Solution to analysis in Home Assignment 4

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Analysis

In this report, i have analysed the questions related to home assignment 4. I have discussed my solutions with Hariharan Gopinath. Hereby, i consent that the results produced are my own results.

1 Smoothing

A)

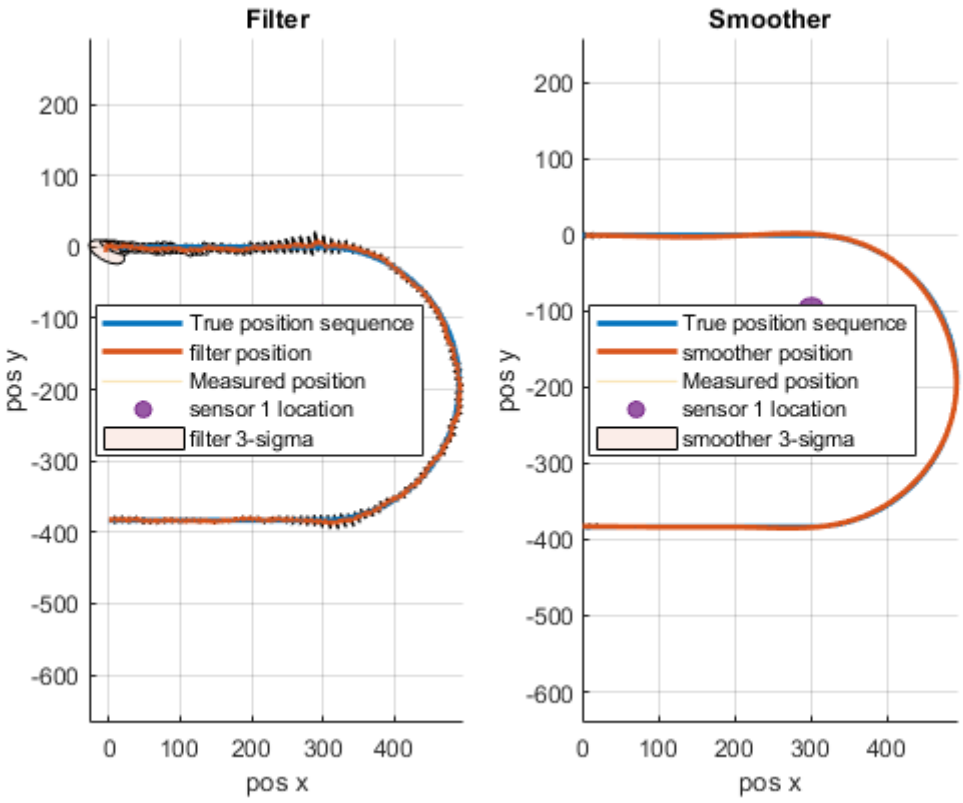

Figure 1: Filter and smoother position estimates

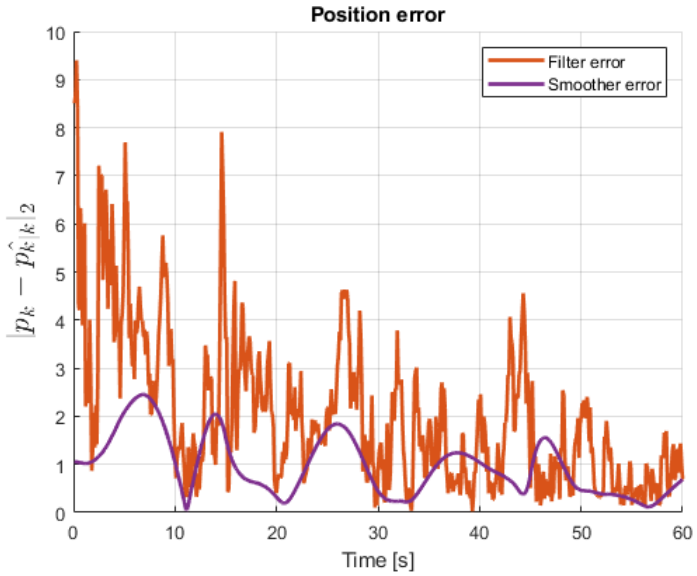

Figure 2: positional error

From the above images we can infer that in comparison with the filter position, the smoother position estimate is much less noisy and replicates the true movement better. Also when comparing the position error graphs, the smoother position estimate is said to have error values lower when compared to the filter position estimate. Also, knowing the values of previous and future measurements makes the smoother position estimate more precise.
At time instances t=10, 20 and 30, the vehicle changes from straight line to curve, the error estimates are similar because the vehicle experiences high yaw accelerations. **B)**

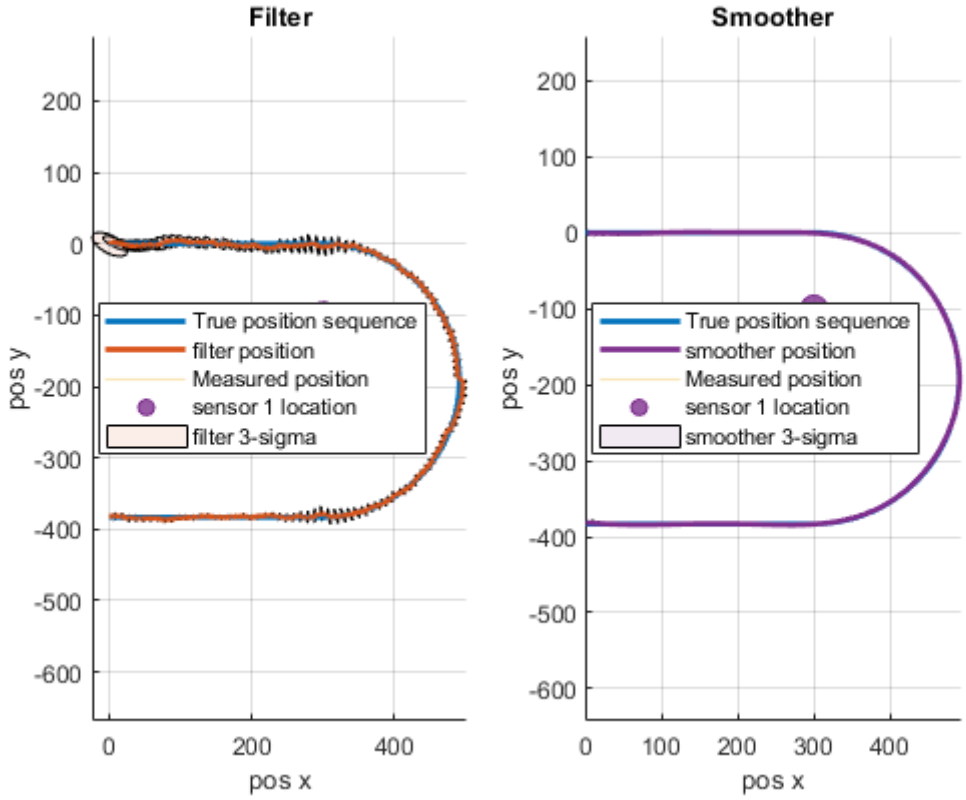

Figure 3: Filter and smoother position estimates at k=300

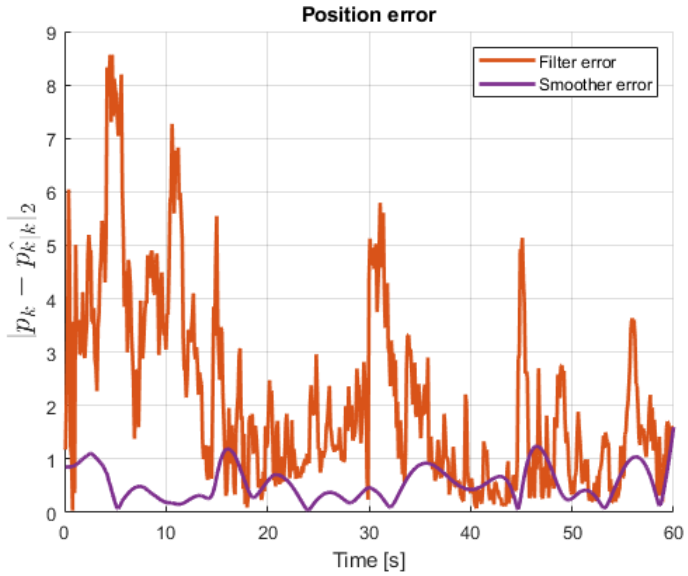

Figure 4: positional error at k=300

The above images depict the x-axis variable in seconds (here t=30 seconds). In the smoother estimation as we already know the prior and future measurements, the estimation is better compared to the filter estimation. As an additional error is added, the error deviation is higher.

2 Particle filters for linear/Gaussian systems

A)

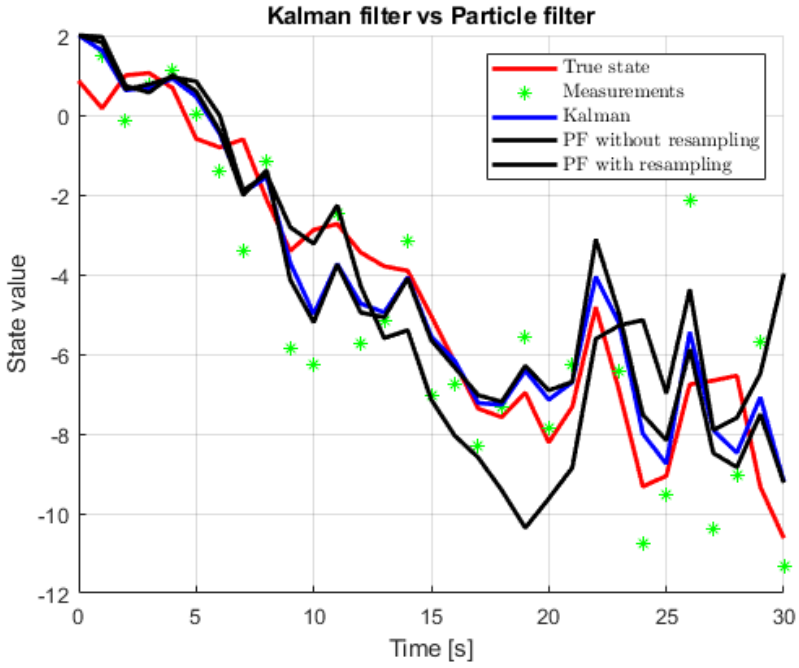

Figure 5: Comparison of the true state with all three filters

The above figures shows the true trajectory and the three filter estimates over time. The particle filter performs well with resampling than withput resampling case. And kalman filter being the optimal filter has the best performance among all three which can be proven with the MSE values which depict the performance.

```
Kalman =

    1.1979


pf1 =

    4.2959


pf2 =

    1.5718
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Figure 6: Performance of the three filters

From the above values, we can infer that the kalman filter performs the best followed by the particle filter with resampling and the particle filter without resampling.

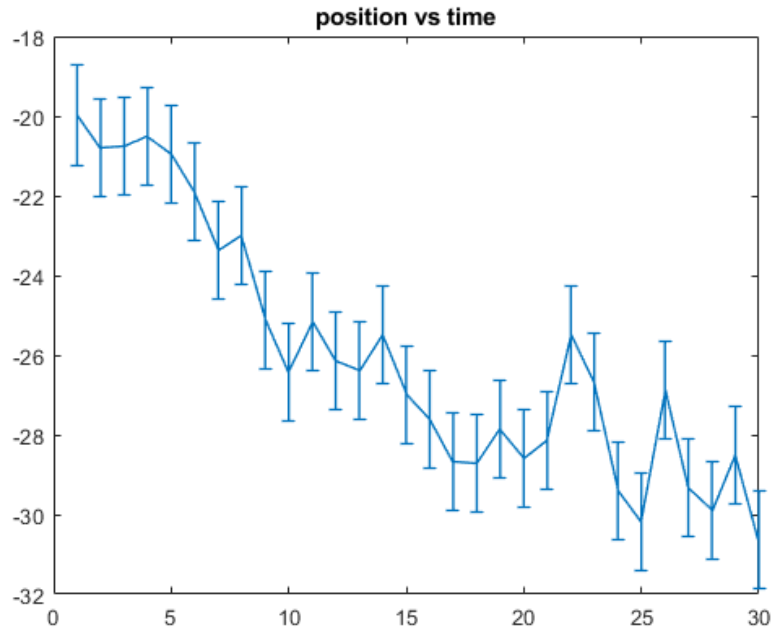

Figure 7: Error and covariance over time

B)

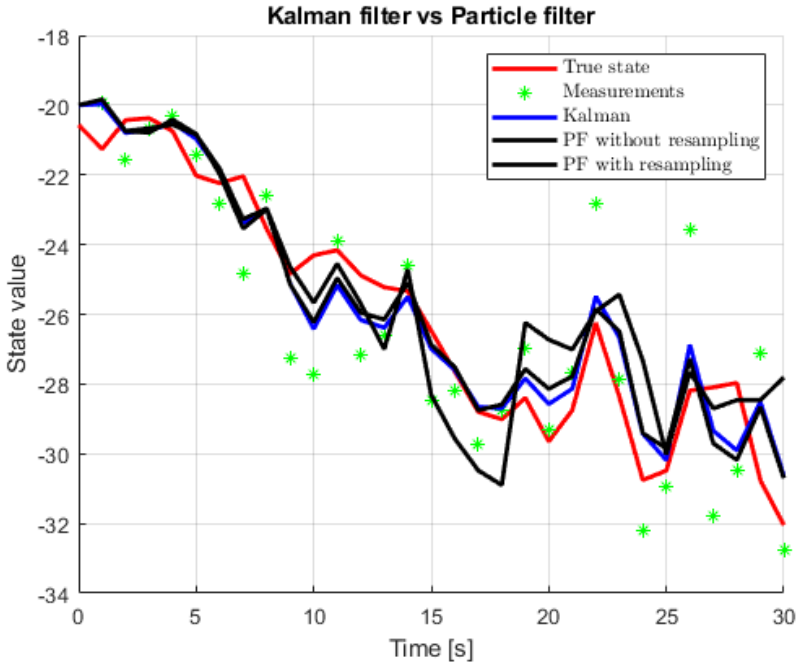

Figure 8: Posterior densities along with both MMSE and MAP estimates

When the values of prior are incorrect (-20,2) with the same trajectory, measurement sequence and number of particles, the estimates produced by the three filters approaches quickly compared to the previous case with prior values 2 and 8.

C,D

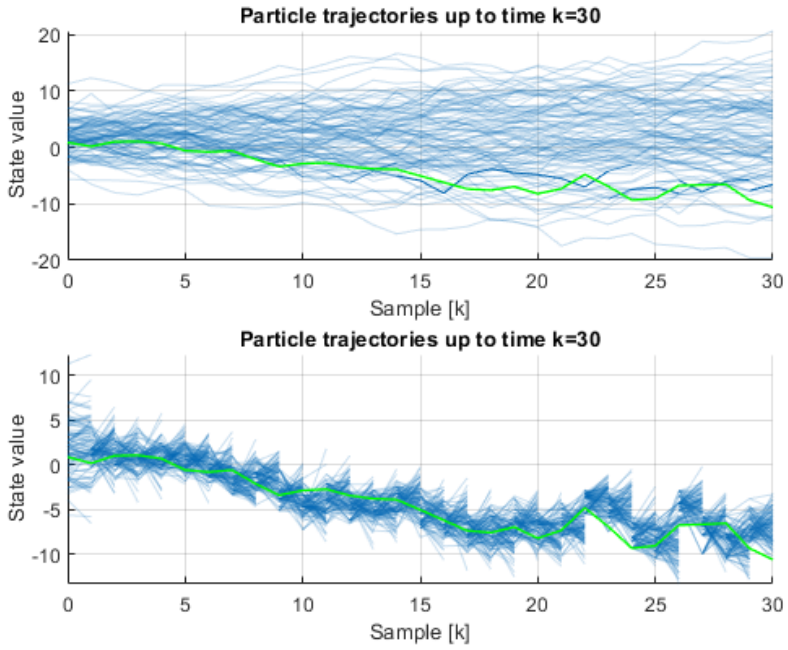

Figure 9: Particle filter without resampling and with resampling respectively

Without resampling, when compared to the true trajectory, due to the high uncertainty in the motion model the particle starts to spread out. And after 30 time steps, majority of the particles among the 100 are found to be far away from the two state. Hence the performance of the filter is much reduced.
With resampling, no degeneracy occurs as the particles with high weight replaces the particles with low weight. On a whole, the particles are close to the true state.