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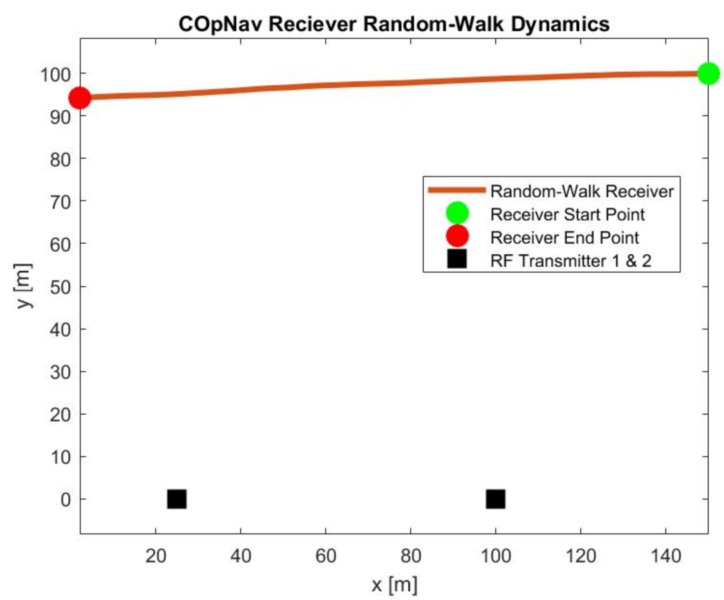
Mini-Project 3

Problem Description:

A vehicle-mounted, or similarly setup, receiver moves with random-walk dynamics to the left (i.e. x-direction velocity only) where it attempts to simultaneously map and localize itself within the environment using the Radio SLAM framework. The environment assumes there are two known radio frequency transmitters which are required for the collaborative opportunistic navigation (COpNav)simulation to be observable. These transmitters serve as signals of opportunity (SOP) for the receiver to obtain an eventually converging bounded estimate of its own states throughout time. This example assumes no clock dynamics are present in either the receiver or the radio frequency transmitters. Also, the radio frequency transmitters produce perfect range measurements due to no clock bias. The simulation layout for this problem statement can be seen in the figure below.



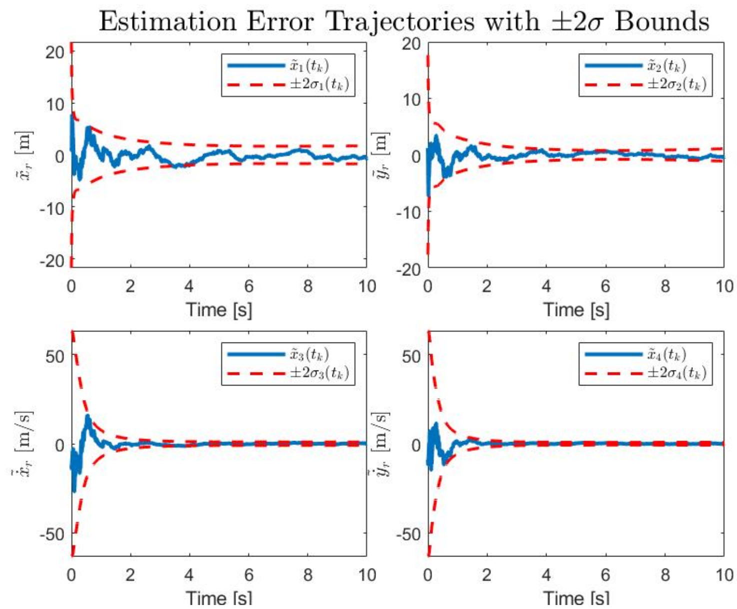
These are the simulation parameters for the three different cases run:

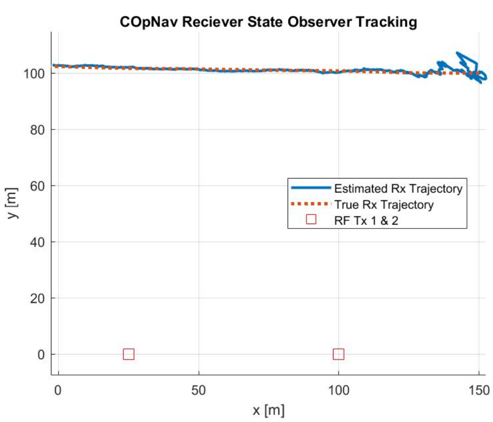
	$x_r(t_0)$	$x_{rf}(t_0)$	$\mathrm{P}(t_0 \vert t_{-1})$
Case 1	$[150, 100, -15, 0]^\top$	$[25, 0, 100, 0]^\top$	$(1 \times 10^3)\mathrm{diag}[1, 1, 1, 1]$
Case 2	$[150, 100, -15, 0]^\top$	$[25, 0, 100, 0]^\top$	$(1 \times 10^3)\mathrm{diag}[1, 3, 1, 1]$
Case 3	$[150, 100, -15, 0]^\top$	$[25, 0, 100, 0]^\top$	$(1 \times 10^3)\mathrm{diag}[1, 1, 1, 1]$

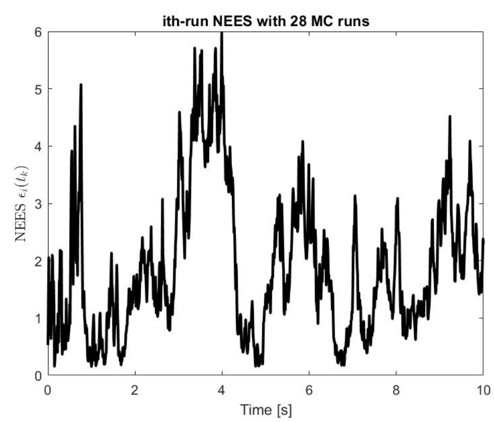
The receiver's process noise specral density was assumed to be $q_x = q_y = 0.1\ m^2/s^4$. Observation noise spectral density was set to 400 m^2. The sampling period T = 1 ms where the total time interval $\in$ [0, 10] sec.

Results:

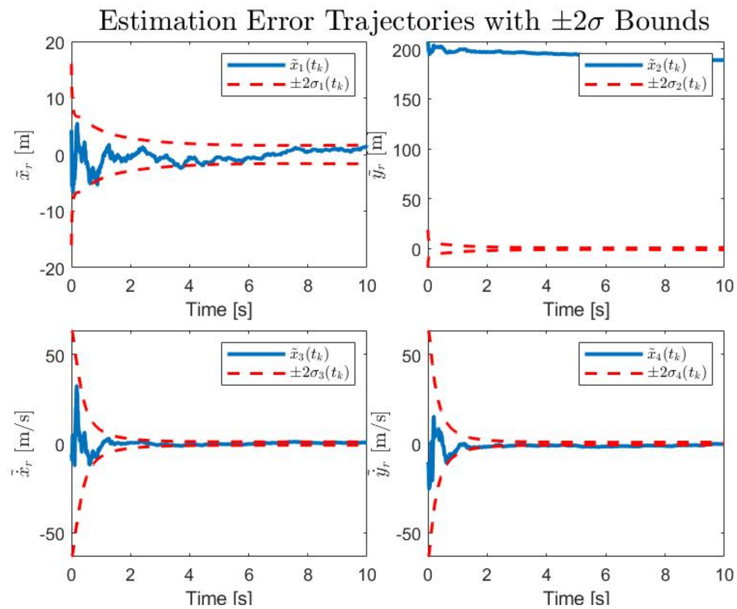
Case 1: Initial Estimate with Y-Position > 0

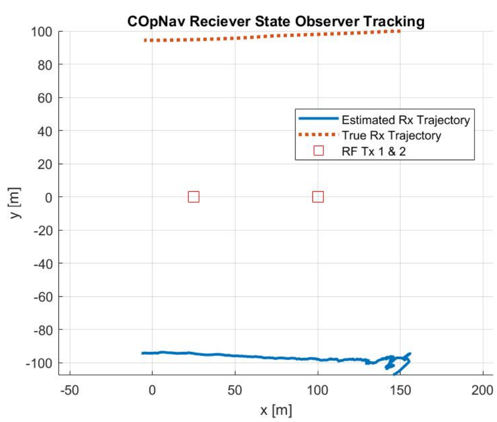


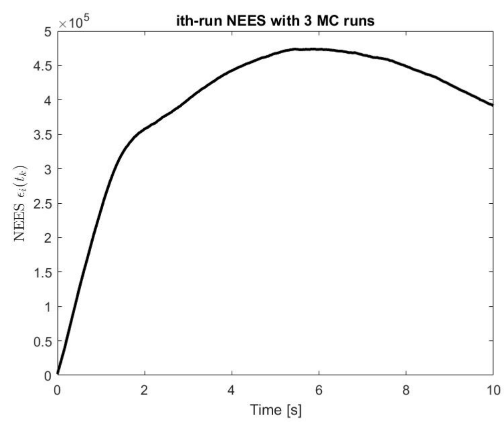




Case 2: Initial Estimate with Y-Position < 0

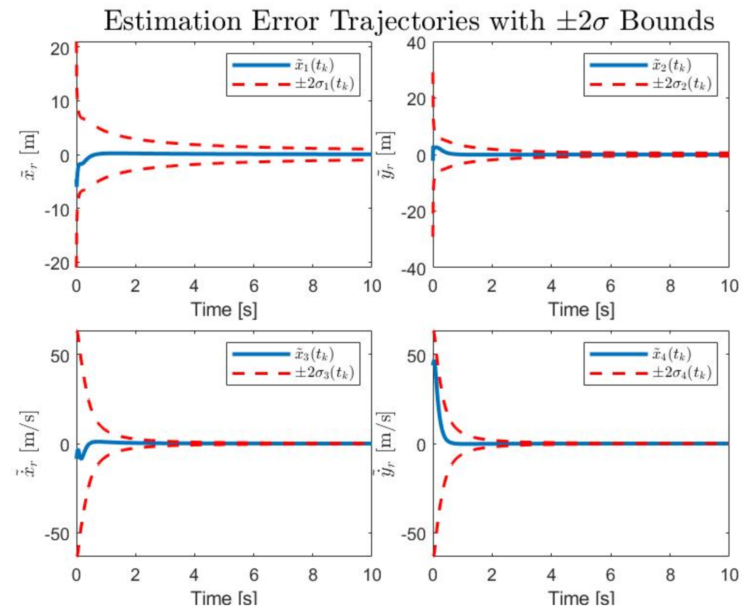


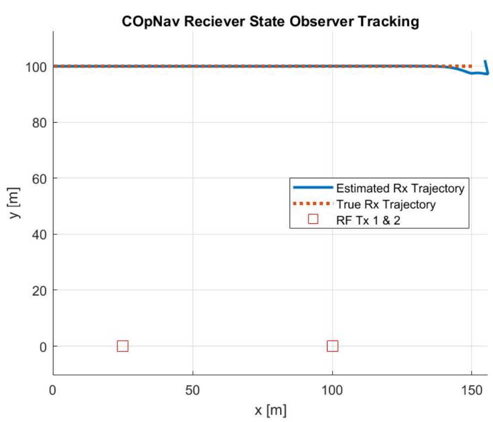


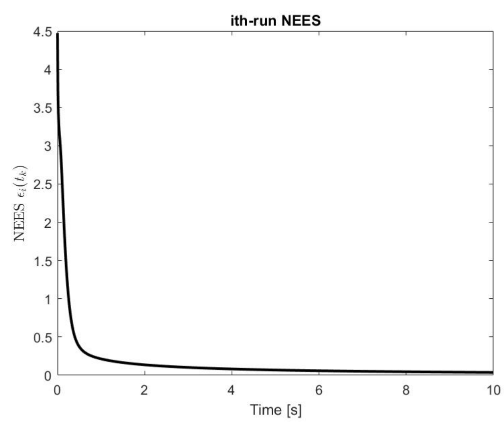


Here, the summation of the normalized estimation error squared (NEES), i.e. $\sum_{k=0}^{N} = \frac{\epsilon(t_k)}{N}$, yielded a large number (approx. 400000). This led me to notice a trend of when the y-position was less than zero, the estimation would converge to the trajectory on the opposite plane. This can be seen in the figures above.

Case 3: No Noise Added to EKF Estimator







Here, the simulation had no process noise (i.e. $q_x = q_y = 0$) but there was a measurement noise covariance to ensure the EKF filter worked. But, the measurements were assumed to be perfect (i.e. z = h[x]) with v_k = 0. The state observers approximately converged to the true state values when noise was set to zero.