Localization lab and homework
Work to be done

Preparation

1. Retrieve the file `StudentDocsLab1.zip` from the Hippocampus Moodle.
2. Create a folder for the lab.
3. Decompress the contents of the zip file in the folder.
4. Read the documents in the following order: the present document, then the "system description" document and then the "programs and data" document. "System description" is fundamental to understand the equations and some parts of the code you have to provide.
5. Using "`ShowOdometry.m`", check the various paths corresponding to each data set. Don't forget to look at the speed data.
6. The files "`EvolutionModel.m`" is missing (you have to write your own) and "`MagnetLoc.m`" contains missing code which you need to provide. The missing code is replaced by "`***`". You can use the localization book to help you in this task.
   To check your own version of "`EvolutionModel.m`", rename "`EvolutionModel.p`" so it is not used by `ShowOdometry`, and check that you obtain the same odometry results with your own function.
7. Put all noises to zero in "`DefineVariances.m`" and execute the program. You will get a lot of warnings from Matlab. Ignore them. Use figure 8 and what you know about the sensor construction to evaluate the measurement noise variance.
8. There is another important parameter to be set: the threshold for the Mahalanobis distance (`mahaThreshold`). It is normally set by using the Matlab `chi2inv` function. You must understand what this function does and use it to determine a proper value for the threshold.
9. Once you have a measurement noise you consider reasonable, set the initial covariance matrix `Pinit`. The standard deviation `sigmaWheels` is now your tuning parameter. If the measurement noise value and initial covariance matrix have been properly set, you should be able to find a proper value for `sigmaWheels`.

Report

There is no report to this lab. A specific session will be organized to evaluate your comprehension of the material. The suggested homework below will help you prepare. If you have any difficulty or question, do not hesitate to ask questions by email or ask for an appointment.

Suggested preparatory homework:

- Make sure the dimensions (number of lines and columns) of each vector and matrix is clear to you. Once the equations of any Kalman filter are given, you should be able to determine said dimensions very rapidly.
- Starting with a correctly tuned filter, test the effects of over-estimating (resp. under-estimating) each of the following parameters and make sure you understand and can explain what happens. In particular, analyze how the term $CPC^t+Q\gamma$ evolves, and how it helps understand the behavior of the Kalman filter.
  - Initial robot position variance.
  - Measurement noise variance.
  - The same test with `sigmaTuning` should be done and understood during the lab

sessions.

- Assuming only the `y` measurement of the magnet is used (say the designer of the program did not realize the `x` is also measured):
  - List all variables/parameters that must be changed in the program.
  - Should `sigmaTuning` be changed? Why? Make sure it is clear to you.
  - It's possible and fast to modify MagnetLoc.m accordingly, but modifying PlotResults.m to suit this new version is a bit more involved and not required for an adequate preparation.