THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO3310 ZA**

BSc Examination

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Artificial Intelligence

Wednesday 9 May 2018: 14.30 – 16.45

Time allowed: 2 hours and 15 minutes

There are **FIVE** questions on this paper. Candidates should answer **THREE** questions. All questions carry equal marks, and full marks can be obtained for complete answers to **THREE** questions. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Only your first **THREE** answers, in the order that they appear in your answer book, will be marked.

There are 75 marks available on this paper.

A handheld calculator may be used when answering questions on this paper but it must not be pre-programmed or able to display graphics, text or algebraic equations. The make and type of machine must be stated clearly on the front cover of the answer book.

QUESTION 1 Natural Language

a) Explain what is meant by **natural languages** as opposed to **formal languages**. Describe **TWO** characteristics of natural language that pose problems for automated language processing.

[4]

b) Explain whether each of the following sets of production rules makes up a **context-sensitive**, **context-free** or **regular** grammar, and write out the shortest non-empty string generated by each.

i. $S \rightarrow S\ a$
$S \rightarrow B\ a$
$B \rightarrow B\ b$
$B \rightarrow b$

ii. $S \rightarrow A\ b$
$S \rightarrow A\ S\ b$
$A\ b \rightarrow c\ b$
$A\ c \rightarrow b\ c$

iii. $S \rightarrow a\ S\ a$
$S \rightarrow \varepsilon$

[6]

c)

i. Write a formal grammar that will generate the sentences in the example text below. You may ignore punctuation symbols and the use of upper or lower case. **[6]**

ii. Explain which constructions you need to cover in your grammar, and how your rules accomplish this. **[5]**

iii. Write out the shortest sentence generated by your grammar, and one at least 10 words long which is not in the example text. Draw a syntax tree for each available parse of both sentences. **[4]**

Text:

Alice saw the Hatter and the March Hare at a table under the tree near the house. A Dormouse sat between them. It was asleep. Alice sat in a large armchair at one end of the table. The table was large, but the Hatter and the Hare and the Dormouse sat together at one end of it.

QUESTION 2 Search and Planning

a) This question is about **uninformed** search. Explain your answers.

i. What is meant by the **frontier** in the context of AI search?
ii. In which uninformed search strategy is the frontier implemented as a FIFO queue?
iii. In which uninformed search strategy is the frontier implemented as a LIFO stack?
iv. In which uninformed search strategy is the frontier implemented as a priority queue ordered by the cost function?
v. Describe a search strategy that combines some benefits of the strategies given as your answers to (ii) and (iii).

[10]

b) Describe **TWO** types of heuristic functions in any domain you have studied during this course, and explain whether each of them is **admissible**.

[6]

c) Assume the following planning problem for making a frugal breakfast, adapted from an example in the Subject Guide:

Goal(OrangeJuice & BeansOnToast); Init(Orange & Beans & Bread)

Action(SqueezeOrange):
Precondition(Orange)
Effect(OrangeJuice)
Action(HeatBeans):
Precondition(Beans)
Effect(CookedBeans)
Action(MakeToast):
Precondition(Bread)
Effect(Toast)
Action(MakeBeansOnToast):
Precondition(CookedBeans&Toast)
Effect(BeansOnToast)

Show the sequence of states that would be visited by a breadth-first planner to solve this problem, using:

i. Progressive planning **[5]**
ii. Regressive planning. **[4]**

Explain your answers.

QUESTION 3 Theory and Philosophy of AI

a) The CO3310 Subject Guide opens with some possible definitions of AI, taken from Russell and Norvig's classic textbook, and asks which most closely matches your intuitive idea of what AI is. With the advantage of having completed this course, compare the definitions listed below and indicate which of them now best matches the view of AI you have formed as a result of your studies and any independent reading. Give reasons for your answer, and discuss any deficiencies your selected definition may still have.

Definitions:

1. '*The effort to make computers think ...* ' (Haugeland, 1985)
2. *'The study of mental faculties through the use of computer models.*' (Charniak and McDermott, 1985)
3. ' *... creating machines that perform functions that require intelligence when performed by people.*' (Kurzweil, 1990)
4. ' *... the study of the design of intelligent agents.*' (Poole *et al.*, 1998)

[10]

b) Self-driving cars constitute an application of AI and robotics which is under active development and already partially deployed. If such a vehicle is involved in an accident which results in death, injury or damage to property, who or what in your opinion should be held responsible? Justify your answer.

i. The operator/occupant of the vehicle
ii. The designer of the AI system
iii. The manufacturer of the vehicle
iv. The AI system itself
v. The dealer/leaser who provided the vehicle
vi. Other parties involved in the incident.

[15]

QUESTION 4 Logic and Reasoning

a) Show which literals can be inferred from the following knowledge base, using:

i. Reasoning patterns
ii. Truth tables.

You should show all steps in your reasoning.

$P \,\&\, Q$
$Q \rightarrow R \vee S$
$P \rightarrow \sim R$

[10]

b) Give the meaning of each the following formulas of Predicate Calculus in ordinary English, and write a logically equivalent expression for each formula using the universal quantifier $\forall$ rather than the existential $\exists$:

i. $\sim\exists x(\text{Swims}(x) \,\&\, \text{Bird}(x))$
ii. $\exists x(\text{Flies}(x) \,\&\, \sim\text{warm-blooded}(x))$
iii. $\sim\exists x\sim(\text{Cat}(x) \,\&\, \sim\text{Fly}(x))$

[6]

c) Suppose there are 120,000 people of voting age in the town of Mainville, of whom 45,000 have college degrees and 55% voted for President Fred F. Friendly in the general election. If one in five who voted for Friendly have degrees, what is the probability of a college graduate voting for this candidate? Calculate your answer and intermediate results to two significant figures, and explain it with reference to Bayes' Rule, showing your working.

[9]

QUESTION 5 Agents and Learning

a) Briefly explain what is meant by the following types of agent:

i. Reflex agent
ii. Reflex agent with state
iii. Goal-based agent
iv. Utility-based agent

[4]

b) Given the definition of rationality presented in the Subject Guide for CO3310, which of the following qualifies as a rational agent, and which of the types listed in (a) above do they belong to (if they do qualify)? Justify your answers, and explain any assumptions you have made.

i. A thermostat
ii. An online service for planning journeys on public transport
iii. A ballcock/float valve (a mechanical device which will block the flow of water once a tank or cistern has been filled to a certain depth)
iv. A robotic vacuum cleaner.

[6]

c) The Appendix contains a copy of Figure 7.2 from the Subject Guide, with example data for learning whether to take a taxi or walk home.

i. Briefly explain how a decision tree can be constructed using **information gain**.
ii. Use the data in the Appendix to construct a decision tree, splitting first on the attribute *Late* and making intuitive decisions on which attributes to split on at subsequent levels.
iii. Can you infer anything from your results about the quality of the input data?
iv. Do you think your results will generalise well to new input data?

Justify your answers. **[15]**

APPENDIX A Example data for Q5(c).

#	Raining	Cold	Late	Nearby	Umbrella	Warmly Dressed	*Taxi?*
1	Yes	No	Yes	Yes	Yes	No	No
2	No	No	Yes	Yes	No	No	No
3	No	Yes	Yes	Yes	No	No	Yes
4	Yes	No	Yes	No	Yes	Yes	No
5	Yes	No	No	No	No	Yes	Yes
6	No	No	No	Yes	Yes	No	No
7	No	Yes	Yes	No	Yes	Yes	Yes
8	No	Yes	No	No	No	Yes	Yes
9	Yes	No	No	No	No	No	Yes
10	No	Yes	Yes	No	Yes	No	Yes
11	Yes	No	No	No	Yes	Yes	No
12	No	Yes	No	Yes	No	Yes	No
13	No	Yes	Yes	Yes	Yes	Yes	No
14	Yes	No	Yes	Yes	No	No	Yes

Figure 7.2: Example data for the learning to determine whether to take a taxi or walk home.

END OF PAPER