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Research Article

Ant Colony Optimization: A Review and Comparison

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Abstract: Many optmization algorithms are developed over period of time, among these most famous and widely used is Ant Colony systems (ACA). Ant Colony Systems (ACS) are the collection of different ant colony optimization algorithms. Different algorithms are used for solve the Travelling salesmen Problem (TCP) but ant colony algorithm is more preferred to solve the travelling salesmen problem. In ant colony best solution is found with the help of cooperating agents called ants. Ants cooperate with each other and communicate using an indirect way with the help of pheromone which is deposited on the edges on the path. To achieve the finest solution, different ant colony techniques are compared. In this study we compared different Ant Colony Systems (ACS) algorithms through their implementation on classical problem of Travelling salesmen Problem (TCP).

Keywords: Ant colony algorithm optimization, neural networks

INTRODUCTION

One of the techniques for obtaining good results of a problem by using graph is Ant Colony. Ant colony optimization algorithm was introduced after observing ant's behavior that is capable of finding direct distance by Goss *et al*. (1989) and Holldobler *et al*. (1992).

Different steps show how ant discovers different path and use the shortest distance to reach the nest. The ant tour is divided in four steps which can be described as. In step 1, two groups of ants are moving, one is moving from left to right known as L group and digit with it, is showing the number of ant and the other group is moving from right to left known as R group and digit with it, is showing the number of ants. The ants reached a split path. As they have no idea which path they should take. So half of the ants take one path and half take the other. In step 2 and 3, ants are moving with same speed those ants which have chosen the upper path have the low amount of pheromones then than those ants which have chosen the lower path, these figure represents that dashed lines are used to shown the value of pheromones, which represent this path is most finest to reach to destination and to find the food, because lower path is shortest. In step 4, we are concluded that ants always choose the shortest distance for discovering provisions and remaining ants locate the trail with the help of pheromones by Dorigo and Gambardella (1997).

The first problem solved by using ant colony algorithm was Travelling Salesman Problem (TSP). Ant colony algorithms are used mostly to resolve TSP. TSP is an equation which is based on following statements:

- A travelling salesman travelling from city to city, this begins from his native land/city
- Required to discover straight path through some specified towns/cities
- All cities should be visit only once
- In the end revisit the home town/city

LITERATURE REVIEW

A lot of research and methods are used for solving TSP because it's a complex problem. It is impossible to find the solution because it's NP hard problem. The space complexity is in O (N!). There are many different algorithms for solving TSP but ant colony algorithm is considered the best because of the following reasons.

To calculate the solution of travelling salesmen problem with the help of using genetic algorithm, the result is obtained by Bullnheimer *et al*. (1997). The result obtained is not required answer as compared to genetic algorithm. The result is more like examination error than having less chance for getting required answer. Genetic algorithm cannot handle the complexity.

On Manyppt (2014) neural network was used for solving travelling salesman problem. The drawback for solving travelling salesman problem with N number of cities requires O (N^2) units and O (N^4) connections. The optimization problem should be solved in space complexity of O (N!) but it was solved in the space of O (2^{N2}).

From their work by Dorigo and Stutzle (2003), ant colony optimization algorithms are used for solving NP-hard questions which arise in many applications.

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Table 1: Observation of ants always try to use the shortest path

References	Year	Authors	Achievement
Ilie and Badica (2010)	2010	Sorin Illie and Costin Badica	Discussed about creating an algorithm using the ant colony system. In this study, the technique proposed is being tested and is compared with the amt colony system. Travelling salesman problem is used to check the effectiveness of the proposed technique.
Balaprakash *et al*. (2009)	2009	Prasanna Balaprakash, Mauro Birattari, Thomas Stutzle, Zhi Yuan and Marco Dorigo	Discussing to propose a technique of ant colony system. This technique estimates the value before being used and gives result on the basis of probability. This study shows positive result relating this technique.
Hammerl (2009)	2009	Thomas Hammerl	Wrote a thesis in which he discussed that ant colony can work more effectively if it is used in the form of a tree. Different variable of ant colony is discussed using the tree method. A new technique is being proposed by using ant colony.
Afshar (2009)	2009	M. H. Afshar	Discussed pipe network method and which ant colony technique is better to use for applying this algorithm that is elitist ant method or min max ant system. It is discussed which method is more effective.
Chu *et al*. (2004)	2004	Shu-Chuan Chu, Jhon F. Roddick and Jeng-Shyang Pan	This study discusses how ant colony is used in creating communication strategy using ant colony. Different strategies are discussed in this study.
Negulescu *et al*. (2008)	2009	Sorin C. Negulescu, Constantin Oprean, Claudiu V. Kifor, Ilie Carabulea	This study is discussing how the problem of route allocation is solved by using elitist ant system. It is discussed how this method is configured and how effective it will be when used in any type of software.
Korb *et al*. (2006)	2006	Oliver Korb, Thomas Stutzle and Thomas E. Exer	Discussing a method named PLANTS which is being used on the basis of ant colony. This method helps in predicting the proteins and languid used in making medicine. Without the use of this method, the process of making medicine is time consuming.

These types of problems are easily solved by ant colony algorithms. The algorithm is not very technical procedure. Algorithmic ideas are standardized in this way. This algorithm was firstly used for solving TSP. It is most efficient and is good choice for solving travelling salesman problems. So our main objective of work presented is to exploite different algorithms of Ant Colony Systems (ACS) through determining their efficiencies, suitability to problem and complexity.

Working of ant colony: The working of ant colony algorithm was developed by observing an ant colony when ants use their cognitive ability for locating provisions and return to colony using the shortest path available by Deneubourg *et al*. (1990).

There have been many experiments done on the nest of ants relating on the choice of finding the shortest distance for discovery provisions. The scientists observed that ants always try to use the shortest path. This is explained as follows (Table 1):

- An ant leaves the colony to find food.
- If it finds food supply, it returns back to colony, parting with traces of pheromones in the way.
- Pheromones are very attractive, forcing the ants to follow the tracks.
- When ants return to the colony, they strengthen the route by leaving more pheromones.
- If there is more than one path to reach the food source, then as the time passes, the shorter path will be frequently used than longer path.
- The short path will be improved and becomes more attractive due to pheromones
- As the use of long route is lessened, the route will disappear eventually.
- Then all the ants will determine and choose to use the shortest route.

Applications of ant colony: Many techniques are derived from ant colony. Many problems have been solved with the help of this method. Some of the research study related ant colony is explained in Table 1.

Techniques: Ant colony algorithm is used for locating the direct path from the starting point to the goal. The ants find the shortest distance by depositing pheromones so other ants can follow in that way.

Many ACO Algorithms are introduced from 1991 to 2001 (Graupe and Gandhi, 2001) which are as follows by Dorigo *et al*. (2006):

- Ant System
- Elitist Ant System
- Rank based Ant System
- Ant Colony System
- Search Stagnation
- Experimental Evaluation
- ACO plus Local Search
- Ant-Q
- Ants
- BWAS
- Hyper-Cube AS

METHODOLOGY AND TECHNIQUES

Several ACO algorithms are introduced from 1991. Given below are the different ant colony algorithms which are used solving TSP.

Ant system: The initial Ant Colony Optimization algorithm was Ant System which was proposed by Dorigo *et al*. (1996). Dorigo *et al*. (1996) proposed that Ant System is one of the ACO algorithms which are used for solving travelling salesman problem. Ant cycle is defined as the pheromone deposition is updated when every ant finishes the trip. There are two main phases of ant system which are:

- Represent ant solution construction
- Pheromone update

From the ant colony, the deposition of pheromone is important for the search. If the initial value of pheromone is too low then it will favor the first tour done by ants and have fewer zones for the search. In contrast if the primary value of pheromones is more than enough then much iteration will be lost in waiting for reduction of pheromones so that ants may add pheromones to favor the exploration.

In ant system, m ants collaborate to construct an expedition to solve Travelling Salesman Problem (TSP) Dorigo *et al*. (1996). It can be started by choosing to put ant in the random chosen city. To choose next city to visit, at every step, ant k use the rule of probability to make a choice. This is known as random proportional rule.

Whenever an ant visits a city, it makes a record, in this way; ant knows which has been visited and which are to be visited. This record defines the feasible neighborhood in the construction rule which is explained in equation which is given above. Besides that, record permit ant k calculate the span of the expedition which may create and repeat the path to deposit pheromones for upcoming global pheromone update.

Pheromones paths are updated, after the ants create their expedition. This happens when pheromones value is decreased on all curves due to a reason and increasing the level of pheromone located on the curve which was traverse by the ants in the tour. Evaporation rate try to evade infinite gathering of pheromones paths and allow the algorithm to avoid the appalling verdict which was in use previously. If ant does not choose the arc, the related pheromone value decreases with number of iteration.

Generally many ants use the arc and especially the shortest paths which have more pheromone as compared to other paths. The path is more likely is chosen by ant in the iteration of the algorithm.

Elitist ant system: Elitist Ant System was proposed by Dorigo (1992), an improved version of ant system was introduced. In this algorithm, a memory was introduced which keeps the record of tour with fine solution. Each iteration is armored with an extra amount pheromone update.

Ant-Q: Ant-Q was proposed by Gambardella and Dorigo (1995). But in 1996, it was rejected, because a new algorithm was proposed which was improved version of Ant-Q and was easy to apply. That algorithm was Ant Colony System.

Ant colony system: Ant Colony System was proposed by Dorigo *et al*. (1996). To improve the ant system algorithm, another algorithm named ant colony system was introduced. In equation given below of the construction, ants choose which city is to be visited next is decided on pseudo random propositional rule. The given algorithm is used to find best tour in minimum number of iteration. But the work which is done by ants is compared to other variable of ant algorithms.

Max min ant system: Max Min Ant System was introduced by Stutzle and Hoos (2000). It is improved algorithm of elitist ant system. The solution of this algorithm is similar to the ant system but the pheromone deposition is different in two ways. The first difference is that pheromone updation is used with purpose of utilizing the best answer. The second difference is that pheromone strength which is present on the boundaries lies between the range. The good trail for the pheromone updation can be found by both global tour and iteration tour. For this algorithm, branching factor is used to determine that algorithm is converged or not.

The branching factor is basically number of outgoing edges which satisfy the above equation. Average of branching factor is calculated by keeping all the edges in mind. If τ is approximately equal to one, then there is only one edge for leaving the node, signifying that ants have found a better trail. For finding new tours, a process has been introduced which is known as smoothing of trials. The smoothing process can alter the trial strength on edges by factor. They can help in exploring an unknown area.

Rank based ant system: Rank-based Ant system (AR) was proposed by Bullnheimer *et al*. (1997). The min algorithm of elitist ant is included in Rank Based Ant System. According to the algorithm, every ant has been allocated a rank on the basis of the performance. The main reason for allocating rank is for pheromone updation. In the pheromone updation phase, updation of pheromone is updated twice the rate for best tours.

CONCLUSION

In this study different ant colony algorithms have been discussed. All the algorithms have the main objective with slight point of view. With the passage of time, the ant colony algorithm has been improved. So it can be concluded that the recent proposed method that

is rank based method is the best method to be used to solve travelling salesman problem and other NP problems which can be easily solved by the ant colony.

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