

Topic#1 - Kalman filter

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About Kalman filter

Advantages: ...

Disadvantages - the following factors have a negative impact on the results of the Kalman filter algorithms:

- significant nonlinearities in the dynamics of the system
- high dimensionality of the system
- observability of a system
- sample spacing, noise intensity etc.

Let's consider a linear dynamical system with discrete time

$$X_{i+1} = \Phi_i X_i + u_i + \xi_i, \quad (1.01)$$

$$Y_i = C_i X_i + \eta_i, \quad (1.02)$$

where $X = [x \ z \ V_x \ V_z]^T$ is state vector;

ξ_i, η_i are discrete stochastic white noise;

$X_{i+1} = \Phi \cdot X_i$ is dynamic equation of the UAV;

$$\Phi(\Delta t) = \begin{bmatrix} 1 & 0 & \Delta t & 0 \\ 0 & 1 & 0 & \Delta t \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \text{ is transition matrix of the UAV;}$$

$Y_i = [y_{1i} \ y_{2i}]^T = [x_i \ z_i]^T$ is measurement vector;

$Y_i = C_i X_i + \eta_i$ is measurement equation;

$$C_i = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}_{2 \times 4} \text{ is measurement matrix;}$$

$$K_{\xi_i} = \begin{bmatrix} D_{\xi} & 0 & 0 & 0 \\ 0 & D_{\xi} & 0 & 0 \\ 0 & 0 & D_{\eta} & 0 \\ 0 & 0 & 0 & D_{\eta} \end{bmatrix} \text{ is covariance matrix of initial state of the}$$

dynamic system;

$$K_{\eta_i} = \begin{bmatrix} D_{\eta} & 0 \\ 0 & D_{\eta} \end{bmatrix} \text{ is covariance matrix of measurement errors.}$$

Case study - Input data

$$X = [3000; 500; 10; -10] \text{ (m), (m), (m/s), (m/s)}$$

$$D_{\bar{R}_0} = 900 \text{ (m}^2\text{)}, D_{\bar{V}_0} = 25 \text{ (m}^2/\text{s}^2\text{)}$$

$$\Delta t = 5 \text{ (s)}, N = 25.$$

Case study - Simulation results

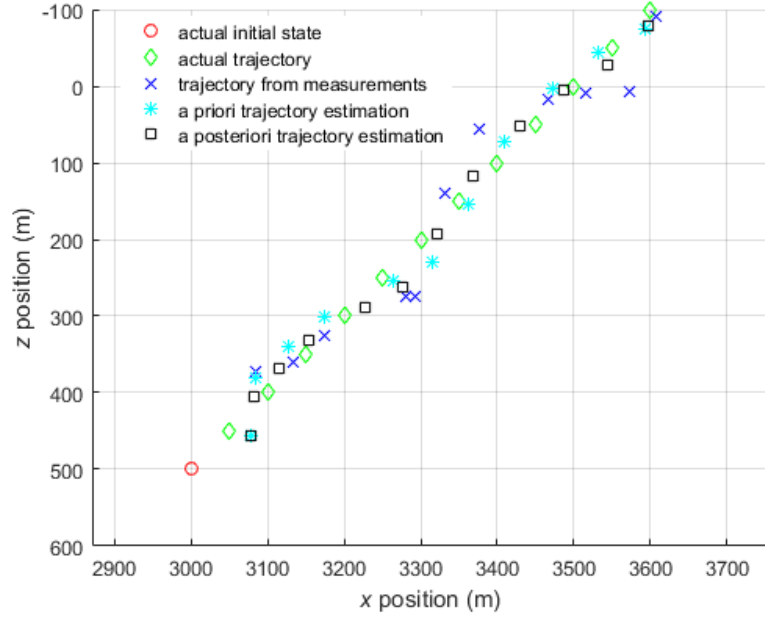


Figure 1.01 State estimation using Kalman filter

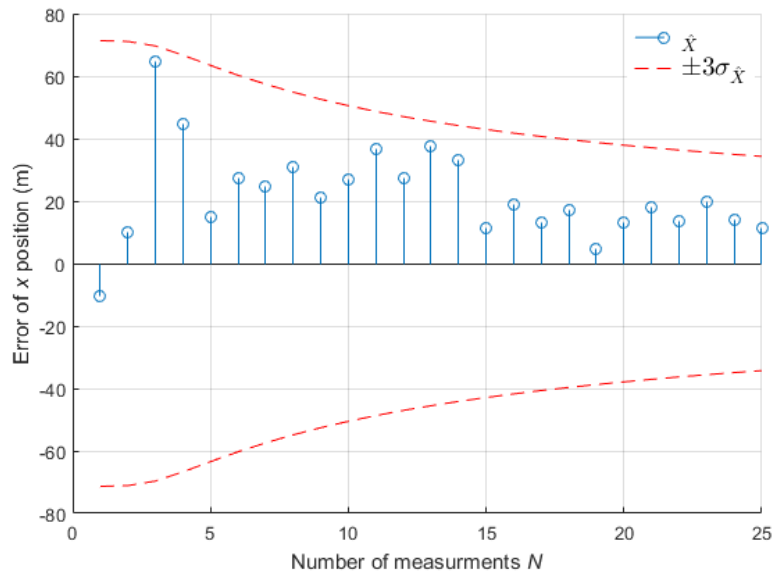


Figure 1.02 Estimation of position errors

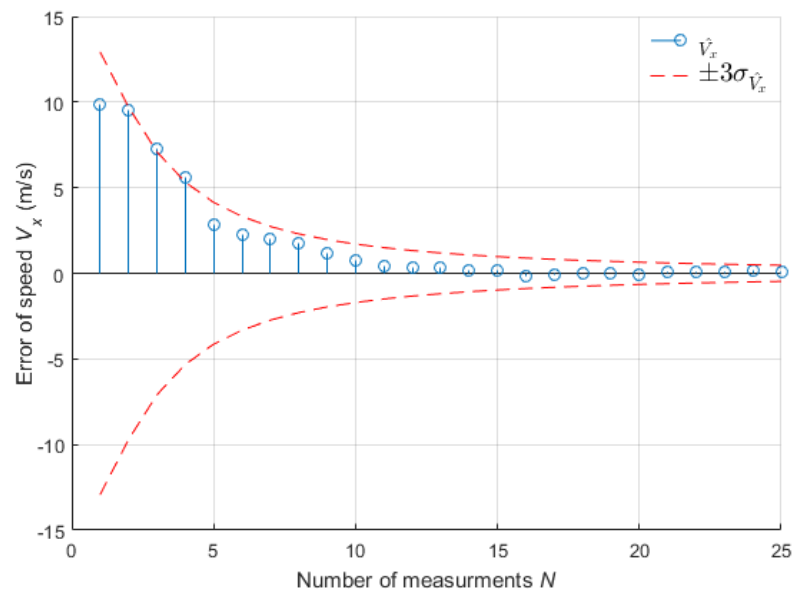


Figure 1.03 Estimation of velocity errors

References

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