Ultrasonic Sensor

**Description**

The test mainly tests the helper methods improving the ultrasonic sensor reading. Actually, it is also a test for whether the robot can detect an object on the path. From previous labs, we observed that the accuracy of feedback data of the ultrasonic sensor was undesirable. The ultrasonic sensor reading tends to fluctuate considerably when the robot orients to open space. We have developed some methods (average filter and median filter) to reduce the inaccuracy. We need to test whether the helper methods we developed can assist us to get a precise ultrasonic reading.

For the test, the general idea is to put an object in front of the robot and adjust the distance between the robot and the object. We will record the output of the median filter and average filter of the ultrasonic sensor readings. Then we will analyze whether the accuracy of these filters meets the requirements of our project and determine in which condition we should use which kind of filter.

**Test 1**

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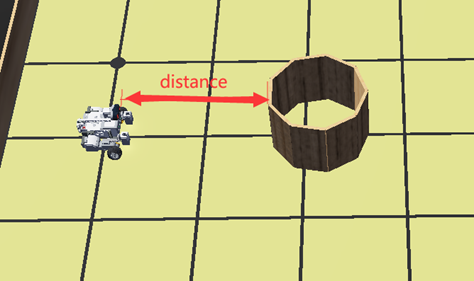
**Hardware version:** 1.0 (in Part 2.5 of [Hardware Document](https://docs.google.com/document/d/11jkA_S_xBqyCbcn2NyMuM-OMDEybDfRy/edit#))

**Software version:** 1.0 (in Part 7.0 of [Software Document](https://docs.google.com/document/d/19JaY5629aUu4Y4rjoQJ-jWyeQLqNSAcr/edit))

**Test Purpose:**

Determine in which range the feedback of the ultrasonic is acceptable after applying the filter on datas.

**Test Procedure:**

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We will place an obstacle in front of the robot. We will see whether the filtered feedback meets our expectations.

1. The robot is placed at (1,3). The starting translation of robot is (0.3048, 0.9144).
2. The relative position of ultrasonic sensor is (0.0092, 0.0384), so the real translation of the ultrasonic sensor is (0.3140, 0.9528)
3. The length of the ultrasonic sensor is approximately 0.05m, so the detect point of the ultrasonic sensor is (0.3640, 0.9528)
4. The robot is oriented to 90°. The starting angle is 90°. The ultrasonic sensor angle is 90°.
5. Place an square obstacle with side length 25.9cm in front of the robot with a certain distance.
6. Run the ultrasonic sensor at a sample rate of 25Hz and use the filter methods to deal with samples. .
7. Print the three filtered feedback on the console.
8. Stop the robot and record the printed data.

**Test Data:**

|  |  |
| --- | --- |
| Trial# | Distance (m) |
| 1 | 0.20 |
| 2 | 0.20 |
| 3 | 0.30 |
| 4 | 0.30 |
| 5 | 0.40 |
| 6 | 0.40 |
| 7 | 0.55 |
| 8 | 0.55 |
| 9 | 0.80 |
| 10 | 0.90 |
| 11 | 1.10 |
| 12 | 1.10 |
| 13 | 1.20 |
| 14 | 1.40 |
| 15 | 1.50 |

**Expected Result:**

|  |  |
| --- | --- |
| Trial# | Distance (m) |
| 1 | 0.20 |
| 2 | 0.20 |
| 3 | 0.30 |
| 4 | 0.30 |
| 5 | 0.40 |
| 6 | 0.40 |
| 7 | 0.55 |
| 8 | 0.55 |
| 9 | 0.80 |
| 10 | 0.90 |
| 11 | 1.10 |
| 12 | 1.10 |
| 13 | 1.20 |
| 14 | 1.40 |
| 15 | 1.50 |

**Test Results:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial# | Median Filter (m) | Maximum error (m) | Minimum error (m) | Mean of three filtered sample (m) |
| 1 | 0.17, 0.17, 0.20 | 0.03 | 0.00 | 0.18 |
| 2 | 0.17, 0.17, 0.20 | 0.03 | 0.00 | 0.18 |
| 3 | 0.25, 0.25, 0.29 | 0.05 | 0.01 | 0.26 |
| 4 | 0.25, 0.25, 0.29 | 0.05 | 0.01 | 0.26 |
| 5 | 0.40, 0.40, 0.40 | 0.00 | 0.00 | 0.40 |
| 6 | 0.40, 0.40, 0.40 | 0.00 | 0.00 | 0.40 |
| 7 | 0.54, 0.54, 0.54 | 0.01 | 0.01 | 0.54 |
| 8 | 0.54, 0.54, 0.54 | 0.01 | 0.01 | 0.54 |
| 9 | 0.74, 0.74, 0.74 | 0.06 | 0.06 | 0.74 |
| 10 | 0.81, 0.81, 0.81 | 0.09 | 0.09 | 0.81 |
| 11 | 0.95, 0.95, 0.95 | 0.15 | 0.15 | 0.95 |
| 12 | 0.95, 0.95, 0.95 | 0.15 | 0.15 | 0.95 |
| 13 | 0.78, 0.78, 0.97 | 0.42 | 0.23 | 0.84 |
| 14 | 0.83, 0.83, 1.04 | 0.57 | 0.36 | 0.90 |
| 15 | 0.85, 0.85, 1.06 | 0.65 | 0.44 | 0.92 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial# | Average Filter (m) | Maximum error (m) | Minimum error (m) | Mean of three filtered sample (m) |
| 1 | 0.17, 0.22, 0.22 | 0.03 | 0.02 | 0.20 |
| 2 | 0.17, 0.22, 0.22 | 0.03 | 0.02 | 0.20 |
| 3 | 0.25, 0.32, 0.32 | 0.05 | 0.02 | 0.27 |
| 4 | 0.25, 0.32, 0.32 | 0.05 | 0.02 | 0.27 |
| 5 | 0.40, 0.40, 0.40 | 0.00 | 0.00 | 0.40 |
| 6 | 0.40, 0.40, 0.40 | 0.00 | 0.00 | 0.40 |
| 7 | 0.54, 0.44, 0.58 | 0.11 | 0.01 | 0.52 |
| 8 | 0.54, 0.44, 0.58 | 0.11 | 0.01 | 0.52 |
| 9 | 0.74, 0.59, 0.80 | 0.21 | 0.00 | 0.71 |
| 10 | 0.81, 0.64, 0.88 | 0.26 | 0.02 | 0.78 |
| 11 | 0.95, 0.74, 1.04 | 0.36 | 0.06 | 0.91 |
| 12 | 0.95, 0.74, 1.04 | 0.36 | 0.06 | 0.91 |
| 13 | 1.02, 0.78, 1.11 | 0.42 | 0.09 | 0.97 |
| 14 | 0.83, 1.19, 1.19 | 0.57 | 0.21 | 1.07 |
| 15 | 0.94, 1.12, 1.12 | 0.56 | 0.38 | 1.06 |

**Test Report:**

The test is performed 15 times for different input distances. In summary, we expect that the ultrasonic sensor returns the value closed to the input distance . We observed that for small values of input distances, the median filter will have stable but not so accurate outcome and the average filter will have relatively fluctuating readings. But the minimal error of the average filter is very small for short distances, meaning that one of outputs of the average filter is very close to our expectations. And we observe that the mean of the outputs of the average filter is closer to the expectation than that of the median filter for the short distance. But for the relatively large distance, both the median filter and average filter fail to work out accurate results. We need to avoid this case in the project since it will cause large errors.

**Conclusion:** Fail

**Action:** Need an algorithm to avoid long distances detection when using the ultrasonic sensor.

**Distribution:** software development, hardware development