

# Applications Of Ant Colony Optimization

## ACO(Travelling Salesman Problem)

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**Abstract**—The ant colony optimization takes inspiration from the foraging behavior of some ant species. These ants deposit pheromone on the ground in order to make some suitable path that should be followed by other members of the colony. The goal of this paper is to introduce ant colony optimization and to survey its most notable applications. In this paper we focus on some research efforts directed at gaining a deeper understanding of the behavior of ant colony optimization algorithms in different fields.

**Keywords**—Ant Colony optimization, metaheuristic algorithm, Parallel Ant Colony Optimization, Immunized Ant Colony Optimization.

### I. Introduction to Ant Colony Optimization

**Ant Colony Optimization (ACO)** is a prototype for designing meta-heuristic algorithms for combinatorial optimization problems. The first algorithm which can be classified within this framework was presented in 1991 and, since then, many diverse variants of the basic principle have been reported in the literature. The essential trait of ACO algorithms is the combination of a priori information about the structure of a promising solution with a posteriori information about the structure of previously obtained good solutions. An ant is a simple computational agent, which iteratively constructs a solution for the instance to solve. Partial problem solutions are seen as states.

### II. Meta-heuristic algorithms

**Meta-heuristic algorithms** are algorithms which, in order to escape from local optima, drive some basic heuristic: either a constructive heuristic starting from a null solution and adding elements to build a good complete one, or a local search heuristic starting from a complete solution and iteratively modifying some of its elements in order to achieve a better one. The meta-heuristic part permits the low-level heuristic to obtain solutions better than those it could have achieved alone, even if iterated. Usually, the controlling mechanism is achieved either by constraining or by randomizing the set of local neighbor solutions to consider in local search (as is the case of simulated annealing or tabu search), or by combining elements taken by different solutions (as is the case of evolution strategies and genetic or bionomic algorithms). The

characteristic of ACO algorithms is their explicit use of elements of previous solutions. In fact, they drive a constructive low-level solution, as GRASP does, but including it in a population framework and randomizing the construction in a Monte Carlo way. A Monte Carlo combination of different solution elements is suggested also by Genetic Algorithms, but in the case of ACO the probability distribution is explicitly defined by previously obtained solution components.

An ACO algorithm includes two more mechanisms: trail evaporation and, optionally, daemon actions. Trail evaporation decreases all trail values over time, in order to avoid unlimited accumulation of trails over some component. Daemon actions can be used to implement centralized actions which cannot be performed by single ants, such as the invocation of a local optimization procedure, or the update of global information to be used to decide whether to bias the search process from a non-local perspective.

ACO attracted the attention of more researchers and relatively a large amount of successful applications are now available. Moreover, a significant corpus of theoretical results is becoming available that provides useful guidelines to researchers and practitioners in further applications of ACO.

One example was the work presented by [ROU01] that relates the ACO with the fields of optimal control and reinforcement learning. The local update rule in ACO corresponds to update in each learning step and the global update rule corresponds to update after one learning episode. The ant colony optimization algorithm was also used for routing and load balancing. This was proposed by [KWA03]. Mitigate from node to node, an artificial ant emulates laying of pheromone by corresponding entry in routing table in a records which records, for example, the number of nodes that pass that node. The ACO routing was different from traditional routing in some issues like routing information, routing overhead and adaptivity and stagnation.

[BLU04] proposed a framework called hypercube framework for ACO. This framework was based on changing the pheromone update rules used in ACO algorithm so that the range of values the pheromone trail parameters can assume is limited to the interval [0,1]. The CT-ACO algorithm uses ant colony optimization to find the solutions of vehicle routing problem. Cyclic transfers enclosed into an ant colony optimization as neighborhood search to improve solutions [LIX05]. The parallel ant colony optimization (PACO) algorithm based on the ants (PACO-A) was presented by

[HON06].et.al to solve multi stage problem. The PACO-A algorithm establishes the same construction graph in each PC attended the parallel computing.

Evolvable hardware(EHW) refers to hardware that can change its architecture and behavior dynamically and autonomously by interacting with its environment.[HAI07] ,took a broad view on the progresses of ant colony optimization-based EHW and address some important issues.The image segmentation is a key process of the image analysis and the image comprehension. .[BO07].et.al,used the basic principle of the ACS in the image segmentation. A novel SAR(Synthetic Aperture Radar) image segmentation algorithm, based on the Ant Colony Optimization (ACO) method was proposed by [LAN07] .The method extended the ant colony algorithm to threshold optimization, two-dimension fuzzy entropy is used as objective function, and ant move direction is determined by trail pheromone.All ants are positioned on randomly generated starting nodes and initial values for trail intensity are set on nodes. The ACO problem space is a multistage search space. Each stage contains several nodes, while the order of node selected at each stage can be combined as an achievable tour that is deemed a feasible solution to the problem.In other word, one path represents a solution value of the thresholds. [YON07] presents a novel algorithm based on ant colony optimization for solving sensor management problem.First we establish a two dimension node graph representation of the problem along which the ant can move properly to construct the candidate solutions.The ant constructs a travel path by repeatedly choosing a transition arc and its corresponding node from the original node and terminating by the constraints and we will get a two dimension SR graph.It had been demonstrated on 8 sensors and 15 target instances.

[WUH07] proposed immunized ant colony optimization.In continuous Ant Colony Optimization,in the internal cycle, there is only one operation, which is the probability move of ant individual. So, the ant individual cannot explore effectively in internal cycle, the efficiency and precision of whole algorithm will be damaged largely. To improve continuous Ant Colony Optimization, here the mature methods used in evolutionary algorithm and artificial immune system are introduced into continuous Ant Colony Optimization, and a new Immunized Ant Colony Optimization (IACO) is proposed for the first time.The ant colony is randomly distributed in the solution space. The site of one ant individual is corresponding to one point of solution space, which is one solution vector. One kind of thickness factor is introduced into selection operation to adjust the score of individual .If the thickness of individual is high, the premature is easy to appear, so the individual whose thickness is high should be restrained and the selection probability of individual whose fitness is large must be high. After the above operations, the hormone information of new ant colony must be updated. . So, the new Immunized Ant Colony Optimization is a very good optimization method, and is suitable to be used in very complicated optimization problem.

[RUE08]The flow shop problem is hard to solve by giving the proper order for job sequence.The ACO has been verified to

be applicable for variable combinatorial problems and scheduling problems. However, the solution obtained from ACO is dependent on the exploitation strategy of state transition rule. Therefore, three different ways of state transition rules, i.e., in order, random order, and Pheromone-related, are investigated in this study. In the ACO, each ant parallel generates one solution. In an iteration, there are K solutions generated, where K is the number of ants. Each ant uses the local update rule to update pheromone value. Among the K generated solutions, the ACO algorithm applies the best solution to increment the pheromone by using the global update rule .Furthermore, a local search is utilized to improve the solution quality. The state transition rule would select the job with maximum pheromone directly. Moreover, the Random order state transition rule has lower computation complexity.The Pheromone-related state transition rule is with high stability for solving problems.The more researches in the future would focus on the setup time or the cases with larger scale in FSP. Moreover, more schemes should be further studied for solving the FSP.

[ZAI08] presented improved noise clustering with ant colony optimization algorithm.Noise clustering, as a robust clustering method,performs partitioning of data sets reducing errors caused by outliers. [DON09] proposed an improved ant colony optimization for communication network routing problem.Using ACO whose colony scale is P,an individual ant simulates a source node and its route is constructed by incrementally selecting destination nodes until all nodes have been visited. To apply the ACO in disassembly planning [HUA08],the first part in disassembly sequence can be regarded as nest of ant colony and the last part regarded as food source.The shortest path represented by optimum disassembly sequence .The ant searching the route from first part to last one.It can be verified that proposed disassembly planning approach with the ant colony optimization algorithm is efficient for finding more feasible non dominated solutions.

The MR brain image segmentation is an important and challenging problem confronting grain mapping [MYU09]. Accurate classification of magnetic resonance images according to tissue types of grey matter (GM), white matter (WM), cerebrospinal fluid (CSF) at voxel level provides a means to assess brain structure. In order to effectively obtain optimal threshold, a better method that uses ant colony optimization algorithm is proposed. The proposed method is defined by the 'food' for object segmentation in image.

[JIN09] proposed the educational tool for ant colony optimization algorithm.The learning tool is used to teach and study the ant colony optimization algorithm. The main idea of the tool is to make easier for the user to study and manipulate the algorithm. The parameters allowed to be changed in the ant colony optimization algorithm like number of ants,number of iterations etc..The students also have the experiments with the tool to manipulate the control parameters for the algorithm. Particle Swarm Optimization algorithms(PSO for short) are the same with Continuous Object Optimization Problems [YAN09], but the convergence velocity is slowly .Utilizing the characteristic of ant colony and particle swarm, we put

forward a mixed ant colony optimization algorithm named PSACO based on the definition area division and particle swarm operator (PS stands for Particle Swarm ,ACO stands for Ant Colony Optimization).It applies to resolve Continuous Object Optimization Problems. [WAN09] applying self-adaptive Ant Colony Optimization for construction Time-Cost Optimization.The time-cost optimization (TCO) problem is a multiobjective problem, which attempts to strike a balance between resource allocation costs and project schedule duration. the intrinsic weakness of premature of the basic ant colony optimization (ACO) by adjusting parameters according to mean information entropy of the ant system. Time and cost are the two important objectives of construction project, and they are intricate related.

Forecasting for coal-seam gas content has a great affect on safety work in exploitation. With the increasing of mining depth, the influencing factors of coal-seam gas content are more and more. And there is complicated nonlinear relationship between the influencing factors of coal-seam gas content and coal-seam gas content [CHU10].Ant colony optimization is applied to select the operational parameters of support vector regression.

The path planning problem was simplified to minimize the path which connects every point by applying the grid method and the visibility graph method [ZHA10]. Then an ant colony optimization algorithm was used to optimize the path between two checkpoints and the orders to arrive. Ant colony optimization algorithm, based on the simulation of ants group behaviors, as a kind of distributed intelligent algorithm, was presented by Colomi and Dorigo in the 1990s.

### III. Conclusions

The Ant Colony optimization has been used in solving the different problems like telecommunication networks,load balancing in networks,routing,Hypercube framework,image segmentation,sensor management etc.A local search mechanism was introduced to increase the probability of escaping from local optima.The ant colony optimization is stochastic algorithm based on social-psychological metaphor and many random operations. After more than ten years of studies, both its application effectiveness and its theoretical groundings have been demonstrated, making ACO one of the most successful paradigm in the metaheuristic area.

For each of these different research directions we explicitly listed those that are ,in opinion ,some of the most interesting open problem.As the ACO research field is currently flourishing,we expect to see many of these problems solved in near future.As a final comment,we note that the ACO research is not only about theory.On the contrary,most of the fields is concerned with experimental work.

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