Smart Canvas: Redefining Digital Workspaces with Intelligent Recognition and Creative Tools

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Abstract— *Have you ever dreamed of bringing your thoughts to life by simply waving your fingers in the air?*

As technology rapidly evolves, we see a transformation across all sectors. With the rise of intelligent devices, human gestures can now seamlessly interact with digital systems. One of the most exciting and challenging frontiers in image processing and pattern recognition is the ability to "write" mid-air!

This paper presents the Smart Canvas, a cutting-edge real-time platform that harnesses advanced fingertip and hand-tracking technologies to enable intuitive, gesture-based digital interactions. Users can freely draw in the air, recognize hand gestures, and execute tasks ranging from alphabet and number recognition to shape identification and hand-based calculations via an integrated virtual calculator. The system also supports character recognition for English as well as Devanagari script. Additionally, it features a powerful translation capability, allowing users to translate text seamlessly between English to Hindi/Marathi. Moreover, Text-to-Speech (TTS) feature transforms recognized text into audible speech, significantly improving accessibility and enriching the user experience.

By utilizing continuous video-based fingertip tracking alongside sophisticated machine learning algorithms, our system achieves remarkable accuracy and efficiency in recognizing multilingual scripts, geometric shapes, and fundamental computational tasks.

This innovative approach significantly reduces processing time and offers a versatile platform suitable for applications in education, accessibility, creative design, and interactive systems. Our findings highlight the system's potential to revolutionize traditional input methods, providing a dynamic, gesture-driven alternative that caters to diverse user needs while enhancing interaction efficiency.

Keywords— *Smart Canvas, Gesture-Based Interaction, Human-Computer Interaction, Gesture Recognition, Machine Learning, Character Recognition, OpenCV, Mediapipe, Devanagari Script Recognition, Multilingual Translation, Virtual Calculator, Real-Time Processing, Digital Art, Intuitive User Interface, Hand Tracking, Pattern Recognition, Educational Technology, Accessibility Solutions, Interactive Design.*

I. Introduction

Imagine a world where the act of creating or interacting with digital content requires nothing more than the movement of your hand in the air. The Smart Canvas project brings this vision to life by allowing users to write, draw, and perform tasks like calculations, all through intuitive hand gestures. This hands-free system removes the barriers of traditional input devices such as keyboards and styluses, offering an innovative solution for digital interaction that is as simple and natural as human motion itself.

At the heart of Smart Canvas lies the integration of powerful computer vision tools, which track and interpret hand movements in real time. The system supports a wide range of functionalities, from alphabet and number recognition to the identification of shapes and even the processing of English & Devanagari words and characters. Users can perform calculations using an interactive virtual calculator, translate words from English to Hindi/Marathi alongside having a text-to-speech feature which, all while maintaining a seamless, gesture-based interface.

Beyond its technological innovation, Smart Canvas addresses significant social and environmental challenges. The system provides an accessible communication platform and reduces reliance on paper, contributing to a more sustainable approach to digital interaction. By offering a safer alternative to the overuse of smartphones, Smart Canvas presents a creative and practical solution for everyday tasks across various fields, including education, art, and accessibility.

This paper details the development, technical implementation, and capabilities of the Smart Canvas system. It highlights its potential to reshape the way users interact with digital environments, providing an intuitive and efficient tool for creativity, communication, and everyday tasks.

II. Literature Survey

The concept of using hand gestures for digital interaction has evolved significantly over the years. Early efforts focused on the fundamental recognition of hand gestures and their integration into digital systems.

The Handwritten Devanagari Character Recognition project (2007), see [7], laid the groundwork for recognizing complex written scripts using geometric and statistical features. This work segmented handwritten characters into distinct zones and employed neural networks for recognition. Though it demonstrated robustness against noise, challenges remained in handling overlapping characters and complex symbols, indicating that recognition of script-based gestures required further refinement.

Building on this foundation, Deep Learning-Based Air-Writing Recognition (2021), see [2], introduced a significant advancement in air-writing recognition, incorporating deep learning techniques to overcome the limitations of previous systems. Their use of a 2D-CNN model not only improved the accuracy of air-writing recognition but also eliminated the need for additional devices, such as sensor bands, that were previously required for gesture tracking.

Despite offering a more robust solution, the research highlighted the challenge of signal duration variability in air-writing tasks. This research was pivotal in moving beyond conventional gesture recognition systems by leveraging the power of deep learning for real-time processing and recognition.

In 2022, the Virtual Air Canvas Using OpenCV and Mediapipe project, see [18], marked a breakthrough in hands-free digital interaction. The project utilized OpenCV and Mediapipe to track and map hand gestures, offering a simple, cost-effective solution for drawing and creating digital content mid-air. The key finding was the efficient integration of Mediapipe for hand tracking, which enhanced the overall system performance compared to earlier systems that relied on basic motion sensing. This hands-free digital canvas paved the way for future developments in gesture-based systems and interactive tools, further advancing the notion of creating art and interacting with digital interfaces through mere hand movements.

A more recent development in this field, Virtual Air Canvas Application Using OpenCV and Mediapipe (2023), see [17], expanded on the concepts introduced by earlier works by integrating fingertip recognition, free-hand writing, and shape recognition. This project utilized the same core technologies—OpenCV and Mediapipe—but focused on refining the precision of gesture tracking and adding new features, such as virtual erasing and shape drawing. The key advantage of this system was its ability to detect and interpret various hand gestures, offering a seamless interface for users to interact with digital platforms without physical tools. The research not only demonstrated the practical applications of hand gesture-based systems in education and virtual design but also laid the foundation for future work to enhance the system with more gestures and voice command capabilities.

The Math with Gestures Using AI project (2024), see [4], extended the scope of gesture-based interaction into mathematical computations. By leveraging computer vision and AI, this system tracked hand gestures in real-time to perform arithmetic operations. This work represented a step forward in creating intuitive, educational tools that allowed users to interact with digital systems seamlessly. A key outcome of this project was its ability to demonstrate the feasibility of applying hand gesture recognition in STEM education, potentially bridging the gap between traditional teaching methods and modern digital technologies.

The Math Notes web application (2024), see [5], provided a practical implementation of gesture-based mathematics for real-world use. By integrating AI-powered computation and gesture tracking into a web-based platform, it demonstrated how hand gestures could be utilized for solving equations and performing calculations without requiring additional devices. The application emphasized accessibility and functionality, making advanced AI systems available to a broader audience through an intuitive interface.

Further advancements were made by predystopic-dev's AI-powered calculator projects (2024), see [6], which presented a modular approach to developing gesture-based mathematical tools. The backend (calc-be) handled gesture interpretation and mathematical computations, while the frontend (calc-fe) integrated these functionalities into a user-friendly interface. These projects highlighted the value of modularity and open-source development in creating scalable, adaptable systems.

The Apple-Inspired AI Calculator (2024), see [8], provided a polished user interface alongside robust AI features. By focusing on aesthetics and usability, this project demonstrated the importance of integrating design principles with advanced AI tools. This work underscored the broader appeal of AI calculators, emphasizing user engagement alongside technical performance.

III. Methodology

The Smart Canvas project leverages advanced computer vision, deep learning, and natural language processing techniques to enable intuitive hand gesture-based interactions with digital content. The system utilizes various techniques for gesture tracking and recognition, transforming mid-air hand movements into actionable digital inputs.

A. Free Hand Drawing

The Free-Hand Drawing feature allows users to draw directly in the air, with hand movements being tracked and rendered as strokes on a virtual canvas. The system uses Mediapipe for real-time hand tracking, which detects the position and movement of the hand, and OpenCV for drawing corresponding lines or shapes on the screen. This enables users to create free-hand sketches or drawings without the need for physical tools, replicating the experience of traditional drawing in a digital environment. As the hand moves in the air, the system continuously updates the virtual canvas, providing seamless feedback to the user. Hand gestures are tracked in real time, and fingertip movements are translated into continuous strokes, providing a natural and intuitive sketching experience.

Hand tracking points refer to specific landmarks on the hand, typically 21 key points such as fingertips, joints, and the wrist. These points are used to track hand movements and gestures in real-time for various applications. Hand detection is achieved using machine learning models like Mediapipe, which detect a hand's position from an input image. Once detected, the model identifies key landmarks such as knuckles and fingertips, creating a set of coordinates that define the hand's structure.

B. English Character Recognition

a. Number Recognition

The Number Recognition feature allows users to draw numbers in the air, enabling numerical input without a physical interface. Hand gestures corresponding to numbers are identified and mapped to digits using gesture detection. A Convolutional Neural Network (CNN) processes and classifies these gestures based on trained datasets, ensuring accurate recognition. Recognized numbers can be displayed or processed for further interaction, such as arithmetic operations.

b. Alphabet Recognition

The Alphabet Recognition feature enables users to write letters mid-air, which the system converts into text. Using Mediapipe and OpenCV, hand gestures for different letters are tracked and processed. Hand gestures for letters are tracked and mapped to its corresponding character in the English alphabet. The system employs a CNN model to analyze gestures, extracting features like stroke direction and shape for accurate classification.

C. Shape Recognition

The Shape Recognition feature identifies basic geometric shapes such as circles, squares, rectangles, triangles, and kites, drawn mid-air. Hand gesture detection algorithms map gestures to specific shapes, analyzing geometric properties like angles, curvature, and symmetry for accurate classification. This feature is particularly beneficial for educational applications and creative projects.

D. Devanagari Recognition

a. Number Recognition

The Hindi Number Recognition feature allows users to draw Hindi numerals in the air. Similar to the English recognition mode, hand gestures are mapped to Hindi digits using gesture detection and CNN classification, facilitating numerical input in Hindi.

b. Alphabet Recognition

The Devanagari Alphabet Recognition feature enables users to write Hindi characters mid-air. The system utilizes image preprocessing techniques to segment handwritten characters, which are then analyzed by a CNN model for accurate classification. After entering this mode, users can draw letters, which are recognized, predicted, and displayed.

E. Virtual Calculator

The Virtual Calculator allows users to perform arithmetic operations in the air using hand gestures. Movements representing numbers and operators (e.g., addition, subtraction) are mapped to their respective symbols in the virtual calculator interface. Gesture recognition algorithms process these inputs, enabling users to input numbers and operators naturally. The system computes results in real time, handling complex expressions for versatile mathematical tasks. The input is sent to an AI-powered API that calculates the result and displays it in real time. This feature supports complex expressions, making it versatile for mathematical tasks.

F. Word Recognition

In this mode, users draw individual words on the screen, which are recognized and displayed. Each word is processed separately. The Word Recognition feature allows users to write entire words mid-air, which the system then converts into text. Using an API key and AI-based processing, the system segments gestures and processes them using a CNN model combined with sequential models like LSTM or Transformers. The gestures are analyzed in sequence to accurately recognize each character and form complete words. The system also incorporates natural language processing (NLP) to enhance accuracy by predicting and correcting errors, making it suitable for hands-free text input in applications such as virtual note-taking and transcription.

G. Translation (English to Hindi/Marathi)

The Translation feature enables real-time conversion of English words into Hindi/Marathi. The system recognizes and processes written words using character recognition techniques. When the user writes a word on the virtual canvas, it is detected and converted into text. This text is then passed through a machine translation model that retrieves the equivalent Hindi/Marathi word. The translated word is displayed on the screen instantly, offering a quick and efficient way for users to translate English words into Hindi/Marathi without requiring external devices or manual input. This feature is beneficial for applications such as language learning, cross-language communication, and real-time assistance in multilingual environments.

H. Text-to-Speech

The Text-to-Speech (TTS) feature transforms recognized text into audible speech, significantly improving accessibility and enriching the user experience. Once the system recognizes a word or sentence, it processes the text and generates speech output in real-time, allowing users to hear the content. This functionality not only provides auditory feedback for users but also makes digital interactions more intuitive by combining visual and auditory inputs. The TTS feature is particularly valuable in applications that require voice-based interaction, such as language learning tools, virtual assistants, and accessibility solutions for users having reading difficulties. By converting text into spoken language, the TTS feature enhances user engagement, enabling a more inclusive and interactive experience.

IV. WORKING OF SYSTEM

The system initiates by setting up modules for hand detection, video frame processing, and gesture interpretation using OpenCV and Mediapipe. Users can navigate to specific functionalities, ensuring a streamlined and user-friendly interaction. Free Hand Drawing is activated by default at the start, this mode enables scribbling on a virtual canvas.

A. English Character Recognition

By hovering over 'English' button, users can switch to this mode to write English Numbers & Alphabets in the air. The system preprocesses the input and utilizes a trained CNN model for reliable character recognition across varied handwriting styles.

B. Shape Detection

Users can hover over ‘shape’ button to identify basic geometric shapes such as circles, squares, and triangles. The system applies geometric feature extraction algorithms to classify air-drawn shapes accurately.

C. Devanagari Character Recognition

By hovering over 'Hindi' button enables the recognition of Devanagari Numbers & Alphabets. The system preprocesses the input to handle variations in strokes and employs a CNN model specifically trained on Devanagari script for precise character recognition.

D. Virtual Calculator

By hovering over ‘Math’ button, this mode gets enabled, mathematical expressions drawn in the air are interpreted and evaluated in real time. This functionality supports basic mathematical operations, providing users with immediate results.

E. Word Recognition

By hovering over ‘Word’ button, it enables users to write complete words in the air. The system incorporates natural language processing (NLP) to enhance accuracy by predicting and correcting errors, making it suitable for hands-free text input in applications such as virtual transcription.

F. Translation

By hovering over 'Translate' button activates the translation feature, where individual English words can be converted into their Hindi or Marathi equivalents using predefined translation libraries.

G. Text-to-Speech

By hovering over the ‘TTS’ (Text-to-Speech) button feature, it converts the recognized text in English into spoken language, enhancing accessibility and user interaction.

H. Pen-Width Customization

The system incorporates a feature allowing users to select pen widths of 5, 10, 15, or 20 pixels, enhancing the flexibility of the virtual drawing experience. This dynamic width selection is integrated seamlessly within the working of the application, enabling users to adjust pen sizes in real-time based on their drawing needs. Whether creating intricate details with finer strokes or bold designs with broader lines, this feature ensures precision and adaptability. The intuitive implementation of this functionality complements the hand tracking system, providing a smooth and customized drawing experience on the virtual canvas.

I. Reset Button

The Reset Button feature provides users with the ability to quickly restore the virtual canvas to its initial state, clearing all drawn content with a single gesture. Positioned for easy access, this functionality allows users to start fresh without manually erasing previous work. When activated, the system clears all existing drawings, shapes, or text from the canvas, giving users a clean slate for new creations.

By incorporating the reset function, the system ensures a smooth, hassle-free experience, enhancing overall usability and encouraging creative freedom.

J. *Gesture Control Framework*

The smart canvas employs a gesture-based interaction model to facilitate intuitive user input and control. The system uses hand-tracking technology to detect specific gestures, enabling functionalities such as drawing, mode switching, content recognition, and canvas management. Below is a detailed explanation of the gestures and their corresponding functionalities.

a. *Index Finger Up*

This gesture is used for drawing or selecting options within the application. When the index finger is raised, the system tracks its position in real-time, allowing users to create lines or interact with interface elements on the canvas.

b. *All Fingers Up*

Raising all fingers simultaneously serves as a command to clear the canvas. This gesture resets the drawing area, enabling users to start afresh without manually erasing previous inputs.

c. *Index and Middle Fingers Up*

This gesture triggers the recognition of drawn content, such as mathematical equations, English words, or Hindi words. Upon detecting this gesture, the application processes the input using text recognition algorithms to provide relevant outputs.

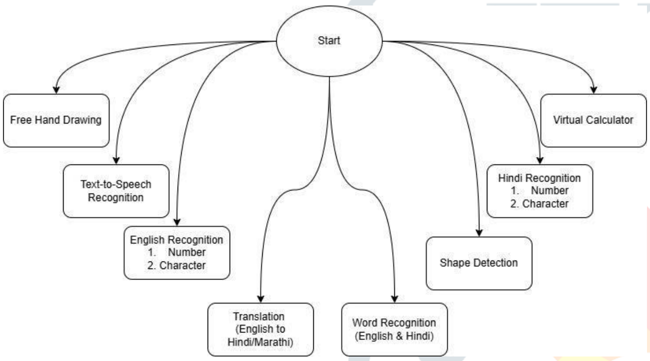

Fig 1: Flow Chart of the System

VII. Implementation Details

A. *Free Hand Drawing in the system*

This feature eliminates the need for physical input devices, offering users a seamless, intuitive way to create digital art. As users move their hands, the system recognizes and renders their gestures in real-time, enabling spontaneous and dynamic drawing.

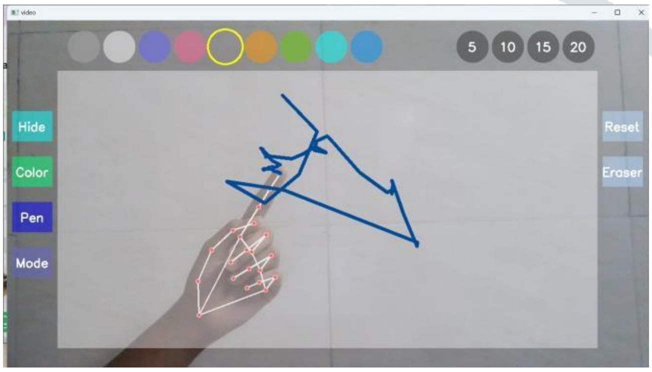

Fig 2: Free Hand Drawing & Landmark Detection in the system

B. *Alphabet Recognition in the system*

In the alphabet recognition mode, users can write English alphabets in the air. The system processes the drawn character using a trained CNN model. Once the character is recognized, and the predicted alphabet is displayed above for user confirmation.

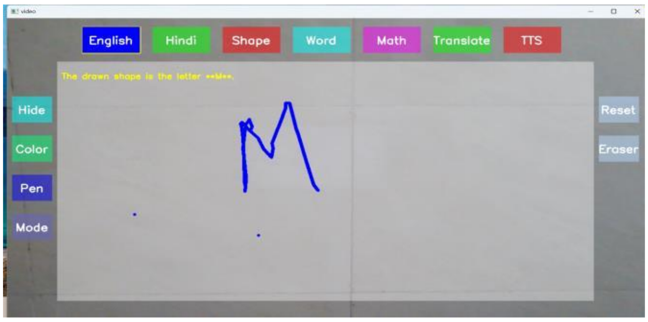

Fig 3: Alphabet Recognition in the system

C. *Shape Recognition in the system*

The users can air-draw basic geometric shapes, such as circles, squares, and triangles. The system detects and processes the shape based on its geometric properties. Upon successful identification, the shape is highlighted, and its name (e.g., "Circle") is displayed above it.

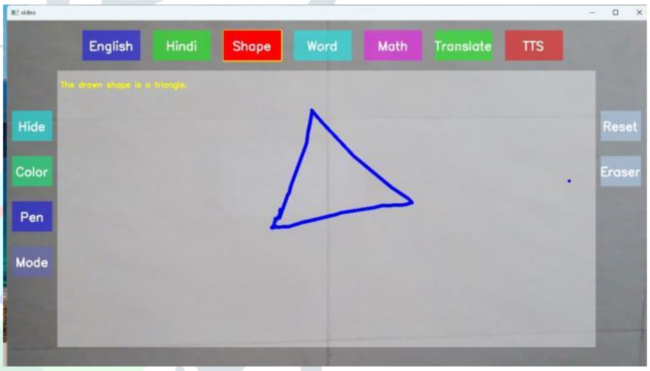

Fig 4: Shape Detection in the system

D. *Devanagari Recognition in the system*

In the Devanagari script recognition mode, the system identifies Hindi numbers (0-9) and consonants as users draw them in the air. Once recognized, displaying the predicted Hindi numeral or consonant above it.

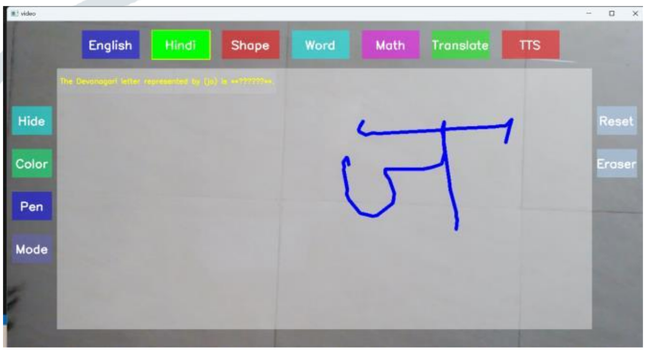

Fig 5: Devanagari Recognition in the system

E. *Virtual Calculator in the system*

In Virtual Calculator Mode, users can air-draw mathematical expressions. The system interprets the expression in real time, evaluates it, and displays the result above the drawn equation. This mode supports basic mathematical operations like addition, subtraction, multiplication, and division, square-root and more.

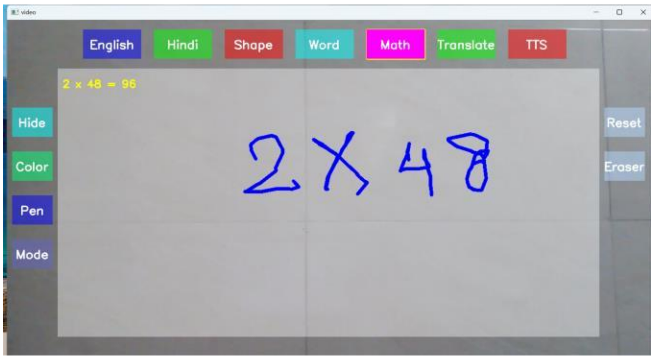

Fig 6: Virtual Calculator in the system

F. *Word Recognition in the system*

In Word Recognition Mode, users can air-write small words in English or Devanagari. The system tokenizes the strokes and reconstructs them into a coherent word using advanced recognition algorithms. Once processed, the recognized word is displayed above the air-written text for verification.

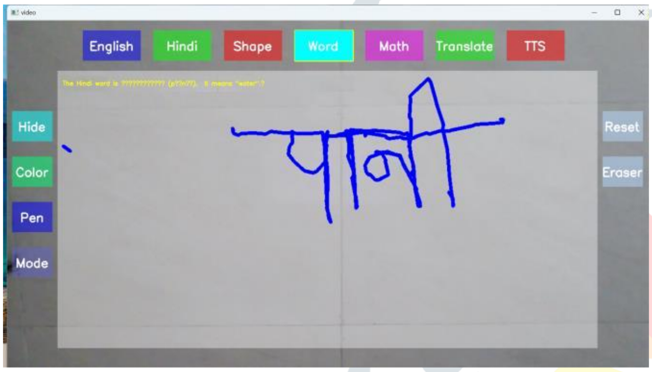

Fig 7: Word Recognition in the system

G. *Translation (English to Hindi/Marathi) in the system*

In Translation Mode, users can input English words. The system translates the input word into its equivalent in Hindi or Marathi using predefined translation libraries. The translated word is displayed alongside the original English term for clarity.

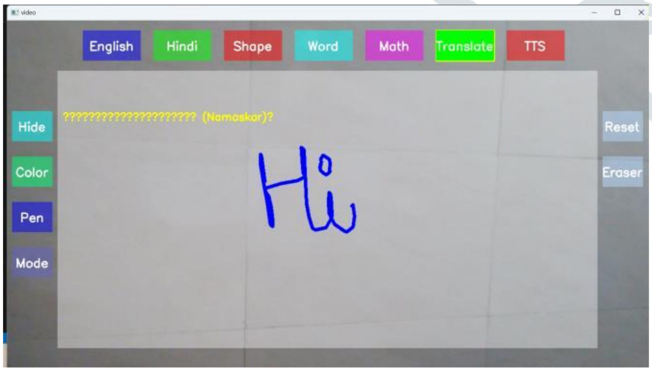

Fig 8: Translation from English to Hindi in the system

H. *Text-to-Speech Recognition in the system*

The Text-to-Speech (TTS) feature converts recognized text into spoken language, enhancing accessibility and user interaction. Once a word or sentence is recognized, the system synthesizes speech output, allowing users to hear the translated or recognized content in real time. This feature enhances accessibility, providing auditory feedback for recognized text and supporting applications like language learning and voice-based interactions.

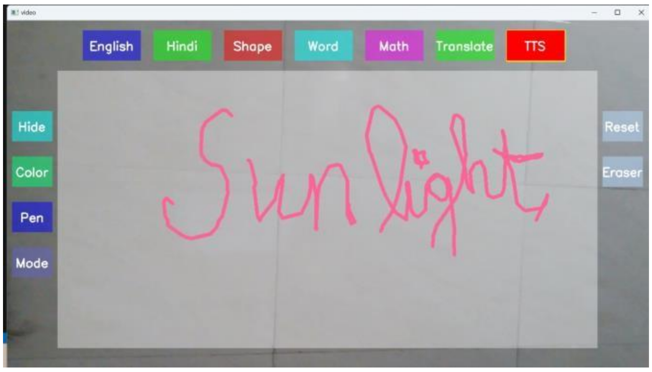

Fig 2: Text-to-Speech Recognition in the system

I. *Hardware – Software Requirements*

The Smart Canvas application leverages standard inbuilt webcams, typically integrated into laptops or monitors, to capture real-time video feeds essential for hand tracking and gesture recognition. These webcams, offering resolutions from 720p to 1080p, connect via USB to facilitate seamless integration. A high-performance CPU with multiple cores and high clock speeds is crucial for the real-time processing of video frames, ensuring efficient execution of hand tracking and gesture recognition tasks. To display the digital canvas and interactions, monitors or projectors are employed—monitors suitable for individual use and projectors ideal for larger audiences.

On the software side, OpenCV handles image processing, webcam interfacing, and UI rendering, while Mediapipe simplifies real-time hand tracking and gesture interpretation. Python v3.9.11.9 ensures cross-platform compatibility and efficient development with its extensive library support. Tensorflow plays a pivotal role in implementing deep learning models for hand gesture and character recognition, enabling accurate and interactive user experiences.

Additional support from the Google Generative AI library allows for the creation of contextually relevant content based on drawn equations or recognized words. The PIL (Python Imaging Library) and Keras assist in manipulating and converting images for model input, while Pygame handles graphical rendering and interaction design. Together, these hardware and software components form the backbone of the Smart Canvas application, delivering a seamless, immersive, and interactive virtual painting experience.

The accuracy of the Smart Canvas system was evaluated through manual testing, where three individuals each performed 50 iterations, resulting in 129 correct recognitions out of 150 attempts that comes to 86% accuracy. It is important to note that accuracy can vary among users, as it depends on factors such as the individual's control over hand gestures and the precision of their strokes. Variability in gesture execution—particularly the accuracy of stroke formation—can significantly impact the system's performance, highlighting the importance of consistent and precise gestures for achieving optimal recognition accuracy.

The Smart Canvas system is an innovative application that seamlessly integrates advanced hand detection, gesture recognition, and deep learning techniques to provide an interactive and versatile platform. By leveraging real-time tracking and processing, it enables a wide array of functionalities, such as free-hand drawing, number and alphabet recognition, shape identification, and interpretation of both English and Devanagari scripts. In addition, features like a virtual calculator and translation, along with text-to-speech recognition further enhance the system's practical utility, making it suitable for diverse use cases.

The system's robust hardware-software integration ensures smooth performance, while its intuitive user interface guarantees ease of use. With support for multilingual recognition, the Smart Canvas system exemplifies the powerful fusion of technology and creativity, offering a platform with significant potential for applications in education, art, and interactive computing. This comprehensive solution empowers users to engage in innovative ways of creative expression and learning while demonstrating the future possibilities of hands-free interaction.

VIII. Conclusion

The Smart Canvas represents a significant step forward in human-computer interaction, enabling seamless, gesture-based digital engagement that transcends traditional input methods. By integrating advanced computer vision techniques the system successfully combines real-time hand tracking, multilingual character and word recognition, and gesture interpretation, translation, text-to-speech recognition and virtual calculator into a unified, efficient platform.

Moreover, the introduction of text-to-speech recognition, and translation from English to Hindi/Marathi extends its capability for real-time multilingual interaction, making it particularly relevant in education, accessibility, and creative domains. By establishing a robust foundation for gesture-driven digital interaction, this research paves the way for further advancements in interactive systems, emphasizing scalability, multilingual adaptability, and cross-domain applications.

References

[1] "Draw in Air — OpenCV Project," SlideShare, Sep. 10, 2023. https://www.slideshare.net/AviralChaurasia2/draw-in-air-open-cv-project

[2] Abir, F.A. et al. (2021) Deep Lch earning based air-writing recognition with the choice of proper interpolation technique, Sensors (Basel, Switzerland). Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8705512/ (Accessed: 23 November 2024).

[3] "HandGestureControlled Digital Drawing: An Implementation of the Air Canvas Project Using OpenCV and Mediapipe — PDF — Computer Vision — Software," Scribd. https://www.scribd.com/presentation/636268131/Untitled

[4] "Unveiling the Air Canvas Project: Where Creativity Meets Innovation",www.linkedin.com.

https://www.linkedin.com/pulse/unveiling-air-canvas-project-where-creativity-meets-innovation- choda 04bmc/

[5] "Create Air Canvas using Python-OpenCV," GeeksforGeeks. https://www.geeksforgeeks.org/create-air-canvas-using-python-opencv/ (accessed Jan. 28, 2024).

[6] prabhatk579, "GitHub - prabhatk579/multilinguistic-air-writing: Real-time Detection of multilinguistic alphabets and digits with use of a generic camera using OpenCV and recognition of detected alphabets and digits using CNN, Python," GitHub, 2022 https://github.com/prabhatk579/multilinguistic-air-writing (accessed Aug. 04, 2024).

[7] Atul, S.S. and Mishra, S.P. *Hand written D. Devanagari character recognition*, *CORE.* Available at: https://core.ac.uk/outputs/53186858/ (Accessed: 20 November 2024).

[8] Ashuna-dev, "GitHub - ashuna-dev/Apple-Inspired-AI-Calculator," GitHub, 2024. https://github.com/ashuna-dev/Apple-Inspired-AI-Calculator?tab=readme-ov-file (accessed Aug. 04, 2024).

[9] S.-K. Lee and J.-H. Kim, "Air-Text," Oct. 2021 doi https://doi.org/10.1145/3474085.3475694

[10] NSTiwari, "GitHub-NSTiwari/Hindi-Character-Recognition-on-Android-using-TensorFlow-Lite," GitHub, 2021. https://github.com/NSTiwari/Hindi-Character-Recognition-on-Android-using-TensorFlow-Lite (accessed Aug. 04, 2024).

[11] Murtaza's Workshop - Robotics and AI, "Math with Gestures using AI," YouTube, May 30, 2024. https://www.youtube.com/watch?v=RhhN0CLnFdc (accessed Nov. 20, 2024).

[12] Predystopic-dev, "GitHub - predystopic-dev/calc-be," GitHub, 2024. https://github.com/predystopic-dev/calc-be (accessed Nov. 20, 2024).

[13] Predystopic-dev, "GitHub - predystopic-dev/calc-fe," GitHub, 2024. https://github.com/predystopic-dev/calc-fe (accessed Nov. 20, 2024).

[14] "Math Notes," Vercel.app, 2024. https://calc-fe.vercel.app/ (accessed Nov. 20, 2024).

[15] Ashuna-dev, "GitHub - ashuna-dev/Apple-Inspired-AI-Calculator," GitHub, 2024. https://github.com/ashuna-dev/Apple-Inspired-AI-Calculator (accessed Nov. 20, 2024).

[16] Pythonlessons, "mltu/mltu at main · pythonlessons/mltu," GitHub, 2022. https://github.com/pythonlessons/mltu/tree/main/mltu (accessed Nov.20,2024)

[17] *Air Canvas using OPENCV, MEDIAPIPE*. Available at: https://www.irjmets.com/uploadedfiles/paper//issue_5_may_2022/22 247/final/fin_irjmets1651836068.pdf (Accessed: 10 November 2024).