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MOBILE ROBOTS - Laboratory 1

Report 1 - Evaluating Measurement Noise Variance

In order to define Q_γ, we need to evaluate the parameters *sigmaXmeasurements* and *sigmaYmeasurements*, that is to evaluate the variances of the measurements taken by the reed sensors of the magnetic field of the sensor placed on the ground.

To establish these values, as explained in class, the team observed the characteristics of the robot and the measurements to evaluate such values. The team assumed a **Uniform Distribution Function (*Figure 1*)**, whose variance is given by the following formula:

$$\sigma^2 = \frac{(b-a)^2}{12}$$

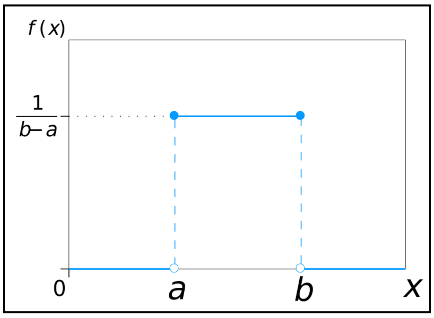

Figure 1 - Probability density function

The problem then lies in establishing the a and b values for the x and the y measurements of our robot. Firstly, the frequency was set to $20\,Hz$. The Y component was easily determined by looking at robot geometry and the Figure 8 provided by the *PlotResults.m* function. It was easy to see that each sensor detects a magnet in the range $[-5,\ +5]\,mm$. Hence, we set $Y_{min} = -5$ and $Y_{max} = 5$, obtaining:

$$\sigma_y^2 = \frac{(Y_{max}-Y_{min})^2}{12} = \frac{10^2}{12}$$

The next step is then to determine the variance on the X-axis which turned out to be slightly more complex. The goal is to establish the a and b values for these measurements. To evaluate them, the team looked at the *Figure 8* provided by the *PlotResults.m* function of the various datasets provided. The idea was to determine (X_{min}, X_{max}) as the distance from the first detection of the magnetic field to its last from a single sensor. After a short analysis, the datasets *twoloops.txt* and *oneloop.txt* were soon discarded, as the trajectory was described by a curve and it was too complex to properly establish the travelled distance when sensing a single magnet. The problem greatly simplified when looking at the datasets *line1magnet.txt*, *line2magnet.txt* and *diagonal45degrees.txt*: in these datasets, the robot moves in a straight line and it is hence much easier to establish the X distance travelled when crossing a magnet. However, we still need to consider that the robot could cross the magnetic field (roughly assumed circular) on a rope or on the diameter of the field. This prompted us to collect the worst-case scenario for each dataset, hence the longest traveled distance by the robot while detecting the same magnet.

The corresponding results in the worst-cases were:

- *line1magnet.txt* = 18 mm
- *line2magnet.txt* = 21 mm
- *diagonal45degrees.txt* = 24 mm

To evaluate our X variance, we then need to select a reasonable value for (X_{min}, X_{max}), taking into account the previous considerations. The choice of $(X_{min} - X_{min}) = 20$ is justified by:

- 20 is within the range of the worst-case scenarios found
- It does not determine overestimation

This led us to evaluate $X_{min} = -10$ and $X_{max} = 10$, so:

$$\sigma_x^2 = \frac{(X_{max} - X_{min})^2}{12} = \frac{20^2}{12}$$

The team did not exclude the possibility that these measurements could have a Gaussian Distribution, since the central values may occur with a larger probability, but we consider the choice of a **Uniform Distribution Function** as a fair choice with the available measurements.
Although this overall solution might lead us to a possible overestimation of the variance, it would be much ever more problematic to underestimate such value. Also, the team did not pick the worst possible case because this could lead to a compromising overestimation.