Homework Module:

Applying Self-Organizing Maps to the Traveling Salesman Problem(TSP)

Purpose: Gain hands-on experience with competitive neural networks, in particular, Kohonen's self-organizing maps.

1 Assignment

Implement a Self-Organizing Map (SOM), as described in the compendium file learn-unsup.pdf [1], and apply it to the Traveling Salesman Problem (TSP), as discussed in that same compendium file. Be familiar with SOMs and their application to TSP before beginning this assignment.

Your system should be able to run on the 3 smallest TSP data sets at the following website:

http://www.tsp.gatech.edu/world/countries.html,

which are western-sahara (29 cities), djibouti(89 cities), and qater(194 cities). Feel free to try it on larger sets as well.

You must be able to produce diagrams similar to those at the bottom of Figure 1 [2]. These diagrams show the neurons of the ring at their current locations, the connections to their two neighbor neurons, and the locations of the TSP cities. You must be able to produce several of these figures during any run so that the progress of the SOM is clearly visible. It doesn't matter whether you write graphic routines to generate these diagrams during the run or whether you write data to a file and plot it out in Gnuplot, EXCEL, etc., but you must produce the diagrams at user-specified intervals during the run.

For **each** of the three TSP data sets, you must generate (at least) 3 such diagrams (to be included in your report). That's 9 diagrams in all. These will show the status of the SOM at the beginning, in the middle, and at the end of the run. You will probably need many more runs to tune your parameters, but it is only these 3 runs that need to be included in the final report.

Your system should also illustrate its progress by printing out the total distance (D) of the current TSP solution encoded by the neuron-ring scaffolding. Since the SOM algorithm does not actually use D, and

[1] Chapter 3 of *The Essence of Neural Networks* (Callan) provides a thorough description of self-organizing maps, as do many other neural-network books and on-line resources, such as Wikipedia.

[2] Reprinted from the the section entitled *Self-Organizing Maps and the Travelling Salesman Problem* in the compendium file learn-unsuppdf

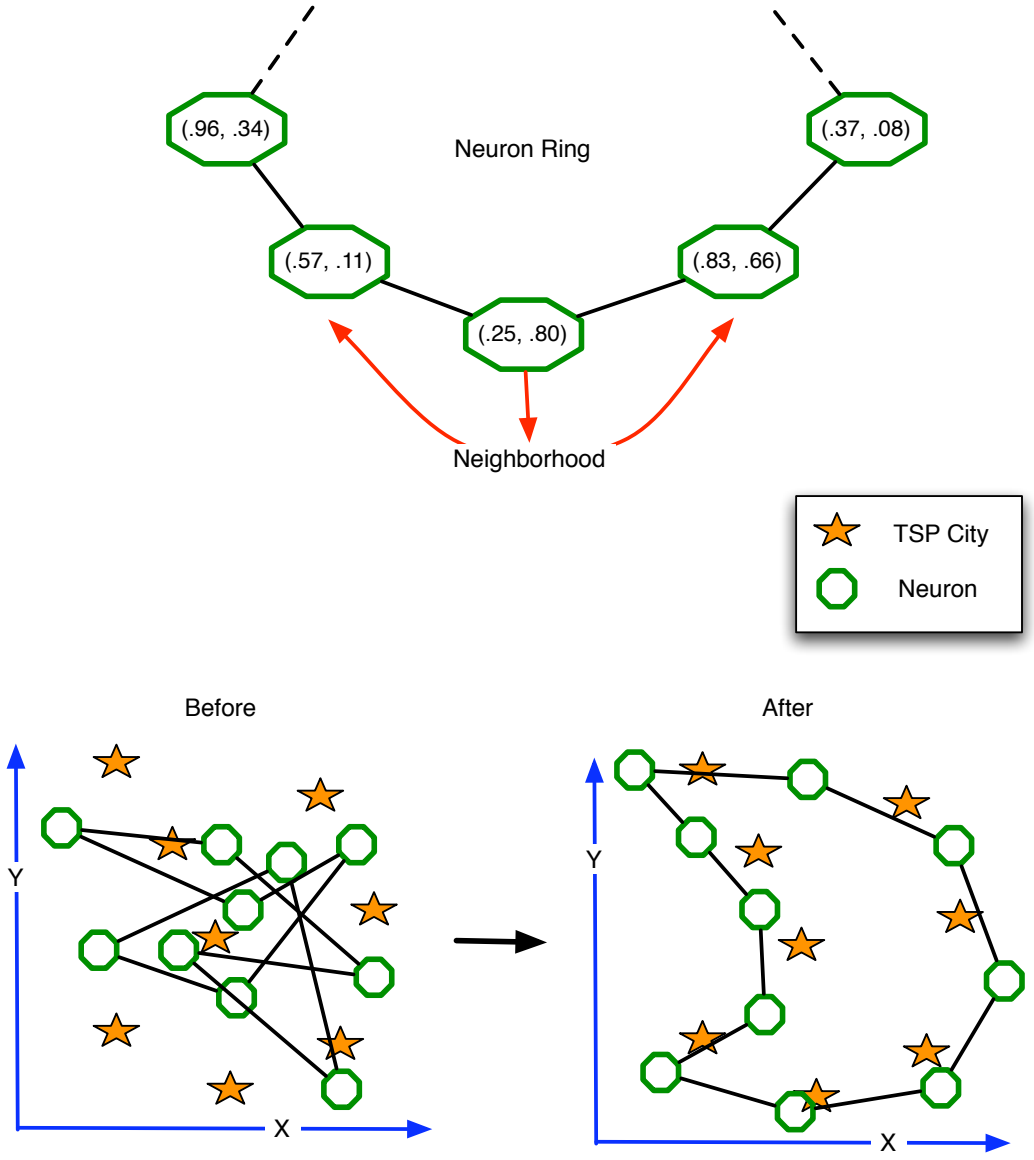

Figure 1: Illustration of the use of a self-organizing map to solve the Traveling Salesman Problem (TSP). (Above) The neuron topology is a ring, with each neuron's weight vector denoting a location in 2-d space. (Bottom) City locations (stars) and neurons (octagons) shown on the cartesian plane, with coordinates corresponding to a) the locations of the cities on a scaled map, and b) the weight vectors of each neuron.

since it requires extra computations to generate it, you need only calculate and display D every k steps of the algorithm, where k is a user-specified parameter.

The following results and parameters must be documented **for each of the 3 runs**:

1. The total distance (D) of the final TSP solution produced at the end of the run.
2. The number of neurons in the ring.
3. The initial neighborhood size and the change in neighborhood size (per timestep).
4. The initial learning rate and the change in the learning rate (per timestep).

2 Deliverables

1. An overview description of your system with text and a diagram or two. **(2 points)**
2. A description of your experiences tuning the system: what parameter values were critical to getting the system to work correctly and **why**? **(1 point)**
3. The 9 diagrams, 3 total distances, and parameter values mentioned above. **(6 points)**
4. Using any sources that you prefer, find 2 published applications of SOMs (i.e. Kohonen networks) and describe each in approximately 1 page of text per system. In your descriptions, be sure to mention the two spaces that are involved, i.e., the two spaces for which the SOM finds a suitable isomorphism. One is always neuron space (whether 1 or 2 dimensional), but the other will vary, depending upon the application. Feel free to include diagrams, and be sure to include at least one full reference/citation for each example. A Wikipedia reference alone is not sufficient, so you will need to track down the actual paper (that is often cited on Wikipedia). Referencing a textbook is fine, so in that case, you need not track down the journal or conference paper. **(6 points)**

2.1 Warning

Depending upon the actual course and semester - your instructor uses this module in various courses - you may or may not be required to do any or all of the following:

1. Demonstrate this module to the instructor or a teaching assistant.
2. Upload the report and/or code for this module to a particular site such as *It's Learning*.

Consult your course web pages for the requirements that apply.