SOM and Image Data Compression

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1. Introduction

The data for learning was a Lena image, a gray scale image. The computer assignments aim to design a self-organized feature map to reduce the vector quantization of images. The computer assignments created a SOFM in MATLAB code [1] with a different number of neurons. The best model was used to reconstruct the different images. The computer assignments provided plots for all networks.

2. Theory

Self-organizing maps are neural networks. In most cases, the training goal is to represent the input dimension space as a map space with two dimensions. The mapped space is made up of components called neurons, which are arranged in a hexagonal or rectangular grid with two dimensions (Figure 1). The number of nodes and their location is predetermined based on the more extensive data analysis and exploration [2].

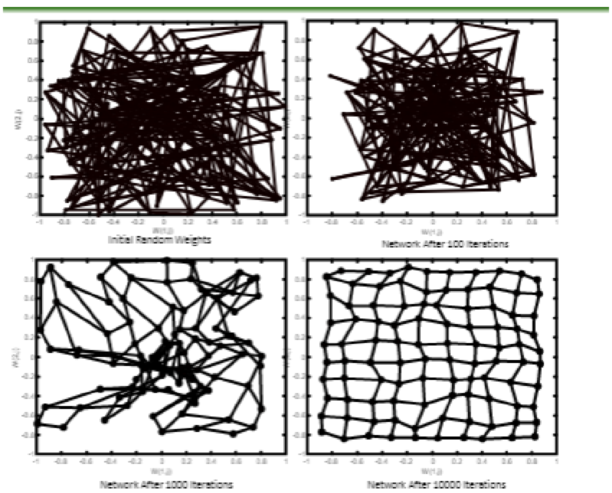

Figure 1 The CNN model,

Each node in map space is associated with a weight vector, which is the node's position in the input space. While the nodes in the map space remain fixed, learning consists of moving the weight vectors to the input data without disturbing the topology obtained from the map space. Once trained, the map can be used to classify additional observations for the input space by finding the node with the closest weight vector to the input.

The approximation for the lateral connection function used in SOFM is

$$y_i(k+1) = f(x_i(k+1) + \sum_{m=-m_0}^{m_0} \gamma_m y_{i+m}(k))$$

Where $x_i(k)$ and $y_i(k)$ are the input and output of the neuron, i at time k and γ_m are the feedback coefficient. The second term shows the effect of all the lateral connections within the excitatory region of $m \in [-m_0, m_0]$.

3. Results and discussion

The first step is to partition one of the images used for training into non-overlapping blocks of sizes 4x4 and train various SOFM networks to establish the codebook vectors. The Matlab code provides five types of SOFM with 16, 32, 64, 128, and 256 neurons in architectures. On all of the networks presented, the topology is presented in Figure 2.

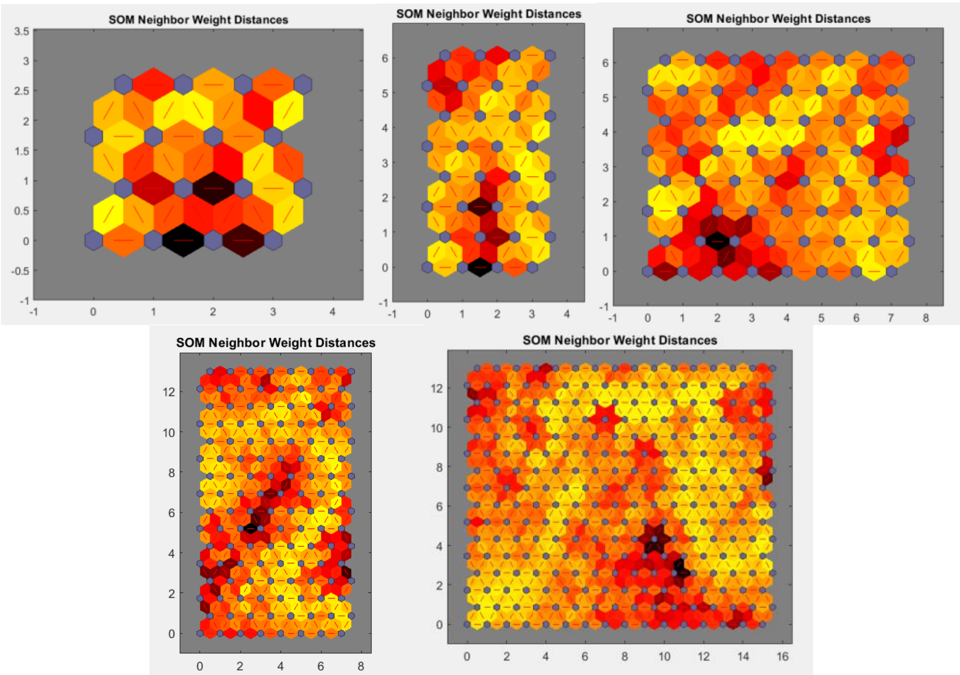

Figure 2 Topology of SOM network [4 4],[4 8],[8 8],[8 16],[16 16]

The SOFM has the same hexagonal topology in all cases. However, the shape of the whole SOM depends on the number of neurons. If the number of neurons is in the square of some number, then the square; otherwise, is it a rectangle. Moreover, the number of most dominant weights is located in the lower half of the topology.

The weights for all network was written in different bits per pixel. The 2 to 8 bites record was chosen for this assignment. The original and reconstructed training images are presented in Figure 3.

Figure 3 Original and reconstructed image with different networks and BPP.

The SNR rate versus BPP is presented in Figure 4 and the compression rate is presented in Table 1.

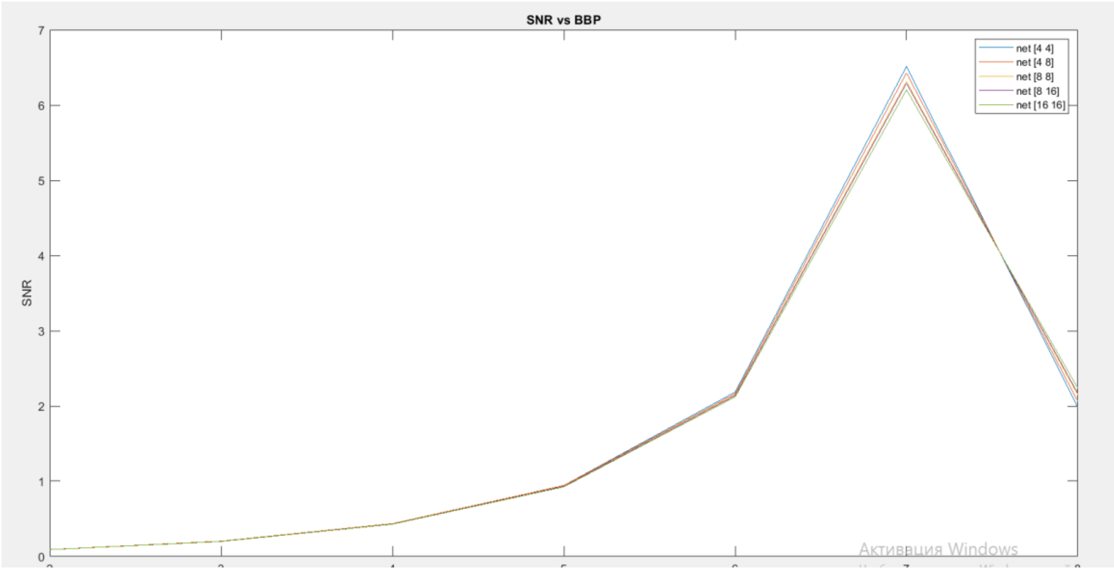

Figure 4 SNR vs. BPP

Neurons	Compression rate
16	32
32	16
64	8
128	4
256	2

Table 1. Compression rate.

The best network from the plot is the network with 16 neurons when the weight is seven bpp. This network was used to encode and reconstruct the image boat presented in Figure 5.

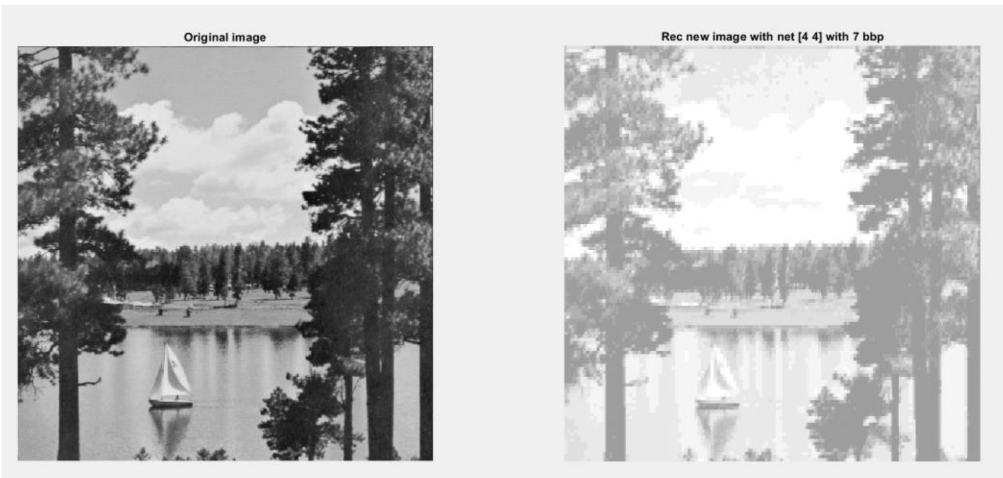

Figure 5 The original and reconstructed boat image

4. Conclusion.

The advantages of the SOM are simple to scale with different sizes of the image. Also, SOM methods are simple to understand. Moreover, SOM is good performance and robustness. However, one major problem with SOMs is getting the correct data. Unfortunately, data need to have a value for each member of the samples' dimensions to generate a map. Moreover, another problem is that every SOM is different and finds different similarities among the sample vectors. Furthermore, SOMs is that they are very computationally expensive.

Thus, the image in this assignment was successfully reconstructed and plotted various relations between SNRs and BPPs. The different topologies were used, and analysis changes of increasing neurons and how they influenced the reconstructed image.

Reference

1. The official MATLAB site: https://www.mathworks.com/
2. The professor M.R Azimi lecture 25-26