ASE 389P-7 Final Exam

Posting Date: December 16, 2024

Exam Rules: Do all problems, writing or printing on standard 8 1/2 by 11 inch paper. Hand in the completed exam to Dr. Humphreys in his office at 8 am on Tuesday, December 17, 2024, or slip it under his office door beforehand. No collaboration or consultation is allowed with any other person besides Dr. Humphreys. He is willing to discuss 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 5 Number 7.
2. **[15 points]** Problem set 6 Number 1.
3. **[15 points]** Problem set 6 Number 2. Instead of generating your own simulated S_k time history in part (c), apply your estimation strategy to `SkSim.mat`. Note that the S_k time history in `SkSim.mat` goes from $k = 0$ to $k = N - 1$. Thus, it has N elements. Estimate ρ, f, and θ, each to one decimal place (e.g., $\hat{f}_{\mathrm{ML}} = 10.5$ Hz).
4. **[40 points]** Problem set 7 Number 2, but instead of `dfDataHead.bin`, use the data file

   `https://radionavlab.ae.utexas.edu/datastore/gnssSigProcCourse/rawintegersamples_fe.bin`

   Each byte in this data file corresponds to a sample, with four sample streams interleaved. Use the script `loadRawSamples.m` to read in the data from this file (with appropriate modifications to the path and filename). Select `stream = 1`, which corresponds to the GPS L1 frequency for the receiver's primary antenna.

   These data were captuerd by the "Radiolynx" front end, whose relevant characteristics are

Radiolynx Front-End Characteristics
Intermediate frequency: $f_{\mathrm{IF}} = 2.391428571429$ MHz
Mixing: low-side mixed
Sampling frequency: $f_s = 9.6$ MHz
Quantization: two level (single bit)

   The `rawintegersamples_fe.bin` data recording is over 60 seconds long. Modify `loadRawSamples.m` as necessary to read data sequentially in manageable-sized chunks (e.g., 1-second).

   There are nine GPS L1 C/A signals with $C/N_0 > 35$ dB-Hz present in the recording. These have Doppler frequencies approximately ranging from -4 kHz to 4 kHz.

   (a) **[15 points]** Acquire PRN 18, whose initial Doppler is around -680 Hz, and track it over 60 seconds.

   (b) **[15 points]** Acquire and track the next strongest six GPS L1 C/A signals, which all have C/N_0 above 40 dB-Hz.

   (c) **[10 points]** Acquire and track the weakest two signals, one of whose C/N_0 drops as low as 35 dB-Hz.

(d) **[3 extra-credit points]** Determine the GPS Week Number for the week in which the data were captured. For this, you'll need to lock onto the 50-Hz navigation data stream and decode the Week Number. See Section 6.2.4 in the GPS Interface Specification IS-GPS-200L. Also see Figure 20-1, where Week Number is abbreviated WN. As shown in Fig. 20-2, the first 8 bits of the TLM are a unique preamble that you can use to identify the beginning of each subframe, and bits 20-22 of the HOW will allow you to identify the subframe.

For each signal tracked, give (i) the PRN identifier, (ii) a plot of the Doppler time history in Hz, (iii) a plot of the S_k time history, with time on the horizontal axis, `abs(real(Sk))` plotted in black (the `abs` operation eliminates the thrashing due to data bits), and `imag(Sk)` plotted in gray, and (iv) a plot of the estimated C/N_0 time history in dB-Hz as derived from your estimate of σ^2_{IQ} (obtained, for example, during acquisition) and your estimate of $E[|S_k|^2]$ over the 60-second interval.

5. **[20 points]** Problem set 7 Number 4, except use the data given below.

```
PRN    tR (seconds)         tS (seconds)
-----------------------------------------
10     142874.031415926     142873.929
18     142874.031415926     142873.930
24     142874.031415926     142873.926
32     142874.031415926     142873.928

Data for PRN 10:
rSvEcef = -7771062.621964    -13392926.713787    21699866.518681
dtIono  = 1.105596e-08
dtTropo = 1.031992e-08
dS      = 0.000124682


Data for PRN 18:
rSvEcef = 4747181.126449    -25802711.537558    3938318.400306
dtIono  = 1.206681e-08
dtTropo = 1.008367e-08
dS      = 0.000324047


Data for PRN 24:
rSvEcef = 14684443.702457    -15351446.405048    15470725.361304
dtIono  = 1.582324e-08
dtTropo = 1.408656e-08
dS      = -0.000394024


Data for PRN 32:
rSvEcef = -15730896.676495    -20849558.582301    5362760.419279
dtIono  = 1.226210e-08
dtTropo = 1.102516e-08
dS      = -0.000018238
```

Hint: The correct ECEF receiver location $[x, y, z]$ (in meters) is one of the following possibilities:

```
(A)  -693606.128   ????           2960669.097
(B)  -742080.456   -5462030.875   ????
(C)  ????          -5456322.852   3208395.305
(D)  -743774.390   -5460644.512   ????
(E)  -751970.424   ????           3193399.042
(F)  -755431.231   ????           3191026.240
```