2024~2025 学年第一学期 智能系统设计(英) 期末正考试题

1.

a) Calculate the output for the sample network shown in Figure 1 with the given values of the weights. The activation functions for the hidden layer is Sigmoid and the output layer is linear. The inputs to the network are generated based on the last digit of your student ID (SSIDs). Use the following formula to calculate the inputs up to two decimal points precision.

A = (last digit of <SSID>) × 0.5   B = (last digit of <SSID>) × 0.2
C = (last digit of <SSID>) × 0.0

The hidden layer activation function (D, E, F, G) is $f(x) = \frac{1}{1+e^{-x}}$, and the output layer (H, I) is a linear function $f(x) = x + 2$. The bias for neurons in the hidden layer and the output layer are 0.5 and 0.6, respectively.
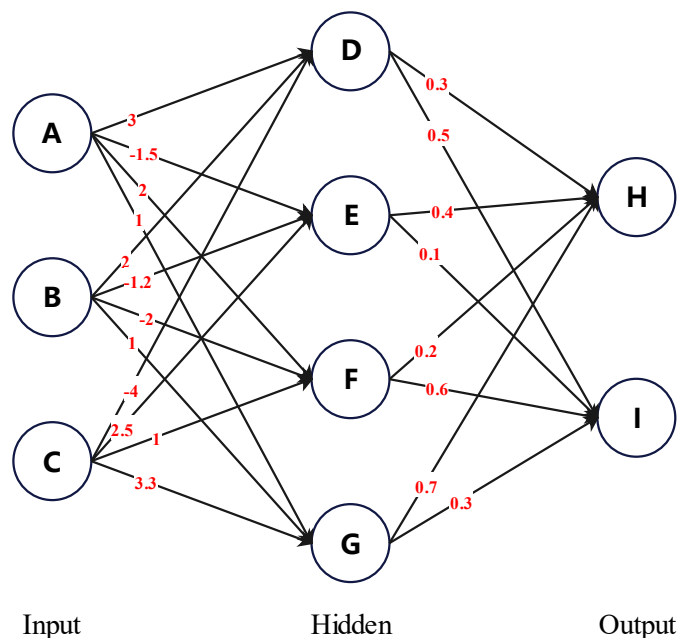

Figure 1

[40%]

b) What is the difference between a neural network designed as an approximator and one designed as a classifier?

[20%]

c) What is the most popular algorithm for training a neural network? Describe the concept of the algorithm.

[20%]

d) What is a training set and how is it used to train neural network?

[20%]

2.

a) A SOM neural network shown in Figure 2 has four inputs and two clusters to be trained using the following training vectors $X_n(1) = [0.2\ 0.3\ 0.8\ 0.1]$, $X_n(2) = [0.6\ 0.9\ 0.9\ 0.8]$ and the initial weights:

$$\begin{bmatrix} 0.5 & 0.2 \\ 0.6 & 0.4 \\ 0.8 & 0.5 \\ 0.3 & 0.5 \end{bmatrix}$$

Calculate the weight changes during the 1st iteration using the training vectors in the given order. The learning rate $\eta = 0.1$
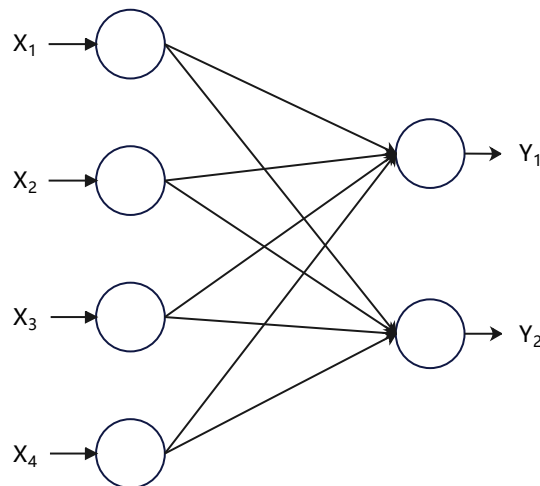

Figure 2

[30%]

b) A fuzzy set is fully defined by its membership functions. Explain how a membership function can model imprecision and vagueness.

[20%]

c) Explain how fuzzy inference mechanisms work, giving two types.

[20%]

d) Two fuzzy sets defined as follows:
A = (0.1/10 + 0.5/20 + 1.0/60 + 0.6/80 + 0.1/100)
B = (0.3/10 + 0.6/20 + 0.9/60 + 0.6/80 + 0.3/100)
i) Find the Cartesian Product
ii) Find (A ∩ B) and (A ∪ B)

[30%]s

3.

a) Genetic algorithm is computing intensive algorithm, what are the selection and regeneration methods. Explain each method and show the advantages and disadvantages of each.

[20%]

b) Minimize the function $f(x) = \sum_{i=1}^{D} x_i^2$ in the range of $-100 \leq x_i \leq 100$ for D=5 using Genetic Algorithm:

i) Define the chromosome and fitness function for the function minimization problem.

[20%]

ii) Draw a flowchart for the different steps in an elapsed generation. Define each step for the function minimization problem.

[20%]

iii) Explain the difference between phenotype and genotype. Identify the phenotype and genotype for the function minimization problem.

[20%]

c) Machine Learning is an important aspect of Artificial Intelligence. Explain the differences between supervised and unsupervised tasks for Machine Learning. Quote an example of each?

[20%]

4.

a) Choose one correct answer from the following multiple-choice questions:
   i) Sampling refers to?
      a. Discretization of the spatial image domain
      b. Inversion of the pixel values
      c. Testing the possible positions an object in an image can take
      d. Discretization of the values an image pixel can take

[10%]

   ii) Quantization refers to?
      a. Discretization of the spatial image domain
      b. Inversion of the pixel values
      c. Testing the possible positions an object in an image can take
      d. Discretization of the values an image pixel can take

[10%]

b) High-definition television (HDTV) generates images (frames) with the resolution in the vertical direction is 1125 pixels. The width-to-height aspect ratio of the images is 16:9. The fact that the resolution in the horizontal direction is in the same proportion as the width-to-height ratio. Each pixel is the colour image has 8 bits of intensity each for a red, a green and a blue component image. These three "primary" images form a colour image. There are 30 images (frames) to get 1 second video. How many bits would it take to store the images from a two-hour HDTV movie.

[30%]

c) If we go from a pixel with coordinate (4,6) to a pixel with coordinate (1,1) through the shortest path, explain how many step(s) are required for 4-adjacency and 8-adjacency, respectively.

[20%]

d) Write down the affine transformation matrices and coordinate equations for scaling and translation.

[30%]

5.

a) Explain using a block diagram with statements on the JPEG compression of a grayscale image.

[20%]

b) Table 1 shows an 8 × 8 block of quantized discrete cosine transform (DCT) coefficients in JPEG. Arrange the alternating current (AC) coefficients in zig-zag order up to the last non-zero coefficient.

Table 1

-11	2	0	0	-1	-1	0	0
0	2	1	1	0	0	0	0
0	-2	0	1	0	0	0	0
-1	0	-1	0	0	0	0	0
-1	1	-1	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

[10%]

c) Consider the following text message:

"aaaaaaaaaccfffffffffffddddddffffffff"

(9 个 a,2 个 c,9 个 f,5 个 d,8 个 f)

Suppose a message contains the following characters with their frequency:

   i) If each character takes 1 byte. How many bits will be used to transmit the message (no compression applied).

[10%]

   ii) Derive the Huffman code for this message.

[40%]

   iii) If the compression technique used in Huffman Coding, how many bits will be saved in the message?

[20%]

6.

a) Suppose that a 3-bit image (L=8) of size 32 × 32 pixels has the intensity distribution shown in Table 2, where the intensity levels are integers in the range [0, L-1] = [0, 7].

Table 2

r_k	$r_0 = 0$	$r_1 = 1$	$r_2 = 2$	$r_3 = 3$	$r_4 = 4$	$r_5 = 5$	$r_6 = 6$	$r_7 = 7$
n_k	127	255	212	164	42	61	100	63

i) Write down the histogram equalization transformation function (both continuous and discrete cases).

[20%]

ii) Calculate the equalized histogram.

[20%]

iii) Briefly explain what histogram matching is.

[10%]

b)

i) Plot a figure that includes the following intensity transformation functions: negative, identity, n^{th} root and n^{th} power, X axis should be the input intensity levels r and y axis should be the output intensity levels s.

[20%]

ii) Show the diagram of box kernel and Laplacian kernel. Explain their usages and identify which kind of filter they are (low pass or high pass).

[30%]