Solution to analysis in Home Assignment 3

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Contents

1 Analysis

In this report I will present my independent analysis of the questions related to home assignment 1. I have discussed the solution with Varun G Hegde but I swear that the analysis written here are my own.

2 Approximations of mean and co-variance

2.1 1 a and b

The samples of y=h(x)+r is generated by first sampling the state density, then dual bearing measurement is computed and random sample noise is added. The three approximations of the mean and covariance are computed using the type of density called EKF, UKF,CKF. This is well scripted in the MATLAB code.

2.2 1 c

Below you can find the plots of y, the sample mean/covariance, as well as the three different approximated means/covariance.

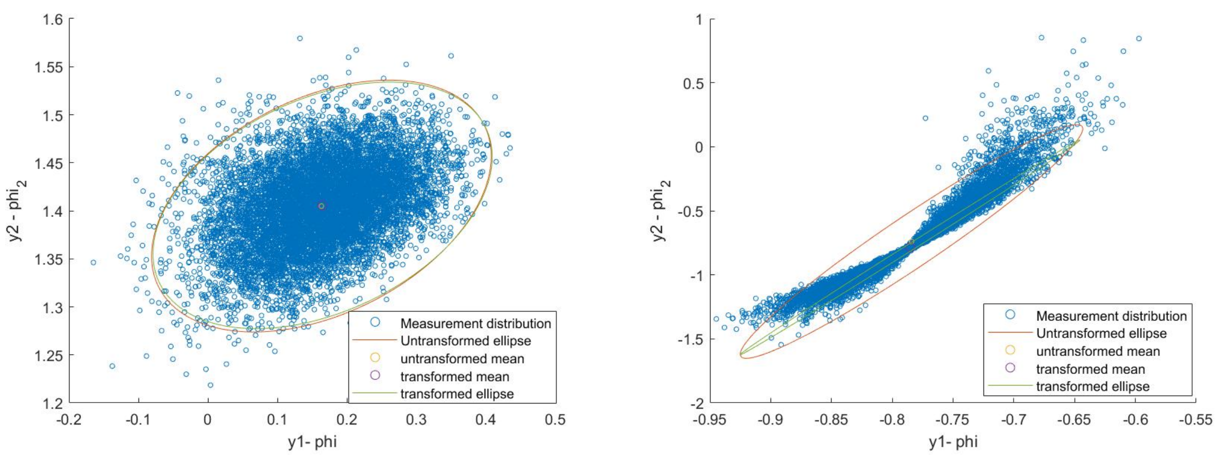


Figure 1: plots of Input EKF

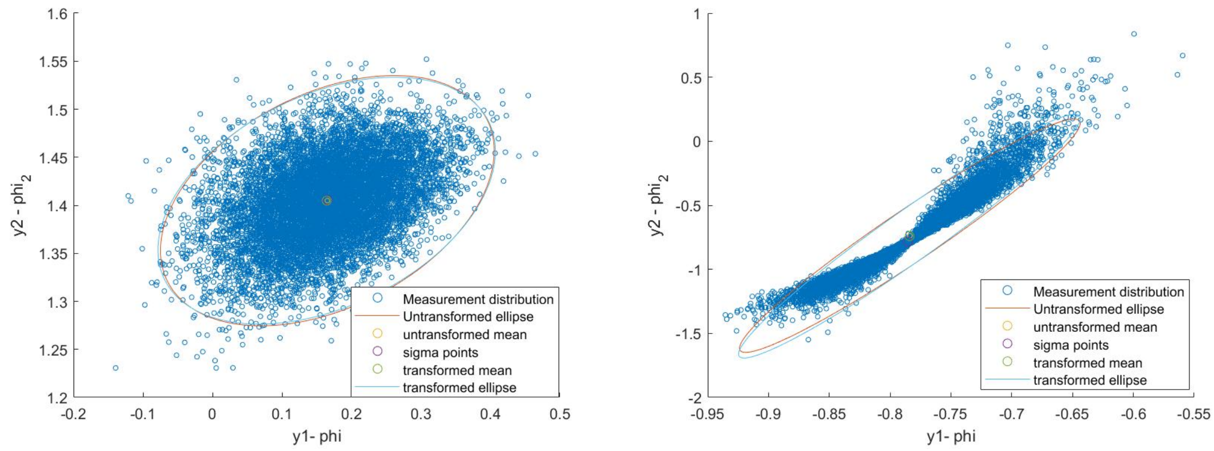


Figure 2: plots of Input UKF

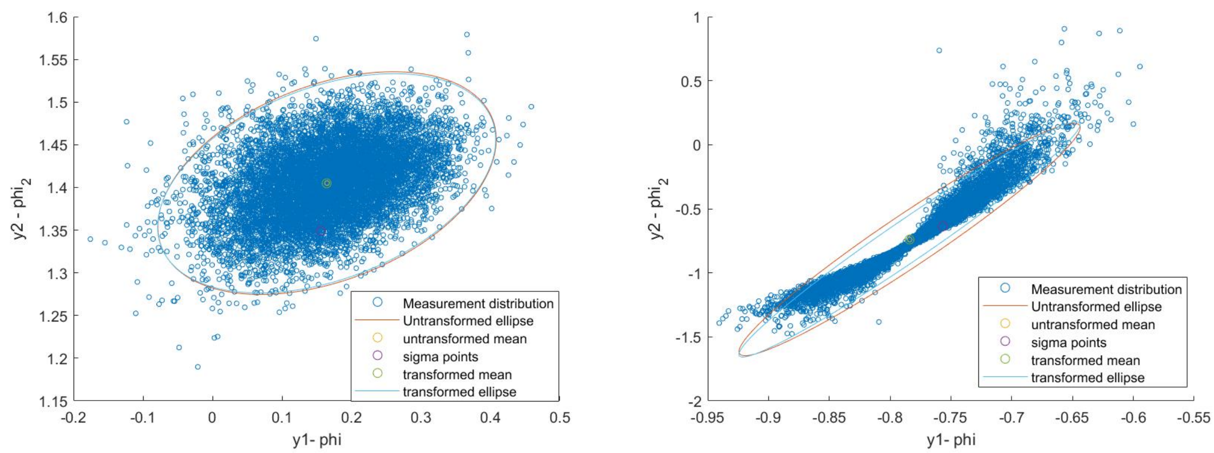


Figure 3: plots of Input CKF

2.3 1 d

The main difference is that for scenario 1 there is equal values of mean of states and difference in co-variance which leads to uncertainty in ellipse axis which makes transformed distribution approximately Gaussian. For scenario 2 the difference in values of mean of states are large making transformed distribution approximately non Gaussian.

CKF is the best choice for approximating non linear transformations. The reasons for individual is stated below:

EKF: Set of Sample mean obtained from the true distribution and the approximated EKF mean shows the inaccuracy of approximation. The approximated 3 sigma ellipse is highly inaccurate which can be observed from the difference in the 3 sigma ellipse of sample distribution and the approximated 3 sigma ellipse. SO finally EKF is bad choice for approximation.

UKF: The Sample mean got from the true distribution and the approximated UKF mean are overlapping and its accurate. The approximated 3 sigma ellipse follows the 3 sigma ellipse of the true distribution fairly well with slight difference which can be observed from the figure. Thus UKF is a good choice for approximating non linear model.

CKF: The Sample mean obtained from the true distribution and the approximated CKF mean are overlapping and more accurate.The approximated 3 sigma ellipse follows the 3 sigma ellipse of the true distribution with high ac- curacy which can be observed from the figure. So I would recommend CKF is the best choice for approximating non linear model.

2.4 1 e

We see that kalman filter and the non-linear kalman filter propagates the mean and covariance of state estimate also these are sufficient statistics for gaussian distribution. with given approximation of mean and covariance yes of course it is a good idea to approximate the density p(y) with gaussian distribution.

But when compare the approximation with samples large number of sample points are lying outside in this case it is not recommended to approximate the non linear distribution.

3 Non-linear Kalman filtering

3.1 a and b

The process and measurement noise standard deviations are considered from the table given. From the given values assume sensors are stationary. For task a state sequence and measurement sequence is generated for 100 time steps. Below you can find plot for the performance of three different non linear kalman filters.

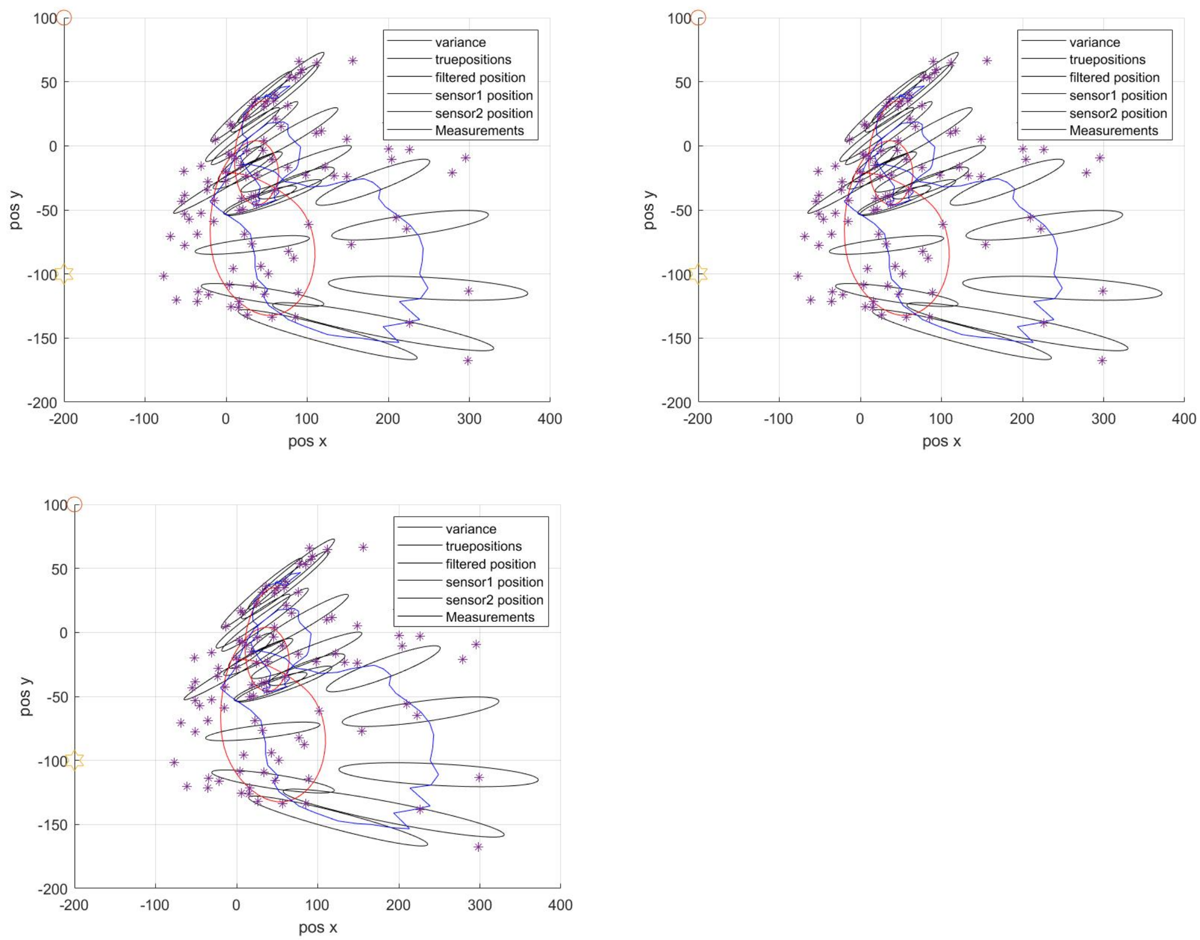


Figure 4: plots of Input 1 EKF, UKF, CKF

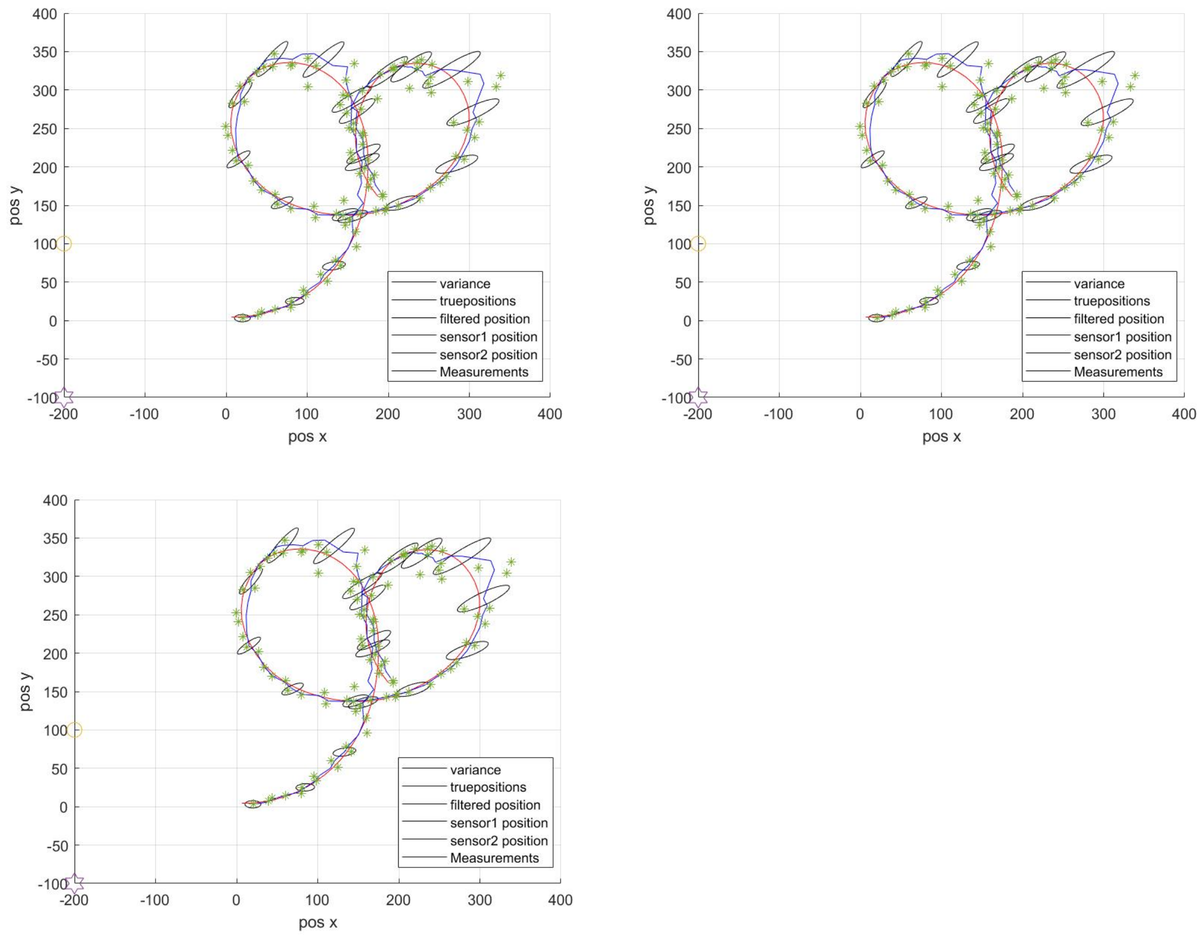


Figure 5: plots of Input 2 EKF, UKF, CKF

Yes, all the filters behaves well in this case except for EKF in terms of filter approximation and estimation. Then because of same variance the error covariance represent the uncertainty well.

when considering the filter approximation UKF and CKF gave better performance compared to other EKF for measurement model 1 and for model 2 all the three filters performance is good because of having equal variance.

3.2 c

100 state/measurement sequences is generated for each sequence and EKF, UKF, CKF is computed. Below you can find the histogram for two different measurement models.

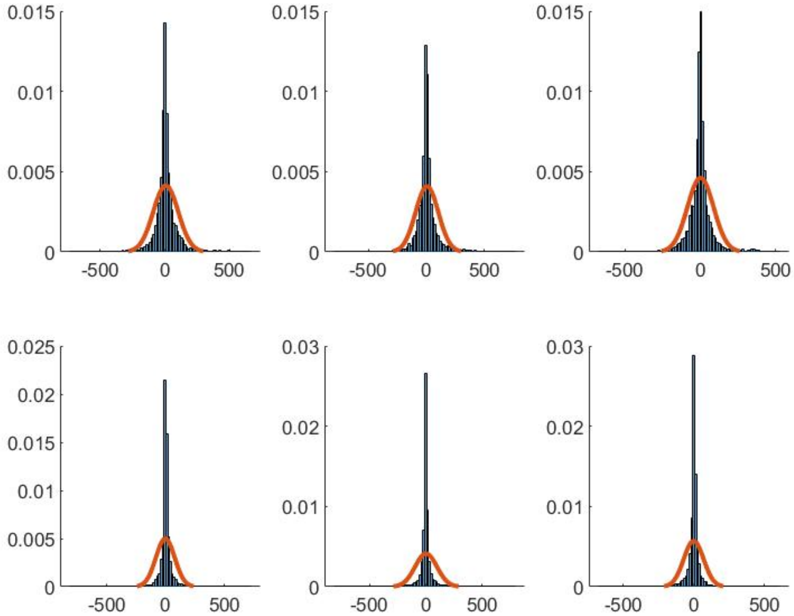


Figure 6: plot of histogram of estimation error for position states in state vector for measurement model 1

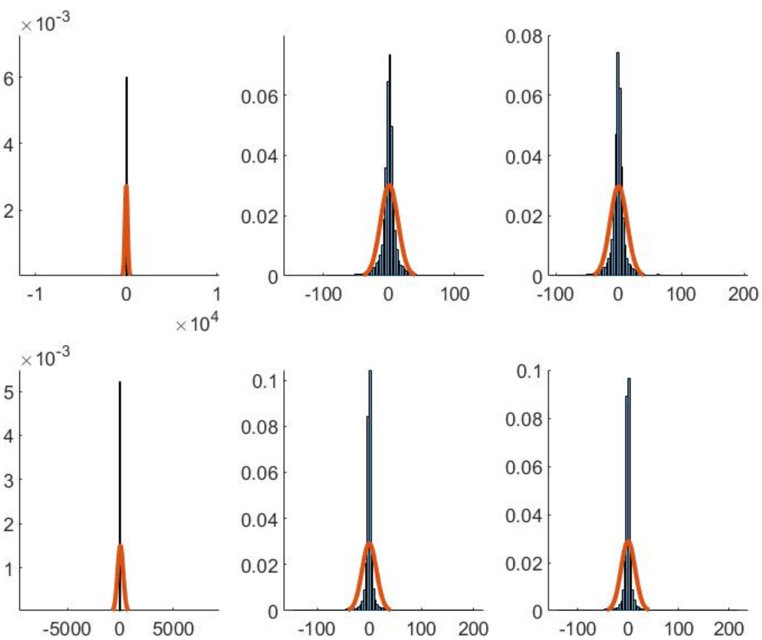


Figure 7: plot of histogram of estimation error for position states in state vector for measurement model 2

yes, the histogram do look like Gaussian with mean 0 and let see the distribution lies within the variance.

4 Tuning non-linear filters

4.1 a

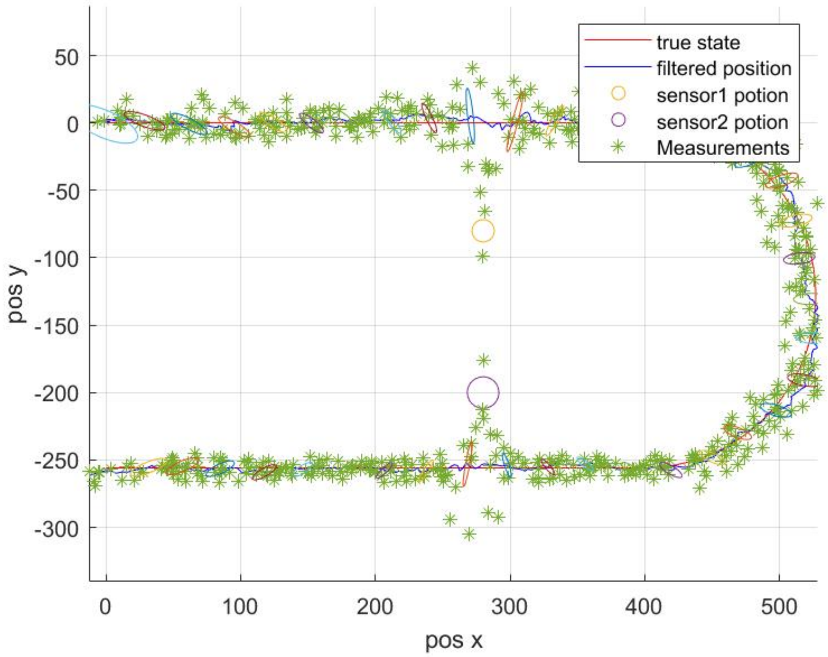


Figure 8: plot with default parameters

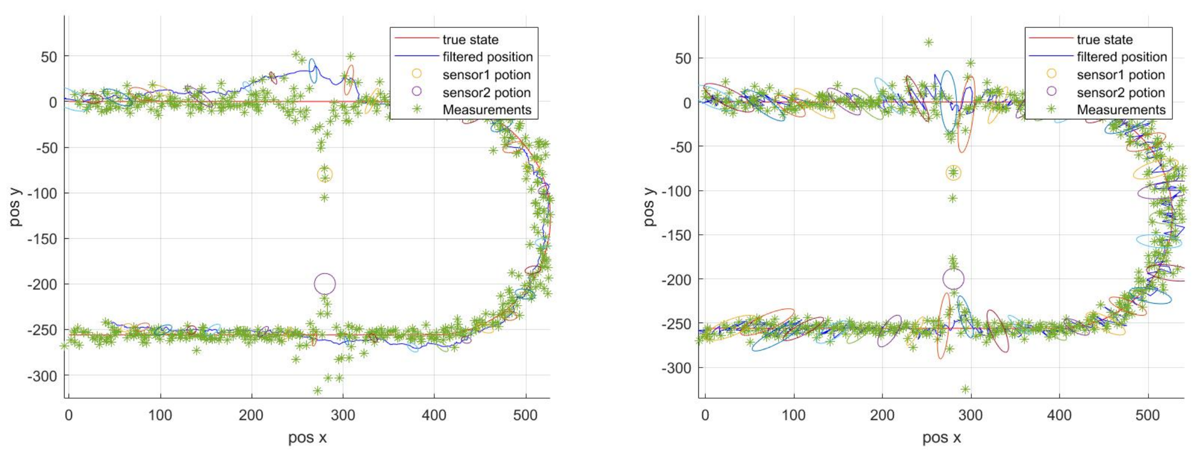


Figure 9: plots with i) one large parameter ii) both large parameter

when increasing the process noise in one parameters shows some projection in filtered position where increasing in both cases the impact in filtered position happens all over the curve.

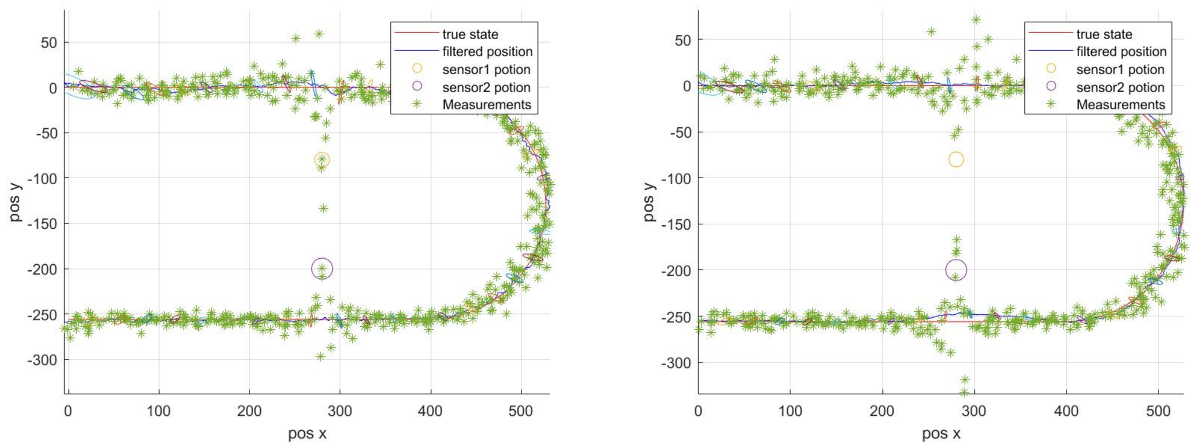


Figure 10: plots with i) one low parameter ii) both low parameter

shows no impact when have low process noise in one parameter and positive deflection when lowering both the parameter.

4.2 b

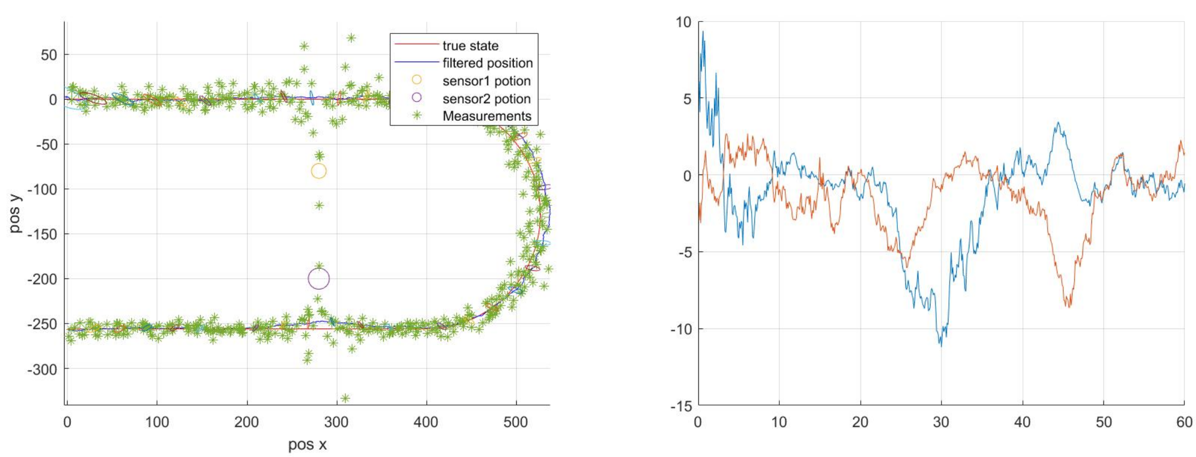
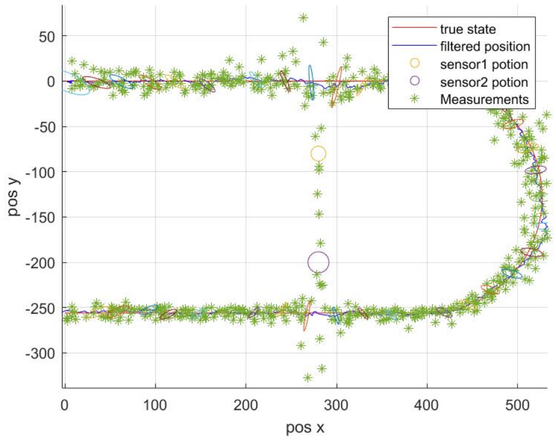


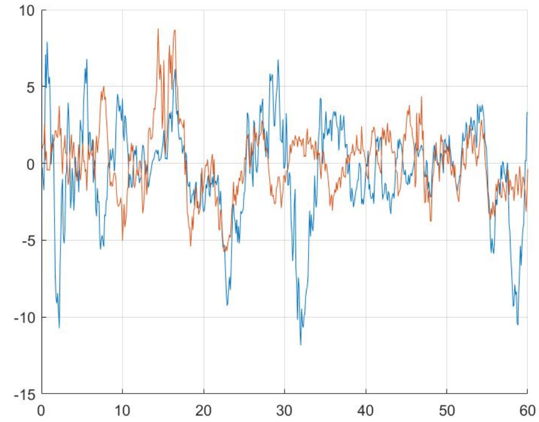
Figure 11: plots of well tuned process model with 0.1*parameter

Here is the fine tune so that we get good position estimates for the whole sequence.

4.3 c

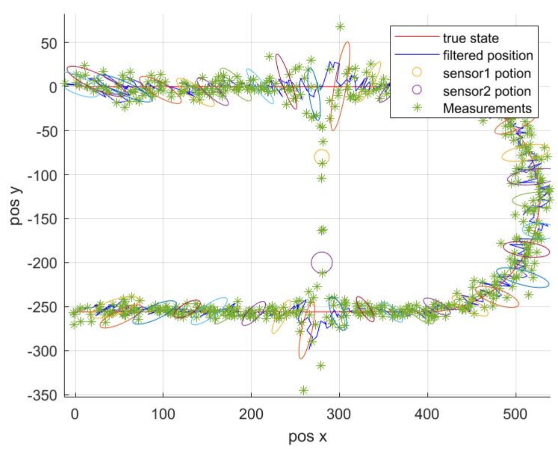


.5



.5

Figure 12: plots with default parameter and error



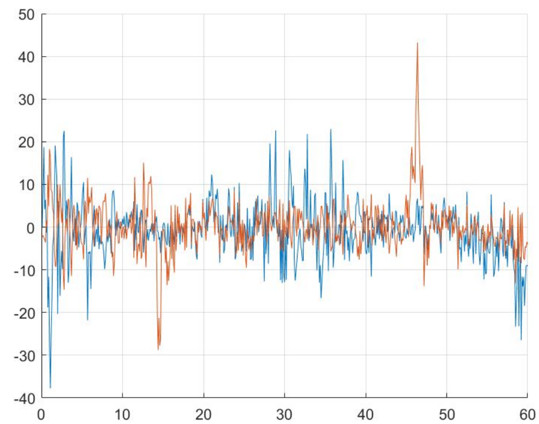


Figure 13: plots with large parameter and error

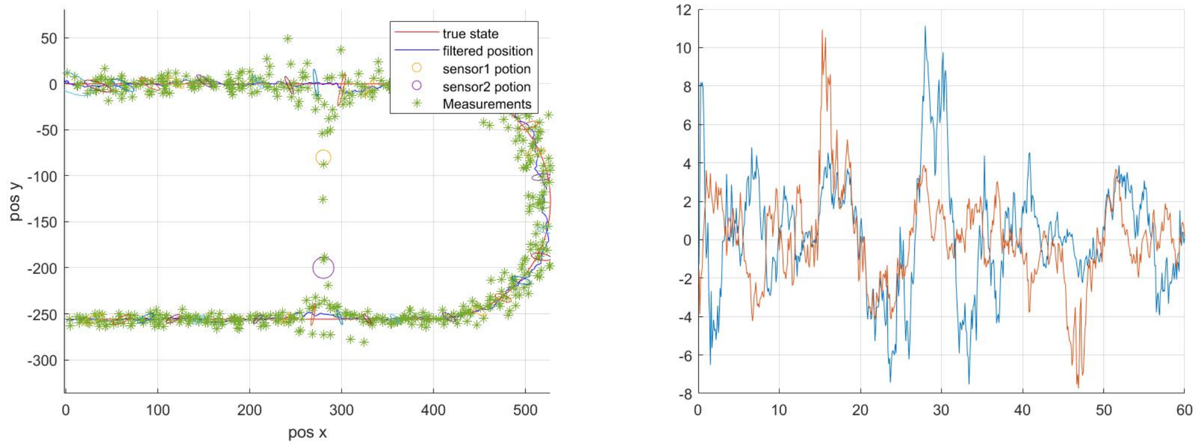


Figure 14: plots with small parameter and error

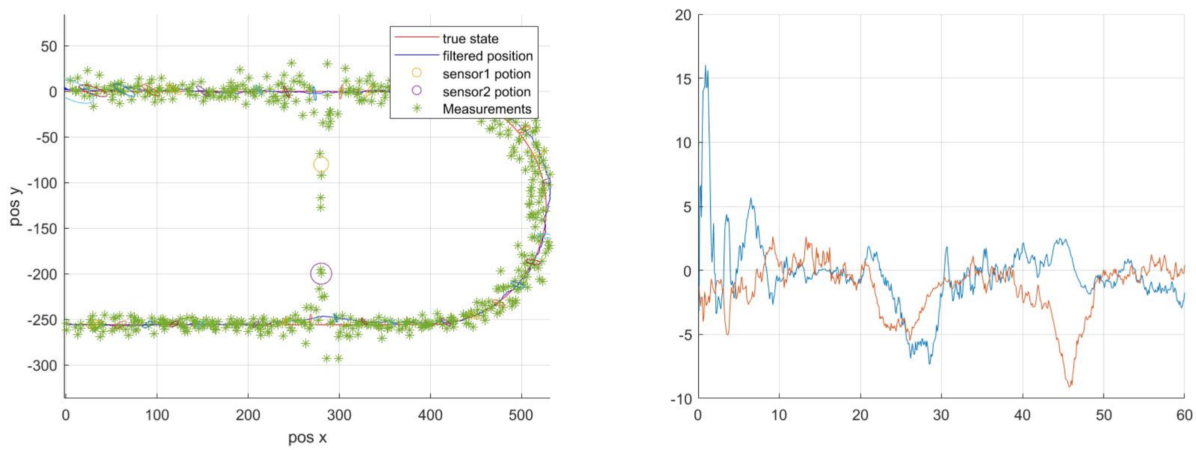


Figure 15: plots of well tuned process model with 0.1*parameter

4.4 d

It is highly difficult for tuning the sensor for simultaneous case like straight and turn. For straight roads it is recommended to have low velocity, heading and turn rate and vice versa for curve roads.