SEMESTER 1 EXAMINATION 2014 - 2015

INTELLIGENT AGENTS

DURATION 90 MINS (1.5 Hours)

This paper contains 5 questions

Answer THREE out of FIVE questions.

An outline marking scheme is shown in brackets to the right of each question.

This examination is worth 60%. The coursework was worth 40%.

University approved calculators MAY be used.

A foreign language translation dictionary (paper version) is permitted provided it contains no notes, additions or annotations.

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**Question 1.**

(a) Discuss the main criticisms of deductive reasoning agents, and describe how Robert Brooks' *subsumption architecture* attempts to overcome these criticisms. Describe how Luc Steels used these ideas to design effective cooperative agents. What are the challenges when trying to apply these approaches in other settings?

[8 marks]

(b) Describe the BDI framework for designing practical reasoning agents.

[4 marks]

(c) A UAV (Unmanned Air Vehicle) is used to search for civilians in a search-and-rescue mission and is equipped with an infrared sensor. The sensor has a true positive rate of 0.8, and a false negative rate of 0.4. The probability of there being a civilian at any time is 0.3. Use Bayes' theorem to calculate the probability that a civilian is present given that the sensor's reading is positive. Explain your answer.

[4 marks]

(d) In the second time step the sensor again reads positive. Calculate the updated probability. What assumptions have you made in doing so?

[4 marks]

**Question 2.**

(a) For each of the following statements decide whether it is true or false and explain why.

(i) A strategy profile is a Nash equilibrium if no player can improve their position given the strategies chosen by other players.

(ii) Safety level strategies are very conservative and so lead to a stable outcome (i.e., Nash equilibrium) if played by all the players.

(iii) Nash equilibrium is also a best possible outcome (that is, one maximising the total sum of players' payoffs).

[6 marks]

(b) Find a pure strategy Nash equilibrium of the game below by iteratively removing dominated strategies. Describe the elimination process!

| | | Player 2 | | |
|---|---|---|---|---|
| | | Left | Middle | Right |
| Player 1 | Up | 4,2 | 6,10 | 9,1 |
| | Middle | 3,12 | 3,4 | 1,2 |
| | Down | 8,9 | 4,9 | 3,8 |

[5 marks]

(c) (i) Find a mixed strategy equilibrium of the game below and compute expected utilities for both players. Show your calculations!

| | | Player 2 | |
|---|---|---|---|
| | | Left | Right |
| Player 1 | Up | 4,4 | 1,3 |
| | Down | 3,1 | 3,3 |

(ii) Now assume that the utility function of the column player has changed as follows:

| | | Player 2 | |
|---|---|---|---|
| | | Left | Right |
| Player 1 | Up | 4,4 | 1,3 |
| | Down | 3,2 | 3,3 |

**TURN OVER**

How does this affect the equilibrium strategies (both pure and mixed) of the column player and/or the row player?

[9 marks]

**Question 3.**

(a) Two final year students decide to appear with purple hair on the last day of studies. However, the night before, each privately begins to reconsider their agreement.

If both appear with their natural hair, they equally enjoy the last day of studies, but it would be more fun for both if they both also dyed their hair purple. However, if only one of them does so, he feels slightly embarrassed, while the other thinks he made a clever decision.

(i) Present a payoff matrix that describes this setting.

(ii) Explain why this game is an example of the Prisoner's Dilemma.

[5 marks]

(b) Describe equilibrium strategies in the Prisoner's Dilemma, when:

(i) The game is played once.

(ii) The game is repeated k 2 N times, for known k.

(iii) The game is repeated k 2 N times, but k is unknown.

(iv) The game is repeated infinitely many times.

[8 marks]

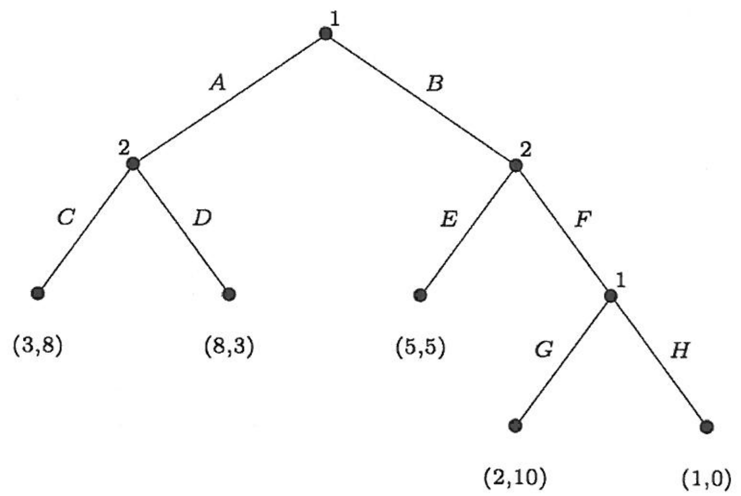
(c) Consider the 2-player extensive-form game with perfect information in the figure below.

(i) Find all its pure strategy Nash equilibria.

(ii) Which of these equilibria are also subgame-perfect equilibria and which are not? Why?

[7 marks]

**TURN OVER**


1
A
B
2
2
C
D
E
F
1
(3,8)
(8,3)
(5,5)
G
H
(2,10)
(1,0)

**Question 4.**

(a) Consider an agent participating in an auction and facing a single opponent. The agent has a willingness to pay, or *value*, of 15. From past experience the agent estimates that his opponent will bid uniformly between 0 and 20. Assume the agent is maximising his expected utility (which is equal to his value minus his expected payment):

(i) Determine the agent's optimal bid when the auction is a second-price sealed bid auction (a.k.a. Vickrey auction). Motivate your answer.

(ii) Suppose that the auctioneer instead uses a first-price sealed-bid auction. Given this, compute the agent's expected utility when he bids 10.

(iii) Determine the agent's optimal bid when the auctioneer uses a first-price auction. Explain your answer. What is the expected utility at this bid?

[8 marks]

(b) The Vickrey auction is equivalent to which other auction? Explain in what way and under which condition(s) these two auctions are considered to be equivalent.

[4 marks]

(c) Compare the 4 main auctions in terms of their ability to sustain collusive agreements. Based on this discussion, in your opinion, which of the 4 auctions is the most susceptible to collusion? [8 marks]

TURN OVER

**Question 5.**

(a) Consider the sequential-offer bargaining game where two agents, 1 and 2, take turns making offers about how to divide a pie of size one. Time runs from $t = 0; 1; 2; \ldots$.

At time 0, agent 1 proposes a split $(x_0; 1 - x_0)$, which agent 2 can accept or reject. If agent 2 accepts, the game ends and the pie is consumed. If agent 2 rejects, the game continues to time $t = 1$, when agent 2 gets to propose a split $(x_1; 1 - x_1)$. Now, agent 1 can accept or reject, and so on.

If agreement to split the pie $(x; 1 - x)$ is reached at time $t$, the payoff for agent 1 is $\delta_1^t x$ and the payoff for agent 2 is $\delta_2^t (1 - x)$ for discount factors $\delta_1; \delta_2 \in (0; 1)$.

(i) Assume only a finite number of offers can be made. What are the subgame-perfect equilibrium strategies for both agents? When do they reach an agreement?

(ii) Assume the game is infinite-horizon. What are the agents' subgame-perfect equilibrium strategies? When do the agents agree? Does any of them has an advantage in the game?

[10 marks]

(b) Consider a B2C Internet company that provides some service to end users. The company has an enterprise value, which is a function $f(n)$ of the number $n$ of its users. On the other hand, when people adopt the service provided by the company, each user $i$ derives a non-negative utility $u_i \geq 0$ from using the service.

Let $N$ denote the population of potential users, and let $F$ denote the company. Consider a cooperative game played by $N \cup \{F\}$ – that is, by the company and potential users.

The characteristic function is given as follows. If a coalition $C \subseteq N$ does not include the company, its value $v(C)$ is 0. If a coalition $C$ does include the company, its value $v(C)$ consists of the company enterprise values and the sum of its users' utilities. That is, for any $C \subseteq N \cup \{F\}$, we have

$$v(C) = \begin{cases} f(|C| - 1) + \sum_{i \in C \cap N} u_i & \text{if } F \in C \\ 0 & \text{otherwise} \end{cases}$$

The game is superadditive, so the grand coalition forms. Compute the Shapley value $\phi$ for the company $F$ and each user $i \in N$.

[10 marks]

**END OF PAPER**