EBU4203 B

Joint Programme Examinations 2023/24

EBU4203 Introduction to Artificial Intelligence

Paper B

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number

BUPT student number

Class number

Simple electronic calculators are allowed
NOT allowed: 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 Yuanwei Liu, Dr Muhammad Salman Haleem

Instructions

<u>Before the start of the examination</u>

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.

<u>During the examination</u>

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.

<u>At the end of the examination</u>

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) State THREE ways that an experiment can fail when uncertainties are not considered appropriately. **[3 marks]**

	Do not write in this column
	3 marks

b) State and discuss THREE ethical challenges associated with the development and use of Artificial Intelligence (AI). **[6 marks]**

	Do not write in this column
	6 marks

c) In a high school classroom, 30% of students study History, 45% study Maths, and 15% study both History and Maths. **[16 marks]**

   i) If two students are randomly selected independently, what is the probability that both of them study Maths? **(3 marks)**

   ii) If a student is randomly selected, what is the probability that he/she studies History but not Maths? **(3 marks)**

   iii) If a student is randomly selected, what is the probability that he/she studies either History or maths? **(6 marks)**

   iv) If a student is randomly selected, what is the probability that he/she does not study History or Maths? **(4 marks)**

	Do not write in this column

	16 marks

Question marking: $\dfrac{}{3} + \dfrac{}{6} + \dfrac{}{16} = \dfrac{}{25}$

Question 2

a) Answer the following questions on Reinforcement Learning (RL): **[11 marks]**

    i) Discuss why a discount factor is necessary in a Markov decision process. **(3 marks)**

    ii) Explain what is a model-free RL. **(3 marks)**

    iii) The actor-critic architecture is a popular RL approach, please give the functionalities of actor and critic, and explain the main idea of this architecture. **(5 marks)**

	Do not write in this column
	11 marks

b) **Figure 1** illustrates a deterministic Markov Decision Process (MDP). The discount factor γ is 0.5. States are represented as A, B, C, and D. Arrows indicate state transition with corresponding actions. The action probability and immediate rewards are denoted by P and R, labelled next to the arrows, respectively. The MDP starts with an initial value function of $V_0(A)=V_0(B)=V_0(C)=V_0(D)=2$.

[14 marks]

Figure 1

i) Complete the Markov Chain transition matrix for the given problem.   **(4 marks)**

ii) For **one iteration**, calculate the value function $V_1(D)$.   **(4 marks)**

iii) For **one iteration**, calculate the value function V_1 of states A, B, and C.   **(6 marks)**

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	14 marks

Question marking: $\dfrac{}{11} + \dfrac{}{14} = \dfrac{}{25}$

Question 3

a) State and explain the FIVE fundamental steps involved in processing an image in Computer Vision. **[10 marks]**

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	10 marks

b) Consider an input image with dimensions of 3x3 pixels. The values of the input image are as follows:

$$[[1, 2, 1],$$
$$[0, 1, 2],$$
$$[1, 0, 2]]$$

[15 marks]

    i)   Is this a coloured image? Explain your answer.   **(5 marks)**

    ii) Using valid padding and a stride of 1, calculate the result of applying the 2x2 convolutional kernel with the following weights: **(5 marks)**

$$[[1, -1],$$
$$[0, 1]]$$

    iii) Based on your answer in part ii), perform max pooling with a 2x2 pooling window and a stride of 2. Calculate the resulting pooled feature map and show its values.

                (3 marks)

    iv) What is the purpose of adding zero-padding to an input image before convolution, and how does it affect the size of the output feature map?   **(2 marks)**

	Do not write in this column

	15 marks

Question marking: $\dfrac{}{10} + \dfrac{}{15} = \dfrac{}{25}$

Question 4

This question is about Natural Language Processing (NLP).

a) The block diagram of 'Classical' NLP Pipeline is illustrated in **Figure 1**. State the names of the missing components, which are labelled as '?' in the diagram. Then, briefly describe their functionalities.   **[6 marks]**
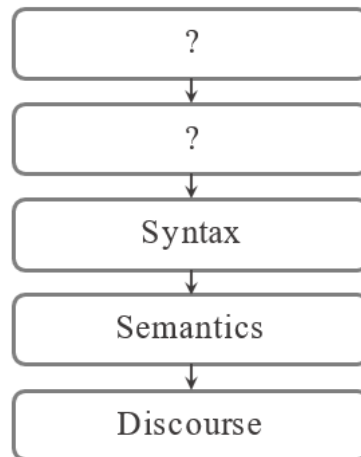

Figure 1

	Do not write in this column
	6 marks

b) Consider a simplified Hidden Markov Model (HMM)-based part-of-speech tagging system with three part-of-speech tags: Noun (N), Verb (V), and Model (M). There are three sentences in the training set, shown as follows:

1. Jane will eat apple

2. Will can meet Jane

3. Will Jane meet Will?

Table 1 shows the co-occurrence table, which can be used to analyze how different parts-of-speech interact within a text corpus. Fill in the missing values labelled by "?" in **Table 1.**

[7 marks]

	Noun	**Model**	**Verb**	**\<End\>**
\<Start\>	2	?	?	?
Noun	?	?	?	?
Model	?	?	?	0
Verb	?	?	?	?

Table 1

	Do not write in this column
	7 marks

c) Consider the following sentence: **[8 marks]**

"The burglar jumps off the compound wall"

You are required to develop the training set for generating word embedding. When the index of the centre word is $i = 2$ and the window size is $W = 2$, the source text and training samples will look like this

Source Text   Training Samples

| The | burglar | **jumps** | off | the | compound | wall |

➡   (? , ?)

i)   Define the training set when $i = 2, W = 1$ **(2 marks)**

ii)   Define the training set when $i = 1, W = 2$ **(3 marks)**

iii)   Define the training set when $i = 0, W = 6$ **(3 marks)**

	Do not write in this column
	8 marks

d) State and explain FOUR main advantages of Long Short Term Memory over traditional Recurrent
   Neural Networks architecture.

[4 marks]

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	4 marks

Question marking: $\dfrac{}{6} + \dfrac{}{7} + \dfrac{}{8} + \dfrac{}{4} = \dfrac{}{25}$

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