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# Lab 4: Localization

## Objective

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

## Data

Table 1 -

| Trial # | Rising angle | Falling Angle |
|---|---|---|
| 1 | -7.6 | -1.4 |
| 2 | -3.2 | 3.4 |
| 3 | -8.1 | 4.8 |
| 4 | -4.3 | 4.5 |
| 5 | -7.5 | 4.1 |
| 6 | -6.5 | 3.6 |
| 7 | -7.4 | 3.2 |
| 8 | -4.5 | 4.1 |
| 9 | -3.2 | 3.6 |
| 10 | -6.2 | 3.5 |

| | Rising-edge | Falling-Edge |
|---|---|---|
| Mean | -5.85 | 3.34 |
| STD VAR | 1.8875322 | 1.74113628 |

## Observations and Conclusions

1. Which of the two localization routines performed the best? Which performed the worst? What factors do you think contributed to the performance (or lack thereof) of each method?

   The Falling edge performed the best with a mean of 3.34 degrees and a standard deviation of 1.74. The rising edge performed the worst with a mean of -5.85 degrees and a standard deviation of 1.89. Overall the falling edge was more consistent as shown by the smaller standard deviation and it was on average closer to the 0° mark as shown through the mean.

   The odometer reading was a big deciding factor in the precision of the results along with the rotation speed of the robot. When taking the results with both methods, the robot was placed facing the origin at 45 degrees. This caused for the robot to stop relatively quickly with falling edge because it would stop when it would notice a wall however, the rising edge would begin to look for a wall and then continue until it no longer saw the wall and then do the same in going in the other direction. Therefore, the robot would be in rotation for a longer time. This would make for a higher accumulated error due to slipping and caused faulty odometer readings. The rotation speed was relatively high in contrast to other robots which caused more slipping. The falling edge however had error only due to slipping for a shorter distance when compared to the rising edge. Overall, the error was acceptable.

2. Why does the light sensor provide a more accurate means of orienting the robot than the ultrasonic sensor?
   The light sensor is more accurate than the ultrasonic sensor for many reasons. The ultrasonic sensor is more sensitive to noise from external objects and can give faulty readings if the filtering is not done thoroughly. When more than one robot would be running on the cause, sometimes the robot would read something that was not there. Furthermore, the ultrasonic sensor uses a predetermines distance (33 cm in this case) to detect a wall however, the robot might only receive the data once the distance is smaller than 33 cm due to polling timing and due to the robot's rotation.
   The light sensor stops once it detects a gridline. The light sensor is less susceptible to noise in this case since the board that the robot is running on has only two colors and therefore it is easier to program it to detect a black line.

3. Propose a means of determining (approximately) the initial position of the robot using the ultrasonic sensor (Hint: Consider the minima of the ultrasonic sensor's readings as the robot rotates). Why is detecting minima with the ultrasonic sensor problematic?

   You can have the robot rotate along the first wall until the ultrasonic sensor reads a minimum. If the robot begins to rotate to the right, the minima will read the y position. If the robot rotates left, this will yield the x position. Next, it will rotate until it detects the second wall and then begin to performed the same task on the second wall. Once it has read the minimum of the second wall, it now has both position points. Using those minima, the position of the robot can be calculated since the origin is known and since the length and width of the grid is known.
   It is problematic because when the sensor reads a value that is too low, it can read it as actually being at a maximum distance away from the sensor. Furthermore, a means of sorting through the data must be implemented in order to read the proper minima.

## Error Calculations

Rising:

Mean:

(-7.60 - 3.20 - 8.10 - 4.30 - 7.50 - 6.50 - 7.40 - 4.50 - 3.20 - 6.20)/10 = (-5.85)

Standard Deviation

$$\sqrt{\frac{\begin{gathered}(-7.60-(-5.85))2\ + \\ (-3.20-(-5.85))2\ +\ (-8.10-(-5.85))2\ + \\ (-4.30-(-5.85))2\ +\ (-7.50-(-5.85))2\ +\ (-6.50-(-5.85))2\ + \\ (-7.40-(-5.85))2\ +\ (-4.50-(-5.85))2\ +\ (-3.20-(-5.85))2\ +\ (-6.20-(-5.85))2\end{gathered}}{9}}$$

Falling:

Mean:

(-1.40+3.40+4.80+4.50+4.10+3.60+3.20+4.10+3.60+3.50)/10 = 3.34

Standard Deviation:

$$\sqrt{\frac{\begin{gathered}(-1.40+3.34)2\ + \\ (3.40+3.34)2\ +\ (4.80+3.34)2\ + \\ (4.50+3.34)2\ +\ (4.10+3.34)2\ +\ (3.60+3.34)2\ + \\ (3.20+3.34)2\ +\ (4.10+3.34)2\ +\ (3.60+3.34)2\ +\ (3.50+3.34)2\end{gathered}}{9}}$$

## Future Improvements

1. Propose a way to avoid small errors more accurately than a clipping filter.

   A median filter would be more accurate than the clipping filter. The median filter goes through sets of data entries and then takes the median of those sets and then uses that value in order to filter the results. For example, the clipping filter only deals with faulty data that reads too far but if it gets a faulty reading of something close that isn't actually there, the robot will stop but the median filter would not because that reading would be too small to be considered the median of the gathered data thus having more accuracy.

2. Propose a sensor design that would result in a more accurate and reliable reading than an ultrasonic sensor.

   Instead of an ultrasonic sensor, a Lidar system can be used. Lidar uses a laser bean in order to determine the distance the robot currently is from the object. Lidar uses light in order to detect the object. It uses the laser beam to light up the object in front of it and then based on the light reading, it is able to determine the distance from the object. It is less susceptible to noise than the ultrasonic sensor due to the differences in the signals; the ultrasonic uses sound while the Lidar uses light.

3. Propose another form of localization than rising-edge or falling-edge.

   As stated in the observation and conclusions section of the report, the robot can rotate and find the minima of x and y (distance that it is from the wall in the x and y directions) in order to get its starting position. Once the starting position is known, the proper rotation can be made in order to orient the robot at 0°. From there, the robot can use the light sensor as mentioned in the method of the lab in order to localize itself.