Instrumentation Tutorial 10 Answers

Instrumentation (Flinders University)

INSTRUMENTATION

ENGR7732, SEMESTER 2

TUTORIAL 10: FASTSLAM

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 particle filter and the state vector of each of the Kalman Filters associated with each particle.

QUESTION 2 – STATE MODEL

Given the state vectors defined in question 1, define the state transition "motion" model for each of the Kalman Filters.

QUESTION 3 – MODEL JACOBIAN

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

QUESTION 4 – LANDMARK UPDATE

Using the results of question 2 and 3, define the prediction stage of the EKF that is tracking the location of landmark 1.

QUESTION 5 – UPDATE PROCESS

Due to multiple filters interacting with each other, a sequence defining the order in which the filters are updated must defined. Define this sequence.

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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 particle filter and the state vector of each of the Kalman Filters associated with each particle.

ANSWER

Particle Filter -> $\boldsymbol{x}_{PF} = \begin{bmatrix} x_r \\ y_r \\ \theta_r \end{bmatrix}$

Kalman Filter -> $\boldsymbol{x}_{KF} = \begin{bmatrix} x_{L_i} \\ y_{L_i} \end{bmatrix}$, One for each landmark i = 1 to 5

QUESTION 2 – STATE MODEL

Given the state vectors defined in question 1, define the state transition "motion" model for each of the Kalman Filters.

ANSWER

$$\boldsymbol{x}_k = \begin{bmatrix} x_{L_i,k} \\ y_{L_i,k} \end{bmatrix} = \begin{bmatrix} x_{L_i,k-1} \\ y_{L_i,k-1} \end{bmatrix}$$

Question 3 – Model Jacobian

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

Answer

$$\widehat{\boldsymbol{F}}_{k-1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Question 4 – Landmark Update

Using the results of question 2 and 3, define the prediction stage of the EKF that is tracking the location of landmark 1.

Answer

$$\boldsymbol{x}_{k|k-1} = \boldsymbol{x}_{k-1|k-1}$$

$$\boldsymbol{P}_{k|k-1} = \boldsymbol{P}_{k-1|k-1} + \boldsymbol{Q}_{k-1}$$

Question 5 – Update Process

Due to multiple filters interacting with each other, a sequence defining the order in which the filters are updated must defined. Define this sequence.

Answer

PF Prediction (Robot Motion)

For i = 1 to 5

    KF Prediction (Landmark Position Uncertainty)

End

PF Correction (Using KF Landmark predicted position and uncertainty)

For i = 1 to 5

    KF Correction (Using updated PF Uncertainty)

End