Machine To Human Vision

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INTRODUCTION

WHO

Visually impaired individuals, ranging from partial blindness to complete blindness.

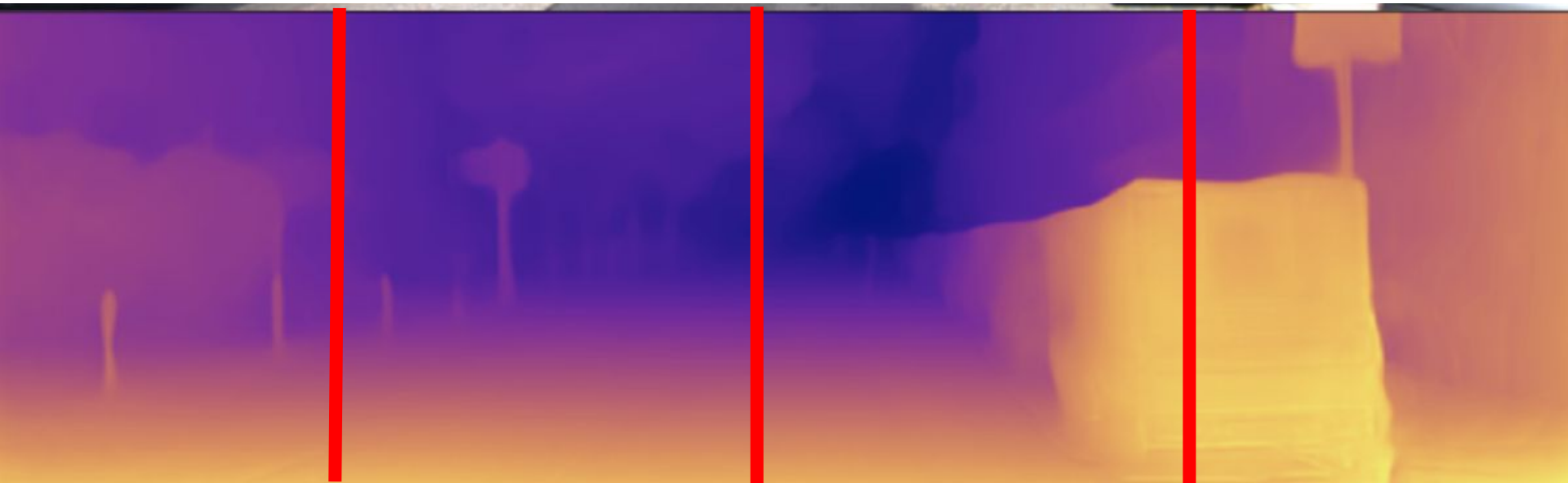
WHAT

An interface by which users receive vital information about their environment.

WHY

Help users perceive objects and surroundings similar to that of someone with normal eyesight.

INTRODUCTION - HIGH LEVEL CONCEPT



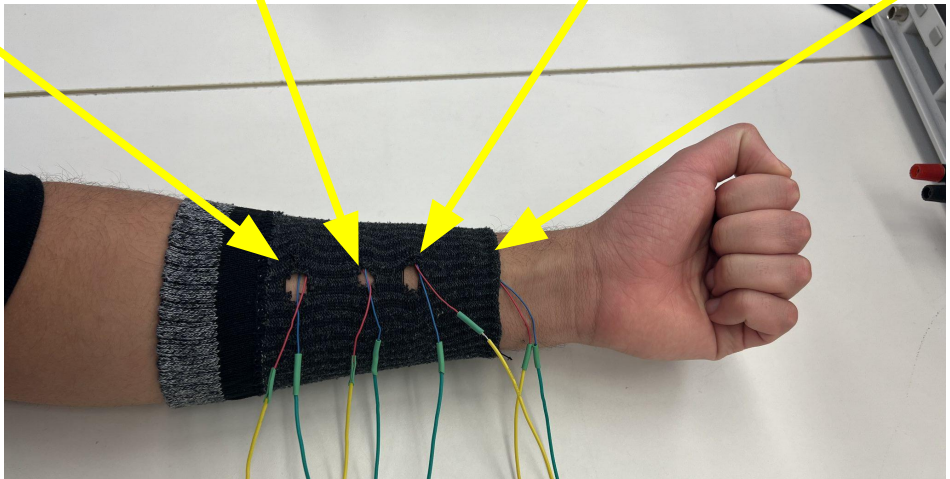
INTRODUCTION - HIGH LEVEL CONCEPT

43%
4 meters

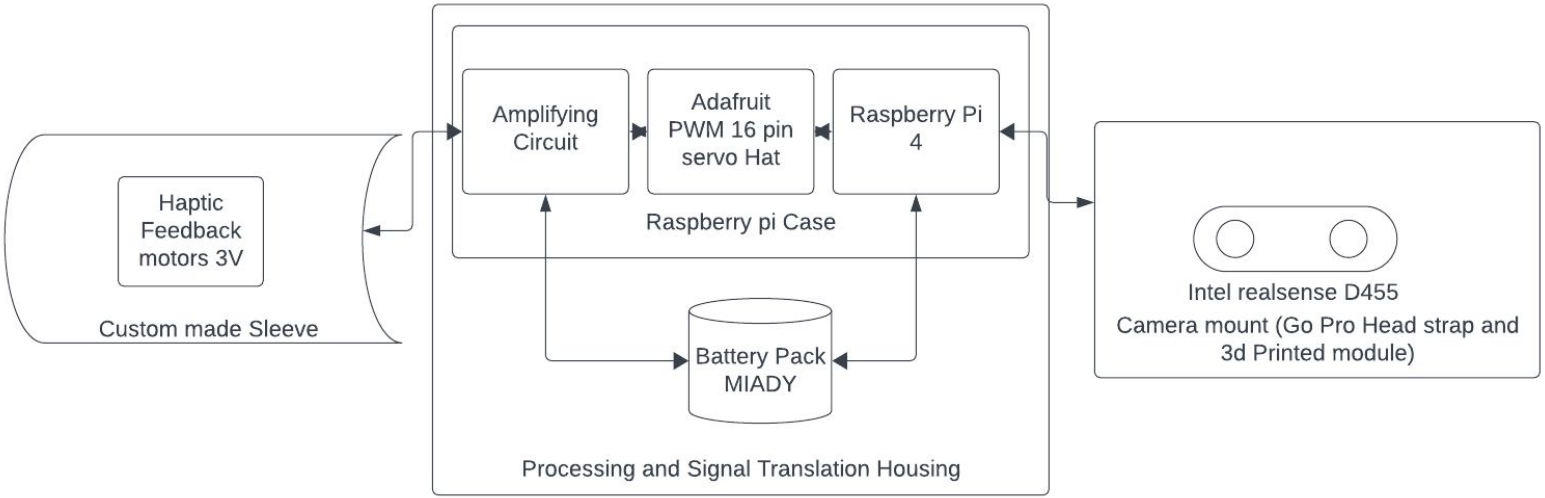
15%
6 meters

72%
2 meters

79%
1.5 meters



INTRODUCTION - HIGH LEVEL DESIGN



DETAILED DESIGN - HARDWARE

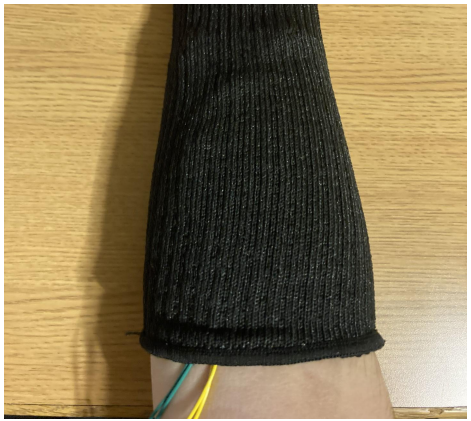
Raspberry Pi 4 for computing.

D455 camera for depth detection.

Portable power bank for power.

Haptic motors for vibrational output.

DETAILED DESIGN - CLOTHING MODULES



Sleeve

Prototype sleeve used in current design

Housing

We are using a chest rig to house the Raspberry Pi, Battery Pack, and transistor circuit.

Camera Mount

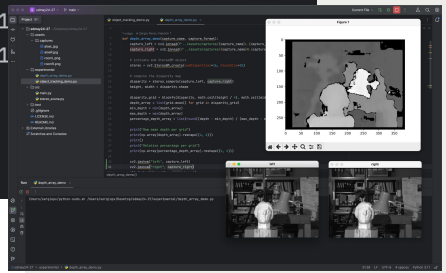
We are using a pre-existing head strap to mount the d455i Camera.

DETAILED DESIGN - SOFTWARE

Libraries: Python realsense2, CV2, & numpy

1. D455i camera depth information is captured as numpy array.
2. Full depth array is condensed into smaller cells to represent the haptic motor grid.
3. A single depth point is calculated from each cell that determines strength of vibration.

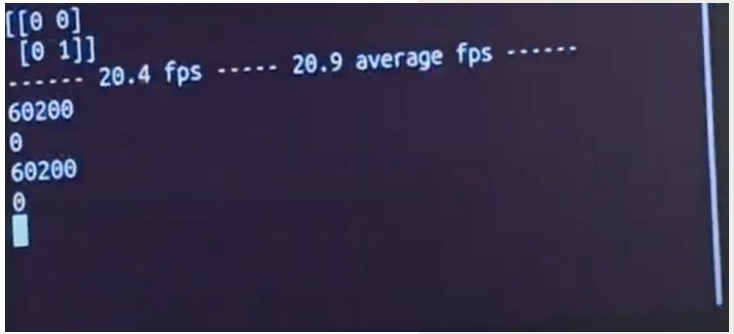
```
/Users/sergiopv/python-sudo.sh /Users/sergiopv/Desktop/sdmay24-2
--- 0.03295 seconds ---
-- COMPUTE TIME PASS --
[[ 82  81  81  81  80  80  81  81  79  82  81  80 115  -1   0]
 [ 82  81  82  81  80  83  81  93  83  84  79  81  83  86  87]
 [ 83  83  88 100 100  99  86  86  84  84  88  82  82  83  83]
 [ 83  83  98  98  99 100  96 120 127  81  81  83  82  84  83]
 [ 82  81  99  99  99  99  97 149 128 240  79 127  86  82  83]
 [ 83  82  80  91  99  98  98 143 219 240 231 127 124  82  84]
 [ 82  82  80  77  99  98  80 128 227 229 240 220 129  82  82]
 [ 83  82  79  92 108 178 176 198 232 228 231 230 132  84  84]
 [ 83  81  79  97 165 170 173 232 240 240 231 231 133 240 225]
 [ 85  82  84  98 167 172 174 170 232 240 240 128 131 202 100]
 [ 82  82  87  97 166 173 175 169 158 1
 [ 85  83  94  95 195 187 174 165 141 1
 [ 86  86 166 173 195 188 175 174 171
 [ 83  87 177 184 184 181 182 181 180
 [ 83  84 199 195 184 183 181 182 180
```

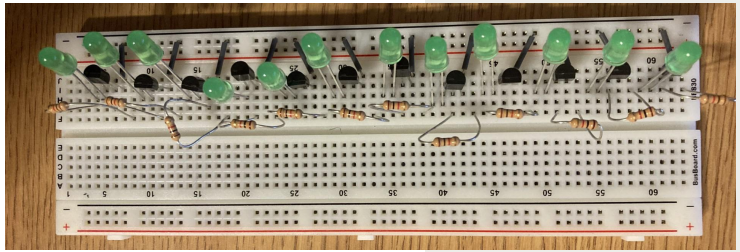


** LARGER NUMBER = CLOSER DEPTH*

PROGRESS MADE

1. Successful integration of D455i camera with Raspberry Pi, Adafruit Hat, and haptic motors.
2. Optimized the Raspberry Pi to read camera data at 70 FPS.
3. Integrated motors into sleeve as a wearable prototype.



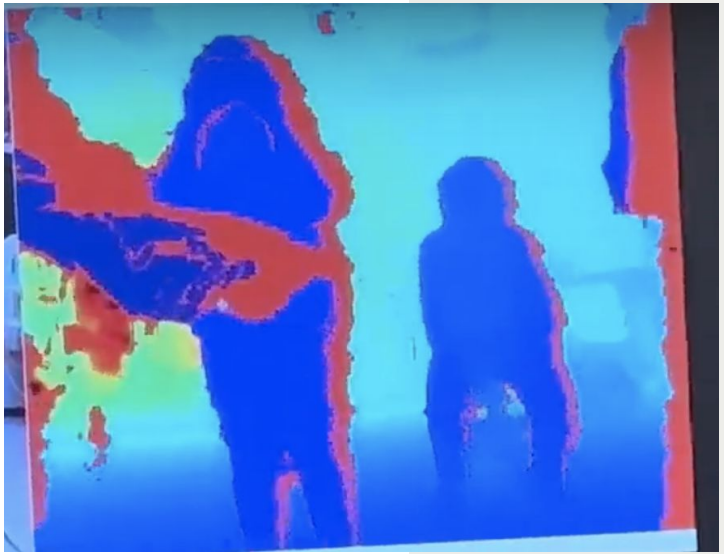


PROGRESS MADE

1. Eliminated D455i camera's detection of shadows of objects.

2. The PWM output ports of the Adafruit HAT output amperage to the haptic motors in proportion to the depth of objects detected by the D455i.

3. New Raspberry Pi SD card with Ubuntu OS and more storage was acquired to account for all necessary Python libraries needed



PROGRESS MADE - OVERALL TASKS

1. Complete final integration of all hardware and software components - 80% complete
   TODO:
   a. Fabricate circuit that connects all 16 haptic motors to Adafruit output pins with proper amperage being output to motors

2. Design haptic motor sleeve that is user friendly and allows skin to sense haptic motor vibrations - 60% complete
   TODO:
   a. Attach all 16 motors to sleeve
   b. Create a cover for motor array to protect user skin

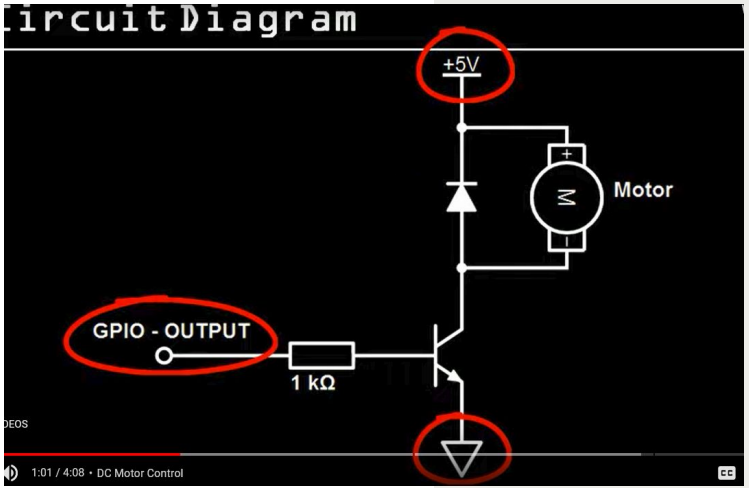
3. Test sleeve for usability, efficacy, and comfort - 30% complete
   TODO:
   a. Test different configurations of motor array
   b. Prepare and run an obstacle course for navigation testing

DEMONSTRATION

CHALLENGES AND SOLUTIONS

We initially had an issue where our Adafruit Pi Hat wasn't outputting enough current to power each motor effectively.

- The low current minimized vibration from the motors.
- We solved this issue by devising a breadboard circuit with transistors that amplify the current.
- We're designing and ordering a PCB to support this circuit for our final design.



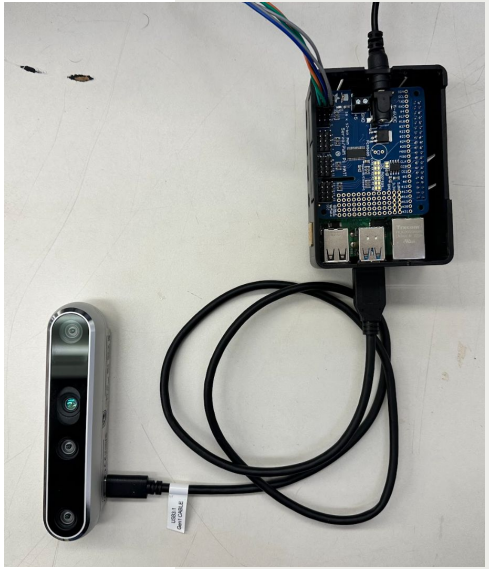
CHALLENGES AND SOLUTIONS

Configuring the haptic sleeve to optimize the user experience continues to be a challenge.

- We need differences in the motors' vibration to be highly perceptible.
- We minimize the vibrations lost to the sleeve by making the fabric covering the motors thin.

The Raspberry Pi was not computing depth data at an adequate framerate.

- We increased the framerate by setting a threshold that removes outlier depth values.



CONCLUSION

- So far, we are able to get depth from the D455 camera, process that data into inputs for the haptics motor, and vibrate a select few motors.
- Remaining work includes:
  - Creating a permanent Raspberry Pi-Breadboard connection.
  - Expanding the software to control 16 motors.
  - Devising an algorithm to translate depth information to useful levels of vibration.
  - Performing navigation testing with a full prototype.
- As the semester closes we are increasing our hours put in, and we are on schedule for completion.