HERIOT WATT UNIVERSITY

SCHOOL OF MATHEMATICAL AND COMPUTER SCIENCES

Computer Science

F21RO2

INTELLIGENT ROBOTICS

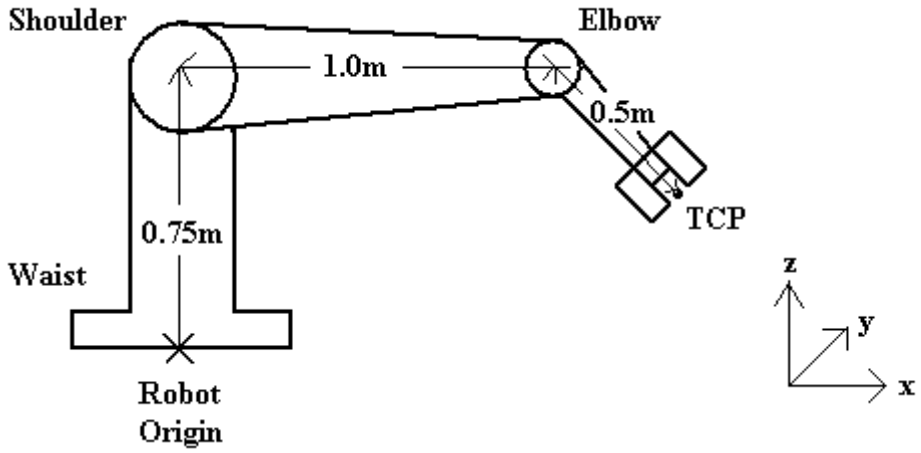
Semester 2 2015/16

Duration: Two Hours

ANSWER THREE QUESTIONS

Answer each question in a separate script book

Q1 Consider the following manipulator geometry with three rotational joints (waist, shoulder, elbow) -



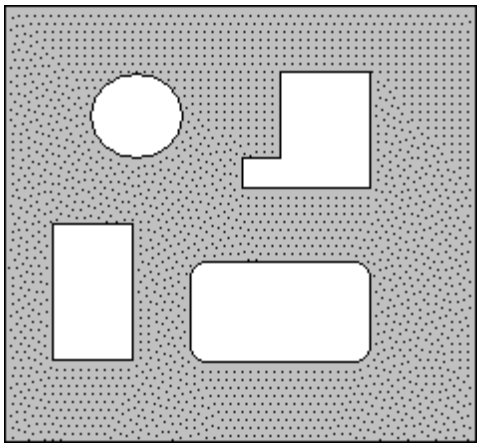
(a) Derive the inverse kinematic equations for the three joint angles for this manipulator. (13)
[Hint: Geometric intuition can be used here]

(b) Solve the inverse kinematic equations for a TCP position, in the robot reference frame, of - (7)

x = 1.0m
y = 0.0m
z = 0.75m

[If you do not have a calculator then you can stop short of calculating the final angles]

Q2 Consider the following floor plan in which the shaded regions are clear space and the white areas represent objects –



(a) It is desired to construct a Voronoi Diagram from a spatial graph of the plan with the aim of identifying, approximately, where sensing points should be located in order to ensure that clear space corridors exist between all of the objects.

i). Draw the spatial graph with the sensing points clearly identified. (5)

ii). Draw the Voronoi Diagram with the clear space regions clearly identified. (5)

[Hint: Expand the floor area to fill a complete page – an approximation to the original will suffice]

(b) i). Construct a Generalised Voronoi Diagram from the plan. (4)

ii). Indicate where the clear space corridors will be found on the diagram. (3)

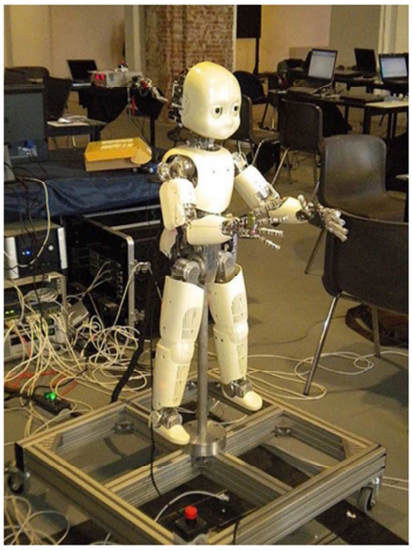
iii). Explain how clearances between an Autonomous Guided Vehicle and the objects can be determined. (3)

Q3

Consider the design of a Human Robot Interaction study to test the following hypothesis:
"The embodiment of a robot changes the complexity of the tutoring behavior of a human towards a robot."

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

My Keepon is small robot that has two modes. In its touch mode, it responds to pokes, pats, and tickles with a rich variety of emotional movements and sounds. In its dance mode, it hears the beat in music or clapping and dances in synchronised rhythm.



iCub is a 1 metre high humanoid robot testbed for research into human cognition and artificial intelligence.
The dimensions of the iCub are similar to that of a 2.5 year old child. The robot is controlled by an on-board PC104 controller which communicates with actuators and sensors using CANBus.
In its final version, the robot has 53 actuated degrees of freedom organized as follows:

- 7 in each arm
- 9 in each hand (3 for the thumb, 2 for the index, 2 for the middle finger, 1 for the coupled ring and little finger, 1 for the adduction/abduction)
- 6 in the head (3 for the neck and 3 for the cameras)
- 3 in the torso/waist
- 6 in each leg

The head has stereo cameras in a swivel mounting where eyes would be located on a human and microphones on the side. It also has lines of red LEDs representing mouth and eyebrows mounted behind the face panel for making facial expressions.

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

(ii)Based on the formal definition explain the difference in "embodiment" of these two robots (see Figure). (3)

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

- The two robot given above
- Two video cameras
- A Laptop to control the iCub robot
- Lab space with table and chairs
- Building blox to teach the robot's how to build a tower

(6)

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

(i) What evaluation metrics would you use and why? (3)

(ii) What participants population would you invite and how many would you invite? (3)

(iii) How would you structure the procedure during each session? (3)

Q4 A robot is in the centre of a room that contains four chests and a lot of garbage.

A red chest is at position corner-1, a blue chest at position corner-2, a green chest at position corner-3, and a black chest at position corner-4.

A charging station plug is hanging from the centre of the ceiling. There chests are large enough so that if the robot makes a tower out of three chests in the centre of the room, and climbs up it, the charge plug will be in reach.

The red chest can be pushed from one place to another but is too heavy for the robot to carry, the blue and green chests can be pushed but can also be lifted so as to stack them on another chest. The black chest can not be moved.

The robot task is to collect all the garbage in the room and put it inside the black chest without running out of battery. The robot battery must be charged when it gets below a certain minimum threshold, otherwise the robot "dies".

The robot battery autonomy is not so good and thus requires the robot to recharge quite often.

(a) Using a Behaviour-Based-Robotics approach, create a subsumption architecture diagram and explain each behaviour and how they interfere on each other. (6)

NOTE: Please assume your robot can have any sensors and actuators.

(b) Describe a cognitive strategy for finding and reaching the charging station plug and discuss what extra abilities your robot will need to carry it out. (6)

(c) Give one advantage and one disadvantage for each of your two strategies. (2)

(d) Assume the charging station plug now has a bright light on top of it visible from anywhere in the room. Does this change either of your two strategies and if so, how? (2)

(e) You are now asked to optimise the garbage collection time so you have decided to build another six robots who all have to collect the garbage without running out of battery. Would you use the same strategy for each robot? Would you add any more sensors/actuators to your robots? Briefly explain the rationale behind your your decisions. (4)

END OF PAPER