ASE 389P-7 Final Exam

Posting Date: December 12, 2022

Exam Rules: Do problems on standard 8 1/2 by 11 inch paper. Hand in the completed exam by 9:30 A.M. on Tuesday, December 13 to Dr. Humphreys in his office. No collaboration or consultation is allowed with any other person besides Dr. Humphreys. You may use non-human outside sources (e.g., books, papers, websites). If you use such sources, please list them.

1. **[15 points]** Problem set 6 Number 1.
2. **[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).
3. **[10 points]** Problem set 6 Number 7.
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. 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
```