Designing an Expanded SOM for Traveling Salesman Problem by Genetic Algorithms

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1 Overview

This paper addresses the issue of evolutionary design of an efficient Expanded Self-Organizing Map (ESOM) for Traveling Salesman Problem (TSP).

The underlying idea of the ESOM [2] is to incorporate the topological neighborhood preserving property of Self-Organizing Map (SOM) and the convex-hull property (a global optimality) of TSP together. The learning rule of its generalized version is as follows:

$$\vec{w}_j(t+1) = c_j(t)\,[\vec{w}_j(t) + \alpha_j(t)\,(\vec{x}_t - \vec{w}_j(t))]$$

where $\vec{w}_j$ is the weight of jth neuron, $\vec{x}_t$ the input city coordinate, $c_j(t)$ the expanded coefficient and $\alpha_j(t)$ the learning rate. Note that ESOM becomes a traditional SOM when $c_j(t) = 1$. While in ESOM, the expanded coefficient $c_j(t)$ (normally > 1) reflects the convex-hull property skillfully and then drives ESOM to learn the global optimality gradually. Furthermore, it should cooperate well with the traditional SOM learning rule so as to achieve a topological neighborhood preseving map. Thus, its efficient manual design seems intractable.

An efficient version of ESOM can be got by a neural-evolutionary system. In this system, the learning rule of neural networks is allowed to evolve, rather than its weights or architecture. Every learning rule is coded into an individual. In order to evaluate its noisy performance more fairly, its fitness depends both on the mean and variance of solutions got on several small-scale TSPs. These good individuals generated in the evolutionary procedure are then tested on a set of validation TSPs and the best one is output as the final learning rule. This test aims to verify their generalization capabilities.

2 Implementation and Results

The neural-evolutionary system has been implemented using genetic algorithms as the underlying evolutionary framework. The computation complexity of the finally evolved ESOM is $O(n^2)$. It has been examined on two comprehensive sets of TSPs. One simulation result and comparison is shown in Figure 1, which indicates that finally evolved ESOM outperforms the Budinich's SOM [1] and the previous ESOM [2] in terms of both solution quality and speed. Thus evolutionary algorithms, along with neural networks, help to further problem-solving capabilities.

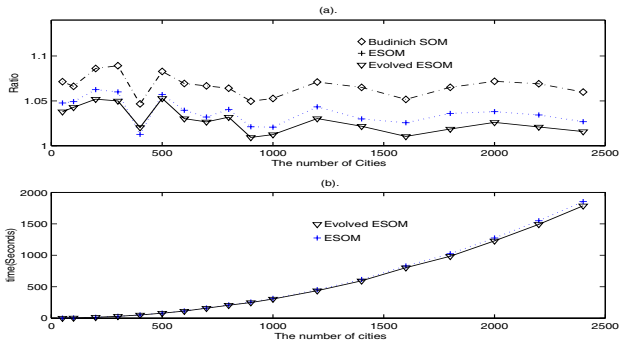

Figure 1: (a) The solution quality (over the theoretical lower bounds) comparison among the evolved ESOM, the ESOM and the Budinich's SOM on a set of 18 random TSPs. (b) The average execution time comparison between the ESOM and the evolved ESOM.

This work is supported by the Hong Kong RGC CERG Grant CUHK 4161/97E.

References

[1] M. Budinich, "A self-organizing neural network for the traveling salesman problem that is competitive with simulated annealing", *Neural Computation*, vol. 8, pp. 416-424, 1996.

[2] K. S. Leung, H. D. Jin and Z. B. Xu, "An improved self-organizing neural network for traveling salesman problem," submitted to *IEEE Transactions on Neural Networks*, 1999.