THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALL

UNIVERSITY OF LONDON

CO3310 ZA

BSc EXAMINATION

COMPUTING AND INFORMATION SYSTEMS, CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Artificial Intelligence

Thursday 9 May 2019: 14.30 – 16.45

Time allowed: 2 hours and 15 minutes

DO NOT TURN OVER UNTIL TOLD TO BEGIN

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.

Appendix A and **Appendix B** are attached at the end of this examination 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.

UL19/0320

QUESTION 1 Theory of AI and Agents

a) The CO3310 subject guide opens with some possible definitions of AI, taken from Russell and Norvig's classic textbook. Which of the following definitions best matches your own view of AI? Give reasons for your answer, and discuss any deficiencies your selected definition may have.

1. '*The effort to make computers think ...* ' (Haugeland, 1985)
2. *'The study of the computations that make it possible to perceive, reason, and act.'* (Winston, 1992)
3. ' *... creating machines that perform functions that require intelligence when performed by people.*' (Kurzweil, 1990)
4. *' ... intelligent behaviour in artifacts.'* (Nilsson, 1998)

[8]

Marks will be awarded for: quality of argumentation [3/8], showing appropriate technical knowledge [3/8], and clarity of expression [2/8].

b) Explain what is meant by an **autonomous agent** in the context of AI and intelligent agent design. Which of the following designs for a "self driving" taxi has the most, and which the least autonomy? Explain your answer.

i. The vehicle's onboard computer includes a 3D model of the route it needs to take. The agent will plan and execute its journey on the basis of this model. The vehicle also has sensors so that the agent can detect and respond to unexpected features in the environment.

ii. The vehicle follows a predetermined route which is encoded in its onboard computer, but is continually monitored by a remote human operator who can take over the controls at any time and has full access to the system's sensors and actuators.

iii. The onboard computer uses location services as well as online mapping applications and traffic updates to plan its route. The agent also uses sensors to detect other traffic, pedestrians and any unexpected obstacles.

[5]

c) Unmanned aerial vehicles (UAVs) or "drones" are increasingly deployed as part of scientific, military or commercial applications with an AI component. Describe any potential similarities and differences between the following two tasks in terms of the task dimensions provided overleaf.

i. A warehouse robot which locates and retrieves items from storage so that they can be prepared for delivery to a customer.

ii. A delivery drone which collects items from a depot and transports them to the customer's home address.

Task dimensions

- Fully versus partially observable
- Deterministic versus stochastic
- Episodic versus sequential
- Static versus dynamic
- Discrete versus continuous
- Known versus unknown
- Single versus multi-agent.

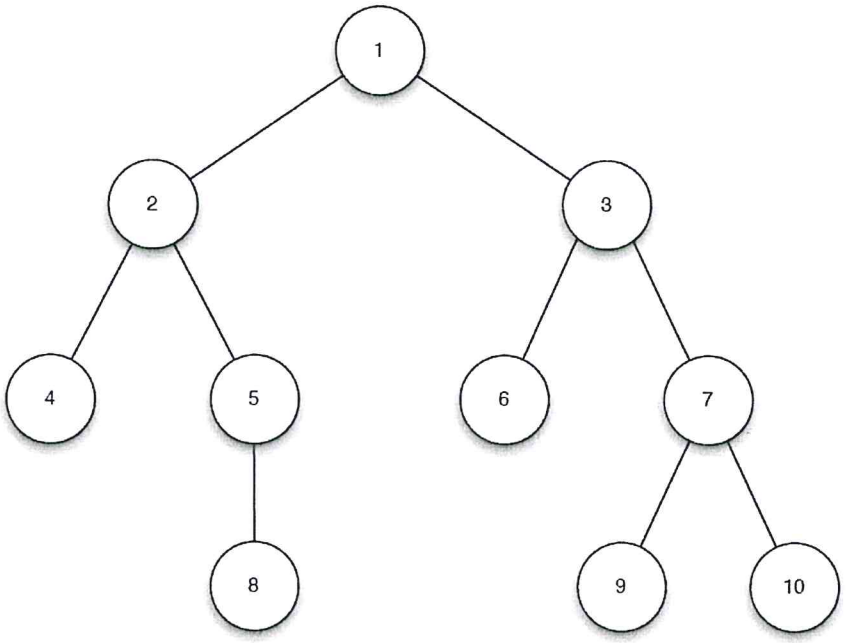
Marks will be awarded for: showing good understanding of the task dimensions [4/12], clearly distinguishing the two environments in terms of the challenges they pose [4/12], quality of argumentation and clarity of expression [4/12].

[12]

QUESTION 2 Search and Planning

a) The figure below is taken from the subject guide for this course and shows an example search tree, indicating a particular order of expansion of nodes.

i. Explain the difference between **informed** and **uninformed** search.
ii. Which uninformed search method will visit nodes in the order shown in the diagram?
iii. Assuming equal path costs at each step, is this search method considered to be complete and optimal? Explain your answer.
iv. If the path costs are not the same for each step, how can this method be adapted to achieve an optimal strategy?
v. Which other simple uninformed search method have you studied during this course? Copy out the diagram below and renumber it to show the order in which this other method will visit nodes.



[5x2]

b) Explain what is meant by the following terms in the context of AI planning:

i. Progressive planning
ii. Subgoal independence
iii. Partial order planning.

[3]

c) Suppose your bedroom is on an upper floor of your house and the kitchen is on the ground floor. You wake in the middle of the night feeling the need to get a snack from the fridge in the kitchen. However, your house has a burglar alarm system which is triggered by detecting motion on the ground floor.

i. Write a PDDL specification for the problem of getting a sandwich from the fridge without setting off the alarm.

[8]

ii. Explain any assumptions you have made in your answer to (i).

[4]

QUESTION 3 Knowledge Representation and Natural Language

a)

i. Explain what is mean by **soundness** and **completeness** in the context of formal logic.

[2]

ii. Show using truth tables whether the following equivalence is true under every interpretation, assuming that A, B and C are arbitrary sentences in propositional logic:

$$(A \rightarrow B) \equiv (\sim B \rightarrow \sim A)$$

[4]

iii. Show using reasoning patterns whether either D or ~D can be inferred from the following knowledge base:

$\sim(A \vee B)$
$C \rightarrow B$
$C \vee D$

[4]

b) Appendix A contains a formal grammar for a small fragment of English, (from the course subject guide).

Determine which of the following sentences are covered by the grammar. Any words in the examples which are not listed in the grammar should be assigned to the appropriate category, and this should be clearly indicated in your answer. Give all possible parse trees for those that are. (You may disregard punctuation and upper/lower case.)

i. Fabio heard a strange noise.
ii. Susanna found a young puppy at the foot of the stairs.
iii. The puppy at the foot of the stairs in the cellar was hungry.
iv. Ahmed saw a puppy that looked tired.
v. The shirt was pale yellow.

[9]

c) The following is an augmented grammar for a very small fragment of English, adapted from the subject guide. Use this grammar to construct an augmented parse tree for the sentence *Jan coughed and sneezed*.

S(pred(obj)) $\rightarrow$ *NP(obj) VP(pred)*
NP(obj) $\rightarrow$ *Name(obj)*
VP(pred) $\rightarrow$ *V(pred)*
VP(λx φ&ψ) $\rightarrow$ *VP(λx φ) and VP(λx ψ)*

Name(Jan) $\rightarrow$ Jan
Name(Miriam) $\rightarrow$ Miriam
V(λx sneeze(x)) $\rightarrow$ sneezed
V(λx cough(x)) $\rightarrow$ coughed

[6]

QUESTION 4 Learning and Reasoning

a) Explain in your own words what is meant by the following terms in the context of probability theory and Machine Learning:

i. Boolean random variable
ii. Discrete random variable
iii. Continuous random variable
iv. Reinforcement learning
v. Markov Decision Process.

[5x2]

b) Suppose you have a normal pair of cube-shaped dice, each with the numbers 1 to 6 on their faces and an equal probability of any of these numbers coming up.

i. Construct a table showing the **joint probability distribution** of A and B after a single throw of the dice, where:

- A = the sum of the two numbers uppermost on the dice is odd;
- B = the sum of the two numbers is less than 7.

[3]

ii. What is the probability that at least one of A and B is true after a single throw? Show your calculation.

[4]

c) The figure below shows a **decision tree** induced from the data in Appendix B. (Both tree and data are taken from the subject guide.)

i. Briefly explain what is meant by **information gain** and how it can be used to construct a decision tree from an example set.

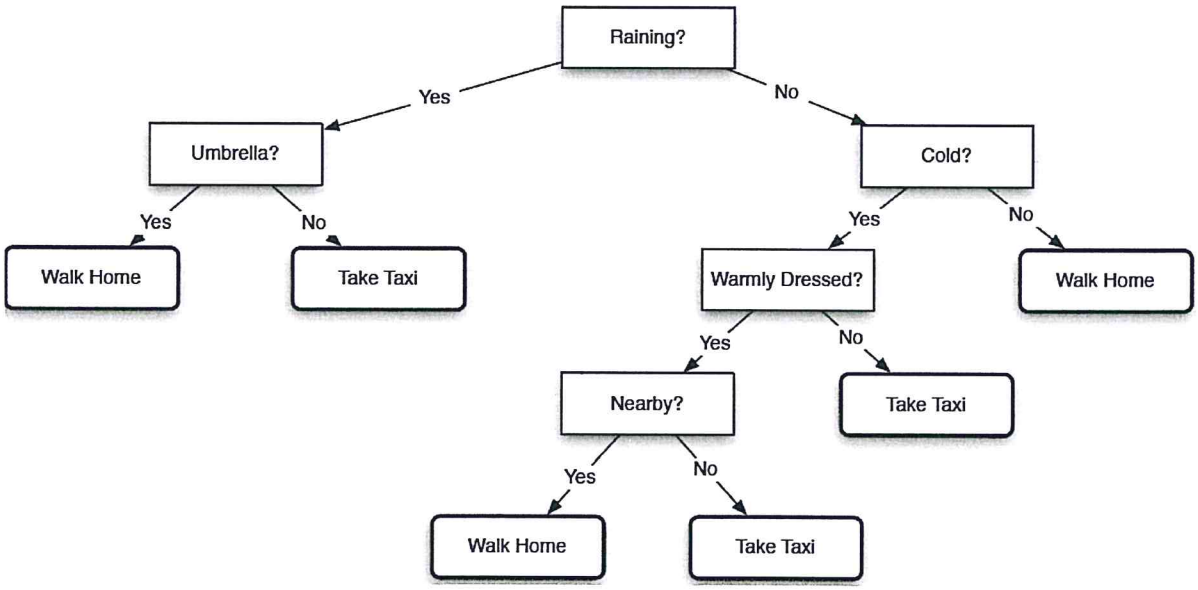
[2]

ii. Copy out the tree diagram and list the examples from the appendix which are classified by each leaf node.

[3]

iii. Discuss whether the tree shown has any surprising or counter-intuitive properties, and if so, what this may indicate about the quality of the input data.

[3]



QUESTION 5 Philosophy of AI

a)

i. Explain what is meant by the distinction between Strong AI and Weak AI.

[4]

ii. John Searle's "Chinese Room" thought experiment is designed to question or even refute the possibility of Strong AI. Briefly describe this scenario, and explain what problems it is intended to pose for Strong AI.

[5]

iii. Russell and Norvig characterise the Chinese Room argument as an "intuition pump" which simply amplifies the prior intuitions of those who engage with it: *"The argument stirs up combatants, but has done little to change anyone's opinion"*. Do you agree with the quoted sentence, and if so, why do think it is true? Explain your answer.

[6]

b) Discuss the following statement from the final chapter of Russell and Norvig (2010):

> "AI, if widely successful, may be at least as threatening to the moral assumptions of 21st-century society as Darwin's theory of evolution was to those of the 19th century".

[10]

For example: how might our "moral assumptions" be threatened if AIs are perceived as conscious entities possessing a sense of self, and how plausible is this scenario?

Marks will be awarded for: showing appropriate technical knowledge and understanding [4/10], quality of argumentation [4/10], clarity of expression [2/10].

END OF PAPER

Appendix A and **Appendix B** are attached on the following pages.

APPENDIX A

Noun →	stench | breeze | wumpus | pits ...
Verb →	is | feels | smells | smell | see | stinks ...
Adjective →	right | dead | smelly | breezy ...
Adverb →	here | ahead | nearby ...
Pronoun →	me | you | I | it ...
RelPro →	that | which | who | whom ...
Name →	John | Mary | Boston ...
Article →	the | a | an | every ...
Prep →	to | in | on | near ...
Conj →	and | or | but | yet ...
Digit →	0 | 1 | 2 | 3 | 4 ...

A selection of the lexicon for ε_0.

$S \rightarrow$	*NP VP*	I + feel a breeze
	| *S Conf S*	I feel a breeze + and + it stinks
$NP \rightarrow$	*Pronoun*	I
	| *Name*	John
	| *Noun*	pits
	| *Article Noun*	the + wumpus
	| *Article Adjs Noun*	the + smelly dead + wumpus
	| *Digit Digit*	3 4
	| *NP PP*	the wumpus + in 1 3
	| *NP RelClause*	the wumpus + that is smelly
$VP \rightarrow$	*Verb*	stinks
	| *VP NP*	feel + a breeze
	| *VP Adjective*	smells + dead
	| *VP PP*	is + in 1 3
	| *VP Adverb*	go + ahead
$Adjs \rightarrow$	*Adjective*	smelly
	| *Adjective Adjs*	smelly + dead
$PP \rightarrow$	*Prep NP*	to + the east
RelClause →	*RelPro VP*	that + is smelly

The grammar for ε_0 with example phrases for each rule.

Figure 6.1: ε_0, a formal grammar for a small fraction of English.
Adapted from Russell and Norvig, Chapter 23, page 891. (RUSSELL, STUART; NORVIG, PETER, *ARTIFICIAL INTELLIGENCE: A MODERN APPROACH*, 3rd edition, ©2010. Electronically reproduced by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.)

APPENDIX B

#	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.