Key steps of FastSLAM

- Extend the path posterior by sampling a new pose for each sample

$$x_t^{[k]} \sim p(x_t \mid x_{t-1}^{[k]}, u_t)$$

- Compute particle weight

$$w^{[k]} = |2\pi Q|^{-\frac{1}{2}} \exp\left\{-\tfrac{1}{2}(z_t - \hat{z}^{[k]})^T Q^{-1} (z_t - \hat{z}^{[k]})\right\}$$

exp. observation

measurement covariance

- Update belief of observed landmarks (EKF update rule)
- Resample

FastSLAM part 1

1: **FastSLAM1.0_known_correspondence**$(z_t, c_t, u_t, \mathcal{X}_{t-1})$**:**

2: *for* $k = 1$ *to* N *do* // *loop over all particles*

3: *Let* $\left\langle x_{t-1}^{[k]}, \left\langle \mu_{1,t-1}^{[k]}, \Sigma_{1,t-1}^{[k]} \right\rangle, \ldots \right\rangle$ *be particle* k *in* $\mathcal{X}_{t-1}$

4: $x_t^{[k]} \sim p(x_t \mid x_{t-1}^{[k]}, u_t)$ // *sample pose*

5: $j = c_t$ // *observed feature*

6: *if feature* j *never seen before*

7: $\mu_{j,t}^{[k]} = h^{-1}(z_t, x_t^{[k]})$ // *initialize mean*

8: $H = h'(\mu_{j,t}^{[k]}, x_t^{[k]})$ // *calculate Jacobian*

9: $\Sigma_{j,t}^{[k]} = H^{-1}\, Q_t\, (H^{-1})^T$ // *initialize covariance*

10: $w^{[k]} = p_0$ // *default importance weight*

11: *else*

FastSLAM part 2

11: *else*

12: $\langle \mu_{j,t}^{[k]}, \Sigma_{j,t}^{[k]} \rangle = \textit{EKF-Update}(\dots)$ *// update landmark*

13: $w^{[k]} = |2\pi Q|^{-\frac{1}{2}} \exp\left\{-\frac{1}{2}(z_t - \hat{z}^{[k]})^T Q^{-1} (z_t - \hat{z}^{[k]})\right\}$

measurement cov. $Q = H \Sigma_{j,t-1}^{[k]} H^T + Q_t$ **exp. observation**

14: *endif*

15: *for all unobserved features* j' *do*

16: $\langle \mu_{j',t}^{[k]}, \Sigma_{j',t}^{[k]} \rangle = \langle \mu_{j',t-1}^{[k]}, \Sigma_{j',t-1}^{[k]} \rangle$ *// leave unchanged*

17: *endfor*

18: *endfor*

19: $\mathcal{X}_t = \text{resample}\left(\left\langle x_t^{[k]}, \left\langle \mu_{1,t}^{[k]}, \Sigma_{1,t}^{[k]} \right\rangle, \dots, w^{[k]} \right\rangle_{k=1,\dots,N}\right)$

20: *return* $\mathcal{X}_t$

FastSLAM part 2 (detailed)

11: *else*

12: $\hat{z}^{[k]} = h(\mu_{j,t-1}^{[k]}, x_t^{[k]})$ // *measurement prediction*

13: $H = h'(\mu_{j,t-1}^{[k]}, x_t^{[k]})$ // *calculate Jacobian*

14: $Q = H\, \Sigma_{j,t-1}^{[k]}\, H^T + Q_t$ // *measurement covariance*

15: $K = \Sigma_{j,t-1}^{[k]}\, H^T\, Q^{-1}$ // *calculate Kalman gain*

16: $\mu_{j,t}^{[k]} = \mu_{j,t-1}^{[k]} + K(z_t - \hat{z}^{[k]})$ // *update mean*

17: $\Sigma_{j,t}^{[k]} = (I - K\, H)\Sigma_{j,t-1}^{[k]}$ // *update covariance*

18: $w^{[k]} = |2\pi Q|^{-\frac{1}{2}}\ \exp\left\{-\frac{1}{2}(z_t - \hat{z}^{[k]})^T\right.$
$\left. Q^{-1}\,(z_t - \hat{z}^{[k]})\right\}$ // *importance factor*

19: *endif*

20: *for all unobserved features* j' *do*

21: $\langle \mu_{j',t}^{[k]}, \Sigma_{j',t}^{[k]} \rangle = \langle \mu_{j',t-1}^{[k]}, \Sigma_{j',t-1}^{[k]} \rangle$ // *leave unchanged*

23: *endfor*

24: *endfor*

25: $\mathcal{X}_t = \text{resample}\left(\left\langle x_t^{[k]}, \left\langle \mu_{1,t}^{[k]}, \Sigma_{1,t}^{[k]} \right\rangle, \ldots, w^{[k]} \right\rangle_{k=1,\ldots,N}\right)$

26: *return* $\mathcal{X}_t$