Smart Fan Control Using Image Processing

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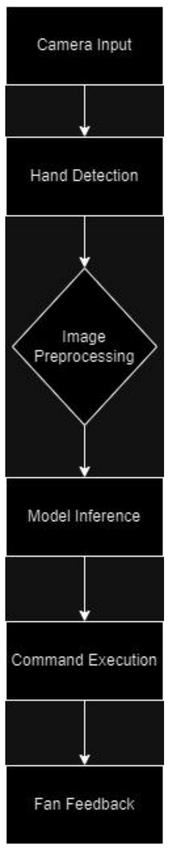
Abstract

This project presents a smart fan control system that utilizes AI and machine learning, specifically neural networks, to recognize hand gestures and control fan operations. Using Google's Teachable Machine, we trained the system to recognize five distinct hand gestures. These gestures are translated into commands such as turning the fan on or off, increasing or decreasing speed, and setting a specific speed. For data collection, an automated process was used to detect hand gestures, eliminating the need for manual polygon annotation. This innovative system integrates deep learning, motor control, and IoT, offering a hands-free solution for controlling appliances.

Introduction

The growing advancements in artificial intelligence (AI) and machine learning (ML) have led to new possibilities for smart home appliances. This project aims to develop a smart fan control system that uses hand gesture recognition, powered by Google's Teachable Machine. Data collection was performed using an automated hand detection process instead of manual annotation tools like the polygon tool. By combining image recognition and hardware control, the system showcases the practical applications of AI in home automation.

Methodology

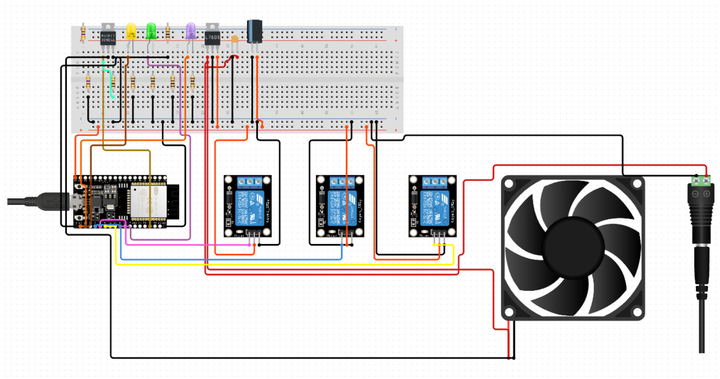


Workflow Chart for Hand Gesture Recognition

- The flowchart details the step-by-step process of how the system recognizes hand gestures and converts them into fan control commands.
- Camera input: The process begins with capturing an image of the hand.
- Hand detection: The system identifies the hand in the image.
- Preprocessing: The image is cropped and resized for further analysis.
- Gesture recognition: The preprocessed image is passed to the Teachable Machine model for gesture identification.
- Command execution: Once a gesture is recognized, the ESP32 sends the appropriate command to control the fan's speed or state.
- Feedback: The system provides feedback through LEDs.

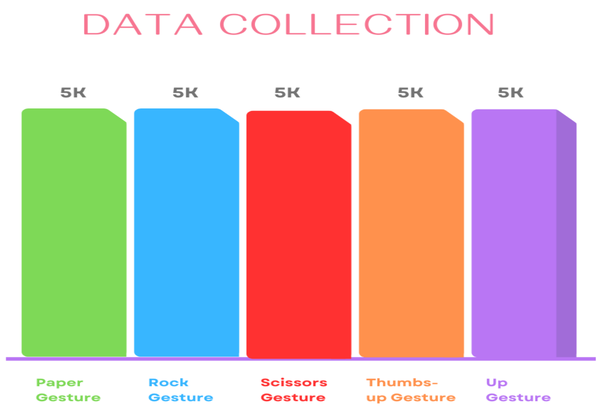
System Architecture Diagram

This diagram illustrates the complete architecture of the smart fan control system. It shows how the components - such as the ESP32 controller, relay module, and fan-interact with each other. It also demonstrates the flow of data from the camera that captures hand gestures to the Teachable Machine model, which classifies the gestures, and the ESP32 that processes the input to control the fan. The diagram highlights the seamless integration of AI with hardware to achieve a fully functional hand gesture-controlled system.



Data Collection

- The bar chart represents the number of images collected for each hand gesture during the data collection phase.
- A total of 5000 images per gesture were captured automatically using OpenCV and the HandDetector module from the cvzone library.
- Each gesture is adequately represented in the dataset.
- This provides a balanced training set for the machine learning model.
- A balanced dataset leads to more accurate gesture recognition.



Model

Accuracy per class

CLASS	ACCURACY	# SAMPLES
Paper	1.00	750
Rock	1.00	750
Scissors	1.00	750
Thumbs_up	1.00	750
Up	1.00	750

The table represents the accuracy per class for the hand gesture recognition model, showing that the model has achieved perfect accuracy (1.00) across all five gesture classes: Paper, Rock, Scissors, Thumbs_up, and Up. For each class, 750 samples were used during training, and the model correctly classified all samples without errors, resulting in a 100% accuracy for each class. This indicates that the model has learned to distinguish these gestures with high precision, and the gesture recognition system is highly reliable for controlling the smart fan in real-time.

Conclusion

This project demonstrated the feasibility of using Teachable Machine and AI-based gesture recognition to control a fan via hand gestures. The automated data collection process using hand detection played a key role in simplifying dataset creation and improving the model's accuracy. The system highlights the potential of AI-driven home automation and offers a foundation for further enhancements, such as incorporating more gestures and optimizing recognition under different environmental conditions.

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