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Lab 4 Report - Localization

Data

Falling Edge Tests

Test #	Measured Theta	Expected Theta	Error
1	88	90	2
2	89	90	1
3	90	90	0
4	89	90	1
5	90	90	0
6	89	90	1
7	85	90	5
8	85	90	5
9	88	90	2
10	89	90	1

Mean	Standard Dev
1.8	1.72

Rising Edge Tests

Test #	Measured Theta	Expected	Error
1	85	90	5
2	83	90	7
3	82	90	8
4	87	90	3
5	84	90	6
6	84	90	6
7	82	90	8
8	85	90	5
9	88	90	2
10	87	90	3

Mean	Standard Dev
5.3	2.00

Observation and Conclusions

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 best performing routine in our experience was the falling edge routine. The abundance of false negatives in US sensor readings forms the leading cause of error in our localization procedure. The rising edge routine is much more susceptible to false negatives because of the importance of discerning noise and false negatives from an actual open space. The falling edge routine, however, is less affected by this issue since the ultrasonic sensor is generally more reliable for accurately representing a wall encounter. This absence of false positives provides an overall more reliable performance with the falling edge routine compared to rising edge.

Why does the light sensor provide a more accurate means of orienting the robot than the ultrasonic sensor?

The light sensor provides a better mean of orienting the robot because it is much more accurate and precise, which makes it more reliable for determining the robot's position than the ultrasonic sensor. A light sensor-based localization method does not have to cope with as many false negatives, and as such, it is both more precise and accurate. Furthermore, since we chose to include a calibration period in our localization procedure, the contrast between the wood floor and lines can be used for line detection instead of absolute values for both elements. As a result, the light sensor localization procedure could be effective in changing lighting conditions and still remain reliable and effective. The light sensor's resolution is also in the order of millimeters

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?

When a robot rotates on-point at its initial position and collects front US distance readings, it will encounter a local minima when placed perpendicularly to a wall. This feature could be used in order to provide an approximation of the robot's initial position by locating the two local minimums corresponding to each wall's perpendicular distance from the robot. Detecting minima with the US sensor is problematic because of how inconsistent and dispersed the distance readings can be. The sensor could, for example, erroneously detect a minima when two disproportionately huge values surround another value.

Error Calculation

Falling Edge:

$$Mean = {}^{\sum Error}/_{\#\ of\ Samples} = \frac{2+1+0+1+0+1+5+5+2+1}{10} = \frac{18}{10} = 1.8$$

$$Standard\ Deviation = \sqrt{\frac{\sum(Errors - Mean)^2}{\#of\ Samples}} = \sqrt{\frac{.04+.64+3.24+.64+3.24+.64+10.24+10.24+.04+.64}{10}} = \sqrt{\frac{29.6}{10}} = \sqrt{2.96} = 1.72$$

Rising Edge:

$$Mean = {}^{\sum Error}/_{\#\ of\ Samples} = \frac{5+7+8+3+6+6+8+5+2+3}{10} = \frac{53}{10} = 5.3$$

$$Standard\ Deviation = \sqrt{\frac{\sum(Errors - Mean)^2}{\#of\ Samples}} = \sqrt{\frac{.09+2.89+7.29+5.29+.49+.49+7.29+.09+10.89+5.29}{10}} = \sqrt{\frac{40.1}{10}} = \sqrt{4.01} = 2.00$$

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Further Improvement

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

A way of avoiding small errors would be to limit the derivative of consecutive values. Such an approach would allow for a successful smoothing of the US data, while still allowing consecutive contrasting values to affect the returned distance reading. This could also be used in conjunction with the averaging of a given number of recent data members as the return value, which would provide an even more effective smoothing and reduce the overall weight of erroneous data.

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

A possible alternative for the ultrasonic sensor could be the implementation of a laser tape measurer to calculate distance instead. Such tools allow for very precise measurements, even over large distances. Typical precision of such devices can go as low as 1.5mm, even with a range of up to 40 meters. A laser-based system would also be able to ping and record distance much faster than the ultrasonic sensor, due to the difference between the speeds of light and sound. An applied example of the utility of using a higher frequency sensor is that reading depth values more often would allow for a more precise detection of the edges, improving localization and navigation.

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

Another localization method that we could have used would be to have the robot do a complete spin and locate the two angles at which the greatest change occurred, then set the respective angles as A and B, depending on the type of the first edge (either rising-falling or falling-rising). It would then be possible to use the same computation technique as in rising edge or falling edge controllers in order to approximate the difference in heading between the odometer and the robot, then face walls in order to locate its X and Y coordinates. It could also be possible to use the initial reading of the robot in order to choose which procedure would be the most effective, as each of them requires less time when first facing a wall for rising edge or when away from a wall in falling edge.