49275 NEURAL NETWORKS AND FUZZY LOGIC (Summer 2021)

ASSIGNMENT 2

QUESTION ONE [50 marks]

This problem is a variation of a pattern recognition problem. It is a simple recognition problem with three numbers 1, 7 and 4, in different forms as shown in Figure 1a.

The six input vectors $\mathbf{x}_1, \mathbf{x}_2, \mathbf{x}_3, \mathbf{x}_4, \mathbf{x}_5, \mathbf{x}_6$ and the corresponding target vectors $\mathbf{d}_1, \mathbf{d}_2, \mathbf{d}_3, \mathbf{d}_4, \mathbf{d}_5, \mathbf{d}_6$ in the training set are:

$$\mathbf{x}_1 = \begin{bmatrix} -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \quad \mathbf{x}_2 = \begin{bmatrix} -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \quad \mathbf{x}_3 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \quad \mathbf{x}_4 = \begin{bmatrix} -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \quad \mathbf{x}_5 = \begin{bmatrix} 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \\ -1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \quad \mathbf{x}_6 = \begin{bmatrix} -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \\ -1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \\ -1 \\ -1 \\ 1 \\ -1 \\ -1 \end{bmatrix}$$

$$\mathbf{d}_1 = \begin{bmatrix} 1 \\ -1 \\ -1 \end{bmatrix}, \mathbf{d}_2 = \begin{bmatrix} 1 \\ -1 \\ -1 \end{bmatrix}, \mathbf{d}_3 = \begin{bmatrix} -1 \\ 1 \\ -1 \end{bmatrix}, \mathbf{d}_4 = \begin{bmatrix} -1 \\ 1 \\ -1 \end{bmatrix}, \mathbf{d}_5 = \begin{bmatrix} -1 \\ -1 \\ 1 \end{bmatrix}, \mathbf{d}_6 = \begin{bmatrix} -1 \\ -1 \\ 1 \end{bmatrix}$$

Assume that the network has 3 hidden layer neurons and all continuous perceptrons use the bipolar logistic activation function $f_2(v) = \frac{1-e^{-v}}{1+e^{-v}}$. . Note that due to the necessary augmentation of inputs and of the hidden layer by one fixed input, the trained network should have 26 input nodes, 4 hidden neurons, and 3 output neurons. Assign "–1" to all augmented inputs.

1.1 Assume that the learning constant is $\eta = 0.4$, and the initial random output layer weight matrix $W(1)$ and hidden layer weight matrix $\bar{W}(1)$ are

$$W(1) = \begin{bmatrix} 0.2007 & -0.0280 & -0.1871 & 0.3366 \\ 0.5522 & 0.2678 & -0.7830 & 0.7526 \\ 0.4130 & -0.5299 & 0.6420 & 0.0620 \end{bmatrix}$$

$$\bar{W}(1) = \begin{bmatrix} -0.2206 & 0.2139 & 0.4764 & -0.1886 & 0.5775 & -0.7873 & -0.2943 & 0.9803 & -0.5945 & -0.2076 \\ 0.1932 & 0.8436 & -0.6475 & 0.3365 & 0.1795 & -0.0542 & 0.6263 & -0.7222 & -0.6026 & 0.3556 \\ 0.6525 & 0.3525 & -0.7127 & -0.2266 & 0.9001 & 0.0526 & 0.3200 & -0.7556 & 0.8162 & -0.2201 \end{bmatrix}$$

$$\begin{bmatrix} 0.7611 & 0.9635 & -0.1627 & -0.0503 & 0.3443 & -0.4812 & 0.8625 & 0.3333 & 0.1565 & 0.7611 \\ -0.2030 & -0.0680 & 0.6924 & 0.5947 & 0.6762 & 0.2802 & -0.1763 & 0.5520 & 0.2588 & 0.3365 \\ -0.1762 & 0.3838 & -0.9662 & 0.4567 & 0.2211 & -0.8686 & 0.0110 & 0.9339 & -0.5050 & 0.1110 \end{bmatrix}$$

$$\begin{bmatrix} 0.3211 & 0.7651 & -0.9820 & 0.2245 & 0.3536 & -0.1562 \\ 0.7628 & -0.5172 & 0.3358 & 0.7878 & -0.1101 & 0.8217 \\ -0.7695 & 0.2020 & 0.3378 & 0.9417 & -0.5127 & -0.3599 \end{bmatrix}$$

Using the error back propagation training, calculate the next weight updates $W(2)$, $\bar{W}(2)$

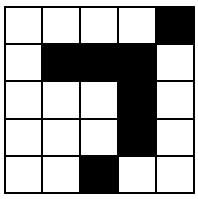
[20 marks]

1.2 The above training set was trained with the same set of initial random output layer weight matrix $W(1)$ and hidden layer weight matrix $\bar{W}(1)$ as above, and a learning constant of $\eta = 0.4$. The training set was recycled when necessary.

Determine the final weight matrices $W_f = W(301)$ and $\bar{W}_f = \bar{W}(301)$ after 50 cycles. Plot the cycle error curve for this training exercise.

[15 marks]

1.3 One of the test number patterns, which is shown below:



i) Calculate the output vector **z** which is generated from the above input. How would the neural network classify this feature input?

ii) Suggest one solution if we want to improve the testing classification performance. Please provide a reason and testing result.

[15 marks]

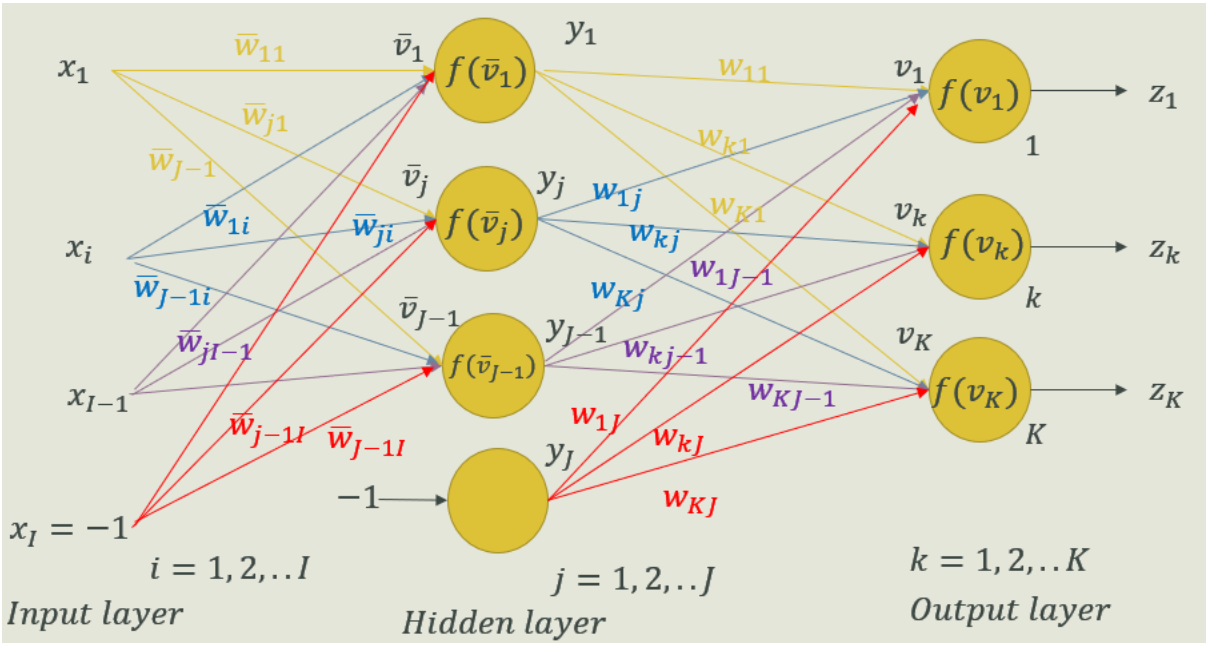
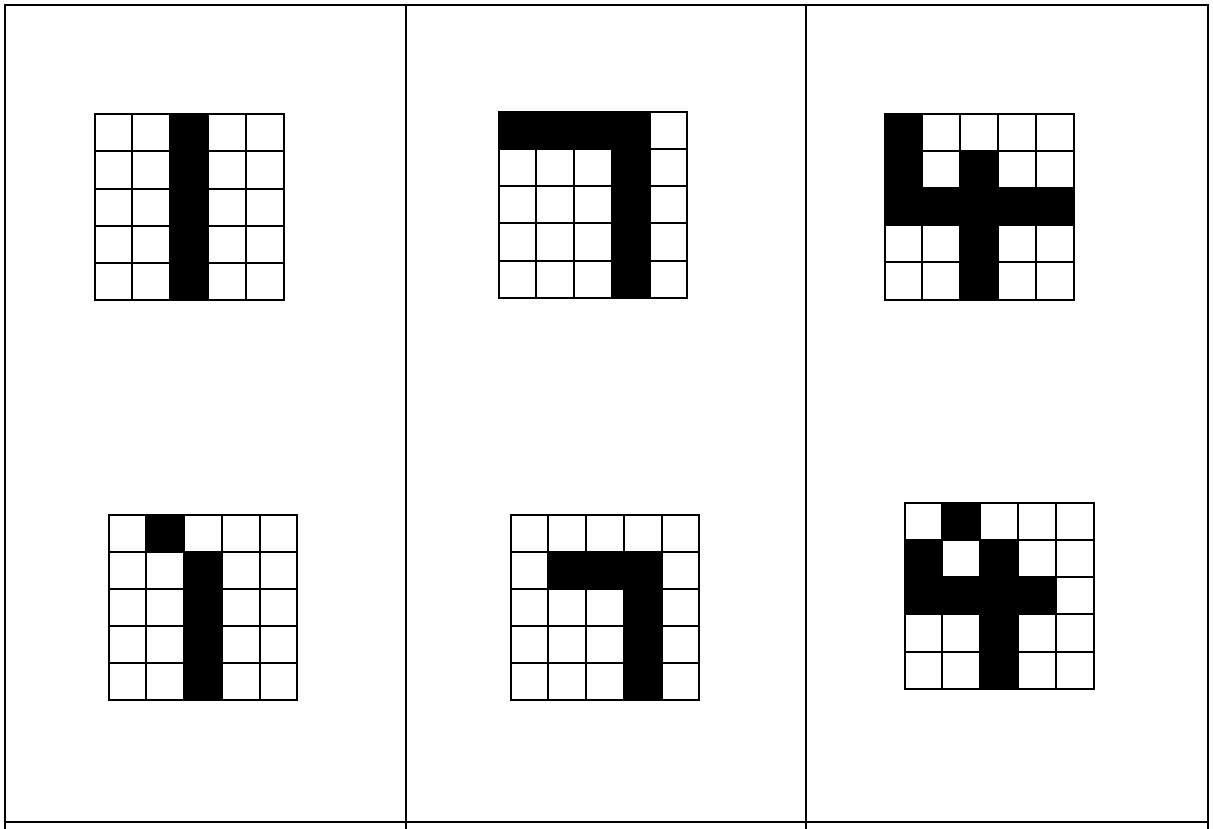


Figure 1a Multilayer Neural Network



Number “1”	Number “7”	Number “4”

Figure 1b. Training Set.

QUESTION TWO [50 marks]

Design a Convolutional Neural Network (CNN) to classify dog and cat images where each class contains 300 images. Firstly, scale all the images to the uniform size. Then, use the designed CNN to classify them, the ratio of training and testing is 7:3.

Please download the data from the following link,
https://1drv.ms/f/s!AgoQNREYWZ_QgZY9QiONBeL8n--znQ.

2.1 In this CNN, there are total 4 convolution layers with 24, 28, 32, and 36 filters, respectively. The filter size of the convolution layers is 5, stride is set at 1, padding is set at 2. Batch normalization is used and the active function is ReLU. After each convolutional layer, a max pooling layer is followed with filter size of 2 and the stride is set at 2. Adam (adaptive learning rate method) is used for training and the initial learning rate is set at 0.001.

Train the network for 50 epochs and show that the network is able to achieve >67% accuracy on the test dataset. [30 marks]

2.2 Optimise the CNN hyperparameters and show that the final testing accuracy is improved by 10% compared with the result of Q2.1 or the final testing accuracy is 75% or above. A briefly analysis should be given. [20 marks]

Figure Q2. Samples of dog and cat images