# Design Principles and Methods - Localization Lab Report

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## 1 Objective

To use the ultrasonic sensor and light sensor to accurately navigate the robot to a known (initial) position and orientation on the field.

## 2 Method

1. Put you odometer and navigation classes created in Labs 2 and 3 in the Odometer.java and Navigation.java files. Working odometer and navigation classes are also provided in case you had failed to complete either lab.

2. Fill in the code for the class called `USLocalizer`. This class actually contains two different localization routines, each of which can be implemented and tested separately. You may need to create extra functions in your Navigation in order to move as you require.

3. Test each localization routine ten times using random starting orientations (but the same starting position, notably in the corner square) and record the error in the final orientation of the robot. Compute the mean and standard deviation for each routine.

4. Based on the standard deviations from (2), determine the best ultrasonic sensor-based localization method for your robot. Use this one for the rest of the lab, but do not remove the code for the other, as you will need to submit it. Also, correct the appropriate constant in your code to make the mean error 0. You should not need to do any additional tests to confirm that your correction in fact made it 0.

5. Fill in the code for the class called `LightLocalizer`. You need not test the accuracy of this part of the localization. You'll require some trigonometric equations as outlined in the Localization tutorial. Follow the process that the tutorial demonstrates. Also when you've found (0, 0) and 0°, travel to (0, 0) and turn to 0°.

6. Demonstrate to a TA the correct operation of your robot's localization. The TA will choose the starting orientation of your robot. As can be inferred from the comments in the provided code, your robot should: a) use the ultrasonic sensor and the routine you developed and tested in (1), (2), and (3) to find and rotate to an approximatation of 0°, b) drive to the point specified in the Localization tutorial. Begin rotating and clocking angles. c) Compute the trigonometric values for the robot's heading and the (0, 0) point, and d) Travel to (0, 0, 0).

# 3 Data

Figure 1: Offset from 0° - Falling and Rising Edge

| Trial No. | Falling Edge (°) | Rising Edge (°) |
|---|---|---|
| 1 | 9.6 | 3.8 |
| 2 | 6.5 | 3.0 |
| 3 | 6.1 | -1.2 |
| 4 | 14.7 | -1.5 |
| 5 | 4.6 | -1.9 |
| 6 | 5.7 | 0.4 |
| 7 | 5.0 | -1.9 |
| 8 | 3.8 | -16.7 |
| 9 | 2.7 | 1.5 |
| 10 | 15.5 | -1.2 |
| Mean | 7.4 | -1.6 |
| Standard Deviation | 4.4 | 5.7 |

# 4 Error Calculations

$$\text{Mean} = \frac{1}{n}\sum_{k=1}^{n} \mathcal{E}_k \tag{1}$$

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{k=1}^{n}(\mathcal{E}_k - \mu_{\mathcal{E}})^2}{n-1}} \tag{2}$$

## 4.1 Falling Edge

Using formula (1), the mean error of the falling edge localization routine will be calculated.

$$\begin{aligned}\mu_F &= \frac{9.6 + 6.5 + 6.1 + 14.7 + 4.6 + 5.7 + 5.0 + 3.8 + 2.7 + 15.5}{10} \\ &= 7.4^\circ\end{aligned}$$

Next, using formula (2), the standard deviation of these measurements will be calcuated.

$$\begin{aligned}\sigma_F &= \sqrt{\frac{(9.6-7.4)^2 + (6.5-7.4)^2 + (6.1-7.4)^2 + (14.7-7.4)^2 + (4.6-7.4)^2 + (5.7-7.4)^2 + (5.0-7.4)^2 + (3.8-7.4)^2 + (3.8-7.4)^2 + (2.7-7.4)^2 + (15.5-7.4)^2}{9}} \\ &= 4.4^\circ\end{aligned}$$

## 4.2 Rising Edge

Using formula (1), the mean error of the falling edge localization routine will be calculated.

$$\begin{aligned}\mu_R &= \frac{3.8 + 3.0 - 1.2 - 1.5 - 1.9 + 0.4 - 1.9 - 16.7 + 1.5 - 1.2}{10} \\ &= -1.6^\circ\end{aligned}$$

Next, using formula (2), the standard deviation of these measurements will be calcuated.

$$\begin{aligned}\sigma_R &= \sqrt{\frac{(3.8+1.6)^2 + (3.0+1.6)^2 + (-1.2+1.6)^2 + (-1.5+1.6)^2 + (-1.9+1.6)^2 + (0.4+1.6)^2 + (-1.9+1.6)^2 + (-16.7+1.6)^2 + (1.5+1.6)^2 + (-1.2+1.6)^2}{9}} \\ &= 4.4^\circ\end{aligned}$$

# 5 Observations and Conclusion

# 6 Further Improvements