UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2003

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
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

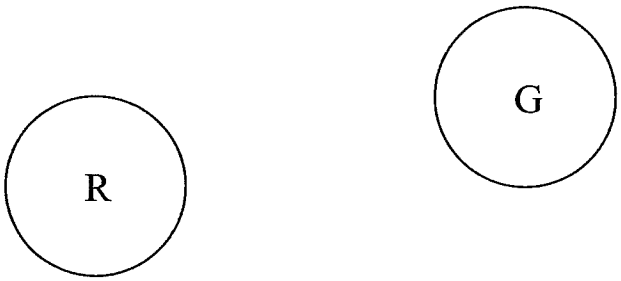
Friday 2 May 2003, 10:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

1a Briefly describe the vector fields approach to controlling the behaviour of a mobile robot. What are its advantages and drawbacks? How is a 'stop forward motion' behaviour handled?

b In the environment depicted below objects R and G are each one meter in diameter and at their closest their perimeters are two meters apart. Object R is red, object G is green and a robot uses their colour to distinguish them.



In three separate diagrams indicate by drawing arrows, the vector forces that can be viewed as acting on some robot in the environment emanating from:

i Object R, which is to be avoided if the robot is within one meter of its perimeter

ii Object A, which is to be approached if the robot is more than one meter from its perimeter, circled clockwise at a constant distance if the robot is between 1 and 0.5 meters of its perimeter, and avoided if it is within 0.5 meters of its perimeter.

iii Objects R and G combined

In the case of iii) 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 of a force and its direction *relative* to the current forward direction of the robot.

Define the functions the vector force acting on the robot from:

i Object R

ii Object G

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

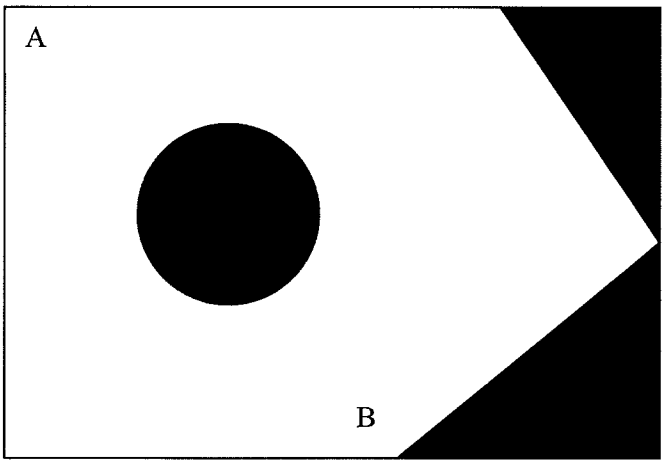
2 The motion of a dimensioned object is harder to plan than the motion of a point. However, reducing a mobile robot to a single point looses vital information about the robot's orientation and shape.

a i In the context of motion planning give one example where such loss of information is critical

ii If we persist with the point planning approach, what must be done to our map of the environment before we can continue?

b Using you answer to part a ii) adjust the following model of the world to take into account the mobile robot shown below which has a fixed orientation. The robot has a square cross section with sides parallel to the edges of the world and cannot rotate. A circle shows the point of interest of the robot.

And here is the existing world map



c Construct a partial visibility graph on your new map that clearly shows two possible routes for the robot from the point marked A to the point marked B.

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

3 A Proportional/Integral (PI) straight line controller can be used to ensure that a two wheeled robot runs in a straight line. More precisely it ensures that the measured rotation of the wheels is the same (it cannot take into account slippage and bumps etc). In a more realistic world, straight line control is not actually very useful, more useful is the ability to follow a wall at some distance.

a Outline, using an annotated diagram, the logical structure of a PI straight line controller

b i Explain carefully why it is essential to sample the shaft encoders, proportional control loops and integral control loops at three *different* rates?

ii Give some approximate values for the three rates described in bi) for a system where a motor has a rotational speed of 6,000rpm with 32 clicks per revolution and a micro processor executing 20Mips.

c i Explain the properties of Monotinicity and Stability and indicate why they are important for a sensor used to implement wall following?

ii Describe two other significant properties of the Sharp GPD202 sensor and explain whether they are good or bad within the wall following context.

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

4a i What is meant by the Instantaneous Centre of Curvature (ICC) for a mobile robot

ii Using a carefully drawn and annotated diagram show where the Instantaneous Centre of Curvature (ICC) of a robot that uses Ackerman steering is located.

iii Use the diagram in part a ii and a second diagram showing the location of the ICC for a tricycle arrangement to explain why the mechanics of steering control of such an Ackerman steered robot is more complex than that required for the tricycle arrangement.

b i What factors need to be known to derive a formula that can be used to compute the ICC of a differential drive system.

ii Derive the formula that computes the appropriate ratio of motor speeds for a differential drive arrangement that achieves a given ICC.

c i Describe how a robot can use dead reckoning to maintain an absolute position

ii In the context of a wheeled mobile robot, what factors can affect the accuracy of dead reckoning?

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