Contents


```
% function Xstar0 = BatchProcess()
% Compute new xhat
% Looks for functions to return:
%   G
%   Htilde
% Inside of /Filters/BatchTools.m

clc; clear all;close all; format compact;tic
warning off MATLAB:nearlySingularMatrix
```

First, Load and Parse Observation Data

```
load('Observations.mat');
t_obs       = obs(:,1);
station     = obs(:,2);
rho_obs     = obs(:,3);
rhodot_obs  = obs(:,4);
```

Pre-Allocations

```
x       = zeros(length(obs));
y       = x;
z       = x;
xdot    = x;
ydot    = x;
zdot    = x;
Xsite1  = x;
Ysite1  = x;
Zsite1  = x;
Xsite2  = x;
Ysite2  = x;
Zsite2  = x;
Xsite3  = x;
Ysite3  = x;
Zsite3  = x;
Phi     = cell(1,length(obs));
y_res   = zeros(2,length(obs));
Xsite   = x;
Ysite   = x;
```

```
Zsite   = x;
theta   = x;
```

Initialize Variables

```
% Calculations for rho, rhodot. Put into bigger functiom sometime
%---------------------------------------------
findrhostar      = @(x,y,z,Xsite,Ysite,Zsite,theta) sqrt(x^2+y^2+z^2+Xsite^2+Ysite^2+Zsite^2
findrhodotstar   = @(x,y,z,xdot,ydot,zdot,Xsite,Ysite,Zsite,theta,theta_dot,rho) (x*xdot + y
                   +(xdot*Ysite - ydot*Xsite)*sin(theta) + theta_dot*(x*Ysite - y*Xsite)*co
                                                          /rho;
%---------------------------------------------

% System Constants
%---------------------------------------------
Phi_Init    = eye(18,18);
tol         = 1e-13;
uE          = 3.986004415e14;        % m^3/s^2
J2          = 1.082626925638815e-3;  % []
Cd          = 2;                     % []
theta_dot   = 7.29211585530066e-5;   % rad/s
time        = t_obs;
%---------------------------------------------

% Information
%---------------------------------------------
sigma_rho   = 0.01;                  % rms std
sigma_rhodot= 0.001;                 % rms std
R           = [sigma_rho^2  ,         0        ; ...
                     0      ,    sigma_rhodot^2];
W = inv(R);
Pbar0       = diag([1e6,1e6,1e6,1e6,1e6,1e6,1e20,1e6,1e6,1e-10,1e-10,1e-10,1e6,1e6,1e6,1e6,1
%---------------------------------------------

% Initial Conditions
%---------------------------------------------
RV_Init     = [757700,5222607.0,4851500.0,2213.21,4678.34,-5371.30];
Station_Init= [-5127510.0 , -3794160.0 , 0.0 ,...               %101
                3860910.0 , 3238490.0  , 3898094.0 , ...        %337
                549505.0  , -1380872.0 , 6182197.0 ];           %394
Const_Init = [uE , J2 , Cd ];
%---------------------------------------------

% Form Initialization State
%---------------------------------------------
Xstar0 = [RV_Init , Const_Init , Station_Init , reshape(Phi_Init,1,length(Phi_Init)^2)]';
```

```
%-------------------------------------------

% Initial xbar0, or a-priori state deviation from reference trajectory
%-------------------------------------------
xbar0       = zeros(18,1);
%-------------------------------------------
```

Perform Batch Loop

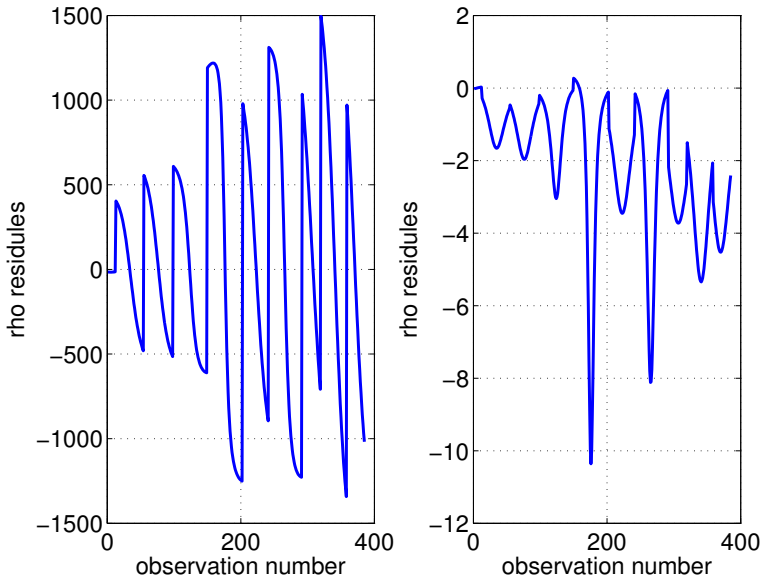
```
num_iterations = 1;
for ii = 1:num_iterations

    % Dynamical Integration
    %-------------------------------------------
    tol_mat     = ones(size(Xstar0)) .* tol;
    options     = odeset('RelTol',tol,'AbsTol',tol,'OutputFcn',@odetpbar);

    [time,StatePhi] = ode45(@StateDeriv_WithPhi,time,Xstar0,options);
    %-------------------------------------------


        % Batch Processing Part
    %-------------------------------------------
    Lam = inv(Pbar0);
    N   = Pbar0\xbar0;  % same as inv(pobar)*xbar0
    N_orig = N;
    Lam_orig=Lam;


    % Reform Phi Matrix
    %-------------------------------------------
    for jj = 1:length(time)
           Phi      = reshape(StatePhi(jj,19:end),size(Phi_Init));
           Xstar    = StatePhi(:,1:18);
           x        = Xstar(:,1);
           y        = Xstar(:,2);
           z        = Xstar(:,3);
           xdot     = Xstar(:,4);
           ydot     = Xstar(:,5);
           zdot     = Xstar(:,6);
           Xsite1   = Xstar(:,10);
           Ysite1   = Xstar(:,11);
           Zsite1   = Xstar(:,12);
           Xsite2   = Xstar(:,13);
           Ysite2   = Xstar(:,14);
           Zsite2   = Xstar(:,15);
```

```
        Xsite3   = Xstar(:,16);
        Ysite3   = Xstar(:,17);
        Zsite3   = Xstar(:,18);

    %-------------------------------------------




%     parfor jj = 1:length(rho_obs)
        theta(jj)          = theta_dot*time(jj);
        Htilde             = zeros(2,18);
        % Check Stations
        %-------------------------------------------
        %Station 1
        if station(jj) == 101
            Xsite(jj)   = Xsite1(jj);   Ysite(jj)=Ysite1(jj);   Zsite(jj)=Zsite1(jj);
            % Find H Tilde
            %-------------------------------------------
            Htilde = FindHtilde(Xsite(jj),Ysite(jj),Zsite(jj),theta(jj),theta_dot,x(jj),xdot
            %-------------------------------------------
            Htilde  = [Htilde , zeros(2,6)];

        end

        %Station 2
        if station(jj) == 337
            Xsite(jj)   = Xsite2(jj);   Ysite(jj)=Ysite2(jj);   Zsite(jj)=Zsite2(jj);
            % Find H Tilde
            %-------------------------------------------
            Htilde = FindHtilde(Xsite(jj),Ysite(jj),Zsite(jj),theta(jj),theta_dot,x(jj),xdot
            %-------------------------------------------
            Htilde  = [Htilde(:,1:9) , zeros(2,3), Htilde(:,10:12),zeros(2,3)];
        end

        %Station 3
        if station(jj) == 394
            Xsite(jj)   = Xsite3(jj);   Ysite(jj)=Ysite3(jj);   Zsite(jj)=Zsite3(jj);
            % Find H Tilde
            %-------------------------------------------
            Htilde = FindHtilde(Xsite(jj),Ysite(jj),Zsite(jj),theta(jj),theta_dot,x(jj),xdot
            %-------------------------------------------
            Htilde  = [Htilde(:,1:9),zeros(2,6),Htilde(:,10:12)];
        end
        %-------------------------------------------
```

```
    % Map To Epoch
    %--------------------------------------------
    H{jj}    = Htilde*Phi;
    %--------------------------------------------

    % Cumulate INFORMATION?? Matrix
    %--------------------------------------------
    Lam       = Lam + H{jj}'*W*H{jj};
    %--------------------------------------------

    % Put into FindG
    %--------------------------------------------
    rhostar   = findrhostar(x(jj),y(jj),z(jj),Xsite(jj),Ysite(jj),Zsite(jj),theta(jj));
    rhodotstar= findrhodotstar(x(jj),y(jj),z(jj),xdot(jj),ydot(jj),zdot(jj),Xsite(jj),Ys
    %--------------------------------------------

    % Find Observation Deviations
    %--------------------------------------------
    ystar       = [rhostar;rhodotstar];
    y_res(:,jj) = [rho_obs(jj);rhodot_obs(jj)] - ystar;
    %--------------------------------------------


    % Cumulate SOMETING?? Matrix
    %--------------------------------------------
    N     = N + H{jj}'*W*y_res(:,jj);
    %--------------------------------------------
end
fprintf('RMS of rho is :  %3.5f \n',rms(y_res(1,:)))
fprintf('RMS of rhodot is :  %3.5f \n',rms(y_res(2,:)))
% Find New State Deviation
%--------------------------------------------
xhat0   = Lam\(N);
%--------------------------------------------

% Update Best Guess of Initial Conditions
%--------------------------------------------
Xstar0  = [Xstar0(1:18) + xhat0; (reshape(Phi_Init,length(Phi_Init)^2,1))];
%--------------------------------------------

% Update a-priori State Deviation
%--------------------------------------------
xbar0 = xbar0 - xhat0;
%--------------------------------------------
```

```
    figure(1)
    subplot(num_iterations,2,2*ii-1)
    plot(y_res(1,:))
    ylabel('rho residules')
    xlabel('observation number')

    subplot(num_iterations,2,2*ii)
    plot(y_res(2,:))
    ylabel('rho residules')
    xlabel('observation number')

end

fprintf('\n\nRunning Time for Batch Processor : %3.5f\n\n',toc)
```

```
ODE integration: 100%    [..........]
   Integration time: 3.1912
RMS of rho is :  732.74831
RMS of rhodot is :  2.90017


Running Time for Batch Processor : 4.44755
```



Display Outputs

```
SumHtWH = Lam - Lam_orig;
SumHtWy = N - N_orig;

fprintf('Sum of H''WH is :\n')
printMatrix(SumHtWH,27,10);
fprintf('\n\n\n Sum of H''Wy is :\n')
printMatrix(SumHtWy,15,5);

fprintf('\n\n\n Output of xhat0 is :\n')
printMatrix(xhat0,27,10)
```

```
Sum of H'WH is :
        15642892.2139638532         96445342.0481109023
87553862.2093564719      39035426229.8915863037
85380621054.4556427002     -89456061116.4034271240
-1.5954227562  286051153800621.4375000000
-7713897.2730123671            94424.1960645709
-55744.7939965413          1837092.6939293954
678092.1290839665           638409.6495227553
-1277860.1201436382           733971.6775837080
635723.5618613327           123510.5898856849
        96445342.0481109023        647567086.6741099358
591096262.6015053988     261992453682.0038146973
568653301031.6795654297    -602809745181.2003173828
-10.7016510482 1995728895595858.5000000000
-52282664.0776869431          -773424.0039953113
1432595.0899111021         10595645.8622289877
7392018.3361077625          1308575.5194160349
-8711564.5189841464          6309531.7304992266
1145230.3956329017          -266474.1940985713
        87553862.2093564868        591096262.6015053988
545069191.1156791449     239589749865.7162170410
517506233589.1514892578    -554569933689.5238037109
-9.8035792463 1834580284670072.5000000000
-48506619.6265168786          -402655.1210385546
1045048.6870896441          8376683.0559452018
7194081.2672169982          1587982.6929616374
-8729815.9775514472          6065287.8468057951
1084368.6505893399          -273346.3020820002
     39035426229.8915939331     261992453682.0038452148
239589749865.7162170410  106661554804651.4062500000
230019289585374.4687500000 -244305773049970.0625000000
-4332.9515060860 803726582978524416.0000000000
-21168772678.9310188293        -50859313.7735307217
```

```
302043238.1972026825       4288498976.4752812386
2916254082.3784904480        611717806.8690390587
-3472182365.3918185234       2884955908.2518606186
206458670.4745006561       -225374609.3335765600
     85380621054.4556274414     568653301031.6795654297
517506233589.1514892578  230019289585374.4687500000
500449734561211.2500000000 -528426575793172.3750000000
-9393.3837935608 1745988440697024256.0000000000
-45491258336.3640747070       -690061915.6090250015
1311456344.9984645844       9736126092.6784706116
6209844895.7019824982       1224063166.9970550537
-7345835814.4685678482       5408488696.8719940186
1469890745.0940928459        -83278163.7571291327
    -89456061116.4034271240    -602809745181.2001953125
-554569933689.5236816406 -244305773049970.0625000000
-528426575793172.3125000000  564925217977991.5000000000
9992.9746072029 -1868777680042144768.0000000000
49351823593.8733901978        453804529.4006270766
-1186627512.8099844456      -8815559900.1859703064
-7155118427.5747156143      -1442785596.3882243633
8473696896.6845960617      -6211919135.8050832748
-1275868107.9849932194        227040169.4953751564
             -1.5954227562              -10.7016510482
-9.8035792463            -4332.9515060860
-9393.3837935608             9992.9746072029
0.0000001772        -33071416.4047614485               0.8680775739
0.0105353831               -0.0212645324              -0.1670443062
-0.1240245340               -0.0250132771
0.1466430480               -0.1057804599              -0.0238949898
0.0031677740
 286051153800621.4375000000 1995728895595858.5000000000
1834580284670072.5000000000 803726582978524544.0000000000
1745988440697024000.0000000000 -1868777680042144512.0000000000
-33071416.4047614485 6357520838113366114304.0000000000
-162933815454797.0937500000   -5176617560516.4169921875
8224474829224.8125000000   27349691260043.2031250000
27574275176521.5312500000      81037364953.2355957031
-27206535197374.7304687500   19159599168762.6289062500
3598318516081.8442382812    -805207179437.5408935547
        -7713897.2730123661        -52282664.0776869431
-48506619.6265168637     -21168772678.9310188293
-45491258336.3640747070      49351823593.8733901978
0.8680775739 -162933815454797.1250000000          4712675.9088873239
4607.5040727804           -47211.4081440844
-617765.3808566579          -571670.9101045745
-87065.8866727704           691156.4551380392
```

```
-593635.2690462477            36198.6465750722
59945.3954439472
          94424.1960645709          -773424.0039953114
-402655.1210385547        -50859313.7735307217
-690061915.6090250015        453804529.4006271362
0.0105353831   -5176617560516.4169921875             4607.5040727804
301411.2586326599          -238883.2131691568
13355.2193051041               0.0000000000
0.0000000000                0.0000000000                0.0000000000
0.0000000000                0.0000000000
         -55744.7939965413          1432595.0899111023
1045048.6870896443        302043238.1972027421
1311456344.9984645844      -1186627512.8099844456
-0.0212645324    8224474829224.8115234375
-47211.4081440844          -238883.2131691568
382196.5541191101            -5925.9028849073
0.0000000000                0.0000000000                0.0000000000
0.0000000000                0.0000000000                0.0000000000
        1837092.6939293954         10595645.8622289877
8376683.0559452018       4288498976.4752812386
9736126092.6784706116      -8815559900.1859703064
-0.1670443062   27349691260043.2031250000
-617765.3808566579            13355.2193051041
-5925.9028849073           547491.3019981384
0.0000000000                0.0000000000                0.0000000000
0.0000000000                0.0000000000                0.0000000000
         678092.1290839666          7392018.3361077616
7194081.2672169982       2916254082.3784904480
6209844895.7019824982      -7155118427.5747156143
-0.1240245340   27574275176521.5351562500
-571670.9101045745               0.0000000000
0.0000000000                0.0000000000           443985.4002217269
-187039.8461420266          -202932.9174915103
0.0000000000                0.0000000000                0.0000000000
         638409.6495227553          1308575.5194160349
1587982.6929616374        611717806.8690390587
1224063166.9970550537      -1442785596.3882243633
-0.0250132771      81037364953.2366943359
-87065.8866727704               0.0000000000
0.0000000000                0.0000000000          -187039.8461420266
489429.5398828702          -185546.2470719735
0.0000000000                0.0000000000                0.0000000000
        -1277860.1201436382         -8711564.5189841483
-8729815.9775514472      -3472182365.3918190002
-7345835814.4685678482       8473696896.6845960617
0.1466430480  -27206535197374.7382812500           691156.4551380392
```

```
0.0000000000                0.0000000000                0.0000000000
-202932.9174915103          -185546.2470719735
467743.5986754843                0.0000000000
0.0000000000                0.0000000000
          733971.6775837080          6309531.7304992266
6065287.8468057951       2884955908.2518606186
5408488696.8719940186      -6211919135.8050832748
-0.1057804599   19159599168762.6289062500
-593635.2690462477               0.0000000000
0.0000000000                0.0000000000                0.0000000000
0.0000000000                0.0000000000           477457.6594665953
-145787.8075451687           -99770.1215443975
          635723.5618613327          1145230.3956329024
1084368.6505893404        206458670.4745006561
1469890745.0940928459      -1275868107.9849936962
-0.0238949898    3598318516081.8452148438
36198.6465750722                0.0000000000
0.0000000000                0.0000000000                0.0000000000
0.0000000000                0.0000000000          -145787.8075451687
666808.3371934118           208656.0639778854
          123510.5898856849          -266474.1940985713
-273346.3020820001       -225374609.3335765600
-83278163.7571291327        227040169.4953751564
0.0031677740    -805207179437.5407714844            59945.3954439472
0.0000000000                0.0000000000                0.0000000000
0.0000000000                0.0000000000                0.0000000000
-99770.1215443974           208656.0639778854
76408.2371207681
```

```
 Sum of H'Wy is :
5486061547.19810
36584442778.58514
33408872159.34251
14834824166248.30859
32158626582387.25391
-34086624652357.96484
     -604.98783
112317807659114768.00000
-2948644630.17576
-27771434.44241
 67040528.11551
603470756.22806
400176817.76198
 91700586.30273
```

```
-484097205.11321
369071814.20939
 75465589.38682
-13494689.60293


 Output of xhat0 is :
              -0.0363025898
              -0.2741066153
              -0.1808766575
               0.0409349622
               0.0327483949
              -0.0147530394
       -9463442.1830325481
              -0.0000006574
               0.1475547229
               0.0000018632
               0.0000013787
              -0.0000002538
             -10.5636296834
               9.9833774037
               5.7943247874
              -5.7819128352
               2.3443688041
               1.5124575876
```