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# A New Optimization Method for Dynamic Travelling Salesman Problem with Hybrid Ant Colony Optimization Algorithm and Particle Swarm Optimization

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***Abstract*—In recent decades, with the introduction of optimization problems, new methods of was optimizing developed. The most important group of optimization techniques is meta-heuristic method. That is able to solve the problems of combination optimizing. The major problems in the combination optimizing such as Dynamic Travelling Salesman Problem (DTSP) is a kind of problems that is close answer to the optimum will introduce in them. So using of the meta-heuristic methods in this kind of problems was the case of concentration in the current years. In this paper a new algorithm based on Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) as the name of ACO-PSO is proposed which of PSO algorithm for tuning parameters of ACO and establishing a balance between global search and local search is used. Experimental results show that the proposed method has good performance.**

***Index Terms*— Meta-heuristic, DTSP, ACO, PSO**

## INTRODUCTION

With the extending of the problems and importance of being optimum, nowadays have more the tendency to the meta-heuristic algorithms. And because of this using of meta-heuristic algorithms in the optimizing of the problems will be extended every day. The major advantage in using of meta-heuristic search flexibility, speed and high performance and is the feature of global search of them. In the recent years using of the meta-heuristic algorithms for solving the DSTP has a good advancement. We can mention to the method of combination algorithms [1, 2 and 3], ACO [4, 5 and 6] and Evolutionary Computation [7, 8].

The DTSP is one of the prominent of combination optimizing of problems. The DTSP for the firstly was introduced by Psaraftis in 1988 [9].

In the meta-heuristic algorithms the searching will be done in a parallel form. And it means that set of elements, will search the space of problems. This algorithms are has a special potential for finding the close solution to being optimum. Majority of these methods will act in a cumulative from and use the fitness function for guiding the search. These algorithms can economize the time and use the Special measures thought for parrying the local optimizing and to the convergent global optimizing. Since the meta-heuristic algorithms with approach parallel to solving problem are always a set of responses create. Swarm intelligence (SI) is a computing and behavioral metaphor for solving the problems that basically is in is inspired of the natural samples and collective behavior.

The ACO [10] is optimizing algorithm based on intellectual behavior of ants are population. In natural, ants without any information about the path, find the shortest way between the food and nest. When ants are walking through the secrete pheromone and a trace will remain. The path length is less after a little time has increased the number of ants and so much more pheromone put on the path place. So ants choose a path that is more pheromones.

PSO [11] is optimizing method that has been inspired from the social behavior of birds. PSO algorithm consist of a group of particles that more in the space of searching for the feasible solution for the problems. Also it has been proven that PSO is efficient for solving many optimization problems and in some cases, the problems that other meta-heuristic techniques are is not affected [12].

In this paper, we use the velocity particle in order to change the rules of moving in closing to the local optimum. Using of this parameters the reason that with keeping the speed of convergence, Exchange information between the elements of the group will be done better and the space of answering is in order to find the global optimum. Thus the efficiency ACO algorithm in escape from local optimum locations will increase.

We have organized the general structure of this paper as follow: In section second introduce literature review; in section third we introduce PSO; in section fourth we introduce ACO; in section five we'll explain the proposed algorithm; in section sixth we'll discuss about valuation and results of the proposed method and finally in section seventh we will draw some conclusions from this paper.

## LITERATURE REVIEW

Obtaining the best possible result for solving problem of

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DTSP with attention to the same special circumstances in this problem, create various ways. So in this type of problems the major purpose of problems is finding the courses that have the lowest cost.

F.S.Gharehchopogh et al [1] use from hybrid algorithms the ACO and genetic algorithm for solving the problem of DTSP. In their paper, they used of the genetic algorithm for the optimizing the obtained paths of the ACO in the searching space of problem. In their paper for producing the initial population in the genetic population of obtaining paths, use of that the ACO. Their purpose of combining the genetic algorithms and ACO was preventing of the precocious convergence and reaching to the better answer. Researchers [2] use a new method for solving the DTSP on based the hybrid of ACO and chaos theory. They in their paper with hybrid ACO algorithm and chaos theory hybrid algorithm have created that length better for DTSP has obtained. In hybrid algorithm law update pheromone by one dimensional logistic function [13] and to is the form of non-linear that can from precocious convergence prevent.

In [3] researchers use for solving the DTSP on based the hybrid method of ACO and gradient descent. They explain in their paper that combining the ACO algorithm and gradient descent are the cause that in the time of sticking in minimum local with Initialize pheromone in the form of gradient descent is the cause of escaping of minimum local. There the proposed algorithm is as follows that for finding the optimum path, algorithms with optional choosing of a city will start. And then all of the neighbor vicinities with the initial city will be evaluated with purpose function. Then among the answers related to the neighbors which answer that has the mostly acceptance will be chosen and the algorithm is repeated until the optimal path is found.

W. Li [14] present a parallel searching algorithm for solving the problem of DTSP. In this paper for finding the optimum answer instead of searching a solution, a set of appropriate answers were analyzed in the form of parallel searching. So the probability of producing an optimum solution among the new solution will be increased.

In [15] researchers using the ACO to solve the problem have been DTSP. In their paper for reaching to the optimum answer in the law of updating the pheromone and the probability of movement some special changing can be created. According to their result we can say that the efficiency of algorithm for reaching to the close answer the optimum gradually will be better.

PSO algorithm is one of the most effective group algorithms that can be workable and reliable for solving the difficult problems. This algorithm in recent years in industrial and scientific purposes has been heavily used. Researchers [16] use from the PSO algorithm in order to finding the shortest route between the cities. They reach to the special result in their paper that PSO algorithm consist a good efficiency for solving the problem of finding the shortest course.

H.Fan in [17] by using the PSO algorithm he focuses on the solving the DTSP. For finding the best route each particle, will change its next position in the space of searching according to the level of its knowledge and the public knowledge of group. After every move in the search space is the fitness of each particle is measured and the next town to travel considering length of the path is obtained by selecting particles.

Because of difficult of finding the shortest path in the graph, researchers [18] use the PSO algorithm for solving the problem of finding the shortest path. The graph that they analyze it in their paper is consist 10 nodes. In this research for finding the shortest path, use the best position of particle in total population is used. In [19] the combination of genetic algorithm and PSO was used for solving the Symmetric Travelling Salesman Problem (STSP). Normally algorithm genetic not efficiency algorithm for solving NP-Hard problems but using the PSO algorithm can change in genetic algorithm to create a more efficient and effective solutions to problems found. In their paper, the PSO algorithm to better fit the mutation and crossover operators are used to achieve the optimal solution. The results show that the hybrid algorithm has better performance than genetic algorithms.

## PARTICLE SWARM OPTIMIZATION

PSO algorithm with inspiring of social behavior of birds was introduced by Eberhart and Kennedy in 1995 [11]. PSO is a simulation of social behavior of birds that in environment are looking for food. Any of birds don't have any information about the place of food. But at every step, know how much of the food distance. Accordingly, the best approach is to find food, bird food is nearest to follow.

PSO algorithm is one of the important algorithms that take the place in the swarm intelligence region [20]. The methods of swarm intelligence by using of cooperation and the competition that create between the answers can find the optimum answer earlier than others. PSO algorithm as an optimization algorithm is a searching on the population that each particle change itself position by passing the time. In PSO algorithm particles will be more in the multi-dimension searching space of the feasible solution of problem. In this space is defined as a criterion for evaluating and measuring the quality of the solutions it are done through. Change the state every particle in a group affected by your experiences or neighborhood knowledge of and behavior search a particle in the group is influenced by other particles. This simple behavior cause finding optimal regions of the search space.

PSO algorithm first of all was the randomly valued with a group of particle that was produced in the space of problem in a random form and searching for will begin fir finding the optimum answer. In a general construction of searching each particle will imitate of particle that has the optimizing fitness function. Therefore in each repetition of algorithm each particle changes his or her next position according to the two variable values. One is the best position that the particle has that until now (pbest) and the next is the best position created by whole population and in fact is the best pbest in the total population (gbest). As concept pbest for each individual is the fact that individual biological memory. In fact, gbest is the general knowledge of the population and when individual can change their position based on the gbest in an effort to reach a population knowledge level of their knowledge level. As concept, the best particle all group members are related to

each other.

According to the gbest and pbest values each particle will use the Equations of (1) and (2) in order to find the next position.

$$v_{i+1} = w.v_i + c_1.r_1.(p_{best_i} - x_i) + c_2.r_2.(g_{best_i} - x_i), \quad (1)$$

$$x_{i+1} = x_i + v_{i+1} \quad (2)$$

In Equation (1) c1, c2 are learning parameters. Function rand () for producing random numbers in the range of [0, 1]. Xi is the very position and Vi is the velocity of particles movement. W is a controlling parameter that controls the impact of the current speed for on the next speed. And create an equal form between the algorithms in searching in the form of local and searching will be done in a global form.

## ANT COLONY OPTIMIZATION

ACO is one of the meta-heuristic algorithms that was introduced Dorigo for the first time [21, 22]. This algorithm was used for solving the complex problems in acceptable time of computing. When the ants are walking, misplace a special smelly material by the name of pheromone in their path. Of course this material will evaporate as soon as possible. But in the short term as the trace ants on the ground remains. The ants have a special ability that can find the shortest path to food by producing the pheromone. The ants will choose the shortest path than ants that who choose the path they will produce more pheromones. As the more pheromone better attract the ants, more and more ants find the shortest way and finally all of the ants find the shortest way. For more analyzing of this issue, imagine that there are two paths to the food that have different the length, ants choose each path with the same probability. Ants that the shorter route went and returned earlier than the other produce more pheromone. As a result, the ants other this route selection and further strengthen the pheromone the path. Eventually all ants will find the shortest path to food.

Movement probability form i city to j city for k ant in t time based on Equation (3) will be expressed. In this equation, is ηij field of vision and is equal with 1/dij (the nearer cities are more probable to choose).

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha} \cdot [\eta_{ij}]^{\beta}}{\sum_{j \in allowed_k} [\tau_{ij}(t)]^{\alpha} \cdot [\eta_{ij}]^{\beta}} & if\ k \in allowed_k \\ 0 & otherwise \end{cases} \quad (3)$$

In Equation (3) τij the amount of pheromone that existing on mane (i, j) in time t. α, β are the impact parameters of existing pheromone and the mane and field of vision of that mane. And allowedk is the set of cities that k ant passes them.

In order to discuss about the other ants for the rule of pheromone updating we use of local updating method. In this method the space of searching is faster and in fact the probability of missing the appropriate route is the reason of catching in the local minimum is very low. The pheromone updating rule on manes is done according to Equation (4).

$$\tau_{ij}(t+n) = (1-\rho) \times \tau_{ij}(t) + \Delta\tau_{ij} \quad (4)$$

In Equation (4), 1-ρ determines the rate of pheromone evaporation from t to t+n. In order to prevent pheromone increase on mane, it is determined 0< ρ <1 limit for ρ. As the amount of ρ is increased, pheromone evaporation rate will increase, too.

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}^{k} \quad (5)$$

$\Delta\tau_{ij}^{k}$ Is amount of pheromone in which the ant k leave on the route (i, j) and in the time interval of t to t+n.

$$\Delta\tau_{ij}^{k} = \begin{cases} Q/L_k \text{ if k ant uses edge (i, j) at time (t, t + n)} \\ 0 \qquad\qquad otherwise \end{cases} \quad (6)$$

In Equation (6), Q is a constant number as Lk is the route length which is travelled by ant K.

## PROPOSED SOLUTION

ACO Using PSO in addition to the main problem of this algorithm is improved to get the optimal local can be useful in two respects. First, learn the parameters of the PSO algorithm can be used in the update process rules and the rule of transition probability. The second advantage of this algorithm causes is adaptive self and the dynamics. Thus, the algorithm ability in adapt to a dynamic environment is strong and against the environmental changes is resistant.

So an optimization algorithm in a dynamic environment must be able to continuously adapt the solution to a changing environment. Therefore, the algorithm is applied to a changing environment that able to change after a change, maintain the previous solution of using multiple modes have populated. Figure (1) shows the schema of the proposed algorithm.

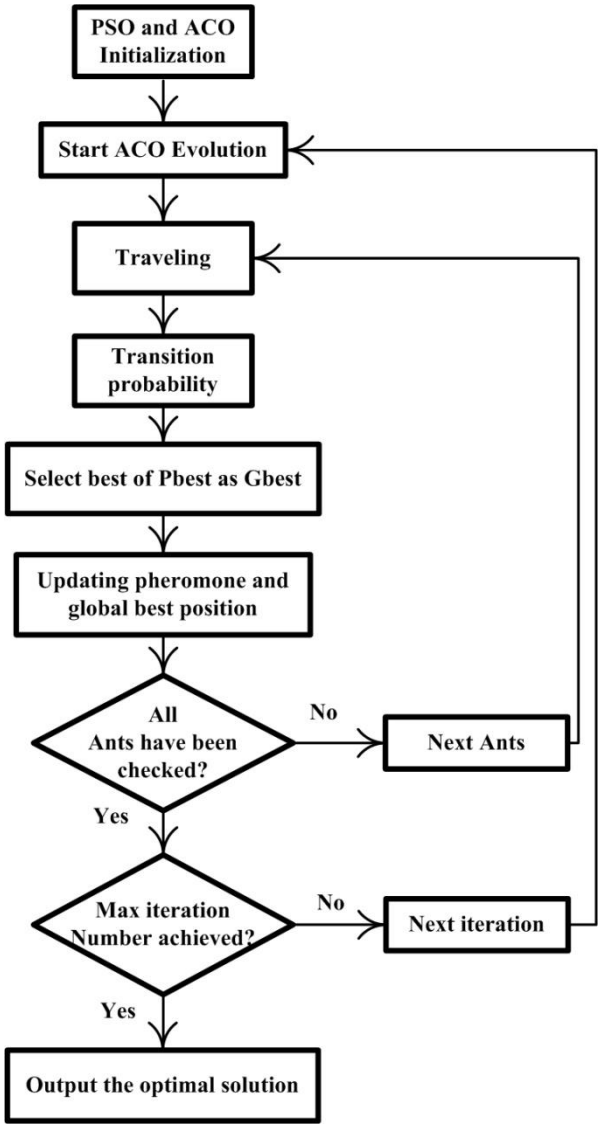


Figure 1: Flowchart of the Proposed Algorithm.

Quasi code of the proposed algorithm based on ACO algorithm and PSO consists of the following steps.

**1. Initialization Parameters**
**2. Loop**
  **For each** ant **do**
  Randomly select a starting city
**3. While** stop criteria not met **do**
**4. Transition Probability Rule**
  **For all** ant **do**
  Calculate length tour according to eq. 7
  **End For**
**5. Update Pheromone**
  **For all** ant m **do**
  Update using learning factors c1, c2
  **For each** city (i, j), update pheromone
  **End for**
**End While**
**Until** end condition

Figure 2: Quasi Code of Proposed Algorithm

A. The Rule of Transition Probability

One of the factors contributing that has a lot of importance in ACO algorithms and has an important role in choosing cities, is the initiative information coefficient in the laws of movement the will be shown with $\eta ij$. This coefficient in repetition of initial algorithm that the impact of pheromone is not so remarkable has an important role. And recognize the side and direction of searching. For this reason in the rule of movement transmission we use PSO algorithm idea that is one of the most workable meta-heuristic methods and has more power in finding the proper answer in is a few time. In a proposed algorithm we use of Equation (7) for reaching to characterize of exploration and exploitation.

$$p_{ij}^{k}(t)=\begin{cases}\dfrac{\left[\tau_{ij}(t)+c1\times r1\right]^{\alpha}\cdot\left[\eta_{ij}+c2\times r2\right]^{\beta}}{\sum_{j\in allowed_k}\left[\tau_{ij}(t)+c1\times r1\right]^{\alpha}\cdot\left[\eta_{ij}+c2\times r2\right]^{\beta}} & \text{if } k\in allowed_k\\ 0 & otherwise\end{cases}$$

(7)

In above Equation, c1 and c2 are the learning parameters for the rule of Transition Probability. In this equation by trying to adding PSO parameter of information interchanging between the ants is the special form of cooperation and learning. Because of this the ability of algorithm has high speed in adaptation with dynamic environment and convergence to nearly optimal solution is better. In Equation (7) the best value of suitability function during the certain number of repetition will be obtained.

In hybrid algorithm to the ants are given possible that the interaction with the environment search, actions that lead to the desired outcome and restrict the actions that led to the unfavorable outcomes to the strategy and the optimal policy is to achieve the most optimal results are achieved. So it is possible for ants to use repetition and learning, environment and other routes have identified and appropriate strategies for achieving near-optimal solutions are selected.

B *Rules of Pheromone Update*

In rules of pheromone updating Pheromone evaporation factor in the beginning of algorithm performing has less accuracy. Thus, the Innovation information of problem for having more power in order to direct the algorithm it is better the rules of pheromone updating should use from learning parameters of PSO algorithm for finding the better routes. And this is the reason that pheromone differences on meeting and not meeting mane should be focused in the repetition of algorithm. Until the chance of not meeting to select mane will in the next repetitions not destroyed completely. The new rules of pheromone updating on mane will be done according to the Equation (8).

$$\tau_{ij}(t+n)=\rho\times\tau_{ij}(t)+\Delta\tau_{ij}$$

(8)

In Equation (8) the amount of $\Delta_{ij}^{k}$ will be done based on

Equation (9).

$$\Delta\tau_{ij} = \frac{Q}{gbest_{(k)}} \quad (9)$$

In Equation (9) $gbest_{(k)}$ is the best length path that is found with Interact and cooperation of ants. Parameter value τij (the pheromone on the main) in the rules pheromone updating will be done by $c_1$ and $c_2$ parameters. Parameters $c_1$ and $c_2$ is the reason of more encouraging of mane extraction that still isn't met with ants. This act is the reason of path exploration by ants for finding the best vicinity in the next repetitions.

## RESULTS AND DISCUSSION

Because the ACO and PSO that obey from random searching, in the vision of convergence speed and reaching to the answer we can not only rely on the performing one repetition of problem. So, for comparing these algorithms are , 30 cities and each algorithm will be done 100 time and the resulted average of this 100time were compared based on number of repetition for reaching to the convergence.
There are several parameters in a proposed algorithm that effect on the action of algorithm. In Table (1) the proposed pheromone on mane will be determined by using the parameter α. β parameter will determine the relative importance to the pheromone on mane. Rho parameter of pheromone weakened (evaporation) over determines the mane. C1 and C2 are the learning parameters minimize the answer.

| Parameter Name | α | β | rho | c1 | c2 |
|---|---|---|---|---|---|
| Value | 1 | 5 | 0.1 | 2 | 2 |

Table 1: Value of Parameters in the Proposed Algorithm

Table (2) shows the comparison of results for proposed and other algorithms. As you seen, proposed algorithm has the better answer to other algorithms for solving the problem of DTSP. Therefore the proposed algorithm is more reliable for to achieve a solution close to the optimal and convergence it for the achieving to answer more.

| Algorithms | Average Solution | Best Solution | Worst Solution |
|---|---|---|---|
| ACO [1] | 385 | 340 | 368 |
| GA[1] | 464 | 349 | 826 |
| Hybrid Algorithm[1] | 384 | 340 | 358 |
| Proposed Algorithm | 369 | 340 | 352 |

Table 2: Comparing the Results of Proposed Algorithm and the Another Algorithm

In proposed algorithm ants by using learning parameter until the end of searching process, keep middle balance of global and local searching in an appropriate method. Because of this proposed algorithm can search effectively the space of problem and obtain the better result. Figure (3) shows the graph of proposed algorithm comparison with other algorithms. As the graph Figure (3) shows the proposed algorithm is more workable.

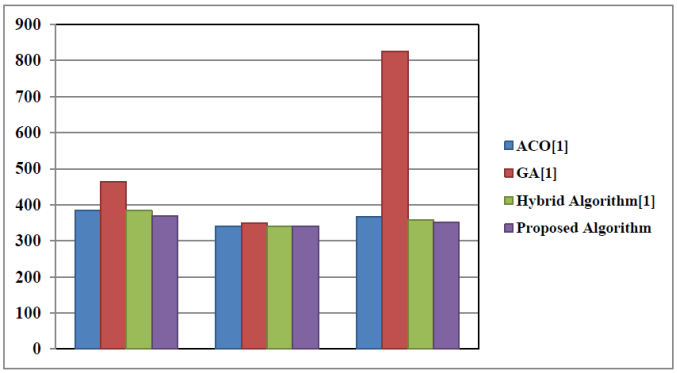


Figure 3: Chart Comparing the Proposed Algorithm with other Algorithms

Table (3) comparison of the proposed algorithm shows the number of replications. As can be seen, increasing the number of repetitions of the proposed algorithm is effective and the possibility of result in changes in the solution is close to optimal.

| Iteration | Proposed Algorithm | | |
|---|---|---|---|
| | Average Solution | Best Solution | Worst Solution |
| 20 | 406 | 354 | 398 |
| 40 | 394 | 348 | 387 |
| 60 | 383 | 345 | 376 |
| 80 | 375 | 342 | 364 |
| 100 | 369 | 340 | 352 |

Table 3: Compare the Effect the Number of Iterations in Proposed Algorithm

Figure (4) shows the comparison graph for repetition of proposed algorithm for reaching to the close answer of optimum. As be shown in results proposed algorithm has better ability in finding global optimum by increasing the number of repetition.

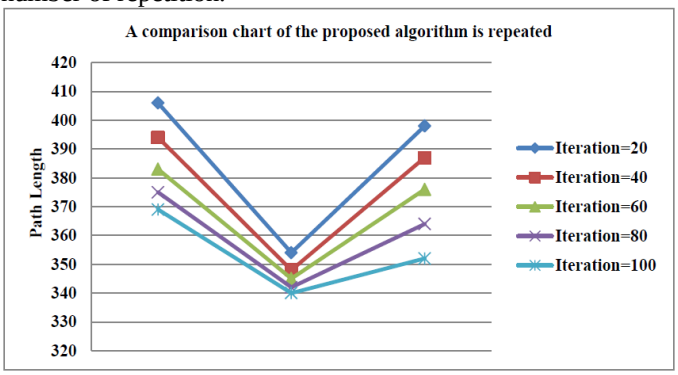


Figure 4: Chart Compares the Number of Iterations of the Proposed Algorithm

*Amount of Parameter Effect on Proposed Algorithm*

Table (4) shows the effect of $c1$ and $c2$ parameters on the best finding path. By using of $c_1$ and $c_2$ parameters each ant will move only with the effect of global searching in the space

of searching. In Table (4) it is clear that increasing of $c_1$ and $c_2$ parameters is the reason of optimum answer.

| Parameters | | Average Solution | Best Solution | Worst Solution |
|---|---|---|---|---|
| c1 | c2 | | | |
| 0.5 | 0.5 | 398 | 345 | 386 |
| 1 | 1 | 383 | 343 | 372 |
| 1.5 | 1.5 | 374 | 342 | 365 |
| 2 | 2 | 369 | 340 | 352 |

Table 4: the Impact of Parameters c1 and c2

As the results of experiment shows that proposed algorithm can be move workable if proposed algorithm has appropriate initialize. In the absence of proper regulation of parameters, proposed algorithm will be tended to the local optimum and encouraging with early convergence. So the accurate regulation of parameters will keep the capability of flexible searching. Figure (5) shows the graph of proposed algorithm based on 50 the repetition for values of c1 and c2. As be seen the proposed algorithm obtain better results by increasing c1 and c2.

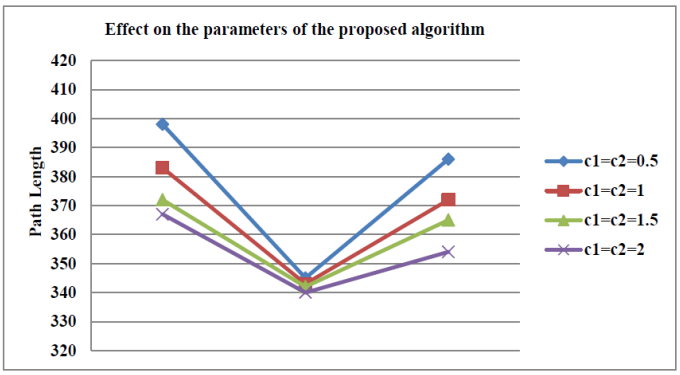


Figure 5: the Chart for the Effect of c1 and c2 Parameters Value.

The parameters of PSO algorithm give the opportunity to the ACO algorithm that ants search more places. The combination of PSO algorithm parameter with ACO algorithm is the reason of finding the better answer for the problem of DTSP and the speed of convergence will not decrease and the algorithm can reach to the global optimum by escaping from local optimum points.

## CONCLUSION

In this paper, we present a new optimizing algorithm with the name of ACO-PSO that is the combination of PSO and ACO. By consideration to the obtaining result we can say that using of PSO this feature provides for ACO algorithm to show the proper reaction against the environmental changes. And can to adapt with changing environments. On the other hand by using of learning parameters participation of ACO algorithm speed the problem of local optimum and convergence increasing will be solved. In total we can reach to the acceptable answer by using of positive characterize of two algorithms.

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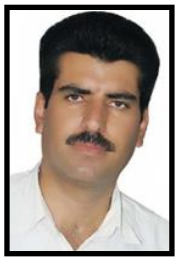

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