415.703FT

THE UNIVERSITY OF AUCKLAND

EXAMINATION FOR Intelligent Active Vision ETC 1998

COMPUTER SCIENCE

BA BSc

(Time allowed: TWO hours)

NOTE: Attempt all questions.
Put the answers in the boxes below the questions.
Use of calculators is *permitted*
This is an *open* book exam

SURNAME:

FORENAME(S):

STUDENT ID:

LOGIN:

TOTAL MARKS (OUT OF 100):

Marks:

A	B	C	D	E	F	G	Total

Surname: ____________________

Forename(s): ____________________

A Camera Callibration

1. What are the three-dimensional real world coordinates of a point with the homogenous coordinates $P = [12, -6, 9, 3]^T$? [5 marks]

   X = 4 Y = -2 Z = 3

2. A sequence T of **scaling and rotation** transformations is applied to a **2 dimensional** cartesian coordinate system. Given the matrix representation, the coordinates of a point in the new coordinate system $v^* = [X^*, Y^*]^T$ can be obtained from the old coordinates $v = [X, Y]^T$ by the formula $v^* = Av$, where A is a 2x2 transformation matrix.

   How many point pairs (v^*, v) are necessary to uniquely determine the transformation matrix A? Choose a set of real world coordinates that allow you to determine the transformation matrix given that you know the image coordinates of those points. [5 marks]

   We have four unknown variables. Each point gives us two equations. Therefore, we need only two points. The easiest way to solve this problem is to take the two points $v_1 = [1, 0]^T$ and $v_2 = [0, 1]^T$.

3. Give the 2-dimensional transformation matrix A of the **translation** T_1 with displacements $(-2, 4)$, that is points are shifted right two units and down four units.

   [5 marks]

$$v^* = Av, \quad \text{with } A = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 1 & -4 \end{bmatrix}$$

Surname: ______________________________

Forename(s): ______________________________

B Network Programming

4. The following is the partial pseudo code for a video server.

```
video_interrupt(int signal_number)
{
   x = findCarXPosition()
   y = findCarYPosition()
   theta = findCarOrientation()
}

main()
{
...
   for(;;)                   /* Infinite Loop */
   {
      host = recv_msg()    /* wait for msg and find return host */
      fmt_msg_x(x,msg)     /* put the x coor. into the msg */
      fmt_msg_y(y,msg)     /* put the y coor. into the msg */
      fmt_msg_t(theta,msg) /* put theta into the msg */
      sendmsg(msg,host)    /* send the message to the host */
   }
...
}
```

This code contains a "critical section." Explain how the video server may sent an incorrect position and/or orientation for the car, although the information was detected correctly by the findCar routines in the interrupt handler. [5 marks]

Assume that the video interrupt is called after formatmsg(x,host), but before sendmsg(theta,host). In this case, the old x value will be combined with the new y and/or theta values.

5. Idenitfy for each of the following functions whether they are used with connected (C) or unconnected sockets (U). [5 marks]

function	U/C	function	U/C
send	C	recv	C
sendto	U	recvfrom	U

Surname: ______________________________

Forename(s): ______________________________

C Kinematic Modeling and Control Theory

6. The following equation is the kinematic model of a rear wheel drive vehicle as used by Samson.

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} \cos\theta \\ \sin\theta \\ \tan\phi/l \\ 0 \end{bmatrix} v_1 + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} v_2$$

The initial configuration at time $t_0 = 0$ is ($x = 10$ cm, $y = 10$ cm, $\theta = 30^o$) and the control inputs are ($v_1 = 10\frac{cm}{s}, \phi = 20^o$).

What is the new configuration x, y, θ of a vehicle with an axle distance l of 10 cm at time $t_1 = 0.2$ seconds. [7 marks]

$$\begin{aligned} \dot{x} &= \cos\theta * v_1 = \cos 30^o * v_1 = 8.66\ \frac{cm}{s} \\ \dot{y} &= \sin\theta * v_1 = 5\ \frac{\text{cm}}{\text{s}} \\ \dot{\theta} &= (\tan\phi)/l * v_1 = 0.36 \text{ Radians} = 0.36/\pi * 180 = 20.52\frac{\text{degree}}{\text{s}} \\ x &= x + \dot{x} * 0.2 = 11.73 \text{ cm} \\ y &= y + \dot{y} * 0.2 = 11.00 \text{ cm} \\ \theta &= \theta + \dot{\theta} * 0.2 = 34.10^o \end{aligned}$$

7. One problem with a kinematic model based on velocity v_1 and steering angle ϕ is that it does not take the time necessary to change the steering angle into consideration. Can modeling the velocity of steering angle change v_2 as done by Samson overcome this problem? Justify your answer. [3 marks]

No, since the equations do not include constraints on the maximum steering angle velocity change, it will not be able to overcome this problem.

8. Balluchi et al suggest a controller for Dubin's car which is based on the following control law

$$\omega = \text{sign}(\hat{R}(t))\text{sign}(\sigma)\frac{u(t)}{R_{min}}$$

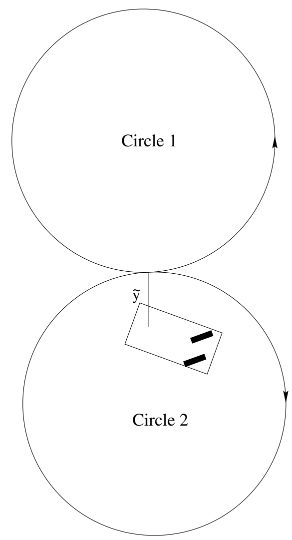
where σ is:

$$\sigma(\tilde{y}, \tilde{\theta}) = -\frac{\tilde{y}}{R_{min}} - \text{sign}(\tilde{\theta})(1 - \cos(\tilde{\theta}))$$

Assume that Balluchi's controller follows a counter clockwise path around circle 1. In the current configuration steering angle $\phi = 30^o$.

Surname: ____________________

Forename(s): ____________________



Given the same configuration, what would be the steering angle for the clockwise path along circle 2? [5 marks]

$\phi = 30^o$. The steering angle is **independent** of the curvature $\hat{R}()$.

9. Assume that the car approaches a line ($y = 100$) on a straight line with $\tilde{\theta} = 60^o$. Calculate the distance from the line $\tilde{y}$, when the controller changes the steering angle? Use $R_{min} = 450$mm. [5 marks]

The controller changes the steering angle when σ is equal to 0. Putting the values for θ into the equation yields:

$$\begin{aligned} 0 &= \frac{\tilde{y}}{R_{min}} - 0.5 \\ \tilde{y} &= 0.5 * R_{min} \\ \tilde{y} &= 225mm \end{aligned}$$

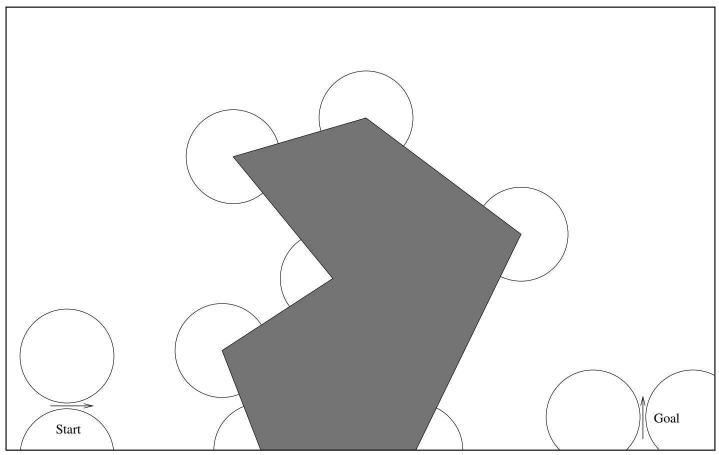
Surname: ______________________________

Forename(s): ______________________________

D Path Planning

10. Show the path that would be generated by Bicchi's EPD algorithm for the following path planning problem. Draw the path traveled and use arrows to indicate directions. Indicate segments that are driven in reverse with a **R**.

[5 marks]



11. Given an A^* search algorithm, which of the following heuristic functions $h(u, v)$ (estimate of the car travel distance from point u to v), are admissible heuristic functions. That is, it is guaranteed that the A^* algorithm finds an optimal solution. Note: Δx is the difference in x coordinates for points u and v, Δy is the difference in y coordinates respectively.

[7 marks]

function	admissible (Y/N)
h(u,v) $= 0$	Y
h(u,v) $= \sqrt{\Delta x^2 + \Delta y^2}$	Y
h(u,v) $= \Delta x + \Delta y$	N

12. Which one of the heuristic functions in question 11 is the best heuristic function for the EPD algorithm.

[3 marks]

h(u,v) $= \sqrt{\Delta x^2 + \Delta y^2}$ since it is a (more accurate) smaller underestimate than $h(u,v) = 0$, but is still admissible.

E Fuzzy Logic and Fuzzy Inference

13. Given are three variables x, y, z, which take on values in the interval from 0 to 10 and three fuzzy sets Slow, Medium, Fast as defined below.

$$\text{Slow}(x) = 1 - \frac{x}{10}$$

$$\text{Medium}(x) = \begin{cases} \frac{x}{5} \text{ if } x \leq 5 \\ 2 - \frac{x}{5} \text{ else} \end{cases}$$

$$\text{Fast}(x) = \frac{x}{10}$$

Calculate the degree of membership of all three sets for $x = 7$. [3 marks]

mSlow(7) = 0.3 mMedium(7) = 0.6 mFast(7) = 0.7

14. Given the rule set shown below, complete the table to calculate the alpha values for all rules, using Min inferencing.

Rule 1: if x is slow and y is slow then z is fast
Rule 2: if x is medium and y is slow then z is medium
Rule 3: if x is slow and y is medium then z is fast

[5 marks]

x	y	mSlow(x)	mMed(x)	mSlow(y)	mMed(y)	$\alpha 1$	$\alpha 2$	$\alpha 3$
2	6	0.8	0.4	0.4	0.8	0.4	0.4	0.8
5	7	0.5	1.0	0.3	0.6	0.3	0.3	0.5
8	8	0.2	0.4	0.2	0.4	0.2	0.2	0.2
4	4	0.6	0.8	0.6	0.8	0.6	0.6	0.6

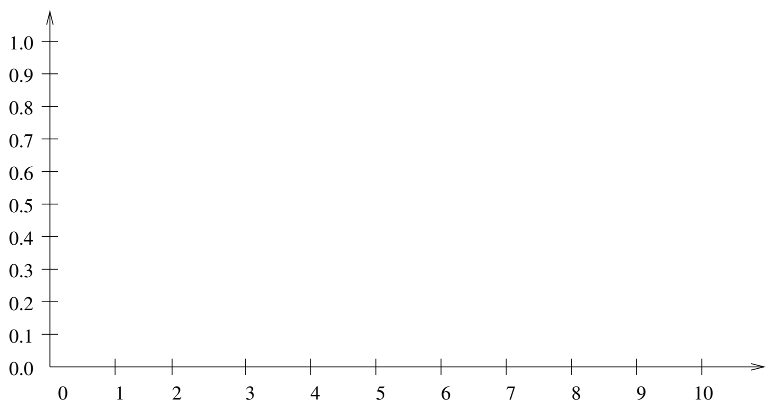
15. Show the fuzzy subset that is assigned to z for each of the three rules for $x = 2, y = 6$. [4 marks]

$$\text{Rule 1:} z = \begin{cases} x/10 \text{ if} x \leq 4 \\ 0.4 \text{ else} \end{cases}$$

$$\text{Rule 2:} z = \begin{cases} x/5 \text{ if} x \leq 2 \\ 2 - x/5 \text{ if} x \geq 8 \\ 0.4 \text{ else} \end{cases}$$

$$\text{Rule 3:} z = \begin{cases} x/10 \text{ if} x \leq 8 \\ 0.8 \text{ else} \end{cases}$$

16. Using Max composition, show the fuzzy subset that is assigned to z by composing the results of **all** three rules. [3 marks]



17. Using centroid defuzzification, what is the crisp output value of z? [5 marks]

$$c = \frac{0*0.0+1*0.2+2*0.4+3*0.4+4*0.4+5*0.5+6*0.6+7*0.7+8*0.8+9*0.8+10*0.8}{0+0.2+0.4+0.4+0.4+0.5+0.6+0.7+0.8+0.8+0.8}$$

$$= \frac{36.4}{5.6} = 6.5$$

Surname: ____________________

Forename(s): ____________________

F Reinforcement Learning

18. Why do reinforcement learners use an **exploration function**? [5 marks]

An exploration function assigns a higher (optimistic) expected reward to states which have not been visited or which have been visited a small percentage of the time. This avoids the problem of the system converging on the first found solution without exploring the remainder of the search space. This problem is also called the exploration–exploitation problem.

G Intelligent System Architecture

19. Name three "sources of uncertainty" for mobile agents in the real world. [5 marks]

- Incomplete world/domain knowledge. Approximate information about the world
- Inaccuracy in the sensors. Noise in the sensors.
- Inaccuracy/Unreliability in the control

20. Name three behaviors that are useful in a soccer playing robot [5 marks]

stop within bounds, turn around, kick a ball in front of you,

21. What is the difference between **purposeful** and **reactive** behaviors as used by Saffiotti. [5 marks]

Reactive behaviors depend only on the current state. Purposeful behaviors are goal oriented and depend on the current state as well as the current set of goals.