Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
ONLINE
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	MOBILE ROBOT
COURSE CODE	:	BEH 42203/ BEJ44703
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

Q1 Consider the following Bayesian filter equation

$$\boldsymbol{Bel}\,(x_t) = \eta\, p(z_t|x_t) \int p(x_t|x_{t-1}, u_t)\boldsymbol{Bel}\,(x_{t-1})dx_{t-1},$$

(a) Evaluate the Bayesian filter equation above and Derive a Kalman Filter equation for correction function $p(z_t|x_t)$ and prediction function $\int p(x_t|x_{t-1}, u_t)\boldsymbol{Bel}\,(x_{t-1})dx_{t-1},$.

(10 marks)

(b) Describe Kalman Filter correction and prediction function for a mobile robot localization.

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(5 marks)

(c) Based on the Kalman Filter equations, produce a python programming for mobile robot localization.

(10 marks)

Q2 Consider the following Particle-filter based-on Bayesian filter equation

$$\boldsymbol{Bel}\,(x_t) = \eta\, p(z_t|x_t) \int p(x_t|x_{t-1}, u_t)\boldsymbol{Bel}\,(x_{t-1})dx_{t-1},$$

(a) Derive a Particle Filter Localization algorithm from the Bayesian filter equation.

(10 marks)

(b) Describe the Particle-filter algorithm for localization.

(6 marks)

(c) Based on the Particle filter algorithm, produce a python programming for mobile robot localization

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(9 marks)

Q3 (a) Define Rao-Blackwellization grid-SLAM.

(5 marks)

(b) A Rao-Blackwellization grid-SLAM equation is given by

$$p(x_{1:t}, m|z_{1:t}, u_{0:t-1}) = p(x_{1:t}|z_{1:t}, u_{0:t-1}) \cdot p(m|x_{1:t}, z_{1:t})$$

Derive a Rao-Blackwellization grid-SLAM algorithm from the equation above.

(10 marks)

(c) Number of effective particles is given by equation Number of effective particles is given by equation $n_{eff} = \frac{1}{\sum_i \left(w_t^{(i)}\right)^2}$. If resampling is done when $n_{eff} < 0.5$, i = 3, t = 2, $w_{t=2}^{(i=1)} = 0.5$, $w_{t=2}^{(i=2)} = 0.5$, calculate what is the value of $w_{t=2}^{(i=3)}$ so that resampling must happen?

(10 marks)

Q4 (a) Define A* path-planning.

(2 marks)

(b) Discuss the process of Dynamic Window Approaches for path-planning.

(3 marks)

(c) Evaluate the 5 differences between A* and Dynamic Window Approaches for path-planning.

(10 marks)

(d) A typical problem of Dynamic Window Approaches (DWA) is given by **Figure Q4(d)**. Analyze the reason of this problem and provide a solution.

(10 marks)

- END OF QUESTION-

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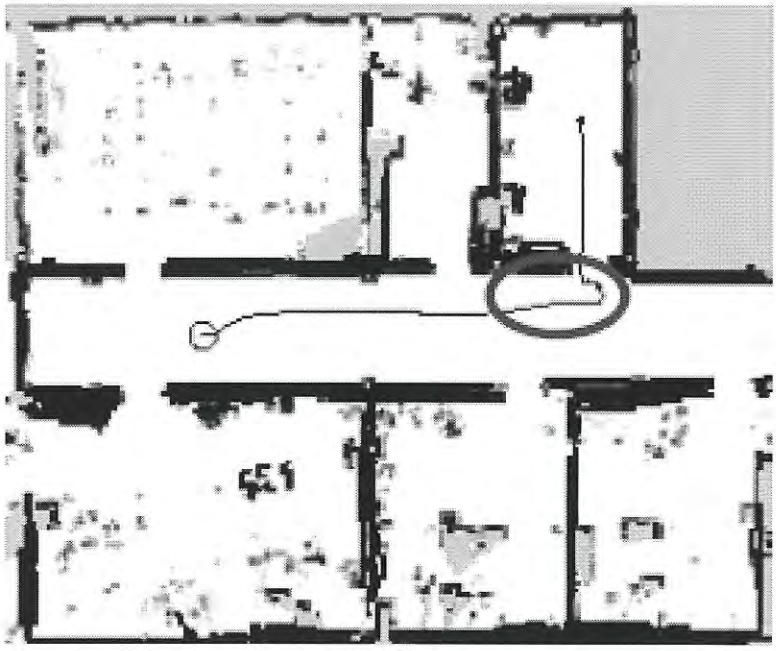

Figure Q4(d)