Modification of the Elite Ant System in Order to Avoid Local Optimum Points in the Traveling Salesman Problem

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Abstract

This article presents a new algorithm which is a modified version of the elite ant system (EAS) algorithm. The new version utilizes an effective criterion for escaping from the local optimum points. In contrast to the classical EAC algorithms, the proposed algorithm uses only a global updating, which will increase pheromone on the edges of the best (i.e. the shortest) route and will at the same time decrease the amount of pheromone on the edges of the worst (i.e. the longest) route. In order to assess the efficiency of the new algorithm, some standard traveling salesman problems (TSPs) were studied and their results were compared with classical EAC and other well-known metaheuristic algorithms. The results indicate that the proposed algorithm has been able to improve the efficiency of the algorithms in all instances and it is competitive with other algorithms.

Keywords: Elite Ant System Algorithm, General and Local Updating, Traveling Salesman Problem, Combinatorial Optimization Problems.

1. Introduction

Ant colony optimization (ACO) which has been inspired by the behavior of real ants seeking a path between their colony and a source of food is one of the most important meta-heuristic algorithms. Initially proposed by Marco Dorigo in 1992, the first algorithm which was called Ant System (AS) aimed at searching for an optimal path between two nodes in a graph. Therefore, a problem is divided into some sub-problems in which the simulated ants are expected to select the next node based on the amount of the pheromone in a trail and the distance to the next node. The decision for choosing the unvisited N_i node by ant k located in node i is made based on formula (1) where τ_{ij} indicates the amount of pheromone on (i, j) edge while η_{ij} shows inverse distance between i and j. However, both are powered by α and β which can be changed by the user. Therefore, their relative importance can be altered.

$$P_{ij}^{k} = \begin{cases} \frac{\tau_{ij}^{\ \alpha} \eta_{ij}^{\ \beta}}{\sum\limits_{j \in N_{i}} \tau_{ij}^{\ \alpha} \eta_{ij}^{\ \beta}} & \text{if} \quad j \in N_{i} \\ 0 & \text{if} \quad j \notin N_{i} \end{cases}$$

$$(1)$$

Ants release $\Delta \tau_{ij}$ which is called "pheromone information" on the respective path while moving from node i to node j. $\Delta \tau_{ij}$ can be calculated by formula (2).

$$\tau_{ii}(t) \leftarrow \tau_{ij}(t) + \Delta \tau_{ij}$$
 (2)

Moreover, the algorithm like its natural version makes use of pheromone evaporation in order to prevent rapid convergence of ants to a sub-optimal path. In other words, pheromone density is reduced in each iteration by $0 \le \rho \le 1$ (set by the user). If τ is the matrix for the existing pheromone on the edges of the respective graph, then it is updated in each iteration by the formula (3).

$$\tau \leftarrow (1 - \rho)\tau \qquad \rho \in [0, 1] \tag{3}$$

Refrences

- 1. Dorigo M., "optimization, Learning and natural algorithms", Ph.D Thesis, Dip.Electtronica e Informazion, Politecnico di Milano Italy, (1992).
- 2. Tsai, C.F., Tsai, C.W., "A new approach for solving large traveling salesman problem using evolution ant rules", in Neural Networks, IJCNN 2002, Proc. of the 2002 Int'l Joint Conf., Vol. 2, Honolulu, IEEE Press, pp. 1540-1545, (2002).
- 3. Wang, J. B., Wang, W., "ACO with Multiple Nests' Cooperation and Its Application on Narrow TSP", 2008 IEEE Swarm Intelligence Symposium St. Louis MO USA, September 21-23, 2008.
- 4. Zhang, P., Lin, J., "An Adaptive Heterogeneous Multiple Ant Colonies System", 2010 International Conference of Information Science and Management Engineering.
- 5. Konga, M., Tiana, P., Kaob, Y., "A new ant colony optimization algorithm for the multidimensional
- 6. Knapsack problem", Computers & Operations Research 35 (2008) 2672 2683.
- 7. Zhang, Z., Feng, Z., "Two-stage updating pheromone for invariant ant colony optimization algorithm", Expert Systems with Applications, dx.doi.org/10.1016/j.eswa.2011.07.062.
- 8. Chenga, C.B, Maob, C.P., "A modified ant colony system for solving the travelling salesman problem with time windows", Mathematical and Computer Modelling 46 (2007) 1225–1235.
- 9. Dreo, J., Siarry, P., "Continuous interacting ant colony algorithm based on dense heterarchy", Future Generation Computer Systems 20 (2004) 841–856.
- 10. Jing, Z., Wei-ming, T., Solution to the problem of ant being stuck by ant colony routing algorithm", The Journal of China Universities of Posts and Telecommunications, 2009, 16(1): 100–105
- 11. Dorigo M., Maniezzo V. & Colorni A., "The antsystem: optimization by a colony of cooperating agents", IEEE Trans on Sys 26, (1996).
- 12. Dorigo, M., & Gambardella, L. M. (1997a). Ant colony system: A cooperative learning approach to the traveling salesman problem. IEEE Transactions on Evolutionary Computation, 1(1), 53–66.
- 13. Gambardella, L. M., & Dorigo, M. (1996). Solving symmetric and asymmetric TSPs by ant colonies. In Proceedings of 1996 IEEE international conference on evolutionary computation, Nagoya, Japan (pp. 622–627).
- 14. Bullnheimer, B., Hartl, R. F., & Strauss, C. (1997). "A new rank based version of the ant system A computational study", Central European Journal for Operations Research and Economics, 7(1), 25–38.
- 15. Stutzle, T., Hoos, H.H., "MAX-MIN ant system", Future Generation Computer System, pp. 889-914, (2000).
- 16. Yadlapalli S., Malik W.A., Darbhaa S., & Pachter M., "A Lagrangian-based algorithm for a Multiple Depot, Multiple Traveling Salesmen Problem", Nonlinear Analysis: Real World Applications 10(4), pp. 1990-1999, (2009).
- 17. Mak, V., Boland, N., "Polyhedral results and exact algorithms for the asymmetric travelling salesman problem with replenishment arcs", Discrete Applied Mathematics, Volume 155(16), pp. 2093-2110, (2007).
- 18. Gavish B., & Srikanth K., "An optimal solution method for large-scale multiple traveling salesman problems", Operations Research 34(5), pp. 698–717, (1986).
- 19. Germs, R., Goldengorin, B., Turkensteen, M., "Lower tolerance-based Branch and Bound algorithms for the ATSP", Computers & Operations Research 39(2), pp. 291-298, 2012.
- 20. Cordeau, J. F., Dell'Amico, M., Iori, M., "Branch-and-cut for the pickup and delivery traveling salesman problem with FIFO loading", Computers & Operations Research 37(5), pp. 970-980, 2010.
- 21. AI A. & Kennington J.L., "Exact solution of multiple traveling salesman problems", Discrete Applied Mathematics 13, pp. 259–276, (1986).
- 22. Laporte G. & Nobert Y., "A cutting planes algorithm for the m-salesmen problem", Journal of the Operational Research Society 31, pp. 1017–1023, (1980).
- 23. Karapetyan, D., Gutin, G., "Lin–Kernighan heuristic adaptations for the generalized traveling salesman problem", European Journal of Operational Research 208(3), pp. 221-232, (2011).
- 24. Rego, C., Gamboa, D., Glover, F., Osterman, C., "Traveling salesman problem heuristics: Leading methods, implementations and latest advances", European Journal of Operational Research 211(3), pp. 427-441, (2011).
- 25. Ryan J.L., Bailey T.G., Moore J.T., & Carlton W.B., "Reactive Tabu search in unmanned aerial reconnaissance simulations", Proceedings of the 1998 winter simulation conference 1, pp. 873–879, (1998).
- 26. Rego, C., "Relaxed tours and path ejections for the traveling salesman problem", European Journal of Operational Research 106(2-3), pp. 522-538, (1998).
- 27. Zhou, W., Li, Y., "An Improved Genetic Algorithm for Multiple Traveling Salesman Problem", 2010 2nd International Asia Conference on Informatics in Control, Automation and Robotics.

- 28. Albayrak, M., Allahverdi, N., "Development a new mutation operator to solve the Traveling Salesman Problem by aid of Genetic Algorithms", Expert Systems with Applications 38(3), pp. 1313-1320, (2011).
- 29. Lawrence, V., Snyder, Daskin, M. S., "A random-key genetic algorithm for the generalized traveling salesman problem", European Journal of Operational Research 174(1), pp. 38-53, (2006).
- 30. Majumdar, J., Bhunia, A. K., "Genetic algorithm for asymmetric traveling salesman problem with imprecise travel times", Journal of Computational and Applied Mathematics 235(9), pp. 3063-3078, (2011).
- 31. Liu, Y. H., "Different initial solution generators in genetic algorithms for solving the probabilistic traveling salesman problem", Applied Mathematics and Computation 216(1), pp. 125-137, (2010).
- 32. Zhao, F., Li, S., Sun, J., Mei, D., "Genetic algorithm for the one-commodity pickup-and-delivery traveling salesman problem", Computers & Industrial Engineering 56(4), pp. 1642-1648, (2009).
- 33. Shen, G., Zhang, Y. Q., "A new evolutionary algorithm using shadow price guided operators", Applied Soft Computing 11(2), pp. 1983-1992, (2011).
- 34. Liu, Y. H., "A hybrid scatter search for the probabilistic traveling salesman problem", Computers & Operations Research 34(10), pp. 2949-2963, (2007).
- 35. Liu, Y. H., "Diversified local search strategy under scatter search framework for the probabilistic traveling salesman problem", European Journal of Operational Research 191(2), pp. 332-346, 2008.
- 36. Marinakis, Y., Marinaki, M., Dounias, G., "Honey bees mating optimization algorithm for the Euclidean traveling salesman problem", Information Sciences 181(20), pp. 4684-4698, (2011).
- 37. Wang, Y. T., Li, J. Q., Gao, K. Z., Pan, Q. K., "Memetic Algorithm based on Improved Inver–over operator and Lin–Kernighan local search for the Euclidean traveling salesman problem", Computers & Mathematics with Applications, In Press, Corrected Proof, (2011).
- 38. Faigl, J., Přeučil, L., "Inspection planning in the polygonal domain by Self-Organizing Map", Applied Soft Computing, In Press, Corrected Proof, (2011).
- 39. Ghaziri, H., Osman, I. H., "A neural network algorithm for the traveling salesman problem with backhauls", Computers & Industrial Engineering 44(2), pp. 267-281, (2003).
- 40. Cochrane, E. M., Beasley J. E., "The co-adaptive neural network approach to the Euclidean Travelling Salesman Problem", Neural Networks 16(10), pp. 1499-1525, (2003).
- 41. Masutti, T. A. S., de Castro, L. N., "A self-organizing neural network using ideas from the immune system to solve the traveling salesman problem", Information Sciences 179(10), pp. 1454-1468, (2009).
- 42. Faigl, J., "On the performance of self-organizing maps for the non-Euclidean Traveling Salesman Problem in the polygonal domain", Information Sciences 181(19), pp. 4214-4229, (2011).
- 43. Chen,S. M., Chien, C. Y., "Solving the traveling salesman problem based on the genetic simulated annealing ant colony system with particle swarm optimization techniques", Expert Systems with Applications 38(12), pp. 14439-14450, (2011).
- 44. Chen, S. M., Chien, C. Y., "Parallelized genetic ant colony systems for solving the traveling salesman problem", Expert Systems with Applications 38(4), pp. 3873-3883, (2011).
- 45. Xing, L. N., Chen, Y. W., Yang, k. W., Hou, F., Shen, X. S., Cai, H. P., "A hybrid approach combining an improved genetic algorithm and optimization strategies for the asymmetric traveling salesman problem", Engineering Applications of Artificial Intelligence 21(8), pp. 1370-1380, (2008).
- 46. Wong, L. P., Low, M. Y. H., Chong, C. S., "A bee colony optimization algorithm for traveling salesman problem", AICMS, pp. 818–823, (2008).
- 47. Shen, G., Zhang, Y. Q., "A new evolutionary algorithm using shadow price guided operators", Applied Soft Computing 11(2), pp. 1983-1992, (2011).
- 48. Zhong, W., Zhang, J., Chen, W., "A novel discrete particle swarm optimization to solve traveling salesman problem", Evolutionary Computation, pp. 3283–3287, (2007).