Todo list of localization lab 1

1. Determine the initial position uncertainty. For that, you have to imagine what the expected precision of the operation can be (putting the robot at a given (x,y,theta)). What you can use :
   a) It's analogous to a « pointing » operation, so the error is typically roughly Gaussian.
   b) For a near-Gaussian error, if you identify a maximum value of the error, then take sigma as maximum error / 3.

2. Determine the variance of the measurement noise. We have intensively discussed the problem in the lab. The main points to remember are :
   a) The noise is the difference between the idealized sensor model (the sensor is a line, the magnet a point) and reality.
   b) The two noises (x and y measurements) have very different origins and should not be mixed up. The noise in x is related to the diameter of the area in which the magnetic field is intense enough to close a reed sensor. The noise in y is related to the spacing between reed sensors. To determine the variance of the noise in the x measurement, concentrate on Figure 7 (preferably for straight line motions, where all points of the robot travel the same distance) and use 20 Hz, which makes it easier. For the noise variance in the y measurement, consider the two possible detection situations (1 or 2 reed sensors activated) and, in each case, determine an interval along y that must contain the magnet.
   c) You have to determine the error distribution to calculate the variances.

3. Determine the Mahalanobis distance, using a chi2 table or the chi2inv function of Matlab. Remember that it depends on the dimension of the measurement vector.

4. Tune the sigma_tuning parameter by trial and error.
   a) Remember to reset frequency to 5 Hz.
   b) Remember why this noise is set by trial and error : because it is used to encompass all the sources of errors of odometry (see class material). The sources of errors are multiple and complex, so it's not possible to predict the variance based on the characteristics of the system only, hence the trial and error process.
   c) Learn to recognize when the tuning parameter is too high (consider the Mahalanobis distances, see how they evolve when the parameter is increased/decreased). Relate this behavior to the expression of the Mahalanobis distance and of the gain, in particular to the term CPCt+Qgamma.
   d) Learn to recognize when it's too low. For that, the twoLoops test is convenient, as it is a longer trajectory, and you know where it should end (at 0,0).

5. A good tuning is a tuning that works for all tests. You should not modify the parameter for each test set.

6. Once the tuning is correct (0.05 may not be the best value, but you can use it for the analysis below), analyze the results of each test ; each of them has something to offer :
   a) The loop trajectories are instrumental to check that the algorithm works.
   b) The twoLoops trajectory has a fairly sharp correction around (60,260). Do you understand why (beware, depending on tuning the correction may be less sharp).
   c) The diagonal45degrees show two diverging straight lines. Do you understand what happened in this test ? Actually, it illustrates an important point of the localization class. Which one ?

d) Check what happens with the line2magnets test when you correctly initialize the position to (0,27,0) and when you don't (it often happens that students start at 0,0,0, check what happens and make sure you understand).
e) With line1magnet, on figure 3 compare the estimated standard deviation for the x and y components of the state. Why are they different ? Compare figures 3 and 4. Why are they the same ?
f) With diagonal45degrees, on figure 3 compare the estimated standard deviation for the x and y components of the state. Why are they the same ? Compare figures 3 and 4. Why are they different ? Generally speaking, do the values in figure 4 vary significantly from one test to another ? Do you understand why I decided to plot the standard deviations expressed in the robot frame ? If it is not yet clear, compare figures 3 and 4 for the circles dataset.
g) Check the estimated paths with the circles data set. Is something wrong with the EKF ? Is it drifting out of control ?

For this analysis section, I encourage you to write a short answer on paper individually and then confront your answers. Did you agree ? Are your fellow student answers clear to you ? If not, confront your points of view. If you can't seem to agree, consult the teacher.