DUBLIN INSTITUTE OF TECHNOLOGY

BSc. (Honours) Degree in Computer Science

Stage 3

SUMMER EXAMINATIONS 2014/2015

MOBILE ROBOTICS [CMPU3025]

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THURSDAY 14TH MAY 1:00 P.M. – 3:00 P.M.

TWO HOURS

ANSWER **ALL FOUR** QUESTIONS.

1. (a) What do you understand by the term "robot"?

(5 marks)

(b) Describe the three Ds of robotics applications and give two examples of areas of usage.

(5 marks)

(c) List the five components of mobile robotics.

(5 marks)

(d) What is the difference between servo and non-servo robots?

(5 marks)

(e) What is the difference between proprioceptive and exteroceptive sensors?

(5 marks)

(f) Briefly describe edge detection in computer vision.

(5 marks)

(g) What is an holonomic wheel?

(5 marks)

(h) Describe the origin of the main advantage of the A* search algorithm over Dijkstra's algorithm.

(5 marks)

2. (a) Describe the working of electric motors.

(10 marks)

(b) List three advantages of stepper motors.

(10 marks)

3. (a) Name two types of sensors unsuitable for indoor navigation and explain why.

(10 marks)

(b) Explain how a robot can improve its belief state in terms of localization by moving.

(10 marks)

4. (a) Consider the following forward kinematic model for a differential drive robot:

$$\xi_I = R(\theta)^{-1}\,\xi_R = R(\theta)^{-1}\begin{pmatrix} (r\phi_1)/2 + (r\phi_2)/2 \\ 0 \\ (r\phi_1)/2l + (-r\phi_2)/2l \end{pmatrix}$$

$$R(\theta)^{-1} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Figure 1: Forward-kinematic model for a differential drive robot with powered wheels of radius *r*. □*i* is the speed of wheel 1, □2 is the speed of wheel 2, and *l* is the distance
between each of the wheels and the midpoint P between the wheels.

Suppose the robot is positioned such that $\theta = \pi/2$, $r = 2$, and $l = 1$ and the robot engages its wheels unevenly with $\phi 1 = 3$ and $\phi 2 = 2$.

Compute the velocity in the global reference frame.

(10 marks)

(b) Consider the following dead reckoning equations for predicting the location of an object given its current pose and the translational and rotational velocities:

$x' = x + x_I \Delta t \cos(\theta)$
$y' = y + y_I \Delta t \sin(\theta)$
$\theta' = \theta + \theta_I \Delta t$

x, y and θ represent the current pose and x_I, y_I and θ_I represent the velocities of the robot in the global reference frame. Δt is the elapsed time.

Suppose the robot currently stands on x=1, y=2 and $\theta = 0$.
Suppose also that the velocities are $x_I = 2$, $y_I = 3$ and $\theta_I = \pi$.

Predict the robot's location after 5 seconds, assuming that the robot completes its translational movement and then rotates.

(10 marks)