2017 Summer Entrance Examination

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Creative Informatics

Instructions

1. Do not open this brochure until the signal to begin is given.
2. Write your examinee ID number below on this cover page.
3. Answer all three problems.
4. Three answer sheets are given. Use a separate sheet of paper for each problem. You may write on the back of the sheet.
5. Write down your examinee ID number and the problem number inside the top blanks of each sheet.
6. Do not remove the answer sheets or this brochure from this room.

Examinee ID ______________________________

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Problem 1

Let us consider to order a mobile robot to move from the start S to the goal G in the grid maze illustrated as in Fig. 1. We can order the robot either of two actions at each cell (state), *up*; move one cell to upward, or *right*; move one cell to the right. When the robot moves into a cell, the robot gets the score written in that cell as the reward. Black cells represent obstacles. We cannot order impossible actions to move to obstacles or outside of the maze. We assume that there are no dead ends in the maze.

-2	2	0	0	G
2	2	■	10	-5
2	2	■	0	-5
S	0	0	0	-5

Fig. 1: Maze and rewards

We consider how we can give the orders at individual cells to reach the goal so that the sum of rewards obtained in the route is maximized. First, let us consider the case where the robot always moves to the ordered direction. State value $V(s)$ at each cell s is defined as the maximum value of the sum of rewards that can be obtained by going from s to the goal. Suppose that the robot moves from cell s to cell s' by order a and obtains the reward $R_{ss'}^{a}$. Then $V(s)$ can be recursively calculated as follows.

$$V(s) = \max_{a \in \{up, right\}} \left\{ R_{ss'}^{a} + V(s') \right\}. \tag{1}$$

We assume that the state value and the reward of the goal are both zero. The order which attains the maximum in the right hand side of equation (1) is called the best order at the cell s. The best route is defined as the route given by a sequence of the best orders from the start S to the goal G. Let's consider an example for which rewards are given in Fig. 2. We can calculate state values of individual cells from the goal according to equation (1), as illustrated in Fig. 3.

4	-1	G
0	1	0
S	0	2

Fig. 2: Rewards

-1	0	0
3	0	0

Fig. 3: State values

Answer the following questions.

(1) Fill out the empty cells in Fig. 3.

(2) Draw the best route in the maze in Fig. 2. Use the symbols $\uparrow$ for *up* and $\rightarrow$ for *right*, and put either of them in each cell in the route.

(3) For each cell s in the maze in Fig. 1, fill the value of $V(s)$.

(4) Draw the best route in the maze in Fig. 1.

Next, let us consider the case where the robot takes an action (*up* or *right*) different from the order with 20% probability. Note that the robot always takes an action following the order when moving toward the other direction is impossible. Here, we define the state value $W(s)$ as the maximum value of the expected value of the sum of rewards that can be obtained by going from s to the goal. We assume that the state value and the reward of the goal are both zero.

(5) Let $P_{ss'}^{a}$ denote the probability that the robot moves from cell s to cell s' by order a. Write down an equation to calculate $W(s)$ recursively.

(6) For each cell s in the maze in Fig. 1, fill the value of $W(s)$. Round down the calculation results to one decimal place.

(7) Draw the order that should be given at each cell in question (6).

(8) Describe the reason for the difference in the answers of questions (4) and (7).

Problem 2

(1) Show the truth table of a half-adder HA (Fig. 1) which outputs 1-bit sum S and 1-bit carry C from two 1-bit binary inputs A and B.

(2) Draw a diagram of the half-adder circuit HA with devices of AND, OR and NOT.

(3) Show the truth table of a full-adder FA (Fig. 2) which outputs 1-bit sum S and 1-bit carry C from two 1-bit binary inputs A, B and 1-bit carry input X.

(4) Draw a diagram of the full-adder circuit FA using two half-adder HA devices. If necessary, you can use AND, OR and NOT devices.

(5) Explain a method to build an n-bit adder for unsigned integers using full-adder FA devices.

(6) Explain a method to build a faster n-bit adder.

(7) Explain a method to execute a subtract operation with an n-bit adder through generating negative number in two's complement, and draw its circuit.

(8) Explain a method to build an n-bit adder-subtractor for unsigned integers with a single n-bit adder and an input signal F to select addition or subtraction, and draw its circuit.

(9) Explain how to build a multiplier to generate a 2n-bit product M from two n-bit unsigned integers A and B.

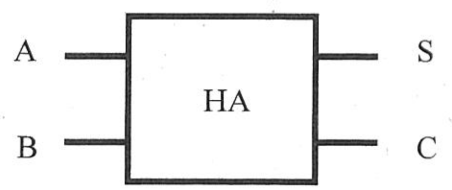

Fig. 1

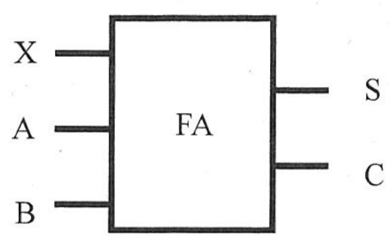

Fig. 2

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Problem 3

Select <u>four items</u> out of the following eight items concerning information systems, and explain each item in approximately 4〜8 lines of text. If necessary, use examples or figures.

(1) Wavelet transformation

(2) Cepstrum

(3) Deep Learning

(4) ZMP (Zero Moment Point)

(5) SSL (Secure Socket Layer)

(6) Targeted e-mail attack

(7) Hough transform

(8) Lambda expression in computer programming

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