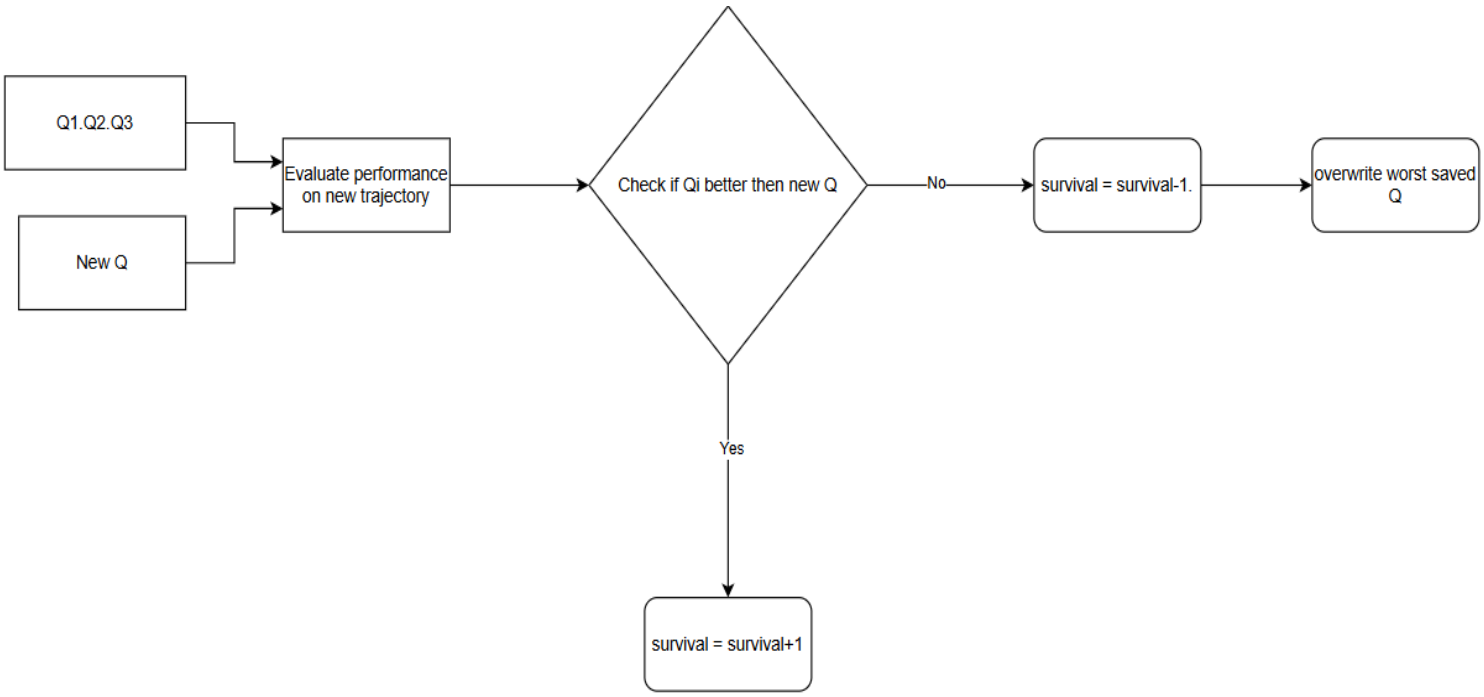
RL Based "monte carlo" optimization

Goal

Estimate an empirical process-noise matrix **Q** that yields **consistently low RMSE** while preserving filter stability and generalization across trajectories.

Flow:



- The test function is :

$$\textbf{Reward to minimize } R = \frac{\mathrm{RMSE}_x + \mathrm{RMSE}_y + \mathrm{RMSE}_z}{3}$$

- Best Q for spiral:

$$\boldsymbol{Q_0} = \begin{bmatrix} \mathbf{0.7863} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{1.1935} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0.0507} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0.3131} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0.0340} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0.0400} \end{bmatrix}.$$

- Best Q for const acceleration KF:

$$Q = \begin{bmatrix} 1.6929 \times 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.1685 \times 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 5.7749 \times 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.1491 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.1514 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.0422 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 4.7873 \times 10^{-6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3.5685 \times 10^{-5} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2.4633 \times 10^{-7} \end{bmatrix}$$

- Best Q for const acceleration UKF

$$Q_{\mathrm{UKF}} = \begin{bmatrix} 4.5835 \times 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 6.2005 \times 10^{-6} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1.1438 \times 10^{-5} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.1438 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.1891 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.0598 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 3.4419 \times 10^{-6} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2.5747 \times 10^{-6} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 7.5969 \times 10^{-6} \end{bmatrix}$$