Exam #2 for **AOE 5784, Model-Based Estimation & Kalman Filtering.** Fall 2024

Exam rules: Do all problems. Hand in completed exam by 1:00 p.m. on Friday Nov 22, 2024 via Canvas if enrolled in the on-line section or as a hard copy to Prof. Psiaki in his 335 Durham Hall office if enrolled in the in-class section. No collaboration or consultation is allowed with any other humans except Prof. Psiaki. He is willing to talk about problems if available. You may use (inanimate) outside sources (e.g. books). If you use such sources, then list them.

[15 pts] Problem 4-7 in Bar-Shalom.

[15 pts] Problem Set 5, Number 2.

[20 pts] Problem Set 5, Number 6, except use the new process noise covariance $Q(k) = 6$ and the new measurement noise covariance $R(k) = 0.05$. Hand in your truth model simulation code, your Kalman filter code, and the requested estimates of the means and covariances of the errors from your two sets of Monte Carlo runs at sample times 10 and 35. Also hand in your Kalman filter's computed covariances at these two sample times. Give these quantities to 14 significant digits (i.e., in MATLAB's "format long").

[15 pts] Problem 5-12 in Bar-Shalom.

[20 pts] Problem Set 6, Number 2. Include in your results the covariance comparison matrix error metric abs($P_{KF}(k)$ - $P_{SRIF}(k)$)./(abs($P_{SRIF}(k)$) + eps^6). This metric gives the relative errors of all the elements of the covariance of the regular Kalman filter, $P_{KF}(k)$, as measured assuming the SRIF covariance $P_{SRIF}(k)$ gives the true value. If the two agree to machine precision, then each of these relative errors will be on the order of 1.e-16, i.e., in the order of 10^{-L}, where L is the number of significant digits stored in MATLAB's double-precision arithmetic. If any of these values are more than several orders of magnitude larger than 1.e-16, i.e., larger than 1.e-13, then there is significant numerical round-off error present in $P_{KF}(k)$ and corresponding loss of precision in its elements. Note that eps = 2.2204e-016 is a special MATLAB constant, like pi. It is the smallest number that can be added to 1 to produce a result that MATLAB recognizes as being different from 1. Its 6^{th} power is included in the above metric in order to avoid any zero-divided-by-zero results, which would produce NaN (not a number) in case a given element of $P_{SRIF}(k)$ is zero and the corresponding element of $P_{KF}(k)$ takes on this correct value. The value eps^6 should be small enough to be negligible for all elements of $P_{SRIF}(k)$ that are not zero.

[15 pts] Problem Set 6, Number 3.