TTK4250 Graded assignment 1: *IMM-PDA*

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Tuning and a brief explaination of the various figures.

Throughout the tuning process of both task 2 and 3 we used multiple plots as measurements of the filters performance. We decided to use logarithmic scale for our NEES and NIS plots as it gave a better visualization when the values were small.
We used a plot of the individual NIS and NEES values for the CV and CT-models as seen in figure 1c. This is only shown in this report for task 2. It gave an indication of the individual models performance and aided in tuning the sigma parameters for each filters. During the tuning process of the joyride data set we observed that the CT model was not confident enough as the NEES values were to low. This was not visible in the NEES plot for the IMM model, as the model primarily trusted the CV model. The NIS values were based on the accepted measurements and used when tuning the measurements variance.
A NEES plot for the combined filter with visible confidence intervals, as seen in figure 1d and 2b, was used for all the models to keep the NEES of our filter within the CI as much as possible, so the covariance of our filter commensurated with the actual state errors.
Figure 1a, 2a, 3a and 4a displays on the left hand side our measurements, the ground truth and colored tracking where the color shows mode probability (blue for CT and purple for CV). The coloring of measurements helped tuning the gate parameter and the the coloring for the mode helped in tuning PI11 and PI22, to get the mode probability to match the trajectory. On the right hand side the mode probability is displayed.
Figure 1b and 2c displays the estimation error.
The tuning for all of the models were done in the same manner. The initial values were chosen by examining the properties of the given data set. We found the average measurement error of the accepted measurements, the average change in velocity and the average change in velocity direction. The final values were found by tuning the parameters through "guesstimation" by comparing the various parameters with our plots.

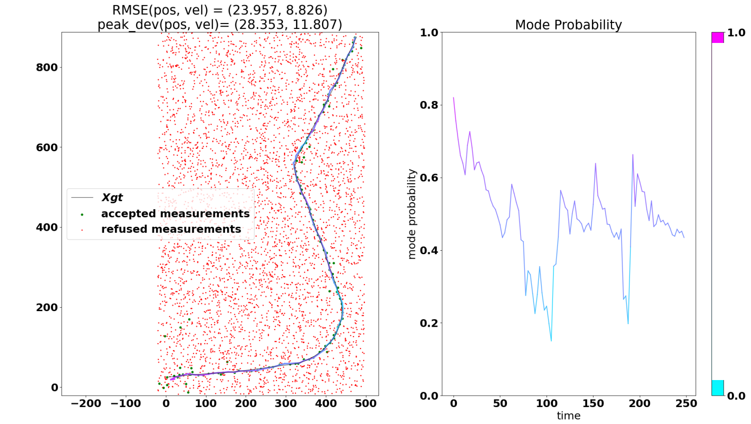
Task 2 - Tuning the IMM to the given data

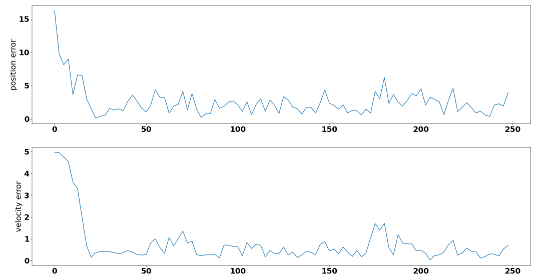
The final values we deemed reasonable for the tuning of the IMM can be seen in table 1, and the resulting performance can be seen in figure 1.
During the tuning process we noticed that there were more misdetected measurements at the start of the tracking than it was during the process. This can be seen figure 1a. The acceptance of some measurements that should not be accepted, led to the model believing it should turn. This was fixed by performing some more rigorous tuning, until we decided the results were satisfactory.
In addition to this, we believe that the occurring misdetections at the start, is caused by a larger uncertainty and estimation error (see figure 1b) at the beginning of the simulation. The single target PDAF also assumes that there can only be one measurement comming from the target at any given time, which means that determining which of the m_k measurements that comes from the target at any given time instant is decided with a 1-PD% = 5% chance of beeing a wrong measurement, thus it may be a real chance that a misdetection has since occured due to the amount of measurements at each time step.
All in all the performance of the imm-pda were deemed satisfactory supported by the results in figure 1d, where we're 91, 85 and 91 percent within the CI relative to a time cost.

Parameter	σ_z	$\sigma_{a,CV}$	$\sigma_{a,CT}$	σ_ω	clutter	Gate size	PD	PI11	PI22
Initial value	17	0.22	0.22	0.014π	0.00005	5	0.95	0.9	0.9
Final value	3	1.2	0.3	0.02π	0.00005	5	0.95	0.9	0.9

Table 1: Tuning parameters for task 2 - Tuning the imm to the given data.

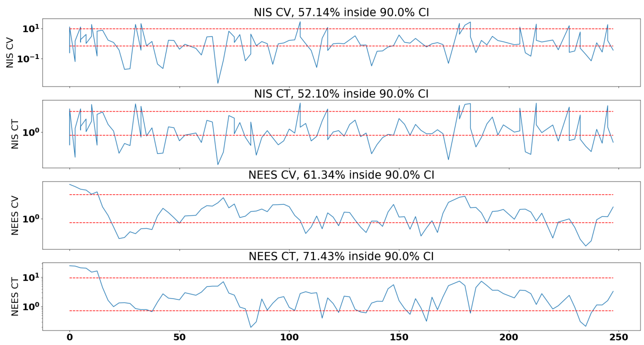
We ended up with a much lower σ_z than what we initially had, where the reduction were motivated by an increase in performance in the NIS CI-plot without costing too much on the NEES CI-plot, and balanced by increasing the acceleration sigmas. The model displayed satisfactory performance regarding when the change between CV and CT occured on the first dataset with theese values, as can be seen in 1a.

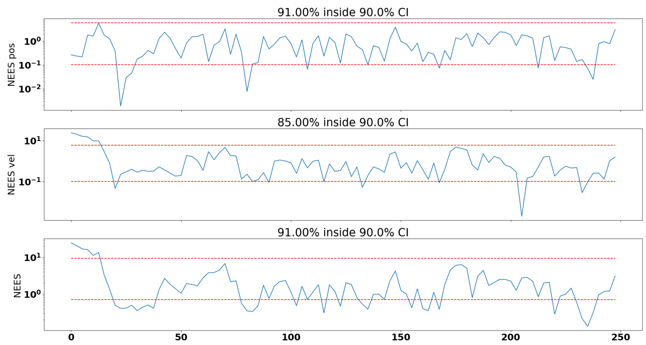




(b) Estimation error in position and velocity

(a) True trajectory, tracking, and measurements (left) and Mode chosen (right)





(c) Individual NIS and NEES for each EKF filter

(d) NEES for pos, vel and total for the IMM filter

Figure 1: Resulting plots for task 2

Task 3 - IMM-PDAF with various estimators

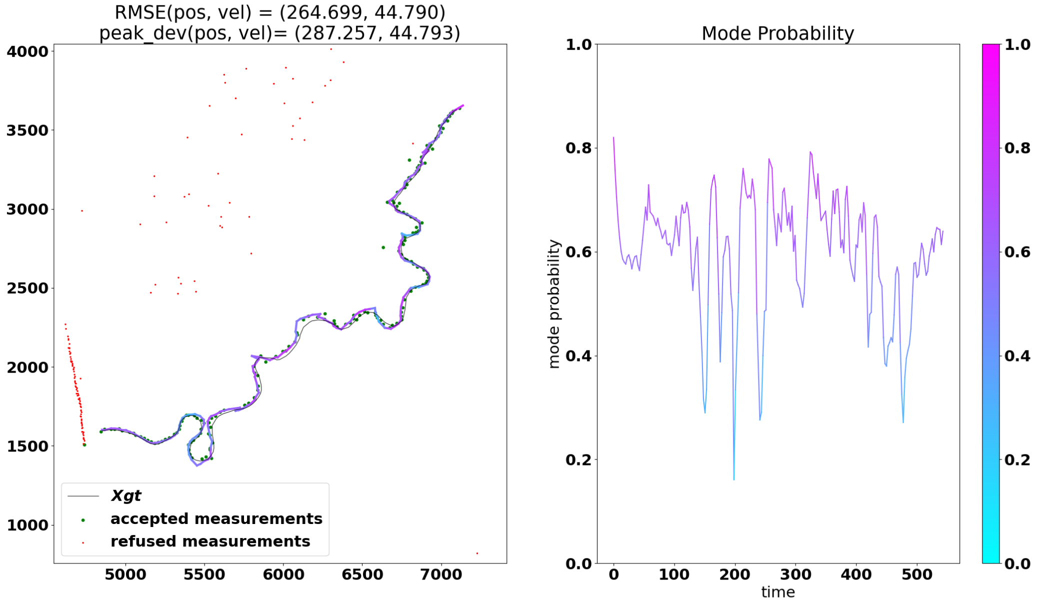
The tuning parameters for the IMM-PDAF on the joyride data set can be seen in table 2. This data set was a lot more challenging than the the generated data, as the maneuvers were stronger. The most difficult part was to get the filter to correctly estimate the mode probabilities. When experimenting single model filters, we observed that both the CV and CT model managed to follow the trajectory by them selves (both had RMSE $\approx$ 305). This was using the same σ parameters as when they were used in combination in the IMMF. Our hypothesis is that the difficulty for the IMM to correctly estimate the current mode is due to both models working adequately most of time. The rapid alteration between the modes also made it difficult. We observe the mode probability of the CT model tend to be high at the end of each turn (light blue), but not during. Better tuning might result in better estimation of modes.
Although both models worked by them selves, the combined tracker performed better. Finally, the IMMF with a third model (CV high), got the best performance (RMSE $=$ 261) although a negligible difference compared to the previous IMMF.
We observed that proposition S7 (7.3.1) seems to not be correct for this data set. The straight line of clutter points at the bottom left is clearly not i.i.d. The points might come from another boat that is detected. Fortunately it does not matter, as the measurements are not accepted by the PDAF. We also observed a bias in the measurement error of the accepted measurements. The average of $\mathbf{x_{Gt}} - \mathbf{z}$ was $\begin{bmatrix}5.9 & -9.6\end{bmatrix}^T$, and the median was $\begin{bmatrix}6.2 & -9.2\end{bmatrix}^T$. This will affect, among other things, the NEES and RMSE.

Parameter	σ_z	$\sigma_{a,CV}$	$\sigma_{a,CT}$	σ_ω	clutter	Gate size	PD	PI11	PI22
Initial value	22.7	1.77	1.77	0.06π	0.00005	5	0.95	0.9	0.9
Final value	22.7	1.2	0.3	0.02π	0.00005	4	0.95	0.9	0.9

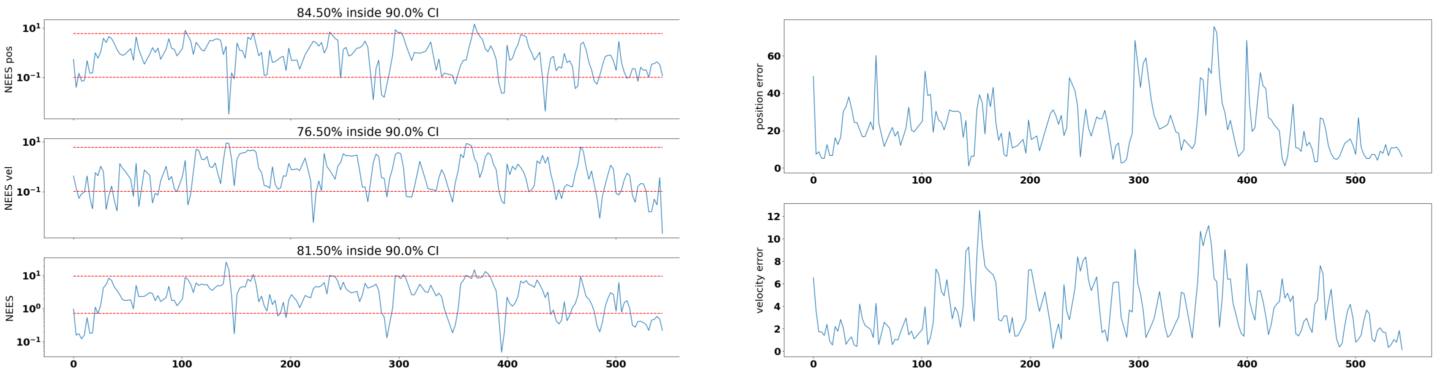
Table 2: Tuning parameters for task 3 - Tuning the imm-pdaf to the joyride data

Results from Joyride tracking with various estimators

CV-CT - model



(a) True trajectory, tracking, and measurements (left) and Mode probability (right)

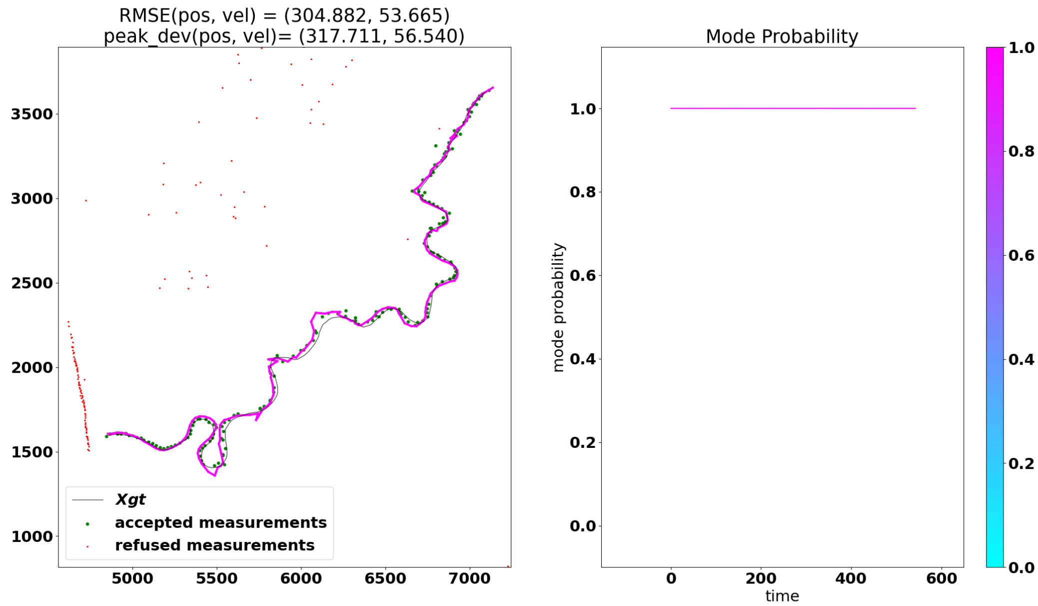


(b) NEES for pos, vel and total for the IMM filter filter

(c) Estimation error

Figure 2: Resulting plots for task 3 with CV-CT

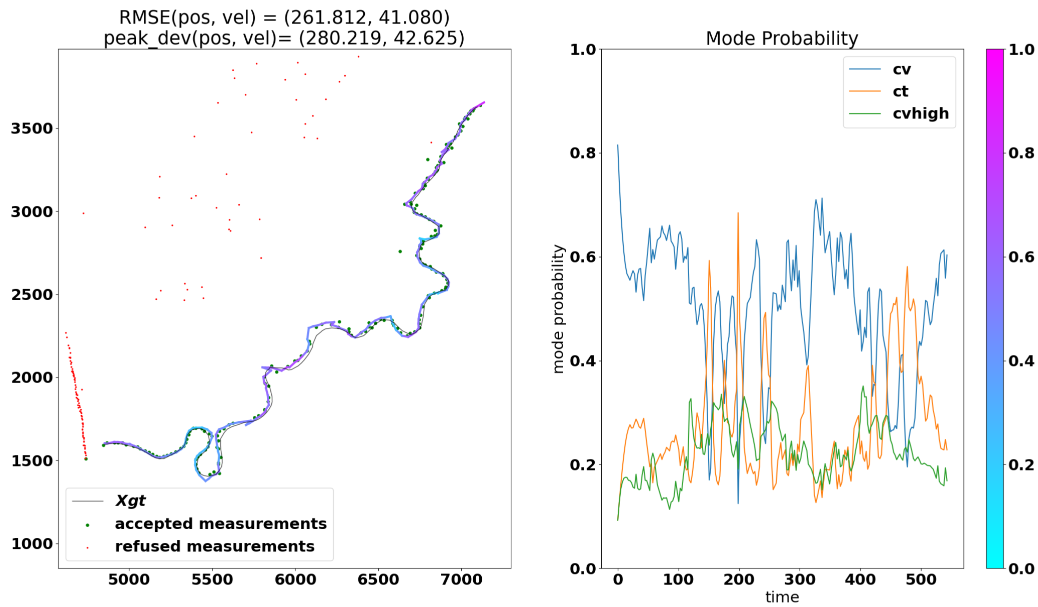
EKF with CV mode



(a) True trajectory, tracking, and measurements (left) and CV mode chosen (right)

Figure 3: Resulting plots for task 3 with EKF and CV

CV-CT-CVhigh



(a) True trajectory, tracking, and measurements (left) and mode chosen (right)

Figure 4: Resulting plots for task 3 with CV-CT-CV high estimator