Department of Electrical & Computer Engineering

Boston University
Electrical & Computer Engineering
EC464 Capstone Senior Design Project

Second Prototype Test Report

by

Team 3
Opticle

Team Members

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I. Required Materials

A. Hardware:
- Raspberry Pi 4 Model B (with 16 GB MicroCenter SD card)
- Charmast Portable Power Bank
- OpenCV AI Kit: OAK-D Camera
- Linear Resonant Actuator
- SB300 Solderable PC Breadboard
- Desktop monitor
- Keyboard
- Mouse

B. Software:
- Python 3 Scripts:
  - Point Cloud Detection
- Motor Control:
  - Raspberry Pi GPIO

C. Other:
- Platinum Extreme Accessory Kit (Chest Mount)
- 3-D Printed Wrist Mount

II. Set-Up

Our set-up was consistent with the second prototype test plan. Prior to the demo, we measured the distances that we wanted to test with the tiles of the Photonics Building Floor so that the person serving as the obstacle knew where to stand for each testing step. One of our team members served as an obstacle to test the detection of our model with varying distances.

Our set-up included both software and hardware components: an object detection Python script that is run on a Raspberry Pi 4, which is connected to an OAK-D camera and wired to a linear resonant actuator. The hardware was attached to a chest mount where the camera was mounted to a screw in the middle and the Pi and portable battery were attached to the body of the user. Both the Pi 4 and OAK-D were connected to a portable battery to receive power. The actuator was attached to a 3-D printed wrist mount, where it was soldered to wires that ran along the user's arm and back to the Pi 4. This wrist mount is meant to be worn like a watch where the actuator is touching the user's skin. The Pi was connected to a keyboard, mouse, and monitor display via HDMI so that the Raspberry Pi Desktop could be used to run the script. The python script utilized the OAK-D camera where it used point cloud data to determine whether an immediate obstacle was in front of the user. Point cloud data was generated by combining both RGB and depth data. By drawing a cuboid of space in front of the user and looking at the density of data points in that cuboid, the system was able to alert the user of nearby obstacles. When an object was detected, the script sent a PWM signal to the appropriate GPIO pin on the Pi 4. The LRA was wired to this GPIO pin which allowed the LRA to receive the pwm signal and vibrate to alert the user whenever an object is detected.

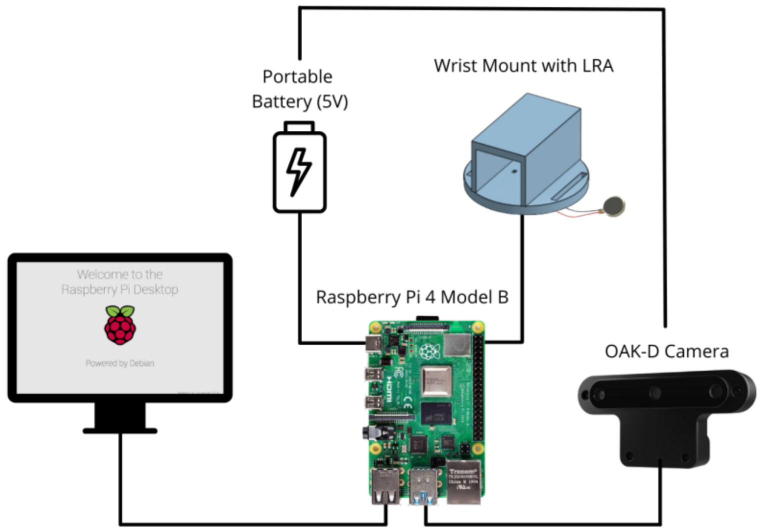

Figure 1. Illustration of Setup

III. Measurements

This table shows the criteria for success that we developed for testing.

Object	**Distance**	**Point Cloud Correct? (Y/N)**	**Detection Prompt Correct? (Y/N)**	**Motor Vibration Correct? (Y/N)**
Person	1.5 m	Y	Y	Y
Person	0.5 m	Y	Y	Y
Person	5 m	Y	Y	Y
No Person	N/A	Y	Y	Y
Chair	1.5 m	Y	Y	Y
No Chair	N/A	Y	Y	Y
Result			6/6	6/6

1. We started the demo by running the file *main.py* and ensuring that the OAK-D camera was running properly. This was satisfied as the computer screen showed the point cloud data and the cuboid in one window.
2. Based on the objects detected, if there was an object present within the cuboid, we ensured that the linear resonant actuator produced a vibration to alert the user. One of our teammates simulated an obstacle.

3. Several tests were performed with varying distances and different positions in the camera frame. First, one person stood in front of the user by 1.5 m. This was followed by the person moving forward by 1 m to a distance of 0.5 m away from the user. The point cloud data showed that there was a person in the cuboid, which shows that our model detects obstacles correctly.
4. The person then left the frame. The monitor showed that there was no obstacle and the motor stopped vibrating.
5. We then tested a much larger distance of detection by asking a person to stand 5m away from the OAK-D camera. The person slowly walked to a distance of 3.5 m until they were 1.5 m away from the camera. The person stepped aside and was no longer in the frame.
6. A chair was then placed 3 m away from the camera. The user then pushed the chair until it was 1.5 m away from the camera. While the obstacle was initially in the point cloud, as the user pushed the object to a distance of 1.5 m away from the camera, the obstacle also showed up in the cuboid.

IV. Conclusions

At the end of last semester, we tested with Bruce, a visually impaired person from the Carroll Center for the Blind. He gave us valuable feedback regarding the design of our project. Bruce emphasized that he cared mostly about whether there was an immediate obstacle within the reach of his cane. From this feedback, we modified our priorities and design for the project.

Based on the results of our testing, we can conclude that our proof of concept works when it comes to detecting obstacles and vibrating actuators based on whether an obstacle is present in the cuboid of the space. This shows that our point cloud model is accurate in notifying the user of obstacles of varying distances.

The design of the overall device was significantly more robust and portable. This was because of a 3D printed watch mount along with 3D printed holders and covers for the raspberry pi and the portable power source. The chest mount is snug fit with no interference in the arm movement of the user which solves an important safety issue. Furthermore, the watch mount has a mold for the motor to sit in that amplifies the vibrations so that it is much easier to feel. This was a significant improvement on the motors being placed on the chest as that is very dependent on the clothes that the user would wear.