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Kalman Filter Matlab Code

```
clear all;clc;close all
addpath(['/Users/kevin/SkyDrive/KTH Work/',...
    'Period 4 2014/GNSS/Labs/L4 ',...
    '- Kalman filtering/']);
```

Import numbers from excel

Measured values from sheet 1

```
data.s1 = xlsread('Measurement.xlsx');
meas.time = data.s1(1:25,1);
meas.east = data.s1(1:25,2);
meas.north = data.s1(1:25,3);
meas.speed = data.s1(1:25,4);
% True values from sheet 2
data.s2 = xlsread('Measurement.xlsx','True values');
true.time = data.s2(1:25,1);
true.east = data.s2(1:25,2);
true.north = data.s2(1:25,3);
true.vel_east = data.s2(1:25,4);
true.vel_north = data.s2(1:25,5);
```

A priori statistics

```
PSD = 0.01; % - PSD (power spectral density) of the
% random acceleration
meas.sd_coord = 3; % m - Standard error of measured coordinates
meas.sd_abs_vel = 0.5; % m/s - Standard error of measured
% abs. velocity
sd_ini_vel = 3; % m/s - Standard error of initial velocity
sd_ini_coord = 10; % m - Standard error of initial coordinates
ve = 3.53; % m/s
vn = 0.86; % m/s
dt = 2; % time difference -> 2 sec between measurements
```

State variables and Equations

```
xk = [meas.east(1) meas.north(1) ve vn];
xk = padarray(xk,24,0,'post');
xk = xk';
% Equation 4
F = zeros(4);
F(1,3) = 1;
F(2,4) = 1;
G = zeros(4,2);
G(3,1) = 1;
G(4,2) = 1;
% Equation 5
Tk = eye(length(F)) + dt * F;
% Equation 9
Q = [ PSD 0 ; 0 PSD];
% Equation 11
QG = G*Q*G';
% Equation 12
Qk = QG * dt + (F*QG + QG*F')*dt^2/2 + F*QG*F'*dt^3/3;
% Equation 15
% covariance matrix of initial state
Qx(:,:,1) = diag([sd_ini_coord^2 ...
    sd_ini_coord^2 sd_ini_vel^2 sd_ini_vel^2]);
Rk = diag([meas.sd_coord meas.sd_coord meas.sd_abs_vel]);
Qxm_predicted = zeros(4,4,25);
```

FOR LOOP

```
for i=1:25
    % Equation 16 Time propagation
    xkm_predicted(:,i) = Tk * xk(:,i);
    %     Qx = cov(xk(:,i));
    Qxm_predicted(:,:,i) = Tk * Qx(:,:,i) * Tk' + Qk;
    vm_predicted = sqrt(xkm_predicted(3,i)^2 +  ...
        xkm_predicted(4,i)^2); % should be equal to speed_meas(1)
    Hk(:,:,i) = [1,0, 0,        0;...
        0, 1, 0,        0;...
        0, 0, xkm_predicted(3,i)/vm_predicted,   ...
        xkm_predicted(4,i) /vm_predicted];
    % Equation 17 Gain
    Kk(:,:,i) = Qxm_predicted(:,:,i) * Hk(:,:,i)'*inv([Rk +  ...
        Hk(:,:,i) * Qxm_predicted(:,:,i) * Hk(:,:,i)']);
    Lk(:,i) = [meas.east(i) meas.north(i)...
        meas.speed(i)]';
    hkm_predicted = [xkm_predicted(1,i) xkm_predicted(2,i) ...
        sqrt(xkm_predicted(3,i)^2 + xkm_predicted(4,i)^2)]';

    xk(:,i+1) = xkm_predicted(:,i) + Kk(:,:,i)*[ Lk(:,i) ...
        - hkm_predicted ]; % Equation18
    %     Measurement update
    % Equation 19
```

```
    Qx(:,:,i+1) = [eye(length(Kk(:,:,i)*...
        Hk(:,:,i)))-Kk(:,:,i)*Hk(:,:,i)]*Qxm_predicted(:,:,i);
    % Equation 22
    %     Lk = [meas.east(i) meas.north(i)...
    %         sqrt((xk(3,i))^2 + (xk(4,i))^2)]';

    %     Hk = inv(xk(:,i))*Lk;
    final.xplot(:,i+1) = xk(:,i);
end
```

Smoothing

```
xkhat(:,25) = xk(:,end);
nStep = 25;
count = nStep;
Qxkhat(:,:,25) = Qx(:,:,end);
for i = 1:(nStep-1)
    Dk = Qx(:,:,count+1)*Tk'*inv(Qxm_predicted(:,:,count));
    xkhat(:,count-1) = xk(:,count) + Dk*[xkhat(:,count) ...
        - xkm_predicted(:,count)];
    Qxkhat(:,:,count-1) = Qx(:,:,count+1) ...
        + Dk*[Qxkhat(:,:,count) - Qxm_predicted(:,:,count)]*Dk';
    count = count - 1;
end
```

Plot

```
final.x1 = xk(1,:)';  % final x values
final.y1 = xk(2,:)';  % final y values
meas.x2 = meas.east;  % original x
meas.y2 = meas.north;  % original y
true.x3 = true.east;  % true x
true.y3 = true.north;  % true y
figure('Units', 'pixels', ...
    'Position', [100 100 500 375]);
hold on;
y1_plot = plot(final.x1,final.y1, ...  % Before Smoothing
xkhat(1,:),xkhat(2,:), ...             % Smoothing
meas.x2,meas.y2, ...                   % Original
true.x3,true.y3);                      % True Plot
hTitle = title('Kalman filtering');
hXLabel = xlabel('Easting [m]');
hYLabel = ylabel('Northing [m]');
hLegend = legend(...
    'Before Smoothing',...
    'Smoothing',...
    'Original',...
    'True Plot',...
    'location','best');
set( gca                        , ...
    'FontName'   , 'Helvetica' );
set([hTitle, hXLabel, hYLabel], ...
    'FontName'   , 'AvantGarde');
```

```
set([hLegend, gca]             , ...
    'FontSize'   , 10           );
set([hXLabel, hYLabel]  , ...
    'FontSize'   , 11          );
set( hTitle                    , ...
    'FontSize'   , 13          , ...
    'FontWeight' , 'bold'      );
set(gca, ...
  'Box'         , 'off'         , ...
  'TickDir'     , 'out'         , ...
  'TickLength'  , [.02 .02]     , ...
  'XMinorTick'  , 'on'          , ...
  'YMinorTick'  , 'on'          , ...
  'YGrid'       , 'on'          , ...
  'XColor'      , [.3 .3 .3]    , ...
  'YColor'      , [.3 .3 .3]    , ...
  'LineWidth'   , 1             );
hold off;
```

Print

```
set(gcf, 'PaperPositionMode', 'auto');
savePath = ['/Users/kevin/SkyDrive/KTH Work/',...
    'Period 4 2014/GNSS/Labs/L4 ',...
    '- Kalman filtering/Figures/'];
print('-depsc2', [savePath 'xDataPlots']);
```

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