Instrumentation Tutorial 9 Answers

Instrumentation (Flinders University)

INSTRUMENTATION

ENGR4732, SEMESTER 2 2014

TUTORIAL 9: EKF-SLAM

QUESTIONS

QUESTION 1 – STATE VECTOR

Given a robot with 3 DOF ,i.e. x, y, θ, in an environment with 5 landmarks that are visible.

Define the state vector to be estimated by the EKF.

QUESTION 2 – STATE MODEL

Given the state vector defined in question 1, define the state transition "motion" model for this system.

QUESTION 3 – MODEL JACOBIAN

Given the model above, define the Jacobian relative to the previous state, x_{t-1}.

QUESTION 4 – MEASUREMENT MODEL

The measurement of each landmark is provided as a range and bearing measurement.

Given the results of the previous two questions, and assuming perfect landmark identification, define the measurement model for landmark 1.

INSTRUMENTATION

ENGR4732, SEMESTER 2 2014

TUTORIAL 9: EKF-SLAM

ANSWERS

QUESTION 1 – STATE VECTOR

Given a robot with 3 DOF ,i.e. x, y, θ, in an environment with 5 landmarks that are visible.

Define the state vector to be estimated by the EKF.

ANSWER

$$\boldsymbol{x}_k := [x \quad y \quad \theta \quad x_{L_1} \quad y_{L_1} \quad x_{L_2} \quad y_{L_2} \quad x_{L_3} \quad y_{L_3} \quad x_{L_4} \quad y_{L_4} \quad x_{L_5} \quad y_{L_5}]^T$$

QUESTION 2 – STATE MODEL

Given the state vector defined in question 1, define the state transition "motion" model for this system.

ANSWER

$$\boldsymbol{x}_k = \begin{bmatrix} x_{k-1} + \delta_{trans}\cos(\theta_{k-1} + \delta_{rot1}) \\ y_{k-1} + \delta_{trans}\sin(\theta_{k-1} + \delta_{rot1}) \\ \theta_{k-1} + \delta_{rot1} + \delta_{rot2} \\ x_{L_1,k-1} \\ y_{L_1,k-1} \\ x_{L_2,k-1} \\ y_{L_2,k-1} \\ x_{L_3,k-1} \\ y_{L_3,k-1} \\ x_{L_4,k-1} \\ y_{L_4,k-1} \\ x_{L_5,k-1} \\ y_{L_5,k-1} \end{bmatrix}$$

Question 3 – Model Jacobian

Given the model above, define the Jacobian relative to the previous state, x_{t-1}.

Answer

$$\widehat{\boldsymbol{F}}_{k-1} = \begin{bmatrix} 1 & 0 & -\delta_{trans}\sin(\theta_{k-1} + \delta_{rot1}) & \\ 0 & 1 & \delta_{trans}\cos(\theta_{k-1} + \delta_{rot1}) & \mathbf{0}_{3\times 10} \\ 0 & 0 & 1 & \\ & \mathbf{0}_{10\times 3} & & \boldsymbol{I}_{10\times 10} \end{bmatrix}$$

Question 4 – Measurement Model

The measurement of each landmark is provided as a range and bearing measurement.

Given the results of the previous two questions, and assuming perfect landmark identification, define the measurement model for landmark 1.

Answer

$$\psi_{L_1,k} = atan2\left(y_{L_1,k} - y_k, x_{L_1,k} - x_k\right) - \theta_k$$

$$r_{L_1,k} = \sqrt{\left(y_{L_1,k} - y_k\right)^2 + \left(x_{L_1,k} - x_k\right)^2}$$