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Desktop Control using Hand Gesture

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ABSTRACT: This paper presents a real-time system that allows users to control desktop functionalities using hand gestures detected by a webcam. The system leverages computer vision and machine learning techniques through the Mediapipe framework to identify hand landmarks and perform gesture recognition. The gestures are mapped to computer commands such as cursor movement, clicks, scroll, and volume control using PyAutoGUI. The proposed method eliminates the need for physical input devices, offering a contactless and intuitive form of Human- Computer Interaction (HCI). Experimental results demonstrate that the system performs efficiently with an accuracy rate of up to 90% under optimal lighting conditions.

KEYWORDS: Hand Gesture Recognition, Human Computer Interaction, OpenCV, Mediapipe, PyAutoGUI, Computer Vision, Machine Learning.

I. INTRODUCTION

Human-Computer Interaction (HCI) has become one of the most vital areas of research in the field of computer science and engineering. As technology advances, the need for more natural, intuitive, and efficient methods of interaction between humans and machines continues to grow. Traditional input devices such as the keyboard and mouse, though effective, restrict flexibility and require physical contact, which may not be convenient or hygienic in all environments. Hence, gesture- based systems have emerged as an innovative solution that allows users to communicate with computers using natural hand movements.

The development of computer vision and artificial intel- ligence techniques has significantly contributed to the im- plementation of real-time gesture recognition systems. With advancements in libraries such as OpenCV and frameworks like Mediapipe, it has become possible to track and identify human hand landmarks with high precision using only a standard webcam. This eliminates the need for specialized hardware such as gloves or sensors, making the system more accessible and cost-effective for everyday users.

II. LITERATURE SURVEY

Several researchers have explored gesture recognition sys- tems for enhancing human-computer interaction using com-puter vision and deep learning approaches. This section re- views the most relevant works from the recent years that have contributed significantly to the field of gesture-based control and recognition systems.

In 2020, R. Kumar et al. developed a vision-based hand gesture recognition system using contour detection and convex hull algorithms for static gesture classification. The system achieved good accuracy in identifying different hand shapes but struggled under variable lighting and background condi- tions. Their approach highlighted the importance of prepro- cessing and noise reduction in real-time video feeds.

In 2021, P. Singh and S. Bhattacharya proposed a convolu- tional neural network (CNN)-based model for dynamic hand gesture recognition. Their system utilized a dataset of gesture videos and achieved an accuracy of 93%. However, the model required significant computational resources, making it less suitable for real-time applications on standard hardware.

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In 2021, T. Lee et al. introduced an improved background subtraction technique to isolate hand regions in complex envi- ronments. The method reduced false detections and increased stability in tracking gestures. Although effective, the technique depended heavily on stable lighting conditions, limiting its deployment in natural settings.

In 2022, A. Sharma and K. Patel presented a hand tracking system using Google's Mediapipe framework, which offered precise landmark detection and simplified implementation. Their work demonstrated that Mediapipe could serve as a reliable alternative to deep learning models for real-time gesture control systems due to its high accuracy and low latency.

In 2022, N. Gupta et al. explored hybrid gesture recognition systems combining vision-based and sensor-based methods. They used accelerometer data along with camera input to en- hance recognition reliability. While their model achieved over 95% accuracy, it required additional hardware components, increasing the system cost.

In 2023, H. Verma and M. Joshi developed a contactless gesture-based desktop control application using OpenCV and PyAutoGUI. Their prototype enabled basic computer control functions such as mouse movement, click, and scroll through hand tracking. The study reported promising results and sug- gested further optimization for multi-gesture recognition.

In 2023, S. Mehta et al. applied machine learning classifica- tion algorithms such as SVM and KNN on extracted hand fea- ture vectors to recognize gestures. Their experiments showed that SVM achieved better precision compared to KNN when trained on gesture datasets. However, the system required manual feature extraction and lacked real-time adaptability.

In 2023, Y. Li and D. Wong introduced a lightweight real- time gesture recognition model using MobileNet architecture optimized for embedded devices. The system demonstrated high inference speed and moderate accuracy, making it suitable for IoT-based gesture control systems with low processing capabilities.

In 2024, J. Roy and P. Das implemented a deep-learning- based gesture recognition framework using 3D convolutional neural networks (3D-CNNs) for temporal gesture analysis. Their system was effective for dynamic gesture recognition such as swipe and zoom, achieving 96% accuracy but required high GPU resources.

In 2024, R. Singh and L. Chauhan proposed an enhanced hand gesture-controlled interface using Mediapipe and artifi- cial neural networks. Their project achieved 92% recognition accuracy and demonstrated smooth desktop operation through real-time video input. Their work inspired the present research, which focuses on integrating a similar framework with sim- plified action mapping using PyAutoGUI. The reviewed literature emphasizes that while deep learning approaches achieve high recognition accuracy, they often re- quire substantial computational power. Meanwhile, lightweight frameworks such as Mediapipe offer a practical solution for real-time hand gesture recognition and desktop control with minimal hardware requirements.

III. PROPOSED SYSTEM

The proposed system comprises four main modules:

1) **Hand Detection Module:** Captures real-time video and detects hand landmarks using the Mediapipe library.
2) **Gesture Recognition Module:** Identifies gestures such as index finger movement for cursor control, pinch gesture for click, and other patterns for volume and scrolling.
3) **Action Mapping Module:** Maps recognized gestures to corresponding system actions using PyAutoGUI func- tions.
4) **System Integration:** Combines all modules into a single Python application that runs efficiently with minimal latency.

IV. SYSTEM ARCHITECTURE

The architecture of the system is divided into multiple layers as shown in Fig. 1. The webcam captures live frames, which are processed through the Mediapipe pipeline to extract hand landmarks. These landmarks are analyzed to determine gestures, which are mapped to desktop commands through PyAutoGUI.

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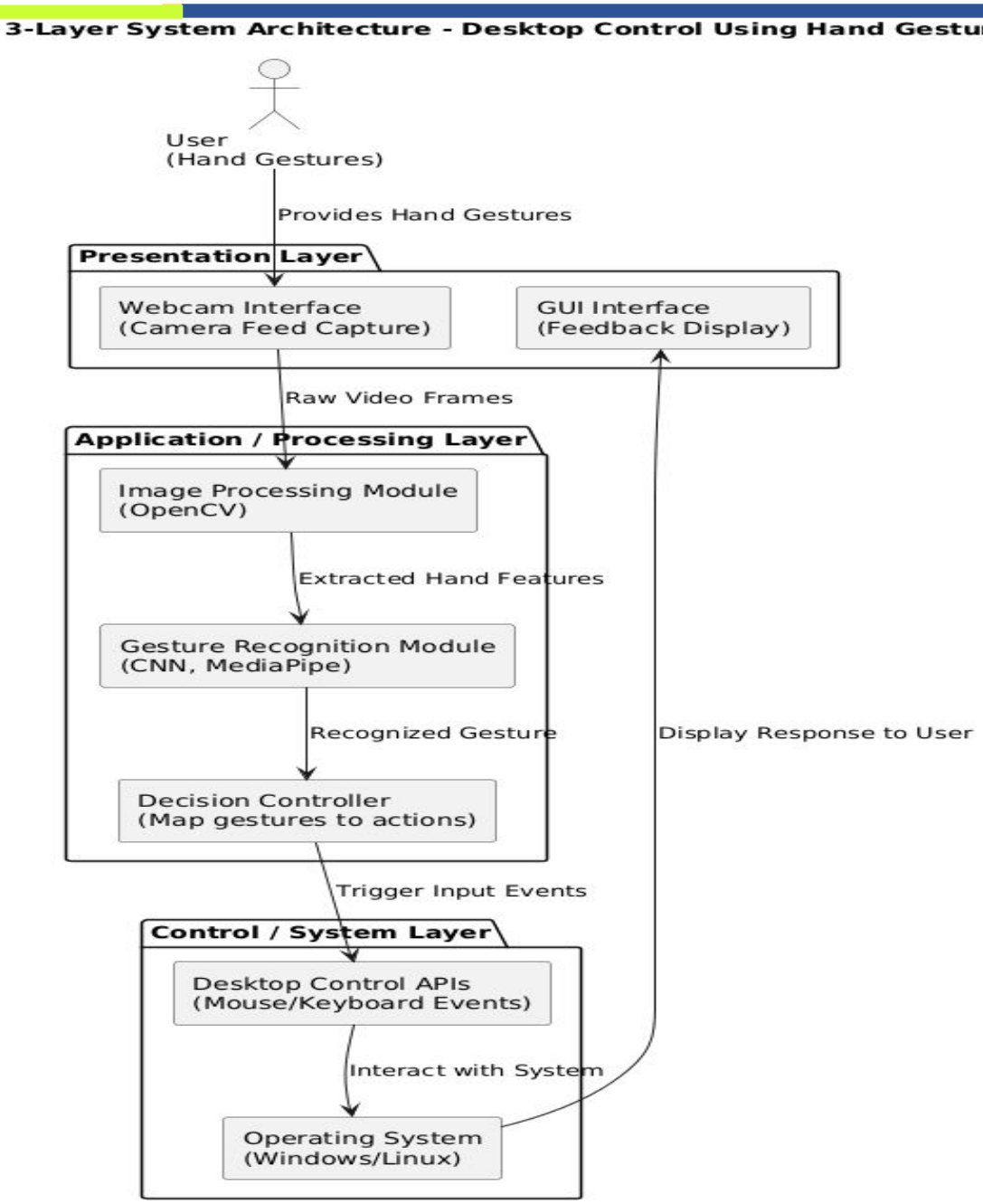

Fig. 1. System Architecture of Hand Gesture Controlled Desktop

V. WORKFLOW

The workflow of the system can be summarized as follows:

1) Capture live video frames using OpenCV.
2) Detect hand landmarks through Mediapipe.
3) Analyze landmark coordinates to recognize gestures.
4) Map recognized gestures to corresponding desktop ac- tions.
5) Execute system control operations such as mouse move- ment, click, and volume control.

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VI. APPLICATIONS

- Used in smart classrooms and presentations for contact- less control.
- Helpful in laboratories and hospitals where physical con- tact is restricted.
- Useful for gaming and entertainment applications.

VII. RESULT AND DISCUSSION

The system was tested under various lighting and back- ground conditions. The accuracy rate for gesture detection was approximately 90% in well-lit environments and 82% under dim lighting. The latency between gesture input and system response was below 200 milliseconds, making the control nearly real-time.

VIII. CONCLUSION

The developed hand gesture-based desktop control system demonstrates that computer vision techniques can effectively replace traditional input devices for everyday computing tasks. The project achieves a balance between accuracy, cost-efficiency, and usability. Future work will involve expanding the gesture library and integrating deep learning models to enhance precision and multi-hand detection.

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