Introduction to machine learning

exam solutions

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1.1 A

1. (10 points) What does the "IKEA test" (designed to test artificial general intelligence) consist of?

Solution: The machine is able to correctly assemble a piece of furniture based on the supplied instructions by controlling a robot.

2. (15 points) What is the supervised learning method? Draw a figure to introduce the mechanisms of the method!

Solution: Given a training set of n example input/output pairs $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, the goal is to approximate the unknown function f that maps input vectors to outputs, so that new data without output (called unlabeled data) can be predicted.

Figure 1: Supervised learning

3. (15 points) What are the main types of deep reinforcement learning algorithms? What is the goal of each approach?

Solution: Deep learning algorithms can be classified based on their strategy for finding the optimal policy.

Value learning: The goal is learning a Q value function, that can be used to find the optimal policy:

$$\pi^*(s) = \arg\max_a Q(s, a)$$

Policy learning: The goal is to directly learn the optimal policy without explicitly estimating the value function. It estimates the policy using a parameterized function, which is fine tuned through a learning process.

$$\pi^*(s) \sim \pi(s)$$

4. (30 points) A genetic algorithm uses binary coded individuals. In a given generation, there are 6 individuals:

$$x_1 = [0110111001], \text{fitness} : 5$$
$$x_2 = [0101100101], \text{fitness} : 27$$
$$x_3 = [1010011100], \text{fitness} : 30$$
$$x_4 = [0010010011], \text{fitness} : 33$$
$$x_5 = [1101101100], \text{fitness} : 5$$
$$x_6 = [1010101010], \text{fitness} : 100$$

Using roulette wheel selection, calculate the expected number of copies of each individual in the crossover while maintaining a constant population size, i.e. select 6 parents, which will be the parents during the crossover! Illustrate the crossover with the selected parent individuals, and then also show the mutation with uniform mutation, assuming a mutation probability of 5% per bit!

Solution:

no.	Initial population	Fitness	$\Pr_i$	Expected count	Actual count
1	0110111001	5	0.025	0.15	0
2	0101100101	27	0.135	0.81	1
3	1010011100	30	0.15	0.9	1
4	0010010011	33	0.165	0.99	1
5	1101101100	5	0.025	0.15	0
6	1010101010	100	0.5	3	3
Sum		200	1.0	6	6

Table 1: Selection

no.	Mating pool	Crossover point	Offspring
2	01 | 01100101	2	01 | 10011100
3	10 | 10011100	2	10 | 01100101
4	0010 | 010011	4	0010 | 101010
6	1010 | 101010	4	1010 | 010011
6	101010 | 1010	6	101010 | 1010
6	101010 | 1010	6	101010 | 1010

Table 2: Crossover

We simulate a 5% chance by flipping every 20th bit.

no.	Offspring	Offspring after mutation
2	0110011100	0110011100
3	100110010<u>1</u>	100110010<u>0</u>
4	0010101010	0010101010
6	101001001<u>1</u>	101001001<u>0</u>
6	1010101010	1010101010
6	101010101<u>0</u>	101010101<u>1</u>

Table 3: Mutation

5. (15 points) What components affect the weight modification in Perceptron's training algorithm.

Solution: The learning rate and the output of the activation function.

6. (15 points) In the Schelling model, what will agent A do if its tolerance level is 45%, its color is RED, and it is in the following neighborhood:

RED	BLUE	RED
BLUE	Agent A	BLUE
RED	BLUE	RED

Solution: The agent will move, since $\frac{4}{8} = 50\%$ of the agent's neighbours are BLUE which is higher then their tolerance level.

1.2 B

1. (10 points) What does the "Coffee Test" (designed to test artificial general intelligence) consist of?

Solution: The machine enters an average home and figures out how to brew coffee:

- finds the coffee machine
- finds the coffee
- adds water
- finds a mug
- brews the coffee by the proper use of the machine

2. (15 points) What is the unsupervised learning method? Draw a figure to introduce the mechanisms of the method!

Solution: Sometimes labelled data is unavailable and in some cases not even its classes and characteristics of are known. The solution to this problem is the group similar data together in so called clusters.

Unsupervised learning takes a given set of unlabeled data, and produces output data (labels) and a function, which maps input to output.

Figure 2: Unsupervised learning

3. (15 points) What components affect the flight vector of a particle in a PSO algorithm?

Solution:

- current position
- current velocity
- distance between current position and pbest
- distance between current position and gbest

4. (30 points) In a wrestling competition, wrestlers are divided into leagues based on their height and weight. Divide the competitors into two leagues ($k = 2$) based on the data obtained using the k-means algorithm. Perform the calculation over two iterations, taking the values of the first and second competitors as the initial center points.

ID	height (cm)	weight(kg)
1	185	76
2	170	66
3	168	68
4	179	74
5	182	73
6	188	75

Solution: First iteration:

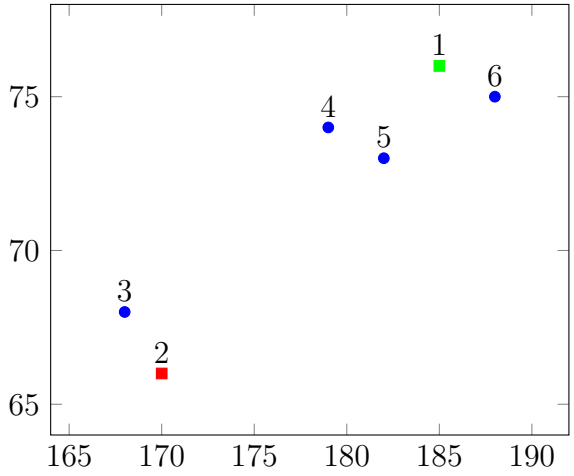

Figure 3: Initialize center points

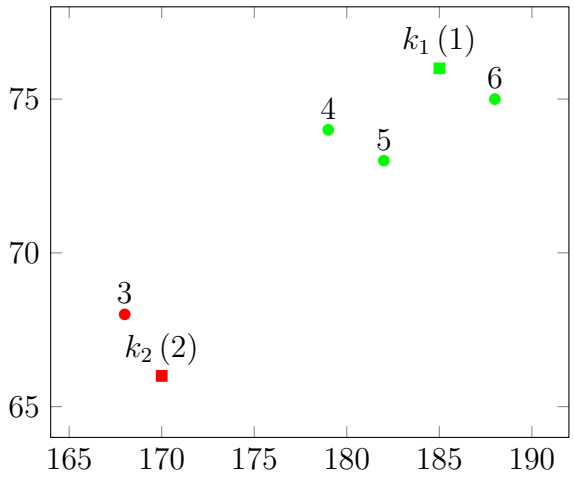

Figure 4: Assign points to nearest center

Recalculate cluster centers:

$$k_1 = \left(\frac{185+179+182+188}{4}, \frac{76+74+73+75}{4}\right) = (183.5, 74.5)$$
$$k_2 = \left(\frac{170+168}{2}, \frac{66+68}{2}\right) = (169, 67)$$

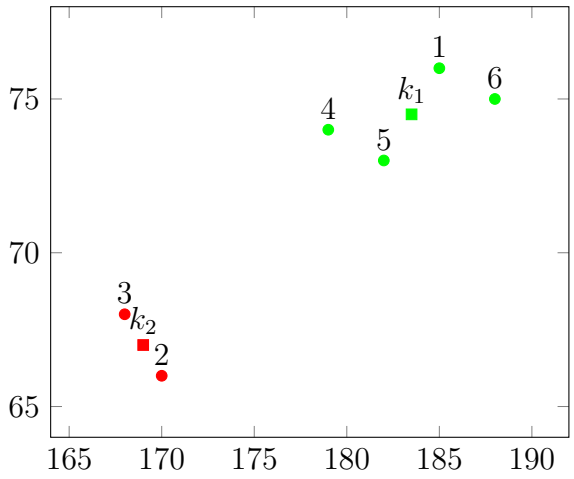

Figure 5: Move cluster centers

Second iteration: Based on the new center points, the points need to be reassigned. In our case no points change ownership resulting in the termination of the algorithm.

5. (15 points) What are the downsides of using a Q-learning method?

Solution:

- only works on discrete action spaces
- policy is computed deterministically, so the model cannot learn stochastic policies

6. (15 points) In the Schelling model, what will agent A, do if its tolerance level is 55%, its color is RED and it is in the following neighborhood:

RED	BLUE	RED
BLUE	Agent A	BLUE
RED	BLUE	RED

Solution: The agent will not move, since $\frac{4}{8} = 50\%$ of the agent's neighbours are BLUE which is lower then their tolerance level.