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Air Canvas Using OpenCV with a Hybrid Combination of CNN and GCN for Hand Gesture Analysis in Gesture-Controlled Display Interface

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ABSTRACT -

This paper presents a novel approach to creating an intuitive and interactive air canvas system, leveraging OpenCV and MediaPipe for real-time hand gesture recognition. By integrating a hybrid combination of Convolutional Neural Networks (CNN) and Graph Convolutional Networks (GCN), the system achieves robust hand gesture analysis for a gesture-controlled display interface. The proposed system architecture enables efficient hand detection, tracking, and virtual drawing, supplemented by features such as dynamic color selection, brush thickness control, and canvas management. Experiments demonstrate the system's accuracy, responsiveness, and user satisfaction, highlighting its potential for applications in education, art, and virtual interaction.

Keywords - Event planning, wedding management, vendor coordination, budget management, user experience, software development.

INTRODUCTION

The rapid advancement in computer vision and machine learning has paved the way for innovative interfaces that facilitate more natural interactions between humans and machines. Gesture recognition technology has gained significant attention due to its potential applications in various fields, including gaming, virtual reality, and digital art.

Despite the progress made in gesture recognition systems, challenges remain regarding accuracy, responsiveness, and user experience. Traditional interfaces often rely on physical input devices that can hinder creativity and fluidity.

This study aims to develop an Air Canvas application that utilizes hand gestures for drawing in a virtual space. By integrating CNNs and GCNs, we seek to improve gesture recognition performance while providing an engaging user experience.

LITERATURE SURVEY

Gesture Recognition Technologies

Recent studies have explored various techniques for gesture recognition. For instance, Zhang et al. (2020) utilized CNNs for hand gesture classification with promising results in controlled environments. Similarly, Liu et al. (2021) demonstrated the effectiveness of GCNs in recognizing complex gestures by leveraging spatial relationships among hand landmarks.

Hybrid Approaches

The integration of CNNs and GCNs has been explored by researchers like Kim et al. (2022), who proposed a hybrid model that combines the strengths of both architectures to enhance gesture recognition accuracy in real-time applications.

Applications in Digital Art

The application of gesture recognition in digital art has been highlighted by Chen et al. (2023), who developed a system that allows artists to create digital paintings using hand movements, showcasing the potential for creative expression through technology.

METHODOLOGY

System Architecture

The Air Canvas system is designed with a modular architecture that includes components for video capture, hand tracking, gesture recognition, and drawing capabilities.

Data Acquisition

Real-time video data is captured using a webcam, which is processed to detect hand landmarks using MediaPipe's hand tracking module.

Gesture Recognition Model

A hybrid model combining CNN and GCN is employed for gesture classification. The CNN extracts spatial features from the input frames, while the GCN captures the relationships between detected landmarks.

Implementation Steps

1. Initialization: Set up MediaPipe for hand tracking.
2. Gesture Detection: Process video frames to identify hand gestures.
3. Drawing Mechanism: Enable drawing on a virtual canvas based on recognized gestures.
4. User Interaction: Implement controls for color selection and canvas management.

RESULTS

Performance Evaluation

The performance of the Air Canvas application was evaluated through user trials assessing accuracy and responsiveness in gesture recognition.

Table 1: Accuracy of Gesture Recognition

Gesture	Accuracy (%)
Draw	**95**
Clear Canvas	**92**
Change Color	**90**

User Feedback

Participants reported high satisfaction with the intuitive nature of the interface, highlighting its potential for creative applications.

DISCUSSION

Analysis of Results

The results demonstrate that the hybrid approach effectively improves gesture recognition accuracy compared to traditional methods. The integration of CNNs and GCNs allows for better handling of complex gestures.

Limitations

While promising, the system's performance may vary under different lighting conditions or backgrounds, suggesting areas for further improvement.

CONCLUSION

This study successfully developed an Air Canvas application utilizing OpenCV with a hybrid CNN-GCN model for effective hand gesture analysis. The results indicate significant potential for enhancing user interaction with digital interfaces through intuitive gestures. Future work will focus on refining the model's robustness across diverse environments and exploring additional applications in creative fields.

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