HW 8

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read_GPSbroadcast, broadcast2xv, adjust year, and read_rinex functions provided from class are used in this homework.

Initialize

```
clearvars -except function_list pub_opt
close all
c = 2.99792458e8; %m/s
f_L1 = 1575.42; % MHz
f_L2 = 1227.60; % MHz

print_vec3 = @(x) ...
    fprintf(sprintf('%13.2f\n%13.2f\n%13.2f\n',x(1),x(2),x(3)));
print_vec4 = @(x) ...
    fprintf(sprintf('%13.2f\n%13.2f\n%13.2f\n%13.2f\n',x(1),x(2),x(3),x(4)));
```

Read the data files

```
eph = read_GPSbroadcast('brdc2550.14n');
obs_data = read_rinex_obs('test.14o');
P1 = 6;
P2 = 7;
C1 = 8;
approx_rx_pos = [-1248596.2520 -4819428.2840  3976506.0340]'; % m
GPS_Week = eph(1,19);
GPS_TOD = [1 03 00];
TOW = eph(1,20)+GPS_TOD(1)*3600 + GPS_TOD(2)*60 + GPS_TOD(3);
fprintf('RINEX location:\n')
print_vec3(approx_rx_pos)
fprintf('\n')
```

```
Parsing RINEX file test.14o
Returning data for all PRNs

ans =

        1049          13
```

```
Total epochs: 131
Finished.

RINEX location:
  -1248596.25
  -4819428.28
   3976506.03
```

Observations at the given epoch

```
obs_at_epoch = obs_data.data(obs_data.data(:,2) == TOW, :);
prn_list = obs_at_epoch(:,3);
num_sats = length(prn_list);

% Ionosphere
iono_free_pseudorange = ...
    (f_L1*f_L1*obs_at_epoch(:,P1) - f_L2*f_L2*obs_at_epoch(:,P2))./ ...
    (f_L1*f_L1-f_L2*f_L2);

% Geometric range, satellite clock correction, relativity correction
geo_range = zeros(num_sats,1);
relativityCorr = zeros(num_sats,1);
satClkCorr = zeros(num_sats,1);
r_sat = zeros(num_sats,3);
for ii = 1:num_sats
    [~, geo_range(ii), tmp] = compute_range(eph, prn_list(ii), TOW, approx_rx_pos)
    r_sat(ii,:) = tmp';
    [~,~,~,relativityCorr(ii),satClkCorr(ii)] = ...
        broadcast2xv(eph,[GPS_Week TOW],prn_list(ii));
end

% Azimuth, Elevation
GPSvec = [2014 09 12 1 03 00];
% navfilename = generate_GPSyuma_name(GPSvec);
[navfilename,statusflag] = download_GPSyuma(GPSvec);
durationhrs = 1;
dt_sec = 3601;
ant_enu = [0 0 1];
mask_min = 0;  % deg
mask_max = 90; % deg
[latgd, lon, alt] = ECEF2ellipsoidal(approx_rx_pos);

[time_wntow, GPSdata] = ...
    ASEN5090_GPSvis(navfilename, 1, GPSvec,...
    durationhrs, dt_sec, latgd*180/pi, lon*180/pi, alt,...
    mask_min, mask_max, mask_min, ant_enu, 0, []);
% rearrange the data to be in the same order as prn list
prn_el = zeros(num_sats,1);
prn_az = zeros(num_sats,1);
for ii = 1:num_sats
    prn_el(ii) = GPSdata.topo_el(prn_list(ii));
```

```
    prn_az(ii) = GPSdata.topo_az(prn_list(ii));
end

T = table(prn_list, iono_free_pseudorange, geo_range, satClkCorr, ...
    relativityCorr, prn_el, prn_az);
fprintf('PRNs and corrections (distances in meters, angles in degrees):\n')
disp(T)
fprintf('\n\n\n\n\n')
```

```
Downloading GPS YUMA file from: http://www.celestrak.com/GPS/almanac/Yuma/
File name: yuma0785.405504.alm

PRNs and corrections (distances in meters, angles in degrees):
    prn_list    iono_free_pseudorange    geo_range     satClkCorr
    ________    _____________________    _________     __________

    18          2.1011e+07               2.1114e+07      1.032e+05
    15          2.0893e+07               2.0833e+07         -60652
    16          2.4701e+07               2.4642e+07         -58603
    26          2.2555e+07                2.254e+07         -15544
    22          2.3265e+07               2.3345e+07          80061
    21          2.1027e+07               2.0912e+07     -1.1497e+05
    29          2.2088e+07               2.2256e+07      1.6781e+05
    27          2.4188e+07               2.4192e+07         4115.5


    relativityCorr    prn_el    prn_az
    ______________    ______    _______

     2.6998           63.304    -83.622
     2.5463           57.302     79.488
      3.994           11.896    -72.048
     1.0851           26.304     46.523
      3.645           25.315    -104.39
    -9.2211           70.773    -26.078
    -0.6098           37.032     174.32
    0.94731           14.817    -40.155
```

Observation/Geometry matrix

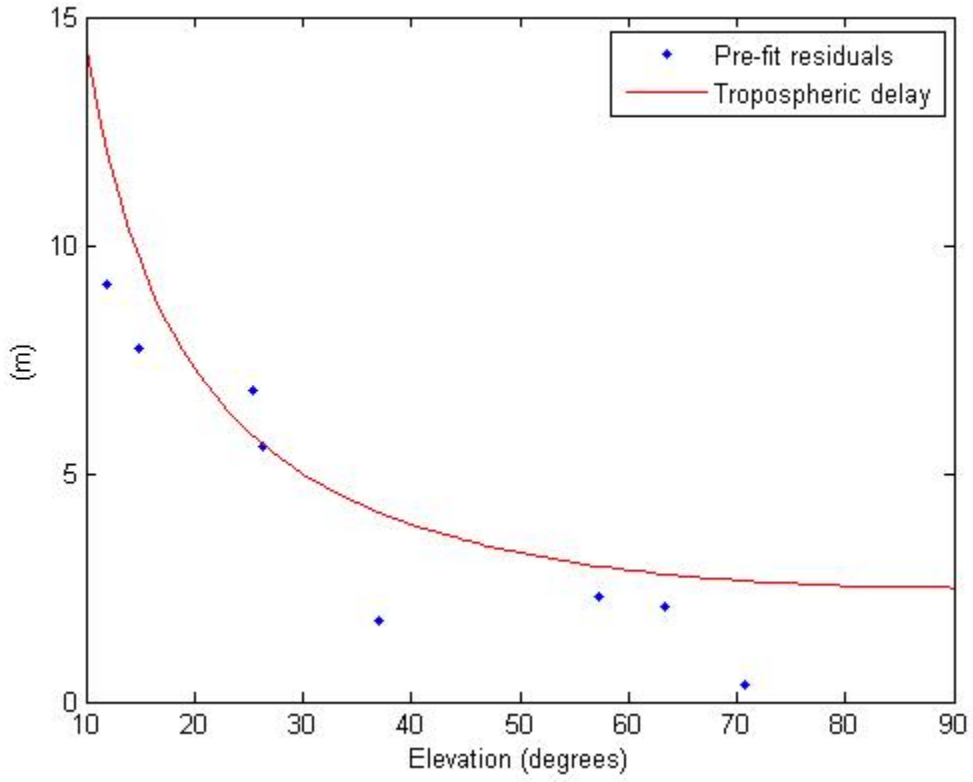
```
A = ones(num_sats, 4); % x, y, z, rx time error
for ii = 1:num_sats
    A(ii,1:3) = -(r_sat(ii,:)-approx_rx_pos')./geo_range(ii);
end
A
```

```
A =

    0.5998    0.5341   -0.5958    1.0000
   -0.3648    0.7107   -0.6015    1.0000
    0.8947   -0.2596   -0.3636    1.0000
   -0.6398    0.1260   -0.7581    1.0000
    0.9666    0.2398   -0.0904    1.0000
    0.2792    0.4998   -0.8199    1.0000
    0.1659    0.9550    0.2457    1.0000
    0.5384   -0.4093   -0.7366    1.0000
```

Prefit residuals

Plotting the residuals and Lecture 15's simple Tropo model vs. elevation

```
dy = iono_free_pseudorange - geo_range + satClkCorr - relativityCorr;

plot(prn_el, dy, '.')
hold on
T_el = 10:90;
plot(T_el, 2.5./sin(T_el*pi/180), 'r')
ylabel('(m)')
xlabel('Elevation (degrees)')
legend('Pre-fit residuals','Tropospheric delay')
```



Least squares solution for position deviation

Find the position deviation from the RINEX location, dx

```
est_deviation = (A'*A)\A'*dy;
est_deviation_with_T = (A'*A)\A'*(dy - 2.5./sin(prn_el*pi/180));

fprintf('Estimated Deviation (m):\n')
print_vec4(est_deviation)
fprintf('Estimated Deviation with Troposphere model (m):\n')
print_vec4(est_deviation_with_T)
fprintf('\n')
```

```
        Estimated Deviation (m):
                -0.99
                -7.87
                 4.60
                 9.28
        Estimated Deviation with Troposphere model (m):
                -0.31
                 0.27
                -0.03
                -1.27
```

Starting from incorrect location

Choosing the center of the earth as the initial guess.

```
approx_rx_pos = [0 0 0]'; % m
b = 0;
for iter = 1:5
    for ii = 1:num_sats
        [~, geo_range(ii), tmp] = ...
            compute_range(eph, prn_list(ii), TOW, approx_rx_pos);
        r_sat(ii,:) = tmp';
        A(ii,1:3) = -(r_sat(ii,:)-approx_rx_pos')./geo_range(ii);
    end
    dy = iono_free_pseudorange - geo_range + satClkCorr - relativityCorr ;
    est_deviation = (A'*A)\A'*dy;
    approx_rx_pos = approx_rx_pos + est_deviation(1:3);
    b = est_deviation(4) + b;
    fprintf('Iteration %d\n',iter)
    fprintf('Estimated Deviation (m):\n')
    print_vec4(est_deviation)
    fprintf('New Position (m, ECF):\n')
    print_vec3(approx_rx_pos)
    fprintf('\n')
end
```

```
        Iteration 1
        Estimated Deviation (m):
          -1551257.50
          -5743499.33
```

```
   4823759.80
   1337058.30
New Position (m, ECF):
  -1551257.50
  -5743499.33
   4823759.80

Iteration 2
Estimated Deviation (m):
    289790.62
    895707.68
   -816001.34
     47666.39
New Position (m, ECF):
  -1261466.88
  -4847791.65
   4007758.46

Iteration 3
Estimated Deviation (m):
     12850.96
     28321.67
    -31206.10
        68.62
New Position (m, ECF):
  -1248615.92
  -4819469.98
   3976552.35

Iteration 4
Estimated Deviation (m):
        18.67
        33.83
       -41.72
         9.28
New Position (m, ECF):
  -1248597.24
  -4819436.16
   3976510.63

Iteration 5
Estimated Deviation (m):
        -0.00
         0.00
         0.00
         9.28
New Position (m, ECF):
  -1248597.24
  -4819436.16
   3976510.63
```

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