Topic#1 - Kalman filter

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About Kalman filter

… Advantages / Disadvantages …

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Let's consider a linear dynamical system with discrete time

$$X_{i+1} = \Phi_i X_i + u_i + \xi_i \,, \tag{1.01}$$

$$Y_i = C_i X_i + \eta_i \,, \tag{1.02}$$

where $X = \begin{bmatrix} x & z & V_x & V_z \end{bmatrix}^T$ 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;

$\Phi(\Delta t) = \begin{bmatrix} 1 & 0 & \Delta t & 0 \\ 0 & 1 & 0 & \Delta t \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ 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;

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

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

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

Case study - Input data

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

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

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

Case study - Simulation results

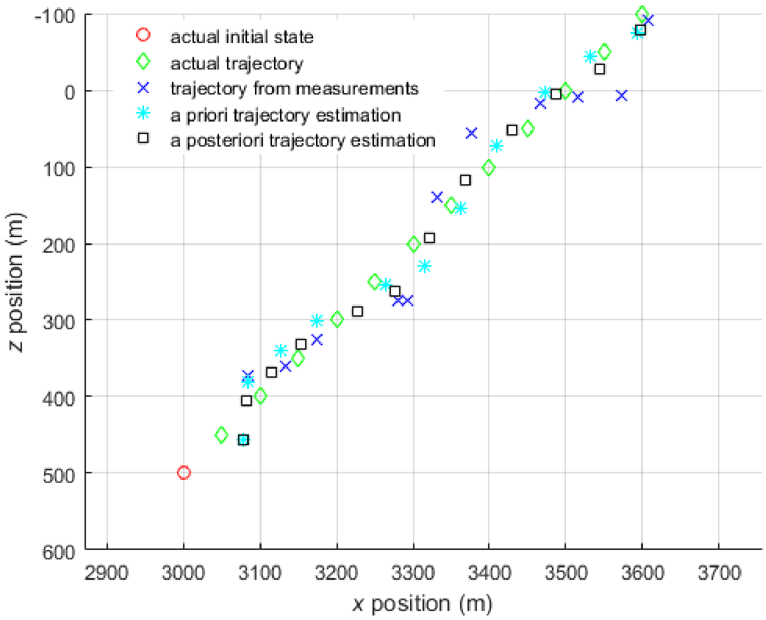

Figure 1.01 State estimation using Kalman filter

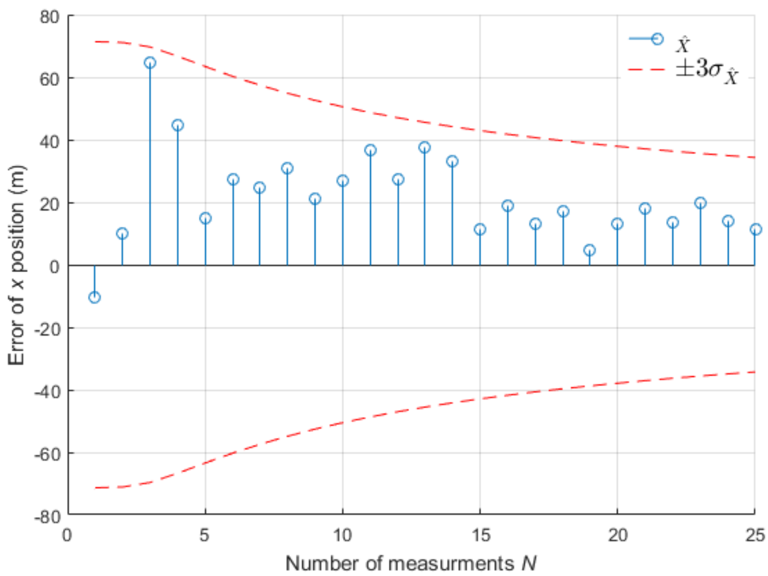

Figure 1.02 Estimation of position errors

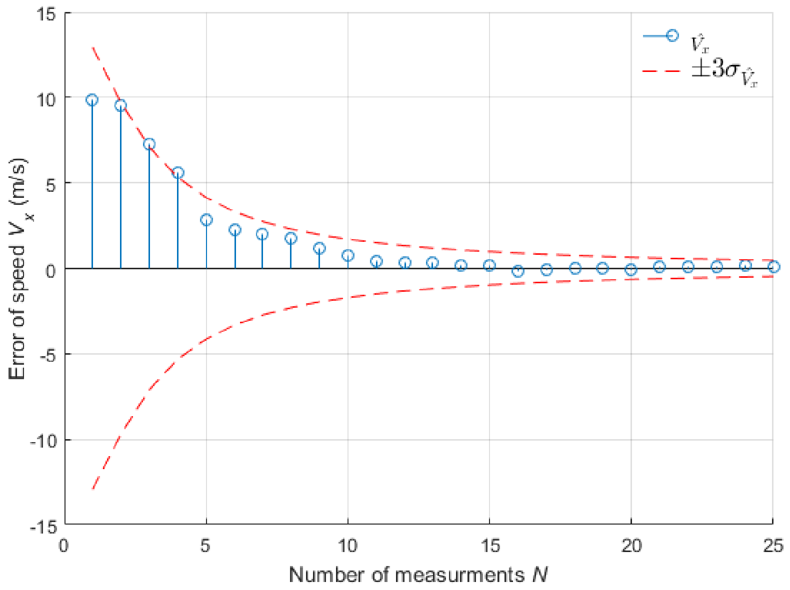

Figure 1.03 Estimation of velocity errors

References

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