EBU4203 Alternative Assessment (Odd Semester - Paper B)

Joint Programme Assessments 2022/23

EBU4203 Introduction to AI

Answering this paper requires **2 hours**; Answers to be submitted within the allocated **3 hours window**.

Answer ALL questions

INSTRUCTIONS

1. **You must NOT share any content from this document during the assessment period.**
2. Your answers must be typed, and diagrams or equations must be written clearly and legibly with black or blue colour **and in English**.
3. You need to submit your answers BEFORE the allocated deadline.
4. **Read the instructions on the inside cover of the questions sheet.**

Examiners

Dr John Woodward; Dr Ethan Lau

Filename: EBU4203_ALT-2022-23_S1B

Instructions

This is an open-book assessment, which should be completed **within 2 hours**. You MUST submit your answers within the allocated time in the timetable.

You MUST complete the assessment on your own, without consulting any other person. You MAY NOT check your answers with any other person.

You can refer to textbooks, notes and online materials to facilitate your working, if you provide a direct quote, or copy a diagram or chart, you must cite the source.

Before you start the assessment

1) Read the questions thoroughly and understand them.

2) Ensure you have all the resources you require to complete and upload the final assessment.

3) If you require any assistance, **raise the issue via the messaging section of this assessment on QMPlus**, immediately.

During the assessment session

1) Use the supplied answer sheet document to enter your answers. Start on a new page for each question. Make sure it is clear which question number you are answering.

2) **Type your answers** in the supplied answer sheet; hand-written equations or sketches can be incorporated into the answer sheet. Please save your work at least every 15 minutes so that you do not risk losing it.

3) When completed answering all questions, perform a word count and list the number of words on the answer sheet, then save the file as pdf before uploading, **only pdf will be accepted**, any other file format will not be accepted.

4) Your submission must be your own work, and you must ensure that you do not break any of the rules in the Academic Misconduct Policy.

Submitting the Assessment

1) You must submit your answers within the scheduled assessment time – do not leave submissions too close to the deadline. NO late submission will be accepted, no exceptions.

2) Make sure you upload and submit the final version before the deadline.

3) Please be aware that submissions will be subject to review, including but not limited to plagiarism detection software.

If you have any problems relating to access or submitting during the assessment period, please contact the email (it-issues@qmbupt.org), state the module code in the subject, and clearly state your name and student ID and any issues you are experiencing. You must use either @qmul.ac.uk or @bupt.edu.cn email address. Requests from external email addresses will not be processed.

Question 1

a) This question is about subjects which contribute to the foundation of artificial intelligence. Each of the following subjects have made contributions to the foundations to the field of:

artificial intelligence;
mathematics,
computer science,
linguistics,

Briefly describe each field and outline (with a few sentences) how each field contributes to the field of artificial intelligence.

[9 marks]

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

[8 marks]

The PEAS acronym means;

i. performance,
ii. environment,
iii. actuators, and
iv. sensors.

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

(4 marks)

ii) In the case of an online chess playing agent give one or two sentences describing each of these four terms in this specific case.

(4 marks)

c) This question is about properties of task environments.

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

i. fully observable vs partially observable
ii. single agent vs multi-agent
iii. competitive vs co-operative
iv. deterministic vs non deterministic
v. episodic vs sequential
vi. static vs dynamic
vii. discrete vs continuous
viii. known vs unknown

Give an example of each for a driverless car and justify your answer with a sentence or two.

[8 marks]

Question 2

a) This question is about different types of agents.
For each of the following 2 types of agent, answer the following 4 questions.
Two types of agent:

- model-based reflex agents
- utility-based agents

Four questions. Please answer all 4 questions for both agents.

i. Briefly describe how the agent processes input from its senses to produce an output 4 actuators.
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]

b) This question is about search in artificial intelligence. 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.

[9 marks]

The 8 queen problem is set up on a 8 x 8 chessboard. Each queen can attack any other queen on the same row, column or diagonal of the chessboard. The aim of the puzzle is to place all 8 queens on the chessboard without any of them attacking any other This puzzle which is often on a chessboard out of plastic or wood.

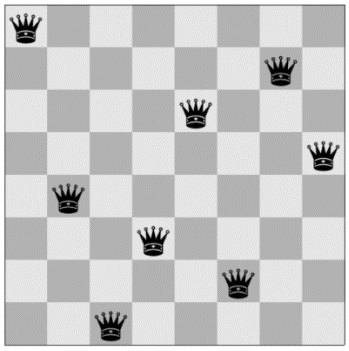

Figure 1. 8-queen problem.

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 mark)

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 mark)

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 mark)

iv. Write down the initial or starting state in your representation.
(1 mark)

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

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

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 which could be used to evaluate a state which is not a goal state. give an example of how this value is calculated, and give the value of this heuristic scoring function for the goal state.
(1 mark)

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

i. Briefly describe the process of evolution and natural selection.
(2 marks)

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

iii. Give a brief description of the genetic algorithm.
(2 marks)

iv. What issues are there when choosing the parameters of a genetic algorithm.
(2 marks)

Question 3

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

[12 marks]

i) Explain THREE ways how an application can fail due to the poor handling of uncertainty.

(6 marks)

ii) During a quality control inspection in a production line, 3% of inspections are defective. 90% of inspections are true positives and 9.6% are false positives. If a product gets a true positive during the inspection, what are the odds the products are actually defective?

(6 marks)

b) Markov Decision Process (MDP) provides a mathematical framework for modelling decision making in stochastic environments.

[7 marks]

i) Formally define the FIVE components of a Markov Decision Process (MDP).

(5 marks)

ii) Differentiate between the terms ***Deterministic*** and ***Stochastic*** policy.

(2 marks)

c) Figure 2 presents the state transition diagram of with the states *A*-*D*.

[6 marks]

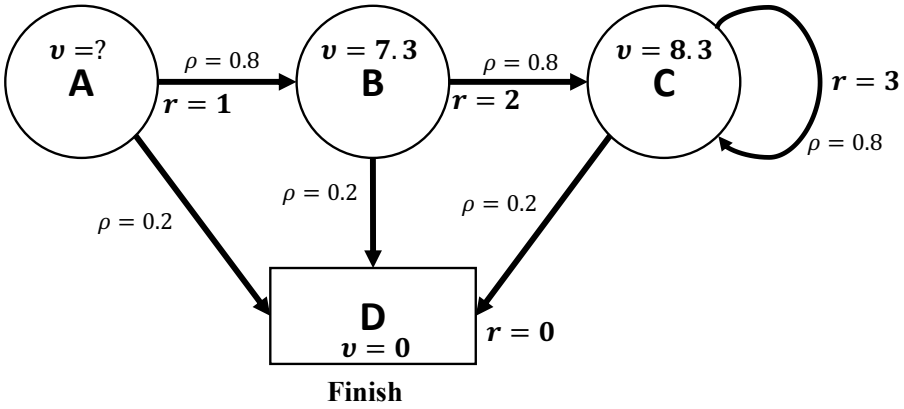

Figure 2.

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

(3 marks)

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

(3 marks)

Question 4

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

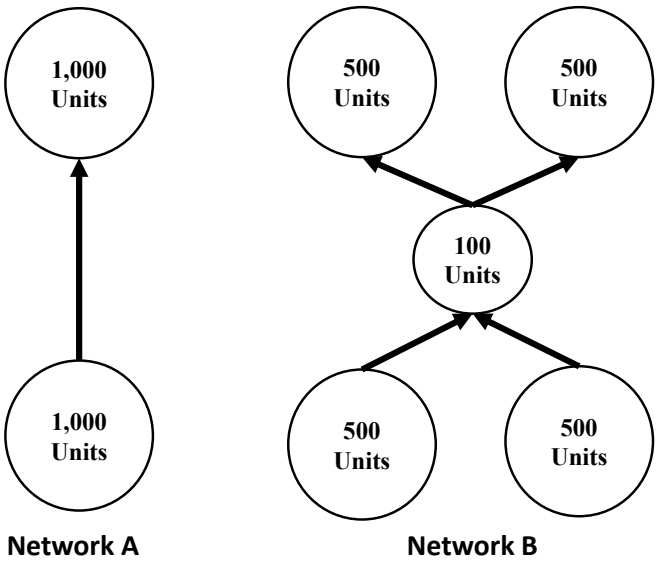

Figure 3.

[10 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) In your own words, explain the usage *Backpropagation* in the context of ANN.

(2 marks)

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

X	Y	F(X,Y)
0	0	0
0	1	0
1	0	0
1	1	1

Table 1.

(4 marks)

b) Table 2 presents a dataset of fast-growing trees (True or False) based on previous amount of fertilisations (Excellent, Moderate, and Poor) and watered regularly (True or False).

Fertilised	Watered	Fast-growing
P	F	F
P	T	T
M	F	F
M	T	T
E	F	T
E	T	T

Table 2.

[15 marks]

i) Describe the goal and the usage of entropy in the machine learning.

(2 marks)

ii) Explain what will happen when the entropy of a dataset is either *Low* or *High*.

(4 marks)

iii) Compute the entropy **H**(*Fast-growing*).

(2 marks)

iv) Compute both the entropy for **H**(*Fast-growing*|*Watered*) and **H**(*Fast-growing*|*Fertilised*).

(4 marks)

v) From iv), compute the Information Gain for both the conditions.

(2 marks)

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

(1 mark)

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, $\boldsymbol{v(s)}$)

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

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, $\boldsymbol{q_\pi(s,a)}$)

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

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

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

$\boldsymbol{\log_2(X)}$ 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

END OF PAPER