Initialisation of parameters

$$\mathbf{x}_0, \mathbf{P}_0, \mathbf{H}, \mathbf{Q}, \mathbf{R}_0,$$

Time update

Compute fundamental matrix:

$$\boldsymbol{\Phi}_{k-1}^{[1]} \approx \mathbf{I}_n + \mathbf{F}_{k-1} T_s$$

Compute *a priori* estimate:

$$\hat{\mathbf{x}}_k^- = \boldsymbol{\Phi}_{k-1}^{[1]} \hat{\mathbf{x}}_{k-1}$$

Compute *a priori* error covariance:

$$\mathbf{P}_k^- = \boldsymbol{\Phi}_{k-1}^{[1]} \mathbf{P}_{k-1} \boldsymbol{\Phi}_{k-1}^{[1]T} + \mathbf{Q}_{k-1}$$

Correct sensor readings

Compute acceleration due to motion:

$$\begin{aligned} \ddot{x} &= -l_1[\omega_1^2 \cos\theta_1 + \alpha_1 \sin\theta_1] - l_2[(\omega_1 + \omega_2)^2 \\ &\quad \cdot \cos(\theta_1 + \theta_2) + (\alpha_1 + \alpha_2)\sin(\theta_1 + \theta_2)] \\ \ddot{z} &= -l_1[\alpha_1 \cos\theta_1 - \omega_1^2 \sin\theta_1] - l_2[(\alpha_1 + \alpha_2) \\ &\quad \cdot \cos(\theta_1 + \theta_2) + (\omega_1 + \omega_2)^2 \sin(\theta_1 + \theta_2)] \end{aligned}$$

Rotate acceleration to body frame:

$$A_{rad} = \mathbf{T}_y^T(\theta_1 + \theta_2 - \tfrac{\pi}{2})\ddot{x}$$

$$A_{tan} = \mathbf{T}_y^T(\theta_1 + \theta_2 - \tfrac{\pi}{2})\ddot{z}$$

Compute gravity estimate:

$$\mathbf{g} = \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} A_x \\ A_z \end{bmatrix} - \begin{bmatrix} A_{rad} \\ A_{tan} \end{bmatrix}$$

Compute corrected angle estimate:

$$\theta_1 + \theta_2 = \mathrm{atan2}(g_y, g_x)$$

Measurement update

Compute Kalman gain:

$$\mathbf{K}_k = \mathbf{P}_k^- \mathbf{H}_k^T [\mathbf{H}_k \mathbf{P}_k^- \mathbf{H}_k^T + \mathbf{R}_k]^{-1}$$

Compute *a posteriori* estimate:

$$\hat{\mathbf{x}}_k = \hat{\mathbf{x}}_k^- + \mathbf{K}_k[\mathbf{z}_k - \mathbf{H}_k \hat{\mathbf{x}}_k^-]$$

Update error covariance:

$$\mathbf{P}_k = [\mathbf{I} - \mathbf{K}_k \mathbf{H}_k]\mathbf{P}_k^-$$

Output