Handy Hand

A mobile robotic arm based on gesture recognition and computer vision

EECS 452: Digital Signal Processing Design Lab – Fall 2023

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Overview

- A mobile robotic arm based on gesture recognition and computer vision
- Pick up and move objects to a given location
- A high degree of freedom robotic arm
- A camera module for distance measurement and object recognition
- Control the robot arm in real-time through computer vision

Robotic arm

- A series of interconnected segments with joints that provide degrees of freedom (DOF) for movement
- Flexible, able to reach any positions and orientations
- DC motors controlled by H-bridges
- All H-bridges controlled by the ESP32 (MCU)
- Adjustable motor speed

System Architecture

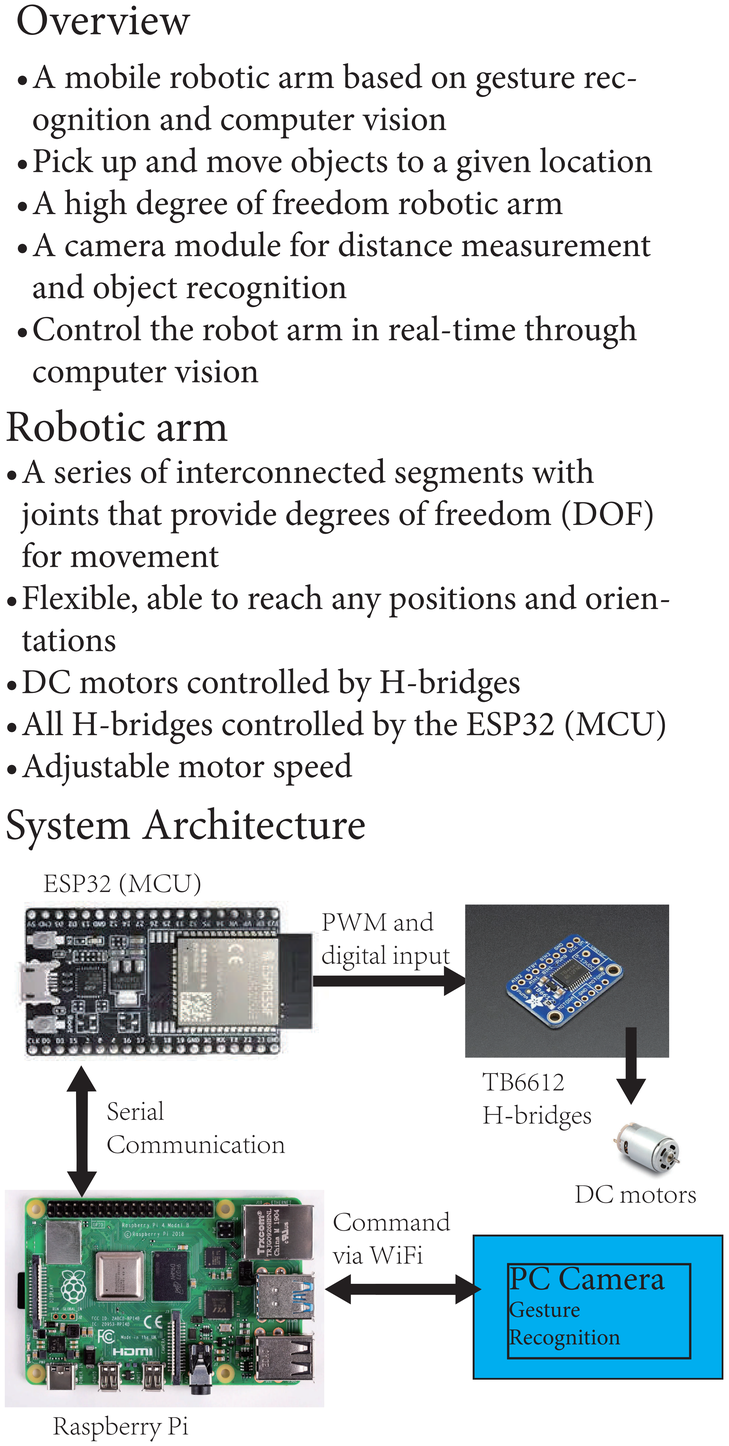


Figure 1. System architecture

Gesture Recognition

- Using Mediapipe, a framework for building multi-modal (e.g., video, audio, any time series data) application ML pipelines
- Obtain coordinates of the key points of the fingers to identify gestures

OpenCV

- Open source computer vision library
- Statistical pattern recognition and clustering
- Measure distance between object and car

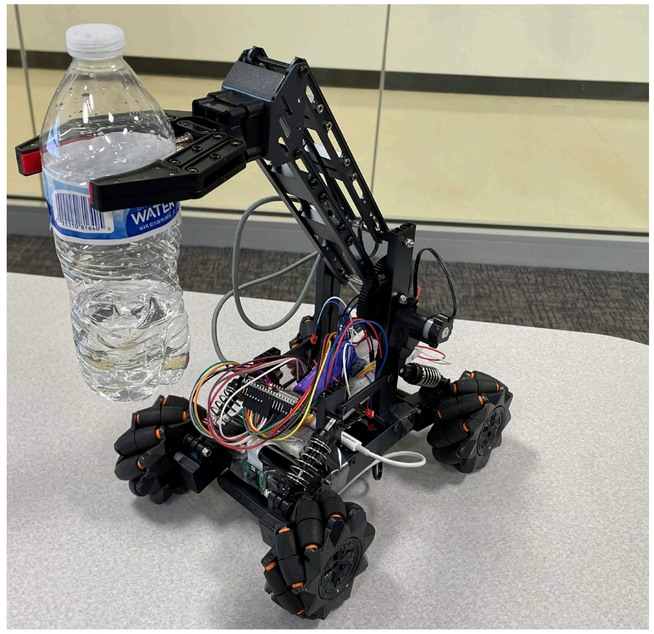


Figure 2. Product Prototype

Communication

- Real-time
- Laptop computer sends commands based on gesture recognition
- Raspberry Pi collects command data from PC via WiFi using socket
- Serial communication between Raspberry Pi and ESP32 (MCU)

Algorithm

- PC side: A buffer that identify the most common recognized gesture within 10 frames
- Implement Mediapipe
- Pi side: Adjustable thresholds for on-board camera's edge detection
- Real-time WiFi communication and Serial communication

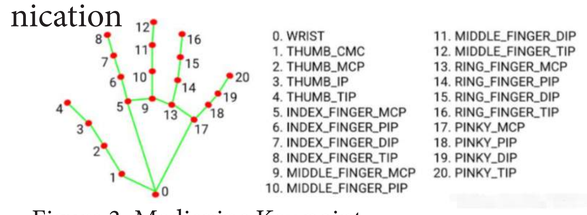
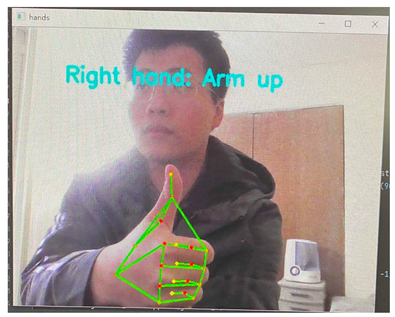


Figure 3. Mediapipe Key point

Result



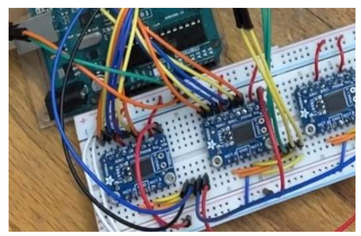


Figure 4. Mediapipe for hand gesture recognition, circuit layout of H-bridges and MCU

- 0.1s delay communication
- 13 types of recognizable hand gesture for both hands
- Real-time hand gesture recognition with accuracy higher than 90%
- Reliable distance measurement with error less than 10%
- Real-time driving motors, with fast and slow modes

Acknowledgement

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