Mini-Project 1

Paper Results

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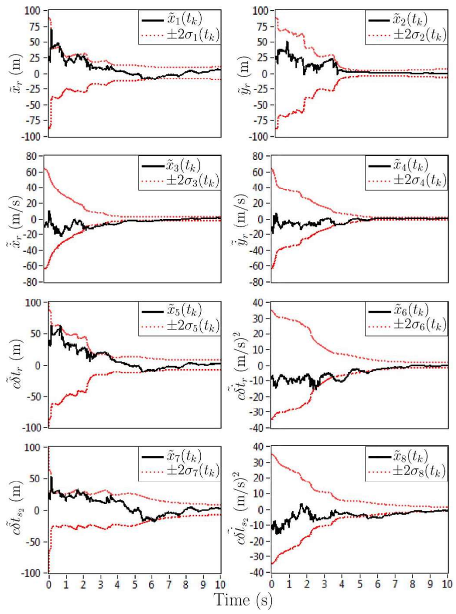


Fig. 1. Estimation error trajectories and $\pm 2\sigma$ bounds for Case 4 in Table I.

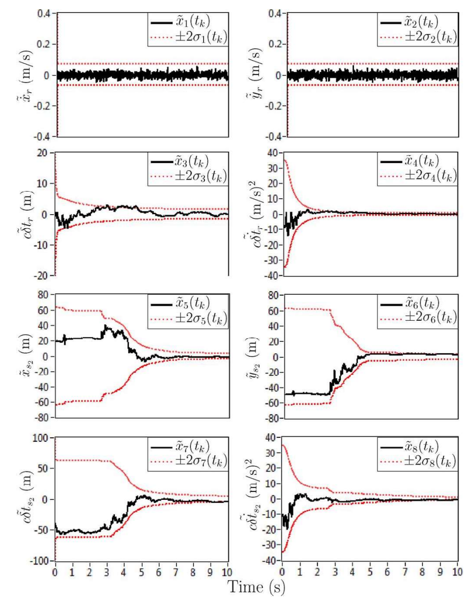


Fig. 2. Estimation error trajectories and $\pm 2\sigma$ bounds for Case 7 in Table I.

and one unknown. The initial estimation error covariance matrices of the receiver and the second SOP were chosen to be $\mathbf{P}_r(t_0|t_{-1}) = (1 \times 10^3)\text{diag}[1, 1, 30, 0.3]$ and $\mathbf{P}_{s_2}(t_0|t_{-1}) = (1 \times 10^3)\text{diag}[1, 1, 30, 0.3]$, respectively.

The simulations for Case 8 considered an environment with a fully known receiver and one unknown SOP. The initial estimation error covariance matrix of the SOP was chosen to be $\mathbf{P}_{s_1}(t_0|t_{-1}) = (1 \times 10^3)\text{diag}[1, 1, 30, 0.3]$.

Figs. 1–3 show the estimation error trajectories $\tilde{x}_i(t_k|t_k)$ for a single-run EKF along with the $\pm 2\sigma_i(t_k|t_k)$ estimation error variance bounds for Cases 4, 7, and 8, respectively. Note that the estimation error variances converge and that the estimation errors remain bounded as would be expected for an observable system.

Figs. 4–6 show the resulting NEES trajectories $\bar{\epsilon}(t_k)$ for $\alpha = 0.01$ along with r_1 and r_2 for Cases 4, 7, and 8, respectively. Note that the $\bar{\epsilon}(t_k)$ values reside within the 99% probability region, which is consistent with a well-behaved estimator operating on an observable system.

VI. Experimental Results

A field experimental demonstration was conducted to illustrate one of the observable cases in Table I, namely, Case 8. The objective was to demonstrate that a COpNav receiver with velocity random-walk dynamics and knowledge of its initial state can estimate the states of an unknown SOP in

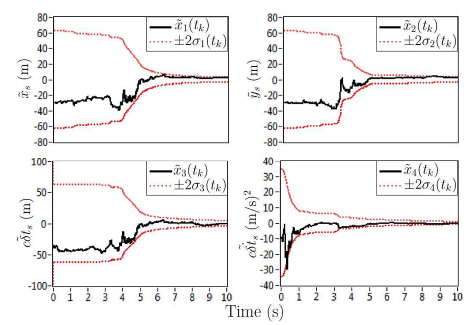
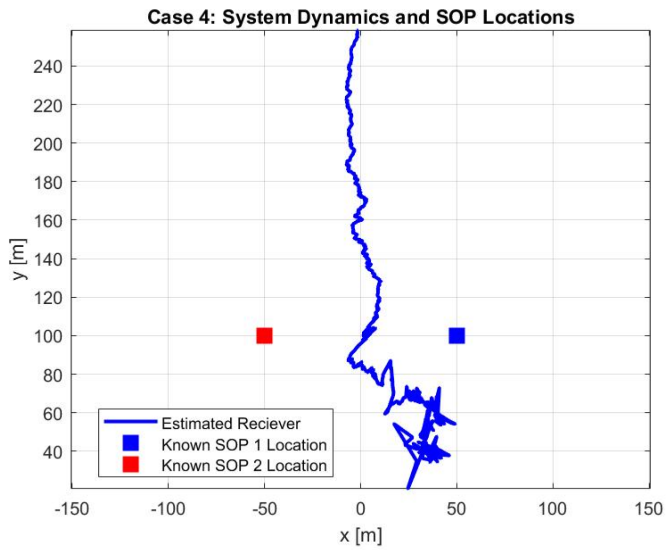


Fig. 3. Estimation error trajectories and $\pm 2\sigma$ bounds for Case 8 in Table I.

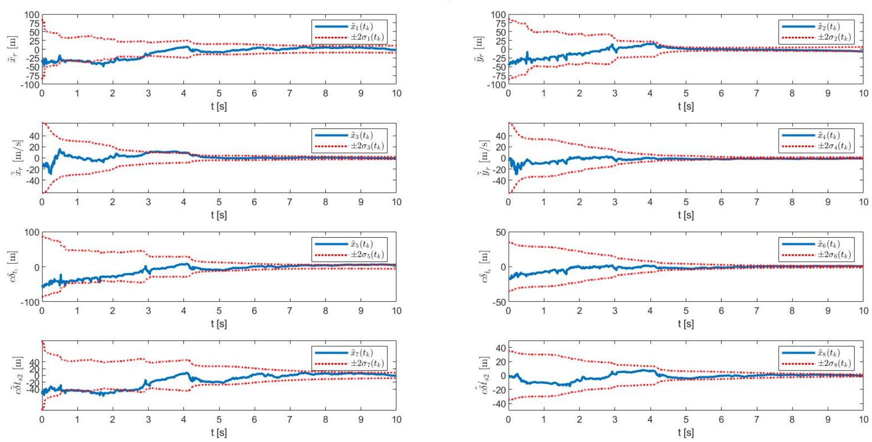
its environment. To this end, two antennas were mounted on a vehicle to acquire and track: 1) multiple GPS signals; and 2) a signal from a nearby cellular phone tower whose signal was modulated through code-division multiple access (CDMA). The GPS and cellular signals were simultaneously downmixed and synchronously sampled via two National Instruments vector RF signal analyzers. These front ends fed their data to a Generalized Radionavigation Interfusion Device (GRID) software receiver [42], which simultaneously tracked all GPS L1 C/A signals in view and the signal from the cellular tower with unknown states, producing pseudorange observables for

Replicated Results

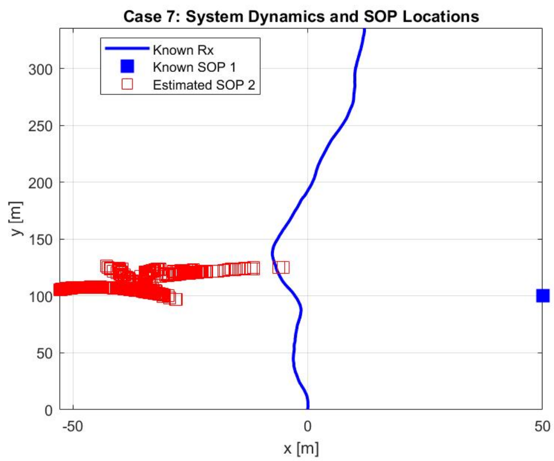
Case 4: Unknown Receiver with SOP 1 Fully Known and SOP 2 Partially Known

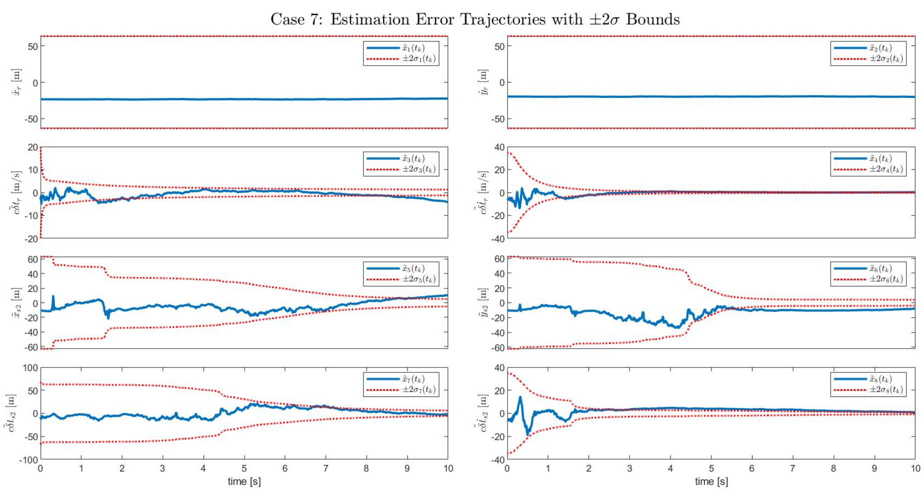


Case 4: Estimation Error Trajectories with $\pm 2\sigma$ Bounds



Case 7: Partially Known Receiver with SOP 1 Fully Known and SOP 2 Unknown





Case 8: Fully Known Receiver and SOP 1 Unknown