

VIRTUAL MOUSE

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ABSTRACT

The emergence of the pandemic has resulted in a technological paradigm shift. The development and use of a virtual mouse in place of a real mouse is one such field of research. This is a step forward in the field of HMI (Human-Machine Interaction). Even if wireless or Bluetooth mouse technology has yet to be established, it is not device-free. A Bluetooth mouse necessitates the usage of a battery and a connected dongle. The presence of additional electronics in a mouse makes it more difficult to use. This system takes frames using a webcam or built-in camera, analyses them to make them trackable, and then detects and performs mouse functions based on the hand gestures performed by users. As a result, the suggested mouse system eliminates the need for a device.

Recently, laptops and computers that can be used with gestures have become very popular. This method is referred to as leap motion. We can control some of a computer or laptop's features by waving our hand in front of it. Computer-based presentations have a number of advantages over overheads and slides. Presentations can be made better by using audio, video, and even interactive programs. Unfortunately, adopting these methods requires more effort than simply using slides or overheads. The speaker is required to use a variety of gadgets with foreign controls (such as a keyboard, mouse, and VCR remote control). These instruments are hard to see in the dark, and adjusting them ruins the display. The most natural and simple way to communicate is through hand gestures. The output of the camera will be seen on the monitor. The idea is to control mouse cursor functions without the usage of a traditional or standard mouse. Using merely a camera, the Virtual Mouse creates a connection between the user and the system. Without the use of mechanical or physical tools, it enables users to interact with equipment and even manage mouse functions.

This study describes a technique for moving the pointer without using any electronic devices. While numerous hand motions will be used to perform tasks like clicking and dragging objects. The suggested system will just

need a webcam as an input device. The proposed system will necessitate the use of Python, OpenCV, and other technologies. The system's screen will display the output from the camera so that the user can further calibrate it.

I. Introduction

The technologies that we typically use in our daily lives have become more minimal as time has gone on, thanks to improvements like Bluetooth or far-off technology. This is especially true of the fields of augmented reality and other devices. This research suggests an artificial intelligence (AI) virtual mouse system that uses hand signals and hand tip recognition to execute mouse limits at advantageous PC cheating mobile PC vision ranges. The proposed system's use of a web camera or a standard camera instead of an outdated mouse device to perform device pointer functions and material functions is the most impartial.

A. Problem Statement

The suggested artificial intelligence (AI) virtual mouse technology can be used to get past problems in the real world, such as when there isn't enough space to use a physical mouse or for persons with hand disorders who can't use one. Because hand gesture and hand Tip detection is utilized to operate the PC mouse operations using a webcam or a built-in camera, the proposed AI virtual mouse can be used to address these concerns. Furthermore, it is unsafe to utilize the devices in the COVID-19 circumstance by contacting them because of the possibility of virus dissemination.

B. Scope

This project shows how to operate a computer using hand gestures and movements, which is one of the most effective ways to use a computer. It's one of the simplest forms of human-computer interaction. It is a cost-effective tactic. This method allows us to swiftly and easily complete keyboard shortcuts as well as nearly any basic operation. By using this technique, we can create our own code that performs whatever action we desire.

C. Aim and Objectives

The primary goal of the proposed AI virtual mouse system is to create an alternative to the standard and conventional mouse system to perform and control the mouse functions. This can be done with the aid of a web camera that records hand gestures and hand tips and then processes these frames to perform the specific mouse function, such as the left click, right click, and scrolling function. The robustness of the proposed system depends on the nature and consistency of the underlying perceptual processes that convert unprocessed visual data into a meaningful symbolic description. The capability of accurately segmenting fingertips and extracting information, the robustness of tracking multiple moving objects under severe occlusions, and the accuracy of skin color detection under varying lighting conditions are all features that contribute to the usability of the developed system. It has been suggested to employ hand gestures as a method of human-computer interaction.

- **IMPROVED ACCURACY:** The hand-mouse interface uses a Kinect sensor to achieve high precision, but the gesture implementation is cumbersome because the user must use both hands to manipulate the mouse. The resolution of the virtual monitor is another restriction on the task in progress. This means that the skeletal joints provided by Kinect, such as the width of the shoulder and the position of the spine, determine the width and height of the virtual screen. For genuine motions, the hand-motion space is relatively constrained. Additionally, in order to do the hand movements, the users must be standing.

- **INCREASED PERFORMANCE:** The virtual mouse system is compared to other virtual mouse systems and assessed on a number of measures, including robustness, accuracy, and speed. The trial results showed a high degree of accuracy (97.37 percentage) and that the system can function effectively in real-world situations with just one CPU. A virtual mouse system powered by AI reaches a high accuracy rate of (97 percentage). This shows that the algorithm does a good job of precisely detecting and distinguishing fingertip and hand motions. It's crucial to remember that the "Scroll function" is less accurate than other movements. This is explained by how challenging it is to comprehend and accurately capture the precise motion needed for scrolling.

- **RESOLUTION AND SENSOR QUALITY:** It's crucial to use a camera with a good sensor and high resolution to improve the performance of a virtual mouse system. Even from a distance, a high-resolution camera can accurately record minute details and delicate hand gestures. A high-quality sensor guarantees minimal noise, increased light sensitivity, and higher image integrity. These characteristics allow the system to function well in a variety of illumination situations and to keep responsiveness, particularly when tracking quick hand movements.

In order to make virtual mouse systems flexible and user-friendly, high-quality cameras with these capabilities are essential. They enable users to interact comfortably from different distances, which is especially advantageous for those with mobility disabilities.

- **WIDE-ANGLE LENS:** A wide-angle lens is essential for improving the functionality of virtual mouse systems. The camera's field of view is significantly widened by a wide-angle lens, enabling it to capture a bigger area in each frame. When the user's hand is placed away from the camera, this is especially helpful. It gives users more flexibility to position their hands ergonomically, enhancing the logical and user-friendly nature of interactions. Additionally, by accommodating a range of hand sizes and preferences, this functionality improves accessibility for a broad user base. It is especially helpful for people with mobility issues who might need a wider range of motion. For the best outcomes, it's crucial to take care of any possible distortion at the frame's edges and take tracking algorithm changes into consideration.

II. Literature Survey

A. Literature Review

In this chapter, we have given our critical evaluation and summary of all research papers that we read related to our project. After reading many reference papers covering the topics related to Virtual Mouse, Hand Gestures, Hand movements, Open CV, PYTHON, etc. We studied the latest existing Systems and found some flaws and flaunt. All those details are given below.

- 1) **PAPER 1: Virtual Mouse: A Low-cost, Non-invasive Computer Interface[1]** : The creation and assessment of a virtual mouse system intended for spinal cord injury (SCI) sufferers. The system works by tracking head motions with a magnetometer and a head-mounted display to operate the mouse pointer on a computer screen. The system of a virtual mouse was tested on six people with spinal cord injuries, and the outcomes revealed that every subject could function. The system requires less mental effort while maintaining great accuracy. The writers advise that the. The virtual mouse technology has the potential to serve as a cheap, unobtrusive computer interface for people. People frequently have little to no use of their hands because of SCI. They also talk about the prospects. Improvement of the virtual mouse system to add new capabilities and make it even better its usability for people with SCI.

- 2) **PAPER 2: Virtual Mouse System using Hand Gestures[2]** : The creation and assessment of a virtual mouse system intended for spinal cord injury (SCI) sufferers. The system works by tracking head motions with a magnetometer and a head-mounted display to operate the mouse pointer on a computer screen. The system of a virtual mouse was tested on six people with spinal cord injuries, and the outcomes revealed that every subject could function. The system requires less mental

effort while maintaining great accuracy. The writers advise that the. The virtual mouse technology has the potential to serve as a cheap, unobtrusive computer interface for people. People frequently have little to no use of their hands because of SCI. They also talk about the prospects. Improvement of the virtual mouse system to add new capabilities and make it even better its usability for people with SCI.

3) **PAPER 3: Virtual Mouse: A Low-cost, Non-invasive Computer Interface for Individuals with Spinal Cord Injuries.[3]** : The creation and assessment of a virtual mouse system intended for spinal cord injury (SCI) sufferers. The system works by tracking head motions with a magnetometer and a head-mounted display to operate the mouse pointer on a computer screen. Six people with SCI were used to test the virtual mouse system, and the results showed that all participants were able to utilize it with good precision and little mental effort. The virtual mouse device, according to the authors, has the potential to provide a low-cost, non-intrusive computer interface for people with SCI, who frequently have little to no use of their hands. They also talk about the possibilities for the virtual mouse system's future development to include more capabilities and further enhance its usability for people with SCI.

4) **PAPER 4: A Virtual Mouse Using a Neural Network Classifier for Users with Physical Disabilities.[4]** : The virtual mouse system can be controlled using head movements and facial gestures. The system uses a depth camera and a neural network classifier to recognize the user's head movements and facial gestures and translate them into mouse cursor movements. The authors describe the design and implementation of the system and evaluate its performance using a user study with eight participants with physical disabilities. The results showed that the virtual mouse system achieved an average accuracy of 88.9 for head movement recognition and 91.7 for facial gesture recognition. The authors suggest that the virtual mouse system has potential as a non-invasive, low-cost alternative computer interface for people with physical disabilities. They also discuss the potential for future development of the virtual mouse system to incorporate additional features and to improve its usability for people with physical disabilities.

5) **PAPER 5: Design and Implementation of Virtual Mouse Based on the Finger Motion.[5]** : A virtual mouse system that can be controlled using finger movements. The system uses an accelerometer and gyroscope sensor attached to the index finger of the user to track the finger motion and translate it into mouse cursor movements. The authors describe the design and implementation of the system and evaluate its performance using a user study with ten participants. The results showed that the virtual mouse system achieved an average accuracy of 96.5 for mouse cursor control tasks and that the participants were able to operate the virtual mouse

system with similar speed and accuracy as a traditional mouse. The authors suggest that the virtual mouse system based on finger motion has the potential as an alternative computer interface for people with disabilities or used in virtual reality environments. They also discuss the potential for future development of the virtual mouse system to incorporate additional features and to improve its usability for people with disabilities.

6) **PAPER 6:A Robust Low-Cost Virtual Mouse Based on Face Tracking. [6]** : It proposes an innovative non-contact virtual mouse system that operates by tracking facial movements. It is specifically designed to assist individuals with mobility impairments in the upper extremities, particularly those with disabilities. What distinguishes this system is its use of a standard web camera for its operation. The primary innovation is an improved optical flow algorithm, which accurately locates facial features defined by an active appearance model. This algorithm significantly enhances the precision and robustness of the system. Notably, the system functions effectively in diverse environmental conditions, including varying backgrounds and lighting levels. Crucially, the system performs well even when the user's face is in rapid motion over a significant range. This makes it a valuable tool for individuals with limited mobility who can control their facial movements. In summary, this paper presents a non-contact virtual mouse system that utilizes facial tracking. It's designed to empower individuals with upper extremity mobility impairments, employing a standard web camera and an improved optical flow algorithm for reliable and accurate performance. The system's adaptability to different environments and its ability to track facial features during rapid movements offer promising prospects for enhancing the quality of life for disabled individuals.

7) **PAPER 7:Virtual Mouse Based on Hand Gesture Recognition using Deep Learning.[7]** : An Employing hand motion to control a virtual mouse system. The system recognizes hand gestures and converts them into mouse cursor motions using a deep learning model based on convolutional neural networks (CNNs). The system's design and execution are described by the authors, who also employ user research with ten users to assess the system's performance. The outcomes demonstrated that the virtual mouse system recognized hand gestures with an average accuracy of 94.5 and that participants could utilize it with a typical mouse's speed and accuracy. The authors contend that a deep learning-based virtual mouse system based on hand gesture detection could be a suitable replacement for traditional computer interfaces for people with disabilities and virtual reality environments. They also discuss the potential for future development of the virtual mouse system to incorporate additional features and improve its usability for people with disabilities.

8) **PAPER 8:Virtual Mouse Control Using Hand Gesture Recognition.[8]** : The system for controlling

a virtual mouse using hand gestures. The system uses a webcam to capture the hand gestures of the user, which are then processed by an algorithm that recognizes the gestures and translates them into cursor movements. The authors describe the design and implementation of the system and evaluate its performance using a user study with six participants. The results showed that the system achieved an average accuracy of 92.3 for hand gesture recognition and that the participants were able to operate the virtual mouse system with similar speed and accuracy as a traditional mouse. The authors suggest that the virtual mouse system based on hand gesture recognition has the potential as an alternative computer interface for people with disabilities or used in virtual reality environments. They also discuss the potential for future development of the system to incorporate additional features and to improve its usability for people with disabilities.

9) **PAPER 9:Virtual mouse based on hand gestures recognition.[9]** : The virtual mouse system can be controlled using hand gestures. The system uses a webcam to capture the hand gestures of the user, which are then processed by a gesture recognition algorithm that translates them into cursor movements. The authors describe the design and implementation of the system and evaluate its performance using a user study with 30 participants. The results showed that the virtual mouse system achieved an average accuracy of 85.33 for hand gesture recognition and that the participants were able to operate the virtual mouse system with similar speed and accuracy as a traditional mouse. The authors suggest that the virtual mouse system based on hand gesture recognition has the potential as an alternative computer interface for people with disabilities or used in virtual reality environments. They also discuss the potential for future development of the system to incorporate additional features and to improve its accuracy and usability for people with disabilities.

10) **PAPER 10:Real-time hand gesture-based virtual mouse for computer control.[10]** : A real-time hand gesture-based virtual mouse system for computer control. The system uses a depth camera to capture the hand gestures of the user, which are then processed by an algorithm that recognizes the gestures and translates them into cursor movements. The authors describe the design and implementation of the system and evaluate its performance using a user study with 10 participants. The results showed that the virtual mouse system achieved an average accuracy of 92 for hand gesture recognition and that the participants were able to operate the virtual mouse system with similar speed and accuracy as a traditional mouse. The authors suggest that the virtual mouse system based on hand gesture recognition has the potential as an alternative computer interface for people with disabilities or used in virtual reality environments. They also discuss the potential for future development of the system to incorporate additional features and improve

its usability for people with disabilities.

11) **PAPER 11: A Comparative Study of Virtual Mouse Control Techniques.[11]** : It discusses the usability, accuracy, and user preference of three different virtual mouse control techniques: hand gesture, head movement, and speech recognition. The authors experimented with 18 participants to evaluate the performance of each technique. The study found that the hand gesture technique was the most accurate and preferred by participants, while the head movement technique was the least accurate and least preferred. The speech recognition technique had moderate accuracy and was preferred by some participants, but it had the highest response time. The authors also conducted a post-experiment survey to gather feedback from the participants on the usability and user experience of each technique. The survey results showed that the hand gesture technique was the most intuitive and easy to use, while the head movement technique was the least intuitive and most difficult to use. Overall, the study concludes that the hand gesture technique is the most effective virtual mouse control technique in terms of accuracy, user preference, and usability. The authors suggest that future research could explore the use of multiple techniques in combination to further enhance virtual mouse control.

12) **PAPER 12:Real-time hand gesture recognition-based virtual mouse for computer control.[12]** : A real-time hand gesture recognition-based virtual mouse system for computer control. The system uses a webcam to capture the hand gestures of the user, which are then processed by an algorithm that recognizes the gestures and translates them into cursor movements. The authors describe the design and implementation of the system and evaluate its performance using a user study with 10 participants. The results showed that the virtual mouse system achieved an average accuracy of 91.7 for hand gesture recognition and that the participants were able to operate the virtual mouse system with similar speed and accuracy as a traditional mouse. The authors suggest that the virtual mouse system based on hand gesture recognition has the potential as an alternative computer interface for people with disabilities or used in virtual reality environments. They also discuss the potential for future development of the system to incorporate additional features and improve its accuracy and usability for people with disabilities.

13) **PAPER 13:Virtual mouse control with hand gesture information extraction and tracking.[13]** : This study focuses on the development of a virtual mouse system utilizing hand gesture tracking through image processing, representing a significant advancement in the realm of human-computer interaction. The primary objective of this research is to augment human-computer interaction by introducing an innovative virtual mouse solution. The study is divided into three key stages: hand gesture tracking, extraction of hand region features, and

classification of these features. Hand gesture tracking is accomplished using the Camshift (Continuously Adaptive Mean Shift) algorithm. The authors utilize the 'bag of visual words' technique to extract features from hand gestures. Subsequently, these features are classified by employing support vector machines (SVMs). To validate the system's efficacy, the researchers conduct thorough tests assessing the accuracy of the tracking, feature extraction, and classification methods. The outcomes of these tests unequivocally demonstrate the successful functionality and performance of the system. This study introduces a novel approach to human-computer interaction, integrating image-based hand gesture tracking to create an efficient virtual mouse system. The incorporation of Camshift for tracking, 'bag of visual words' for feature extraction, and SVMs for classification collectively contribute to a robust and effective system. Through extensive testing, the study confirms the system's operational excellence, highlighting its potential to revolutionize user interactions with computers and other digital devices. In summary, this research constitutes a notable advancement in human-computer interaction, introducing a virtual mouse system founded on image processing and hand gesture tracking. The amalgamation of these techniques, supported by comprehensive testing, underscores the system's operational success and its capacity to enhance user experiences with digital technologies.

14) **PAPER 14: A Virtual Mouse Using a Neural Network.[14]** : Based on user input, the system forecasts the intended movement of a mouse pointer using a neural network. According to the scientists, this method might offer those with physical limitations or in situations where a physical mouse is not available an alternative to conventional physical mouse devices. A neural network is trained to anticipate the intended movement of the mouse cursor based on the position of the marker using the virtual mouse system, which uses a camera to track the position of a marker connected to the user's head. The accuracy and response times of the system were compared to those of a real mouse by the authors to assess how well it performed. The research discovered that the virtual mouse technology accomplished comparable levels of accuracy and response time to the physical mouse device, indicating that the neural network-based system is a viable alternative to traditional mouse devices.

15) **PAPER 15: Virtual Mouse Pad: A Novel Interface for Handheld Devices.[15]** : A virtual mouse pad interface that works with handheld devices and lets users use the touchpad on the back to control the mouse cursor. According to the authors, in some situations, this interface might be a more practical and intuitive option than standard touchscreen-based interfaces. The device's touchpad, which is separated into two areas for left and right mouse clicks, and its virtual pointer, which is displayed on the screen, make up the virtual mouse pad interface. The interface's accuracy, responsiveness,

and user-friendliness were assessed by the authors through a comparison with conventional touchscreen-based interfaces. According to the study, compared to conventional touchscreen-based interfaces, the virtual mouse pad interface exhibited better accuracy and faster response times, suggesting that it might offer a more practical and user-friendly method of controlling the mouse cursor on portable devices. Additionally, the researchers discovered that participants favored the virtual mouse pad interface over conventional touchscreen-based interfaces, indicating that it might enhance the user experience in some situations. All things considered, the study report offers a fresh method for controlling virtual mice on portable electronics, which may find usage in a variety of fields such as productivity software, mobile gaming, and accessibility technologies. The authors propose that to improve the usability and accessibility of the virtual mouse pad interface, future studies might investigate the use of additional input modalities, such as voice commands.

16) **PAPER 16: Deep Learning-Based Real-Time AI Virtual Mouse System Using Computer Vision to Avoid COVID-19 Spread.[16]** : An official statement from Wiley and Hindawi concerning the retraction of a published article. The reason for this retraction was the identification of systematic manipulation within the publication process. The manipulation encompassed issues like inconsistencies in the article's scope, description, data accessibility, improper citations, incoherent content, and manipulation of the peer-review process. These anomalies cast doubt on the reliability of the article. The investigation also uncovered deficiencies in complying with human-subject reporting requirements. Wiley and Hindawi acknowledged their failure to identify these issues before publication and have subsequently instituted additional safeguards to uphold the integrity of research. The corresponding author was contacted to express their agreement or disagreement with the retraction, with the responses documented. This notification underlines the publishers' dedication to maintaining the quality and transparency of research.

17) **PAPER 17: Virtual Mouse Control by Head Gestures and Eye Blinks.[17]** : A virtual mouse control system that uses head gestures and eye blinks as input modalities. The authors suggest that this system could provide an alternative to traditional physical mouse devices for individuals with physical disabilities or for situations where a physical mouse is not available. The virtual mouse control system uses a camera to track the user's head movements and an electrooculography (EOG) device to detect eye blinks. The system maps the user's head gestures and eye blinks to mouse cursor movements and clicks, allowing the user to control the virtual mouse using natural movements and gestures. The authors evaluated the performance of the virtual mouse control system by comparing it to a physical mouse device in terms of accuracy and response time. The study found

that the virtual mouse control system achieved similar levels of accuracy and response time to the physical mouse device, indicating that the system is a viable alternative to traditional mouse devices. Overall, the research the paper presents a promising approach to virtual mouse control using head gestures and eye blinks, which could have applications in assistive technology and other domains where physical mouse devices are not suitable or accessible. The authors suggest that future research could explore the use of additional input modalities, such as voice commands or facial expressions, to further enhance the usability and accessibility of the virtual mouse control system.

18) **PAPER 18: Embedded virtual mouse system by using hand gesture recognition.[18]** : Human-computer interaction (HCI) is becoming more and more integrated into our daily lives in the digital age. The goal of HCI has been to improve the intuitiveness of computer interfaces for a long time. One of the most common and organic ways that people communicate is with their hands. However, vision-based hand gesture identification continues to be a challenging task. To tackle this problem, this research presents an embedded virtual mouse system based on hand gesture recognition. The system uses several strategies to accomplish its goals. To distinguish between foreground and background areas and identify the region of interest, skin detection, and motion detection techniques are used. The centroid of an item is located using the linked component labeling algorithm, and hand area recognition and gesture interpretation are supported by other procedures involving arm removal and the convex hull algorithm. The study's findings show how effective the system is and how it can function dependably even in unfavorable environmental circumstances. This embedded virtual mouse technology presents a promising way to improve human-computer interaction, making it more natural and intuitive by utilizing hand movements.

19) **PAPER 19: A finger-tracking virtual mouse realized in an embedded system.[19]** : A novel concept of a virtual mouse controlled by finger movement, offering users the ability to interact with their computers or TV systems without the need for physical contact with real objects. The system employs a rapid and dependable method to track the position of a finger's tip, comprised of four key steps. To begin, the system detects skin-color pixels through color segmentation, utilizing the chrominance component of input data from a CMOS image sensor. This initial step helps isolate the finger against the background. Following that, density regularization processes are implemented to enhance the regions with skin-color pixels, thereby refining the finger tracking. The system also utilizes an efficient window search technique to minimize computational load, ensuring swift and responsive performance. In the final step, a finger-tip tracking algorithm is applied to precisely locate the position of the finger's tip. Additionally, a specific finger movement is employed to trigger clicking actions. The virtual mouse

is designed to run on an embedded Linux system and has been demonstrated to function successfully. It exhibits a swift response time and accurately tracks the finger's position, providing users with an intuitive and touchless means of interacting with their devices. This innovative approach holds promise for enhancing user experiences and offers a glimpse into the future of touchless control interfaces.

20) **PAPER 20: A Novel Virtual Mouse Using Finger Gestures.[20]**: A virtual mouse control system that uses finger gestures as input modalities. The authors suggest that this system could provide a more intuitive and convenient way to control the mouse cursor on touchscreens, particularly for users with limited dexterity or mobility. The virtual mouse control system uses a camera to track the user's finger movements and gestures, which are mapped to mouse cursor movements and clicks. The authors evaluated the performance of the system in terms of accuracy and user preference, comparing it to traditional touchscreen-based interfaces. The study found that the virtual mouse control system achieved higher accuracy and lower response time than traditional touchscreen-based interfaces, indicating that it could provide a more efficient and intuitive way to control the mouse cursor on touchscreens. The authors also found that the virtual mouse control system was preferred by participants over traditional touchscreen-based interfaces, suggesting that it could improve user experience for certain tasks. Overall, the research paper presents a novel approach to virtual mouse control on touchscreens, which could have applications in a wide range of domains, including mobile gaming, productivity apps, and accessibility technology. The authors suggest that future research could explore the use of additional input modalities, such as voice commands or eye tracking, to further enhance the usability and accessibility of the virtual mouse control system.

III. Proposed Methodology

A. Methodology

1. In this suggested method, we can transform videos into still photographs and process them by gathering the crucial time images and videos from web cameras. The next stage is to extract the various fingertips from the transformed images, which are made up of photographs.

2. Once the extraction procedure is complete, the points will be located using the designated ID of the matching fingertips. This procedure is known as the detection mode and point detection. Following the point detection, it will follow the pointer's movement across the screen. After that, we can use the mouse to make a selection.

3. The Virtual Gesture Mouse project: Uses a camera and OpenCV, a Python computer vision package, to build a well-structured AI virtual mouse system. The way this method works is by using a connected computer to examine the edges the camera captured. Greyscale images with pixel values ranging from 0 (representing black)

to 255 (representing white), color layers with channels (Blue, Green, and Red), and binary representations that specifically identify dark or light components as 0 or 1 are just a few of the formats that images can be handled in.

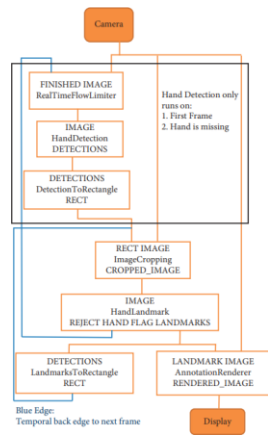


Fig. 1. PROJECT FLOW DIAGRAM

4. Moving Hand through the Window using Rectangular Area: The AI virtual mouse framework makes use of the helpful algorithmic rule and switches the mouse's coordinates from the camera screen to a full-screen computer window. When the hands are detected and we are unable to see which finger is engaged in the specific mouse action, a rectangular box is drawn over the computer window at a distance from the camera location whenever we tend to occasionally move the mouse pointer across the window.

5. Detect the Fingertips and doing the Mouse Cursor Movements: In this framework, the AI mouse analyzes the finger that is up by misrepresenting the spot co-ordinate of the specific finger that it will find by using the Media-Pipe, which results in the individual bits of the up fingers, and then the real mouse function is used to carry out its tasks.

B. Algorithms

These are the following algorithms we use in making of these project

1. Transformational algorithm: The transformational method is used by the AI virtual mouse system to transfer the fingertip coordinates from the webcam screen to the computer window full screen for mouse operation. An equation used to transform input or output data from one set of conditions to another in computer graphics as an alternative to a look-up table. Images that need to be converted from one color space to another, such as RGB to CMYK, are frequently done using transformation algorithms.

2. Gesture Tracking: The Media Pipe system is used for the characteristic of hand signals and hand development, and the Open-CV library is used for PC machine vision for the common goals the AI considers to keep and

see the hand developments and fingertip. Gestures can come from any body movement or state, although they usually start with the hand or the face. The discipline includes the study of emotion identification based on hand and facial motions. Users can interact with devices without touching them directly by using simple gestures.

Although there have been numerous attempts to translate sign language using cameras and computer vision algorithms, gesture recognition techniques are also used to identify and recognize posture, movement, and other human characteristics. Through gesture recognition, computers may now begin to comprehend and interpret human body language in a way that was previously impossible using text or plain old graphical user interfaces (GUIs).

3. Media-Pipe: A technology called Media-Pipe is used in conjunction with a Google open-source framework to apply in various AI pipelines. The Media-Pipe system is advantageous for cross-stage improvement since the edge work makes exploitation of the measurement data. When using this system often with various sounds and recordings, the Media-Pipe structure, which is multi-modular, is used. The Media-Pipe structure is used by engineers to build and deconstruct frameworks using diagrams. It is also used to support frameworks for machine purposes.

Developers construct and analyze systems using graphs using the MediaPipe framework. Systems for application development are also developed using this framework. The pipeline configuration is used to carry out the processes in the MediaPipe-using system. The built-in scalability of the pipeline allows for use on both desktops and mobile devices. The MediaPipe framework is built around three key components: a framework for sensor data retrieval, a collection of calculator-like components, and a performance evaluation system.

A pipeline is a graph made up of units called calculators, one of which is connected to another by streams through which data packets pass. Anywhere in the graph they create for their application, developers can add or remove their own custom calculators. Using MediaPipe, a graph is formed where each node is a calculator and the nodes are connected by streams to produce a data-flow diagram.

4. Open-CV MODULE: C vision is an interaction that enables us to comprehend how images and recordings are stored, controlled, and used to extract information. The foundation or typical application of artificial intelligence is PC Vision. Open-CV's most popular version was 1.0. OpenCV is provided under a BSD license, making it free for both academic and commercial use. With C++, C, and Windows, Linux, Mac OS, iOS, and Android are supported along with Python and Java connection points. The primary focus of Open-CV's development at the time was on continuous applications for increased computational productivity.

The primary application of OpenCV in this paper is video capture. OpenCV is also used for tasks including face recognition, optical character recognition, vision-guided

robotic surgery, 3D organ reconstruction, and QR code scanner, among others. We can use OpenCV to conduct specialized object detection, such as the detection of eyes, faces, and other specific things. We can also analyze films by estimating the motion within the video, removing the backdrop from the video, and tracking items inside it. Building OpenCV applications requires the usage of fundamental data structures like Scalar, point, etc., which are covered by OpenCV. 'import cv2' in Python is used to import the OpenCV library.

Object Classification - A model is trained on a dataset of specific items in object classification, and the model then assigns new objects to one or more of your training categories.

Object Identification - Our model will recognize a particular instance of an object when doing object identification.

C. PROJECT FLOW:

WORKING OF GESTURE RECOGNITION :

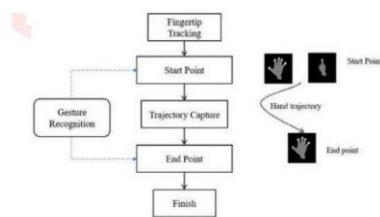


Fig. 2. Working of gesture recognition

1. Gesture recognition technology enables computers to interpret human body language, decreasing the reliance on traditional text and graphical interfaces. Gestures primarily involve movements of the face or hands and serve as a means to convey information and concepts. While gesture recognition is a relatively recent field with ongoing research, there is a limited number of publicly accessible implementations. Various techniques, including glove-based methods, have been devised for the detection and interpretation of gestures.

2. Gestures represent a fundamental and expressive form of human communication, particularly valuable for computer interaction and applications like gaming. The development of successful gesture interfaces necessitates the consideration of social and commercial factors. It is essential to acknowledge that there is no universal solution for automatic hand gesture recognition, as its effectiveness is influenced by factors such as user culture, the application's domain, and the specific environment in which it is deployed.

• **Gesture Image Collection Stage:** This is the stage for input data collection where hand, body, or face gestures are recorded and classified.

• **Gesture Image Pre-processing Stage:** This step uses techniques such as edge detection, filtering, and normalization to capture the main gesture characteristics. It fits the input gesture into the model used for gesture recognition.

• **Image Tracking Stage:** Following gesture picture pre-processing, image tracking is used to capture both the orientation and position of the object making the movements. One or more trackers, such as magnetic, optical, acoustic, inertial, or mechanical ones, may be used to accomplish this.

• **The Recognition Stage:** The recognition phase, which is sometimes seen as the last step in gesture control in VR systems, is the last but certainly not least. After a successful feature extraction process that follows picture tracking, in which the gesture's recognized features are stored in a system utilizing sophisticated neural networks or decision trees, the gesture's command or meaning is stated. The gesture has gained official recognition, and the classifier is now able to associate every test movement input with the appropriate gesture class.

D. CO-ORDINATES OF HAND DOTS :

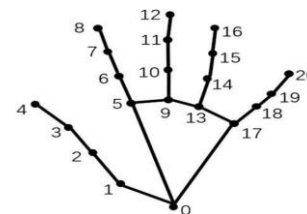


Fig. 3. Co-ordinates of HAND-DOTS

1. **HAND DETECTION:** In the first step of this procedure, a computer vision system detects the presence of a hand in a frame of an image or video. This can be done by using a variety of methods, including both conventional approaches like background subtraction and deep learning-based object identification models like YOLO or SSD.

2. **HAND LANDMARK DETECTION:** The next stage of hand detection focuses on finding and tracking certain hand points after successful hand detection. The use of specialized models created to precisely identify these important landmarks is known as hand landmark detection. Notably, MediaPipe and OpenPose are two frequently used frameworks for this purpose, both of which provide pre-trained models noted for their excellent accuracy in landmark localization.

• **Categories of Hand Landmarks:**

a. **Fingertips:** Fingertip landmarks are associated with the tips of each finger on the hand, and they serve a critical role in gesture detection and tracking hand movements.

b. **Knuckles:** Knuckle landmarks correspond to the knuckles or joints of the fingers and provide essential information regarding hand posture and finger flexion.

c. **Palm Landmarks:** These encompass various points situated on the palm itself, including the center of the palm and the base of the thumb. These points are invaluable for tracking the overall position and orientation of the hand.

d. **Coordinate Representation:** In this context, the coordinates of hand landmarks are conventionally represented within a 2D Cartesian coordinate system, denoted as (x, y) . Typically, the origin point $(0,0)$ is established at a specific reference location within the frame, often at the top-left corner. These coordinates are expressed in pixel units, signifying the precise positions of the landmarks within the image or video frame.

• Advantages

1. The primary benefit of employing hand gestures to engage with a computer is that it allows for non-contact human-computer input.

2. By not using the mouse, you can lower the cost of your gear.

3. convenient for individuals who are not at ease using a touchpad.

4. The framework may be helpful for controlling various games and other programs that depend on user-defined gestures for control.

• Limitations

1. However, it appears that the current version is more practical and user-friendly.

2. It has been recommended to make the input modalities less reliant on the user's hand motions.

3. The creation of a separate gesture vocabulary framework may be another significant component of the linked development.

4. If another colored rubber is in the webcam's field of view while it is working, the color detection algorithm may have trouble detecting it.

• Overview

1. Hand motions are recognized and tracked using the proposed interface. It is straightforward to create a basic, trustworthy hand gesture vocabulary that may be utilized by a human operator to communicate control information to a computer system when hand tracking and fingertip detection are combined.

2. Even though laptops have a variety of quick access options for hand and mouse gestures, we can use the laptop or webcam to recognize the hand gesture and operate the mouse as well as carry out standard tasks like controlling the mouse pointer, selecting and deselecting items using the left click, and so on with our project.

• Tools and Technologies used

1. **Hand tracking:** The MediaPipe Hand Landmarker task enables you to identify the hands' landmarks in an image. This task can be used to localize the hands' important spots and create visual effects on top of the hands. This assignment generates hand landmarks in image coordinates, hand landmarks in world coordinates, and handedness (left/right hand) of multiple identified hands

using picture data from a machine learning (ML) model as static data or a continuous stream.

2. **Numpy:** NumPy is a key tool in data manipulation, it's important to note that creating a complete hand gesture recognition system is a complex task that may require additional libraries and tools. You may also want to explore libraries like OpenCV for computer vision tasks, and possibly even specialized hand gesture recognition libraries or APIs if available. Keep in mind that creating a hand gesture recognition system is a broad and challenging project that goes beyond the capabilities of NumPy alone, and it involves multiple aspects of computer vision and machine learning.

3. **Smoothing:** The choice of smoothing method may be influenced by the hand gesture recognition system's particular needs, including the nature of the gestures, the amount of noise present in the input data, and the desired ratio of responsiveness to smoothness. By enhancing the stability and readability of the motions, these methods can aid in enhancing the accuracy of gesture recognition systems.

4. **Time:** The duration of hand gestures can vary significantly depending on the particular gesture, its intended application, and the cultural setting. Hand gestures are a type of nonverbal communication that can be used to express commands, feelings, or information. It's vital to remember that there is no set amount of time for each gesture and that the duration of hand motions can vary greatly depending on the context. Usually, a hand gesture's duration is just long enough to convey its intended meaning.

5. **Autopy:** Autopy is a Python library used for automating mouse and keyboard input. It allows you to control and simulate mouse movements, button clicks, and keyboard key presses. While it's not specifically designed for hand gesture recognition, you can use Autopy in combination with other libraries to create a system that responds to hand gestures. To implement hand gesture recognition, you might consider using a computer vision library like OpenCV to capture and process video frames from a webcam. OpenCV can help you detect and track hand gestures in real time. You would then use Autopy to perform actions based on the detected gestures

6. **Math:** Math plays a crucial role in understanding and interpreting hand gestures, especially in fields like computer vision, image processing, and gesture recognition.

7. **Hand detector:** In hand gesture recognition, a hand detector is an essential component that helps identify and locate the hand or hands in an image or video frame. There are various techniques and technologies used for hand detection in this context.

8. **Haar Cascades:** Haar cascades are a machine-learning object detection method used to identify objects in images or video. They can be trained to detect hands, making them useful for hand detection in gesture recognition systems. HOG (Histogram of Oriented Gradients):

HOG is a feature descriptor that captures local gradients of intensity in an image. It's often used in combination with a classifier to detect hands by recognizing their distinct texture and shape.

9. . **Background Subtraction:** This method involves subtracting the static background from a frame to isolate the moving hand. It's commonly used in real-time hand gesture recognition applications.

10. . **Skin Color Segmentation:** In some cases, skin color can be used as a cue for hand detection. By segmenting regions of an image with skin-colored pixels, the hand can be detected.

11. . **Motion Detection:** Simple motion detection algorithms can also be used to identify the movement of hands within a frame, although they may not provide precise hand localization.

IV. Experiment Results and Evaluation

1. The various functions and conditions used in the system are explained in the flowchart of the real-time AI virtual mouse system in Figure 4.

USER INTERACTION FLOW CHART:

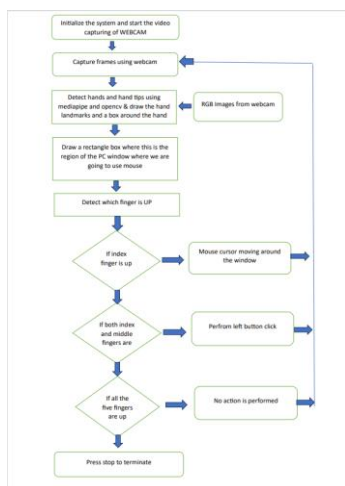


Fig. 4. user interaction flow chart of VIRTUAL MOUSE

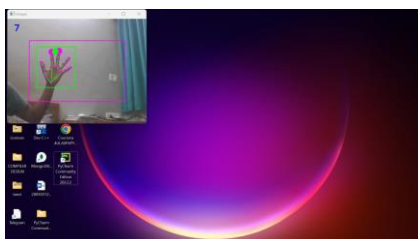


Fig. 5. Capturing video using the webcam

2. The proposed AI virtual mouse system is based on the frames that have been captured by the webcam in a laptop or PC. By using the Python computer vision library OpenCV, the video capture object is created and the web camera will start capturing video, as shown in Figure 5.

The web camera captures and passes the frames to the AI virtual system.

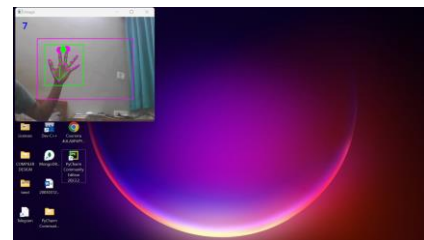


Fig. 6. Rectangular box for the area of the computer screen where we can move the cursor.

3. The AI virtual mouse system makes use of the transformational algorithm, and it converts the coordinates of fingertip from the webcam screen to the computer window full screen for controlling the mouse. When the hands are detected and when we find which finger is up for performing the specific mouse function, a rectangular box is drawn concerning the computer window in the webcam region where we move throughout the window using the mouse cursor, as shown in Figure 6.

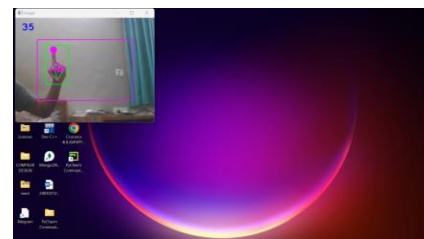


Fig. 7. Detection of which finger is up.

4. In this stage, we are detecting which finger is up using the tip of the respective finger that we found using the Media Pipe and the respective coordinates of the fingers that are up, as shown in Figure 7, and according to that, the particular mouse function is performed

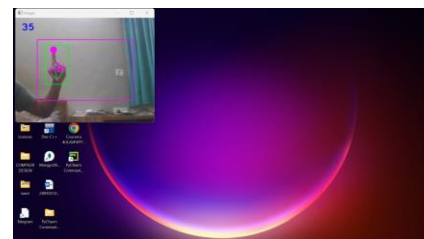


Fig. 8. Mouse cursor moving around the computer window.

5. If the index finger is up with tip or both the index finger with tip and the middle finger with tip is up, the mouse cursor is made to move around the window of the computer using the AutoPy package of Python, as shown in Figure 8.

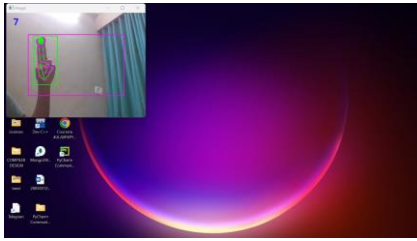


Fig. 9. Gesture for the computer to perform double click.

6. If both the index finger with tip and the middle finger with tip are up and the two fingers are attached, the computer is made to perform the double click using the pinout Python package, as shown in Figure 9.

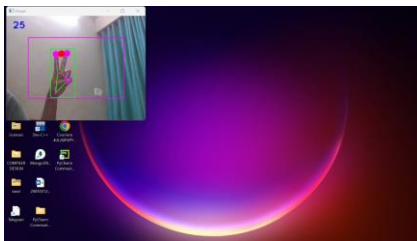


Fig. 10. Gesture for the computer to remain stable.

7. If both the index finger with tip and the middle finger with tip are up and there is distance between the two fingers the computer is made to not perform any mouse events in the screen, as shown in Figure 10.

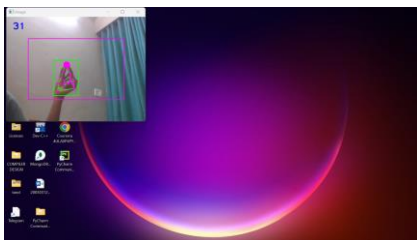


Fig. 11. Gesture for the computer to zoom in.

8. If both the index finger with tip and the thumb finger with tip are up and the two fingers are attached, the computer is made to perform the zoom-in using the input Python package, as shown in Figure 11.

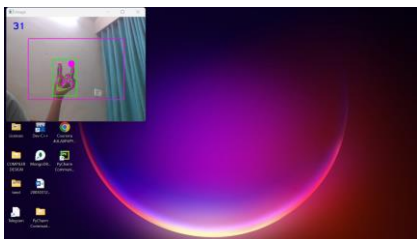


Fig. 12. Gesture for the computer to zoom out.

9. If both the index finger with tip and the thumb finger with tip are up and there is a distance between the two

fingers is less than 30 px, the computer is made to perform the zoom out using the pinout Python package, as shown in Figure 12.



Fig. 13. Gesture for the computer to not act.

10. If all the fingers are up with tip, the computer is made to not perform any mouse events on the screen, as shown in Figure 13.

V. Conclusion and Future work

A. Conclusion

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 hand gestures 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 limitations of the existing systems. Since the proposed model has greater accuracy, the AI virtual mouse can be used for 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 small decrease in accuracy in right click mouse function and some difficulties in clicking and dragging to select the text. Hence, we will work next to overcome these limitations by improving the fingertip detection algorithm to produce more accurate results.

B. Future work

The proposed AI virtual mouse has some limitations such as the right click mouse function and also the model has some difficulties in executing clicking and dragging to select the text. These are some of the limitations of the proposed AI virtual mouse system, and these limitations will be overcome in our future work. Furthermore, the proposed method can be developed to handle the keyboard functionalities along with the mouse functionalities virtually which is another future scope of Human-Computer Interaction(HCI).

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