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ARTIFICIAL INTELLIGENCE BASED VIRTUAL MOUSE USING HAND GESTURES

Neerja Arora
Assistant Professor, Ajay Kumar Garg Engineering College, Ghaziabad, U.P.,India
aroraneerja@akgec.ac.in

Abstract: **Similar with speech, Gestures are also the choice for providing the interface between a computer system and a human being. With the enhancement of humancomputer interaction (HCI) area, research in the domain of gesture recognition has grown very fast. A gesture-controlled HCI system allowsan individual to enter commands to the computer system through various movements of the hands, head and other body parts and we know that the most widely used part of our bodyapart from the face is – ourhand, which can be used for generating gestures, recognition of hand gestures from visual images or videos has wide range of applications. In this paper, the types of hand gestures,the methods to acquire gestures, analysis of most prominent techniques of gesture recognition, application areas of hand gestures are covered.**

Keywords: **Human Computer Interaction(HCI), Gestures, Virtual Mouse, Artificial Intelligence (AI), MediaPipe framework, OpenCV.**

I. NTRODUCTION

Hand gestures are the natural and effortless way of communication. Here, we have to develop a ***Virtual Mouse*** which can be controlledthrough Recognition of Hand Gestures. The aim is to perform various mouse movements (*for eg.Cursor navigation around the screen, scrolling*, left click, right click, *double click, and volume and brightness control* etc.) using Hand Gestures.

The proposed system aims to alleviate thevarious real-world problems such asvirtual mouse can be used at the places where there is noavailable space forusingtraditional mouse or for disabled people who are unable to operate a physical mouse.

So, the virtual mouseprovides alternative interface for the users who face difficulty in using physical mouse.

Also, touching the physical devices is not safe, in the situation of COVID-19, because it may result in a spread of the virus. Thus, the proposed AI based virtual mouse is the alternativeto avoidthis problemsince various hand gestures and finger Tips detection can beconsidered to performvariousmouse operationsusing the webcam or in-built camera.

The designed system needs to be easily scalable and adaptable to allcategories of devices and environments. The input commandsthrough users can be controlled virtuallythrough-Dynamic or Sta tic hand gestures.

Hand gestures can be classified into two ways such as: **static gestures (simplegestures)** and **dynamic gestures (trajectory-based gestures)**.

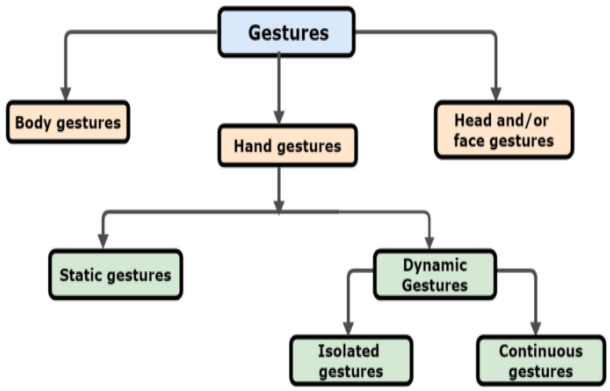

Figure 1: Classification of Hand Gestures

a) Gesture Acquisition

We can acquirethe data in raw form for hand gesture-recognition system by using below two methods:

1. Using Sensors
2. Using Vision basedcameras

First approach uses various types of sensors or other equipmentswhich are attachedphysically to user's hand or arm such that the position, motion and trajectories of the handand fingers can be captured.

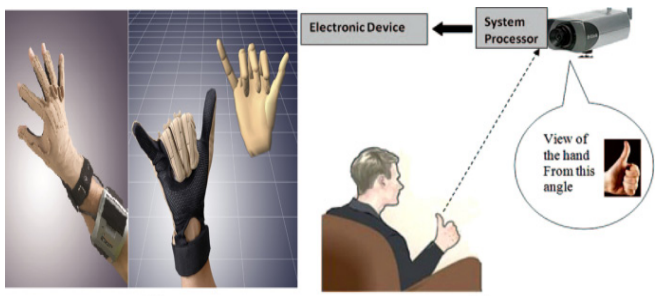

Figure 2: Sensor based approach

Various Sensor dependent methods are:

1. **Glove-based:** this methoddetectsthe position, acceleration, bending of the hand &fingers and degree of freedom of the hand.
   Flex sensors, gyroscope, accelerometer are the examples of Glove-based sensors
2. **EMG (Electromyography):** itmeasures the electrical pulses through muscles of human and interpret the captured signal to detect the movements of finger.
3. **Wi-Fi and radar based:** these methodsuse the radio-waves, broad-beam radar or spectrogram to detect any change in the strength of signal.

***Vision-based* approaches** are based on acquiringthe images/
videos of person's hand gestures using various cameras.
We can use Single cameras,Stereo-camera and multiple camera-based system, Light coding technique such as projection of light to get the 3D view of an object using PrimeSense, Microsoft Kinect, Creative Senz-3D or Leap Motion Sensors.

Invasive methods likebody markers like colored hands, wrist bands, and marked fingers can also be used.

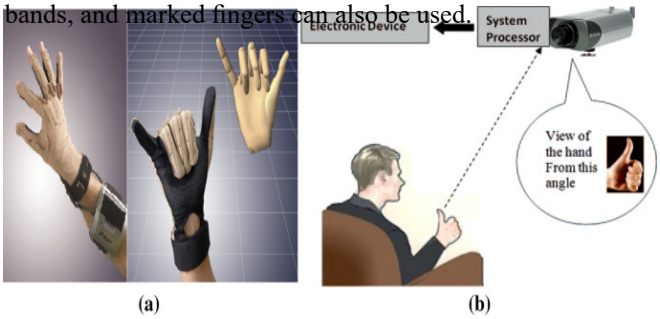

Figure 3: Vision based approach

The system captures the images of various movements of an individual's handusing cameras, which will be thenrecognizedby AI algorithm. The recognition model is first trained withthecollection of hand gestures images to understand and recognize different gestures.

After recognition, they areconverted into a corresponding movement of mouse, which can beperformed on the computer screen.

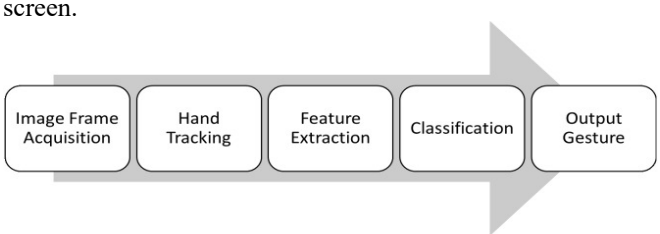

Figure 4: Workflow of hand gesture recognition

It is a priority that gestures should be predicted correctlyfor meaningful and efficient communication.various techniques, classifiers, and algorithmsare available to recognize gesturesin a better way and we have to choose the best approach so that it enhance human–computer interactions.

1.3 Objective

To develop and implement a system through which people can communicate with the computer system solely usingvarious hand gesturesis our objective. It provides an alternativeto physical PC mouse and allowsan individual to perform various mouse functions.

Also, we caninclude more features in this application to get better functionalities from the system which makes it scalable and more efficient than physical mouse.

II. ALGORITHMS AND TOOLS USED

To detect hand and finger tips in the input image or video, **Media Pipe** and **Open cvare** used, which areone of the effectiveopen-source library to perform the CV related tasks. Also, machine learning algorithm is used for recognizing the hand gestures and capture their movements.

1. Media Pipe Framework (open-source, developed by Google)

It enables the users to developreal-time computer vision applications which supports cross-platform, it has pre-existing tools and components*(like object detection, pose estimation, hand tracking, facial recognition etc.)*to process and analyzethe input video and audio data.

The various tools offered byMediaPipe frameworkto train and deploy machine learning models can be executed in real-time environment on various h/w platforms (CPUs, GPUs,) and on specialized accelerators (Edge TPU by Google). Also, it allows the generated models to interact with other machine learning libraries (like TensorFlow and PyTorch)by providing interfaces, and it works with several programming languages, like C++, Python, and Java.

For tracking hand movements, Detection and characterization of a hand or palm(gesture recognition) in real time, the Media Pipe uses**Single-shot detector model.**

2. Opencv

It is freely available computer vision and Machine Learning software library which helps programmers to develop various computer vision applications like image/video Filtering, feature extraction, recognition of objects, tracking of objects. *Basically, large variety of tools and techniquesare provided by OpenCV to work with images and videos, which makes it a patent library for developing numerous computer vision based applications.*

III. SYSTEM ARCHITECTURE

To implement the proposed virtual mouse based on hand gestures, we have to follow the three important steps, which includes:

1. Tracking of Hand Gestures

A BlazePalm model is applied to detect the palm on the full input image of the hand and will returnthe bounding box with oriented hand.

2. Extracting the features of Hand regions

Now, the bounded region of image defined by the palm detector is operated by landmark model of hand whichoutputs 3D hand keypoints.

3. Classifying those extracted features

In this step, gesture recognizer(or classifier)is applied on the previously calculated keypointswhich generates discrete set of gesturesafter classifying the configuration.

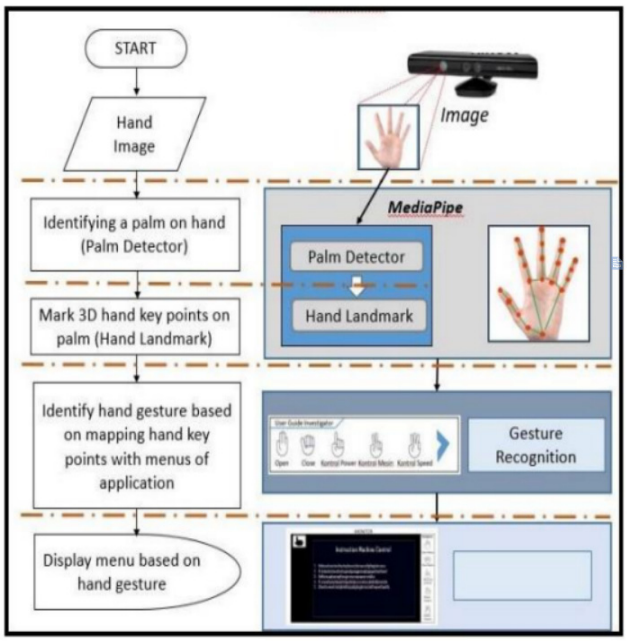

Figure 5: System Architecture

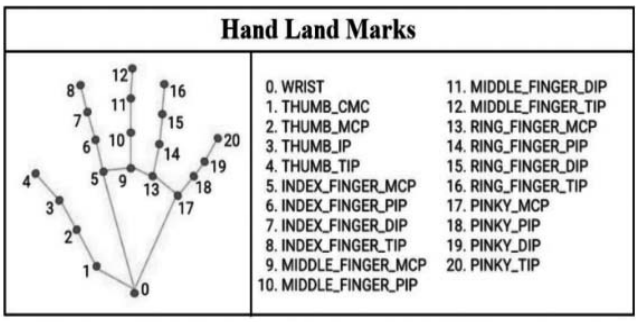

Figure 6: Hand Co-ordinates or Landmarks

SYSTEM IMPLEMENTATION

The proposed system performs the functions of physical mouse via hand gestures with the help of Computer Vision techniques which is a alternative way of existing wired and wireless models.

Some importantHand gestures for performing various mouse functions are :-

Gesture 1: tomovethe cursor around the computer screen

(In this case, the mouse cursor will move around the computer screen if the index finger having tip Id-1 is up or the index finger having tip Id -1 as well as the middle finger with tip Id-2 are up)

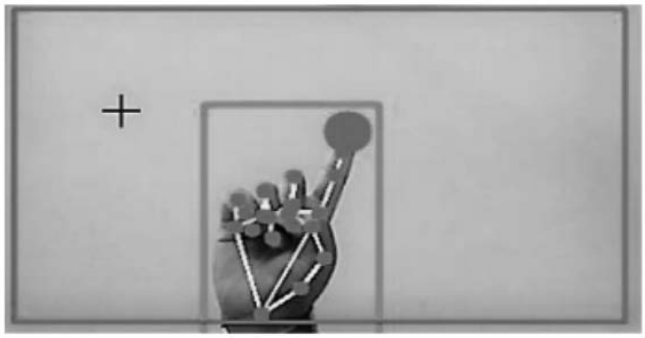

Figure 7: Gesture 1

Gesture 2: for performing the Left Click

(To perform Left click mouse function on thecomputer screen, the index finger having tip Id-1 as well as the thumb having tip Id-0 should be up and the distance between these two should be less than 30pxcomputer screen**)**

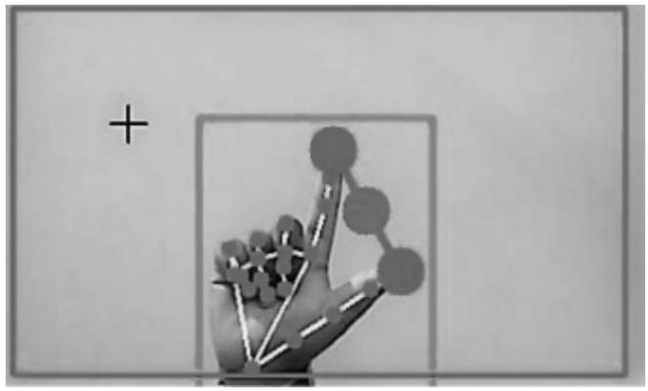

Figure 8: Gesture 2

Gesture 3: for performing the Right Click

(To perform Right click mouse function on the computer screen, the index finger having tip Id-1 as well as the middle finger having tip Id-2 should be up and the distance between these two fingers should be less than 40 px**)**

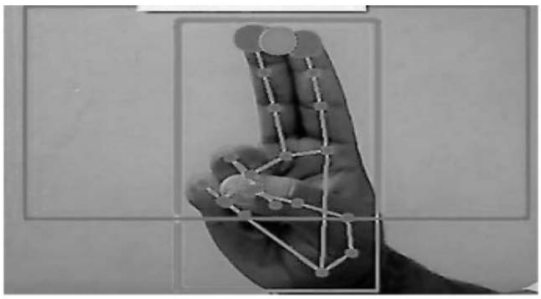

Figure 9: Gesture 3

Gesture 4:to perform scrolling function on computer screen in upward direction

(To perform scrolling function in upward direction on the computer screen, the index finger having tip Id-1 as well as the middle finger having tip Id-2 should be up and the distance between these two fingers should be greater than 40 px to move up the page**)**

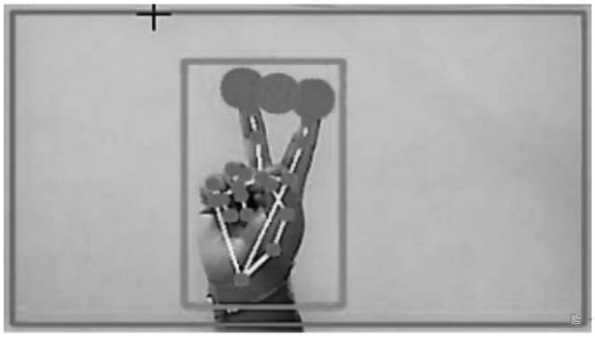

Figure 10: Gesture 4

Gesture 5: to perform scrolling function on computer screen in downward direction

(To perform scrolling function in downward direction on the computer screen, the index finger having tip Id-1 as well as the middle finger having tip Id-2 should be up and the distance between these two fingers should be greater than 40 px to move up the pageand theyhave to be moved down the page together**)**

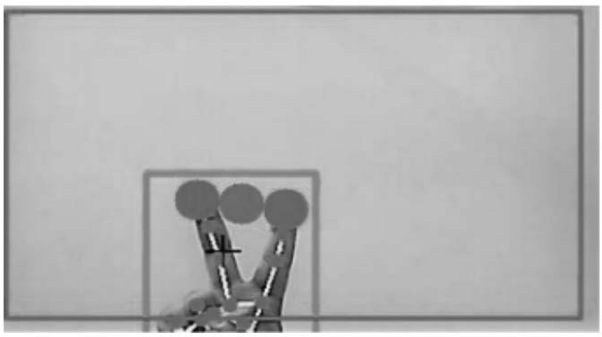

Figure 11: Gesture 5

Gesture 6: Neutral Gesture- for performing no action

(If all five fingers with tip Id- 0, 1, 2, 3, and 4are up, no function is performedon the screen related to any mouse events**)**

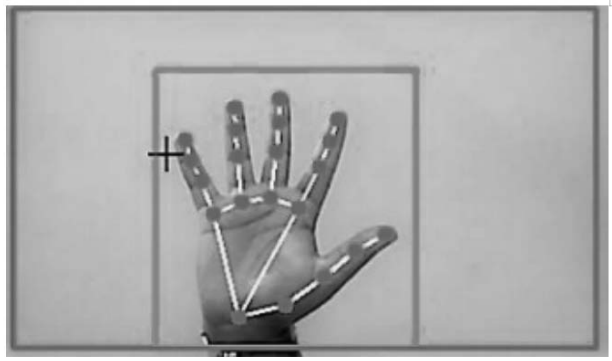

Figure 12: Gesture 6

V. EXPERIMENTAL RESULTS AND EVALUATION

For better results, thedeveloped system is tested indifferent conditions of light and at various distances from the computer screen.

The experiment was performed 25 times (in normal light conditions-10 times, in dim light conditions-5 times, in close distance from the webcam-5 times, and in far distance from the webcam-5 times) by each of the 40 persons and thus generatingtotal 600 different gestures with manual labelling, and the outcomes for the performed experimentsare shown below.

Table 1: Experimental results.

Hand tip gesture *	Mouse function performed	Success	Failure	Accuracy (%)
Tip ID 1 or both tip IDs 1 and 2 are up	Mouse movement	100	0	100
Tip IDs 0 and 1 are up and the distance between the fingers is <30	**Left button click**	99	1	99
Tip IDs 1 and 2 are up and the distance between the fingers is <40	**Right button click**	95	5	95
Tip IDs 1 and 2 are up and the distance between the fingers is >40 and both fingers are moved up the page	Scroll up function	100	0	100
Tip IDs 1 and 2 are up and the distancebetween the fingers is >40 and both fingers are moved down the page	Scroll down function	100	0	100
All five tip IDs 0, 1, 2, 3, and 4 are up	No action performed	100	0	100
Result		594	6	99

*Finger tip ID for respective fingers: tip Id 0: thumb finger; tip Id 1: index finger; tip Id 2: middle finger; tip Id 3: ring finger; tip Id 4: little finger.

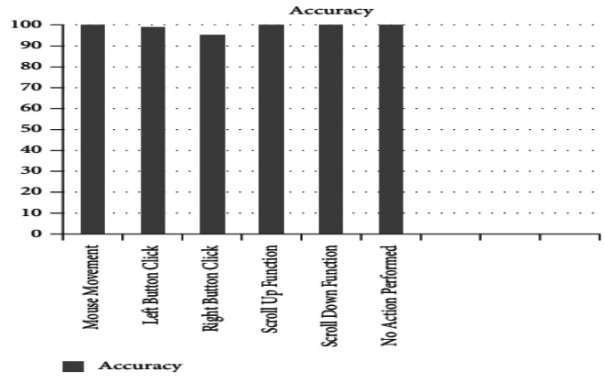

Figure 13 Graph of Accuracy

Table 2: Comparison with existing models.

Existing models	Accuracy (%)
Virtual mouse system using RGB-D images and fingertip detection [16]	96.13
Palm and finger recognition based [17]	78
Hand gesture-based virtual mouse [18]	78
The proposed AI virtual mouse system	99

VI. APPLICATIONS

The virtual mouse system using Artificial Intelligence can be usedin many areas; it is useful in reducing the space requirements for using the physical mouse, and worked as an alternative fortraditional physical mouse.

Few applications of proposed system are:-

Because of COVID-19 pandemic, the use ofphysical devices is not safeas it may spread the virus by using physicaldevices as they need to be touched. Thus, the virtual mouse is an option to performfunctions of mouse by recognizing hand gestures.

Virtual mouse is helpfulin robotics and automation industries to control robots without the use of physical devices.

2-D & 3-D pictures can be createdthrough AI based virtual devicesthroughhand gestures.

AI based virtual mouse can be utilized in the field of VR and AR based games, which eliminates the need of mouse devices. People with disabled hands utilize this system to perform the various functions of mouseon the computer screen.

The proposed system can be used to design virtual prototypes.

VII. CONCLUSION AND FUTURE SCOPE

The various types of hand gestures, gesture acquisition methods, the analysis of most prominent techniques of gesture recognition, applications are included in this paper.The hand gesture recognition is an evolving topic that has huge applications But, still more research is needed in this field. It also has to expandto cover all areas of AI and ICT such as gaming consoles, smart televisions, tablets, smartphones, laptops and desktops.

Due to inclusion of hand gesture recognition in some gaming consoles,the sales of gaming consoles (like Xbox and PlayStation) has increased which may grow more and more over time.

Smart televisions also expects a better growth after inclusion of hand gesture recognition capabilityin them which may increase their purchasing rate (Hexa, 2017) and this rate is expected to increase over 28% from the year 2017 to 2024.

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ABOUT THE AUTHOR

Ms. Neerja Arora, is currently working as Assistant Professor (CSE department) in Ajay Kumar Garg Engineering College, Ghaziabad. She has completed her B.Tech from Lingayas's College, Faridabad (formely affiliated to Maharshi Dayanand University, Rohtak and now a deemed university) and M.Tech from TIT&S College, Bhiwani. She has more than 8 years of teaching experience. Her area of interests is image processing and machine learning.