UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2001

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
MEng Honours Degrees in Computing Part IV
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

PAPER C333=I3.25

ROBOTICS

Friday 4 May 2001, 14:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

1 There are a variety of wheel arrangements that are suitable for autonomous mobile robots. In particular Differential, Synchro and Ackerman (car) arrangements are of particular interest.

a i Briefly describe (with the aid of a diagram) each of these three types of wheel arrangements and in particular how steering is achieved.

ii For each of these three arrangements of wheels describe some advantages and disadvantages they would have within the context of a small robot, based on a 10cm circular chassis, that is exploring an office environment.

b i What is the Instantaneous Centre of Curvature (ICC)?

ii For each of the three wheel arrangements described above, explain how the ICC could be calculated. You do *NOT* need to give any formula or do any calculations at this stage.

c Derive a formula that defines the ICC of a differential drive robot based on the speeds of each wheel. The motors are mounted on an axle of length l, you may assume each wheel is ideal and the radius is r.

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

2 a It is well known that sensors can give Incomplete, Inaccurate and Ambiguous results. Explain what is meant by these 3 terms using the following types of sensors as examples; Infra red range detecting sensors (such as the Sharp GP202); Ultra sonic range finders such as that produce by Polaroid; Any vision based system capable of producing low resolution black and white images from a single fixed camera.

b How does sensor fusion attempt to overcome the problems described in part a?

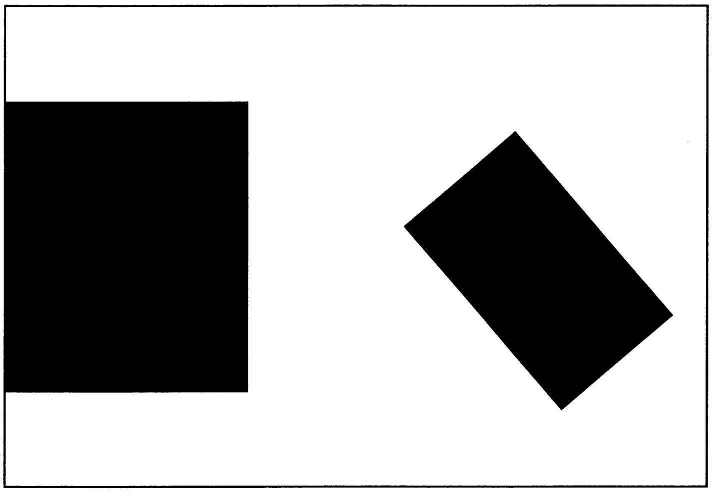
c i What constraints, both environmental and computational limit the accuracy of Global Positioning Systems (GPS)?

ii How does a Differential GPS system attempt to overcome the environmental problems described in part i)?

iii Differential GPS still does not overcome the computational problems that occur in systems based on timing of electromagnetic radiation. How could you adapt the concept of the GPS system such that the computational requirements are relaxed? You may assume that the new system is to work over a small area (say 10x10 meters) but the accuracy must be in terms of mm.

The three parts carry, respectively, 40%, 20%, 40% of the marks.

3 a Construct the freeways associated with the following diagram



b i) Give a functional description of a tropistic agent and a hysteretic agent.

ii) When the memory set of an hysteretic agent is finite, what is an alternative way to define its interaction with its environment.

c Sometimes it is convenient to factor the control program of a robotic agent into different and independent behaviours, each of which determines an action response to the current percepts that is appropriate for that behaviour.

i) Give examples of this sort of factoring.

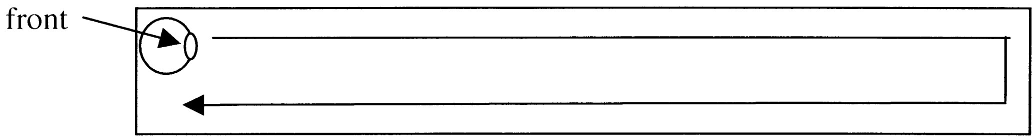
ii) When one or more of these component behaviours determine a different action response a problem arises as to how to select from, or to combine these alternatives. Describe two ways in which this might be done.

d Describe the potential fields or action vectors technique for defining a movement action response for a mobile robot. Give the definition of a suitable action function generating a response vector for the behaviour of keeping to the middle of a corridor or path.

The four parts carry, respectively, 40%, 20%, 20%, 20% of the marks.

4a i) Briefly describe the Russel and Norvig P.A.G.E. Analysis of an agent or robot.

ii) Suppose you had to design a robot cleaner to automatically polish a corridor floor as depicted in the figure. The corridor is straight and it takes two journeys along the corridor to cover it. The robot must stop as soon as it detects an obstacle in front of it and continue when it no longer detects the obstacle. After completing the polishing it returns to its original position pointing down the corridor and stops. Suggest percepts and actions that would be suitable for use by the robot control program. You can assume it can tell the difference between an obstacle and a wall in front of it. You do not have to give details of the control program. Such a control program is to be given in answer to part b iii) of this question.



b i) What is a Teleo-Reactive (T-R) program. Give an informal operational semantics.

ii) What is the regression property of a T-R program? What is the completeness property? In what sense is a T-R program that is complete *and* satisfies the regression property a universal program for achieving some state of the world as perceived by a robotic agent executing the program. How is this goal state represented in the program?

iii) Using the percepts and actions you gave in answer to a ii) of this question, give a T-R program for the polishing robot. [Hint: You could use state variables that are changed by various rules of the program, and tested by other rules, to indicate what stage the task has reached. You might find it useful to distinguish four stages – going up the corridor, turning at the end, coming back down the corridor and, finally, returning to its start location.]

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