University of Wollongong

School of Computing and Information Technology

CSCI464/964 **Computational Intelligence**

Assignment 3 **(Due: 11 PM 5 May)** **10 marks**

--- Part 1 (Self Organizing Map, 5 marks) ---

Aim: This assignment is intended to provide basic experience in implementing self-organizing map (SOM). After having completed this assignment you should know how to realize an SOM network, understand its training process, and interpret the learned weights.

Assignment Specification:

1. A subset of the MNIST data set (http://yann.lecun.com/exdb/mnist/) is provided with this assignment in "SOM_MNIST_data.txt". It consists of 5,000 examples, each of which corresponds to one column of this text file. Each example has been reshaped from a 28 by 28 gray-level image into a 784-dimensional feature vector. You will be able to view the original images by reshaping each feature vector back and display the 28 by 28 matrix with appropriate image-processing software.
2. Read the lecture notes and other resources (for example, Chapter 9 of [1]) to review SOM. Basically, given a dataset, SOM aims to learn a set of prototypes of the data and spatially arrange the prototypes in a way that is indicative of the data distribution in the original input space. Implement an SOM neural network and train its weights with the provided dataset. The default size of the 2D lattice is 10 by 10. You can use a reasonably larger or smaller size according to the computational resource available to you. An example code written in Matlab is provided for your reference. Note that you are required to implement SOM in C++ by yourself and are **NOT** allowed to use this Matlab code for this assignment.
   [1] Neural Networks and Learning Machines (3rd Edition), Simon Haykin, Pearson, November 2008.
3. Write a report on this part. It shall include
   1) A brief introduction on the MNIST data set (read the above link) and the examples provided in this assignment;
   2) An introduction of the steps of training an SOM neural network. In particular, describe the two phases (ordering and convergence) of the training process and how to set the learning parameters in the two phases;
   3) The change of the weights between two consecutive epochs is indicative of the convergence of the training process. To characterize this change, for each weight vector compute the Euclidean distance between its values in the t-th and (t+1)-th iterations, and then use the sum of all the Euclidean distances as a criterion. Plot the value of this criterion with respect to the number of epochs and describe its evolution;
   4) Plot the learned weight vectors of the 2D lattices corresponding to the following three stages. The first one is at the initialization stage and the third one is at the convergence (or stable) stage, while the second one is in between. Each weight vector shall be plotted as a 28 by 28 image. Example figures of the first and last stages are provided in next page for your reference. Note that your figures are not necessarily same as the examples.
   5) You are encouraged to investigate various settings to train this SOM neural network, including the number of training examples, the size of 2D lattice, the learning rate, the size of neighborhood, and the number of epochs, etc. Provide detailed discussion and analysis of what you have observed and experienced.

Submit:

Parts 1 and 2 will be submitted together. The submission instruction will be released with the part 2 of this assignment shortly.

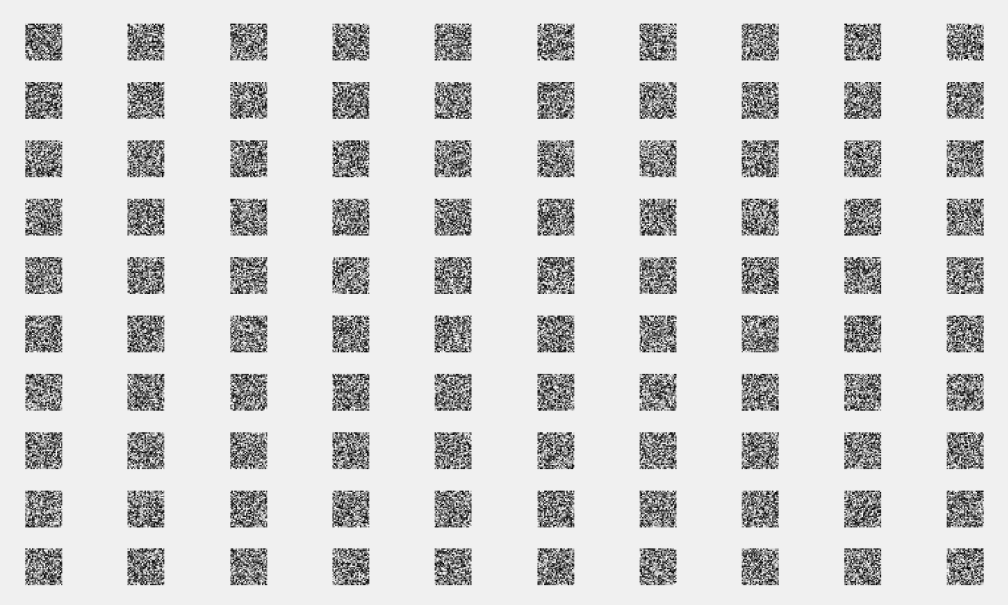

Fig. 1 Visualization of the **initial** weight vectors

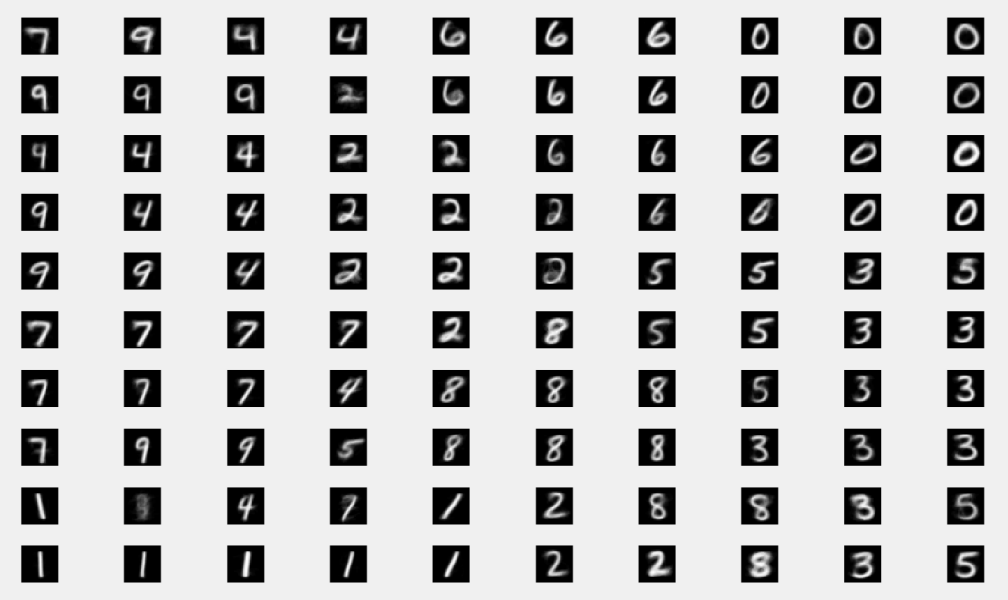

Fig. 2 Visualization of the **evolved** weight vectors