IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 1, October 2024

Air Canvas Using MediaPipe for Computer Vision in Unity 3D Hand Tracking

Rushabh Gangurde[1], Ketan Ahire[2], Sahil Tadage[3], Prof. S. A. Lavangale[4]
Department of AIML (Artificial Intelligence & Machine Learning) [1,2,3,4]
Loknete Gopinath Munde Institute of Engineering Education & Research (LoGMIEER), Nashik, India

Abstract: *In this paper, we present the implementation of an Air Canvas using MediaPipe for Computer Vision within a 3D environment using the Unity Game Engine. In our previous work, we found that, regardless of the initial parameters, simulations often led to rapid extinctions. In this model, we implemented an Air Canvas and Computer Vision system integrated with Unity's 3D World. Our goal was to achieve system stabilization, long-term operation, and more realistic simulation by incorporating 3D evolution. Using the Unity Game Engine, we created and managed a closed 3D ecosystem environment, either based on artificial or real-world maps. This simulation of ecosystems and the analysis of the data generated can serve as a starting point for further research, particularly in sustainability. Our system is openly accessible, allowing users to customize and upload their parameters, maps, and objects, and define inheritance and behavioural patterns, enabling them to test their hypotheses based on the data generated. The goal of this article is not to create and validate a model but to provide an IT tool. For evolutionary researchers, the system allows the creation and presentation of simulations, including animated conference presentations for enhanced visualization and engagement. The use of 3D simulation is particularly valuable for educational purposes, engaging students and increasing their interest in 3D interactive worlds. Students can observe how ecosystems behave, how natural selection supports adaptability, and how competition impacts species.*

Keywords: Air Canvas, Computer Vision, Unity, 3D Simulation, Ecosystem

I. INTRODUCTION

Computer-generated simulations have grown increasingly prominent in the field of informatics, especially in the visualization of real-time environments. These simulations allow researchers to monitor and study the interactions of various objects and creatures within a digital space, providing insight into their behaviours. Similarly, 3D computer vision technology has become a powerful tool for improving how humans interact with machines, enabling applications such as hand gesture recognition and interactive visual interfaces. In this project, we focus on the implementation of an Air Canvas using MediaPipe and Unity Game Engine. The Air Canvas allows users to draw in a 3D environment through hand gestures tracked by computer vision technology. By capturing hand movements in real-time, MediaPipe serves as the backbone of the system, detecting and tracking hand landmarks to enable accurate interaction.

The use of Unity's 3D environment provides a dynamic space for users to visualize their drawings in real time, enriching the experience with the ability to manipulate objects and scenes. This combination of hand-tracking and 3D interaction holds potential for educational applications, artistic expression, and human-computer interaction (HCI) research. The goal of this project is to build a robust system where users can interact with the virtual world in a more immersive and intuitive manner, bridging the gap between the physical and digital realms. In this paper, we explore the technical implementation, challenges, and applications of our system in the context of 3D interaction and real-time feedback.

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II. LITERATURE SURVEY

SR. NO.	TITLE	YEAR	AUTHOR	DISCUSSION
1	" Air canvas application using Opencv and numpy in python. "	2021	Saoji, S. U., Dua, N., Choudhary, A. K., & Phogat, B.	"Air Canvas" application utilizes OpenCV and NumPy in Python toenable real-time hand gesture-based drawing. It
2	"Overview, and methods of correlation filter algorithms in object tracking."	2021	Liu, S., Liu, D., Srivastava, G., Połap, D., & Woźniak, M.	detects hand movements using computer vision techniques and allows users to draw in the air withfingertip tracking.
3	"Hand Tracking Based Human- Computer Interaction Teaching System,"	2022	Naganandhini, K., Sowmya, B., Pavish, S., Nitesh, J., Karthika, R., & Prabhu	This project leverages simple yet powerful libraries to create an interactive and engaging digital canvas experience.

Table 1 : Literature Survey

III. PROPOSED METHODOLOGY

This Paper Implementing the "Air Canvas" project utilizing MediaPipe and Unity Game Engine is designed to createan interactive 3D drawing environment controlled through hand gestures. The project begins with the use of MediaPipe's advanced hand-tracking capabilities, which employ machine learning models to detect 21 key landmarks on a user's hand in real-time. This detection is achieved by leveraging a webcam to capture the hand's movements, where MediaPipe processes the frames to extract detailed coordinates of each finger joint. The key landmarks, specifically the fingertip and index finger joints, are crucial for gesture recognition in this system.

Once the hand-tracking data is captured, the next step involves interpreting specific hand gestures. A single finger, typically the index finger, is assigned the task of selecting colors from a color palette, which is represented as UI boxes within Unity. These UI boxes are responsive to the hand's position and allow for color changes by recognizing when the fingertip intersects with a particular box. The selection of colors is crucial to the drawing process, allowing users to switch dynamically between different colors.

The system identifies a two-finger gesture—usually using both the index and middle fingers together. The movementof these fingers is mapped to a 3D virtual brush within the Unity environment. The brush traces the coordinates of the user's hand in 3D space, rendering lines that simulate free-hand drawing. The coordinates of the hand landmarks are transmitted from MediaPipe to Unity via socket communication. This step involves converting the 2D coordinates from the hand-tracking data into Unity's 3D coordinate system, where these coordinates control the virtual brush's movement.

Additionally, to control when drawing is enabled or disabled, a toggle system is implemented via a key press—most commonly the "D" key. This allows the user to easily switch between drawing and non-drawing modes without needing complex gestures. When the "D" key is pressed, the system either activates or deactivates the drawing functionality, depending on the current mode.

The drawing process itself is managed within Unity's environment, where a LineRenderer component is used to draw lines based on the fingertip's position in space. The LineRenderer dynamically updates its position based on the hand's movement, creating a real-time drawing effect. The integration of Unity with MediaPipe provides a seamless experience where users can draw in 3D space with high responsiveness and precision.

Further enhance the interactive experience, the project incorporates additional features such as changing brush sizes, shapes, and colors through hand gestures or keyboard inputs. The entire system is designed to be user-friendly, allowing users to interact naturally with the 3D canvas through gestures, creating an intuitive interface for drawing and interacting within the virtual space.

Combining MediaPipe's robust hand-tracking and Unity's 3D rendering, this project showcases the potential for gesture-based controls in virtual environments, offering a novel way to interact with and manipulate 3D spaces using nothing more than hand movements.

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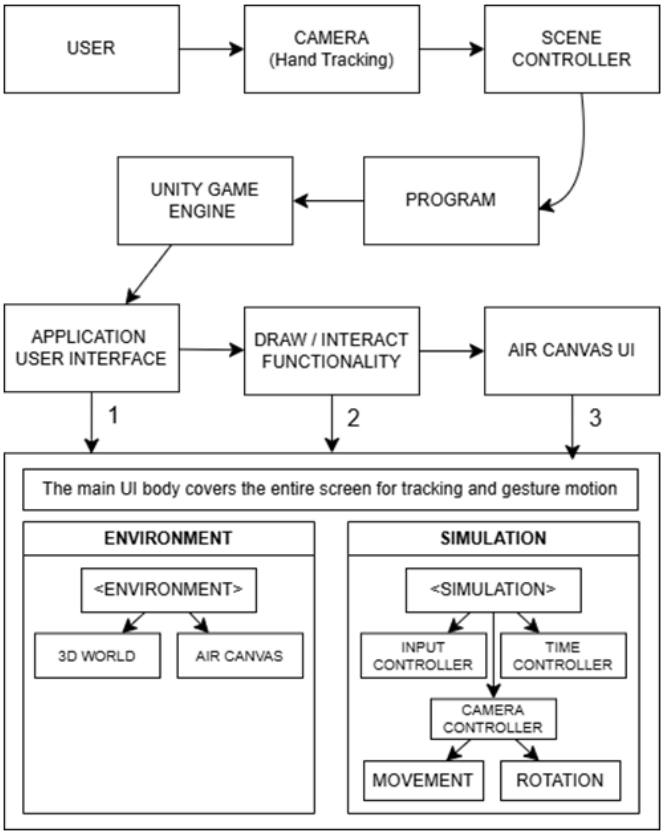

Fig. 1 : SYSTEM ARCHITECTURE

IV. RESULT AND DISCUSSION

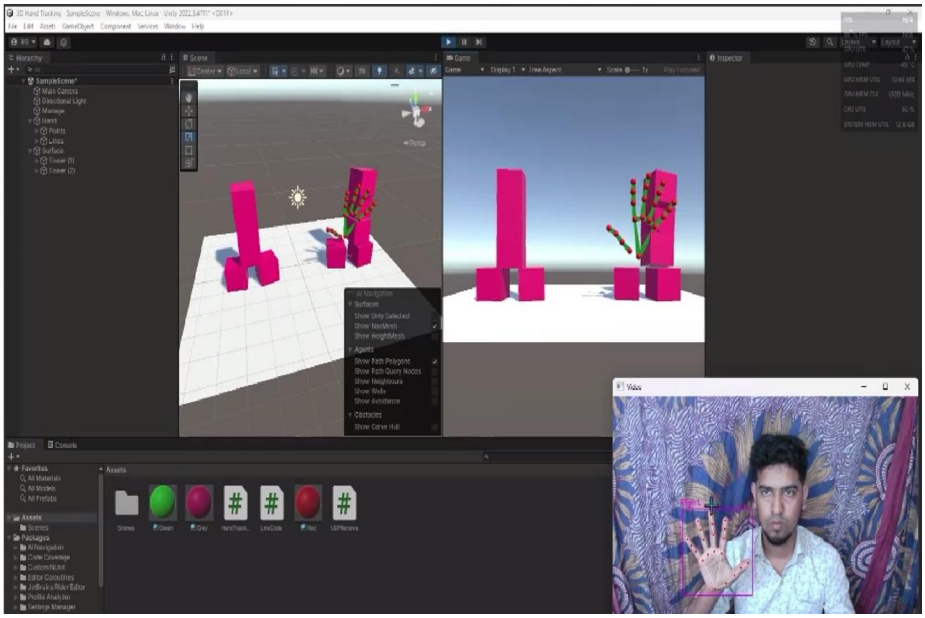

Fig. 2 : Unity Test Model

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- **Hand Tracking Integration**: Implement MediaPipe's hand tracking module within Unity to detect and track hand movements in real-time. This involves using MediaPipe's machine learning models to identify hand landmarks and map them to Unity's coordinate system.
- **Gesture Recognition**: Define specific hand gestures for drawing, color selection, and other interactions. For instance, using two fingers to draw and a single finger to select colors or tools. Implement algorithms to recognize these gestures and trigger corresponding actions within the application.
- **3D Environment Setup**: Design a virtual canvas within Unity where users can visualize their drawings. This includes setting up the scene, lighting, and camera perspectives to ensure an immersive experience.
- **User Interface Development**: Create an intuitive UI for color selection, brush size adjustment, and other drawing tools. Ensure that the interface is user-friendly and accessible, enhancing the overall user experience.
- **Performance Optimization**: Optimize the application to handle real-time processing of hand tracking data and rendering of the 3D environment, ensuring smooth and responsive interaction

V. APPLICATION

"Air Canvas using MediaPipe in Unity 3D" project has diverse applications across multiple fields. In education, it can be used as an interactive teaching tool, allowing educators to engage students with gesture-based learning, such as drawing and writing in virtual environments. This application could be expanded to fields like STEM education, where students can manipulate virtual objects or draw complex diagrams in mid-air, enhancing the learning experience.

Education:

- Gesture-based learning for drawing and writing in virtual environments.
- Useful for STEM education to manipulate virtual objects and create complex diagrams.

Digital Art and Design:

- Artists can draw or paint in mid-air using hand gestures.
- Ideal for dynamic art creation and design prototyping in 3D spaces.

Architecture and Design:

- Enables sketching and visualizing designs in 3D environments, allowing for more fluid prototyping.

Accessibility and Assistive Technologies:

- Allows individuals with limited mobility to interact with computers via gestures.
- Eliminates the need for traditional input devices, enhancing accessibility.

Gaming and VR/AR:

- Enhances immersive experiences by enabling natural interaction with virtual environments.
- Improves interactivity in games and simulations through gesture recognition.

VI. FUTURE WORK

- **Natural Interaction**: Enables users to interact with digital content using intuitive hand gestures, reducing thelearning curve associated with traditional input devices.
- **Enhanced Engagement**: Provides an immersive experience that can be particularly beneficial in educationalsettings or creative applications, fostering greater user involvement.
- **Versatility**: The application can be adapted for various use cases, including virtual reality, interactive presentations,and art installations, demonstrating the flexibility of combining MediaPipe with Unity.

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