Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	MOBILE ROBOTIC
COURSE CODE	:	BEJ 44703
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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

Q1 TECHRON SDN BHD is a company that provides large pond cleaning using autonomous mobile robot. The mobile robot uses encoder to get velocity, v and IMU to get angular velocity, w.

(a) Derive the mobile robot motion model equation.

(8 marks)

(b) Calculate the robot position at time t = [10s, 20s, 80s] given $v = 8ms^{-1}$, $\omega = 2\ degs^{-1}$, initial x=5 , initial y=8 and initial theta=20.

(8 marks)

(c) If the sensor noise for v and ω is 15 %, analyze how much percentage of error increases for each (x, y, θ) at time t= 10s.

(4 marks)

(d) Develop a python code to compute the mobile robot motion model.

(10 marks)

Q2 (a) Given the initial equation of a robot posterior is $bel(x_T) = p(x_{0:T}, m|z_{1:T}, u_{1:T})$. By using Bayes rule, total probability rule and Markov assumption, proof the Bayes filter equation of a robot posterior is as follows:

$$bel(x_t) = \eta p(z_T|x_T) \int \quad p(x_T|u_T, x_{t-1}) bel(x_{t-1}) dx_{t-1}.$$

(10 marks)

(b) Evaluate the Bayesian filter equation in **Q2(a)** and derive a Kalman Filter equation for a correction function $p(z_t|x_t)$ and a prediction function $\int \quad p(x_{t-1}, u_t) Bel\ (x_{t-1}) dx_{t-1}$.

(10 marks)

Q3 (a) Define grid map.

(5 marks)

(b) A grid map equation is given by:

$$p(m|x_{1:t}, z_{1:t})$$

Derive a grid map algorithm (include the probability and binary Bayes filter) from the equation above.

(10 marks)

(c) Given by the observation sensor data $z_{1:t}$ and localization data $x_{1:t}$ calculate the belief ***Bel(m$^{|xy|}$)*** of each 4-grid map in **Figure Q3(c).**

(10 marks)

Q4 (a) Define A* path-planning.

(2 marks)

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

(3 marks)

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

(10 marks)

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

(10 marks)

-END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER / SESSION : SEM I 2022/2023
COURSE NAME : MOBILE ROBOTIC
PROGRAMME CODE : BEJ
COURSE CODE : BEJ 44703

Hits :4 **Miss:6**	**Hits :3** **Miss:7**
Hits :9 **Miss:1**	**Hits :10** **Miss:0**

Figure Q3(c)

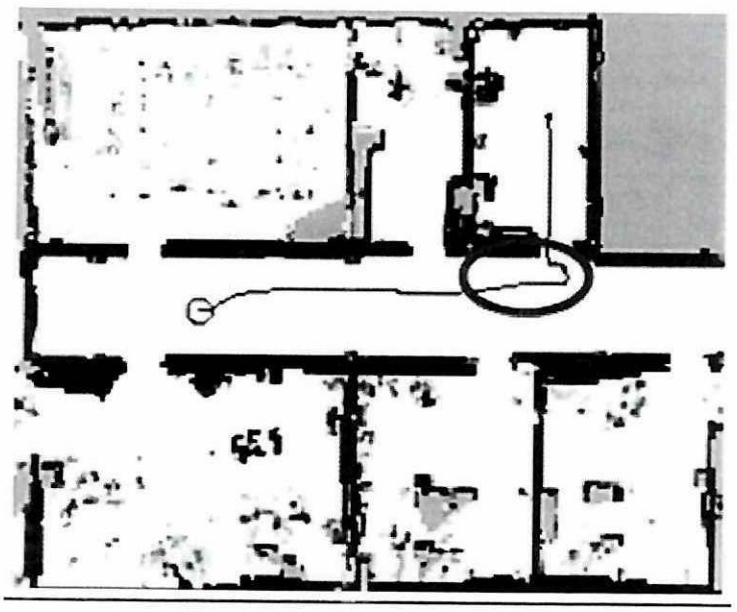

Figure Q4(d)