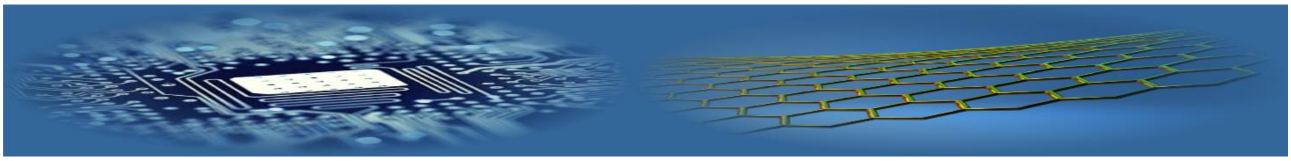

Ant colony optimization algorithm: advantages, applications and challenges

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Abstract

Ant Colony optimization is a technique for optimization that was introduced in early 1990's. ACO algorithm models the behaviour of real ant colonies in establishing the shortest path between food sources and nests and this technique is applied on number of combinatorial optimization problem, communication networks and robotics. This paper introduces the advantages of using the ACO algorithms with the help of some problem examples and the challenges faced for solving the problems. Initially, the paper discusses about the biological inspiration and behaviour of ant colony and then relates with the real life problems.

Keywords:

Ant colony optimization (ACO),
pheromone,
Travelling Salesman Problem (TSP)

1 Introduction

In the real world, ants are able to find the shortest path from the source to the destination (food) without using any visual cues. While moving from source to destination the ants deposit a chemical called pheromone on their way, and each ant prefers to follow the direction which is rich in pheromone. By using this behaviour of ants, the researchers have related the meta heuristic algorithm to define methods applicable to a wide set of different problems. Ant Colony Optimization (ACO) is part of larger field of research termed ant algorithms or swarm intelligence that deals with algorithmic approaches that are inspired by the behaviour of ant colonies and other insects. In ACO, artificial ants build solution to the considered optimization problem at hand and exchange information on the quality of these solutions via a communication that is reminiscent of the one adopted by real ants. The aim of this paper is to introduce ant colony optimization and to survey its application.

Problems to be discussed: TSP, quadratic assignment problem. Job-shop scheduling problem

2 ACO to solve NP Complete Problem like Travelling Salesman Problem

The travelling salesman problem can be considered as a complete graph with n vertices, we can say that a salesman wishes to make a tour by visiting each city exactly once and finishing at the city he starts from. There is an integer cost c(i,j) to travel from city i to city j, and the salesman wishes to make tour whose total cost is minimum, where the total cost is the sum of the individual costs along the edges of the tour.

In ant colony optimization the problem is tackled by simulating a number of ants moving on a graph that encodes the problem itself.

The artificial ants are having following properties:

1. Give individual ants limited amount of memory
2. Record trip to destination
3. Upon reaching destination, scan to eliminate loops
4. Retrace steps on the return trip, ignore pheromone trail
5. Apply pheromone only on the return trip.

3 ACO Algorithm overview

1. Initialize all of the arcs with a uniform pheromone level, initially (p=0).
2. Randomly place ants on the grid.
3. Progress Forward.
4. Eliminate the loop in the path traced.
5. Retrace steps
6. Globally update the trail by evaporating a portion of the pheromone according to parameters.
7. Apply the amount of pheromone to retrace arc.
8. Loop or exit

Consider the situation in the Fig.1, when searching for food ants initially explores the area surrounding their nest in a random manner. While moving, ants leave a chemical pheromone trail on the ground. Ants can detect the pheromone and the path with strongest pheromone is chosen by the other ants. Therefore the pheromone trails will guide other ants to the food source. This communication between the ants via pheromone trails-known as stigmergy- enables them to find the shortest path between their nest and the destination.

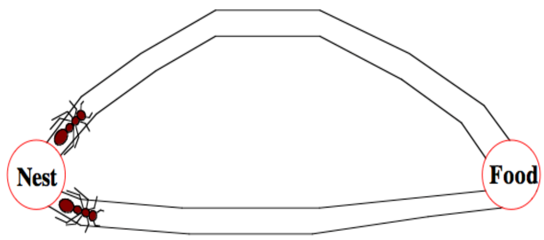


FIGURE 5 Ant selects the random path to go from source to destination

While considering the computation using ACO, we assume that initially the probabilities of the ants for selecting the path are equal and they do not leave pheromone while going from nest to food. We assume that the time taken by each ant per unit distance is constant, as can be seen from Figure 2 at time=t, one of the ants has already reached the destination whereas the other is still on the way back to the nest. If the situation repeats itself, the deposition of pheromone on the shortest path will be strong and after some interval of time all the ants leaving from nest to food will choose the shortest path as shown in Figure 3 and hence will be considered as the optimized path to reach from nest to food.

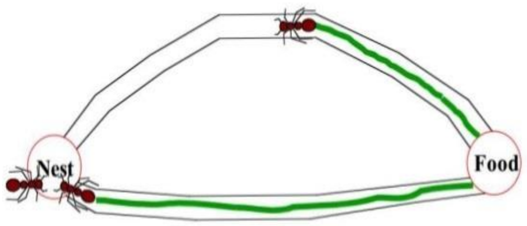
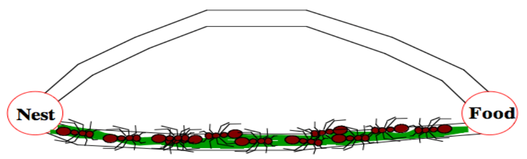


FIGURE 6 During return journey ant leaves behind the traces of pheromones



The scenario illustrate the situation when there are two ants moving from one point to another, now consider the real time TSP in which there are i cities. During construction of a feasible solution, ants select the following city to be visited by probabilistic decision rule. The probability rule between two nodes j, called Psuedo-Random-Proportional Action Choice Rule, and it depends upon two factors: the heuristic and metaheuristic.

pij = [Tij]a[ŋij]b,

∑ [Tij]a[ŋij]b,

where Tij is the amount of pheromone on the edge (i,j); a is the parameter to control the influence of Tij; ŋij is the desirability of edge (i,j); b is the parameter to control the influence of ŋij.

4 Applications

Many NP problems can be solved by using ant colony optimization; one of them is Graph colouring problem. The problem can be described as follows: given m colours, one has to find a way of colouring the vertices of a graph such that no two adjacent vertices are of same colour. The feasible solution to this problem is solved by ACO which is referred in paper. Other applications include Scheduling problem, routing in telecommunication network, traffic dispersion routing etc.

5 Conclusions

ACO is a recently proposed metaheuristic approach for solving hard combinatorial optimization problems. Artificial ants implement a randomized construction heuristic which makes probabilistic decisions. ACO is a class of algorithms, whose prime member called ant system was initially proposed by Colorni, Dorigo and Maniezzo. The idea was inspired by the behaviour of real ants and their way of approaching to the destination (food) from the source with the help of pheromone**.**

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