Version
1.1

Project Name
Glow 2024

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Hardware Research

Introduction

In this hardware research for Glow 2024, the objective was to identify a sensor that could replace the previous hardware for a human proximity detection system. The sensor would be installed within a 2-meter-tall by 50 cm-wide white acrylic pillar, designed to light up and play a sound when someone approached or touched it. To achieve this, we focused on two sensors: the DFRobot 24GHz mmWave and the Hi-Link HLK-LD1125H-24G.

We selected these sensors for several reasons. First, one of the main goals was to lower the cost of the current hardware in the pillar, making the installation more budget-friendly. Second, we aimed to eliminate the dead zones present in the hardware setup of the existing time-of-flight sensors. The DFRobot sensor was chosen due to the detailed information available online, which helped us assess its suitability for our needs. On the other hand, the Hi-Link sensor was selected for its ability to provide detailed information through mmWave technology, such as distance measurements. Additionally, we wanted to take another look at mmWave sensors, believing that the Hi-Link model would address the limitations observed with the first sensor, particularly in terms of functionality and accuracy.

This document provides a detailed evaluation of each sensor, highlighting their strengths and weaknesses in this context.

Requirements

1. **Accurate Human Proximity Detection:** The sensor should reliably detect when a person is at a touching distance of the pillar and trigger the light and sound interaction accordingly.
2. **Multi-person Detection:** The sensor must be able to detect and track multiple people around the pillar simultaneously. This requirement is crucial to prevent false triggers when one person leaves the area while others remain.
3. **Low Cost:** The sensor should be lower in cost than the current hardware option in the pillar (time of flight) to ensure the overall project remains within budget.

DFRobot 24GHz mmWave Sensor

The first sensor tested was the DFRobot 24GHz mmWave, priced at 31 euros. This sensor offered a range of up to 9 meters for detecting the presence of people. However, during testing, it showed some limitations. While it could confirm if someone was nearby, it could not provide information about how close they were to the sensor, a critical requirement for this project. Additionally, the sensor had a limited sensing angle when placed on top of the pillar, detecting only directly below. Attempts to place the sensor at the bottom facing upward resulted in unreliable readings, further reducing its usability. Though it could serve as a backup detection sensor, it did not meet the accuracy and reliability requirements for the project.

Hi-Link HLK-LD1125H-24G Sensor

The second sensor tested was the Hi-Link HLK-LD1125H-24G, which cost 12 euros and offered more advanced features than the DFRobot mmWave sensor. This sensor provided the ability to measure the distance between the sensor and a person, allowing for more precise control of the pillar's interaction zone. Additionally, it could detect whether a person was moving or stationary, which added to its versatility. The sensor also had a 45-degree sensing angle, creating wider coverage for proximity detection. However, the main disadvantage of this sensor was its inability to monitor more than one person at a time. If two people were near the pillar and one walked away, the sensor would lose track of the remaining person, making it unsuitable for the project's needs.

Testing

Both sensors were tested using a similar method to ensure fair results. We connected an ESP32 microcontroller to each sensor and programmed it to read the data received. A small LED was attached to show when a person was detected within the sensor's range. For the DFRobot 24GHz mmWave sensor, we used a 2-meter detection range and conducted tests with the pillar (see video hardware_test_1).

For the Hi-Link HLK-LD1125H-24G sensor, we set up a more complex system. In addition to the LED, we added a second light on a breadboard with a small buffer circuit. This buffer made the second light turn on if the first light stayed on for longer than one second, indicating that the lights below the pillar should turn on. This setup aimed to improve the readings for the Hi-Link sensor within the 2-meter range. While this worked well, the Hi-Link sensor has a major limitation: it can only focus on one person at a time. This could cause problems if multiple people are near the pillar.

Conclusion

Following extensive testing of both mmWave sensors, it was concluded that neither the DFRobot 24GHz mmWave nor the Hi-Link HLK-LD1125H-24G was reliable enough for the Glow 2024 installation. The DFRobot sensor lacked precision in detecting distance, and the Hi-Link sensor's inability to monitor multiple people simultaneously presented a significant limitation. As a result, the focus will shift towards testing other sensor technologies, such as ultrasonic sensors or time-of-flight sensors, which may provide more accurate and dependable results for human proximity detection in this installation.

Sensor Comparison

Feature	DFRobot 24GHz mmWave	Hi-Link HLK-LD1125H-24G
Price	€31	€12
Detection Range	Up to 9 meters	Up to 7 meters
Distance Measurement	No	Yes
Multi-person Detection	No	No
Detection Angle	Narrow (direct line of sight, limited coverage)	45-degree angle, wide coverage
Movement Detection	No (only detects presence)	Yes (can detect moving and stationary individuals)

Related Documents

Linked Document	Description
https://github.com/Glow-Delta/dfrobot-mmwave	Code used for testing DFRobot 24GHz mmWave Sensor
https://github.com/Glow-Delta/hilink-mmwave	Code used for testing Hi-Link HLK-LD1125H-24G Sensor
hardware_test_1	test result on pillar using DFRobot 24GHz mmWave Sensor
hardware_test_2	test result walking from distance to pillar using DFRobot 24GHz mmWave Sensor