① robmap Ex03 02.11.17

$\mathcal{N}$1

a.) prediction step: the previous state x_{t-1} and the current control u_t are computed using a certain motion/state transition model to estimate the new state $\tilde{x}_t$ $p(x_t|u_t, x_{t-1})$

correction step: the estimated state $\tilde{x}_t$ and the current observations z_t are computed using a observation/measurement model to calc a refined/corrected state estimation x_t $p(z_t|x_t)$ =D whole BF $p(x_t|z_t, x_{t-1}, u_t)$

b.) $p(x_t/u_t, x_{t-1})$: state transition probability; pobability density function of x_t given that control vector u_t and previous state x_{t-1} are the case

$p(z_t|x_t)$: measurement probability: prob. density function of the measurement z_t given that the current state x_t is the case

$bel(x_t)$: believe; probability density function of current state x_t calculated with accumulated $z_{1:t}$ and $u_{1:t}$ (sensor and control data). What's the probability that x_t is the case given current and past sensor and control data?

c.) $\cancel{p(x_t|u_t, x_{t-1}) = p(x_t|u_t, \bar{\mu}_t) = \mathcal{N}(\bar{\mu}_t, \bar{\Sigma}_t)}$

$\cancel{p(z_t|x_t) = \mathcal{N}(h(\bar{\mu}_t), Q_t)}$

$\cancel{bel(x_t) = \mathcal{N}(\mu_t, \Sigma_t)}$

d.) μ_t: mean value of current state estimate $n \times 1$

Σ_t: covariance of current state estimate $n \times n$

G_t^x: jacobian of motion model 3×3

G_t: jacobian of state transition model (motion + map) $n \times n$

R_t^x: covariance/uncertainty of motion model 3×3

R_t: gaussian noise added to state estimate of prediction step $n \times n$

②

g: non-linear state transition function $n \times 1$

h: non-linear measurement function $m \times 1$

H_t: Jacobian of measurement model $m \times m$

Q_t: covariance / uncertainty of measurement model $m \times m$

K_t: Kalman gain; defines to which degree measurement is $m \times 1$ included into state estimation

Nr 2

a.)

$$\begin{pmatrix} x_t \\ y_t \\ \theta_t \end{pmatrix} = \begin{pmatrix} x_{t-1} + \delta_{trans} \cos(\theta_{t-1} + \delta_{rot_1}) \\ y_{t-1} + \delta_{trans} \sin(\theta_{t-1} + \delta_{rot_1}) \\ \theta_{t-1} + \delta_{rot_1} + \delta_{rot_2} \end{pmatrix}$$

$$G_t^x = \begin{pmatrix} 1 & 0 & -\delta_{trans} \sin(\theta_{t-1} + \delta_{rot_1}) \\ 0 & 1 & \delta_{trans} \cos(\theta_{t-1} + \delta_{rot_1}) \\ 0 & 0 & 1 \end{pmatrix}$$

b.)

$$h(\bar{\mu}_t, j) = z_t^i = \begin{pmatrix} r_t^i \\ \phi_t^i \end{pmatrix} = \begin{pmatrix} \sqrt{(\bar{\mu}_{j,x} - \bar{\mu}_{t,x})^2 + (\bar{\mu}_{j,y} - \bar{\mu}_{t,y})^2} \\ \operatorname{atan2}(\bar{\mu}_{j,y} - \bar{\mu}_{t,y}, \bar{\mu}_{j,x} - \bar{\mu}_{t,x}) - \mu_{t,\theta} \end{pmatrix}$$

$$\delta_x = \bar{\mu}_{j,x} - \bar{\mu}_{t,x} \qquad \delta_y = \mu_{j,y} - \mu_{t,y} \qquad q = \delta_x^2 + \delta_y^2$$

$$\text{low } H_t^i = \frac{1}{q} \begin{pmatrix} -\sqrt{q}\delta_x & -\sqrt{q}\delta_y & 0 & \sqrt{q}\delta_x & \sqrt{q}\delta_y \\ \delta_y & -\delta_x & -q & -\delta_y & \delta_x \end{pmatrix}$$

Nr 1

C.)

$$p(x_t \mid u_t, x_{t-1}) = \mathcal{N}(x_t; \bar{\mu}_t, \bar{\Sigma}_t)$$

$$p(z_t \mid x_t) = \mathcal{N}(z_t; h(\bar{\mu}_t), Q_t)$$

$$bel(x_t) = \mathcal{N}(x_t; \mu_t, \Sigma_t)$$