Final Presentation
Gesture-Controlled Speaker

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    b. Data processing
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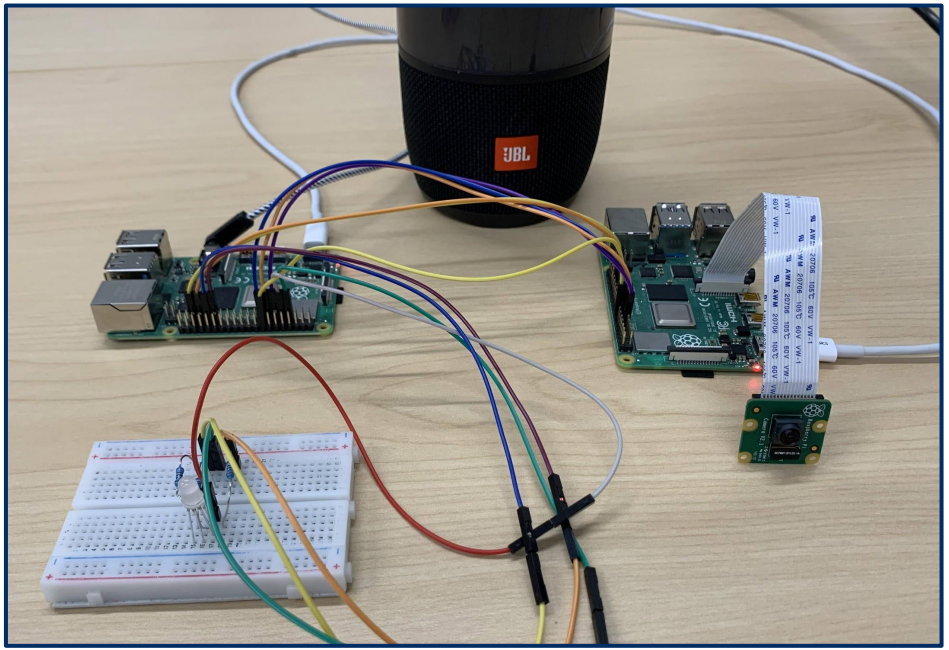
Introduction

Speaker that responds to five hand gestures

- Raise & Lower Volume
- Play & Pause
- Skip Song
- Go Back a Song



Motivation

Hygiene

- No physical contact
- Possibility of social distancing

Accessibility

- Voice control can be difficult to use with an accent or speech impediment

Adaptability

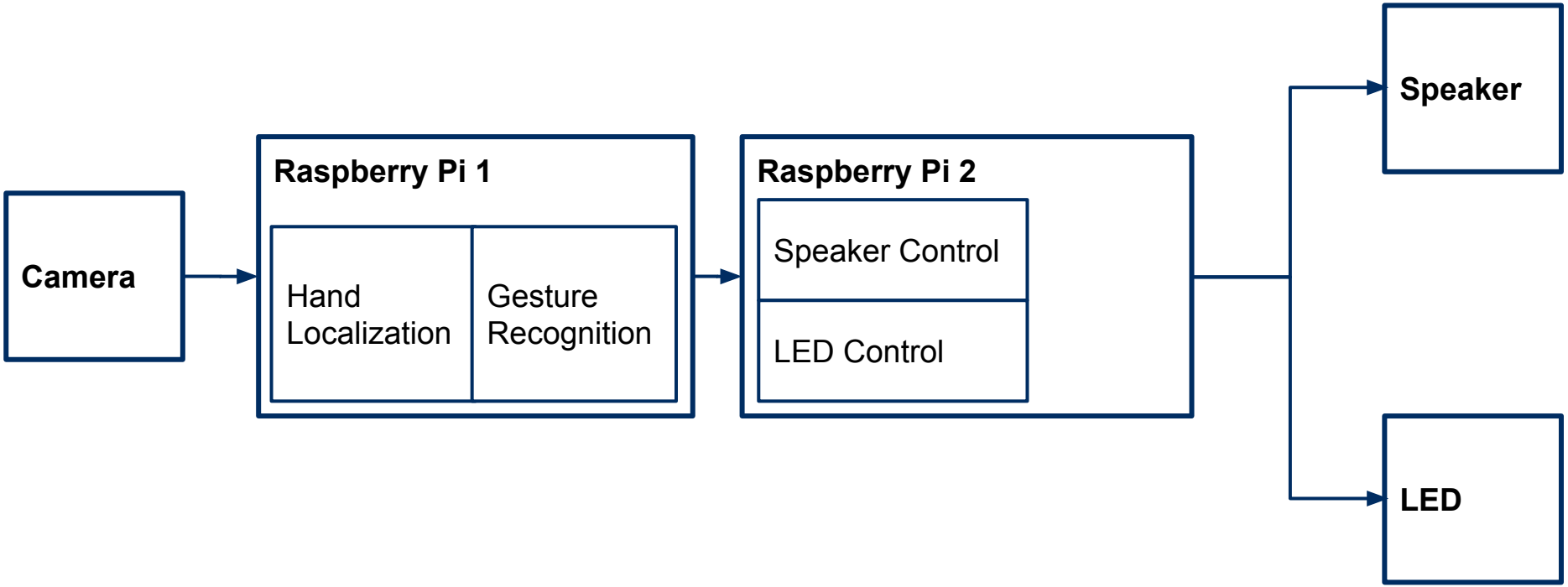
- Technology can be applied to other products

Work Breakdown

	Isabel	Dale	Renee	Kevin	Eli	Theo
Team Lead					X	
System Integration	X	X	X	X	X	X
IR/other sensor selection and integration		X		X		X
Image feature extraction	X		X		X	
Machine learning model selection and training			X		X	
Speaker integration	X	X		X		X
Lighting system integration				X		
Music selection		X		X		

System Architecture

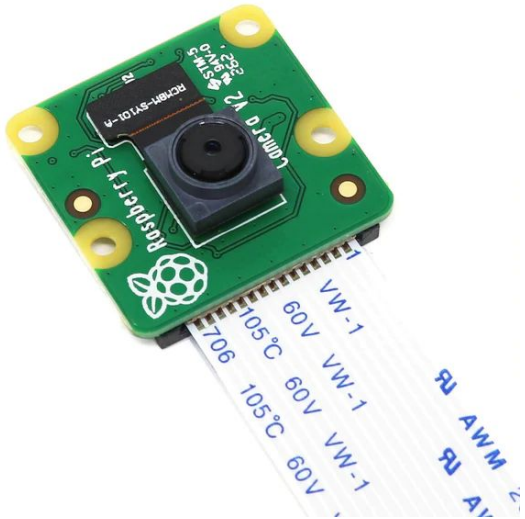
Three main phases: data acquisition, data processing, decision and actuation



Data Acquisition

Raspberry Pi Camera

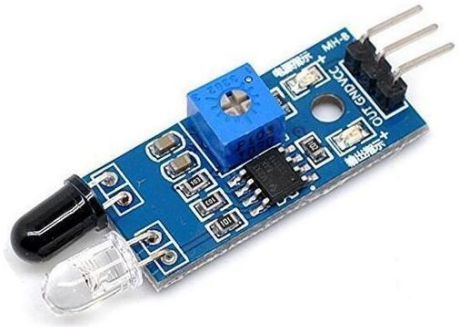
- Used to send image data to RPi to be processed
- Camera continuously captures images
  - Sent to gesture decision making RPi (RPi 1)
- Could run up to 30fps



Data Acquisition

IR Sensor

- Was going to be used to limit processing/active time of system
- Decided not to include in final design due to unreliability
  - Sensors either didn't have a sufficient range or their data transmission was inconsistent
- Inconsistencies could be due to lack of ground-ground between RPis
  - By the time this issue was discovered, we found the IR was unnecessary anyway



Data Processing - Goal

Hand Localization

- Given a camera frame, find and isolate relevant hands
- Return hand data

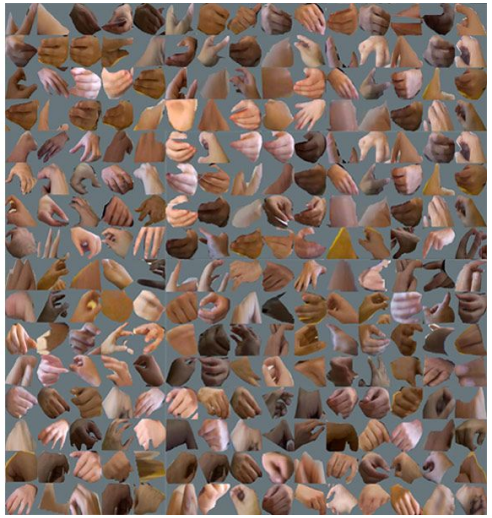
Gesture Classification

- Given hand data, determine which hand gesture is being made
- Return identified gesture

Hand Localization - Process

Tensorflow + transfer learning

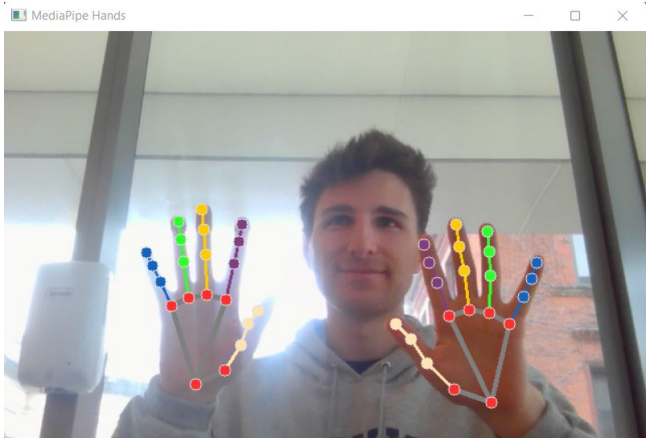
- Slow training process
- Required lots of data
- Low fps

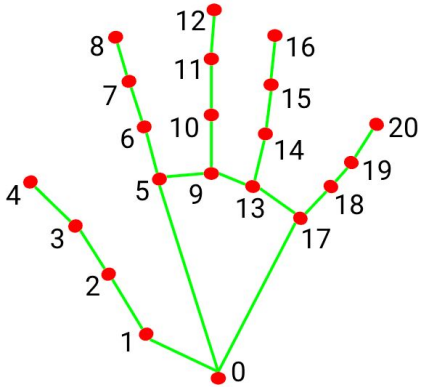


Hand Localization - Result

MediaPipe (Google’s open-source ML pipelines)

- Palm detection model operates on full image, returns a hand bounding box
- Hand landmark model operates on cropped image, returns 21 hand keypoints
- Fastest option





0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP

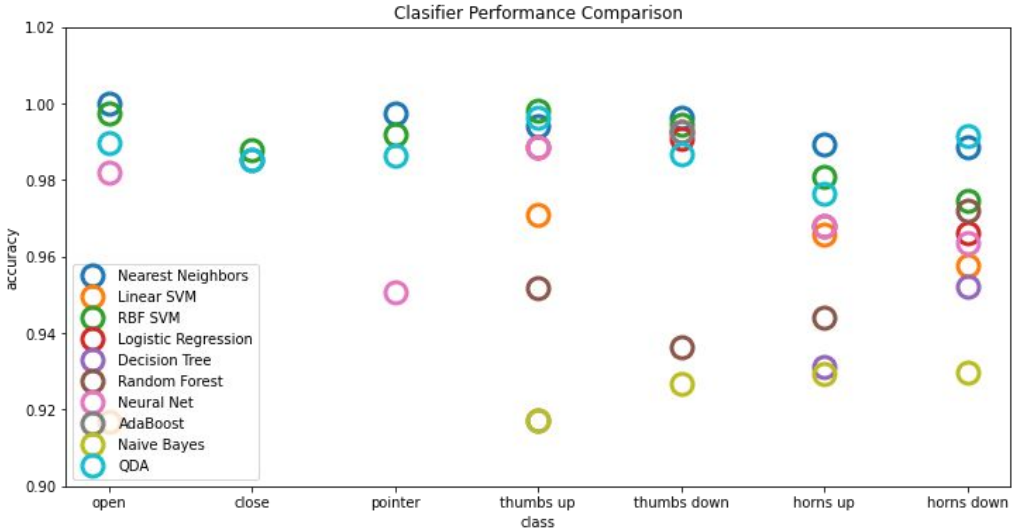
Gesture Classification - Process

Classification based on images

- CNN is slow, heavyweight
- Implementation with 10 gestures: ~50% misclassification

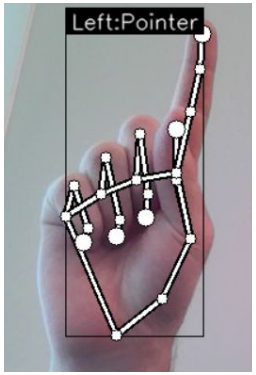
Classification based on keypoints

- Fast, accurate
- Lighting invariant

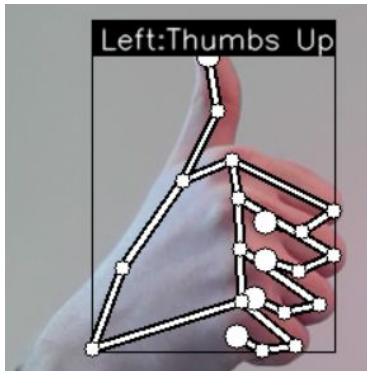


Gesture Classification - Results

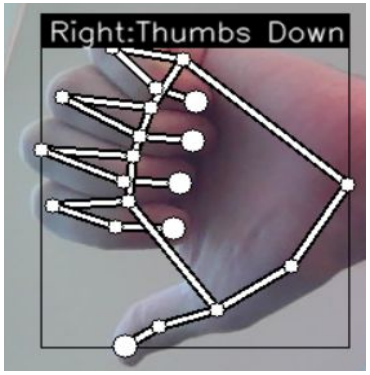
Detect and respond to five gestures with ~92% accuracy



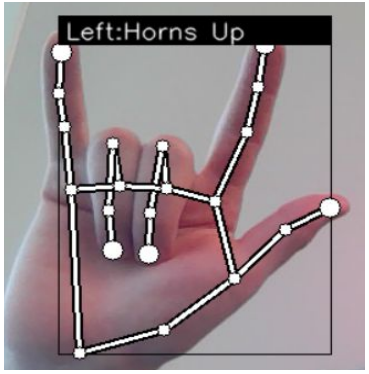
Play/Pause



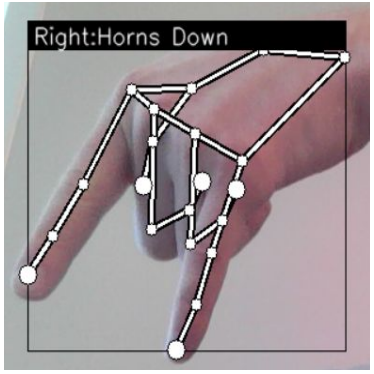
Volume Up



Volume Down



Skip Song



Go Back a Song

Decision and Actuation - Goal

Command Speaker

- Assign each gesture a number, which corresponds to a speaker function
- Gesture number passed to speaker program, perform function

LED Feedback

- Light up an LED to let user know that their gesture was detected
- Each gesture would correspond to a different color on the LED

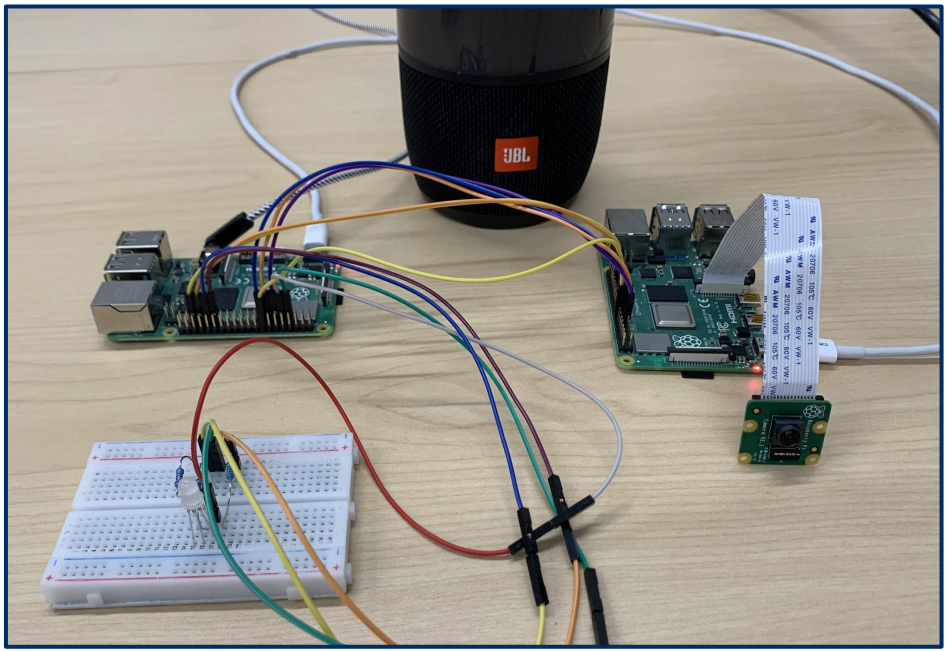
Decision and Actuation - Process

VLC Media Player with AUX speaker

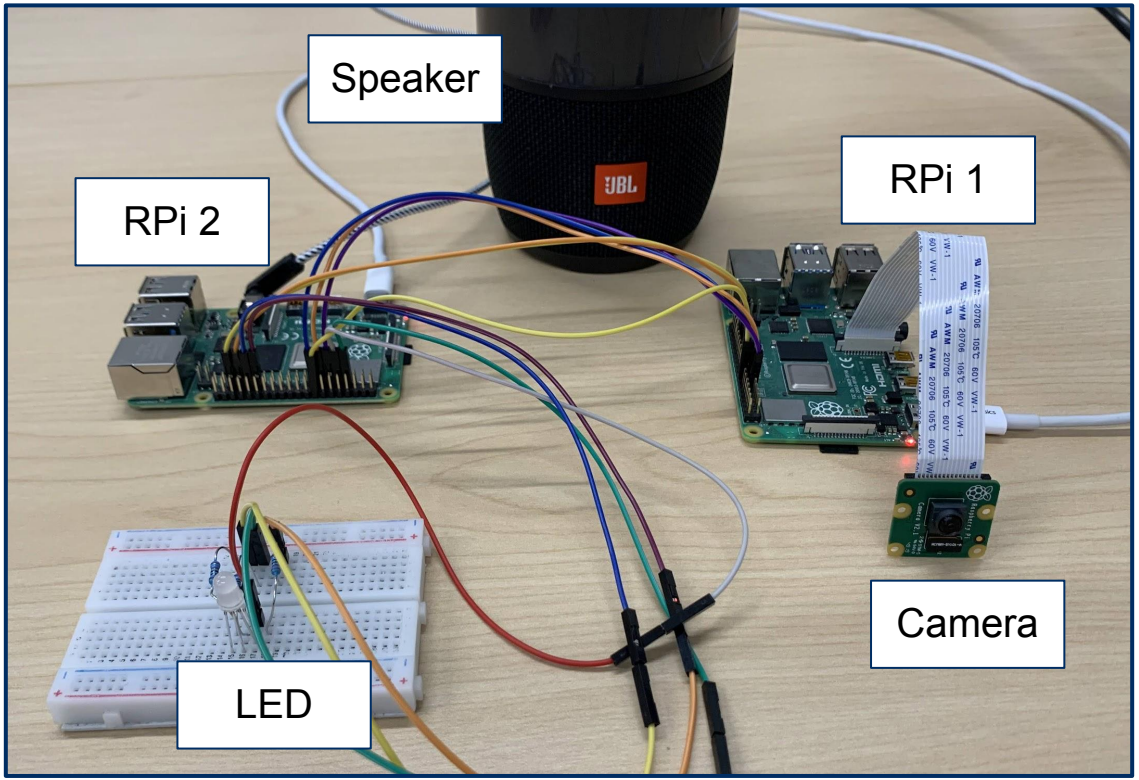
- Pause/play, set volume functions for playlist of pre-downloaded songs

Double RPi Setup

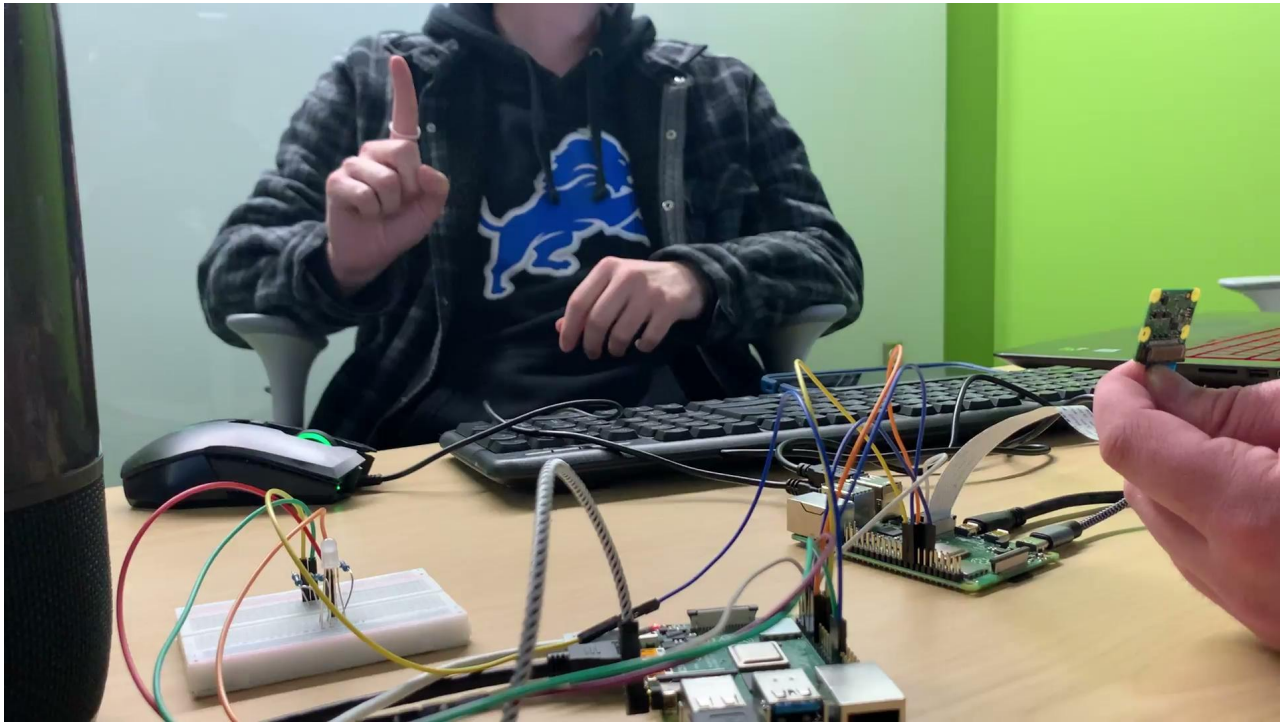
- One RPi does not have the power to perform gesture detection and actuation
- Send detected gesture to second RPi via GPIO



Decision and Actuation - Result



Demo



Design Expo

Future Work

- Second sensor that is more robust than original IR sensor
- Second LED to show user if there hand is being fully detected
- Code starts up with Raspberry Pi
- Encasing around entire system

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