Verifying performance specifications of HLS-LFCD2 using LiDAR subscriber

1. Abstract

This experiment verifying the performance specifications of the HLS-LFCD2 LiDAR sensor on the TurtleBot3, focusing on the minimum and maximum ranges, distance accuracy and distance precision of the sensor. By implementing a ROS package to observe and analyze the data from LiDAR sensor, we evaluated the sensor's accuracy and precision in capturing distance measurements. The distance measured by sensor is compared with that measured by a tapeline to get the accuracy and precision specifications, and the experimental results are compared with the reference performance specifications provided in the HLS-LFCD2 manual to analyze the discrepancies during the usage of the HLS-LFCD2.

2. Introduction

The HLS-LFCD2 is a laser distance sensor (LDS) widely used in mobile robotics applications for mapping and obstacle detection. Mounted on the TurtleBot3, this sensor offers 360-degree scans on a horizontal plane with high resolution. The objective of this experiment is to assess the sensor’s range, accuracy, and precision by creating a ROS package that prints LiDAR readings, then processing and analyzing these readings through ROS tools such as RViz and a custom script.

3. Method

3.1 Setting up the Environment:

We first installed the required ROS packages and configured the TurtleBot3 to interface with the HLS-LFCD2 sensor. The specifications for the LDS were studied through documentation, and setup was conducted according to Sections 8.5.2 and 8.5.3 of ROS Robot Programming.

3.2 Creating the ROS Package:

A new ROS package named Lab3 was created to facilitate data capture. The package subscribes to the LiDAR /scan topic, allowing real-time data collection of distance readings from various orientation. The code was modified to ensure compatibility with the HLS-LFCD2 sensor and to print the distance values from 0 degree orientation.

3.3 Data Collection:

Write a python program named “lidar_”to capture and print the distance value measured to the terminal. Moving the TurtleBot3 from near to far, we find the value jumping at two specific distances, which is the measured minimum and maximum ranges of the sensor. And then, put the TurtleBot3 at several points which have exact distance measured by a tapeline and capture the LiDAR readings.

3.4 Data Analysis:

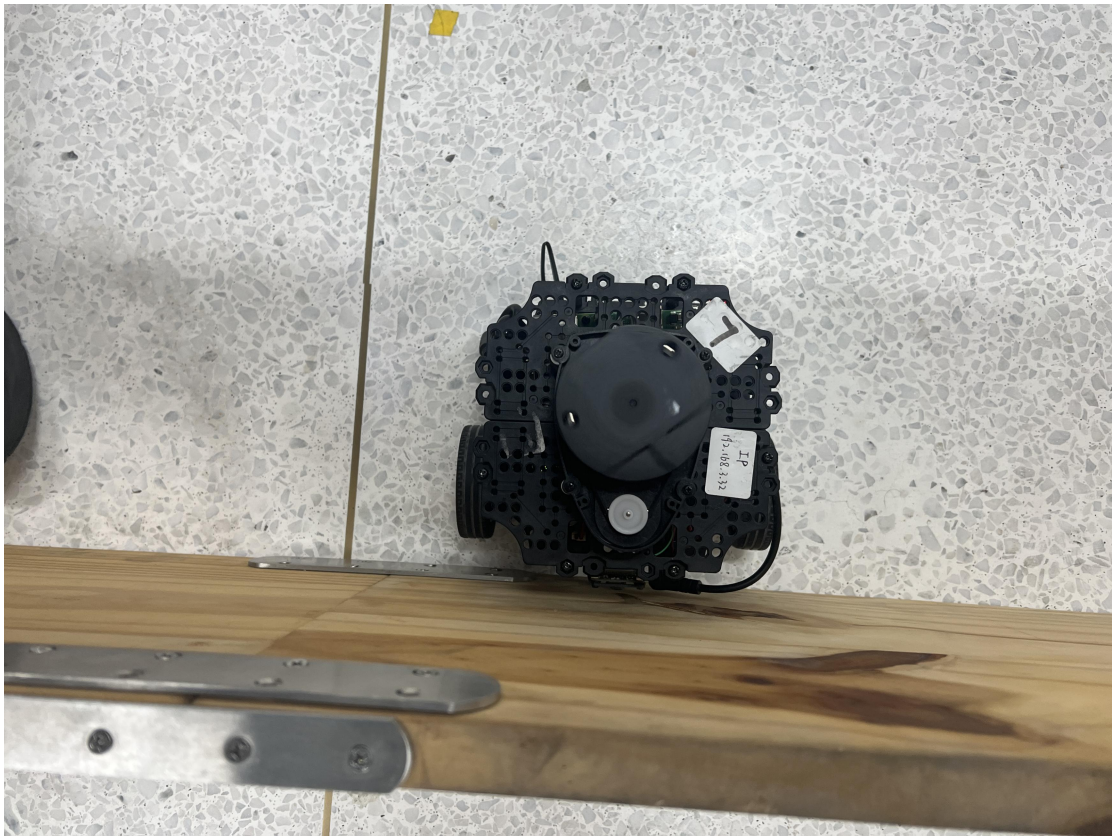
According to the definitions of LiDAR accuracy and precision, process the data collected before.

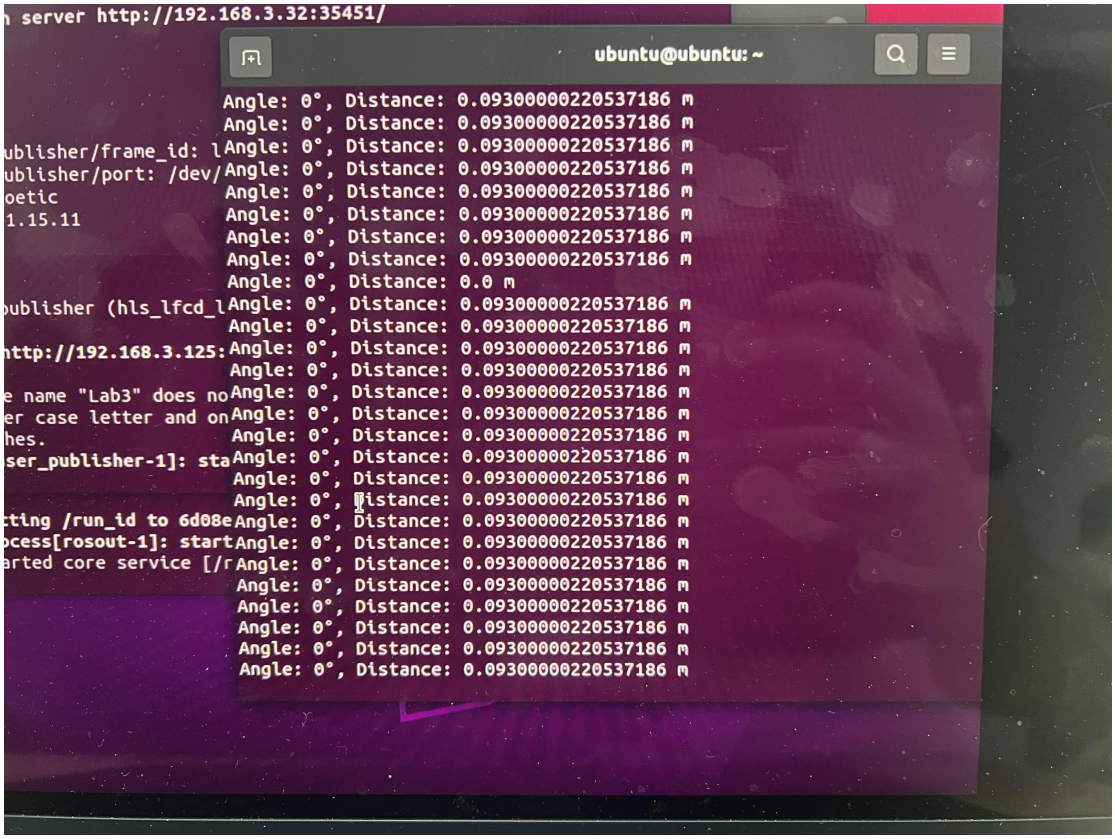
The accuracy was assessed by comparing the average measured distances with the known reference distance. And the precision was calculated by analyzing the standard deviation of repeated measurements at a fixed position.

4. Results

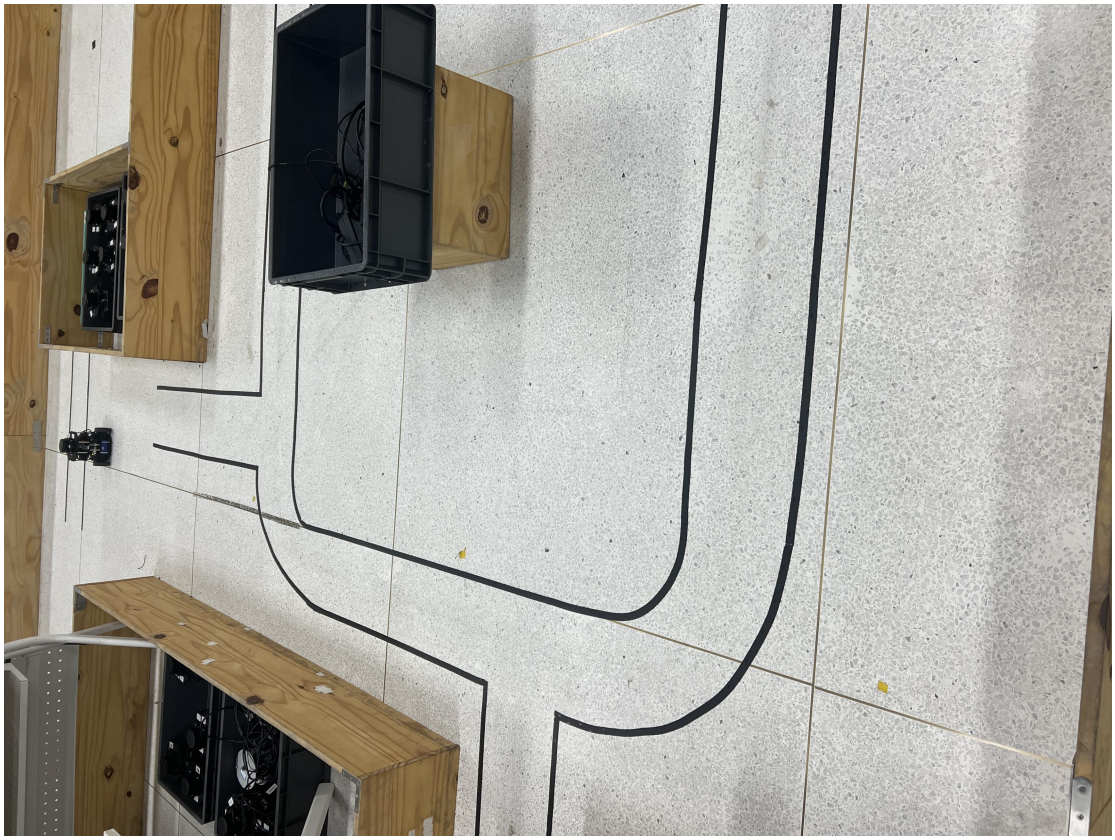
4.1 Minimum and Maximum ranges

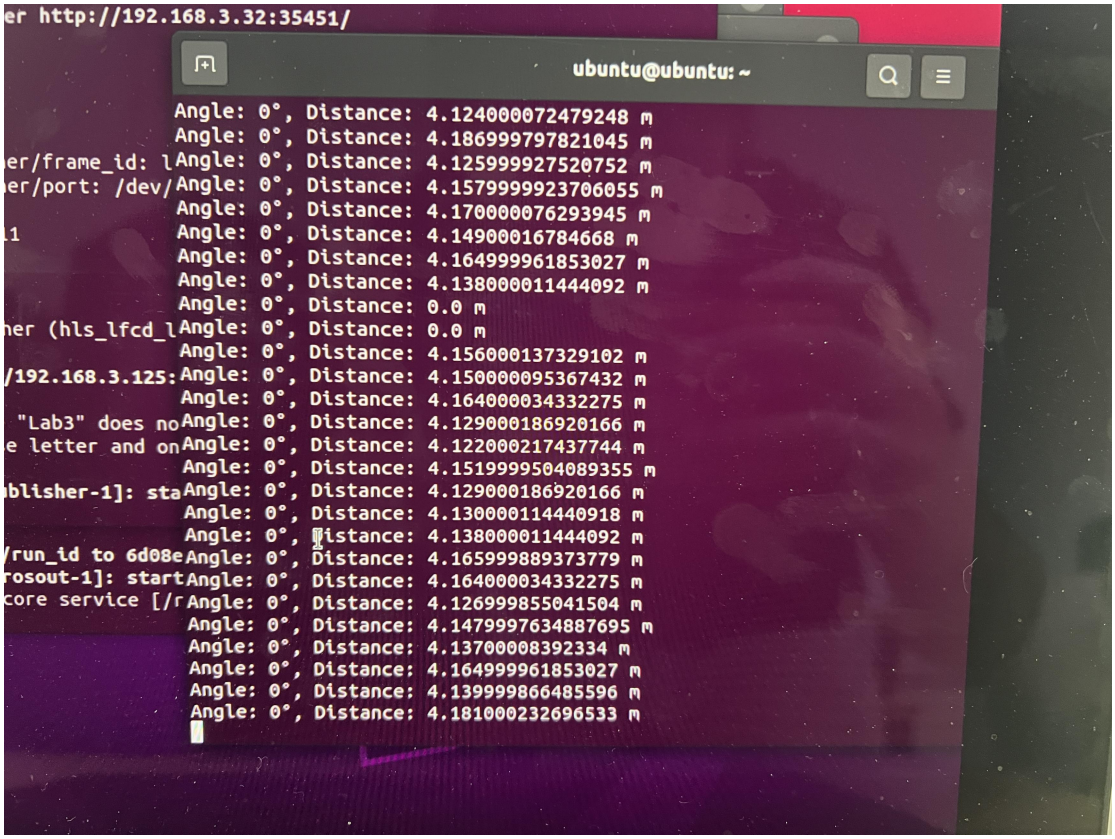
Minimum range: approximately 0.093m





Maximum range: approximately 4.15m (It's obviously that when distance goes too far, the effects from external factors on the sensor significantly enlarge.)





4.2 Distance accuracy and precision

At distance of 0.3m:

average	accuracy	precision
0.308025905	0.008025905	0.000159268

At distance of 1.5m:

average	accuracy	precision
1.494875002	-0.005124998	0.005618974

At distance of 2.0m:

average	accuracy	precision
1.97064783	-0.02935217	0.006131904

5. Discussion

The HLS-LFCD2 sensor demonstrated reliable performance within its specified range and exhibited accurate distance measurements with minimal deviation. The observed precision aligns closely with the specifications provided by the manufacturer, validating the sensor's stability in controlled environments. Minor discrepancies in accuracy can be attributed to environmental factors such as lighting and surface reflectivity, which are common challenges in LiDAR-based distance measurements.

6. Conclusion

This experiment verified the range, accuracy, and precision of the HLS-LFCD2 LiDAR sensor on TurtleBot3. The sensor met the performance criteria within the expected tolerance, confirming its suitability for use in real-world robotic applications. Future experiments may include testing the sensor under varying environmental conditions to further explore its robustness.