UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2002

BEng Honours Degree in Computing Part III
BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
BSc Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part III
MSc in Advanced Computing
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute
This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER C333=I3.25

ROBOTICS

Tuesday 23 April 2002, 10:00
Duration: 120 minutes

Answer THREE questions

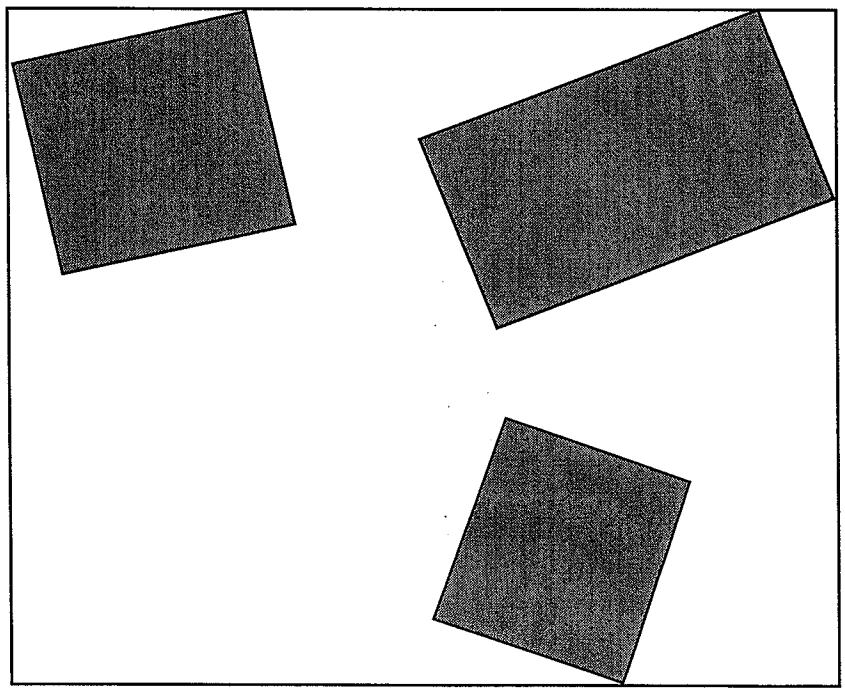
Paper contains 4 questions
Calculators not required

1a There are a number of ways of calculating a path for a robot given a predefined map of its surroundings.

i) Describe both the 'visibility graph' and 'freeway' approach to path planning.

ii) What are the advantages and disadvantages of these two methods?

b i) Construct 4 freeways associated with the following diagram that would allow a robot to navigate between the obstacles.



ii) Use the freeways you have constructed in part b i) to illustrate the operation of the sweep line algorithm which can be used to find the intersection of the freeways. Your answer should show the various states of the active line segments and the event list.

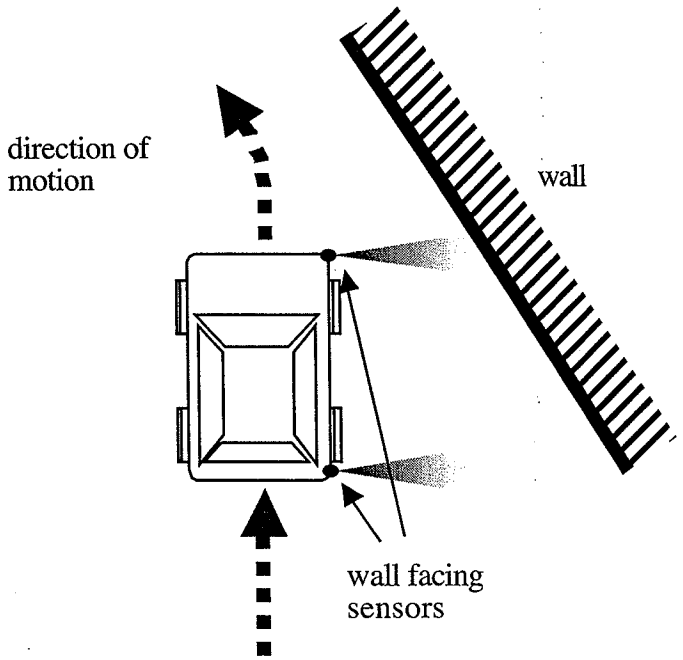
The two parts of this question carry equal marks.

2a i) A variety of locomotion systems can be used for mobile robots. Legs, Tracks and Wheels are the most common. For each of these systems, outline the advantages and disadvantages, in terms of hardware and software control, associated with using that particular locomotion system on a small, autonomous robot.

ii) Wheels are the most common form of locomotion for robots and there are a variety of wheel arrangements. Differential, Synchro and Ackerman arrangements are the most common. Describe these three wheel arrangements and illustrate the associated control problems (both hardware and software) when they are used to drive a robot that has a sense of orientation as well as position.

b i) You are required to build a small mobile robot with limited processing power and memory. You have available sensors of the following kinds: ultrasonic, infrared and vision (i.e. video). Which of these sensors would you use, and why?

ii) Your robot will be required to follow a wall at a given distance. It will do this by sensing the distance to the wall, and correcting its course accordingly (see the diagram below). Why might you choose to use two wall facing proximity sensors, instead of just one? How would your robot determine if it is heading towards a wall, away from it, or running parallel to it?



The two parts of this question carry equal marks.

Turn over....

3a i) What is a Teleo-Reactive (T-R) program?

ii) What does it mean to say that a T-R program is complete?

ii) Indicate, with a diagram, how a T-R rule sequence might be implemented electronically. Compare this implementation with the Brooks subsumption architecture for building robot control systems. Point out the differences.

b Suppose you are asked to program a remote control vacuuming robot. The robot is to have a fairly simple design. It will respond to a signal from a remote control device. This will start and stop the robot. When started it moves forward, avoiding obstacles, until its gets the remote control signal again, when it stops. It has sensors that enable it to detect obstacles within 50cms on its left and on its right and to estimate their distance away. If it detects an obstacle on its left, it will swivel to the right. Similarly, if it detects an obstacle on its right, it will swivel to the left. In both cases it will continue with its forward motion unless the detected obstacle is within 20cms. In this case the forward motion terminates and it just swivels left or right. It resumes its forward motion when it no longer detects an obstacle within 20cms either on its left or right. An obstacle immediately in front will be detected as an obstacle both on its left and on its right. The robot prioritizes avoiding obstacles detected on its left, that is it swivels right in preference to swivelling left.

Give a T-R program for realizing this behaviour assuming an appropriate set of persistent tests and actions. In a T-R rule you are allowed to execute more than one persistent action and to change some internal state of the robot recorded as the value of a state variable. State clearly what your tests and actions do.

The two parts of this question carry, respectively, 40%, 60% of the marks

4a Briefly describe the vector fields approach to controlling behaviour of a mobile robot. What are its drawbacks?

b In four separate diagrams indicate the vector forces that can be viewed as acting on some robot at any position within the rectangular walled space below, emanating from:

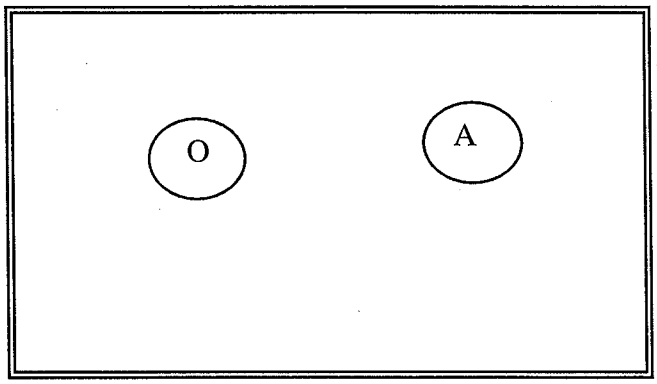
i) Object O, which is to be avoided,

ii) Object A, which is to be approached.

iii) Any two adjacent walls, which are to be avoided

iv) O and A combined

In the case of iv) indicate a position in which the combined vector force acting on the robot may be zero.



c When the vector forces that are considered to be acting on a robot at any time are computed the robot can use its sensors to compute the strength and direction of each force. Give formulas that the robot might use to compute the force acting upon it:

i) by a wall that it determines is parallel to its current direction of motion a distance D away, where the repulsive effect can be ignored when D is greater than some distance F.

ii) by an obstacle that is to be avoided which it detects lies in a direction A degrees to the left of its current direction of motion a distance D away, where the repulsive force can be ignored if D is greater than some distance F.

The three parts carry, respectively, 30%, 40%, 30% of the marks

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