Odometer

**Descirption**

The objective of the test is to evaluate the error of the odometer. Although the odometer class is already implemented as a part of starter code, it is not perfect and its error still exists. When the robot moves or turns, there is a deviation between odometer reading and real-world position. We want to find out how large the deviation is.

The testing method is making the robot move straight for different distances and turns by different angles. The corresponding odometer readings will be recorded and the deviation between it and its expected value will be calculated.

**Test 1**

**Date:** 2021/3/22

**Tester:** Junjian Chen

**Author:** Junjian Chen

**Hardware version:** 1.2 (in Part 2.5 of [Hardware Document](https://docs.google.com/document/d/11jkA_S_xBqyCbcn2NyMuM-OMDEybDfRy/edit#))

**Software version:** 1.3 (in Part 7.0 of [Software Document](https://docs.google.com/document/d/19JaY5629aUu4Y4rjoQJ-jWyeQLqNSAcr/edit))

**Purpose:** Evaluate the deviation of readings of odometer the actual angles and positions of the robot when turning or moving straight individually

**Procedure:** 1.Place the robot where the center of the wheels are located at (1,8) and face 0 degree

1.Set the odometer to (0.3048,2.4384,0)

2. Start the odometer

3. Turn the robot by different sets of angle

4. Record the actual angles in webot and the theta of the odometer

5. Calculate the error of angle by the following formula:

error=Final Angle(Odometer)-Final Angle(Webot)

6. After completing different sets of angle test, place the robot at (1,1) and face 90 degree

7. Set the odometer to (0.3048,0.3048,90)

8. Remove the obstacle and let the robot move straight for different sets of distances

9. Record the actual position of the robot and the coordinate(in feets) of the odometer

10. Calculate the error of distance by applying the formula of Euclidean error distance

**Test Data:**

Test of angle error of odometer:

|  |  |
| --- | --- |
| Trial# | Turning Angle/degree |
| 1 | 30 |
| 2 | 60 |
| 3 | 90 |
| 4 | 120 |
| 5 | 150 |
| 6 | 180 |
| 7 | 270 |
| 8 | 360 |

Test of distance error of odometer:

|  |  |
| --- | --- |
| Trial# | Distance Moved  /feet |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 4 |
| 5 | 5 |
| 6 | 6 |
| 8 | 7 |
| 7 | 8 |

**Expected Results:**

Test of angle error of odometer:

|  |  |  |  |
| --- | --- | --- | --- |
| Trial# | Final Angle/degree | Odometer Reading/degree | Error  /degree |
| 1 | 30 | 30 | 0 |
| 2 | 60 | 60 | 0 |
| 3 | 90 | 90 | 0 |
| 4 | 120 | 120 | 0 |
| 5 | 150 | 150 | 0 |
| 6 | 180 | 180 | 0 |
| 7 | 270 | 270 | 0 |
| 8 | 360 | 360 | 0 |

Test of distance error of odometer:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial# | Distance Moved  /feet | Actual Coordinate  /(x,y) | Odometer Reading  /(x,y) | Error distance  /feet |
| 1 | 1 | (2,1) | (2,1) | 0 |
| 2 | 2 | (3,1) | (3,1) | 0 |
| 3 | 3 | (4,1) | (4,1) | 0 |
| 4 | 4 | (5,1) | (5,1) | 0 |
| 5 | 5 | (6,1) | (6,1) | 0 |
| 6 | 6 | (7,1) | (7,1) | 0 |
| 8 | 7 | (8,1) | (8,1) | 0 |
| 7 | 8 | (9,1) | (9,1) | 0 |

**Test Results:**

Test of angle error of odometer:

|  |  |  |  |
| --- | --- | --- | --- |
| Trial# | Final Angle(Webot)  /degree | Final Angle(Odometer)  /degree | Error  /degree |
| 1 | 29.51 | 29.96 | 0.45 |
| 2 | 59.59 | 59.92 | 0.33 |
| 3 | 89.38 | 89.88 | 0.50 |
| 4 | 118.60 | 119.84 | 1.24 |
| 5 | 148.40 | 149.80 | 1.40 |
| 6 | 178.42 | 179.63 | 1.21 |
| 7 | 267.87 | 269.92 | 2.05 |
| 8 | 356.95 | 359.80 | 2.85 |

Test of distance error of odometer:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial# | Distance Moved  /feet | Actual Coordinate  /(x,y) | Odometer Reading  /(x,y) | Error distance  /feet |
| 1 | 1 | (2.00,1.00) | (2.00,1.00) | 0 |
| 2 | 2 | (3.00,1.00) | (3.00,1.00) | 0 |
| 3 | 3 | (4.00,1.00) | (4.00,1.00) | 0 |
| 4 | 4 | (5.00,1.00) | (5.00,1.00) | 0 |
| 5 | 5 | (6.00,1.00) | (6.00,1.00) | 0 |
| 6 | 6 | (7.00,1.00) | (7.00,1.00) | 0 |
| 7 | 7 | (8.00,1.00) | (8.00,1.00) | 0 |
| 8 | 8 | (9.00,1.00) | (9.00,1.00) | 0 |

**Test Report:**

The unit test of odometer consists of two parts: test of angle and distance. They are performed with 8 sets of different angles to rotate and distance to move respectively. As we can see the error of the distance test is very tiny and can be ignored. When it comes to the angles, the difference between the actual angle and the odometer reading increases as the turning angle increases, with a maximum of 2.85 degrees when turning by 360 degree.

**Conclusion:** The error of theta of the odometer increases with turning angles and the error of x and y is extremely low.

**Action: None**

**Distribution:** software development

**Test 2**

**Date:** 2021/3/22

**Tester:** Junjian Chen

**Author:** Junjian Chen

**Hardware version:** 1.2 (in Part 2.5 of [Hardware Document](https://docs.google.com/document/d/11jkA_S_xBqyCbcn2NyMuM-OMDEybDfRy/edit#))

**Software version:** 1.3 (in Part 7.0 of [Software Document](https://docs.google.com/document/d/19JaY5629aUu4Y4rjoQJ-jWyeQLqNSAcr/edit))

**Purpose:** Evaluate the deviation of readings of odometer from the actual angles and actual positions of the robot at complex case

**Procedure:** 1.Place the robot where the center of the wheels are located at (3,3) and face 0 degree

1. Set the odometer to (0.9144,0.9144,0)
2. Start the odometer
3. Use the method directTravelTo2() to navigate to different points
4. Calculate the error of distance by applying the formula of Euclidean error distance
5. Record the deviation of angles from the expected value of angles

**Test Data:**

|  |  |  |
| --- | --- | --- |
| Trial# | Start Point/(x,y) | Destination Point/(x,y) |
| 1 | (3,3) | (4,4) |
| 2 | (3,3) | (4,5) |
| 3 | (3,3) | (5,4) |
| 4 | (3,3) | (6,4) |
| 5 | (3,3) | (4,2) |
| 6 | (3,3) | (5,2) |
| 7 | (3,3) | (6,2) |
| 8 | (3,3) | (1,4) |

**Expected Results:**

For all trials, the readings of the theta in the odometer are expected to equal to the actual final angle. The reading of the x and y are expected to equal to the x and y of the actual final position.

**Test Results:**

|  |  |  |  |
| --- | --- | --- | --- |
| Trial# | Final Angle(Odometer)  /degree | Final Angle(Webot)  /degree | Deviation of Angle/degree |
| 1 | 45 | 44.67 | 0.33 |
| 2 | 26.57 | 26.09 | 0.48 |
| 3 | 63.43 | 62.75 | 0.68 |
| 4 | 71.57 | 70.71 | 0.86 |
| 5 | 135 | 133.71 | 1.29 |
| 6 | 116.57 | 115.32 | 1.25 |
| 7 | 108.43 | 107.55 | 0.88 |
| 8 | 333.43 | 333.92 | 0.49 |

|  |  |  |  |
| --- | --- | --- | --- |
| Trial# | Final Position(Odometer)/(x,y) | Final Position(Webot)/(x,y) | Error distance  /feet |
| 1 | (4,4) | (4.02,4.02) | 0.03 |
| 2 | (4,5) | (4.03,5.03) | 0.04 |
| 3 | (5,4) | (5.02,4.03) | 0.04 |
| 4 | (6,4) | (6.03,4.04) | 0.05 |
| 5 | (4,2) | (3.98,2.03) | 0.04 |
| 6 | (5,2) | (4.97,2.04) | 0.05 |
| 7 | (6,2) | (5.95,2.05) | 0.07 |
| 8 | (1,4) | (1.03,4.03) | 0.04 |

**Test Report:**

In the complex case, there are relatively larger deviations on positions and angles in the odometer compared to the previous test. It can be observed that the larger the distance and the larger angle the robot turns, the larger the error distance is. And the larger angle the robot turns, the higher the deviation of the angle is. In this case, the odometer will be not accurate when navigating to a waypoint at a long distance and large turning angle.

**Action:** Use light localization combined with manually setting the odometer to minimize the deviation of reading of the odometer from actual reading while navigating.

**Distribution:** software development