ASE 381P Exam #2

Posting Date: November 13, 2019

Exam Rules: Do all problems. Do problems on standard 8 1/2 by 11 inch paper. Hand in the completed exam as you enter class at our usual time, 2:00 pm on Thursday, November 14, 2019. No collaboration or consultation is allowed with any other person besides Dr. Humphreys. He is willing to talk about problems if he's available. You may use non-human outside sources (e.g., books). If you use such sources, please list them.

1. [**10 points**] Problem Set 4, Number 1. In addition to doing what the original problem asks, do the following. Create a square grid of initial guesses covering the range $x_i \in \{-10, -9, ..., 9, 10\}$, for $i = 1, 2$. Find all the unique final points of convergence of Newton's method on this range of initial conditions and mark each of these points with a unique symbol on a 2-d plot covering the range of x_1 and x_2. Then mark each initial guess with a smaller version of the symbol associated with its convergence point. If an initial guess fails to converge, leave a blank spot at the location of that guess. Note in words how many convergence points there are on this range and describe qualitatively the apparent structure in the plot you created.

2. [**10 points**] Problem Set 4, Number 2.

3. [**15 points**] Problem Set 4, Number 3. For this problem, you need only hand in a printout of your code and results. Do the problem using QR factorization to solve the linearized least squares problem. Use step size adjustment to ensure convergence in which the size of $\Delta\hat{\boldsymbol{x}}$ falls below some reasonable threshold that you choose. Use the following measurement history instead of the one listed in the problem set:

```
zhist =
   0.380522980099649
  -0.937893887500619
  -2.568861909017112
  -5.780043794471402
  -5.484192626331365
  -2.987309363580615
  -1.065589854303113
   1.286281960892803
   3.687753634356679
   6.673091483609936
   7.148528020590929
```

4. [**15 points**] Problem Set 4, Number 4 with the following modifications:

   (a) Use the measurement data in `radarmeasdata_missile_new.mat`.

   (b) First estimate the missile's initial position and velocity using only the radar range data, just as described in Problem Set 4, Number 4, except using `rhoahist` and `rhobhist` from the new data set.

   (c) Next estimate the missile's initial position and velocity using both range and bearing data from both radar stations. Assume that the bearing measurement model is as presented in lecture with

$\sigma_{\theta a} = 0.01$ and $\sigma_{\theta b} = 0.03$ radians. Bearing measurements are stored in the vectors `thetaahist` (for radar "a") and `thetabhist` (for radar "b"). Compare the size of the estimation error covariance matrices. By how much did the bearing data improve the initial position and velocity estimates?

(d) Next determine whether the missile's initial position and velocity are observable using only bearing data from radar "a." Do this as follows: Use the best initial position and velocity estimate from your previous solutions as an initial guess for the bearing-only solution. Examine the rank of the appropriate linearized measurement sensitivity matrix H. What does this rank imply?

(e) Also examine the estimation error covariance matrix associated with this solution. Are the diagonal elements of this matrix small enough for the estimates to be useful?

Turn in a paper copy of your code, including all relevant sub-functions you may have written.

5. **[10 points]** Problem Set 4, Number 5.

6. **[15 points]** Problem 4-4 in Bar Shalom.

7. **[10 points]** Problem Set 5, Number 3, except use the new process noise covariance $Q(k) = 10$ and the new measurement noise covariance $R(k) = 0.025$. Hand in your Kalman filter code, plots of your estimated time histories for the two components of $\boldsymbol{x}$, and a plot of $\epsilon_\nu(k) \triangleq \nu(k)^T S^{-1}(k)\nu(k)$ vs. k. Also, hand in your terminal state vector estimate and state estimation error covariance matrix.

8. **[15 points]** Problem Set 6, Number 2.