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Virtual Mouse using Hand Gesture Recognition

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Abstract*—Hand gesture recognition system received great attention in the recent few years because of its manifoldness applications and the ability to interact with machine efficiently through human computer interaction. In this paper a survey of recent hand gesture recognition systems is presented. Key issues of hand gesture recognition system are presented with challenges of gesture system. Review methods of recent postures and gestures recognition system presented as well. Virtual Mouse with Hand Gesture Recognition is a project that shows a novel way to control mouse movement with a real-time camera / Web camera. Our idea is to employ a camera and computer vision technologies to manage mouse tasks (clicking and scrolling), and we demonstrate how it can do all that existing mouse devices can. This project demonstrates how to construct a mouse control system. The proposed system is made up of nothing more than a sensor which is a normal-resolution webcam that can follow the user's hand in two dimensions. Python and OpenCV will be used to build the system. Hand gestures are the most natural and effortless manner of communicating. The camera's output will be displayed on the monitor. It improves the recognition of human hand postures in a Human Computer Interaction application, reduce the time spent computing and improve user comfort related to human hand postures. The authors developed an application for computer mouse control. Based on the proposed algorithm and selected hand feature, the application has good time-based performance. The user finds it easier to operate the system due to the proposed hand postures. Summary of research results of hand gesture methods, databases, and comparison between main gesture recognition phases are also given. Advantages and drawbacks of the discussed systems are explained finally.

Keywords—Deep Learning, SVM, CNN, Virtual Hand, HCI (Human Computer Interaction)

I. INTRODUCTION

The most efficient and expressive way of human communication is through hand gesture, which is a universally accepted language. It is pretty much expressive such that the dumb and deaf people could understand it. In this work, real-time hand gesture system is proposed. Experimental setup of the system uses fixed position low cost web camera high definition recording feature mounted on the top of monitor of computer or a fixed camera on a laptop, which captures snapshot using Red Green Blue [RGB] color space from fixed distance. This work is divided into four stages such as image preprocessing, region extraction, feature extraction, feature matching. Recognition and the interpretation of sign language is one of the major issues for the communication with dump and deaf people. In this project an effective hand gesture segmentation technique has been proposed based on the preprocessing, background subtraction and edge detection techniques [1]. Pre-processing is defined as procedure of formulating data for another process. The main objective of the preprocessing process is to transform the data into a form that can be more effectively and effortlessly processed. In the proposed work, the pre-processing techniques are created on the basis of different types of combinations from the subsequent hand gesture image processing operations such as capturing image, removing noise, background subtraction, and edge detection and these image processing methods are discussed is as follows.

Initially, the hand gesture images are captured from the vision based camera, The hand gestures can be observed with the different kind of interfaces like "data gloves" that accurately records every abduction angles and digit's and position sensors for wrists and optical orientation or electromagnetic, requiring the user to wear trackers or gloves. Habitually, the glove based interfaces even need the user to be hitched to the computer, all minimizing time to user comfort and interface, conversely, vision based interfaces offer unencumbered interaction with human. By this paper we are aiming in creating a cost free hand recognition software for laptops and PCs with a web-cam support. The project covers as a hand recognition tool which could be used to move the mouse pointer, perform simple operations like clicking and other hand gesture operations like moving file from computer to computer through delicate socket programming and performing simple but fascinating operations that could be covered with the hand recognition.

With the development technologies in the areas of augmented reality and devices that we use in our daily life, these devices are becoming compact in the form of Bluetooth or wireless technologies. This paper proposes an AI virtual mouse system that makes use of the hand gestures and hand tip detection for performing mouse functions in the computer using computer vision. The main objective of the proposed system is to perform computer mouse cursor functions and scroll function using a web camera or a built-in camera in the computer instead of using a traditional mouse device. Hand gesture and hand tip detection by using computer vision is used as a HCI [1] with the computer. With the use of the AI virtual mouse system, we can track the fingertip of the hand gesture by using a built-in camera or web camera and perform the mouse cursor operations and

scrolling function and also move the cursor with it. While using a wireless or a Bluetooth mouse, some devices such as the mouse, the dongle to connect to the PC, and also, a battery to power the mouse to operate are used, but in this paper, the user uses his/her built-in camera or a webcam and uses his/her hand gestures to control the computer mouse operations.

II. Related Works

In 2010, Y. Adajania et. al developed a Virtual Keyboard Using Shadow Analysis[2]. This system detects keyboard, hands shadow, finger tips using colour segmentation and sobel technique. Ambient lighting conditions required for this system. This system can analyze 3 frames per second.

In 2011, S. Hernanto et al. built a method for virtual keyboard using webcam[10]. In this approach, two functions are used for finger detection and location An Interactive Computer System with Gesture-Based Mouse and Keyboard 3 detection. This system used two different webcams which are used to detect skin and location separately. The average time per character of this virtual keyboard is 2.92 milliseconds and the average accuracy of this system is 88.61%.

In 2013, M. H. Yousuf et al. introduced a keystroke detection and recognition model using fingertip tracking [25]. They captured real time movements of finger joints and successfully recognised 28 keys.

In 2015, I. Patil et al. constructed a virtual keyboard interaction system using eye gaze and eye blinking [16]. Their system first detects face and then detects eye and nose region to recognize an eye blink. The OpenCV java framework is used in this approach. In 160X120 frame size, this approach achieves 48% accuracy and in 1280X960 frame size, 98% accuracy is achieved.

In 2016, Hubert Cecotti developed a system for disabled people named a multi-modal gaze-controlled virtual keyboard [6]. The virtual keyboard has 8 main commands for menu selection to spell 30 different characters and a delete button to recover from error. They evaluated the performance of the system using the speed and information transfer rate at both the command and application levels. V. Saraswasti et al. introduced a system for disabled people entitled Eye Gaze System to Operate Virtual Keyboard [18]. First it captures the user's face and gets the position of eye gaze which is used as reference point in the later stages. Haar Cascade method was used to extract features of face, and Integral Projection method was used to get the position of the eye movement. Based on their experiment, the ratio between the duration of normal writing and duration of typing using their system for two words is 1:13.

In 2017, S. Bhuvana et al. constructed a virtual keyboard interaction system using webcam [5]. This system can detect the hand position over the virtual keyboard. This system provides a white paper virtual keyboard image and detects which character is pointed. This approach used built-in function of Image Processing Toolbox in MATLAB.

In 2018, Jagannathan MJ et al. presented a finger recognition and gesture based augmented keyboard system [13]. The system was developed using OpenCV libraries and Python. Palm detection is used for typing on the augmented keyboard. Virtual Keyboard performs based on the movement of the finger.

In 2019, K. Hassan et al. presented a system to design and develop a hand gesture based virtual mouse [20]. They captured different gestures via webcam and performed mouse functions according to the gestures. This system achieved 78%-90% accuracy. The system does not work efficiently in the complex or rough background.

In 1990, Quam introduced an early hardware-based system; in this system, the user should wear a DataGlove]. The proposed system by Quam although gives results of higher accuracy, but it is difficult to perform some of the gesture controls using the system.

Dung-Hua Liou, ChenChiung Hsieh, and David Lee in 2010 proposed a study on "A Real-Time Hand Gesture Recognition System Using Motion History Image." The main limitation of this model is more complicated hand gestures.

Monika B. Gandhi, Sneha U. Dudhane, and Ashwini M. Patil in 2013 proposed a study on "Cursor Control System Using Hand Gesture Recognition." In this work, the limitation is stored frames are needed to be processed for hand segmentation and skin pixel detection.

Vinay Kr. Pasi, Saurabh Singh, and Pooja Kumari in 2016 proposed "Cursor Control using Hand Gestures" in the IJCA Journal. The system proposes the different bands to perform different functions of the mouse. The limitation is it depends on various colors to perform mouse functions.

Chaithanya C, Lisho $omas, Naveen Wilson, and Abhilash SS in 2018 proposed "Virtual Mouse Using Hand Gesture" where the model detection is based on colors. But, only few mouse functions are performed.

EXISTING SYSTEM:

The existing system consists of the generic mouse and track pad system of monitor controlling and the non-availability of a hand gesture system. The remote accessing of monitor screen using the hand gesture is unavailable. Even-though it is largely trying to implement the scope is simply restricted in the field of virtual mouse. The existing virtual mouse control system consists of the simple mouse operations using the hand recognition system, where we could perform the basic mouse operation like mouse pointer control, left click, right click, drag etc. The further use of the hand recognition is not been made use of. Even-though there are a number of systems which are used for hand recognition, the system they made used is the static hand recognition which is simply recognition of the shape made by hand and by defining an action for each shape made, which is limited to a number of defined actions and a large amount of confusion.

Disadvantages:

The projected AI virtual mouse using hand signal structure could in like manner be familiar with beat issues inside the

spot like things where there isn't any space to use a genuine mouse and set up for individuals who have issues in their grip and don't appear, apparently, to be prepared to manage a real mouse.

III. System Overview

A. Proposed System

Using the current system even-though there are a number of quick access methods available for the hand and mouse gesture for the laptops, using our project we could make use of the laptop or web-cam and by recognizing the hand gesture we could control mouse and perform basic operations like mouse pointer controlling, select and deselect using left click, and a quick access feature for file transfer between the systems connected via network LAN cable. The project done is a "Zero Cost" hand recognition system for laptops, which uses simple algorithms to determine the hand, hand movements and by assigning an action for each movement.

Advantages:

The main objective of the proposed AI virtual mouse system is to develop an alternative to the regular and traditional mouse system to perform and control the mouse functions, and this can be achieved with the help of a web camera that captures the hand gestures and hand tip and then processes these frames to perform the particular mouse function such as left click, right click, and scrolling function.

B. System Architecture

Based on the hand gestures, the computer can be controlled virtually and can perform left click, right click, scrolling functions, and computer cursor function without the use of the physical mouse. The algorithm is based on deep learning for detecting the hands. Dataset collection is collecting data which contains hand gesture details.

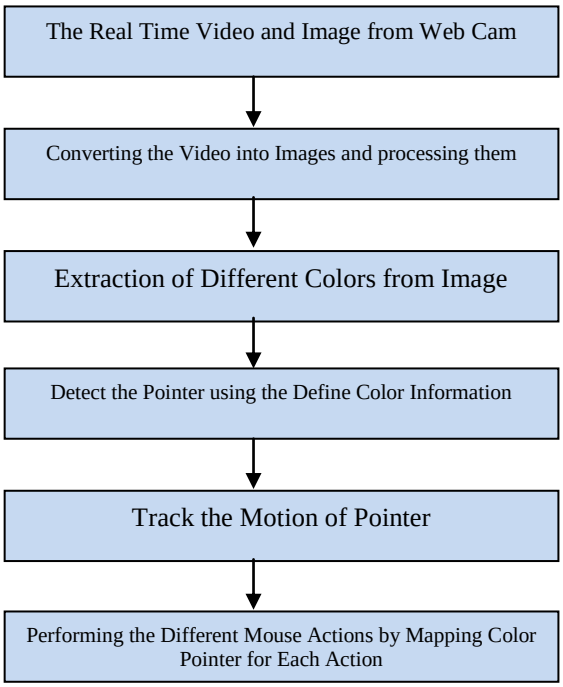

Fig : System Architecture for Virtual mouse

C. Application

The AI virtual mouse system is beneficial for several applications; it will be reduce the space for using the physical mouse, and it is employed in situations where we cannot use the physical mouse

- Amidst the COVID-19 situation, it's not safe to use the devices by touching them because it's going to lead to a possible situation of spread of the virus by touching the devices, that the proposed AI virtual mouse may be accustomed control the PC mouse functions without using the physical mouse.
- 2D and 3D images may be drawn using the AI virtual system using the hand gestures.
- AI virtual mouse are often accustomed play virtual reality- and augmented reality-based games without the wireless or wired mouse devices.
- Persons with problems within their hands can use this method to regulate the mouse functions in the computer.
- In the sphere of robotics, the proposed system like HCI may be used for controlling robots. In designing and architecture, the proposed system will be used for designing virtually for prototyping.

D. Dataset Collection

For the characteristic of area of hand signals and hand development, the Media Pipe system is utilized, and Open-CV library is utilized for PC machine vision the standard purposes the AI contemplations to keep and see the hand developments and fingertip.

E. Attributes Selection

Attribute or Feature selection includes the selection of appropriate attributes for the prediction system. This is used to increase the efficiency of the system. Various attributes of the hand like gender, finger type, fasting mouse function, hand action etc are selected for the prediction. The Correlation matrix is used for attribute selection for this model.

Finger Tip Gesture	Mouse Function Performed	Accuracy (%)
Tip Id 1 or both tip Id's 1 and 2 are up	Curser movement	100
Tip Id 0 and 1 are up and the distance between the fingers is <15	Left click	95
Tip Id 0 and 1 are up and the distance between the fingers is <20	Right click	98
Tip Id 0 and 1 are up and the distance between the fingers is >20 and both fingers are moved down	Scroll up	100
Tip Id 0 and 1 are up and the distance between the figures is <20 and both fingers are moved up	Scroll down	100
All five tip Id's 0,1,2,3,4 are up	No action	100
Result		100

Fig : Input Dataset Attributes

F. Implementation

We all use new technology development in our everyday life. Including our devices similarly after we speak about technology the most effective example may be a computer. A computer has evolved from a really low and advanced significantly over the decades since they originated. However we also use the identical setup, which have a mouse and keyboard. Though the technology have made many changes within the development of computers like laptop where the camera is now an integrated a part of the pc. We still have a mouse which is either integrated or an external device. This is how we've got encounter the implementation a brand new technology for our mouse where we can control the pc by finger tips and this method is thought as Hand Gesture Movement. With the help of our fingers, we will be ready to guide our cursor.

For this project we've used Python because the base language as it is an open source and simple to grasp and environment friendly. The packages that are required here is Autopy and OpenCV. Autopy is a Python module for programmatically controlling the mouse and keyboard. OpenCV through which we can control mouse events. Processing to extract required data so adds it to the computer's mouse interface in keeping with predefined notions. Python is employed to write the file. It uses of the cross platform image processing module OpenCV and implements the mouse actions using Python specific library Autopy .Real time video captured by the Webcam is processed and only the two finger tips are extracted with the use of those two fingers we can use our mouse. Their centres are measured by using the system webcam finger tips moments, and therefore the action to be taken is decided supported their relative positions and their respective distance give us the idea how far we should . The first goal is to use the function cv2.VideoCapture ().This function uses to capture the live stream video on the camera. OpenCV will create a very easy interface to try to this. To capture a image we want to form an video capture object. We then covert this captured images into HSV format.

1. Hand Detection:

This module is responsible for detecting the presence of a hand in the video feed captured by the camera. It uses skin color segmentation and morphological operations to isolate the hand region from the rest of the frame.

2. Hand Tracking:

Once the hand region has been detected, this module tracks the movement of the hand by applying a series of mathematical operations to determine the hand's position, velocity, and direction.

3. Gesture Recognition:

This module is responsible for interpreting the movement of the hand and recognizing specific hand gestures. It uses machine learning algorithms and statistical models to match the observed hand movements with predefined gestures.

4. Cursor Control:

This module simulates the actions of a physical mouse and controls the computer's cursor movements based on the movement of the hand. It also detects click events by tracking changes in the hand's position and velocity.

5. Drag and Drop:

This module enables the user to drag and drop objects on the computer's screen by recognizing the corresponding hand gestures and simulating mouse clicks and movements.

6. Volume and Brightness Control:

This module allows the user to control the volume and brightness of the computer by making specific hand gestures. It captures the hand's movement and translates it into appropriate keyboard or mouse commands to control the volume and brightness.

7. Mouse Movement

We have to first calculate the center of both detected red object which we can easily do by taking the average of the bounding boxes maximum and minimum points. now we got 2 co-ordinate from the center of the 2 objects we will find the average of that and we will get the red point shown in the image. We are converting the detected coordinate from camera resolution to the actual screen resolution. After that we set the location as the mouse position. but to move the mouse pointer it will take time. So we have to wait till the mouse pointer reaches that point. So we started a loop and we are not doing anything there we are just waiting will the current mouse location is same as assigned mouse location. That is for the open gesture.

8. Clicking

The next step is to implement the close gesture. The operation is performed by clicking the object and dragging it. It is similar to the open gesture, but the difference is we only have one object here so we only need to calculate the center of it. And that will be placed on the location where we will position our mouse pointer. Instead of mouse release operation we will be performing a mouse press operation.

9. Drag

In order to implement the dragging we indroduce a variable ‘pinchflag’. It will be set to 1 if it was clicked earlier. So after clicking whenever we find the open gesture we check if the pinchflag is set to 1. If it is set to one then Drag operation is performed otherwise the mouse move operation is performed.

G. Data Preprocessing

Data Pre-Processing is an important step for the creation of a machine learning model. Initially, data may not be clean or in the required format for the model which can cause misleading outcomes. In pre-processing of data, we transform data into our required format. It is used to deal with noises, duplicates, and missing values of the dataset. Data pre-processing has the activities like importing datasets, attribute scaling, etc. Preprocessing of data is required for improving the accuracy of the model.

IV. METHODOLOGY

Deep learning is a machine learning technique that teaches computers to do what comes naturally to humans: learn by example. Deep learning is a key technology behind driverless cars, enabling them to recognize a stop sign, or to distinguish a pedestrian from a lamppost. It is the key to voice control in consumer devices like phones, tablets, TVs, and hands-free speakers. Deep learning is getting lots of attention lately and for good reason. It’s achieving results

that were not possible before. In deep learning, a computer model learns to perform classification tasks directly from images, text, or sound. Deep learning models can achieve state-of-the-art accuracy, sometimes exceeding human-level performance. Models are trained by using a large set of labelled data and neural network architectures that contain many layers.

This Project is developed by using CNN algorithm. A Convolutional Neural Network (ConvNet/CNN) is one of the Deep Learning algorithms which can take in an input image, assign importance to various aspects/objects in the image and be able to differentiate one from the other. It is used for analyzing the virtual images by processing the data with grid like topology. The main purpose of the CNN (or) ConvNet is classifying or identifying the objects of the image.

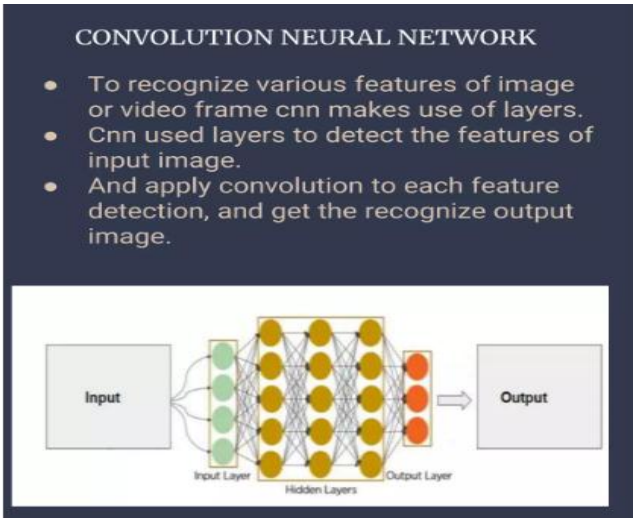

Fig : Convolutional Neural Network architecture

Working Principle of CNN:

- To recognize various feature of image or video frames CNN makes use of layers.
- CNN used layers to detect the features of input image
- Apply convolution to each feature detection and get the recognize output image.

Algorithm: It works in 6 steps:

- The first step is to capture the image using the camera.
- The camera then extracts and recognizes the human hand from the input image.
- Then the position of the human hand is stored in the system using the regular" coordinate-system".
- Then when the second frame is captured. The position of the hand from the second frame is captured and is stored in the system.
- Then the position of both hands is compared and then the cursor moves accordingly.
- Now for the system of clicking the angle between the two hands of the finger is measured and if the angle is less than 15 degrees the system responds to it as a left-click. In this way, the complete working of the mouse can be done with bare hands.

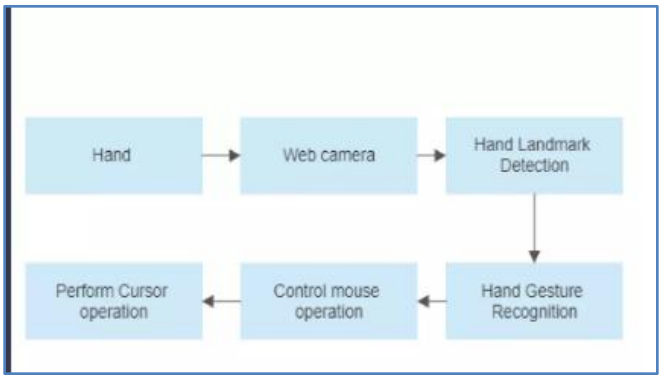

Fig : Hand gesture methodology

Advantages:
Virtual Mouse using Hand gesture recognition allows users to control mouse with the help of hand gestures. System's webcam is used for tracking hand gestures. Computer vision techniques are used for gesture recognition. OpenCV consists of a package called video capture which is used to capture data from a live video. Main thing we need to identify are the applications the model is going to develop so the development of the mouse movement without using the system mouse.

V. Experimental Results And Analysis

The proposed system controls the functions of mouse pointer by detecting red, and perform the mouse functions such as left click, dragging, cursor movement, and the file transfer between two systems in a same network. This method detects the red color objects for the mouse control. The user uses the red color objects on their finger tip for the better performance. When the number of contours are two, then it perform the simple mouse movement action. Otherwise, when the number of contour is one then it perform the left click. This system also supports the simple file transfer between two or more systems in the same network connection.

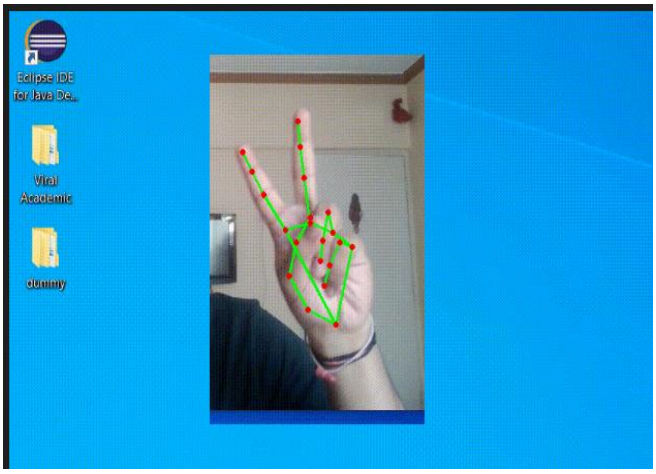

Fig : Cursor Movement

The left side of the computer's screen act as a communication channel between the systems. ie, the file which is to be copy should drag and drop on the left side of the computer's screen. Then the dropped file will be copied to the destination or the receiver system. The idea of improving human-computer interaction through computer vision is presented in the suggested AI virtual mouse system. Because there are so few datasets available, it is challenging to compare testing of the AI virtual mouse system. For tracking of the hand gestures and hand tip detection, the webcam has been placed at various distances from the user in order to evaluate the hand gestures and finger tip detection in various lighting situations. Our virtual mouse model performed extremely well, with 99 percent accuracy, as compared to earlier methods. When compared to existing virtual mouse models, it is clear that the suggested AI virtual mouse has outperformed them all in terms of accuracy. The new aspect of the suggested model is that it can virtually control a computer in a manner similar to a physical mouse, including performing most mouse actions including left and right clicks, scrolling up and down, and mouse pointer movement utilizing finger tip recognition.

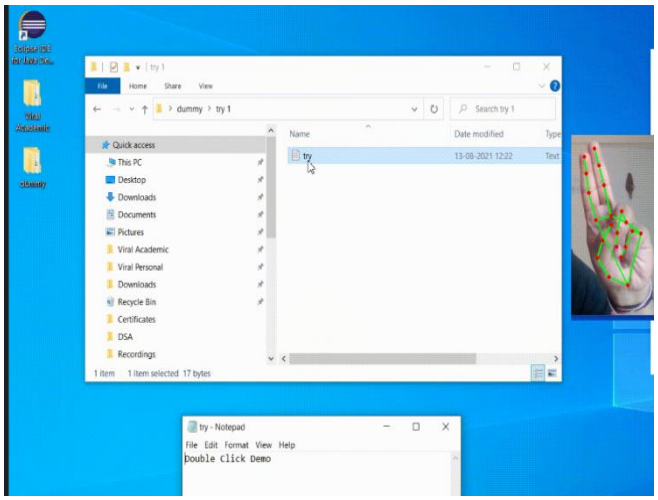

Fig : Double Click

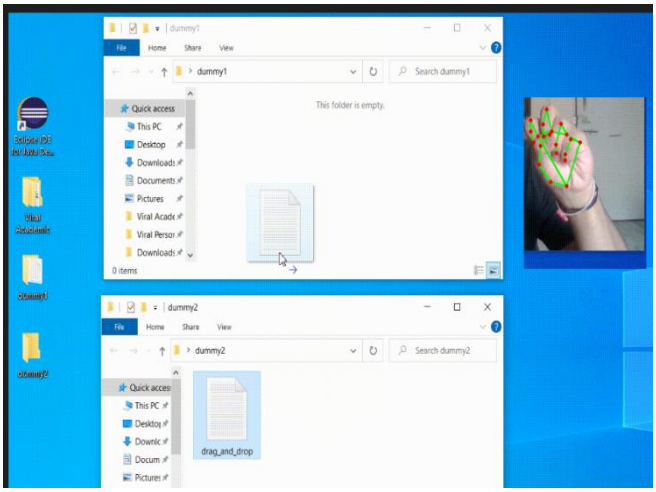

Fig : Drag and Drop

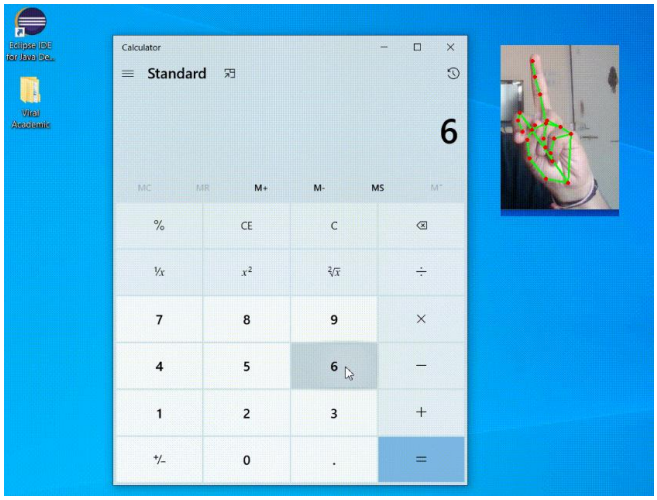

Fig : Single Click

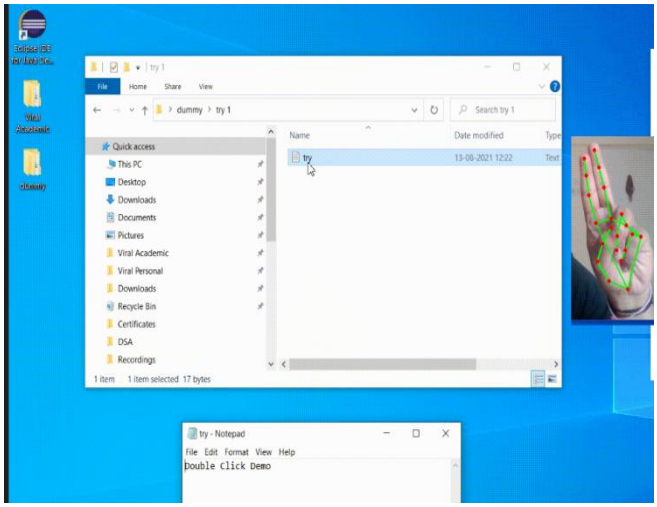

Fig. Double Click

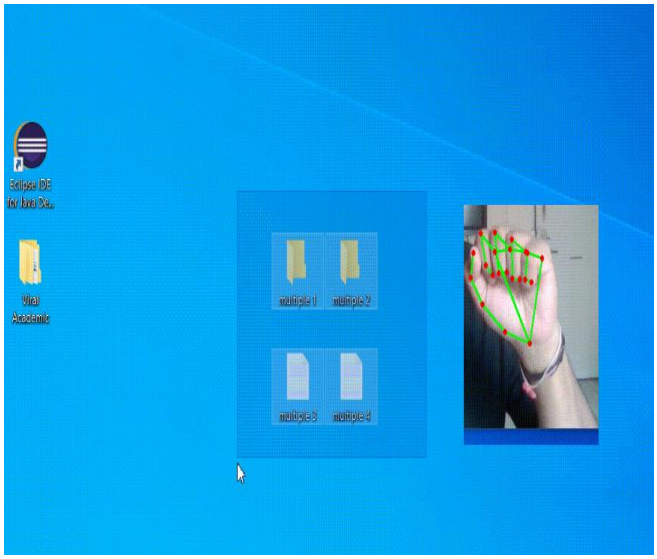

Fig. Select All

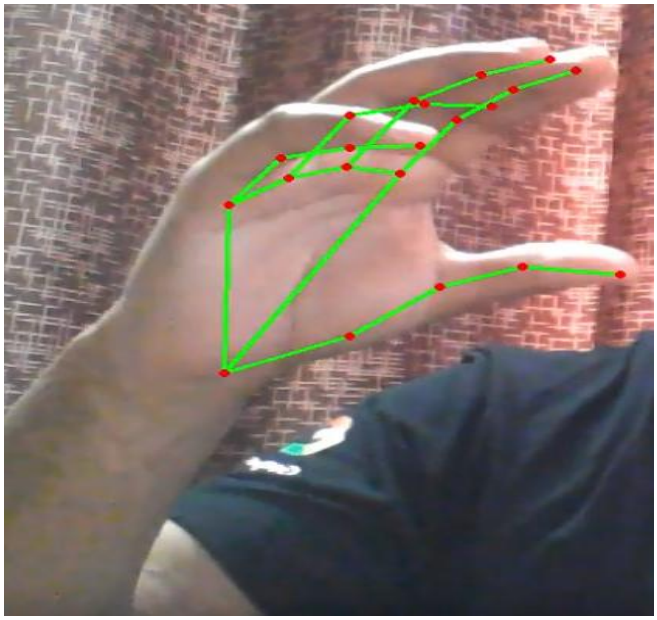

Fig. Right hand for brightness

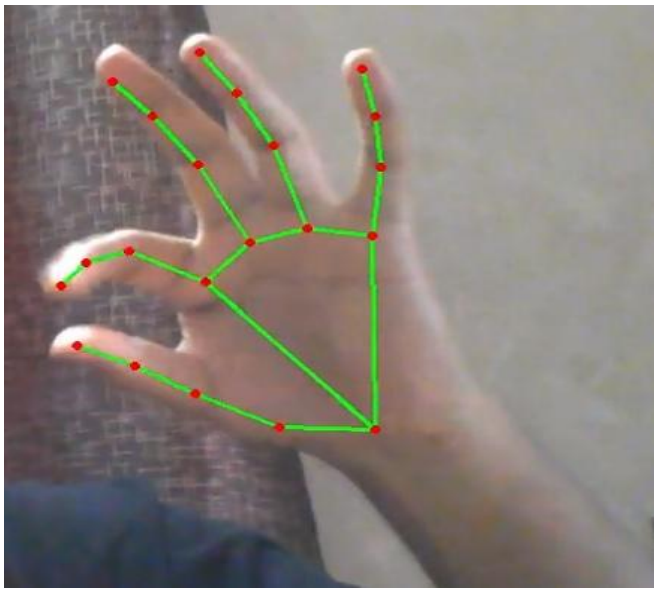

Fig. Left Hand for Volume Control

VI. CONCLUSIONS

In this project, we are working on a system to control the mouse cursor using a real-time camera. The system is based on computer vision algorithms and can do all Mouse tasks. However, it is difficult to get stable results because of the variety of lightning and skin colors of human races. Presentations would be easier with this system, and work space would be saved by using it. It provides features such as enlarging and shrinking Windows, closing window, etc. by using the Palm and multiple fingers. In order to make physically challenged people use desktops and laptops as smart as normal people, and consider the use of new edge technologies, this software is designed to make them as comfortable as the normal people. $e 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. We have successfully implemented the cursor movement using the hand gesture. This is a project which uses the whole new technology making the human computer interaction in an easy and friendly way with a very minimal project cost.

VII. FUTURE ENHANCEMENT

In future, we can implement this task using new innovative, primitive and more advanced mathematical materials for image processing and investigate on different hardware solutions that would result in more accurate hand detections. The future work will include implementation of additional gestures which will enable the user to perform more functions with ease. In future work, there are several features and improvements needed in order for the program to be more user friendly, accurate, and flexible in various environments. The following describes the improvements and the features required: a) Smart Recognition Algorithm Due to the current recognition process are limited within 25cm radius, an adaptive zoom-in/out functions are required to improve the covered distance, where it can automatically adjust the focus rate based on the distance between the users and the webcam. b) Better Performance The response time are heavily rely on the hardware of the machine, this includes the processing speed of the processor, the size of the available RAM, and the available features of webcam. Therefore, the program may have better performance when it's running on decent machines with a webcam that performs better in different types of lightings.

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