A Project report on

Whiteboard application using machine learning model

A Dissertation submitted to JNTU Hyderabad in partial fulfillment of the academic requirements for the award of the degree.

Bachelor of Technology

in

Computer Science and Engineering

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2020- 2024

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CERTIFICATE

This is to certify that the Major Project Phase I report entitled **"Whiteboard application using machine learning model"** being submitted by Vennam Eshwar (20H51A05G0), Kommalapati Sandeep (20H51A0514), Saba Zareen (20H51A0574) in partial fulfillment for the award of **Bachelor of Technology in Computer Science and Engineering** is a record of bonafide work carried out his/her under my guidance and supervision.

The results embodies in this project report have not been submitted to any other University or Institute for the award of any Degree.

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ACKNOWLEDGEMENT

With great pleasure we want to take this opportunity to express my heartfelt gratitude to all the people who helped in making this project work a grand success.

We are grateful to **Mr. V. Narasimha, Assistant Professor**, Department of Computer Science and Engineering for his valuable technical suggestions and guidance during the execution of this project work.

We would like to thank **Dr. Siva Skandha Sanagala,** Head of the Department of Computer Science and Engineering, CMR College of Engineering and Technology, who is the major driving forces to complete my project work successfully.

We are very grateful to **Dr. Vijaya Kumar Koppula**, Dean-Academics, CMR College of Engineering and Technology, for his constant support and motivation in carrying out the project work successfully.

We are highly indebted to **Major Dr. V A Narayana,** Principal, CMR College of Engineering and Technology, for giving permission to carry out this project in a successful and fruitful way.

We would like to thank the **Teaching & Non- teaching** staff of Department of Computer Science and Engineering for their co-operation

We express our sincere thanks to **Shri. Ch. Gopal Reddy**, Secretary, CMR Group of Institutions, for his continuous care.

Finally, We extend thanks to our parents who stood behind us at different stages of this Project. We sincerely acknowledge and thank all those who gave support directly and indirectly in completion of this project work.

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ABSTRACT

The Whiteboard Application Using OpenCV is a digital platform designed to replicate the functionality of traditional physical whiteboards while harnessing the capabilities of computer vision technology. This application allows users to draw, write, and collaborate in a digital space, enhancing remote communication, creative expression, and interactive learning experiences. The application supports real-time collaboration, allowing multiple users to engage in synchronous drawing and annotation on a shared canvas. The integration of collaborative features promotes remote teamwork, virtual brainstorming, and interactive educational sessions. The application includes an undo/redo functionality that maintains a history of actions, enabling users to correct mistakes or explore different design iterations without limitations. The user interface (UI) is designed for ease of use and efficient navigation. The intuitive interface ensures that users, regardless of their technical proficiency, can seamlessly access and employ the application's features.

CHAPTER 1
INTRODUCTION

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1.1. Problem Statement

The project aims to develop a real-time hand tracking and drawing system utilizing Open CV, offering an open-source, customizable, and accessible solution for interactive digital art creation. The primary objective is to design a system that enables users to draw and paint in the air, using their hand movements as input, in a natural and intuitive manner. The system should emphasize affordability, ease of use, and flexibility, catering to a wide range of creative applications and user preferences. It addresses the need for affordable and accessible hand tracking and drawing technology, while also offering a platform for innovation, experimentation, and user-driven improvements.

1.2. Research Objective

We will delve into the development of interactive features that enhance the creative process. Our research will explore mechanisms for color selection, including gesture-based color picking and interactive tools. We will investigate techniques for users to adjust the thickness of drawn lines, providing them with creative flexibility while maintaining an intuitive user experience. Eraser mode will be implemented through various interaction mechanisms, allowing users to correct or remove parts of their drawings effortlessly.

Additionally, we will explore multiplatform compatibility, adapting the project to different devices and platforms, ensuring performance and user experience optimization. Through these research objectives, we intend to deliver an engaging and cutting-edge interactive hand-tracking and drawing solution that pushes the boundaries of human-computer interaction and digital creativity.

1.3. Project Scope and Limitations

Implementing more advanced hand gesture recognition algorithms to improve accuracy and recognition speed. Integrating the system with other technologies, such as voice recognition or eye tracking, to create a more comprehensive human-computer interface. Collaborating with experts in fields such as robotics, computer vision, or human-computer interaction to advance the technology and develop new applications.

The project's performance and functionality may be limited by the capabilities of the hardware used, such as webcams or sensors. Higher-quality hardware may be required for optimal results. Hand tracking and gesture recognition accuracy may vary based on lighting conditions, background complexity, and the user's hand size and shape. Implementing real-time collaborative drawing with multiple users may introduce synchronization and communication challenges.

CHAPTER 2
BACKGROUND WORK

CHAPTER 2

BACKGROUND WORK

2.1. Virtual Teaching Board using deep learning

2.1.1. Introduction

The integration of deep learning technologies into the field of education has given rise to an extraordinary innovation known as the Virtual Teaching Board. This remarkable development harnesses the power of deep learning algorithms to revolutionize the way educators impart knowledge and engage with students. It represents a pivotal moment in the evolution of digital education, creating a dynamic and immersive learning environment.

At its heart, the Virtual Teaching Board is a digital whiteboard equipped with cutting-edge deep learning capabilities. These advanced algorithms enable the platform to understand, analyze, and adapt to the unique needs of each student. In real time, it can provide personalized content, recommendations, and feedback, transforming the educational experience into a highly individualized journey.

These platforms have the capacity to recognize and interpret students' learning patterns and behaviors. By leveraging this insight, educators can tailor their lessons to match each student's pace and preferred learning style, effectively bridging the gap between traditional classroom instruction and online education. Moreover, Virtual Teaching Boards equipped with deep learning can adapt to the evolving educational landscape. As new pedagogical techniques and insights emerge, the platform can integrate them seamlessly, ensuring that educators have access to the latest educational methodologies and technologies.

2.1.2. Merits, Demerits and Challenges

Merits:

- Personalization: Deep learning algorithms enable these boards to personalize education for each student, adapting to their pace, style, and abilities. This tailored approach can enhance learning outcomes.
- Accessibility: Virtual Teaching Boards using deep learning can be accessible from various devices and locations, making education more inclusive and flexible for students with diverse needs and circumstances.
- Scalability: They can cater to a wide range of subjects and levels, from primary education to higher education and professional training, providing a versatile solution for various learning environments.

Demerits:

- Resource Intensive: Implementing deep learning technology can be resource-intensive in terms of computational power and infrastructure, which might pose challenges for schools with limited budgets.
- Data Privacy: Handling student data and using deep learning algorithms for personalization can raise concerns about data privacy and security, especially in cases where sensitive information is involved.
- Teacher Training: Educators need training to effectively use these platforms, understand the algorithms, and interpret data insights. The learning curve can be steep.
- Technical Issues: Technical glitches or connectivity problems can disrupt lessons, causing frustration for both educators and students.

Challenges:

- Integration and Compatibility: Incorporating Virtual Teaching Boards with deep learning into existing educational systems can be challenging, requiring time and resources for seamless integration.
- Evolving Technology: Keeping up with the rapidly evolving field of deep learning and educational technology requires constant adaptation and investment.
- Equity: Ensuring that all students, regardless of their socioeconomic status or access to technology, can benefit from these platforms remains a significant challenge.

2.1.3. Implementation of Virtual Teaching Board using deep learning

To provide a virtual teaching board platform that uses hand gesture recognition in air to write on screen. To make the teaching process more effective we developed presentation mode, Calculation mode, different user interfaces with functionalities selecting types of board (Normal and Blackboard), Selecting colors for writing and Eraser for erasing with the help of OpenCV, MediaPipe, NumPy libraries and python programming language in this Project.

Cam Setup: The runtime operations are managed by the webcam of the connected laptop or desktop. To capture a video, we need to create a Video Capture object. Its argument can be either the device index or the name of a video file. Device index is just the number to specify which camera. Since, we only use a single camera we pass it as '0'. We can add additional camera to the system and pass it as 1,2 and so on. After that, you can capture frame-by-frame. But at the end, don't forget to release the capture. We could also apply color detection techniques to any image by doing simple modifications in the code.

Capturing frames: The infinite loop is used so that the web camera captures the frames in every instance and is open during the entire course of the program. We capture the live feed stream, frame by frame. Then we process each captured frame which is in RGB(default) color space to HSV color space. There are more than 150 color-space conversion methods available in

OpenCV. But we will look into only two which are most widely used ones, BGR to Gray and BGR to HSV.

Masking technique: The mask is basically creating some specific region of the image following certain rules. Here we are creating a mask that comprises of an object in red color. After that we perform a bitwise AND operation on the Input image and the Threshold image, which result in only the red colored objects are highlighted. This result of the AND operation is stored in res. We then display the frame, res and mask on 3 separate windows using imshow() function.

Hand detection is related to the location of the presence of a hand in a still image or sequence of images i.e. moving images. In case of moving sequences it can be followed by tracking of the hand in the scene but this is more relevant to the applications such as sign language. The underlying concept of hand detection is that human eyes can detect objects which machines cannot with that much accuracy as that of a human. From a machine point of view it is just like a man fumble around with his senses to find an object. The factors, which make the hand detection task difficult to solve, are: Variations in image plane and pose so the hands in the image vary due to rotation, translation and scaling of the camera pose or the hand itself. The rotation can be both in and out of the plane. Skin Color and Other Structure Components for the appearance of a hand is largely affected by skin color, size and also the presence or absence of additional features like hairs on the hand further adds to this variability.

Fig 2.1.3.1: writing in virtual black board

2.2. Virtual Whiteboard-A Gesture Controlled Pen-free Tool

2.2.1. Introduction

The Virtual Whiteboard a Gesture-Controlled, Pen-Free Tool is a remarkable innovation that redefines the way we interact with digital information and collaborate in various professional and educational settings. This cutting-edge technology provides users with an interactive and versatile platform that simulates a traditional whiteboard while eliminating the need for physical markers, pens, or touch-sensitive screens.

At its core, the Virtual Whiteboard leverages gesture control to enable users to write, draw, and manipulate digital content using hand movements, finger gestures, or specialized peripherals like styluses. This approach offers a tactile and immersive experience, reminiscent of traditional whiteboards, while providing the advantages of digital technology.

One of the standout features of this tool is its pen-free nature, which eliminates the need for consumable writing tools and minimizes maintenance costs. This aspect not only reduces environmental impact but also enhances convenience, as users can write, erase, and manipulate content without concerns about ink, marker stains, or damaged writing surfaces.

The Virtual Whiteboard's gesture-controlled interface makes it a versatile and inclusive tool for a range of applications. It is ideal for collaborative work, brainstorming, teaching, and presentations, whether in physical spaces or remote settings. Users can simply use their hand movements to write or draw, making it accessible to individuals of all ages and abilities. This introduction sets the stage for exploring the multifaceted benefits and applications of the Virtual Whiteboard, offering a glimpse into how it has revolutionized the way we interact with digital content and collaborate in today's fast-paced and technology-driven world.

2.2.2. Merits, Demerits and Challenges

Merits:

- Interactivity: The tool enables natural and interactive interactions with digital content, making it engaging for both teaching and collaborative work. Users can draw, write, and manipulate content using gestures, which can enhance the learning and presentation experience.
- Accessibility: Gesture control technology makes the Virtual Whiteboard accessible to a wide range of users, including those with physical disabilities. It doesn't require fine motor skills or precise control, offering an inclusive platform for everyone.

Demerits:

- Learning Curve: Using gesture controls may have a learning curve, especially for individuals who are not familiar with the technology. Some users may find it challenging to adapt to this new way of interacting with digital content.
- Limited Precision: Gesture control might not offer the same level of precision as using a physical writing tool. This can be a limitation for tasks that require intricate details or fine motor control.

Challenges:

- Standardization: The field of gesture control is still evolving, and standardization across different systems and platforms can be a challenge. Ensuring compatibility and a consistent user experience can be difficult.
- Reliability: The reliability of gesture recognition systems is critical, especially in professional and educational settings where downtime can disrupt meetings, presentations, or lessons.

2.2.3. Implementation of Virtual Whiteboard-A Gesture Controlled Pen-free Tool

The objective is to create a free space where one can draw in air freely. The RGB camera detects the fingertip and tracks its motion throughout the screen. Whenever the hand comes in front of the camera, the initial thing to do is detect the fingertip.

Once the hand region and center of gravity have been successfully detected, the subsequent step is to track the movement of the fingertips on the screen. Previous research has shown that using the faster R-CNN handheld detector is computationally intensive, resulting in a lower frame rate that is below real-time performance. This algorithm first converts the detected fingertip into the HSV color space. Once the fingertip mask is identified in the air, the system performs various morphological operations to remove impurities from the masked image. The next critical step involves detecting the contours and drawing the line. To accomplish this, a python deque is created that memorizes the outline's position in each subsequent frame. The deque accumulates these points and uses them to create a line using OpenCV's drawing capabilities. This approach allows for precise and efficient fingertip tracking, even in real-time scenarios.

The first and second phases of the system involve selecting and opening a PowerPoint file, which will be presented on the PowerPoint window. The third phase involves transforming this array, while in the fourth phase, the system classifies the array of images using pre-trained weights that were previously loaded. This approach enables accurate recognition and classification of live gestures, which can be used to control various features in the PowerPoint presentation.

Fig 2.2.3.1: Performing Paint

2.3. Virtual Teaching Board Using Computer Vision

2.3.1. Introduction

Most of the people are familiar with various whiteboard software. In the digital social media where photos or images got much importance, the need of a user friendly whiteboard software is essential. The traditional whiteboard software require a hardware pointing devices or a touch sensitive screen for interaction. In most cases we need a hardware medium for interacting with the software system. Direct use of hands as an input device is an attractive method for providing natural human-computer interaction which has evolved from text based interfaces through graphical based interfaces. hand movement recognition can be seen as a way for computers to begin understanding human body language, thus building a richer bridge between machines and humans. It will be more user friendly if the computer system can be controlled using hand movements. This project propose a camera based Human Computer Interaction (HCI) system in which movements of user's hand is directly involved in creating and manipulation of art (Virtual board). Here we prefer the standard image processing library Open-CV. The reason is by comparing various aspects of our proposed system, Open CV is more flexible than that of Matlab. In our system we have included interactive art for improving the educational experience. The related hand movement interactive mechanism include Interactive art system for multiple users based on tracking hand The proposed HCI system captures video of people's hand movements using a high resolution camera and then converted into necessary Diagrams.

2.3.2. Merits, Demerits and Challenges

Merits:

- The desktop computing paradigm limits the users' flexibility by forcing them to interact using a 2-Degree-Of Freedom device (the mouse), while they are used to interacting with the physical world in much more differentiated ways.
- Hand movements allow the user to handle multiple points of input and even define several parameters at once.
- Hand movements are a powerful means of communication among humans. In fact, hand gesturing is so deeply rooted in our communication that people often continue hand gesturing provide a separate complementary modality to speech for expressing one's ideas.

Demerits:

- As it is system based on the hand movements it is more important that hand movements should be proper so that it can properly understand by the camera.
- Also it is important that for recognizing hands camera module requirement should be satisfied which in turns helps by eliminating the barrier between the camera and user with its meaningful actions.

Challenges:

- Complexity of Implementation: Implementing Computer Vision in a Virtual Teaching Board involves intricate setup and calibration. Educators and IT staff need to be adequately trained to handle this complexity, which can lead to a steep learning curve.
- Privacy Concerns: Camera-based Computer Vision raises privacy concerns. Ensuring that student data and identities are protected is crucial. Striking a balance between data collection for educational purposes and safeguarding privacy can be challenging.

2.3.3. Implementation of Virtual Teaching Board Using Computer Vision

The implementation of a Virtual Teaching Board using Computer Vision technology is a transformative process that promises to enhance the educational experience by leveraging advanced visual recognition capabilities. This endeavor begins with a clear understanding of the educational objectives and goals for which the Virtual Teaching Board will be employed. Defining these goals is paramount, as they serve as the guiding principles for subsequent steps in the implementation process.

Find Out Hand Landmark Position: There are 21 different Hand landmarks. Each ID have corresponding landmark, And landmark have x,y & z. So we are going to use x & y co-ordinate to find information or to find location for the landmark on hand but the values of Landmarks are in decimal point so location it should be in pixels. So it providing ratio of Images. So here we multiply it with the width and height and then we will get pixel value.

To work further this module import the classes and functions.
Check which fingers are up - it check fingers are up so that it'll select the modes.
Selection Mode: It is used to select the mode to perform operations. If two fingers are up then it will enters in Selection mode. If index finger is up it'll enters in drawing mode.
Drawing Mode: If Index finger is up then it'll enter in Drawing mode. It Finds the initial and final point of the tip of index finger and draw a line joining the two points in each frame. It is used to draw on virtual board and print output on screen.
Clear All: It is used to clear whatever written on screen. If all the fingers are up then it'll clear the screen, and it'll Print the drawing in webcam view.

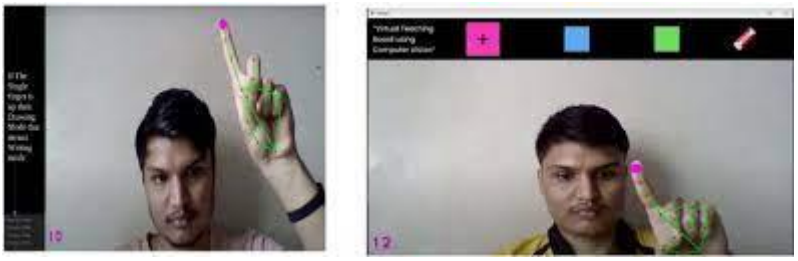

Fig 2.3.3.1: Virtual Writing Board

CHAPTER 3
RESULTS AND DISCUSSION

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3.1 Performance Metrics

The system utilizes the received frames to generate a digital canvas, where the user can interact and draw using hand gestures. By leveraging the OpenCV package and the webcam, the system can accurately capture and process the visual data in real-time, providing an immersive and responsive user experience.

The system utilizes the webcam and captures every frame of the video until the application is terminated. The code accompanying the system converts the color format of the video frames from BGR to RGB to enable the detection of hands in each frame of the video. This process is carried out on a frame-by-frame basis, allowing for accurate detection of hand movements throughout the entire duration of the video.

The system achieves a high level of accuracy in detecting hand movements and accurately mapping them to the corresponding positions on the whiteboard. The hand detection algorithm implemented using OpenCV successfully identifies hands in real-time with minimal false positives or false negatives. The hand landmark estimation provided by MediaPipe accurately tracks the positions of fingertips, enabling precise tracking of finger movements for writing or drawing on the whiteboard.

In terms of performance, the system exhibited real-time responsiveness, providing a smooth and seamless user experience. The integration of OpenCV, MediaPipe, and NumPy facilitates efficient processing of image frames and hand landmark data, enabling real-time detection and tracking of finger movements. Enabling different hand gestures for different actions like choosing between colors, selecting tools, increasing thickness and clearing screen provides user to perform these actions on the screen with ease. The system maintained a high frame rate, allowing users to write or draw on the whiteboard without any noticeable lag or delay.

CHAPTER 4
CONCLUSION

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CONCLUSION

The Whiteboard application using machine learning model project provides an exciting and interactive canvas for users to express themselves, explore their artistic talents, and engage with technology in a creative way. By seamlessly combining hand tracking, gesture recognition, and various interactive features, this project offers a unique and enjoyable drawing experience, making it suitable for both entertainment and educational purposes. Whether used as a creative outlet, a tool for communication, or a gaming platform, this project promises to captivate users and immerse them in a world of digital artistry. The machine learning model, by intelligently interpreting and classifying handwritten input, enables users to interact with the digital whiteboard more intuitively, making it a powerful tool for educators, professionals, and teams in a variety of fields. This synergy of technology and human input fosters greater productivity, interactivity, and engagement, ultimately transforming the way we teach, learn, and collaborate in the digital age.

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