CS 424 : MP4 report

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1 Modeling the Robot

We assume that the robot travels with a velocity of v and has a sensor sampling period of T. If D_t and D_{t+T} are the positions of the robot at time t and $t+T$ respectively, then

$$\Delta D = d = d_{t+T} - d_t \approx \text{Distance travelled in time T} * \Delta\theta$$

Since

$$\text{Distance travelled in time T} = v * T$$

We get

$$\Delta D / \Delta\theta = v * T$$

This is the gain of our Robot component in the control loop. In our implementation, we fix

$$v = 120\, in/s$$

$$T = 25\, ms$$

Hence $g(R) = 3$ inches/radians where $g(R)$ is the gain of the robot component in the control loop. Since the Robot also samples after a delay of T, it has a phase shift $p(R) = \omega T$, where ω is the angular frequency of oscillation.

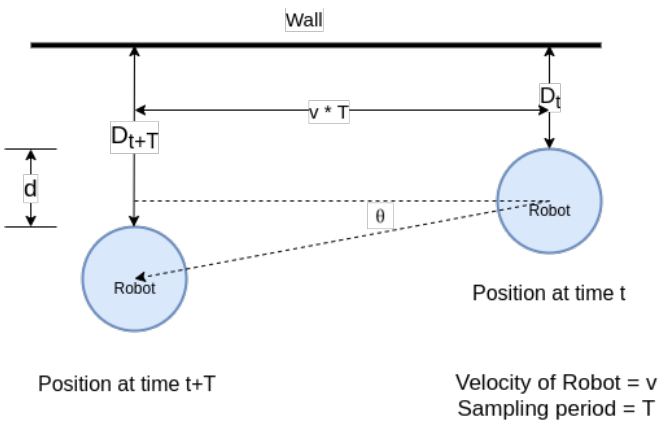

Figure 1: Modeling the Robot

2 Modeling the Sensor

We measured and modeled the relationship between physical distance of the robot from the wall and the wall signal reading. The measurements were recorded using a ruled notebook sheet with fixed interval of 0.86 cm. Data were entered into an Excel spreadsheet with a polynomial regression conducted. We noticed that a 5^{th} order polynomial gives a perfect fit to the graph.

The measurements were conducted on both sides of the wooden wall to ensure accuracy and reduce possible biases. Biases occurred during measurements were also taken care of by repeating the same

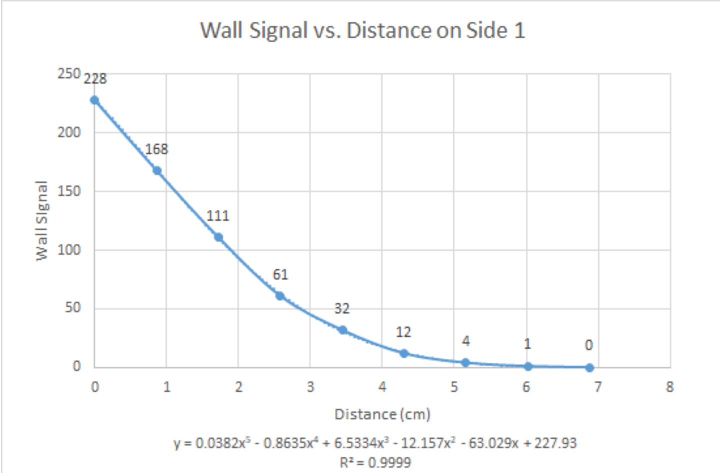

Figure 2: Wall sensor readings vs Distance for Rough side

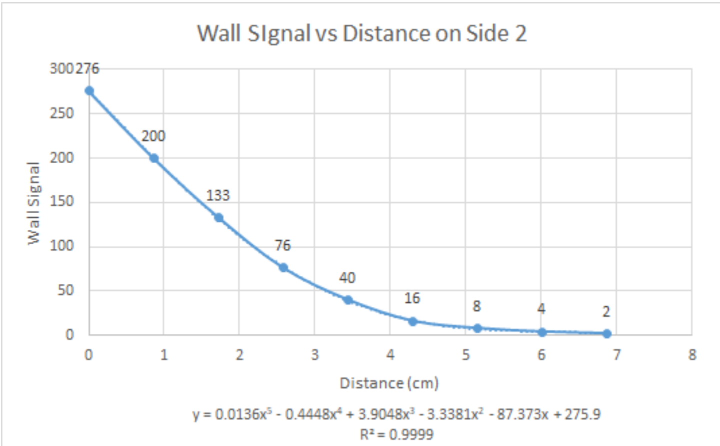

Figure 3: Wall sensor readings vs Distance for Plain side

measurement on a set distance and take its median (assuming empirically that wall sensor readings on a relatively closely related interval should be continuous). The derivatives of the two models and their local maximums were calculated and applied as actual parameters during programming.

The gain of our wall sensor component, $g(S)$, in the control loop is effectively the slope of the graph. We numerically calculated the maximum value of the absolute derivative of the graph to obtain $g(S) = 28.2\,\text{sig/inches}$ where sig are the units of the wall sensor readings. We model sensor readings to be instantaneous, hence the phase shift $p(S)$ of this component is zero

3 Modeling the Controller

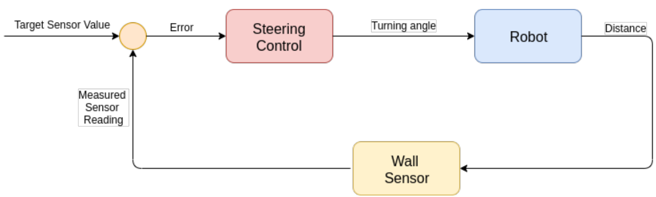

Figure 4: The Control Loop

We build a Proportional ('P') controller for our Steering control module. By tuning and testing, we figured out that a loop gain of **0.075** works best in our navigation module. Since the controller is of the form

$$\text{Angle to turn} = K * \text{Deviation from Wall Signal Reading}$$

the gain of the controller $g(C)$ is K. As we are using a Proportional controller, the phase shift $p(C)$ is zero as well.

Phase Equation:

$$p(C) + p(R) + p(S) = \pi$$

$$\Rightarrow 0 + \omega T + 0 = \pi$$

$$\Rightarrow 2\pi f * T = \pi$$

$$\Rightarrow f = 2\,\text{Hz}$$

Gain Equation:

$$g(C) * g(R) * g(S) = 0.075$$

$$\Rightarrow K * 3\,\text{inches/radians} * 28.2\,\text{sig/inches} = 0.075$$

$$\Rightarrow K = 8.8652482 \times 10^{-4}\,\text{radians/sig}$$

We have set the target wall signal value for our controller as 15 *sig* in our implementation.