THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALL

UNIVERSITY OF LONDON

CO3310 ZB

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.

An appendix is 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.

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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 automation of] activities that we associate with human thinking'* (Bellman, 1978)

2. *'The study of mental faculties through the use of computer models.'* (Charniak and McDermott, 1985)

3. *' ... how to make computers do things at which, at the moment, people are better.'* (Rich and Knight, 1991)

4. *' ... the study of the design of intelligent agents.'* (Poole *et al.*, 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) The course materials categorise agent types in terms of PEAS descriptions:

- **P**erformance measure
- **E**nvironment
- **A**ctuators
- **S**ensors.

i. Explain what is meant by a **rational agent** in terms of these concepts.

[3]

ii. Give examples of suitable performance measures and typical environment, actuators and sensors for a medical diagnosis system.

[4]

c) Game-playing systems have been a continual focus of AI research since its inception, and many of these systems now equal or surpass expert human players.

i. Describe the game of **chess** in terms of the types of task environments listed below.

[8]

ii. What difference does it make if the game is played with a clock, limiting the time each player is allowed to consider their next move?

[2]

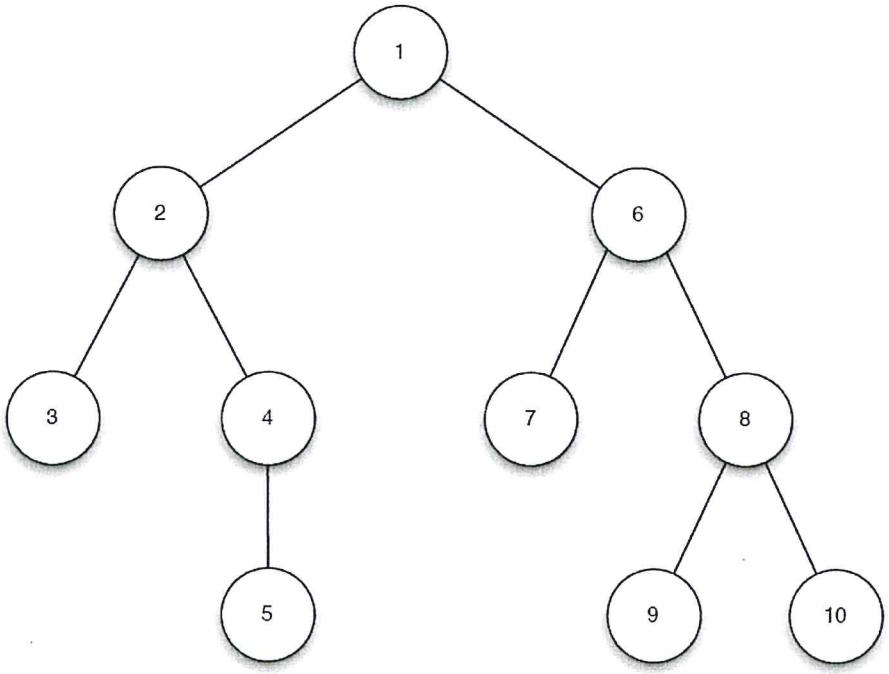
Task dimensions

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

QUESTION 2 Search and Planning

a) The figure below is 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 a finite branching factor and maximum depth, is this search method considered to be complete and optimal? Explain your answer.
   iv. 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.
   v. Which of the two methods given in your answers to (ii) and (iv) has the greater space complexity? Describe a search method which combines the advantages of both these methods in terms of space complexity, completeness, and optimality.



[5x2]

b) Explain the meanings of the following terms in the context of AI planning:

i. Regressive planning
ii. Relaxation
iii. Linearisation.

[3]

c) Suppose a retail outlet incorporates a warehouse where goods are stored in stacked crates, and customer orders are serviced by robots which:

1. Locate the crate containing the product;
2. Pick up the product – this may involve removing other crates from the one the product is stored in;
3. Return all crates to their normal position;
4. Place the product on a conveyor belt which transports it to the customer service counters. At this point the product is removed by a human picker.

i. Write a PDDL specification for the problem of retrieving a digital camera kit from the warehouse and bringing it to the counter. You may need to devise a simple scheme for identifying products, crates (and their locations), conveyors, and counters.

[8]

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

[4]

QUESTION 3 Knowledge Representation and Natural Language

a)

i. State what is meant 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:

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

[4]

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

$$A \,\&\, B$$
$$B \rightarrow C \vee D$$
$$A \rightarrow \sim C$$

[4]

b) The appendix 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 sentences. (You may disregard punctuation and upper/lower case.)

i. Nigel feels a fresh breeze.
ii. Balthasar found a green wumpus at the foot of the stairs.
iii. The wumpus at the foot of the stairs in the cellar was green.
iv. Fatima saw a wumpus that looked dead.
v. The carpet was bright red.

[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 *Aslan stood and roared*.

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(Aslan) $\rightarrow$ Aslan
Name(Reepicheep) $\rightarrow$ Reepicheep
V(λx roar(x)) $\rightarrow$ roared
V(λx stand(x)) $\rightarrow$ stood

[6]

QUESTION 4 Learning and Reasoning

a) Explain what is meant by the following terms in the context of probability theory:

i. Boolean random variable
ii. Discrete random variable
iii. Continuous random variable.

[3x2]

b) Suppose that after graduating, you are employed for several years as a software developer and reach a point where you see no further career progression in your company, without taking on managerial roles which do not appeal to you. You are considering either starting out on your own as an independent consultant, or accepting a position with a Big Five tech company. Discuss how **machine learning** techniques could be used to construct a **decision tree** to help in this choice.

[9]

c) Suppose a music college has 375 students, of whom 67 are learning to play the guitar. If one in 10 of the students is left-handed, and half of the left-handed students are learning guitar, what is the probability that a guitar student will be left-handed? Calculate the answer using Bayes' Rule, showing your calculations and explaining each step of your answer. Give your results and interim calculations to two significant figures.

[10]

QUESTION 5 Philosophy and Ethics of AI

a) Alan Turing's "Imitation Game" is the original and probably still the best known operational test for machine intelligence.

i. Describe the Turing Test (as it has come to be known) and explain the criteria for deciding whether a computer can be considered to be intelligent, on the basis of its performance in the test.

[5]

ii. Evaluate **one** of the objections to Turing's claim which he discusses in his original paper.

[4]

iii. Explain what is meant by Strong vs Weak AI, and compare these two claims in terms of philosophical approaches to the mind-body problem outlined in the subject guide: **dualism**, **materialism**, **biological naturalism** and **functionalism**.

[6]

b) Discuss the following statement by mathematics professor and science fiction author Vernor Vinge, quoted by Russell and Norvig (2010):

"Within 30 years [from 1993], we will have the technological means to create superhuman intelligence. Shortly after, the human era will be ended".

[10]

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

END OF PAPER

An appendix is attached on the following page.

APPENDIX

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
$RelClause \rightarrow$	*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.)