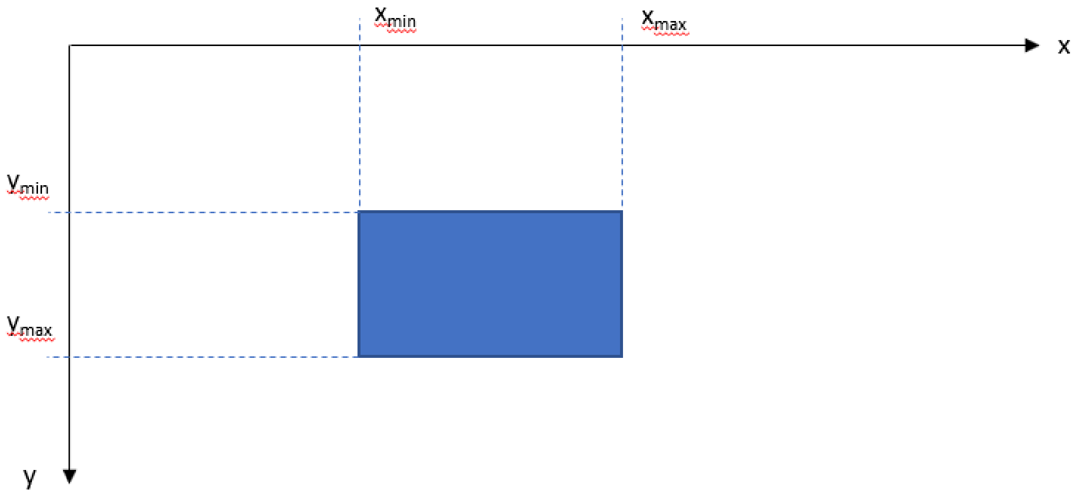
Pattern Kalman Filtering

Bounding box edge coordinates



Pattern location (bounding box) is determined by four edge coordinates: x_{min}, x_{max}, y_{min} and y_{max}. vx_{min}, vx_{max}, vy_{min} and vy_{max} are corresponding velocities.

Each edge coordinate is filtered separately and identically. x_{min} is used here as an example.

State equation in differential form:

$$\frac{d}{dt}\begin{bmatrix} x_{min}(t) \\ vx_{min}(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} * \begin{bmatrix} x_{min}(t) \\ vx_{min}(t) \end{bmatrix} + \epsilon(t)$$

State equation in difference form:

$$\begin{bmatrix} x_{min}(k+1) \\ vx_{min}(k+1) \end{bmatrix} = A * \begin{bmatrix} x_{min}(k) \\ vx_{min}(k) \end{bmatrix} + \varepsilon(k)$$

$$A = \begin{bmatrix} 1 & \Delta \\ 0 & 1 \end{bmatrix}$$

where Δ is the time increment and ε Gaussian noise with covariance R:

$$R = \begin{bmatrix} 0.1 & 0 \\ 0 & 1.0 \end{bmatrix}$$

Measurement equation

$$z(k) = C * \begin{bmatrix} x_{min}(k) \\ vx_{min}(k) \end{bmatrix} + \delta(k)$$

$$C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

where δ is Gaussian noise with covariance matrix Q:

$$Q = [200.0]$$

Kalman filter initialization:

$$\mu(0) = \begin{bmatrix} x_{min}(0) \\ 0 \end{bmatrix}$$

where x_{min} (0) is the first location measurement.

$$\Sigma(0) = \begin{bmatrix} 200.0 & 0 \\ 0 & 10\,000.0 \end{bmatrix}$$

Kalman filter update:

$$\mu_1(k) = A * \mu(k-1)$$

$$\Sigma_1(k) = A * \Sigma(k-1) * A^T + R$$

$$K(k) = \Sigma_1(k) * C^T * (C * \Sigma_1(k) * C^T + Q)^{-1}$$

$$\mu(k) = \mu_1(k) + K(k) * (z(k) - C * \mu_1(k))$$

$$\Sigma(k) = (I - K(k) * C) * \Sigma_1(k)$$