GESTURE-BASED HUMAN INTERACTION USING ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

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ABSTRACT

The primary objective of the project is to develop a user-friendly interface that enables users to perform various operations using hand gestures. The system recognizes a set of hand movements, including right click, left click, double click, drag and drop, zoom in, zoom out operations. The proposed system utilizes AI-powered Media Pipe Hands for real-time hand landmark detection and Machine Learning techniques to perform image processing and object tracking. In addition, this project introduces a mechanism to activate/deactivate the hand gesture recognition system through keyboard operations based on the user need. Also, when an undefined gesture is recognized, this system triggers an alert to prevent from any unintentional action being performed.

KEYWORDS - Gesture-based interaction, Human-Computer Interaction, MediaPipe, OpenCV, PyAutoGUI, Virtual mouse, Unintentional Gesture.

I. INTRODUCTION

In 2018, a system introduced which is based on smart gestures especially for needed people. They used clustering, Support vector machine (SVM) methodology to achieve the goal. Joint color-depth hand gesture, NTU hand Digit Dataset, ASL Finger Spelling Dataset are used to train the model. Classifications are CNN feature extraction, k-Means Algorithm. This application has high accuracy and depth camera as well as having problem is images in datasets may not give best results in all cases. it can also make feature representation smaller and more manageable [1].

A system introduced in 2020[2], it is also a human-computer interaction using hand gestures. Computer vision leap motion is the methodology used in this system. they take dynamic data as input. Rock, Paper, Scissors based classification is used. This is an approach mainly for identifying gestures quickly and the disadvantage with this system is only limited and static gestures identified. The system has a future scope of improving gaming interface for players.

Another system in 2018[3], which is also for Human-computer interaction using gestures. they used Depth Sensing Camera, Kinect as methodology. they classified the data by using Kalman filter. It solves a problem of capturing the in-depth data and as well as this system supports only the static gestures and limited gestures. In future It may support voice recognition and motion recognition, which can be integrated to build a highly interactive system.

The integration of an activation/deactivation of gesture recognition into our system represents a significant step forward in enhancing user interaction. This process involves pressing the ‘s’ button on keyboard to toggle the gesture recognition system. Furthermore, if the system recognizes the undefined gesture an alert window is triggered preventing from performing the random actions. Touchless interaction between humans and computers presents significant challenges especially concerning accuracy, reliability and user experience. Developing technologies like gesture recognition, voice commands and eye tracking system. But there’s still progress to be made in perfecting these methods for seamless interaction.

Gesture recognition is having many challenges that involves various algorithms, each one will be addressing different algorithms commonly used in gesture recognition. Here are some of the algorithms for the gesture recognition: Deep Learning Algorithms, Hidden Markov Model (HMMs), Decision Tree and Random Forests, Support Vector Machine (SVMs), Principal Component Analysis (PCA)and Feature Extraction Method, Dynamic Time Warping (DTW), Gesture Matching Algorithms, Graphical Models, Fuzzy Logic and Rule-Based System, Clustering Algorithms. These algorithms can be used individually or in the combination, depends on complexity of gesture recognition and specific requirements of the application.

Interaction with computer through hand gestures via computer vision (CV) technology involves using cameras and algorithms to interpret and respond to specific movements of head or fingers. The process of enabling computer interaction through hand gestures involves several distinct stages, each crucial for accurately recognizing gestures and translating them into meaningful actions. PyAutoGUI is a python library designed for GUI automation, including controlling the mouse and keyboard. These actions could include moving the cursor, clicking, dragging, or performing other mouse related functions on the computer interface. If an unrecognized or unintended gesture occurs, ensure the system defaults to a safe or neutral state rather than executing random actions. Combining multiple strategies offer a more robust solution. Allow users to adjust sensitive settings or define their own gestures. This gives them more control and reduce the likelihood of unintentional action.

Implement thresholds for recognizing gestures. This might involve analyzing the speed, duration, or specific patterns of a gesture before interpreting it as intentional. Train the system to recognize common unintentional gestures and filter them out. Unintentional gestures causing the system to perform random action can indeed be quite problematic. To tackle this issue effectively, you'll need a strategy that focuses on distinguishing international ones. Enhance the system's ability to different between intentional and unintentional gestures. This might involve analyzing the context or characteristics of the gesture, such as speed, duration, or specific patterns. If the system's response to unrecognized gestures leads to potential system damage and data loss, addressing this becomes even more critical.

For critical actions that might cause system damage or data loss, introduce confirmation prompts. Tis ensures that even if a gesture is recognized, the system won't execute the action without explicit user confirmation. Introduce multiple layers of user authentication before executing critical actions. This prevents unauthorized or accidental access to action that can cause damage. Inform users about the potential risk associated with certain gestures and advice caution while using them until the issue is resolves. Introduce multiple layers of user authentication before executing critical action. This prevents unauthorized or accidental access to actions that can cause damage. Inform users about the potential risks associated with certain gestures and advise caution while using them until the issue is resolved. Introducing an alert mechanism for unrecognized gestures can serve an effective safety net.

The main objective are to improve user-computer interaction by recognizing a wide range of hand gestures, offering a more experience and providing the facility to activate/deactivate the gesture recognition system with keyboard shortcuts.

II. LITERATURE SURVEY

[1] In 2019, Mohamed A. Rady, Sherin M.Yousrf, Salema F. Fayed, "Smart Gesture Application for Special-need people", developed using clustering and SVM methodologies, but static images in dataset may not give the best results in all cases. [2] In 2020, Dan-Ioan Gota, et.., al, had introduced "Computer Interaction using hand gestures" using computer vision(CV) and leap Motion, but there are some bugs identifying in the leap motion SDK.

[3] According to Kai Li, Jun Cheng, et., al(2018), they have developed "Tracking and

Recognition based Human-Computer Interaction System", using Depth sensing Camera and Kinect sensor, But Only the static gestures are supported. [4] In 2018, Sherin Mohammed Sali Shjideen and Preetha V H, has introduced "virtual Mouse using hand gestures ", using the AdaBoost classification algorithm, main drawback is only about 15˚ rotation can be efficiently detected from the method's performance. [5] In 2022, Riya Jain et.., al, introduced "Human Computer Interaction using hand gestures", which uses Sensor Based Instrumented Glove and Computer Vision Approach. It is difficult to encounter pain with the Sensor Based instrumented Glove.

[6] According to Alberto Tellaeche Iglesias, Ignacio Fidalgo Astorquia, Juan Ignacio Vazquez Gomez, Srajit Saikia,"Gesture based interaction using RCNNs", high computation capacities are needed for CNN.It is a sensor-based project which is very useful bus has disadvantages also. [7] A system named "Virtual Mouse using Hand Gestures" was introduced in 2018[7]. This system employs the Masking Technique approach. The primary function of this system is to transfer files between two systems connected to the same network. The drawback is that hands must employ color caps in order to make hand movements.

[8] According to Mohammad Naveed Khan et.., al , "Mouse Cursor Control Using Hand Gesture Recognition" is developed using openCV and Mediapipe, the gestures specified in system are limited.This system is used to control the limbs of the patients and is very useful.

[9] In 2022, Abeer Alnuaim , Mohammed Zakariah , et.., al ,introduced "human interaction with hand gesture detection using ResNet", by using Open CV methodology, as they used dataset, the static data can't give the best results for all gestures.[10] A different system called " gesture control virtual mouse " was also introduced in 2022[10]. Open Computer Vision (CV) was employed. The primary benefit is that dynamic movements are recognized input. The drawbacks include a minor reduction in the precision of the right-click function and challenges when selecting text by clicking and dragging. The goal is to create fingerprint capture techniques in the future that yield results that are more precise.

[11] In 2023, Ranjith GC and Saritha Shetty has invented "A Real Time Virtual Mouse System" by using Open CV, but when there is an unintentional gesture recognized, automatically random actions are performed. [12] According to V.V. Reddy, et.., al (2020),they proposed "Colored Finger Tips and Hand Gesture Recognition" using Open CV and media pipe, but it detect the unintentional gestures which makes the unneccesary actions to perform. [13] In 2023, K.Bharath Reddy, Md. Fayazuddin, M. John Manohar has developed "Virtual Mouse by Artificial Intelligence" using Open CV, but the specified gestures are limited in this system.

[14] In 2023 Victor Chang1,et.., al, have developed "Hand Gesture Recognition Management in a Challenging Environment" using image processing and pattern matching, the system cannot perform dynamic gesture recognition tasks.[15] According to Vijay Kumar Sharma, Vimal Kumar, Md. Iqbal, Sachin Tawara, Vishal Jayaswal(2020), had developed "Virtual Mouse Control using hand gesture" by using openCV, but the angle of gestures was predefined here. [16] In 2023, Ruben E.Nogales and Marco E.Benalcazar, have introduced "Hand Gesture Recognition Using Automatic Feature Extraction" in which mainly leap motion controller is used and a challenge for RNN is to construct neural networks with fixed parameters. [17] According to N. Meghana, et..., al(2023),had developed "HUMAN-COMPUTER INTERACTION using gestures" using openCV and mediapipe, the drawback is when there is an unintentional gesture recognized, automatically random actions are performed.

[18] In 2020, Abhishek B1,et.., al, proposed "Hand gesture recognition using machine learning" using tensor flow, it can detect the undefined gestures. [19] In 2020, A. Mohanarathinam1, K.G.Dharani1, R.Sangeetha2, G.Aravindh1, P.Sasikala1, developed

"Study on Hand Gesture Recognition" using PCA feature analysis, noise level of the image is high. [20] In 2023, Hongyu Zhou, et.., al, have introduced "Human–Computer Interaction Technology using gestures" using visual sensing recognition, there may be multiple signal - transmitting devices neccesary to obtain high precisely results.

III. METHODOLOGY

Our Project implements a gesture recognition and control system using a webcam and hand gestures. It utilizes various libraries such as openCV, Mediapipe, PyAutoGUI, and others to detect hand gestures, classify them, and execute corresponding actions. The script begins with necessary imports, including OpenCV for computer vision tasks, Mediapipe for hand tracking, PyAutoGUI for controlling mouse and keyboard actions, and other modules for specific functionalities.

The gesture recognition is based on Mediapipe's hand tracking feature, which tracks the landmarks (specific points) of the hand in the captured video frames. The script defines classes and functions to interpret the positions and movements of these landmarks to recognize gestures.

The HandRecog class processes hand landmark data to determine the current gesture based on finger positions, distances, and orientations. It also handles fluctuations due to noise in the data. The Controller class manages the execution of commands corresponding to detected gestures. It includes methods for controlling mouse movements, clicking, scrolling, adjusting system brightness and volume, and handling specific gestures such as pinching.

The Gesture Controller class orchestrates the entire gesture recognition and control process. It captures video frames from the webcam, processes them using Mediapipe to detect hand landmarks, classifies hand gestures, and calls the appropriate methods in the Controller class to perform actions based on recognized gestures. The script provides a user interface through OpenCV's window, where the video feed with detected hand landmarks and recognized gestures is displayed. It also allows the user to start and stop the gesture recognition system by pressing the 's' key and exit the application by pressing the 'Esc' key.

- pyautogui.moveTo() for cursor movement.
- pyautogui.click() for left click.

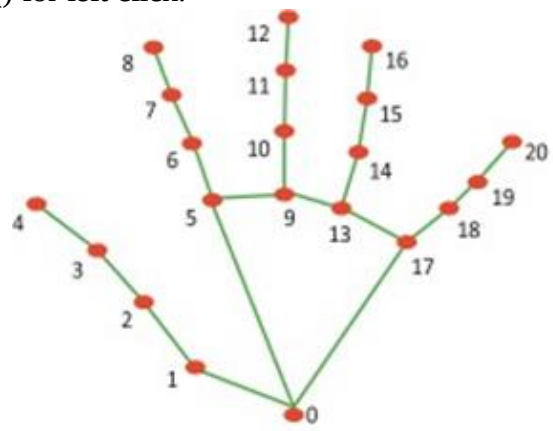

Fig.1: Landmark or Co-Ordinates in the Hand [6]

Fig.1 shows the operations include mouse movement, right click, left click, double click, drag and drop and scrolling. when the system recognizes an undefined gesture which is triggered by the unintentional hand movements of the user, the system performs random actions according to the gesture recognized. To address this problem, this project introduces a mechanism that triggers an alert window when an undefined gesture is recognized, so that it prevents from any unintentional action being performed.

In addition, this project introduces a mechanism to activate/deactivate the hand gesture recognition system through keyboard operations based on the user need. Users can control the computers by executing predefined gestures in the air, eliminating the limitations of conventional input devices like mouse.

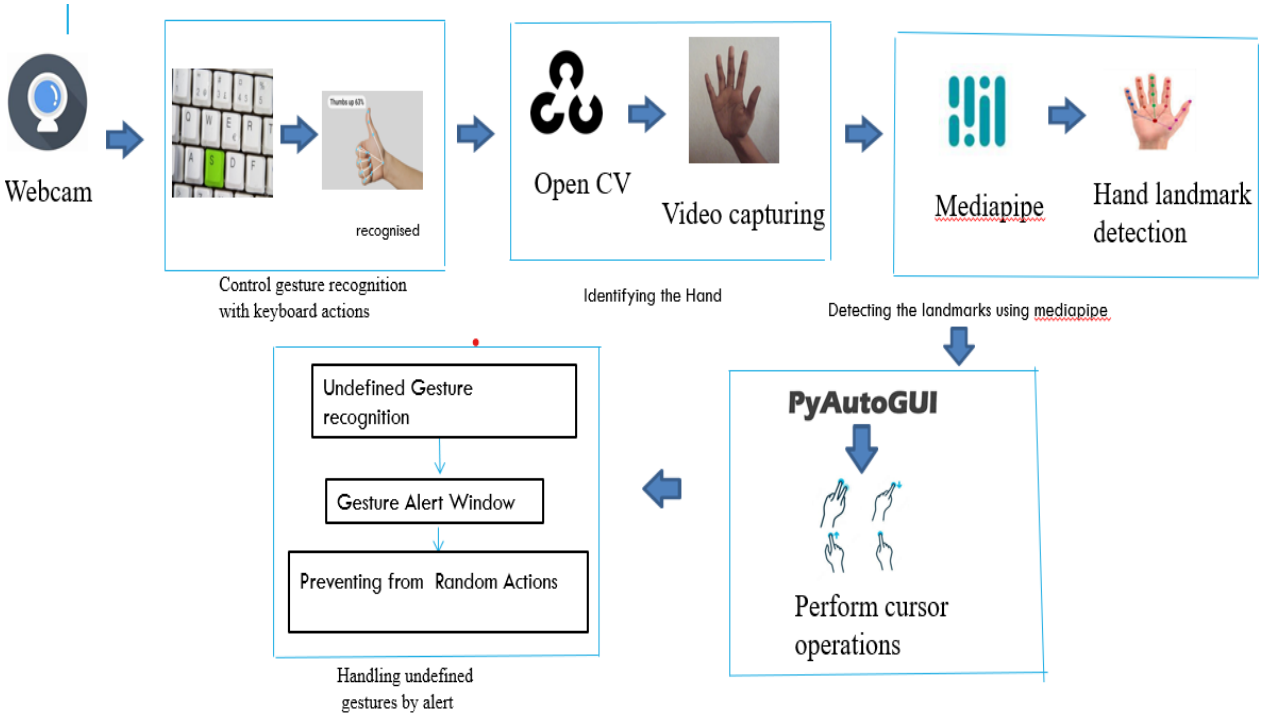

Fig.2: System Architecture

Fig.2 Explains about the project starts by initializing the video interface through webcam. The system uses OpenCV which is open source computer vision library to process the video. Once the video has been processed, the system uses MediaPipe library to detect and identify landmarks on the user's hand. Once the gestures are recognized, the system translates these gestures into cursor operations. These cursor operations are performed with the help of PyAutoGUI. When an undefined gesture is recognized, this system generates an Alert window to prevent from unintentional actions being performed. Activating/deactivating the hand gesture recognition system through keyboard operations based on the user need.

IV. RESULTS

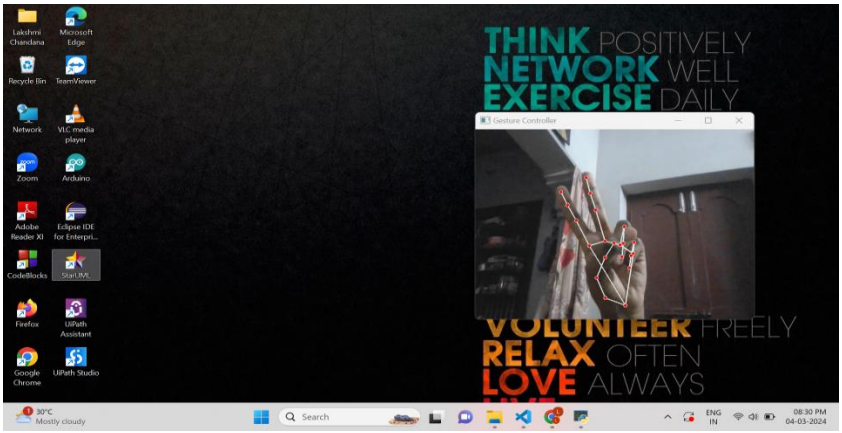

Fig.3: Mouse Movement

Fig.3 Represents how to perform the cursor movement, user need to move hand in the direction to which the cursor need to move

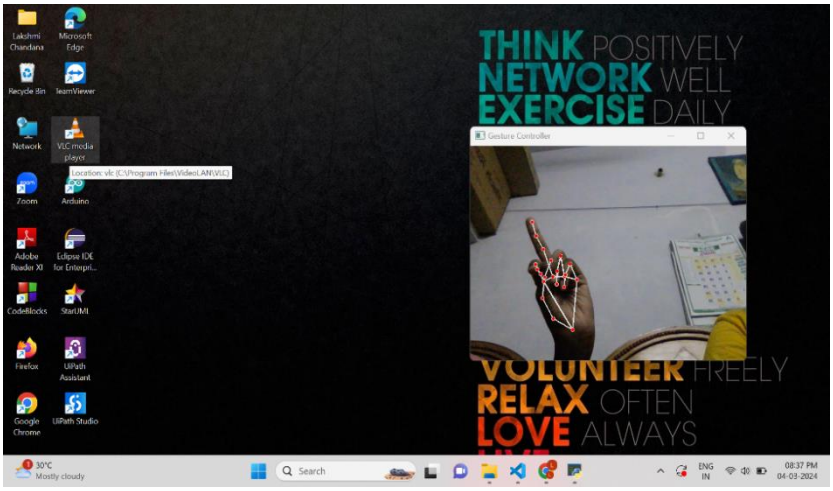

Fig.4: Left-Click

Fig.4 Defines how to perform the left click operation, user need to close the index finger.

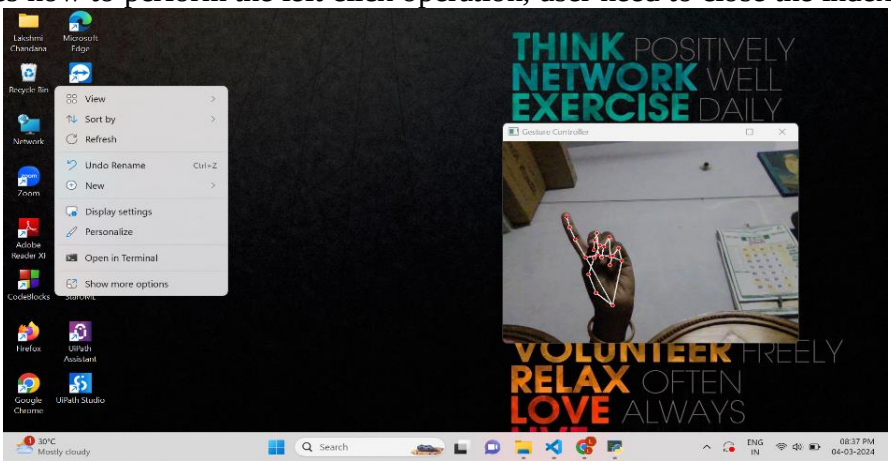

Fig. 5: Right-Click

Fig.5 Expresses how to Perform right click operation, user need to close the middle finger.

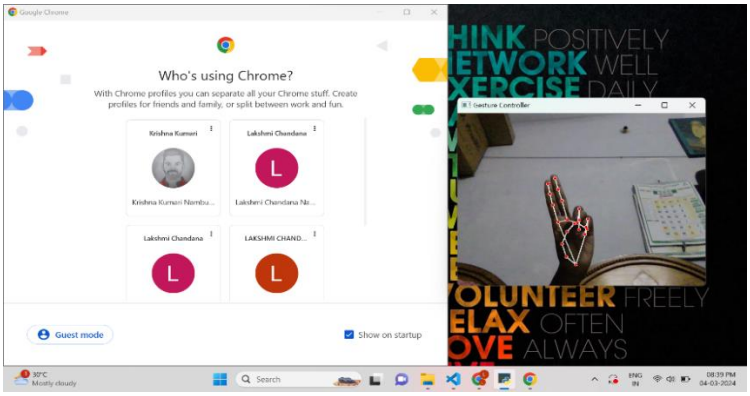

Fig. 6: Double- Click

Fig.6 Illustrates how to open any application, user need to perform double click operation by moving index finger and middle finger together.

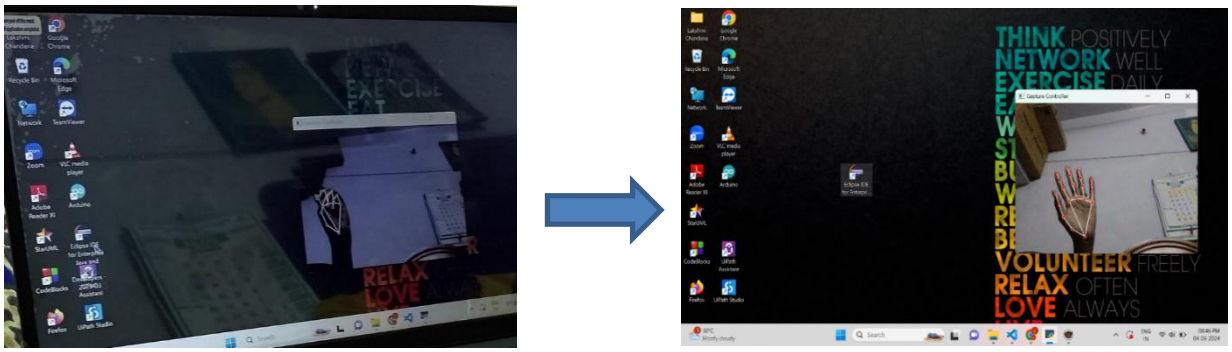

Fig.7: Drag and Drop

Fig.7 Portrays how to drag any icon, user need to place the cursor on that particular file which we want to move the position and close all the fingers which helps us to select that file and open all the fingers when we need to drop the file at a different place.

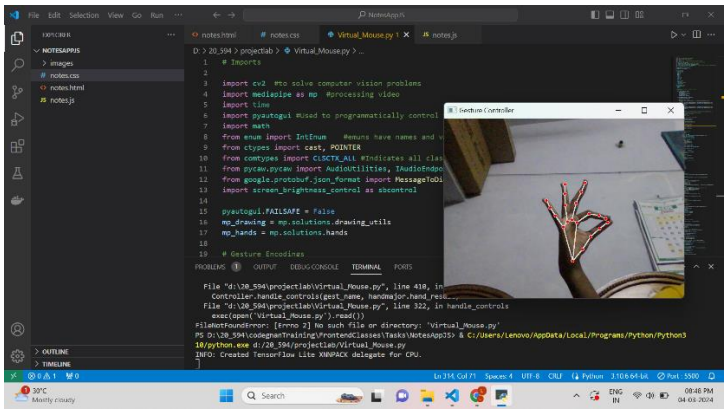

Fig.8: Scroll Operation

Fig.8 Depicts how to scroll the page up or down, user need to move the hand with the gesture up to scroll the page up and the user need to move the hand with the gesture down to scroll the page down.

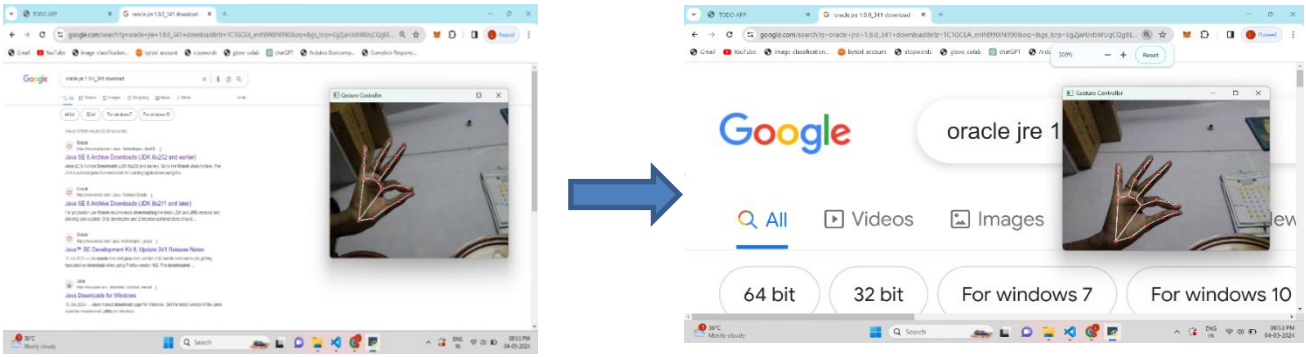

Fig.9: Zoom In and Zoom Out (Move Left / Right)

Fig.9 Explains how To perform Zoom In / Zoom Out operations, on the screen user need to move the hand with the gesture Right for the zoom in operation and Left for the zoom out operation.

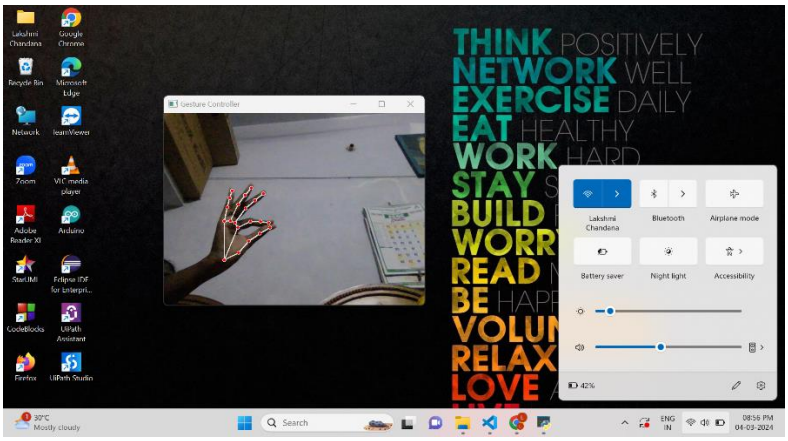

Fig.10: Brightness Increase / Decrease (Move Up / Down)

Fig.10 Shows how to increase and decrease the system brightness, user need to perform the above hand gesture upwards to increase the brightness and to decrease the brightness, user need to perform the above hand gesture downwards.

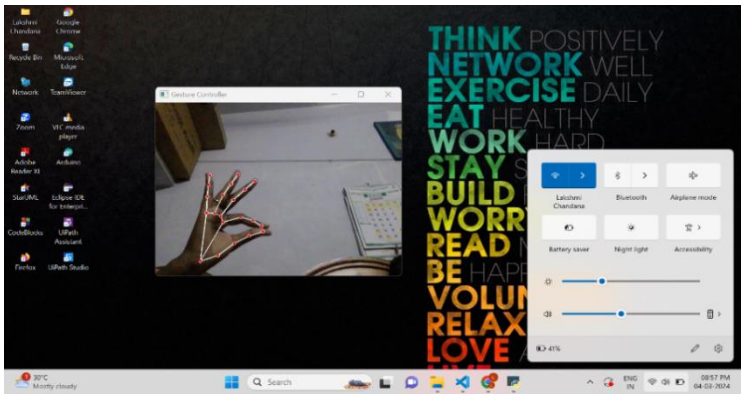

Fig.11: Volume Increase / Decrease (Move Left / Right)

Fig.11 Describes how to increase and decrease the system volume, user need to perform the above hand gesture to the right to increase the volume and to decrease the system volume, user need to perform the above hand gesture to the left.

V. CONCLUSION

The Gesture-based Computer Interaction (HCI) system introduced in this project has revolutionized the way people interact with computers. This system allows users to control digital interfaces using hand gestures, which is more natural compared to traditional input devices like a mouse. It overcomes the limitations of regular mouse interfaces and offers a smooth and effective solution for various tasks, including precise cursor movements.

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