北京郵電大學

Queen Mary University of London

For examiners' use only

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EBU4203 A

Joint Programme Examinations 2022/23

EBU4203 Introduction to AI

Paper A

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number										
BUPT student number										
Class number										

NOT allowed: electronic calculators and electronic dictionaries.

INSTRUCTIONS

1. **You must NOT take answer books, used or unused, from the examination room.**
2. Write only with a black or blue pen **and in English**.
3. Do all rough work in the answer book – **do not tear out any pages**.
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. **Read the instructions on the inside cover.**

Examiners

Dr John Woodward, Dr Ethan Lau

Filename: 2223_EBU4203_A No answer book required

Instructions

Before the start of the examination

1) Place your BUPT and QM student cards on the corner of your desk so that your picture is visible.

2) Put all bags, coats and other belongings at the back/front of the room. All small items in your pockets, including wallets, mobile phones and other electronic devices must be **placed in your bag in advance**. **Possession of mobile phones, electronic devices and unauthorised materials is an offence.**

3) Please ensure your mobile phone is switched off and that no alarm will sound during the exam. **A mobile phone causing a disruption is also an assessment offence.**

4) Do not turn over your question paper or begin writing until told to do.

During the examination

1) You must not communicate with or copy from another student.

2) If you require any assistance or wish to leave the examination room for any reason, please raise your hand to attract the attention of the invigilator.

3) If you finish the examination early you may leave, but not in the first 30 minutes or the last 10 minutes.

4) For 2 hour examinations you may **not** leave temporarily.

5) For examinations longer than 2 hours you **may** leave temporarily but not in the first 2 hours or the last 30 minutes.

At the end of the examination

1) You must stop writing immediately – **if you continue writing after being told to stop, that is an assessment offence.**

2) Remain in your seat until you are told you may leave.

Question 1

a) This question is about the Turing test. The Turing test is a basic test of (artificial) intelligence.

(total 9 marks)

i) Briefly describe how the Turing test should be conducted (i.e. what are the rules and goals of the test, if any).

[4 marks]

ii) Criticize the Turing test and explain why it is not a good test of general intelligence.

[3 marks]

iii) What is the Total Turing test or Physical Turing test? What problems does it overcome compared to the basic Turing test?

[2 marks]

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		9 marks

b) This question concerns the PEAS description of a task environment.

(Total 8 marks)

The PEAS acronym means;

performance,
environment,
actuators, and
sensors.

i) Give one or two sentences describing what each of these terms means in general.

[4 marks]

ii) In the case of a football-playing robot give one or two sentences describing each of these four terms in this specific case.

[4 marks]

	Do not write in this column

		8 marks

c) This question is about properties of task environments.

(total 8 marks)

A task environment can be classified as having each of the following characteristics;

1. fully observable vs partially observable
2. single agent vs multi-agent
3. competitive vs co-operative
4. deterministic vs non deterministic
5. episodic vs sequential
6. static vs dynamic
7. discrete vs continuous
8. known vs unknown

Give an example of each for a robot vacuum cleaner and justify your answer with a sentence or two.

[8 marks]

	Do not write in this column

		8 marks

Question marking $= \frac{}{9} + \frac{}{8} + \frac{}{8} = \frac{}{25}$

Question 2

a) This question is about different types of agents. Draw a diagram showing the relationship between the agent and the environment, and include the sensors and actuators. Show any internal structure of the agent.

(Total 8 marks)

For each of the following 2 types of agent, answer the following 4 questions.

Two types of agent:

simple reflex agents
goal-based agents

Please answer all 4 questions for both agents.

i) Describe how the agent processes input from its senses to produce an output for actuators (e.g. emphasize the relationship to being reflex- or goal- based).
ii) What are the advantages of this type of agent?
iii) What are the disadvantages of this type of agent?
iv) How can learning be incorporated into the agent?

[8 marks]

	Do not write in this column
	8 marks

b) This question is about search in artificial intelligence (AI). Many problems exist in the real world and we need to think about how to represent them on a computer so AI algorithms can solve them. This question concerns formally stating a problem as a search problem.

(total 9 marks)

The 8 puzzle has 8 tiles labelled 1-8 in a 3 by 3 grid, and one blank square. Each tile can slide vertically and horizontally as shown in figure 1 below. This is a children's puzzle which is often made out of plastic or wood.

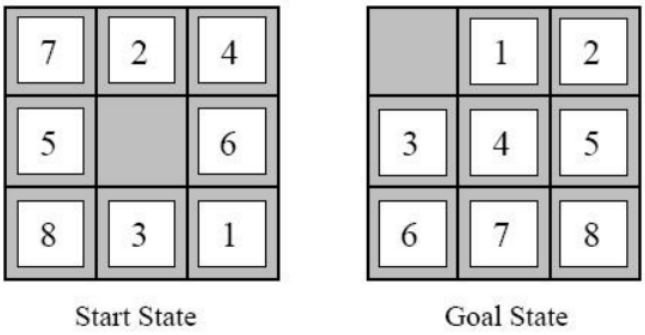

Figure 1. The start state and goal state of an 8-puzzle

Describe each of the following;

i) How can the state be represented on a digital computer (give an example. Hint; think about data structures and how would represent data with a programming language you know).

[1 marks]

ii) What is being abstracted (i.e. represented in the state), and give an example of what is not being abstracted (i.e. not represented in the state).

[1 marks]

iii) How many states are there in total? It may be difficult to estimate the exact number of states, so state if it is an underestimate or overestimate. Explain how you calculated the number.

[1 marks]

iv) Write down the initial or starting state in your representation given the figure above.

[1 marks]

v) Write down the goal or goal States in your representation.

[1 marks]

vi) The actions that the agent (or human player) is able to perform.

[1 marks]

vii) Draw a diagram of least two states and the action(s) that are needed to move between them.

[2 marks]

viii) Give an example of a heuristic scoring function. Give an example of how this value is calculated, and give the value of this heuristic scoring function for the goal state.

[1 marks]

	Do not write in this column
	9 marks

c) This question is about nature inspired algorithms, which are often used as motivation for computational search algorithms.

(total 8 marks)

i) Briefly describe the natural process of simulated annealing when cooling metals.

ii) Explain why it could be used as a motivation for a computational search algorithm.

iii) Give a brief description of the simulated annealing algorithm.

iv) What issues are there when choosing the parameters of a simulated annealing algorithm.

[8 marks]

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		8marks

Question marking $= \frac{}{8} + \frac{}{9} + \frac{}{8} = \frac{}{25}$

Question 3

a) ***Uncertainty*** arises in partially observable or stochastic environments in any area of applications.

(Total 11 marks)

i) Propose the THREE methods for handling uncertainty with ONE example for each method.
[6 marks]

ii) Given the following information, what is the probability that a junk email is received if the Junk-mail Filter identifies a potential junk email and blocks the legitimate email from reaching your inbox?

1% of received emails are *junk*.
90% of filtered junk emails are *true positive*.
7% of filtered junk emails are *false positive*.

[5 marks]

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	11 marks

b) Figure 2, below, presents the state transition diagram of a mini puzzle maze with the states *A*-*D*.

(total 4 marks)

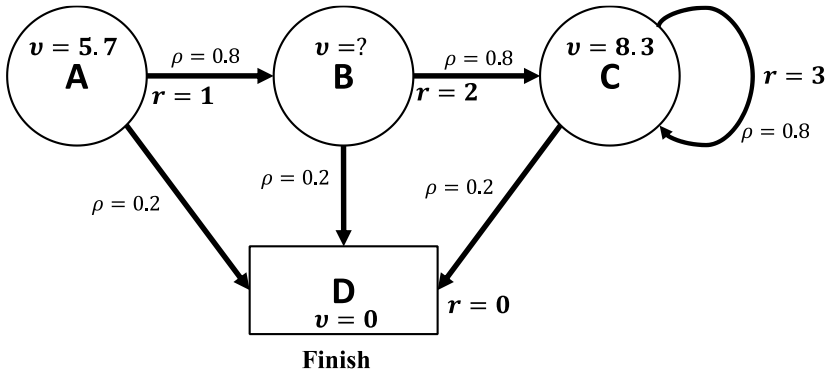

Figure 2.

i) Complete the Markov Chain transition matrix for the given problem.

[2 marks]

ii) Calculate the value $\boldsymbol{v}$ of the state *B* with the discount factor $\boldsymbol{\gamma}$ = 0.8 based on the value of rewards $\boldsymbol{r}$.

[2 marks]

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	4 marks

c) Consider the following Markov Decision Process (MDP) in Figure 2. The discount factor $\boldsymbol{\gamma}$ is 0.5. States are represented as *A, B, C* and *D*. Lower case letter *ab*, *ba*, *bc*, *ca* and *cb* represents action/transition values. **(total 10 marks)**

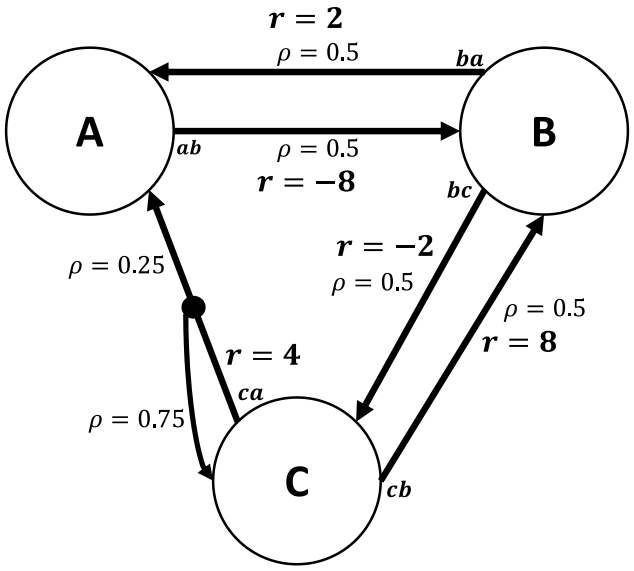

Figure 2.

i) Explain the objective of a rational agent in the MDP and the way to act on the objective. **[2 marks]**

ii) From Figure 2, apply ONE synchronous iteration of iterative policy evaluation (i.e. one backup for each state $\boldsymbol{v}(A), \boldsymbol{v}(B), \boldsymbol{v}(C)$) to compute a new value function $\boldsymbol{v_2}(s)$. Assume the uniform random policy $\pi_1(s, a)$. with equal probabilities (50:50). Start with an initial value function of $\boldsymbol{v_1}(A) = \boldsymbol{v_1}(B) = \boldsymbol{v_1}(C) = 2$. **[3 marks]**

iii) Apply only ONE iteration of policy improvement to compute a new policy $q_{\pi_2}(s)$.

[3 marks]

iv) Maintaining the order, write out the action values with the optimal policy from iii).

[2 marks]

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	10 marks

$$= \frac{}{11} + \frac{}{4} + \frac{}{10} = \frac{}{25}$$

Question 4

a) In your own words, describe the concept of ***Ambiguity*** of communication with natural language. Provide TWO examples of different kinds of ambiguity (in English) and explain the examples accordingly.

(total 4 marks)

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	4 marks

b) The Figure 3 below shows the two different Artificial Neural Network (ANN) Diagram with multilayer perceptions. Assume that all layers use linear activation functions.

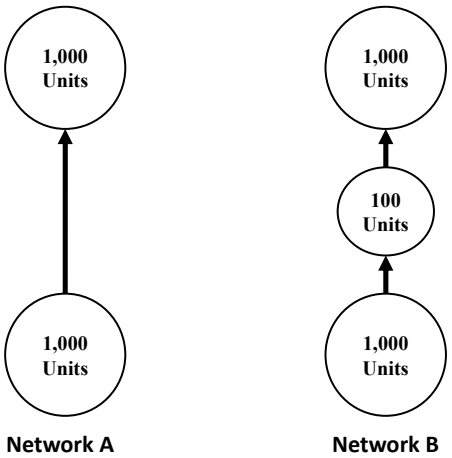

Figure 3.

(total 8 marks)

i) What are the THREE advantages of Network B over A?

[3 marks]

ii) Alternatively, what is the main advantage of Network A over B?

[1 mark]

iii) Represent the Boolean function in Table 1. as a single unit from an ANN. Include the threshold in the network diagram.

X	F(X)
1	0
0	1

Table 1.

[4 marks]

	Do not write in this column
	8 marks

c) The entropy is the measure of disorder/impurity that forms the basis of how decision trees are being constructed. Table 2 presents a dataset of students passing a module (Yes or No) based on their previous GPA (Excellent, Moderate, and Poor) and whether they revised (Yes or No).

GPA	Revised	Passed
P	N	N
P	Y	Y
M	N	N
M	Y	Y
E	N	Y
E	Y	Y

Table 2.

(13 marks)

i) Differentiate **Low** and **High** entropy of the information gain in the decision tree.

[4 marks]

ii) Compute the entropy H($passed$).

[2 marks]

iii) Next, compute both the entropy for H($passed|GPA$) and H($passed|revised$).

[4 marks]

iv) From iii), Compute the Information Gain for both the conditions.

[2 marks]

v) Based on your answers from iv), which attribute should be used as the root of a decision tree?

[1 mark]

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	13 marks

Question marking $= \frac{}{4} + \frac{}{8} + \frac{}{13} = \frac{}{25}$

APPENDIX

Conditional Probability

$$P(B|A) = \frac{P(A \cap \mathrm{B})}{P(A)}$$

Bayes rule

$$P(A|B) = \frac{P(B|A).P(A)}{P(B)}$$

$$P(A|B) = \frac{P(B|A).P(A)}{P(B|A).P(A) + P(B|A').P(A')}$$

Bellman's expectation equation for reward value function (V-function, $\boldsymbol{v(s)}$)

$$\boldsymbol{v}(s) = \mathbb{E}[R_{t+1} + \gamma v(S_{t+1})|S_t = s\,]$$
$$v(s) = R_s + \gamma \sum_{s\prime \in S} \mathcal{P}_{ss} v(s')$$

Bellman's expectation equation for state-value function (V-function, $\boldsymbol{v_\pi(s)}$)

$$v_\pi(s) = \mathbb{E}_\pi[R_{t+1} + \gamma v_\pi(S_{t+1})|S_t = s]$$

Bellman's expectation equation for action-state value function (Q-function, $\boldsymbol{q_\pi(s,a)}$)

$$q_\pi(s,s) = \mathbb{E}_\pi[R_{t+1} + \gamma q_\pi(S_{t+1}, A_{t+1})|S_t = s, A_t = a]$$

Information Gain

$$I(X,Y) = \mathrm{H(Y)} - \mathrm{H}(Y|X)$$

Entropy

$$\mathrm{H}(X) = -\sum_{i=1}^{n} P(X=i)\log_2 P(X=i)$$

Conditional Entropy

$$\mathrm{H}(Y|X) = -\sum_{x\in X}\sum_{y\in Y} p(x,y)\log_2 p(y|x)$$

$\log_2(X)$ approximation:

$\log_2(1/8)$	-3
$\log_2(1/4)$	-2
$\log_2(1/3)$	-1.58
$\log_2(3/8)$	-1.42
$\log_2(3/7)$	-1.22

$\log_2(1/2)$	-1.00
$\log_2(4/7)$	-0.81
$\log_2(5/8)$	-0.68
$\log_2(2/3)$	-0.58
$\log_2(3/4)$	-0.42
$\log_2(7/8)$	-0.19
$\log_2(1)$	0
$\log_2(2)$	1
$\log_2(3)$	1.59

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