HERIOT WATT UNIVERSITY

SCHOOL OF MATHEMATICAL AND COMPUTER SCIENCES

Computer Science

F21RO

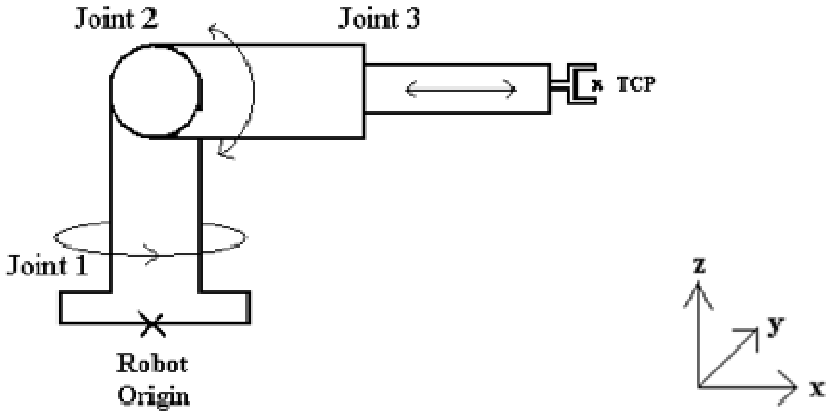
INTELLIGENT ROBOTICS

Semester 2 2017/18

Duration: Two Hours

ANSWER THREE QUESTIONS

Q1 Consider the following three-joint manipulator geometry –



Joint 1 and Joint 2 are revolute and Joint 3 is prismatic. Joint 2 is located a distance d_1 above the robot origin, i.e. the Tool Centre Point (TCP) is at a height of d_1 in the above diagram. The TCP is located a distance d_2 from Joint 2 when the radial joint is fully retracted, i.e. when the arm extension is set to 0.

(a) Derive the inverse kinematic equations for the three joints of this manipulator. [Hint: A geometric solution can be used here] (9)

(b) Hence derive the inverse Jacobian for the manipulator. (11)

Q2 (a) Describe the five main types of industrial manipulator geometry. Give examples of when each might be used in preference to the others. (10)

(b) Identify the three main types of actuator used for industrial robots. Compare their accuracy and speed. (4)

(c) An automated work-cell is required to paint the words “Produce of Scotland” onto sacks of grain. Each sack enters the cell on a conveyor and halts whilst a robot holds a stencil with the words cut out against it. A second robot then sprays paint over the stencil. (6)

Discuss the geometries, actuators and control methods which should be used for the two robots.

Q3

Consider the design of a Human Robot Interaction study to test the following hypothesis:
"The design of a robot can influence the users' behaviour, in such a way that they feel awkward to engage with it (Uncanny-valley effect)."

(a) For your study you can use these two robots:

The Geminoid robot has no on-board computing power and therefor needs to be controlled via a laptop or a computer to move and do any action

The Mykeepon is a small robot that has two behaviour modes on its on-board computer. The touch mode, will allow the robot to respond to pokes, pats and tickles with a rich variety of emotional movements and sounds. In dance mode, it hears the beat in music or clapping and dances in synchronised rhythm.

(i) What is the "Uncanny valley effect"? (5)

(ii) What is the formal definition of "embodiment"? (2)

(iii) Based on the formal definition explain the difference in "embodiment" of these two robots (see Figure). (2)

(b) Describe a **setup** for your study using the following equipment. (5)

- The two robots given above
- Two video cameras
- A laptop to control the Geminoid robot
- Lab space with table and chairs
- Software to create an interaction between the robots and the participants.

(c) Design the process of a human-robot interaction study considering the hypothesis given above:

(i) What evaluation metrics would you use and why? (2)

(ii) From what populations would you invite participants, and how many would you invite? (2)

(iii) How would you structure the procedure during each session? (2)

Q4

(a) What is Evolutionary Robotics? (5)

(i) What is a genotype and how does it relate to a chromosome? (3)

(ii) What is the fitness of an organism, how does this relate to survival of the fittest? (3)

(iii) Explain mutation and crossover points. (3)

(b) What is evolutionary game theory? How can it be used to explain ritualised animal behaviour? (6)

END OF PAPER