AUGMENTED WHITE BOARD USING COMPUTER VISION

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Abstract -

Augmented whiteboard tech merges physical and digital realms via computer vision, revolutionizing virtual whiteboards with motion tracking and augmented reality (AR) for engaging learning. The system relies on an advanced camera setup to track user hand motions in real time, converting them into digital ink on a virtual whiteboard as they move through the air. Immersive online learning is made possible by seamlessly integrating physical motions with digital technology. This augmented whiteboard's unique feature is real-time collaboration.Real-time drawings are shown to viewers, including instructors and students, encouraging interaction. Due to its quick response it is suitable for remote learning. Teachers can use it for classroom clarity,student engagement, and comprehension. It serves as an interactive meeting tool for team members to visualize ideas instantly. Architects and designers can swiftly share sketches with clients.

Keywords -

Augmented Reality,Open Source Computer Vision Library,Visualization Tool Kit.

1 Introduction

The advent of the COVID-19 pandemic in late 2019 triggered a seismic shift in various aspects of our lives, profoundly impacting businesses and educational institutions worldwide. Among the affected professions, teaching underwent a transformative evolution, transitioning from traditional classroom settings to a virtual realm necessitated by global lockdowns and the surge in online activities. This shift to online education posed significant challenges, particularly for educators accustomed to conventional teaching methods honed over years or even decades. The move to online teaching demanded adaptation to new tools and technologies, with educators grappling with the limitations of virtual platforms. Many found themselves relying on rudimentary tools like a computer mouse, resulting in a pedagogical experience characterized more by squiggles than coherent instruction. The absence of adequate equipment in students' households compounded the difficulties of teaching to larger audiences. In response to these challenges, there emerged a transformative solution the Augmented Whiteboard, leveraging the power of computer vision technology.This innovative tool, exemplified by the AirBoard, offers a revolutionary approach to online teaching. By seamlessly integrating digital pads with screens, the 'Augmented Whiteboard' provides educators with a dynamic canvas for instruction. This not only facilitates a more organic and comprehensible teaching method but also significantly reduces the associated costs. The Augmented Whiteboard goes beyond traditional online teaching tools, allowing teachers to project their content onto displays while utilizing the air as an interactive canvas. This breakthrough not only enhances the quality of instruction but also addresses the financial constraints faced by practitioners.As a result, educators can approach their virtual classrooms with greater confidence,knowing that they have a powerful and intuitive tool at their disposal to engage and instruct students effectively. The following exploration will delve deeper into the functionalities and benefits of the Augmented Whiteboard in transforming the landscape of online education.

2 Literature Survey

Augmented Reality for Studying Hands on the Human Body for Elementary School Students[1]

This paper focuses on hands-on learning in elementary education with a specific emphasis on studying the human body. While the methodology is not explicitly stated, the authors highlight the engagement of elementary students with the human anatomy.The paper underscores the potential of augmented reality (AR) to enhance the educational experience for young learners.

Development of Augmented Reality (AR) for Innovative Teaching and Learning in Engineering Education[2]

Enzai and team present an exploration of AR development for innovative teaching in engineering education. The methodology is not explicitly detailed, but the paper underscores the positive impact of AR on fostering innovation within engineering education. It offers insights into leveraging AR for more effective and engaging teaching methods.

Mobile Augmented Reality in Vocational Education and Training[3]

This paper delves into the realm of mobile augmented reality (AR) applied in vocational education and training. While it highlights the advantages of utilizing AR in this context, the authors do not extensively discuss potential limitations related to the use of mobile technology in educational settings.

Enhancing the Attractiveness of Learning through Augmented Reality[4]

Iftene and Trandabˇat, explore the role of augmented reality in increasing the attractiveness of learning materials. Despite lacking detailed information on potential challenges, the paper emphasizes the positive impact AR can have on enhancing the appeal of educational content.

Development of an Interactive Training Support System for Drawing and Painting Skill on a 3D Object with AR and Haptic Interface[5]

Shima and Soga's paper focuses on interactive training for drawing and painting skills using AR and haptic interfaces. While emphasizing skill development on 3D objects, the paper does not extensively detail the effectiveness of the haptic interface in this context.

Mathematics and Geometry Education with Collaborative Augmented Reality[6]

This paper explores the integration of collaborative augmented reality in mathematics and geometry education. While highlighting the positive enhancements in these subjects, the authors do not thoroughly discuss the collaborative aspects of the proposed methodology.

Augmented Reality in Teaching and Learning English Reading: Realities, Possibilities, and Limitations[7]

Jamrus and Razali's paper explores the application of augmented reality (AR) in teaching English reading, with a predominant focus on its possibilities rather than a thorough examination of potential limitations. The authors extensively discuss the positive aspects of AR, emphasizing immersive learning experiences and heightened engagement. However, the paper lacks a comprehensive analysis of challenges that may arise during AR integration, such as technological constraints, costs, and potential distractions. A more balanced approach, considering both benefits and limitations, is crucial for informed decision-making by educators and stakeholders in the evolving landscape of AR in English reading education.

Crowd-board: An Augmented Whiteboard to Support Large-Scale Co-design[8]

This paper introduces "Crowdboard," an augmented whiteboard explicitly crafted to streamline extensive co-design projects. By prioritizing robust support for largescale collaborative efforts, the authors also conscientiously address potential challenges inherent in such expansive collaborations. The contribution of this paper extends beyond the introduction of Crowdboard by offering valuable insights into the dynamics of collaborative design projects and the innovative application of augmented reality to foster collective creativity.

3 System Development

3.1 System Architecture

The diagram shows the process of sending frames from a client, such as a camera,to a server for real-time object detection. The camera captures frames and sends them to the server. The server receives the frames, detects the outlines of objects in the frames, processes the frames for object detection, and then live streams the output.

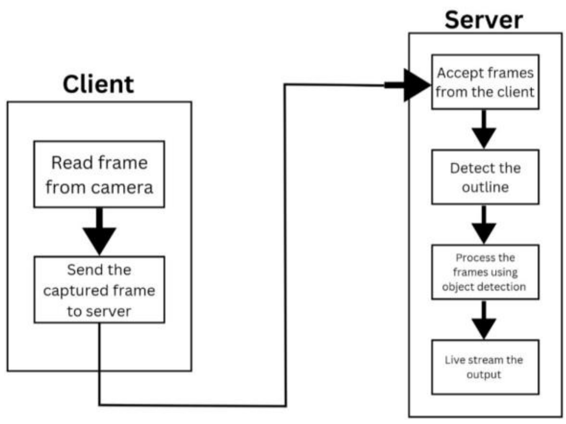

Figure 1. System Architecture

3.2 Data Flow Diagram

The Data Flow Diagram shows the working of an Augmented White Board Using Computer Vision. The Data Flow Diagram outlines the steps involved in the process of object detection and identification. It shows the process done at various levels.

Level 0

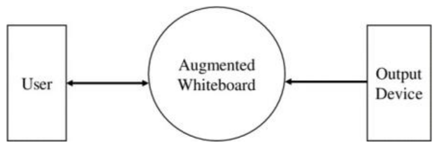

Figure 2. Level 0

The Level 0 consists of the following:

1. **User:** Users interact with the whiteboard.The user can draw by using the finger.

2. **Augmented Whiteboard:**The Augmented Whiteboard recognizes and tracks the movement of the finger to draw the content.It displays the user and the content drawn by the user through output devices.

3. **Output Device:** The output device shows the content drawn by the user through output device.

Level 1

The Level 1 shows the functions performed by the Augmented Whiteboard.It involves the following processes:

1. **Image/Frame Acquisition:** The input is taken through the camera as frames.Once the object is detected, this step involves capturing the object from the image. This can be done using various techniques such as cropping, masking, etc.

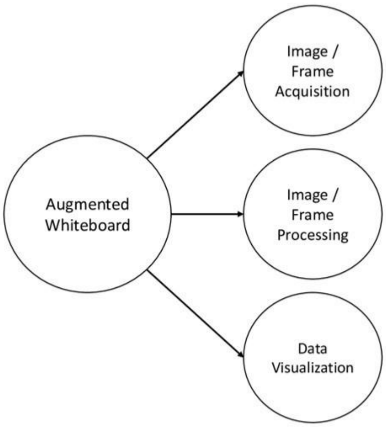

Figure 3. Level 1

2. **Image/Frame Processing:** The images/frames are processed after detecting outlines and objects, additional processing may be applied. This could include filtering noise, refining object boundaries, or any other enhancements to improve the accuracy of the augmented experience.

3. **Data Visualization:** The output device shows the content drawn by the user through output device.

Level 2.1

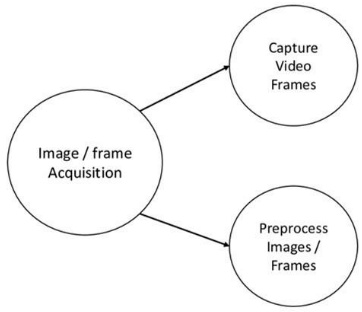

Figure 4. Level 2.1

The Level 2.1 involves the following processes:

1. **Capture Video Frames:** The input is taken through the camera as frames.Once the object is detected, this step involves capturing the object from the image. This can be done using various techniques such as cropping, masking, etc.

2. **Preprocess Images/Frames:** The images/frames are processed after detecting outlines and objects, additional processing may be applied. This could include

filtering noise, refining object boundaries, or any other enhancements to improve the accuracy of the augmented experience.

Level 2.2

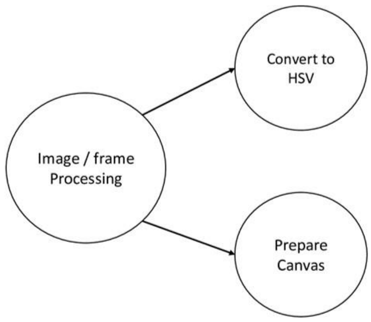

Figure 5. Level 2.2

The Level 2.2 involves the following processes:

1. **Convert to HSV:** The captured frames are converted into HSV Frame.

2. **Prepare Canvas:** The images/frames are processed after detecting outlines and objects.The canvas is prepared.

Level 2.3

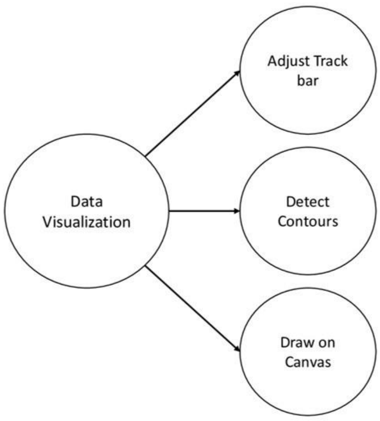

Figure 6. Level 2.3

The Level 2.3 involves the following processes:

1. **Adjust Track bar:** The track bar is adjusted to track the motion of the object.

2. **Detect Contour:** Computer vision algorithms, such as edge detection or contour finding, can be employed to identify the boundaries of objects in the frames.

3. **Draw on Canvas:** The contents are drawn by the user on the canvas.The contents are displayed on the screen.

3.3 Module Description

3.3.1 Client Side

1. **Frame Capturing Module:** The process begins with a camera capturing video frames of the whiteboard or the surrounding area. The camera can be a standalone device or integrated into a computer or mobile device.

2. **Frames Sending Module:** The client, which can be a computer or any smart device,sends the captured video frames to a remote server for processing. This step often involves establishing a network connection between the client and the server.

3.3.2 Server Side

1. **Frames Accepting Module:** The server receives the frames transmitted by the client. This might involve a server waiting for incoming connections or polling for data.

2. **Outline Detection Module:** The server processes each frame to identify the outlines of objects on the whiteboard. Computer vision algorithms, such as edge detection or contour finding, can be employed to identify the boundaries of objects.

3. **Object Detection Module:** Beyond simple outline detection, the server can use more advanced object detection technology to identify specific objects within the frames.

4. **Frame Processing Module:** After detecting outlines and objects, additional processing may be applied. This could include filtering noise, refining object boundaries, or any other enhancements to improve the accuracy of the augmented experience.

5. **Output Module:** The server, now enriched with information about the whiteboard content, live streams the augmented frames back to the client. The live stream can be sent in real-time, allowing users to view an enhanced version of the whiteboard with additional information or annotations.

3.4 System Requirements

3.4.1 Hardware Requirements

1. **Camera:** A high-resolution camera (at least 720p) with a wide field of view is required to capture the user's hand movements and the surrounding environment.

2. **Processor:** A powerful processor (at least 1.8 GHz) is needed to process the video stream and perform the necessary computations for augmented reality. For this a CPU or an SoC (System-on-Chip) with a built-in GPU can be used.

3. **Memory:** At least 4 GB of RAM is required to store the video frames,computer vision algorithms, and AR content. More memory will allow for smoother performance and more complex AR effects.

4. **Storage:** A fast storage device (such as an SSD) is necessary to store the video files, computer vision models, and AR content. At least 16 GB of storage capacity is recommended.

5. **Display:** A high-resolution display (at least 1080p) is required to display the AR content and the user interface. You can use a monitor, TV, or a specialized display for augmented reality applications.

6. **Operating System:** A 64-bit version of Windows, macOS, or Linux is recommended.

3.4.2 Software Requirements

1. **Python:** A robust and versatile programming language like Python is essential for developing an AR application. You can use Python 3.x or higher for your project.

2. **OpenCV:** A computer vision library like OpenCV is necessary for image processing, object detection, and feature extraction. OpenCV provides a wide range of functions for these tasks, including image filtering, shape detection, and object recognition. For example, OpenCV's Haar cascades can be used for object detection and tracking.

3. **scikit-image:** A machine learning library like scikit-image is useful for image processing and feature extraction. It provides a variety of functions for image analysis,including edge detection, thresholding, and morphological operations.

4. **PyOpenGL:** An OpenGL library like PyOpenGL is required for creating 3D graphics and animations. PyOpenGL provides a high-level API for rendering 3D objects, lighting, and shading, which are critical for an immersive AR experience.

5. **VTK:** A 3D visualization library like VTK (Visualization Toolkit) is useful for creating interactive 3D visualizations and simulations. It provides a wide range of functions for visualizing data, including surface reconstruction, volume rendering, and mesh generation.

6. **NumPy and SciPy:** Numerical computing libraries like NumPy and SciPy are essential for scientific computing and data analysis. They provide a wide range of functions for linear algebra, optimization, statistics, and other tasks that are critical for an AR application.

7. **Matplotlib and Seaborn:** Data visualization libraries like Matplotlib and Seaborn are useful for visualizing data and creating interactive visualizations. They provide a variety of functions for creating graphs, charts, and other visualizations, as well as handling events and user input.

4 Methodology

In the initial phase of this interactive augmented whiteboard system, the process begins with Frame Initialization. This involves capturing video frames and subsequently converting them to the HSV color space, a crucial step in enhancing color-based processing capabilities. Following this, the system proceeds to Canvas and Ink Setup, where an augmented reality canvas is established, featuring ink buttons designed for color selection. This canvas serves as the virtual workspace for the ensuing creative interaction. The third stage, Color Detection and Tracking, is pivotal in ensuring precision and responsiveness. During this phase, the system fine-tunes color detection parameters,enabling it to accurately identify and track the center coordinates of a marker. This meticulous tracking is essential for maintaining a seamless and intuitive user experience. Finally, the culmination of these processes is observed in Real-time Drawing.The tracked coordinates obtained from the Color Detection and Tracking phase,the system dynamically draws points on both the captured video frames and the augmented reality canvas. This integration results in an immersive and interactive augmented whiteboard experience, where users can engage in real-time drawing with precision and fluidity. The synergy of frame initialization, canvas and ink setup, color detection,and real-time drawing contributes to the development of a sophisticated and engaging augmented reality platform.

4.1 Algorithm

Step1: START

Step2: Start reading the frames and convert the captured frames to HSV colour space (Easy for colour detection).

Step3: Prepare the canvas frame and put the respective ink buttons on it.

Step4: Adjust the trackbar values for finding the mask of coloured marker.

Step5: Preprocess the mask with morphological operations (Erotion and dilation).

Step6: Detect the contours, find the center coordinates of largest contour and keep storing them in the array for successive frames (Arrays for drawing points on canvas).

Step7: Finally draw the points stored in array on the frames and canvas.

Step8: STOP

4.2 Implementation

In the initial phase of the project, the focus was on implementing the foundation for an "Augmented Whiteboard using Computer Vision." The project aimed to address the identified problem of enhancing online learning, collaboration, and real-time idea visualization through the development of an augmented whiteboard system. The initial steps involved a comprehensive literature review to understand existing solutions and technologies. Subsequently, an algorithm was prepared to integrate motion tracking and augmented reality (AR) features. The interface was also carefully designed to ensure user-friendly interaction. This phase laid the groundwork for the subsequent stages, providing a solid framework for the development and integration of computer vision capabilities into the augmented whiteboard system. The user can choose the colour from the panel by simply pointing the tip of finger on the colour, and draw with the tip of finger with the corresponding colour chosen.The tip of the finger is tracked by motion tracker and the digital ink is displayed. The Eraser button is used for erasing the drawn content.

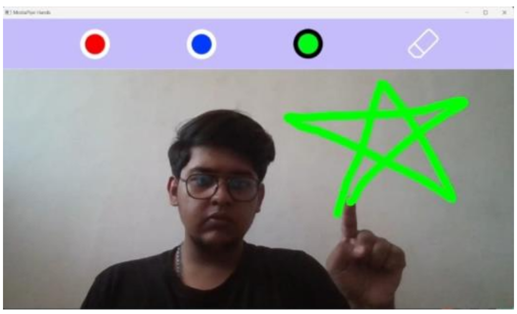

Figure 7. Draw

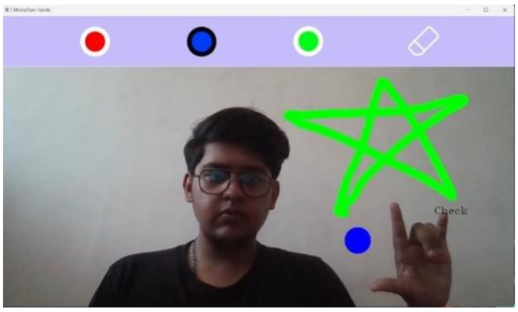

Figure 8. Check

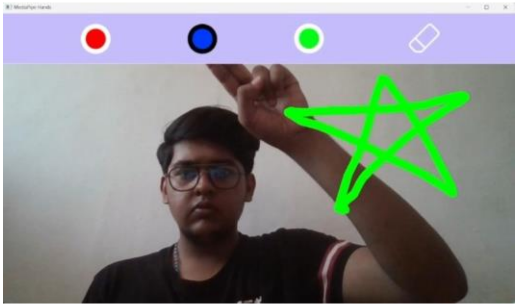

Figure 9. Select Colour

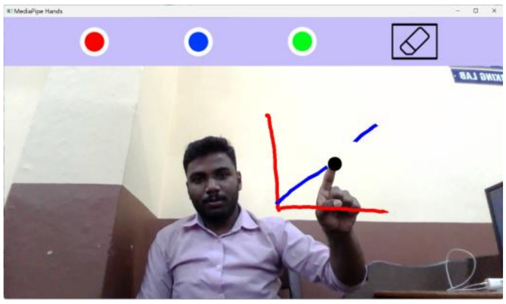

Figure 10. Erase

5 Conclusion

The augmented whiteboard stands at the forefront of innovation, seamlessly merging the tangible and virtual realms through the synergistic integration of computer vision, motion tracking, and augmented reality technologies. This groundbreaking fusion holds transformative potential, particularly in the realm of education, where it can revolutionize the learning experience. At its core, the augmented whiteboard is a testament to the convergence of physical and digital worlds. By harnessing the power of computer vision, it can interpret and react to real-world actions, enabling a dynamic and interactive interface. Motion tracking further enhances its capabilities, allowing users to engage with content in ways previously unimaginable. Through the lens of augmented reality, information is overlaid onto the physical environment, creating an immersive and enriched learning space. In the educational landscape, the impact of the augmented whiteboard is profound. Real-time collaboration takes center stage, as students and educators alike can engage with content simultaneously. This not only fos- ters a more interactive learning environment but also pro- motes collaborative problem-solving and creativity. The tra- ditional limitations of physical classrooms are transcended, opening up new possibilities for distance learning and global collaboration.

Authors contributions

The work is done by authors.

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Data availability

The labeled dataset used to support the findings of this study are available from the corresponding author upon request.

Competing interests

The authors declare no competing interests.

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