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Advanced Kalman Filtering and Sensor Fusion

Linear Kalman Filter Summary

System Model:

$$x_k = \mathbf{F}_{k-1}x_{k-1} + \mathbf{G}_{k-1}u_{k-1} + w_{k-1}$$
$$z_k = \mathbf{H}_k x_k + v_k$$

Assumptions:

$$\underbrace{\begin{aligned} w_k &\sim N(0, \mathbf{Q}_k) \\ v_k &\sim N(0, \mathbf{R}_k) \end{aligned}}_{\text{Gaussian Distribution with zero mean and given covariance matrix}}$$

$$\left.\begin{aligned} E(w_k w_j^T) &= \mathbf{Q}_k \delta_{k-j} \\ E(v_k v_j^T) &= \mathbf{R}_k \delta_{k-j} \end{aligned}\right\} \text{Not correlated with time}$$

$$E(w_k v_j^T) = 0$$

Process noise and Measurement noise are independant

Predict:

$$\hat{x}_k^- = \mathbf{F}_{k-1}\hat{x}_{k-1}^+ + \mathbf{G}_{k-1}u_{k-1}$$
$$\mathbf{P}_k^- = \mathbf{F}_{k-1}\mathbf{P}_{k-1}^+\mathbf{F}_{k-1}^T + \mathbf{Q}_{k-1}$$

Update:

$$\tilde{y}_k = z_k - \mathbf{H}_k\hat{x}_k^-$$
$$\mathbf{S}_k = \mathbf{H}_k\mathbf{P}_k^-\mathbf{H}_k^T + \mathbf{R}_k$$
$$\mathbf{K}_k = \mathbf{P}_k^-\mathbf{H}_k^T\mathbf{S}_k^{-1}$$
$$\hat{x}_k^+ = \hat{x}_k^- + \mathbf{K}_k\tilde{y}_k$$
$$\mathbf{P}_k^+ = (\mathbf{I} - \mathbf{K}_k\mathbf{H}_k)\mathbf{P}_k^-$$