UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

B. Sc. Examination 2010

All Computing Programmes

IS53024A (CIS341) Artificial Intelligence

Duration: 2 hours and 15 minutes

Date and time:

There are FIVE questions on this paper.

Full marks will be awarded for complete answers to THREE questions.

Electronic calculators may be used. The make and model should be specified on the script and the calculator must not be programmed prior to the examination.

THIS PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

Question 1 Negotiation in Task-oriented Games

Consider the following scenario. Agent Ag_1 has been assigned the tasks $\{t_1, t_2\}$ and agent Ag_2 has been assigned the tasks $\{t_3, t_4\}$. The costs to agent Ag_1 of performing each of the four tasks $\{t_1, t_2, t_3, t_4\}$ are as follows:

$c_1(t_1) = 20$
$c_1(t_2) = 10$
$c_1(t_3) = 3$
$c_1(t_4) = 0$

The costs to agent Ag_2 of performing each of the four tasks $\{t_1, t_2, t_3, t_4\}$ are as follows:

$c_2(t_1) = 8$
$c_2(t_2) = 10$
$c_2(t_3) = 2$
$c_2(t_4) = 24$

The agents might be better off if they decide to negotiate and swap their tasks and make a *deal*. The only proviso is that in any deal they must still complete two tasks. The agents agree to use the *monotonic concession protocol* for negotiation.

(a) Describe the *monotonic concession protocol* and the Zeuthen Strategy. [7]

(b) Show what will happen when agents Ag_1 and Ag_2 both use the Zeuthen strategy and the monotonic concession protocol. What is the final utility to both agents in the resulting deal? [7]

(c) Consider the following scenario.

Agent Ag_1 has been assigned the tasks $\{t_1, t_2, t_3\}$ and agent Ag_2 has been assigned the tasks $\{t_4, t_5, t_6\}$.

The costs to agent Ag_1 are as follows:

$c_1(t_1) = 5$
$c_1(t_2) = 7$
$c_1(t_3) = 3$
$c_1(t_4) = 4$
$c_1(t_5) = 2$
$c_1(t_6) = 1$

The costs to agent Ag_2 are as follows:

$c_2(t_1) = 1$
$c_2(t_2) = 2$
$c_2(t_3) = 3$
$c_2(t_4) = 7$
$c_2(t_5) = 5$
$c_1(t_6) = 8$

Sketch what would happen if the same strategy applied in (b) was repeated and write down the final deal. (Note that agents must always offer a deal where there are three tasks.) [7]

(d) Would the Zeuthen strategy still provide an optimal solution if agents could offer an arbitrary (rather than fixed) number of tasks? What would be the advantages and disadvantages of this approach? [4]

Question 2 Agent Utility and Agent Argumentation

(a) This part is concerned with agent utility.

i. Discuss some of the strategies that agents might use for measuring utility over the course of a run and how these strategies relate to the design of the motivations of an agent. [4]

ii. If the utility is bounded, describe what is meant by an optimal agent and also what is meant by bounded rationality. [2]

Consider the environment $Env = \langle E, e_0 \rangle$ which has initial state e_0 and six other possible states.

$E = \{e_0, e_1, e_2, e_3, e_4, e_5, e_6\}$

The function τ is the function for updating the environment when an action is performed, and is defined as follows:

$\tau(e_0 \stackrel{\alpha_1}{\rightarrow}) = \{e_1, e_2\}$

$\tau(e_0 \stackrel{\alpha_2}{\rightarrow}) = \{e_3, e_4, e_5, e_6\}$

Suppose there is one agent Ag and this agent has two actions available to it, α_1 and α_2, respectively.

$Ag(e_0) = \{\alpha_1, \alpha_2\}$

Assume the probabilities of the various runs are as follows:

$P(e_0 \stackrel{\alpha_1}{\rightarrow} e_1 \mid Ag, Env) = 0.5$

$P(e_0 \stackrel{\alpha_1}{\rightarrow} e_2 \mid Ag, Env) = 0.5$

$P(e_0 \stackrel{\alpha_2}{\rightarrow} e_3 \mid Ag, Env_1) = 0.2$

$P(e_0 \stackrel{\alpha_2}{\rightarrow} e_4 \mid Ag, Env_1) = 0.1$

$P(e_0 \stackrel{\alpha_2}{\rightarrow} e_5 \mid Ag, Env_1) = 0.1$

$P(e_0 \stackrel{\alpha_2}{\rightarrow} e_6 \mid Ag, Env_1) = 0.6$

Finally, assume the utility function u is defined as follows:

$$u(e_0 \stackrel{\alpha_1}{\to} e_1) = 0$$

$$u(e_0 \stackrel{\alpha_1}{\to} e_2) = 100$$

$$u(e_0 \stackrel{\alpha_2}{\to} e_3) = 50$$

$$u(e_0 \stackrel{\alpha_2}{\to} e_4) = 40$$

$$u(e_0 \stackrel{\alpha_2}{\to} e_5) = 60$$

$$u(e_0 \stackrel{\alpha_2}{\to} e_6) = 50$$

Given these definitions:

iii. Determine the expected utility of the agent choosing the action α_1 with respect to *Env* and u. [3]

iv. Determine the expected utility of the agent choosing the action α_2 with respect to *Env* and u. [3]

v. State, with explanation, which action is optimal with respect to *Env* and u. Discuss what kinds of agents might decide to chose the non optimal action. [4]

(b) This part is concerned with argumentation

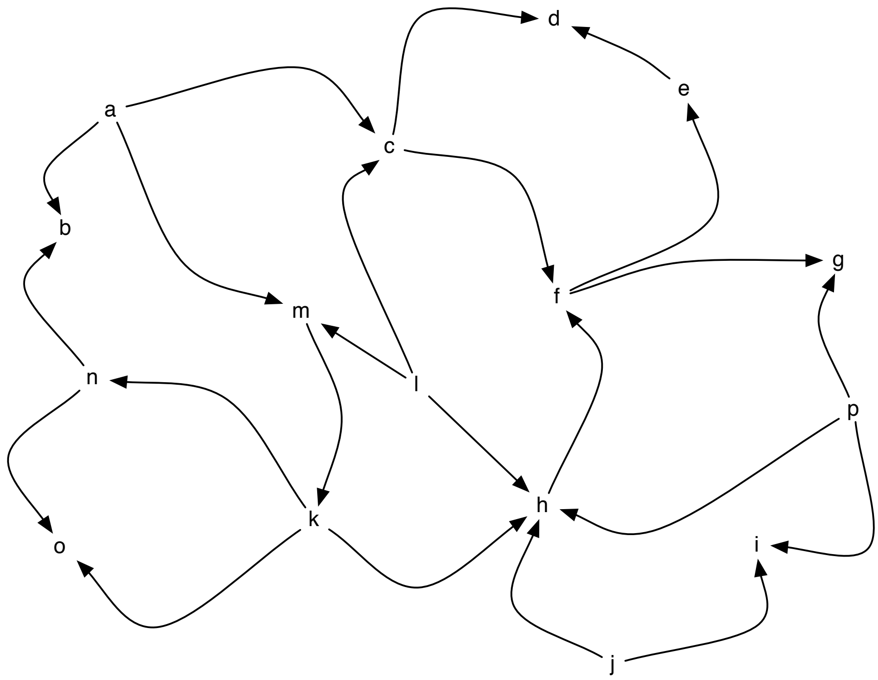
i. Define what it means when we talk about one argument *attacking* another. [1]

ii. Define what it means when we talk about an *acceptable* argument. [1]

iii. Given the diagram below, explain the status of the following arguments and which are acceptable to an agent (*in*) and which are not acceptable (*out*) justifying your answer in each case. [7]

A
B
C
D
E
F
G
H
I
J
K

L
M
N
O
P



Question 3 Natural Language

(a) Give examples of three different ways that natural language expressions can be ambiguous. Where possible illustrate your answer with appropriate formal representations.

[3]

(b) A natural language system has the following grammatical and lexical rules:

s ⟶np vp	det ⟶[the]
np⟶np conj np	det ⟶[a]
np⟶det n	n ⟶[cat]
np⟶pro	n ⟶[dog]
vp⟶vp conj vp	n ⟶[sparrow]
vp⟶v np	pro ⟶[it]
vp⟶v	v ⟶[saw]
	v ⟶[chased]
	v ⟶[barked]
	conj⟶[and]

The start symbol is s which represents a sentence. Using the above grammar, draw as many syntax trees as you can (if any) for the sentences:

(i) The dog chased a cat and a mouse and a sparrow.

(ii) The dog saw a cat and barked and chased it.

[5]

(c) The grammar shown in (b) above includes *left-recursive rules* such as np ⟶ np conj np.

(i) What problems does this pose for a top-down, left-to-right parsing strategy, for instance using Prolog DCGs?

(ii) How can you modify the grammar so that it still accepts the same sentences but has no left-recursive rules?

[10]

(d) How can you modify the grammar from (b) so that it will not accept the examples marked with * below but will still accept examples (b)(i - ii) above?

[7]

(i) * The dog barked a cat.

(ii) * The dog saw a cat and chased.

(iii) * The cat saw.

Question 4 Semantics, logic and reasoning

(a) State whether the following statements are consistent, contradictory, contingent or necessarily true. (NB more than one may apply). Justify your answers.

i. Mary has six children. Peter believes that Mary has three daughters and four sons.

ii. John's sister has five children. John is an only child.

iii. Either there is a finite set of prime numbers or the number of primes is infinite.

iv. John believes that the world will end on December 21st, 2012. David believes that the world will not end on December 21st, 2012.

v. John is a university lecturer. John is a cellist.

vi. Either it will rain tomorrow or it will be dry.

vii. John is a university lecturer. John is a chimpanzee.

viii. David wears a ring on each finger. David wears nine rings.

[4]

(b) Suppose a knowledge base contains the following facts:

Socrates is Greek.

Socrates is a man.

All Greeks are philosophers.

No Romans are philosophers.

Some Greeks are fishmongers.

Assuming these facts to be true, which of the following arguments are **valid** and which are **invalid** according to the principles of classical logic? Justify your answers. [5]

i. Socrates is Greek. Therefore, Socrates is a philosopher.

ii. Socrates is Roman. All Romans are fishmongers. Therefore, Socrates is a fishmonger.

iii. $2 + 2 = 5$. Therefore, Socrates is a fishmonger.

iv. Socrates believes that $2 + 2 = 5$. Therefore, Socrates is not a mathematician.

v. Socrates is Persian. Therefore, $2 + 2 = 4$.

(c) Using truth tables, show whether the following statements of Propositional Logic are equivalent:

$(p \vee q) \rightarrow r$

$(p \to r) \vee (q \to r)$

[4]

(d) Using only the symbols $\neg$ and $\vee$, construct formulas with the same truth-tables as

i. $p \wedge q$

ii. $p \to q$

iii. $p \leftrightarrow q$

[6]

(e) Give the meaning of each the following formulas of Predicate Calculus in ordinary English:

(i) $\forall x(Swims(x) \to \neg Bird(x))$

(ii) $\neg \exists x(Feathered(x) \wedge Flies(x) \wedge \neg Bird(x))$

(iii) $\forall x(Bird(x) \wedge Fly(x))$

(iv) $\neg \exists x(Albatross(x) \wedge \exists y(Eagle(y) \wedge \neg Larger(xy)))$

[6]

Question 5 Search

(a) Describe three types of problems to which AI search algorithms could be applied, other than route-finding.

[6]

(b) i. Explain the terms **optimal** and **complete** with regard to search algorithms.

ii. Give two examples each, of algorithms which are:

complete and optimal

neither complete nor optimal

iii. Why might you choose to use a search algorithm which is not optimal or complete?

[5]

(c) Suppose you arrive at King's Cross Underground station at 16.00 hours with the intention of taking a Victoria line train to Victoria station. However, it turns out that the Victoria line is subject to delays and the next train will depart at 16.40. Other trains which will shortly depart are the Piccadilly line at 16.05, or the Northern line at 16.10. Assume that it takes 5 minutes to change tube trains or from the tube to a bus. The two tables below show the lines and travelling times between stations, and the optimal non-stop travelling time from each station to Victoria. Given this information, how would you calculate the fastest route to Victoria using: [14]

i. depth-first search

ii. breadth-first search

iii. uniform-cost search

iv. greedy search?

Explain your solutions and give a diagram of the search space.

From	**To**	Line	**Minutes**
King's Cross	Holborn	Piccadilly	10
King's Cross	Camden Town	Northern	14
King's Cross	Victoria	Victoria	21
Holborn	Green Park	Piccadilly	15
Green Park	Westminster	Jubilee	7
Green Park	Victoria	Bus	16
Westminster	Victoria	Circle	10
Camden Town	Golders Green	Northern	32
Golders Green	Edgware	Northern	17

Station	**Nonstop to Victoria**
King's Cross	17
Holborn	20
Green Park	12
Westminster	8
Camden Town	30
Golders Green	45
Edgware	55
Victoria	0