NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2021-2022

CE4046/CZ4046 – INTELLIGENT AGENTS

Apr/May 2022 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 4 pages.
2. Answer **ALL** questions.
3. This is a closed-book examination.
4. All questions carry equal marks.

---

1. (a) What are the three types of nodes in a decision network?

(3 marks)

(b) Two most common types of tasks for agents to perform are *achievement tasks* and *maintenance tasks*. Explain what these two types of tasks are.

(4 marks)

(c) Environments can be characterized as *static* vs. *dynamic*. Describe what these environment properties are. In addition, indicate the key property that an intelligent agent needs to achieve in a dynamic environment.

(6 marks)

(d) Consider the environment $Env_1 = <E, e_0, \tau>$ defined as follows:

$E = \{e_0, e_1, e_2, e_3, e_4, e_5, e_6\}$
$\tau(e_0, \alpha_0) = \{e_1, e_2\}$
$\tau(e_0, \alpha_1) = \{e_2, e_3\}$
$\tau(e_1, \alpha_2) = \{e_3\}$
$\tau(e_2, \alpha_3) = \{e_4, e_5\}$
$\tau(e_3, \alpha_4) = \{e_2, e_6\}$

Note: Question No. 1 continues on Page 2

$\tau(e_i, \alpha_i)$ defines the state transition for the environment in state e_i, given action α_i. Assume that there are two possible agents for this environment Ag_1 and Ag_2, which are defined as follows:

$Ag_1(e_0) = \alpha_0$ $\quad$ $Ag_2(e_0) = \alpha_1$
$Ag_1(e_1) = \alpha_2$ $\quad$ $Ag_2(e_2) = \alpha_3$
$Ag_1(e_2) = \alpha_3$ $\quad$ $Ag_2(e_3) = \alpha_4$

Assume $|r|$ gives the total number of states in a particular run r. For example, $|r_1| = 3$ if $r_1 = (e_0, \alpha_0, e_3, \alpha_2, e_5 \mid Ag_1, \text{Env}_1)$. The probability P and utility U of each run are given as follows:

$P(r \mid Ag_1, \text{Env}_1) = 4/(|r| + |r|)$ $\quad$ $U(r) = 10 - |r|$
$P(r \mid Ag_2, \text{Env}_1) = |r|/9$

(i) Write down all possible runs for Ag_1 and Ag_2.

(6 marks)

(ii) Calculate the expected utility for Ag_1 and Ag_2. Which one of the two agents is optimal with respect to Env_1 and U?

(6 marks)

2. An agent inhabits a world with two states, S and S'. It can perform one of the two actions, a and b. Action a does nothing, and action b flips from one state to the other state.

Consider this world as a Markov Decision Process (MDP). The reward of each state is as follows: $R(S) = 3$, and $R(S') = 2$.

Set the discount factor $\gamma = 0.5$.

Apply the policy iteration algorithm to determine the optimal policy. Assume that the initial policy has action a in both states.

(a) What are the two main steps involved in the policy iteration algorithm? Elaborate the purpose of each step.

(6 marks)

(b) Show each step in full during each iteration. What is the optimal policy?

(19 marks)

3. (a) COVID-19 has disrupted supply chains around the world. Two years into the pandemic, the global supply chain continues to sputter and break down. Each day comes news of choked ports, out-of-place shipping containers, record freight rates, and other problems that cause disruption and defy easy answer. List and briefly explain a few key ideas in multi-agent systems which can be used to improve the currently disrupted global supply chain in a post-pandemic world.

(5 marks)

(b) The Contract Net protocol is the most widely studied protocol in cooperative distributed problem solving. Describe the main steps of the Contract Net.

(5 marks)

(c) Briefly explain why Vickrey auctions are truthful.

(5 marks)

(d) Coalitional games model scenarios where agents can benefit from cooperation. When agents join coalitions, a coalition structure is formed. Explain the concept of stability and fairness of a coalition structure.

(5 marks)

(e) Voting is widely used to make group decisions and voting is vulnerable to manipulation. It is known that we can use complexity to avoid vote manipulation. Briefly explain the idea.

(5 marks)

4. Consider the two payoff matrices 1 and 2 in Table Q4a and Table Q4b respectively. The first number in each entry is the payoff received by the row player **A**; while the second number is the payoff received by the column player **B**. Payoff matrix 1:

Table Q4a

	B: left	**B: right**
A: up	**(2, -4)**	**(-3, -2)**
A: down	**(1, 1)**	**(-2, -4)**

Note: Question No. 4 continues on Page 4

Payoff matrix 2:

Table Q4b

	B: left	**B: right**
A: up	**(4, 0)**	**(0, 6)**
A: middle	**(2, 1)**	**(4, 1)**
A: down	**(1, 4)**	**(3, 1)**

(a) Identify the dominant strategies (if any) of each player in these two payoff matrices. Briefly explain your answer.

(5 marks)

(b) Identify which strategy pairs (if any) in these two payoff matrices are in Nash equilibrium. Briefly explain your answer.

(8 marks)

(c) Identify which outcomes in these two payoff matrices are Pareto optimal. Briefly explain your answer.

(7 marks)

(d) Identify which outcomes in these two payoff matrices maximize social welfare. Briefly explain your answer.

(5 marks)

END OF PAPER

CE4046 INTELLIGENT AGENTS
CZ4046 INTELLIGENT AGENTS

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.