ASEN 5070: Statistical Orbit Determination
Final Project Requirements and Suggestions

Due: December 15, 12:00pm

General Requirements

The project must be turned in via D2L as a searchable PDF with all software attached as an appendix. There is a maximum of 25 pages allowed for the write-up (excluding appendices). The maximum score allowed upon completing the required elements is a 90. The remaining 10 points are earned through extra elements selected by the student. A maximum score of 100 may be awarded.

Required Elements

1. General overview of the OD problem and the batch and sequential algorithms. No derivations are required and you do not have to include the provided equations for the dynamics and observation models ($A(t)$ or $H$ matrices) presented in homework assignments.

2. Discussion of the results. Compare and contrast the batch processor and the conventional Kalman filter (with and without the Joseph update). Discuss the relative advantages, shortcomings, applications, etc., of the algorithms. Keep in mind that you should discuss the residuals, covariance, and state for each filter implemented.

3. Show plots of residuals for all algorithms. Include RMS values. Plot the trace of the covariance for position and velocity for the sequential filter for the first iteration. (You may want to use a log scale.) Plot the covariance ellipses for the batch and CKF at the final time. Compare the state estimates produced via the two filters.

4. Discuss any numeric issues in the two filters. These will be most evident in the CKF. When plotting the trace of $P$ for the position and velocity, do any numerical problems show up? If so discuss briefly how they may be avoided.

5. Contrast the relative strengths of the range and range-rate data. Generate solutions with each data type alone for the batch and discuss the solutions. How do the final covariances differ? You could plot the two error ellipsoids for position. What does this tell you about the solutions and the relative data strength?

6. Consider the case where the position of one of the stations is not “fixed” in the Earth-fixed frame. Why did you fix one of the stations? Does it matter which station is fixed?

7. A discussion of what you learned from the term project and suggestions for improving the project.

Possible Extra Elements

1. Code the Extended Kalman Filter. Note that, due to numeric issues, an EKF that yields expected results is harder than it appears for this project.

2. How does varying the $a$ priori covariance and data noise covariance affect the solution? What would happen if we used an a priori more compatible with the actual errors in the initial conditions, i.e., a few meters in position etc.
3. Do an overlap study (see lectures).

4. Code the Potter algorithm and compare results to the conventional Kalman filter.

5. Solve for the state deviation vector using the Givens square root free algorithm. Compare solution and RMS residuals for range and range rate from Givens solution with results from conventional batch processor (Cholesky and/or Matlab inversion).
Overview of grading process:

- Subject to change until one week before the project due date.
- Each element will be worth the indicated number of points.
- If a student completes all required elements (and nothing else), the maximum score is 90/100

Quality of Report

_____ Overall, did the student use complete sentences, good organization, etc. (5 points)

_____ Quality of figures (labels, clarity, etc.) (5 points)

_____ Quality of tables, equations, and other elements (5 points)

Required Elements

_____ General description of the OD problem (5 points)

_____ Description of the Batch processor and Kalman filter (5 points)

_____ Present results for residuals, covariance, and state for the batch and CKF (with and without Joseph formulation). Includes plots, RMS of residuals, etc. (20 points)

_____ Discussion and comparison of results for the two filters. Includes a comparison of results, shortcomings of each method, numeric issues, etc. (20 points)

_____ Processing of: (1) range only, and (2) range-rate only. Discussion of the results. (10 points)

_____ Discussion of why we fix one of the stations. Does it matter which one we fix? Includes results to support findings. (10 points)

_____ What did you learn during the final project? Improvements? (5 points)
**Extra Elements**

* Note that up to 10 points may be awarded for any extra element. Number of points awarded varies with difficulty and depth of analysis. A maximum of 10 total may be awarded.

______ EKF; Description, application, use, and analysis

______ Study of solution variation with changes in the $P_0$ and $R$ matrices

______ Overlap study

______ Compare results from the Potter algorithm to the conventional Kalman filter.

______ Implement Givens or Givens square-root free algorithm. Compare the benefits of this algorithm with other similar methods.

______ Thorough study of application of process noise to data provided for Homework #11.

______ Other elements?