Master Experiment II – Complexity of Neural Networks

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**Dataset** **and Preprocessing**

The MNIST handwritten digit database contains black and white images of handwritten digit (0~9) with image size of 28x28 pixels. The original image is a 28x28 2D matrix with pixel values in the range of [0,255]. To properly construct an associate memory neural network, I transform all values to -1/1 and flattened each matrix to a 1D vector with length 784.

**Associate Memory Network**

A picture containing text, clipart

Description automatically generatedA picture containing text, clipart

Description automatically generatedIn this experiment, the associate memory network learns the pattern of 4 training images of digit 0, 1, 2, 3 respectively. Next, the network is tested to recognize the original training images, as well as 4 testing images that are slightly different. I compute the normalized inner product to measure the similarity between the recognized image and each training image. I also visualize the recognized image.

A picture containing logo

Description automatically generated Training Images Testing Images

[0.8648, 0.676, 0.7526, 0.7474]

[0.676, 0.8648, 0.7577, 0.7423]

[0.6939, 0.699, 0.9235, 0.7245]

[0.699, 0.6939, 0.7347, 0.9133]

Results for Training Images

A picture containing chart

Description automatically generated[0.8648, 0.676, 0.7526, 0.7474]

[0.676, 0.8648, 0.7577, 0.7423]

[0.699, 0.6939, 0.7347, 0.9133]

[0.699, 0.6939, 0.7347, 0.9133]

Results for Testing Images

Given training images as input, the network correctly recognizes the image. We can visually confirm that each recognized image looks similar to digit 0, 1, 2, 3 respectively. Quantitatively, the inner product is maximized between each recognized image and the correct training image . Given testing images as input, the predictions are accurate except digit 2, which is recognized as 3. Furthermore, adding the number of network inference iterations does not affect the results.

**Capacity of Associate Memory Network**

Qr code

Description automatically generatedQr code

Description automatically generatedI train a network to recognize 10 images of digit 0,1,…,9. However, the trained network fails to give the correct prediction. For all digits, the network converges to predict digit 8 after 3 iterations. One potential reason is that high similarity between the training images (avg 0.6481 inner product) confuses the network.