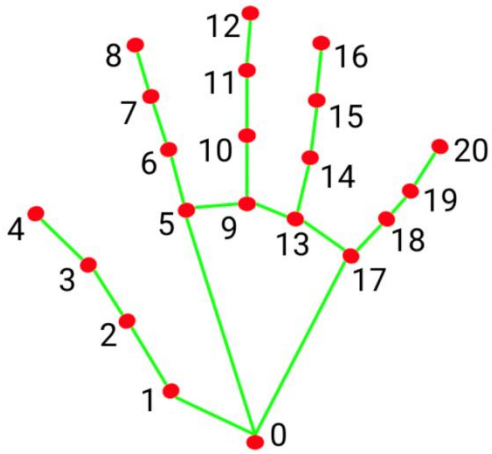
This AI virtual mouse system utilizes laptop or PC images, employing the Python computer vision tool OpenCV to create a video capture object. A web camera records frames, subsequently processed by the virtual AI system.

Analysing the video for hand gesture :-

The AI virtual mouse system employs a webcam to capture frames throughout the program execution. These images are converted to RGB, facilitating hand identification on a frame-by-frame basis.

Hand recognising Landmarks :-

Employing hand coordinate movement between the webcam and computer window, the AI virtual mouse method facilitates transformative mouse actions. After finger tip and hand recognition, identified fingers for cursor movement can generate a reference box on the screen, enabling observable cursor movements within the window.



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 :- Landmarks in Hand

Checking the finger which is up and performing mouse operation :-

For seamless hand coordinate transfer from webcam to full-screen computer window, the AI virtual mouse employs a transformative approach. Once hands are detected and specific finger movements recognized, a rectangular box forms in the camera's region referencing the computer window. This allows easy mouse pointer movement within the window.

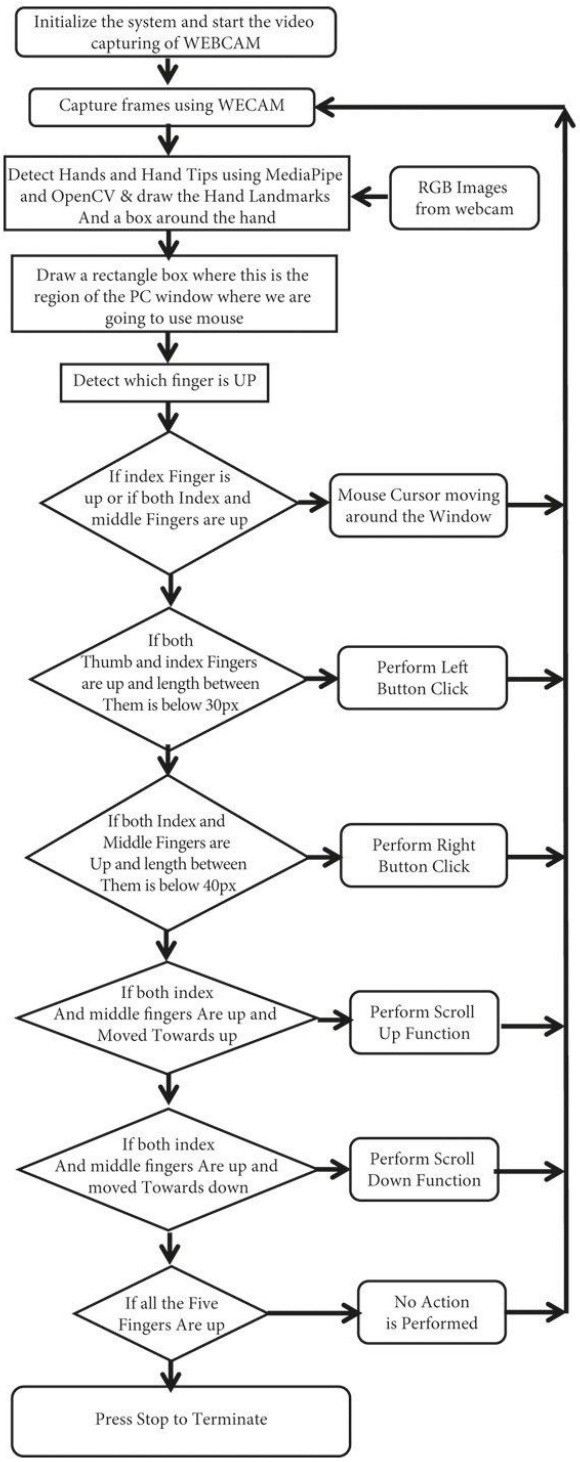


Fig :- The real-time gesture-based virtual mouse system's flowchart

6. EXPERIMENTAL SETUP

1. Data collection :- Collecting information on mediapipe , cv , hand landmark detection and how these can be combined to create a hand gesture controlled mouse. Also referring to various journals.

2. Using Open-CV to capture real-time video frame by frame

3. Use the MediaPipe Hand module to detect hands in each video frame and its landmarks' coordinates(like fingertips, palm center, etc.).

3. Gesture Recognition: Define the gestures you want to recognize (like left and right click , scrolling etc). Implement logic to detect these gestures based on the movement and positions of hand landmarks.

4. Controlling the mouse cursor using a relevant python library and then using the created logic to figure out and then execute the necessary commands/gestures/clicks,also implementing error handling.

5. Testing and checking how our model works and changing and tweaking details as per the accuracy of the model.

7. CONCLUSION

In conclusion, the development of the Virtual Mouse system marks a significant advancement in human-computer interaction. Designed with user-friendliness and real-time functionality in mind, this system offers a cost-effective and straightforward alternative to traditional input methods. The primary goal of the virtual mouse is to revolutionize cursor control by replacing physical mouse and other hardware devices with intuitive hand gestures. Its potential extends beyond convenience; it has the capability to mitigate the spread of COVID-19, as the system enables touchless operation, reducing the need for physical contact.

The success of the virtual mouse system, demonstrated without the necessity of hardware devices, is a testament to its viability. By addressing existing limitations and providing a more accessible means of navigation, the system marks a significant step forward in technology. Moreover, the integration of voice assistant support further elevates the user experience, allowing for additional device control through voice commands in conjunction with hand gestures. As this technology continues to evolve, the possibilities for innovative solutions enhancing user interaction and accessibility are bound to expand.

The fusion of real-time camera technology, hand gestures, and voice control has the potential to redefine the way individuals engage with their

devices. The Virtual Mouse system showcases the innovative spirit of technology and its commitment to creating more inclusive and efficient digital experiences for users of all backgrounds.

8. TENTATIVE CHAPTER PLAN FOR THE PROPOSED WORK

CHAPTER 1: INTRODUCTION

Taking overview of the project , and creating a introduction of our project highlighting the necessary tools and languages required.

CHAPTER 2: LITERATURE REVIEW

Studying multiple journals and research papers and figuring out the existing system of controlling mouse using hand gestures and creating a literature survey based on the findings.

CHAPTER 3: OBJECTIVE

Noting the use cases of the project and highlighting the need for it

CHAPTER 4: METHODOLOGIES

Working out how the flow of creating of the project will occur, and finding the necessary libraries which will be used for hand gesture recognition and execution of the laptop mouse clicks and scrolling.

CHAPTER 5: EXPERIMENTAL SETUP

In this we will explain how we will make our project , show the stepwise flow of the creating of the virtual mouse.

CHAPTER 6: CONCLUSION AND FUTURE SCOPE

Concluding the project , along with finding the future scope of the project , like the things or features that can be added in future to further improve the project

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