HERIOT-WATT UNIVERSITY

SCHOOL OF MATHEMATICAL
AND COMPUTER SCIENCES

COMPUTER
SCIENCE

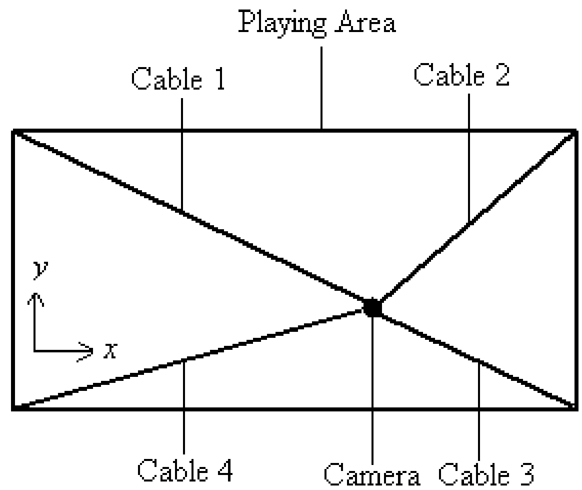
ROBOTICS & AUTOMATION

2 Hours

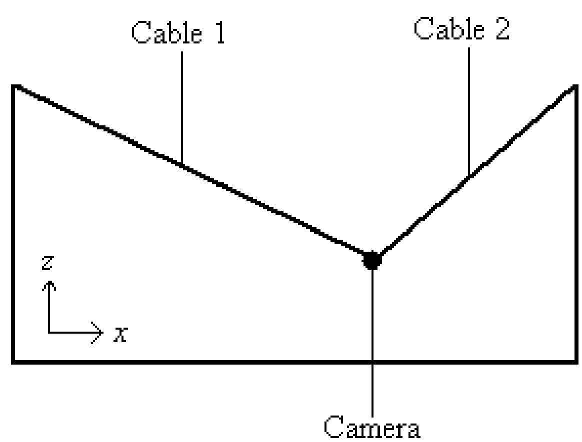
Answer THREE questions

Candidates may only use a University approved Calculator

Q1 Consider the following diagrams depicting the plan and side elevations of an overhead camera system mounted above a rectangular sports playing area, such as a football or rugby pitch -



PLAN VIEW



SIDE VIEW

The camera is moved around above the players' heads by means of four actuators each of which "reels in" or "plays out" one of the cables. By this means the camera can be located at any (x,y,z) position above the pitch. Let the dimensions of the pitch be X and Y and the height of the actuators (maximum elevation of the camera) be Z.

(a) Derive the inverse kinematic equations for the four actuators which will enable the operator to drive the camera to any (x,y,z) position. I.e. derive equations for the cable lengths necessary to achieve a given (x,y,z) position for the camera.

(10)

(b) Suppose that the video image captured by the camera is fed into a ball-tracking system which is able to continuously derive the (x,y) position of the ball automatically. Suppose also that the instantaneous velocity of the ball can be continuously determined by the tracking system.

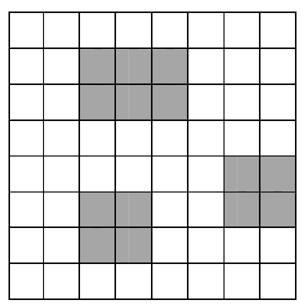
Given the x and y components of the instantaneous velocity of the ball, derive the inverse kinetic equations which will enable the four actuators to operate at the correct speed for the camera to follow the ball whilst maintaining a constant height, H, above the playing surface.

(10)

Q2 (a) Explain how quadtrees can be used to represent composite maps for Automated Guided Vehicles

(5)

(b) Constuct the quadtree for the following 2-D floor plan, where the shaded areas are objects and everything else is free space.



(10)

(c) What is the main drawback of the quadtree representation? Illustrate your answer with reference to the quadtree created in part (b).

(5)

Q3 (a) Explain the difference between reactive behaviour and cognitive behaviour.

(6)

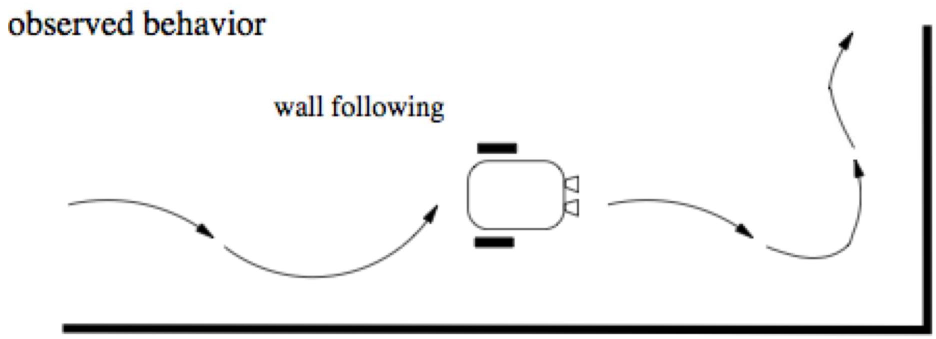
(b) Is there some way of measuring self-organisation when it appears in a swarm model? Give an example.

(7)

(c) Define emergent behaviour. Is there some way of determining when an emergent property appears in a swarm model?

(7)

Q4 Given the observed behaviour below.



(a) Describe the mechanism used to generate this “wall following” behaviour. (4)

(b) Could the same mechanism generate a different behaviour? Explain why? (4)

(c) Create a genetic encoding for a controller to evolve this “wall following” behaviour in a two-whelled robot with only 3 distance sensors, one at the front and one at each side. You will use a Genetic Algorithm to evolve the population of controllers. Define also the fitness function. (12)

END OF PAPER