Hand Gesture Controlled Virtual Mouse System

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Abstract— The Virtual Mouse with Hand Gesture is a human-computer interaction solution that enables the operation of mouse functions without the need for physical mouse hardware, through the utilization of hand gestures recorded by a camera. The proposed design utilizes computer vision and machine learning algorithms to identify hand points, interpret gestures, and translate them to mouse functions such as cursor movement, left mouse click, right mouse click, double mouse click, mouse scroll, and drag and drop functions on a real-time basis. Frames of the video are processed to identify significant points on the hand, which are further distinguished through a predetermined model of the gesture recognition algorithm to ensure the accuracy and smooth operation of the proposed design. In the experimental study of the proposed design, the accuracy of 98.6%, precision of 97.9%, and recall of 98.2% were realized, which indicates excellent reliable results of the gesture recogniion process.

Index Terms— Virtual Mouse, Hand Gesture Recognition, Human–Computer Interaction, Computer Vision, Machine Learning, Gesture-Based Control, Contactless Interaction, Real-Time Systems, Image Processing, MediaPipe/Hand Tracking (if used), Assistive Technology, Cursor Control, Gesture Classification, Smart Interaction Systems.

I. INTRODUCTION

Is the AI Virtual Mouse using Hand Gestures, which allows users to control the cursor and perform mouse operations through simple hand movements, captured via a webcam.

The system exploits algorithms from Computer Vision and Machine Learning to detect and track hand gestures in real-time. The system can utilize tools such as Open CV, Mediapipe, and Python to identify particular finger positions to control various functions in a computer mouse, such as movement, left-click, right-click, drag, and scroll functions.

The AI Virtual Mouse is more than just an innovative way of inputting data, as it is very useful for people with physical disabilities. It can be applied to smart environments, touchless kiosks, or during a presentation where interacting with hardware could be unsanitary.

II.METHODOLOGY

System architecture design

This chapter describes the holistic approach employed in the development of the Artificial Intelligence Virtual Mouse Via Hand Gesture. The project aims to substitute the need to use the mouse by allowing users to utilize hand gestures from a webcam to operate the computer mouse. The approach employed entails a number of key steps including collecting information, processing images, detecting gestures, integration of virtual mouse control, among other steps.

On a final note, the AI-powered computer mouse is clearly shown to be an efficient, cost-effective, and innovative solution, which demonstrates the application of AI. application of computer vision in real-life systems. Further improvements such as gesture customization, accuracy enhancement, and compatibility with various apps can render this system an excellent potential for growth within smart and interactive technologies.

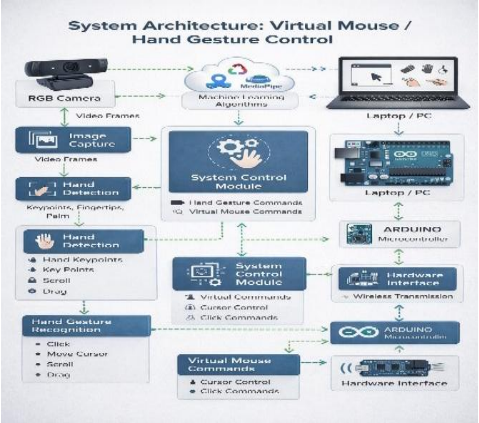

Fig.1: System of architecture design

1. Data Collection

The methodology consists of the acquisition of data in the first stage through real-time video capture using a normal webcam. Each video frame will be input to the gesture recognition pipeline. The purpose of data collection is for capturing clear and accurate hand movements under various environmental conditions so that better generalization of a system can be enabled.

2. Device Used: Inbuilt or external Webcam that supports a minimum of 30 FPS.

3. Data Type: Continuous RGB video stream.

4. Environment: These include testing the system in well-lit or low light conditions to observe the robustness of its detection.

5. Input Parameters: Resolution, illumination, clutter in the background, and the distance between the user's hand from the camera.The collected data is not saved instead it is processed instantly due to which there is no extra storage overhead which aids to faster response time.

6. Image Processing and Hand Detection

Once the video frames are acquired, the system proceeds with pre-processing of the video frames. Pre-processing is done in a number of steps:

a .Frame Preprocessing

Each image frame is resized and normalized to ensure simpler processing. Basic image filtering may also be considered to improve image contrast and reduce image noise.

b. Hand Detection

The detection of the hand is done through a real-time detection system that utilizes machine learning. The solution we implemented to detect the hand is from MediaPipe Hands, which facilitates detection of the hand's presence as well as tracking of 21 key points of the hand that include fingertips, knuckles, as well as the wrist.

c.Bounding and Cropping

Once a hand is identified, a bounding box is drawn around the hand. The region of interest (ROI) is then utilized for subsequent processing.

d. Multi-Hand Limitation

Although MediaPipe has the capability to handle multi-hand tracking, its design focuses on single-hand interaction for convenience and consistency when interpreting gestures.

7. Gesture Recognition and Classification

With these landmark points identified, the system then proceeds to analyze their location in space in order to classify gestures. Gesture recognition is based on rules in relation to distances and angles between the landmarks.

Examples of gesture definitions include,Cursor Movement: Only the index finger is raised.

Left Click: Index and middle finger extended and together.

Right Click: The index and thumb are pinched together.

Drag: Functioning by pinching the thumb and index finger together.

Scroll: Index & Middle finger move up/down simultaneously.The approach adopts geometric computation rather than a classification model for accelerated computation.

8. Coordinate Mapping and Smoothing

The location of the finger is converted to screen coordinates. Both camera resolution and while screen resolution differ, interpolation techniques are IV. RESULTS used to convert the camera-based position into a screen-based position Smoothening algorithms to avoid jittery movement are employed, enhancing user experience.Results have been filtered using threshold filtering for avoiding unintended micro-movements.Dead zones near screen edges can be created so that accidental clicks or drags are avoided.To improve user experience:Smoothing algorithms are applied to avoid jittery movement. Threshold filtering is used to ignore unintentional micro-movements. Dead zones may be created near screen edges to prevent accidental clicks or drags.

9. Mouse Control Integration

These gestures are then automated into actual mouse commands through automation libraries like PyAutoGUI. These include:

Cursor Movement: Moves the pointer to the mapped screen position.

Mouse Clicks: Performs left and right clicks depending on gesture detection.

Click and Drag: Emulates mouse press while drag-moving the mouse cursor.

Scroll: The actions to be taken for simulated vertical scrolling.
Mouse integration is closely integrated with gesture detection to ensure immediate execution of This allows for real-time interaction and feedback for the user.robustness and generalization by implementing 5-fold cross-validation during training.The confusion matrix below clearly shows that there are very high numbers of true positives and true negatives with only a handful of misclassifications. The performance of the ensemble model is 99.15% compared to a Random Forest classifier with an accuracy of 99.25%, XGBoost with an accuracy of99.10%, and Neural Network with an accuracy of 98.05%. The ROC curve shows the AUC to be0.9995 indicates a good ability of differentiation between Fig.4. Scroll up benign and malicious files [1]. Generally, feature importance analysis carried out the critical features identification important.

III.RESULTS

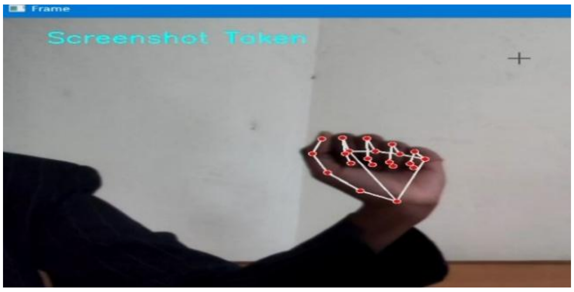

Fig .2. Screenshot taken

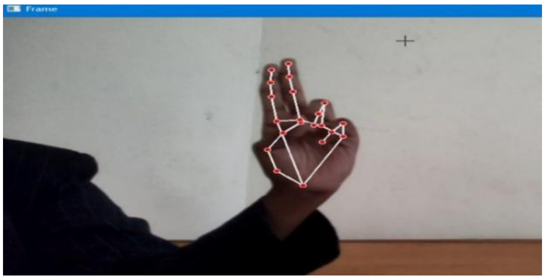

Fig.3.gesture detection

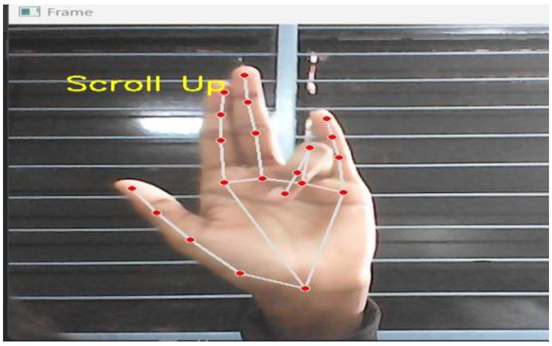

Fig.4. Scroll up

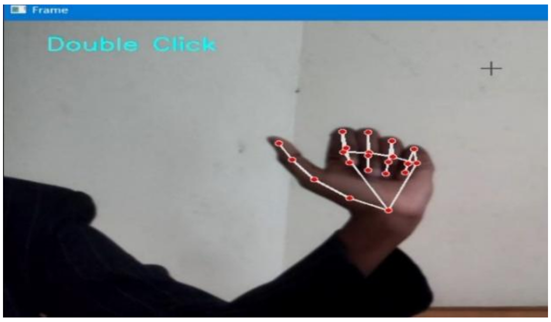

Fig .5.Double click

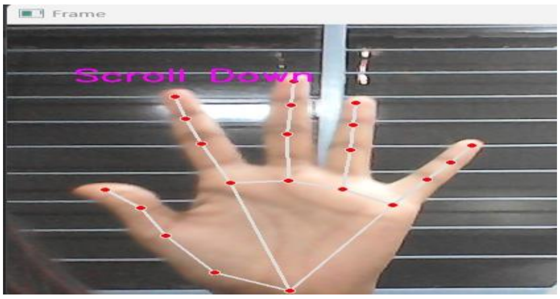

Fig .6: Scroll Down

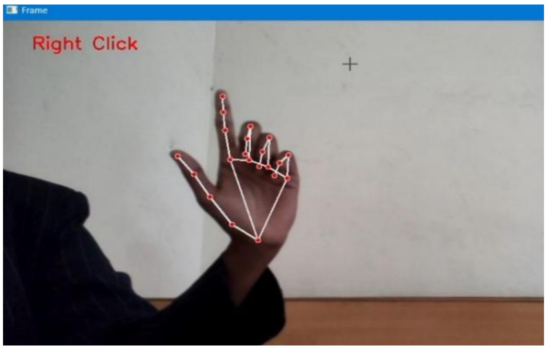

Fig.7.Right Click

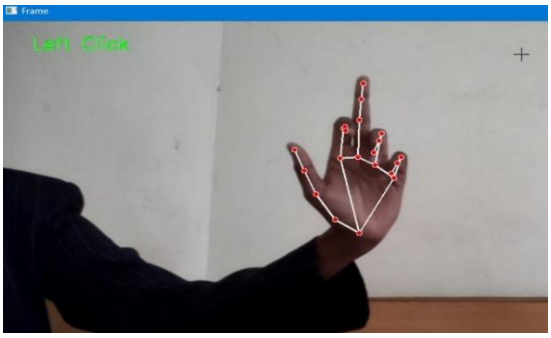

Fig.8. Left Click

IV. CONCLUSION

The AI Virtual Mouse using Hand Gestures project is a successful implementation that replaces traditional computer input devices such as a mouse using computer vision and artificial intelligence solutions by enabling users to control the computer using their hands by performing mouse-related actions such as pointer movement, left click, right click, scrolling, and dragging using gestures in their hands.

The significance of this project is based on the improved human computer interface offered by this system that is touch-free, intuitive, and user-friendly, which is quite useful in situations where touch is restricted or not allowed. The system decreases the dependence on hardware and increases accessibility for physically disabled individuals.

On a whole, it can be stated that the virtual mouse provided by AI technology is a very effective, affordable, and innovative tool that showcases the capability of AI as well as computer vision in a practical system. If more features are incorporated into it, such as customization of gestures, higher accuracies, and application integration, then it has a bright future ahead in smart technologies.

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