Global Journal of Pure and Applied Mathematics.
ISSN 0973-1768 Volume 12, Number 1 (2016), pp. 711-722

http://www.ripublication.com

# Using Proposed Hybrid Algorithm for Solving the Multi Objective Traveling Salesman Problem

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**Abstract**

In this research has been the use of proposed hybrid algorithm to solving the multi-objectives Traveling Salesman problem through the integration of the algorithm ant colony optimization With Genetic algorithm, the proposed algorithm consisted of two phases, the first phase in which the use of ant colony optimization algorithm (ACO) in the construction of primary community Genetic algorithm and the second phase in which the use of genetic algorithm in accelerating access the optimal solution, the results showed the superiority of the proposed algorithm to the rest of used algorithms the Genetic algorithm (GA)ant colony optimization algorithm, Simulated annealing algorithm (SA), Tabu search algorithm.

**Keywords:** Ant colony optimization, Genetic algorithm, meta heuristic algorithm, multi objective optimization, traveling salesman problem

## Introduction

The model of the Traveling Salesman Problem and write a short (TSP) in some sources or references it is called term (sales man), is one of the models of operations research, which received wide attention in previous years and to its importance in the process of determining the optimal path through cities where visiting each city once before returning to the city that started, and that the process of selecting the best path depends directly on the type of objective function is the achievement of one objective or multi objective In that one, as well as the nature of the objective to be achieved is a matter of Traveling Salesman Problem used by companies during the distribution of the different tasks to workers or departments or teams has, in order to achieve the lowest cost of mobility Packman, shortest path, and also less possible to Beachcomber, Beachcomber company represent tasks with cities that will visit. many of the researchers on the application method of Traveling Salesman practice, Health 2000 used int Rajesh mata in achieving field visits for patientsChronic where you use the sales man in determining the best path to work medical teams during visits, and in the same area. And in 2015 the researcher Bakhaytmethod of MOTSP to accelerate and codify the transport mechanism used in the General company for grain processing.

The book of Gutin and Punnen [6] analyzes various methods for the TSP and for some of its variants; the chapters of Johnson and McGeoch [1, 2] are devoted to heuristics respectively for the symmetric and asymmetric versions of the TSP.

Other interesting reviews are related to the use of metaheuristics for the TSP: [3] is a survey of local search (LS) methods, [12] of genetic algorithms (GA) and [10] of memetic algorithms applied to TSP.

And in recent years has been the use of TSP base compared to improve many artificial intelligence algorithms.

## The Mathematical model for The Multi objective Traveling Salesman problem (MOTSP)

The traveling salesman problem is certainly the best-known and most studied NP-hard single-objective combinatorial optimization problem (COP). We recall the formulation of the MOTSP: given N cities and p costs $c^k_{i,j}$ $(k = 1, \ldots, p)$ to travel from city i to city j, the MOTSP consists of finding a tour, i. e. a cyclic permutation ρ of the N cities, minimizing

$$\text{“min”} \quad zk(\rho) = \sum_{i=1}^{N-1} c^k_{\rho(i),\rho(i+1)} + c^k_{\rho(N),\rho(1)} \, k = 1, \ldots, p \qquad (1)$$

The majority of the instances treated in the following cited papers concern the symmetric biobjective case (p = 2); sometimes p = 3.

One of the first papers concerning MOTSP is the study of Borges and Hansen [6]. It is devoted to the “global convexity” in multi objective combinatorial optimization problems in general, MOTSP in particular. The authors analyzed the landscape of local optima, considering the classical 2-opt neighborhood (two edges are deleted and replaced with the only possible pair of new edges that does not break the tour) and using well-known scalar zing functions like the weighted sum of the objectives or the Tchebycheff function. They indicated the implications of the distribution of local optima in building multi objective meta heuristic to approximate $2Z_N$.

The process of using the methods of the previous best solution (Branch and Bound) for optimum path that achieves all the functions of the target difficult to implement and is Efficient in terms of speed to connect to the best solution is required, because the number of tracks that can are used by traveling salesman on the move is a (permutation the number of cities that will travel to them minus one). For example, if the number of cities that will travel to it Beachcomber 5 cities, the number of tracks that can are used by the (4 * 3 * 2 * 1) equal to 24 path Imagine the number of lanes will increase too big greater the number of cities that will travel to it Beachcomber called the fitness complex issues as a way of branching and specifically only be effective if they count the cities are smaller or equal to 20 cities, so it requires that there be ways to solve the problem be Efficient fit with this case, but It is intuitive ways after what is called Meta heuristic algorithms that link to the best solution by identifying the best path to achieve multiple objectives Problem Rover and advance much faster way of Branch and Bound method.

## Meta heuristic algorithms

Meta heuristic algorithms are Artificial intelligence methods that create an optimal solution and ascertained, particularly in matters large and many restrictions and in a very short time compared to the classical methods, which are electrical installations are developing traditional methods for the purpose of initial solutions are of high quality and very quick and intelligent, the most important types of these algorithms are genetic algorithm Genetic Algorithm (GA), Ant colony optimization algorithm (ACO), Simulated annealing algorithm(SA) Tabu search algorithm(TS). The key stages of implementing these algorithms begin first phase of formation of the first solution: then alternative solutions group configuration stage and the stage of improvement and accept the most appropriate solution, and the last stage is the stage stop in the absence of improvement in current values.

**Genetic Algorithm for solving MOTSP:**

**1.** Initialize the matrices of the problem.

**2.** Initialize the parameters of the algorithm is the number of chromosomes so that each chromosome represents a complete solution to the problem and also assess the probability of crossover and mutation.

**3.** Create initial population generation by generating a set of chromosome randomly each chromosome represents a complete solution for the problem.

**4.** Calculation of objective function for each chromosome in society as objective function using equation (1).

**5.** use the selection process for the way his astonishment the idea lay roulette this way to divide the society on the roulette wheel where the solution aggregates supplied objective function has better have more space to choose to be a candidate to appear in the output.

**6.** use of Crossover process by matching partial crossover (PMX) by choosing the chromosomes of society and certain permutations including the idea are as follows:

P1: **2 8 0** 1 3 4 5 7 9 6
P2: **1 0 5** 4 6 8 9 7 2 3

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O1: **1 0 5** 2 3 4 8 7 9 6
O2: **2 8 0** 4 6 5 9 7 1 3

**7.** as a result of random mutation resulting personnel site is through a switch in some regions of chromosome and are as follows:

Before mutation 1**0** 5 2 3 4 8 **7** 9 6

After mutation 1**7** 5 2 3 4 8 **0**9 6

**8.** Continue configuring subsequent generations and stop at the end of the number of iterations.

**Ant colony optimization algorithm for solving MOTSP:**

**1.** Initialize the matrices of the problem.

**2.** Initialize the parameters of the problem represented by the size of the problem and also enter the parameters of the algorithm and the ants are a researcher and also impact the pheromone evaporation parameter and my weight for each of the pheromone and informationheuristic.

**3.** Calculation of informationheuristic matrix is as follows:

$$\eta_{i,j} = \frac{1}{\sum_{i1=1}^{p} d_{(i1,i,j)}} \qquad (2)$$

**4.** calculate the probability of transmission of each Ant to city and be by the following equation:

$$P_{i,j}^{k} = \begin{cases} \dfrac{{\tau_{i,j}}^{\alpha}.{\eta_{i,j}}^{\beta}}{\sum_{j\in N_i^{(k)}} {\tau_{i,j}}^{\alpha}.{\eta_{i,j}}^{\beta}} & if\ j \in N_i^{(k)} \\ o\ otherwise \end{cases} \qquad (3)$$

where τ(i, j) is the amount of pheromone trail on edge (i, j), β is a parameter which weighs the relative importance of pheromone trail and of closeness, $N_i^{(k)}$ is a set of cities which remain to be visited when the ant is at city i. α and β are are two adjustable positive parameters that control the relative weights of the pheromone trail and of the heuristic visibility

**5.** When you move any Ant researcher about a specific path begins with the pheromone evaporation the pheromone effect is calculated after each round of Ant researcher according to the following equation:

$${\tau_{i,j}}^{t+1} = (1-\rho).{\tau_{i,j}}^{t} \qquad (4)$$

**6.** after the end of all the ants in its current iteration researcher (t) should impact the pheromone on the borders problem and be as equation:

$${\tau_{i,j}}^{t+1} = (1-\rho).{\tau_{i,j}}^{t} + \rho.\sum_{k=1}^{m} \Delta\tau_{i,j}^{k} \qquad (5)$$

Where

$(1-\rho)$is the pheromone decay parameter $(0<\rho<1)$ where it represents the trail evaporation when the ant chooses a city and decides to move

$\Delta\tau_{i,j}^{k}$: The change in the quantity represents the pheromone between two cities in question are calculated as follows:

$$\Delta\tau_{i,j}^{k} = \frac{Q}{L_k} \quad (6)$$

$Q$: Represents the amount of fixed works to find amount of change in the quantity of the pheromone between cities as specified range.

$L_k$ :is the length of the tour performed by ant k and

m: is the number of ants

**7.** Continuing to examine the ants by the amount of the pheromone researcher for each iteration of the algorithm depends upon the expiration of the number of iterations.

**Simulated annealing algorithmfor solving MOTSP:**

**1.** Initialize the matrices of the problem**.**

**2.** Initialize the parameters for the algorithm is reduced temperature parameter.

**3.** Generating the first solution (S) represents a complete solution for the issue with the calculation of the objective function f (s).

**4.** To make the solution $(S^* = S)$and also make the $f^* = f(s)$

**5.** the first solution generating method neighborhood (N (S)) and here you will use a property change (Shift Move) where you choose two pieces within the current solution and then we switch point first and second allowance cutting movement the rest of the site as shown in the following: second allowance cutting movement the rest of the site as shown in the following:

Before 1 5 2 **3 4 8** 7 9 6

After 1 7 5 2 **8 4 3** 9 6

**6.** Calculations of the objective function for the new solution $S^{\circ}$if $f(S^{\circ}) < f^*$make $S^* = S^{\circ}$and also$f^* = f(S^{\circ})$, otherwise go to step (7).

**7.** Calculate the probability ($p$) of the resulting solution according to the following equation:

$$p = e^{-\frac{|f(s') - f(s)|}{T}}$$

And then generate a random number (Z) between [0, 1] If $p < Z$make$S^* = S^{\circ}$and also$f^* = f(S^{\circ})$, otherwise refer to step (5).

**8.** Reduce the temperature by the following equation:

$$g(T,t) = T.\alpha$$
$$s.t.\alpha < 1$$

**9.** Stop scale is continuing steps (5-8) until they get the condition stop end number of iterations. t

**Tabu search algorithmfor solving MOTSP:**

**1.** Initialize the matrices of the problem**.**

**2.** Generating the first solution (S) represents a complete solution for the issue with the calculation of the objective function f (s).

**3.** generate a new solution from the current solution by neighborhood and search is through a switch in two locations of the problem and are as follows:

Before 1 **5** 2 3 4 8 7 **9** 6

After 1 **9** 2 3 4 8 7 **5** 6

**4.** calculation of the objective function for the new solution, if the objective function for the new solution, we replaced the new solution to the previous solution otherwise we log switch in the Tabu list and then make a new random switch remote switches either ban list ban list would be as follows:

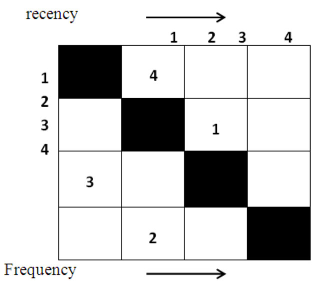


**Figure 1: Tabu Structure [1]**

**5.** Repeat the algorithm until the stop condition is the end number of occurrences.

Tabu search algorithm of powerful algorithms to access good solutions early on but sometimes interference in local optimization algorithm and it is difficult to go out in search of new areas to diversify in the algorithm we clear memory into the Tabu list.

**ProposedHybrid algorithm ACO-GA for Solving MOTSP:**

Hybridization method helps in creating diverse solutions and avoid local optimization in earlier times so in this research we will integrate algorithm with the behavior of various hybrid algorithm of two phases the first phase is the use of ant colony optimization algorithm to create new solutions in the second stage is the use of genetic algorithm to increase the efficiency of the algorithm in the optimization algorithm solutions diversification ant colony and then updated his liquidator the pheromone and update solutions ant colony optimization algorithm and continue repeating the work algorithm until the condition is met Stop with the end of the number of occurrences of the College, the following figure shows the stages of the work of the proposed algorithm:

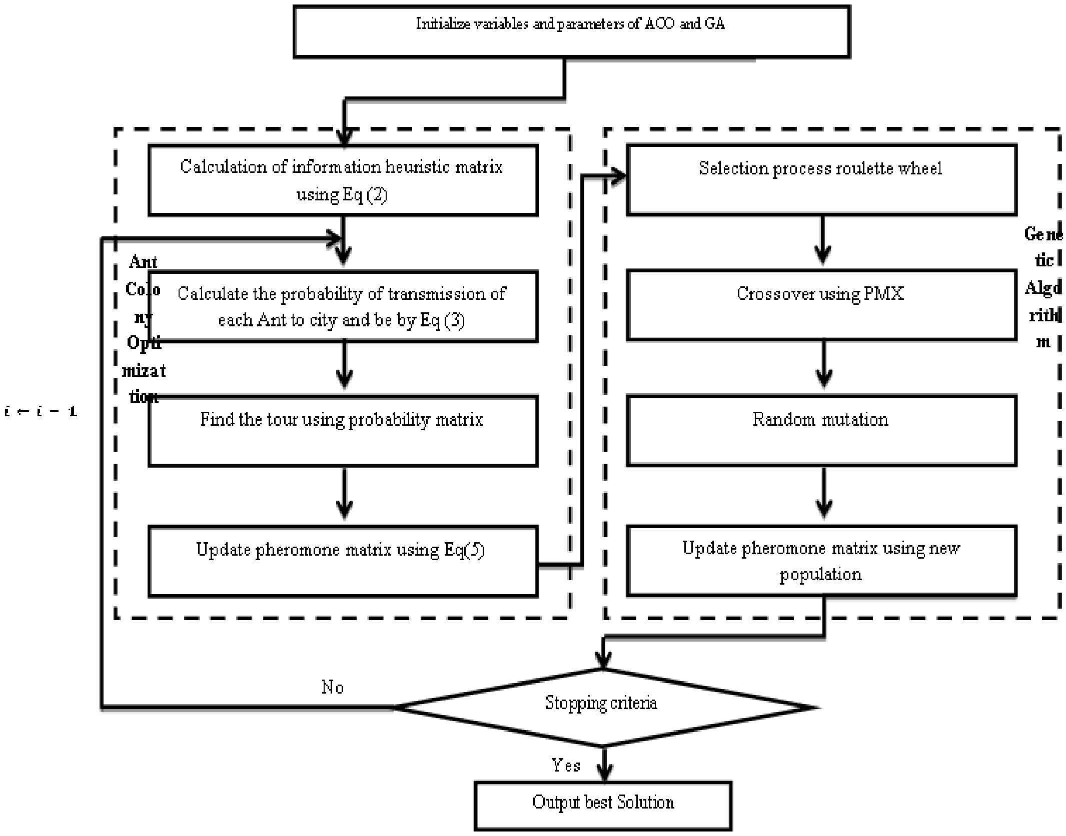


**Figure 2:** The flow chart for the proposed algorithm.

## Experimental Results

The Multi objective Traveling Salesman problemparticularly difficult problem does not have polynomial time algorithm to do test the efficiency of the algorithm proposed for other algorithms will generate similar matrices problem randomly and a reluctance among different and then we will calculate the efficiency of each algorithm by calculating the amount of the level of achievement of ambitious resolve problem. Test questions generated randomly in the absence of test problems from this category in library operations research issues and the lack of governance capacity in certain algorithm solution through one test question so we generate 10 random problems, Table 1 lists the parameter setting of the proposed algorithm. To show the performance of the proposed algorithm,

**Table 1:** Parameters settings of the proposed algorithm.

| Parameters | Values |
|---|---|
| Number of Ants | 2N |
| $Q$ | 2. 7 |
| $\rho$ | 0. 05 |
| $\alpha$ | 0. 8 |
| $\beta$ | 1. 0 |
| $PCrossover$ | 0. 5 |
| $Pmutation$ | 0. 1 |

Performed experiments using a computer with an Intel Celeron Dual-Core processor and 2GB RAM and used Matlab as the programming language to implement the algorithm.

**The proposed metric to compare the algorithms in Multi objective Traveling Salesman problem:**

Multiple objective are generally combinatorialoptimization problem any solution cannot achieve all the goals in problem since it is using more than one algorithm in this research and the difficulty of judging the specific algorithm preference we will derive a criterion to find every algorithm preference in achieving objectives problem. the proposed metric will be using Zimmerman method in solving the fuzzymultiple objectives optimization to find the amount allowed for each objective and conversion goals and constraints to make ambitious variable (H) in the objective function The goal is expand that amount whenever this variable near one closer solution of all goals, and target can be written in the form under the Zimmerman method as follows:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} c_{ij}x_{ij} \leq (1-H)*\tau + LB \ \ldots \qquad (7)$$

Where

LB: Lower bound for objective

H: Aspiration criteria

$\tau$: The value of the allow target and there would be

$\tau = UB - LB$

And compensation

$$f\ \ (x) = \sum_{i=1}^{n}\sum_{j=1}^{m} c_{ij}x_{ij}$$

$\tau = UB - LB$

From Eq(7)

$$f\ \ (x) \le (1 - H) \times (UB - LB) + LB$$

$$f\ \ (x) \le UB - LB - H \times (UB - LB) + LB$$

$$f\ \ (x) \le UB - H \times (UB - LB)$$

$$H \times (UB - LB) \le UB - f(x)$$

$$H = \frac{UB - f\ \ (x)}{UB - LB}$$

**Table 2:** The results of the comparison between the algorithms for 10 MOTSP instance

| Instance | algorithm | $f_1(x)$ | $f_2(x)$ | $f_3(x)$ | $H$ |
|---|---|---|---|---|---|
| Eucl30 | GA | 841 | 1112 | 973 | 0. 474264 |
| | ACO | 945 | 814 | 905 | 0. 55472 |
| | SA | 1404 | 1107 | 1212 | 0. 224913 |
| | TS | 900 | 863 | 905 | 0. 553713 |
| | HACO | 971 | 695 | 892 | 0. 587202 |
| | BEST | GA | HACO | HACO | HACO |
| Eucl60 | GA | 2316 | 2374 | 2365 | 0. 307227 |
| | ACO | 1497 | 1662 | 1779 | 0. 580524 |
| | SA | 2716 | 2888 | 2921 | 0. 117562 |
| | TS | 1695 | 1837 | 1937 | 0. 512012 |
| | HACO | 1557 | 1709 | 1556 | 0. 594705 |
| | BEST | ACO | ACO | HACO | HACO |
| Eucl90 | GA | 3980 | 3941 | 3703 | 0. 194515 |
| | ACO | 2375 | 2464 | 2535 | 0. 548265 |
| | SA | 4294 | 4634 | 4574 | 0. 036811 |
| | TS | 2751 | 2921 | 2878 | 0. 450212 |
| | HACO | 2420 | 2206 | 2463 | 0. 572275 |
| | BEST | ACO | HACO | HACO | HACO |
| Eucl120 | GA | 5608 | 5413 | 5397 | 0. 190258 |
| | ACO | 3304 | 3159 | 3392 | 0. 56798 |
| | SA | 6189 | 6018 | 5588 | 0. 112152 |
| | TS | 3792 | 3694 | 3804 | 0. 48557 |
| | HACO | 3010 | 3182 | 3115 | 0. 600326 |
| | BEST | HACO | ACO | HACO | HACO |
| Eucl150 | GA | 7033 | 6963 | 6628 | 0. 148755 |
| | ACO | 3862 | 3814 | 4279 | 0. 5585 |
| | SA | 7376 | 7512 | 7398 | 0. 06991 |
| | TS | 4599 | 5052 | 5206 | 0. 421756 |
| | HACO | 3542 | 3767 | 3935 | 0. 592732 |
| | BEST | HACO | HACO | HACO | HACO |

| | | | | | |
|---|---|---|---|---|---|
| Eucl180 | GA | 8507 | 8313 | 8468 | 0. 120594 |
| | ACO | 4423 | 4493 | 4464 | 0. 586859 |
| | SA | 8606 | 9108 | 9015 | 0. 06545 |
| | TS | 5897 | 6365 | 5913 | 0. 39987 |
| | HACO | 4433 | 4107 | 3992 | 0. 619243 |
| | BEST | ACO | HACO | HACO | HACO |
| Eucl210 | GA | 9717 | 10173 | 9864 | 0. 152053 |
| | ACO | 4989 | 5054 | 5357 | 0. 606947 |
| | SA | 11132 | 10359 | 10359 | 0. 087539 |
| | TS | 7188 | 7569 | 6861 | 0. 410875 |
| | HACO | 4841 | 5045 | 4736 | 0. 632386 |
| | BEST | HACO | HACO | HACO | HACO |
| Eucl240 | GA | 11257 | 11409 | 10975 | 0. 090306 |
| | ACO | 5610 | 5430 | 5797 | 0. 594227 |
| | SA | 11786 | 12334 | 11239 | 0. 038655 |
| | TS | 8255 | 8418 | 8547 | 0. 343221 |
| | HACO | 4892 | 5644 | 5145 | 0. 629159 |
| | BEST | HACO | ACO | HACO | HACO |
| Eucl270 | GA | 12303 | 12759 | 12682 | 0. 10942 |
| | ACO | 6537 | 6380 | 6227 | 0. 593344 |
| | SA | 12927 | 13730 | 14100 | 0. 031515 |
| | TS | 9462 | 9860 | 10188 | 0. 324121 |
| | HACO | 5930 | 5845 | 5944 | 0. 630694 |
| | BEST | HACO | HACO | HACO | HACO |
| Eucl300 | GA | 13147 | 14860 | 14437 | 0. 105948 |
| | ACO | 7264 | 6882 | 7109 | 0. 595668 |
| | SA | 14860 | 15252 | 14959 | 0. 044451 |
| | TS | 10685 | 10725 | 11419 | 0. 328039 |
| | HACO | 6280 | 6678 | 6541 | 0. 636633 |
| | | | | | |
| | BEST | HACO | HACO | HACO | HACO |

## Conclusion

In this paper, we proposed the ACO-GA algorithm, which is a combination of the Genetic algorithm and theAnt Colony Optimization algorithms, to solve the MOTSP. We use ant colony systems algorithm as a first stage and then in the second stage using genetic algorithm for a specified number of iterations to help improve the solutions generated by genetic algorithm and then after the end of the genetic algorithm we update the pheromone matrix to assist algorithm ACO-GA to explore new areas in the solution space of the proposed algorithm has proven its superiority in solving the MOTSP compared with the rest of the algorithms used in the comparison.

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