Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 3, No. 4, March : 2024

HAND GESTURE BASED VIRTUAL MOUSE AND CALCULATOR

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ABSTRACT
The emergence of Augmented Reality (AR) and Virtual Reality (AR) technologies has spurred innovations in Human-Computer Interaction (HCI). Among these innovations, gesture-based control systems have garnered significant attention for their intuitive and immersive user experiences. In this paper, we present an advanced approach to control a virtual mouse and virtual calculator using hand gestures, offering an alternative to traditional input devices such as mice and calculator. Our system utilizes computer vision techniques to track and interpret hand movements in real-time. By employing depth-sensing cameras or RGB cameras with sophisticated algorithms, we accurately detect hand gestures and translate them into corresponding mouse and calculator actions. The proposed method enables users to navigate computer interfaces, manipulate objects, and interact with virtual environments seamlessly. We discuss the design and implementation of the virtual mouse control system, including gesture recognition algorithms, hand tracking techniques, and integration with existing software frameworks. Additionally, we evaluate the performance and usability of the system through user studies, assessing factors such as accuracy, responsiveness, and user satisfaction.

Keywords:
Gesture Controlled, Virtual mouse, Hand Landmarks, Virtual Calculator, OpenCV, Computer Vision, Human-Computer Interaction, Seamless Experience.

1.INTRODUCTION
In the rapidly evolving landscape of Human-Computer Interaction, innovative technologies continue to redefine the way we interact with digital devices. One such groundbreaking project is the "Hand Gesture-Based Virtual Mouse and Calculator," which aims to revolutionize traditional input methods by leveraging the power of hand gestures.
This project is designed to provide users with an intuitive and hands-free interface, enabling them to control a Virtual Mouse and perform basic arithmetic calculations using natural hand movements. By eliminating the need for physical input devices like a mouse or keyboard, this system not only enhances user convenience but also opens up new possibilities for accessibility, especially for individuals with physical disabilities.

1.1 Problem Statement
With the proliferation of touch-based devices and the advancement of gesture recognition technology, there is a growing interest in developing intuitive and interactive interfaces for a wide range of applications like Virtual Mouse and Virtual Calculators. While traditional calculators rely on physical buttons or touch screens for input, integrating hand gesture control offers a novel and potentially more immersive user experience. By leveraging computer vision and gesture recognition techniques, users can navigate digital interfaces and manipulate virtual objects through intuitive hand movements.
Additionally, addressing ergonomic considerations is crucial to prevent user fatigue or discomfort during prolonged use. Designing intuitive and ergonomic hand gestures that minimize physical strain while maximizing precision and control is paramount for long-term usability.

2. REVIEW OF LITERATURE

1. Vantukal Reddy, Thumma Dhyanchand, Galla Vamsi Krishna, Satish Maheshwaram (2020). "Virtual Mouse Control Fingertips and Hand Gesture Recognition". IEEE-HYDCON, DOI: **10.1109/HYDCON48903.2020.9242677, pp. 1-5.**

- Authors: Thumma Dhyanchand, Vantukal Reddy, Satish Maheshwaram, Galla Vamsi Krishna
- Published in:2020 IEEE-HYDCON International Conference on Engineering in the 4th Industrial Revolution.
- This paper presents a virtual mouse control using hand gesture recognition, image processing, neural network algorithm, python, OpenCV and pyautogui. The limitation of this mouse is using colored fingerprints.

2. Kollipara Sai Varun. I Puneeth, Dr. T. Prem Jacobi (2019) "Virtual Mouse Implementation Using OpenCV ". 3rd International Conference on Trends in Electronics and Informatics, DOI: **10.1109/ICOEI.2019.8862764, pp. 435-438.**

- Authors: Dr. T Prem Jacob, Kollipara Sai Varun, I Puneeth.
- Published in:2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI)
- This paper presents a virtual mouse using OpenCV, IP, deep learning, numpy, anaconda. The system can recognize several hand gestures, enabling users to control the mouse pointer and perform left and right clicks.

3. Sherin Mohammed, V H Preetha (2018) "Hand Gesture - Virtual Mouse for Human Computer Interaction". International Conference on Smart Systems and Inventive Technology, DOI: **10.1109/ICSSIT.2018.8748401, pp. 543-546.**

- Authors: Sherin Mohammed, V H Preetha.
- Published in:2018 International Conference on Smart Systems and Inventive Technology (ICSSIT)
- They used Mat-lab software, Two cameras. This system got 90% correct detection for both views under enough light conditions.

4. Mohith Tanwar, Gita Rani, Prashanth Chamoli (2019). "Hand Gesture Recognition Based Calculator". International journal of computer science and mobile computing, ISSN: 2320-088X, vol. 8(10), pp. 149-158.

- Authors: by Mohith Tanwar, Gita Rani, Prashanth Chamoli.
- Published in: International Journal of Computer Science and Mobile Computing, Vol.8 Issue.10, October- 2019, pg. 149-150
- This paper presents a hand gesture-based virtual calculator using a neural network, hand recognition, OpenCV and a webcam. The system recognizes hand gestures for arithmetic operations and number inputs and also compares the accuracy and response time of their system with a traditional calculator.

5. Preeti Niranjan, Brijesh Pandey, F. Massoma Nigar (2016). "Virtual calculator using hand gesture recognition via support vector machine". International journal of innovative research in science, engineering and technology, ISSN: 2319-8753, DOI:10.15680/IJIRSET.2016.0510020, vol.5(10), pp. 17637-17642.

- Authors: Preeti Niranjan, Brijesh Pandey, F. Masooma Nigar.
- Published in: International Journal of Innovative Research in Science, Engineering and Technology vol.5, Issue 10, October 2016
- The system uses a webcam to capture hand gestures and OpenCV library for image processing. The system uses thresholding, contour detection, and contour area calculation to recognize hand gestures.

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3. SYSTEM DESIGN

3.1 Introduction

By detecting and analyzing the fingertip ids as shown in **Figure 1,** and hand movements and gestures, the system translates these actions into corresponding commands, enabling seamless interaction with Graphical User Interfaces (GUIs) and applications.

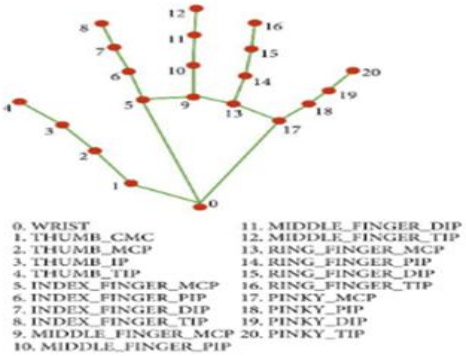

Fig 1: Hand Landmarks

By leveraging hand gestures and advanced computer vision techniques, this system exemplifies the convergence of technology and human-centered design to create more natural and efficient user interfaces. The process starts by activating the webcam, capturing an image, and forwarding it to the system. The system then processes the image, performing tasks like facial recognition, and sends the results back to the user and vice-versa.

3.2 UML Diagrams

3.2.1 Use Case Diagram

A use case is an appraisal of a system function that provides an actor with an apparent outcome. The determination of the system boundary i.e., the distinction between the tasks carried out by the system and those carried out by its surroundings comes from the identification of actors and use cases. The user initiates the process by turning on the webcam. The system then records the hand gesture in real time, extracts its elements, categorizes them, and recognizes the gesture based on the hand's landmarks. The output is displayed by the system once it completes the gesture activities as shown in **figure 2.**

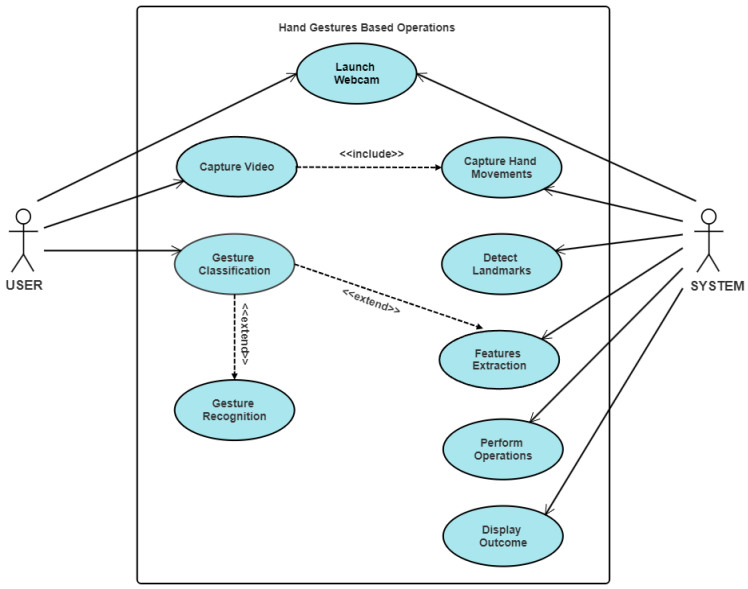

Figure 2: Use Case Diagram

3.2.2 Class Diagram

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ISSN: 0970-2555
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The class diagram represents static structure of the software, defining the classes, their attributes and their relationships. The class diagram for hand gesture based virtual mouse and calculator represents static structure of the software, defining the classes, their attributes and their relationships. The movements class has attributes like left or right hand. The left-hand class has attributes which are performed using left hand like scrolling, zooming. The right-hand has attributes which are performed using right hand like cursor movement, volume and brightness control etc. as shown in figure 3.

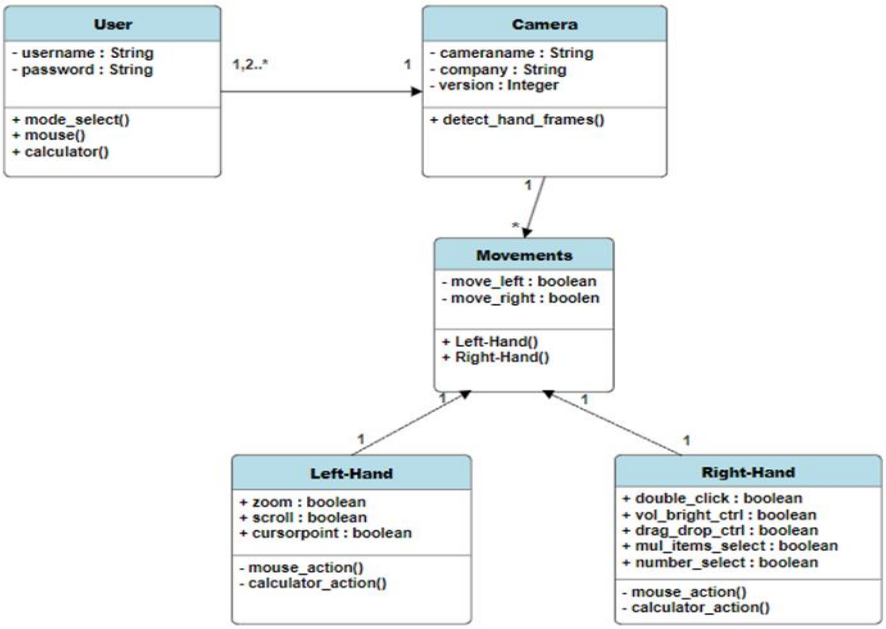

Figure 3: Class Diagram

3.2.3 Sequence Diagram

One kind of interaction diagram that shows how messages are sent and received between items or system components over time is a sequence diagram. Sequence diagrams make it easier to comprehend how various system components work together to accomplish particular functionality.

The **Figure 4** illustrates the chronological order of interactions between the virtual mouse and calculator components. It begins with the user initiating interaction with the system, followed by the activation of the webcam component. The frames which are captured are then transmitted to the system for processing. Within the system, various processes occur sequentially. First, hand detection algorithms are applied to identify and isolate the user's hand within the captured frames. Next, feature extraction techniques are employed to extract key features from the detected hand. These features are then subjected to pattern matching algorithms to recognize specific gestures. The matched results determine the appropriate action to be taken, which could include controlling a virtual mouse or calculator interface. Finally, the action output is generated, representing the system's response to the user's gestures.

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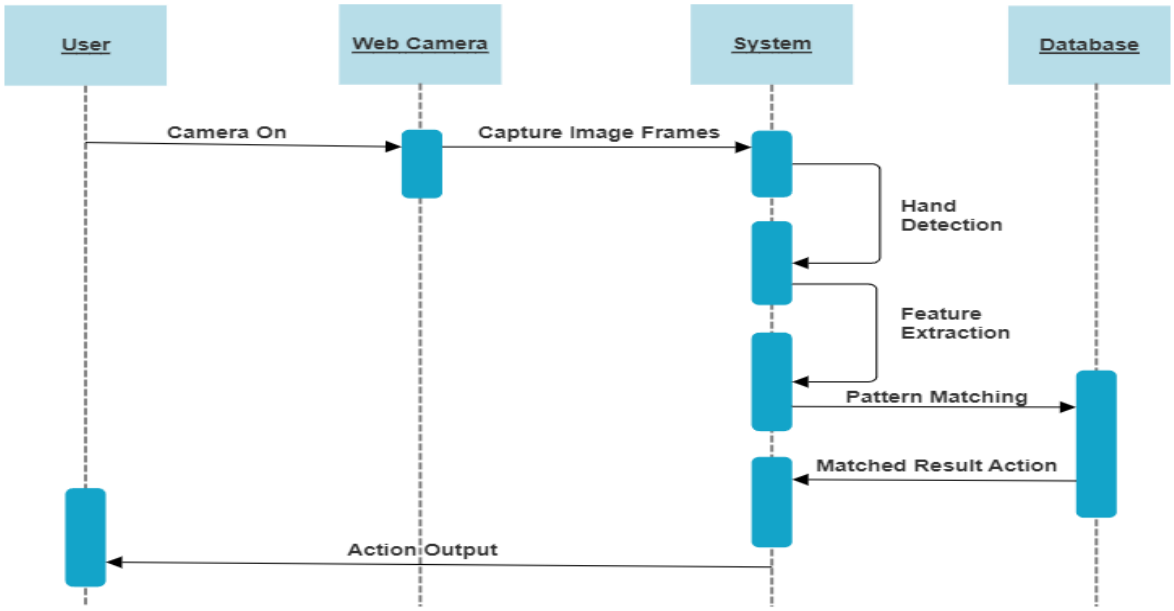

Figure 4: Sequence Diagram

3.2.4 State Chart Diagram

A state machine that depicts class behaviour is described by a state chart machine. By simulating the life cycle of each class of object, it represents the dynamic beviour of objects across time and displays the actual state changes rather than the processes or commands that cause those changes. It explains the transition of an object between two states.

There are many components in hand gesture based virtual mouse and calculator as shown in **figure 5.** The process begins with the start state and next the camera on state represents that the system is ready to capture the hand movements and detects the hand landmarks. The system analyses the landmarks to classify and selects the specific action and the system translates the recognized gesture into corresponding virtual mouse movements or calculator actions. Then the system recognizes the specific hand gesture and executes the corresponding action and the process ends with the end state.

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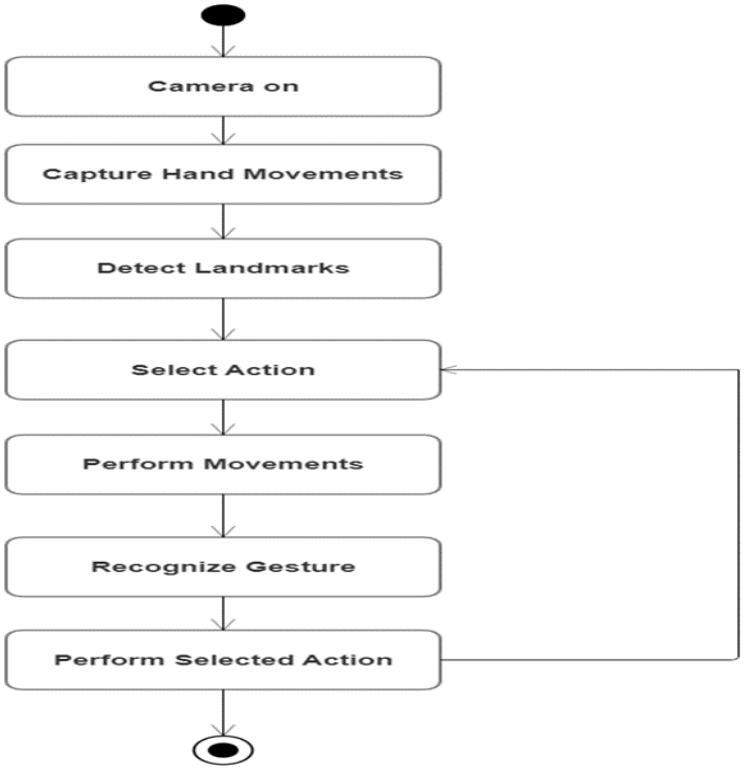

Figure 5: State Chart Diagram

3.2.5 Activity Diagram

The way the user's data will flow is depicted in the activity diagram, also called control flow. Based on the user's desired action, the diagram below illustrates how the input from the user will be transformed into the output. The choices the system will make in order to produce the intended results are depicted in the diagram.

The activity diagram for hand gesture based virtual mouse and calculator shown in **Figure 6,** illustrates flow of activities involved in the system's operation. The process starts with the start state and then the web camera input captures the video frames and processes the image by improving the accuracy and adding the filters. Based on the points on the hand the landmarks are detected and classifies as left or right hand. Based on the particular hand landmark the gesture interpretation i.e., identification of gesture is done. Then the interpreted gesture is translated into corresponding Virtual Mouse and Calculator operation and the action is executed and the process ends with the stop state.

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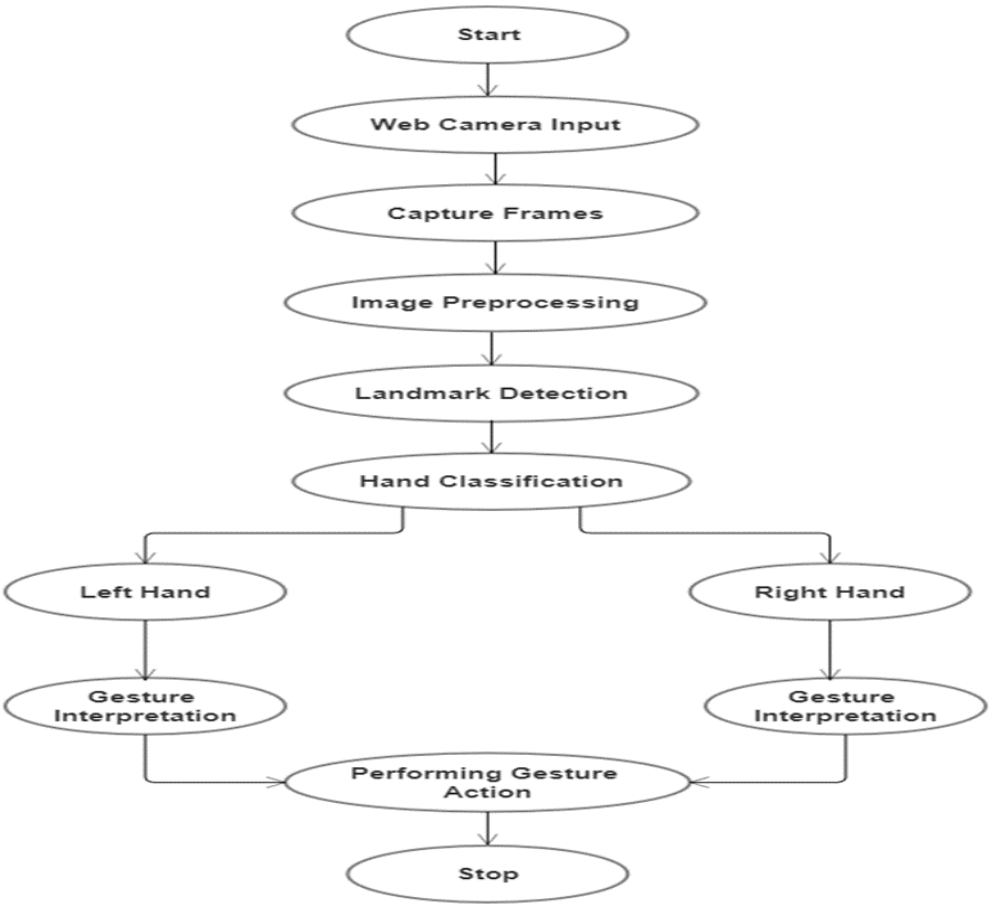

Figure 6: Activity Diagram

3.2.6 ER Diagram

A database's entities and their relationships are represented graphically in an Entity-Relationship diagram. They provide a visual representation of the entities, attributes, and relationships that make up the database, helping both designers and stakeholders to understand the structure and behavior of the data. The diagrams help to identify the key entities, their attributes, and the relationships between them, facilitating the normalization process to ensure data integrity and reduce redundancy.

As shown in **Figure 7,** the central entities include the user, represented by attributes such as username and program, interacting with the system by providing the user input. The system itself is another entity, encapsulating all its functionalities. The frames which are captured by webcam contains hand landmarks, which are detected and processed by the system for gesture recognition. The recognized gestures are then associated with specific actions, such as controlling a Virtual mouse or Virtual Calculator.

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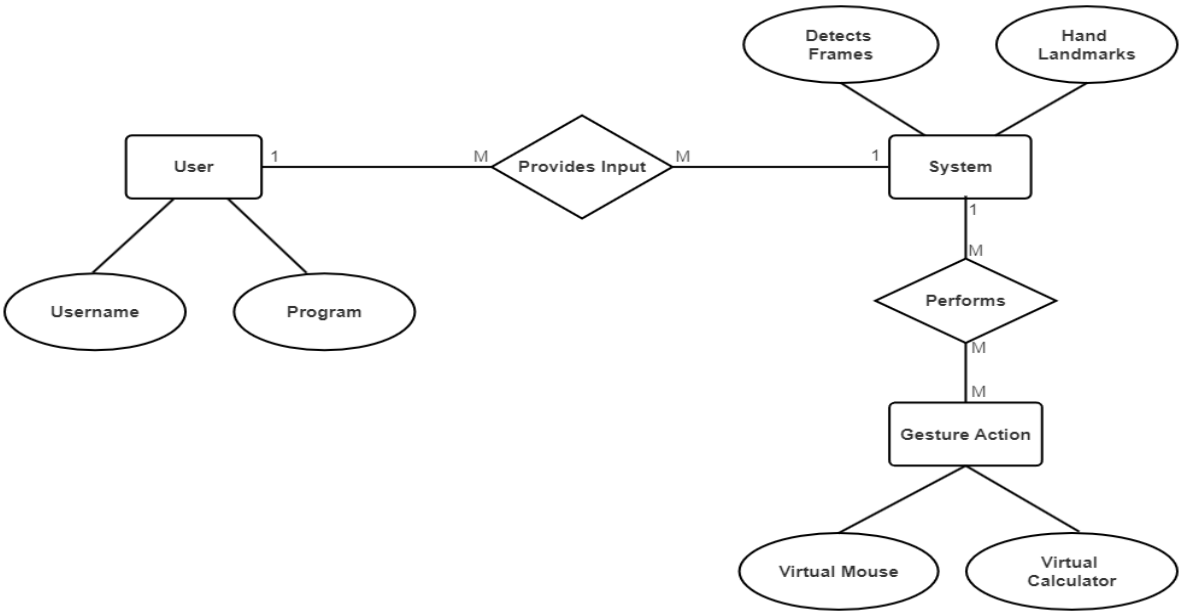

Figure 7: Entity Relationship Diagram

4. SYSTEM IMPLEMENTATION

The implementation of various functionalities using different hand gestures involves a combination of computer vision, gesture recognition and system control. The gesture recognition is done by analyzing the hand landmarks to recognize various gestures used for different tasks like left-click, right-click, double-click, steady cursor, volume and brightness control, zooming, scrolling.

The video capture object from 'cv2.VideoCapture' class is used to capture information from webcam. Then, MediaPipe processes frames and hand landmarks are detected. The outline is drawn using the drawing utility functions once the gesture is identified. The frames which are processed are then converted to RGB. Based on the distance between the fingertips and specified coordinates of hand landmarks, different operations are performed. According to the program, if the distance between the index finger and middle finger tips is zero then operation 'double-click' will be performed. If all the landmarks are in a way as shown in the MediaPipe hand landmarks then cursor movement will be freeze. Many other mouse functionalities which are listed earlier can also be implemented virtually using hand gestures.

A virtual calculator using hand gestures is a user-friendly and innovative technology that enables individuals to perform mathematical calculations through hand movements. The program uses libraries like OpenCV for hand gesture detection and scikit-learn for machine learning. It uses scikit-image and numpy to process the captured frames for hand detection. It converts the frame to grayscale, apply thresholding, and use contours to identify the hand. The system uses a web camera as its primary input source which detects and interprets specific gestures made by the user, translating them into corresponding calculator inputs. Users can simply manipulate the air around them to input numbers and operators, creating a seamless calculator experience that enhances accessibility and ease of use.

5. OUTPUT

The fingertips points are considered for recognition of the gesture. By detecting which finger is up using the tip id of the respective finger using the media pipe and respective coordinates of the fingers that are up, the gesture is recognized and the mouse operation is performed.

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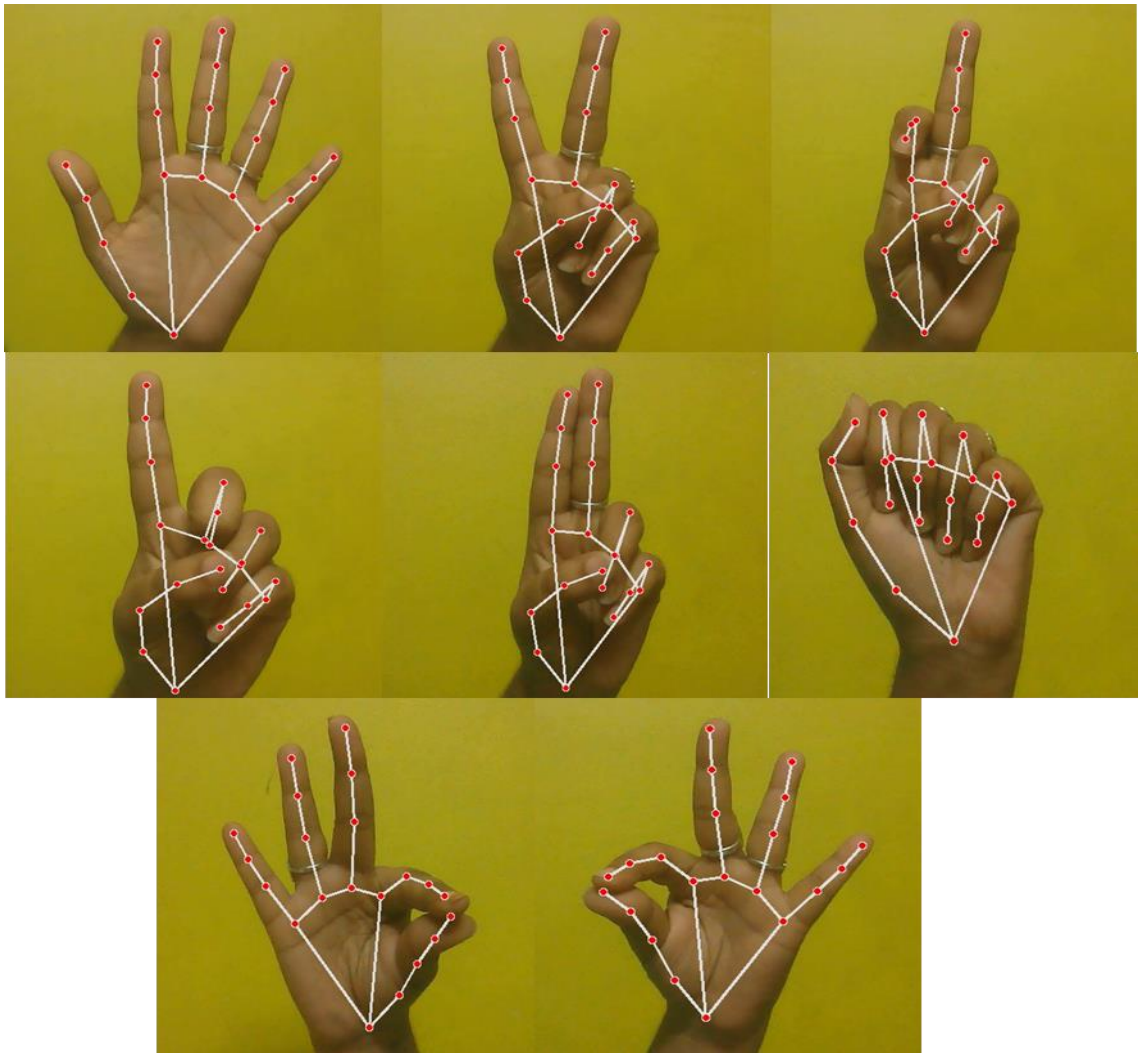

Figure 8: Hand gestures for Virtual Mouse Operations

The gestures for Virtual Mouse operations which are shown in figure 8 are:
Cursor movement, no movement, Right click, Left click, Drag and drop or Multiple items selection, Double click, Volume and brightness control, Scroll or Zoom control.
The basic arithmetic operations that can be performed using free hand gestures is shown in figure 9:

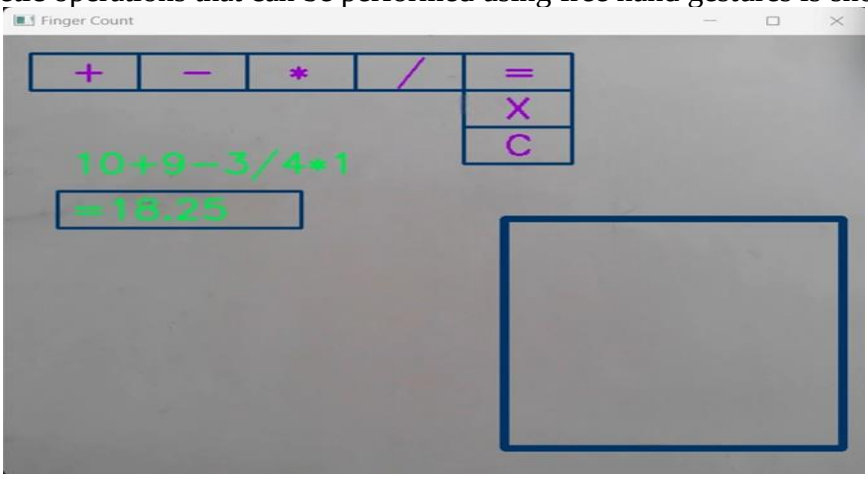

Figure 9: The calculator Operation

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The hand gesture-based virtual mouse redefines the conventional mouse-input paradigm, offering a touchless and dynamic alternative. This innovative system improves the power of computer vision which enables the users to handle the devices through hand gestures by eliminating the need for a physical device like a mouse. This can be achieved by the help of an in-built webcam that processes a live video feed and recognizes the hand gesture to execute a specific mouse function. This offers increased accessibility and convenience for individuals with mobility challenges or those who prefer hands free computing experience. This technology is used for various applications like gaming, multimedia control, presentations and virtual reality etc. Similarly, the hand gesture-based virtual calculator introduces a novel approach to perform mathematical operations. By recognizing and interpreting predefined hand gestures, users can effortlessly navigate a virtual calculator interface without the need for physical buttons or touchscreens. It provides greater flexibility, easier to adapt and less prone to physical damage. The numbers are recognized based on the gestures and a cursor point is used to select operators and result. Based on the gesture recognized, the corresponding arithmetic calculation can be done. This project introduces the development of hand gestures based virtual mouse and calculator which showcase the potential interaction with digital devices.

6.2 Future Scope

The need of additional hardware devices is reduced by a virtual mouse and calculator that use hand movements to minimize workspace. Because it enables users to virtually operate their computer wuth hand moovements, it might also be helpful for those who would rather work witthout being connected to a physical device. The Virtual Calculator promises potential advancements and applications that could significantly impact various fields. As technology continues to advance, the future of a virtual calculator based on hand gestures holds exciting possibilities, making computing more immersive, interactive, and seamlessly integrated into our daily lives. It can evolve to meet the evolving needs of users, offering a more intuitive experience. As we move towards a future of more inclusive and accessible technology, hand gesture interfaces offer a bridge between users and machines, breaking barriers and providing a seamless computing experience for individuals of all abilities.

Acknowledgement

We would like to express our sincere gratitude to all those who contributed to the successful completion of this project. We are especially thankful for the unwavering support received from our project guide throughout the project. Their feedback and mentorship played a crucial role in shaping the success of our project.

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