ECSE 211 - Design Principles and Methods

Lab 4 - Localization

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1 Data

Table 1 : **Falling Edge**

Trial	Deviation From X-Axis ($Degrees$)
1	1.3
2	0.8
3	2.1
4	1.5
5	1.7
6	2.2
7	2.3
8	1.6
9	0.5
10	0.7
Mean: 1.24	Standard Deviation: 0.650

Table 2 : **Rising Edge**

Trial	Deviation From X-Axis ($Degrees$)
1	2.3
2	1.5
3	2.9
4	2.4
5	2.7
6	1.9
7	1.3
8	2.4
9	1.5
10	1.0
Mean: 1.99	Standard Deviation: 0.595

2 Observation & Conclusion

- **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 method was the FALLING EDGE and the worst method was the RISING EDGE. The falling edge method performed better because our filter was better when filtering false positives than false negatives.

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

  According to documentation, the view of the ultrasonic sensor has a view of 20 degrees wide. This single factor creates a lot of false values, making our data less precise than using the light sensor. In addition, our light sensor was placed very low to the ground, creating a very narrow view and very minimal chances of error. In addition, the ultrasonic sensor also captures a lot more noise from the surrounding environments, which has to be tuned out in order to obtain accurate results.

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

  Since the robot is always positioned on the diagonal we know that the x and y values will always be equal along this line.We could use the ultrasonic sensor to find the shortest distance to the wall an once it is found we know that both the x and y values must be the length of the tile subtracted by this reading (30.48 - shortestDistance). As the robot will also start in the 3rd quadrant with respect to the defined (0,0) these values will need to be negative (ie -(30.48 - shortestDistance)). However, this is problematic once again due to the fact that our ultrasonic sensor has a view of 20 degrees, making our data not very precise.

3 Error Calculations

Falling Edge

- Mean:
  $\mu = \frac{1}{N}\sum_{i=1}^{N} \Delta X$;

  Where:
  N: number of trials
  X: deviation from x-axis

  $\mu = \frac{1.3+0.8+2.1+1.5+1.7+2.2+2.3+1.6+0.5+0.7}{10}$
  $\mu = 1.24$

- Standard Deviation:
  $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$;

  Where:
  N: number of trials
  x_i: deviation from x-axis
  μ: the mean

  $\sigma = \sqrt{\frac{1}{10}(0.06^2 + (-0.44)^2 + 0.86^2 + 0.26^2 + 0.46^2 + 0.96^2 + 1.06^2 + 0.36^2 + (-0.74)^2 + (-0.54)^2)}$
  $\sigma = 0.650$

Rising Edge

- Mean:
  $\mu = \frac{1}{N}\sum_{i=1}^{N} \Delta X$;

  Where:
  N: number of trials
  X: deviation from x-axis

  $\mu = \frac{2.3+1.5+2.9+2.4+2.7+1.9+1.3+2.4+1.5+1.0}{10}$
  $\mu = 1.99$

- Standard Deviation:
  $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$;

  Where:
  N: number of trials
  x_i: deviation from x-axis
  μ: the mean

  $\sigma = \sqrt{\frac{1}{10}(0.31^2 + (-0.49)^2 + 0.91^2 + 0.41^2 + 0.71^2 + (-0.09)^2 + (-0.69)^2 + 0.41^2 + (-0.49)^2 + (-0.99)^2)}$
  $\sigma = 0.595$

4 Further Improvements

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

  We could use a median filter instead. The main idea of the median filter is to run through the signal entry by entry, replacing each entry with the median of neighboring entries. By doing this, we can almost completely avoid random spikes and noise.

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

  We could use a laser sensor instead of an ultrasonic sensor. In a laser sensor, the distance between the sensor and target is measured by calculating the speed of light and the time since light is emitted and until it is returned to the receiver. A laser sensor is a lot more precise in measurement and has a very narrow target range, unlike the large radius in the ultrasonic sensor.

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

  We could do a wall follower along the wall until our light sensor detects a black line. Then we can follow this line until we find the intersection that is our estimated origin, and do our usual light sensor localization to make it more precise.