

Project Report: Real-Time Hand Gesture Recognition

Project Title

Real-Time Hand Gesture Recognition Using Computer Vision

Objective

The primary goal of this project was to develop a real-time system capable of recognizing hand gestures using computer vision techniques. The aim was to facilitate touchless human-computer interaction, which is increasingly relevant in areas like sign language interpretation, robotics control, and virtual environments.

Tools and Technologies Used

- Programming Language: Python
- Libraries and Frameworks:
 - OpenCV (for real-time video processing)
 - MediaPipe (for efficient hand tracking and landmark detection)
 - NumPy (for array and mathematical operations)
- Hardware Requirements:
 - Webcam (for capturing real-time hand gestures)

Methodology

The project follows these major steps:

1. Video Capture: The webcam is accessed in real-time to capture hand movements.
2. Hand Detection and Tracking: MediaPipe's hand solution is used to detect hand landmarks efficiently.
3. Gesture Recognition: Based on the relative positions of landmarks, specific gestures (such as counting fingers) are identified.

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4. Result Display: The detected gestures are displayed on the video feed with bounding boxes and landmark overlays.

Features

- Real-time processing with minimal delay
- Detection of multiple hand gestures (such as open hand, fist, and numerical finger count)
- Visual feedback including gesture labels and hand tracking annotations

Results

- The system successfully recognized gestures in real-time with high accuracy under good lighting conditions.
- It was capable of distinguishing gestures involving different numbers of fingers and provided live visual feedback through OpenCV windows.

Challenges Faced

- Variability in lighting conditions occasionally affected detection accuracy.
- Differentiating between similar gestures required careful calibration of landmark coordinates.
- Performance dropped slightly when multiple hands were present or when the background was cluttered.

Conclusion and Future Work

The project demonstrates a functional prototype for real-time hand gesture recognition using open-source tools. Future improvements could include:

- Integration of a machine learning model for more complex gesture classification.
- Enhanced robustness to lighting and background variations.

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- Extension to dynamic gestures (such as waving or directional motion).