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Group 22
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LAB 4: LOCALIZATION

Data

	Physical Angle		Expected Angle		Delta (error)	
Trial Number	**Falling Edge**	**Rising Edge**	**Falling Edge**	**Rising Edge**	**Falling Edge**	**Rising Edge**
	deg. +/- 0.5 deg.		deg. +/- 0.5 deg.		deg. +/- 0.5 deg.	
1	91.5	83.5	90.0	90.0	1.5	6.5
2	92.0	87.5	90.0	90.0	2.0	2.5
3	95.5	91.5	90.0	90.0	5.5	1.5
4	89.5	90.0	90.0	90.0	0.5	0.0
5	90.0	89.5	90.0	90.0	0.0	0.5
6	90.5	82.0	90.0	90.0	0.5	8.0
7	86.0	82.5	90.0	90.0	4.0	7.5
8	87.0	87.5	90.0	90.0	3.0	2.5
9	91.5	90.5	90.0	90.0	1.5	0.5
10	90.5	84.5	90.0	90.0	0.5	5.5

Mean (Falling Edge)	Mean (Rising Edge)	Standard Deviation (Falling Edge)	Standard Deviation (Rising Edge)
1.9	3.5	1.8	3.1

Observations and Conclusions

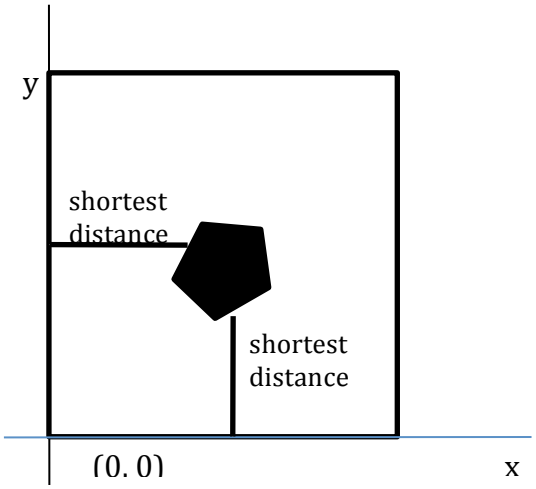
1. The lightLocaliser was more precise than the USLocaliser.

   For the USLocaliser, although the wheels are at set to rotate of opposition direction yet in the same manner, the center still shifts while the robot rotate. The difference in the motion of the two wheels is difficult to eliminate as it depends on several factors, such as friction and the level of battery. The robot does not perfectly turn at single point. Hence, the calculation and the turnTo() methods are slightly off. In the end, all the little errors add up to a noticeable one by the end of the localization routine. Also, we set the robot to rotate in a slow speed so that it can sense the wall with a higher accuracy. This helped the robot to find its original position more precisely.
   For the lightLocaliser, the odometer is extremely important. In this part, the robot uses the angle provided by the odometer, as well as the x and the y readings. The

efficiency of the odometer is crucial for success. If imperfect, the robot would will not travel to its initial position.

2. The light sensor is less probably to detect false negatives and false positive, unlike the ultrasonic sensor. To be more precise, the light sensor senses the lines on the board with a high accuracy. If found, the errors are often due to the loss of color of line. However, the ultrasonic sensor happens to sense false positives. Other robot's ultrasonic output and noise in general are common factors of the false positive responses. Also, the delay of the ultrasonic reading is also a key of the inaccuracy of the USLocaliser. The ultrasonic sensor takes more time to read the distance compared to the light sensor reading the colors, which affects the whole motion of the robot, and increases the inexactitude.

3. As the robot rotates 360 degrees, it keeps tract of the minimum distances. The shortest distances to the wall correspond to the x and y components. Therefore, using these values and its angle at that point, it can easily calculate its current position. Then from that point, it can travel to the initial position.
   This method can be erroneous if the tools and the environment are not in perfect conditions. If the walls have holes in them or are not flat, then the ultrasonic sensor would sense wrong distances. The sensor is not perfectly effective. The detection of false negative and false positives is problematic as well.



Error Calculations

1. Calculating Mean
Method: sum of deltas divided by the number of occurrences
Falling Edge: (1.5+2.0+5.5+0.5+0.0+0.5+4.0+3.0+1.5+0.5)/10 = **1.9**
Rising Edge: (6.5+2.5+1.5+0.0+0.5+8.0+7.5+2.5+0.5+5.5)/10 = **3.5**

2. Calculating Standard Deviation
Method:
1. Minus each difference by mean
2. Square each result from step 1
3. Sum each result from step 2
4. Divide the result from step 3 by one less than the number of occurrences (10-1=9)
5. Square root the result from step 4

Falling Edge: [((1.5-1.9)^2+(2.0-1.9) ^2+(5.5-1.9) ^2+(0.5-1.9) ^2+(0.0-1.9)^2+(0.5-1.9) ^2+(4.0-1.9) ^2+(3.0-1.9) ^2+(1.5-1.9) ^2+(0.5-1.9)^2)/9]^0.5 = **1.8**

Rising Edge: [((6.5-3.5)^2+(2.5-3.5) ^2+(1.5-3.5) ^2+(0.0-3.5) ^2+(0.5-3.5)^2+(8.0-3.5) ^2+(7.5-3.5) ^2+(2.5-3.5) ^2+(0.5-3.5) ^2+(5.5-3.5)^2)/9]^0.5 = **3.5**

Future improvements:

1. In order to reduce small errors, we can place the sensor at the center of rotation of the robot. In this case, although the robot would shift a little from its position while turning, the overall error in the distance read would be minimalized, as opposed to when the sensor was place in the front of the robot.

2. Instead of using an ultrasonic sensor, we could use a touch sensor. The concept is similar to the falling edge. Whenever the robot touches the wall, it logs its current angle and then rotate the other way to find the second wall. This will decrease the reading errors, since the distance between the robot and the wall is fixed (assuming the robot is placed along the 45^o axis). The distance is no longer calculated, yet physical.

3. Another form of localization: assuming that the robot is placed along the 45^o axis
    - turn 360 degrees and logs the two angles where the sensor senses a minimum distance (these two distances should be the same)
    - Make sure that the angles are 90^o apart
    - Use the average of the two angles to calculate the corresponding angle of 0^o
    - turn to that position