Assignment 1

COMP3211

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Questions 1

1A

Answer: **No**, a boundary-following robot can not be designed with sensory inputs(s_2, s_4, s_6, s_8) only without memory. Without tracking the state of the agent, the information of corner, i.e. s_1, s_3, s_5, s_7 can not be computed and thus the agent will lose its track under situation in Fig.1. According to the rule, the agent should move south because the out-boundary is at position s_7, but without information about s_7, the agent does not know where is the boundary and would lose its track.

Figure 1: Lost Track of Situation

1B

Answer: With historical information, the agent can decide its action using the production system and state-machine. Then s_5 can be computed by tracking the previous state.

$$s_5 = (pa = W) \cdot ps_6$$

Assuming there is not tight space and ignore going south along the east wall situation.

Question 2

2A

$$1.6 \cdot x_1 + 3.3 \cdot x_2 + (-1.1) \cdot x_3 + (-2.1) \cdot x_4 + 0.5 \cdot x_5 \geq 2$$

Construct the following boolean truth table 1:

x_1	x_2	x_3	x_4	x_5	Result	Expression
x	1	x	0	x	True	$x_2\bar{x}_4$
1	1	0	1	x	True	$x_1x_2\bar{x}_3x_4$
x	1	0	1	1	True	$x_2\bar{x}_3x_4x_5$
1	1	x	1	1	True	$x_1x_2x_4x_5$
1	0	0	0	1	True	$x_1\bar{x}_2\bar{x}_3\bar{x}_4x_5$

Table 1: Truth Table

$$TLU = x_2\bar{x}_4 + x_1x_2\bar{x}_3x_4 + x_2\bar{x}_3x_4x_5 + x_1x_2x_4x_5 + x_1\bar{x}_2\bar{x}_3\bar{x}_4x_5$$

2B

$$1.6 \cdot x_1 + 3.3 \cdot x_2 + (-1.1) \cdot x_3 + (-2.1) \cdot x_4 + 0.5 \cdot x_5 \geq 10$$

No boolean function can be derived since 1.6+3.3+0.5<10.

Questions 3

Answer:

3A

$$\text{Fitness} = \frac{\text{Number of correct predictions}}{\text{Total number of inputs}}$$

3B

Choose an random index i for parent program a and b, and obtain children program $x = a[:i] + b[i:]$, $y = b[:i] + a[i:]$.

3C

selects the top k perceptron (based on fitness) from the current generation and copies them to the next generation without changes.

3D

No mutation.

3E

The initial generation consists of 100 perceptrons. Each perceptron is generated by initializing its weights and threshold randomly from $[-1, 1]$.

3F

The evolution stops when one of the following conditions is met:

- A perceptron achieves a fitness score greater than or equal to 0.95.
- The maximum number of generations 100 is reached.

3G

```
Stopping early at generation 24 with fitness 0.95
Best Perceptron Weights: [-0.03432519 -0.59439591 -0.84821531  0.57355586  0.44566365 -0.40460343
  0.84334062 -0.45814035  0.58350261]
Best Perceptron Threshold: 0.14991154722750866
Fitness: 0.95
```

Figure 2: Output

Question 4

Answer: The boolean expression that corresponds to the perceptron of move north action is given by the weights after training.

$$\texttt{north\_weight} = [1.0, -2.0, -2.0, 0.0, 0.0, 0.0, 0.0, 1.0, -1.0]$$

which can be written as:

$$s_1 + (-2)s_2 + (-2)s_3 + s_8 \geq 1$$

Boolean expression: $\texttt{go-north} = (s_1 + s_8)\bar{s}_2\bar{s}_3$

s_1	s_2	s_3	s_8	Expression
1	0	0	x	$s_1\bar{s}_2\bar{s}_3$
x	0	0	1	$s_8\bar{s}_2\bar{s}_3$

Table 2: Boolean Expression for Go North

Question 5

Answer: No, because this is not a linearly separable problem. For the decision `go east`, for example, it is expressed as $s_2\bar{s}_4 + s_3 = s_2\bar{s}_4 + \tilde{s}_4 \cdot (pa = S) \cdot \bar{s}_2$ where s_2 and $\bar{s}_2$ cannot exist at the same time.