# CS 8790: Solution to assignment 5

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## Report:

The sensor's state is a 3D measurement of the position of the target however the observations are obtained in lower dimensions (1D and 2D) with respective transformation matrix $H$.

In the provided data file comes with a mixture of those 1D and 2D observations and only differentiated by the dimensionality encoded at the beginning of each measurement. Thus, reading the dimension value(integer) is crucial to determine the numbers of subsequence data(floats) to be extracted to get an observations. In the case that the observation is one dimensional the number of float value to read is $1 + 1 + 3 = 5$, one value for mean $z$, one for covariance $R$ and three for the transformation matrix $H$. For 2 dimensional observation, the numbers of value to read from the data file is $2 + 3 + 6 = 11$, two for the mean, three for the covariance and 6 for the transformation matrix.

After obtaining the observation, we can initialize the filter with the mean $x$ equals to zero and covariance $P$ to a large number then combine them together using the below fusion equation until all observations are fused.

$$x = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, P = \begin{bmatrix} 100000000 & 0 & 0 \\ 0 & 100000000 & 0 \\ 0 & 0 & 100000000 \end{bmatrix}$$

**1.** The final mean $x$ and the new covariance $P$ are computed using innovation form of the fusion equation:

$$x_{new} = x + W(z - x)$$
$$P_{new} = P - WSW^T$$

where

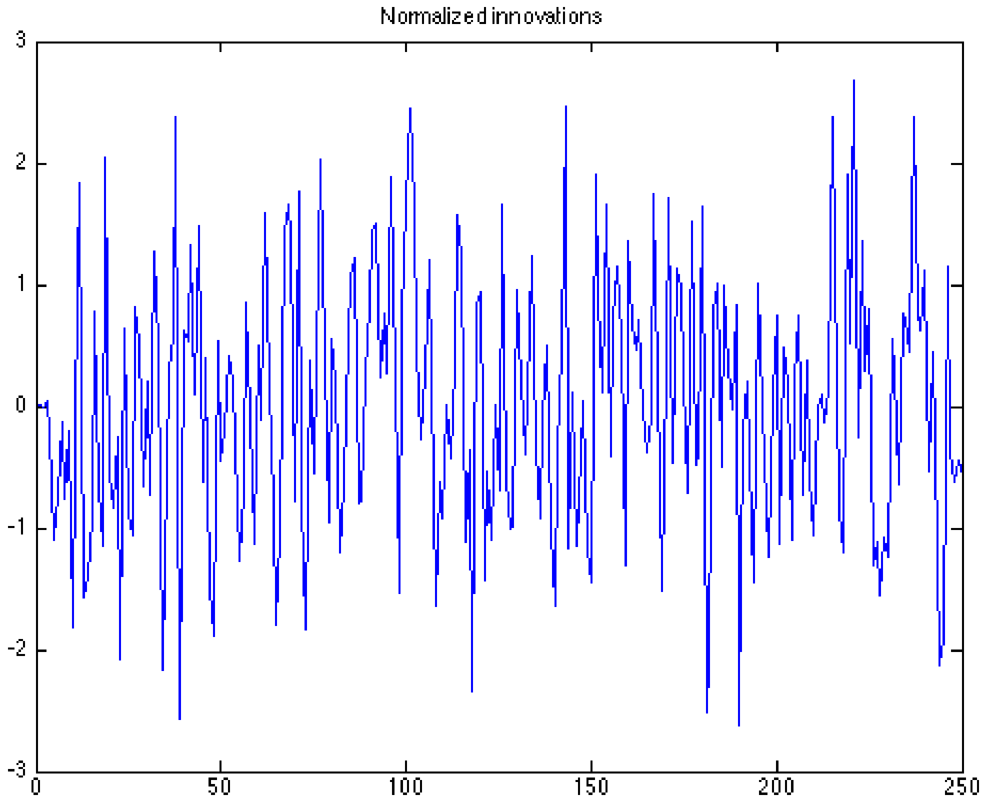
$$S = R + P$$
$$W = PS^{-1}$$

$$x_{final} = \begin{bmatrix} 12.895992 \\ 130.398454 \\ 23.494780 \end{bmatrix}$$

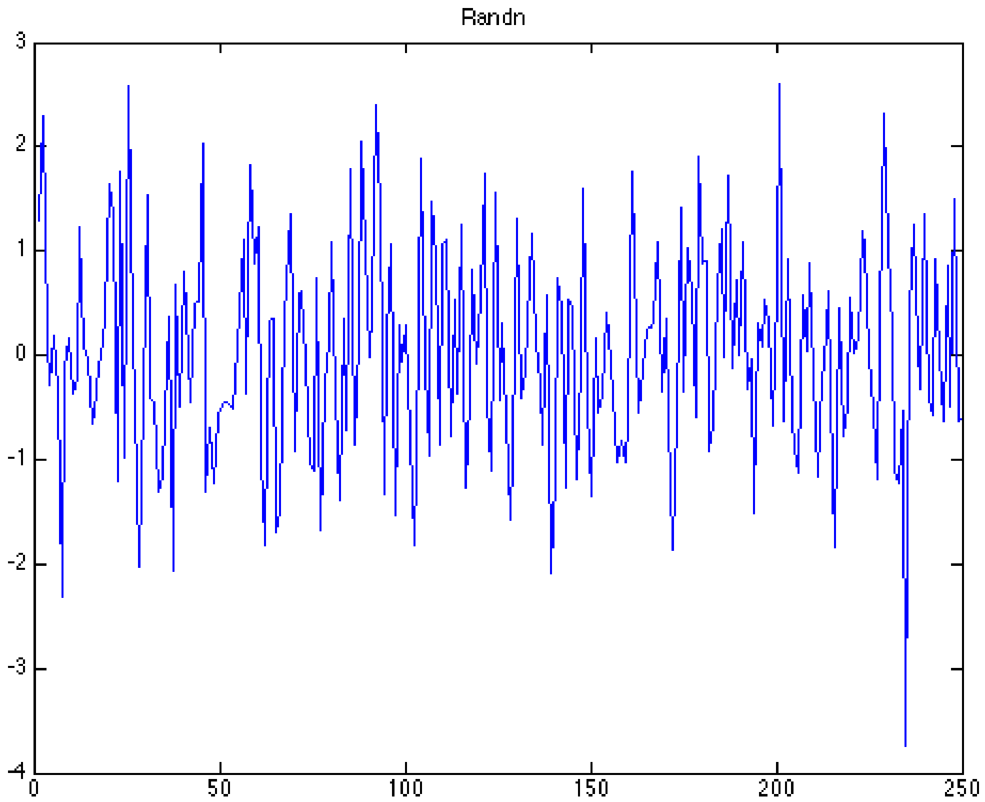
$$Square\ root\ of\ P_{final} = \begin{bmatrix} 0.002755 & 0.001226 & 0.000953 \\ 0.001226 & 0.003708 & 0.002179 \\ 0.000953 & 0.002179 & 0.004934 \end{bmatrix}$$

**2.** Plots:

Normalized innovations:


Normalized innovations
3
2
1
0
-1
-2
-3
0
50
100
150
200
250

Randn:


Randn
3
2
1
0
-1
-2
-3
-4
0
50
100
150
200
250

## Appendix:

assignment_5.m

```
% initialize filter
x = [0; 0; 0];
P = diag(ones(1,3) * 10^8); % large covariance P
normalized_innovations = [];

% open data file
fid = fopen('A5-MeasurementData.txt');
row = 0;
while ~feof(fid)
    d = fscanf(fid, '%d', 1);
    if ~isempty(d)
        row = row + 1;
        [z, R, H] = getObservation(fid, d);
        [x, P, v] = update(x, P, z, R, H);
        normalized_innovations(row, 1) = v(1);
    end
end
% close file
fclose(fid);

% final estimate (x, P)
fprintf('Final mean x =\n%14f %14f %14f\n', x);
fprintf('The final covariance P =\n');
fprintf('%14f %14f %14f\n', P);

% plots
figure
plot(normalized_innovations)
title('Normalized innovations')

figure
plot(randn(row, 1))
title('Randn')
```

getObservation.m

```
function [ z, R, H ] = getObservation( fid, d )
%getObservation - read observation from data file
%   fid - file pointer
%   d   - dimension of the observation

    if (d == 1)
        observation = fscanf(fid, '%f', 5);
        z = observation(1);
        R = observation(2);
        H = observation(3:5)';
    elseif (d == 2)
        observation = fscanf(fid, '%f', 11);
        z = observation(1:2);
        R = [observation(3:4)'; observation(4:5)'];
        H = [observation(6:8)'; observation(9:11)'];
    end
end
```

update.m

```
function [ x, P, v ] = update( x, P, z, R, H )
%update - update sensor estimate
%   incorporate information from new observation (z, R, H)

    S = (H * P * H') + R;
    W = (P * H') / S;
    P = P - (W * S * W');
    innovation = (z - H * x);
    x = x + W * innovation;
    v = sqrtm(S) \ innovation;
end
```