

Air Canvas: A Gesture-Controlled Interactive Digital Drawing Board

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Abstract—Air Canvas is a digital drawing system that utilizes computer vision and hand tracking to facilitate natural air gestures for manipulating virtual brushes. By employing OpenCV and MediaPipe, this system achieves real-time hand detection and tracking, converting hand gestures into digital sketching.

The system comprises the HandTracker class, which analyzes video input with a confidence threshold of 0.8 to provide hand landmarks and gesture detection. It also includes an application interface that supports various features such as freehand drawing, shape creation, color selection, brush size adjustment, and an eraser tool. These features are available on a canvas with dimensions of 1280x720 pixels. The state machine pattern is responsible for controlling the visibility of the user interface.

Air Canvas improves digital engagement by enabling users to easily become proficient in gesture-based drawing. This work enhances the field of human-computer interaction by demonstrating the actual application of gesture recognition technology. It aims to improve accessibility for those with restricted mobility and provide artists with a more intuitive drawing experience.

Index Terms—HandTracker, ColorRect, OpenCV, MediaPipe, Numpy, Hand Detection, Landmark Detection, Computer vision, detectionCon, trackCon, Air Canvas, maxHand, findHands, Color selection, Brush size selector, Eraser tool, Gesture recognition, Human-computer Interaction (HCI), Digital drawing board.

I. INTRODUCTION

The advancement of Human-Computer Interaction (HCI) has enabled the creation of intricate and significant interactions within digital platforms.

Gesture-based interfaces are a crucial advancement in response to the increasing need for technology to provide users with natural and captivating methods of interaction. This paper introduces “Air Canvas”, an interactive digital drawing board that utilizes gesture-based controls. Users can create and interact with a virtual canvas using hand gestures, enhancing their creative experience.

Air Canvas utilizes cutting-edge technology, such as the MediaPipe framework and OpenCV, to achieve real-time hand tracking and gesture detection.

The ‘HandTracker’ class, implemented in the submodule, offers a standardized interface for performing fundamental actions managed by this system. It utilizes hand landmark detection from the MediaPipe library to identify and process hand-related motions. Primitive configuration parameter settings (referred to as ‘detectionCon’ or ‘trackCon’) are used to optimize the process of detection and tracking.

The ‘findHands’ function analyzes the video input to identify and exhibit hand landmarks, while the functions ‘getPosition’ and ‘getUpFingers’ interpret these landmarks into motions such as pointing, pinching, or swiping. Air Canvas optimizes the capabilities of these attributes by providing interactive widgets using the ‘ColorRect’ class. This class creates on-screen buttons that allow users to select brush sizes, colors, and shapes, as well as an eraser tool. This paper provides a detailed explanation of the precise steps involved in managing the display and user interaction on a virtual canvas. It utilizes OpenCV techniques, including the use of ‘cv2.circle’, ‘cv2.line’, and ‘cv2.addWeighted’ functions. The program also includes an improved cooling mechanism to provide a gradual and seamless transition between tools, leading to a more organic and effortless tool switching experience.

Air Canvas addresses fundamental challenges in gesture-based interfaces, such as accurately tracking hand movements and promptly analyzing intricate gestural data. This product is highly versatile and adaptable, making it suitable for seamless integration into various sectors such as digital art, education, and interactive media. This paper offers a thorough examination of the organization, techniques, and delivery of the Air Canvas framework. The testing results offer empirical proof of the system’s effectiveness and usefulness.

The purpose of developing Air Canvas was to expand the field of natural user interfaces, allowing for more engaging and intuitive digital interactions that inspire creativity in both users and artists.

A. Problem Statement

The field of Human-Computer Interaction (HCI) has seen a growing need for interfaces that do not require physical contact and are easy to use, in order to improve accessibility and user experience. Current input modalities such as mouse, keyboard, and touchscreen are functional but can hinder the ability to have intuitive and expressive interactions with people. In order to do this, a system with the ability to analyze all aspects of intricate hand movements in real-time is necessary. This system would enable individuals to engage with digital environments in a manner that closely resembles their interactions in the physical world. The objective of this project is to tackle these concerns by developing a gesture-controlled interactive digital drawing board called “Air Canvas”. This innovative device incorporates state-of-the-art hand tracking and gesture recognition technologies, resulting in a more intuitive and captivating creative experience.

II. RELATED WORK

A. Figures and Tables

Virtual Air Board using Python

Abhishek Kumar, Aman Kumar Jha, Amrit Shandilya, Saurav Kumar Dubey, and Chaitra undertook a literature survey to gather information for their project titled “Virtual Air Board using Python”. They utilized the research conducted by Mingyu Chen et al. on air-writing recognition and Ivan Culjak’s introduction to OpenCV to establish the fundamental principles of character recognition and image processing. The authors utilized the knowledge and expertise of Gloria Bueno García in image processing with OpenCV, Joolekha Bibi Joolee’s study on brush tip tracking, and Benjamin Bach’s work on augmented reality to improve the functionality and interaction of their virtual drawing tool.

Virtual Air Board

The research paper titled “Virtual Air Board” by Manish Kumar et al. presents a novel virtual whiteboard system designed to enhance engagement in online lectures and meetings. The system employs computer vision techniques, specifically OpenCV and MediaPipe, to enable users to create drawings in the air using their fingertips, which are equipped with vibrant markers or caps, so eliminating the requirement for conventional writing instruments. The system utilizes real-time hand motion tracking, allowing users to effortlessly generate digital artwork, choose shapes and colors, and employ an eraser tool. The design prioritizes the monitoring of hand coordinates to provide a smooth drawing experience, demonstrating the ability to greatly enhance collaboration in digital contexts.

Air Doodle: A Realtime Virtual Drawing Tool

The researchers, Soham Pardeshi, Madhuvanti Apar, Chaitanya Khot, and Atharv Deshmukh, created a system called “Air Doodle: A Realtime Virtual Drawing Tool” that enables users to make drawings in the air using hand gestures. The system captures these movements and instantly displays them on a digital canvas. The author’s primary objective was to develop a user-friendly interface that utilizes computer vision techniques to recognize and track hand motions. They utilized image processing methods to assure precise identification of hand gestures, facilitating seamless and accurate drawing experiences. The device is engineered to be very responsive,

offering instantaneous feedback as users draw in the air. This makes it a practical instrument for creative expression and interactive applications.

Real Time Hand Gesture and Painting using Computer Vision

The research article titled “Real Time Hand Gesture and Painting Using Computer Vision” authored by Prof. Prajakta Kuchewar and colleagues investigates the application of OpenCV and MediaPipe in developing a system that enables painting through hand gestures on a virtual canvas. The device improves communication for those with hearing problems and decreases paper consumption. The authors emphasize the necessity for progress in handwriting recognition and fingertip detection, suggesting an innovative interface that merges artistic expression with technology.

AirCanvas

The work titled “AirCanvas” by Harshada Chaudhari et al. introduces an air writing system that use computer vision techniques to enable users to create drawings in the air using a colored marker. The system employs OpenCV to monitor the motion of markers and translate finger movements into digital drawings. This is achieved by analyzing real-time webcam images in the HSV color space. The main characteristics of this technology include the ability to identify and outline shapes, as well as the capability to create lines. This has the potential to be used in smart wearable devices, with the goal of improving the way users interact with digital surroundings.

Virtual Painter Using Artificial Intelligence and OpenCV

Prof. Mrs. Nethravati T L and her student’s work “Virtual Painter Using Artificial Intelligence and OpenCV” describes an application that tracks hand movements and lets users sketch on a screen with finger gestures. The system recognizes hand landmarks using Python, OpenCV, and MediaPipe, allowing the user to sketch with the index finger and pick options with both the middle and index fingers. With customizable colors and an eraser, this interactive, real-time tool provides a simple drawing interface. The research showcases a useful application of human-computer interaction, and future improvements could include speech synthesis and text recognition for visually challenged people.

Virtual Sketch using OpenCV

Pranavi Srungavarapu and her co-authors reference the research conducted by Guennouni et al. and Chandan et al., which investigate the use of OpenCV for object identification and tracking. This is a critical component for their virtual sketching project. Druzhkov et al. and Guravv’s findings on gesture recognition, together with Culjak et al.’s analysis of OpenCV, provide evidence for the utilization of these technologies in the development of an interactive sketching tool that responds to finger movements.

Virtual Pen Using Python

A software system for employing hand movements to draw in 3D space is described in the paper “Virtual Pen Using Python” by Puja A. Chavan and coworkers. For hand identification and tracking, it makes use of Python libraries like OpenCV, Mediapipe, and NumPy. This enables users to create shapes and free-hand sketches in the air, which are then projected on a virtual canvas. The goal of this technology is to improve accessibility for both regular users and digital artists by replacing pricey drawing tablets. Using a webcam to record hand movements, the system interprets gestures to carry out artistic activities. To promote user involvement, future upgrades will include features like customizable brush widths and stroke erasers.

Digitized Interaction: A Gesture-Controlled Whiteboard System with OpenCV, MediaPipe and NumPy

A method for employing hand gestures to operate a digital whiteboard is presented in the paper “Digitized Interaction: A Gesture-Controlled Whiteboard System with OpenCV, MediaPipe and NumPy” by Singh et al. To enable interaction without physical contact, the system tracks and recognizes hand motions using the OpenCV, MediaPipe, and NumPy libraries. The main goal is to improve user experience in professional and educational environments by providing smooth writing and drawing through natural motions. Gestures are recognized by the system through video input, and it converts them into commands for the whiteboard interface. The authors emphasize how it could change how whiteboards are used traditionally by providing a cleaner, more participatory option.

Computer Vision Based Virtual Sketch Using Detection

The development of a virtual sketching system utilizing OpenCV, MediaPipe, and NumPy for hand gesture identification is explored in the paper “Computer Vision Based Virtual Sketch Using Detection” by Santosh Dhaigude et al. This device recognizes human hand and finger gestures to draw on a digital canvas, increasing

the interactive nature of instructional films and improving online learning during the epidemic. It overcomes the drawbacks of conventional art by enhancing human-computer connection with machine learning algorithms in place of tangible tools. The system's prospective uses include instructional tools and gesture-controlled robotics. It is made to be both affordable and user-friendly. The authors stress how it has the ability to change both digital art techniques and conventional instructional approaches.

III. METHODOLOGY

A. Hand Tracking

The Air Canvas system is centered around the HandTracker class, which utilizes Mediapipe for effective hand tracking. This class initializes Mediapipe's hand detection and tracking modules, configuring parameters such as mode, maxHands, detectionCon, and trackCon. These parameters govern the static image mode, the maximum number of hands to detect, and the thresholds for minimum detection and tracking confidence.

The findHands method processes each video frame to identify and visualize hand landmarks [10]. It converts the frame to RGB format and employs Mediapipe's capabilities for processing [4]. If the draw parameter is set to True, the detected landmarks are rendered using OpenCV's drawing functions.

B. Gesture Recognition

Gesture recognition is accomplished by examining the spatial arrangements of hand landmarks. The getPosition method retrieves the (x,y) coordinates of each landmark and returns a list containing these positions. This functionality is essential for recognizing specific gestures based on the relative positions of the hand landmarks.[4][5]

The getUpFingers method identifies which fingers are raised by analyzing the positions of key landmarks. For example, an extended index finger is recognized if the y-coordinate of its tip is lower than that of the middle knuckle.[6] This binary representation (up or down) for each finger is collected in a list [9], which is subsequently utilized to interpret various gestures.

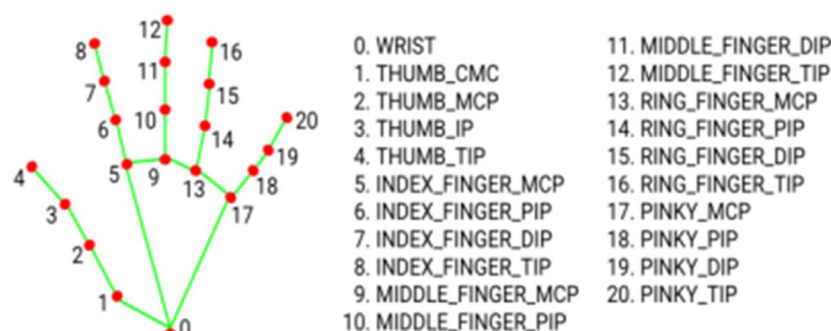


Figure 1. Hand landmark

C. Interface Design and Drawing Implementation

The interface includes interactive elements that are developed using the ColorRect class. This class facilitates the creation of colored buttons and tools on the interface, each with unique capabilities such as altering the brush color, size and selecting drawing shapes [2].

The main function of the system is to do drawing tasks in real-time, where the movements of the hand control the activities of drawing on a canvas.[7] The system classifies different tools such as a brush, eraser and shapes (square, circle, triangle) by examining the recognized gestures and positions of the landmarks [9].

The interface features interactive elements, such a color palette, brush size selectors, and form buttons, allowing users to easily switch between different tools and customize their sketching experience. These elements respond to hand movements, providing a dynamic and flexible interface.

D. System Integration

To ensure a seamless user experience, it is crucial to integrate hand tracking, gesture detection, and interface design into a cohesive system.

The real-time processing loop receives video frames, analyzes hand landmarks, detects motions, refreshes the interface, and executes drawing commands with negligible delay.[8] This link is established by utilizing efficient coding methodologies and leveraging the functionalities of OpenCV and Mediapipe [1].

The Air Canvas project demonstrates the potential of gesture-controlled digital drawing systems by combining advanced computer vision algorithms with a user-friendly interface [7]. The robust hand tracking and gesture recognition capabilities ensure accurate and immediate interaction, making it an essential tool for both professional creatives and enthusiasts.

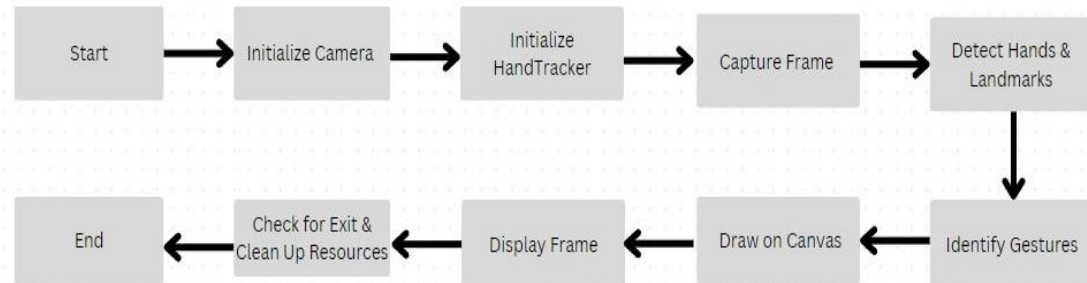


Figure 2. System Block Diagram

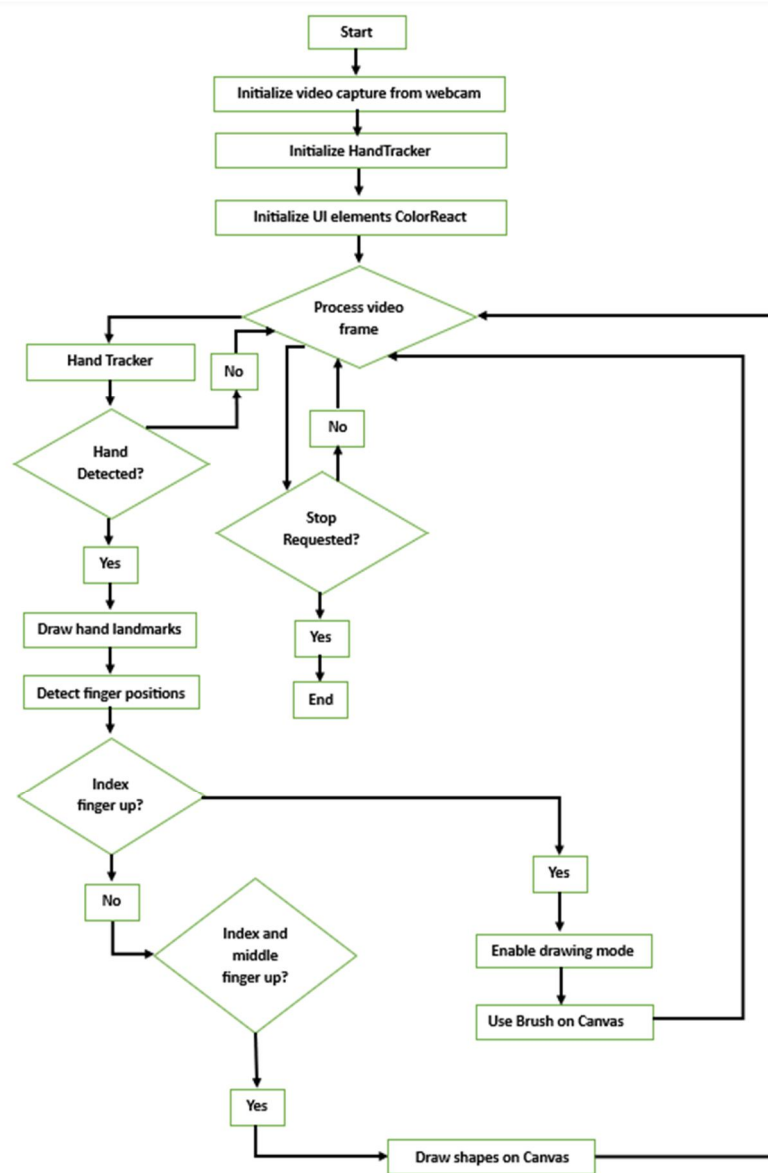


Figure 3. Flow Chart explaining the complete function of project

IV. RESULT RECEIVED

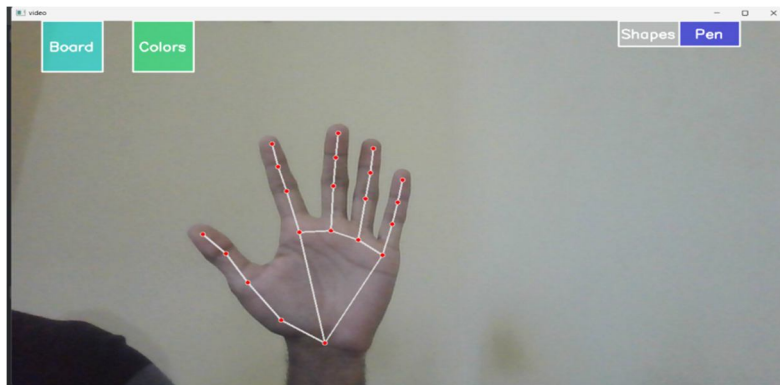


Figure 4. Hand Detection on Digital Canvas

When the code is executed, Figure 4 showcases the activation of the digital canvas and the precise detection of the hand within the camera frame using Mediapipe. The technique utilizes a system to detect and monitor particular locations on the hand, establishing links for the goal of generating visual representations. This enables accurate gesture-driven sketching and effortless tool selection on the canvas.

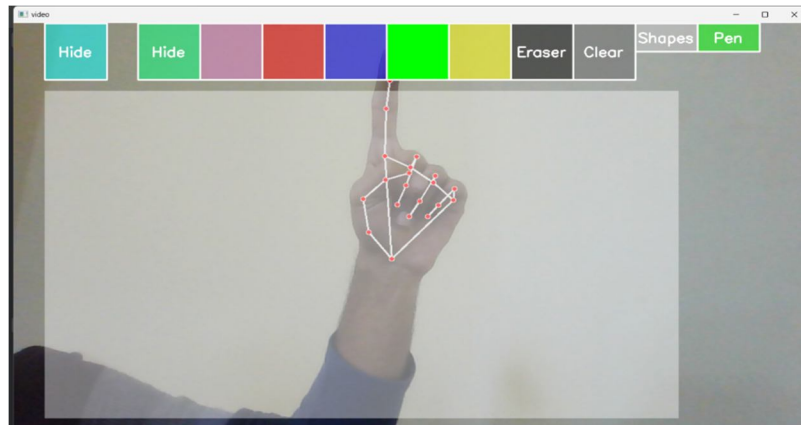


Figure 5. Color Selection using Index Finger

Figure 5 demonstrates that the index finger is used to choose a color from the currently accessible palette. Colors are selected by positioning the index finger above the color rectangles. The code includes the colors red, blue, green and yellow as well as a feature for selecting a color at random.



Figure 6. Drawing Lines with Selected Colors

Figure 6 illustrates five lines on the canvas, with each line representing one of the specified colors: red, blue, green, yellow, and a color chosen randomly. The lines are created by gliding the index finger smoothly across the canvas after choosing the preferred hue.

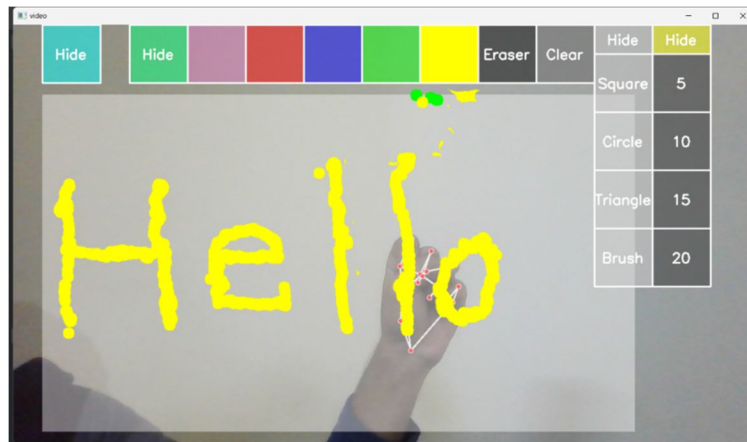


Figure 7. Writing 'Hello' with Brush Mode in Yellow

To choose the 'Brush' option, simply click on it in the shapes dropdown menu depicted in Figure 7. The term "Hello" is rendered in a yellow hue utilizing a brush with a magnitude of 20, selected from the assortment of choices for pen size. To conceal the shape and pen size choices, just click the 'Hide' button once you have made your selection.

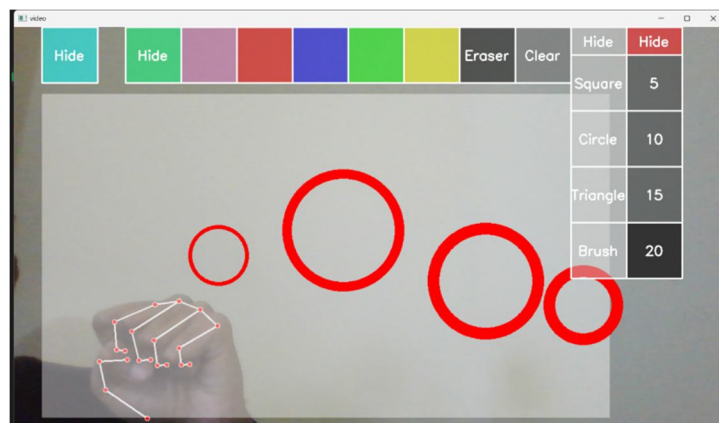


Figure 8. Drawing Circles in Red with Varying Sizes

Figure 8 illustrates the selection of the circle option from the shapes menu, which leads to the creation of four red circles of different sizes: 5, 10, 15 and 20. This showcases the ability to modify the measurements of a shape according to user input.

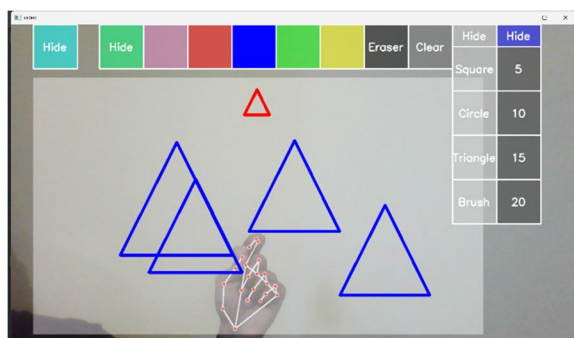


Figure 9. Drawing Triangles in Blue

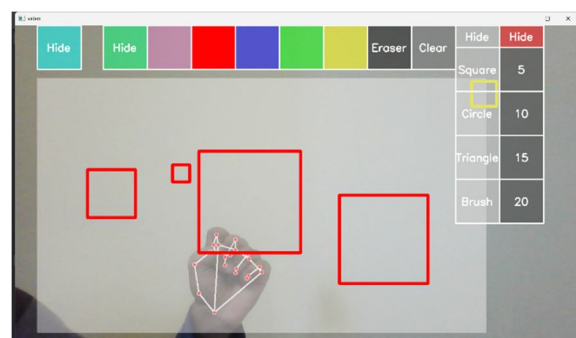


Figure 10. Drawing Squares in Red

Figure 9 illustrates the choice of the triangle option from the shapes menu, leading to the creation of many blue triangles. This emphasizes the practical capabilities of the triangle sketching tool. Figure 10 demonstrates the utilization of the square function from the shape's menu, exhibiting several red squares. This demonstrates the capacity to create square forms.

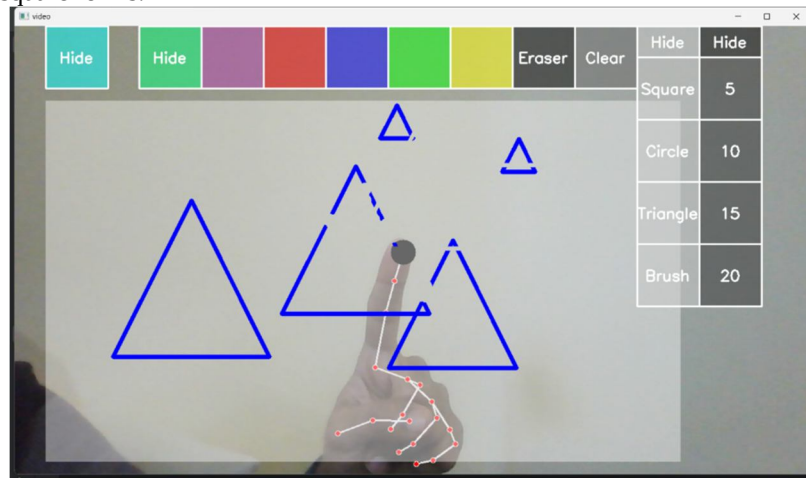


Figure 11. Erasing Shapes Using the Eraser Tool

The eraser button depicted in Figure 11 serves the purpose of eliminating triangles that have been formed earlier. The eraser's dimensions can be modified by adjusting the pen size settings, enabling accurate elimination of specified sections on the canvas.

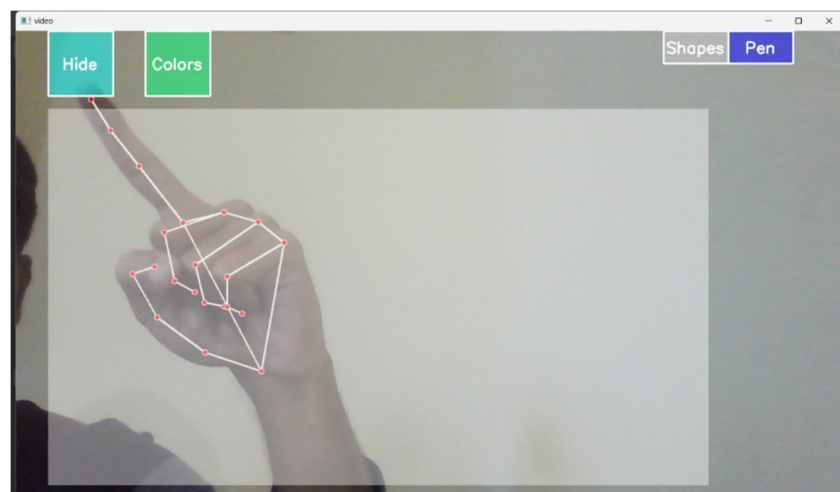


Figure 12. Clearing the Canvas

Figure 12 illustrates the process of eliminating content from the canvas by employing the eraser and clean buttons. The board has been reset and the 'Hide' button, located in the top left corner, is now visible. This button allows the hiding of the drawing board, demonstrating the capabilities of the digital canvas's cleanup and concealment features.

V. CONCLUSION

The Air Canvas design seamlessly integrates hand tracking technologies with a digital sketching interface. The system utilizes Mediapipe and OpenCV to facilitate precise hand recognition and tracking of key points, allowing for seamless and gesture-driven interactions on a digital surface. Users may effortlessly select colors, draw shapes, and eliminate items with straightforward hand movements, resulting in an exceptionally intuitive and user-friendly interface.

The results demonstrate the system's proficiency in accurately reading hand gestures to produce precise sketching and seamless tool selection. The inclusion of various forms, sizes, as well as the eraser and clear functions significantly enhance the canvas's functionality and adaptability. This project demonstrates the potential of gesture-controlled technology in the field of digital art and design, offering an interactive and innovative approach to user interaction.

VI. FUTURE SCOPE

The future progression of the Air Canvas project offers a multitude of encouraging opportunities for growth and enhancement. A possible improvement may be the incorporation of a virtual keyboard feature, which would enable text entry using hand movements, thus simplifying tasks like typing and manipulating text using gesture-based shortcuts. In addition, expanding the application to become a comprehensive digital painting platform would provide artists and designers with a wide range of sophisticated tools, such as dynamic brush settings, layer management, and customized color palettes. It would also include functionality for importing and exporting artwork. By integrating features like real-time collaboration, annotation capabilities, and interactive lesson modules, converting Air Canvas into an interactive learning tool has the potential to revolutionize remote teaching in the educational sector. Furthermore, improving the accuracy and effectiveness of gesture recognition can be achieved by implementing individualized gesture training, incorporating multi-gesture capabilities, and allowing for sensitivity changes. These enhancements would result in more precise and interactive user experiences. Investigating the fusion of augmented reality (AR) and virtual reality (VR) technologies has the potential to generate captivating settings for drawing and design. This would allow users to engage with virtual canvases and take part in interactive seminars. Enhancing the platform's interoperability to encompass mobile applications, interaction with cloud services, and access through web-based interfaces will augment its accessibility and flexibility. Utilizing artificial intelligence could augment the system by incorporating intelligent functionalities such as AI-assisted sketching, style transformation, and content identification. Ultimately, the establishment of a user community may greatly improve user involvement and promote the interchange of creative ideas by implementing features such as profile creation, online galleries, social sharing, and collaborative challenges. These developments have the potential to transform Air Canvas into a versatile tool for artistic expression, instructional innovation, and collaborative interaction.

REFERENCES

- [1] A. Kumar, A. K. Jha, A. Shandilya, S. K. Dubey, and C. A, "Virtual Air Board Using Python," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 5, no. 5, pp. 3110, May 2023, doi: 10.56726/IRJMETS39154
- [2] M. Kumar, S. Samanta, S. Naik, and N. Bhaskar, "Virtual Air Board," *The International Journal of Analytical and Experimental Modal Analysis*, vol. 15, pp. 906-908, Mar. 2023 , ISSN: 0886-9367.
- [3] S. Pardeshi, M. Apar, C. Khot, and A. Deshmukh, "Air Doodle: A Realtime Virtual Drawing Tool," *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 10, no. IV, pp. 160-165, Apr. 2022, doi: 10.22214/ijraset.2022.40919
- [4] P. Kuchewar, D. Asole, K. Tiwari, M. Kumbhare, S. Panchal, S. Kite, A. Sukhadeve, and L. Lonare, "Real Time Hand Gesture and Painting Using Computer Vision," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 5, no. 12, pp. 361, Dec. 2023, doi: 10.56726/IRJMETS47045.
- [5] H. Chaudhari, P. Khevalkar, A. Shirke, S. Halde, and N. Choudhary, "AirCanvas," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 4, no. 6, pp. 5608-5610, Jun. 2022 , doi: 10.56726/IRJMETS47045.
- [6] N. T. L., R. L. Patil, S. Bhavana, S. R. Choudhury, and M. S., "Virtual Painter Using Artificial Intelligence and OpenCV," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 4, no. 1, pp. 1614-1617, Jan. 2022.
- [7] P. Srungavarapu, E. P. Maganti, S. Sakhamuri, S. P. K. Veerada, and A. Chinta, "Virtual Sketch Using Open CV," *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, vol. 10, no. 8, pp. 107-108 ,Jun. 2021, ISSN: 2278-3075
- [8] P. A. Chavan (Cholke), A. Shilimkar, S. Sheth, P. Shevale, A. Shikalkar, S. Shewale, and S. Shimare, "Virtual Pen Using Python," *NeuroQuantology*, vol. 20, no. 19, pp. 1010-1012, Nov. 2022, doi: 10.48047/nq.2022.20.19.NQ99092.
- [9] S. Singh, H. Shukla, K. Sharma, H. Tyagi, and J. Prasad, "Digitized Interaction: A Gesture-Controlled Whiteboard System with OpenCV, MediaPipe, and NumPy," *IPEC Journal of Science & Technology*, vol. 2, no. 1, pp. 43-49, Jun. 2023, ISSN: 2583-3286.

- [10] S. Dhaigude, S. Bansode, S. Waghmare, S. Varkhad, and S. Suryawanshi, "Computer Vision Based Virtual Sketch Using Detection," *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 10, no. I, pp. 264-268, Jan. 2022, ISSN: 2321-9653.
- [11] Suresh, A. "Air Canvas: Expressing Creativity in the Real World with OpenCV and Python." *2023 International Conference on Energy, Materials and Communication Engineering (ICEMCE)*. IEEE, 2023.
- [12] Singh, Khyati, Nikita Punia, and K. R. Seeja. "Innovations in Air Writing: Redefining Digital Canvases." *Nikita and Seeja, KR Seeja, Innovations in Air Writing: Redefining Digital Canvases (June 3, 2024) (2024)*.
- [13] Gulati, Shaurya, et al. "Paint/Writing Application through WebCam using MediaPipe and OpenCV." *2022 2nd International Conference on Innovative Practices in Technology and Management (ICIPTM)*. Vol. 2. IEEE, 2022.
- [14] Tiwari, Satyam V., Deep A. Vartak, and Ms Soniya Khatu. "Virtual Hand Gesture Painting."
- [15] Mall, Jyotsana, Komal Rani, and Deepak Khatri. "Air Writing: Tracking and Tracing." *Computer Vision and Image Processing: 5th International Conference, CVIP 2020, Prayagraj, India, December 4-6, 2020, Revised Selected Papers, Part III 5*. Springer Singapore, 2021.
- [16] Singh, Swapna, et al. "Digitized Interaction: A Gesture-Controlled Whiteboard System with OpenCV, MediaPipe and NumPy." *IPEC*. Vol. 2. 2023.
- [17] Ali, Sami Haj, and Hüseyin Aygün. "Shape Detection Using Air-Drawing." *2023 11th International Symposium on Digital Forensics and Security (ISDFS)*. IEEE, 2023.
- [18] J. Patel, S. Singh, R. Bansal, R. Saxena and P. Mazumdar, "Virtual Board: A Digital Writing Platform for Effective Teaching-Learning," *2022 IEEE 6th Conference on Information and Communication Technology (CICT)*, Gwalior, India, 2022, pp. 1-5, doi:10.1109/CICT56698.2022.9997986.