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Ant Colony Optimization (ACO) in Disaster Information Network

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Abstract
Swarm intelligence is a relatively new approach to problem solving that takes inspiration from the social behaviors of insects and of other animals. In particular, ants have inspired a number of methods and techniques among which the most studied and the most successful is the general purpose optimization technique known as ant colony optimization. The goal of this article is to introduce ant colony optimization and to survey its most notable applications. A better understanding of the theoretical properties of ACO algorithm is certainly another research direction that will be pursued in the future

Introduction
We present the concept of swarm intelligence, and describe its principles and mechanisms. We also describe the most successful artificial swarm intelligence systems together with the natural phenomena that inspired their development. We present the concepts of individual and social learning, and describe the main mechanisms involved in social learning.

Swarm Intelligence:
Swarm intelligence has become a research interest to many research scientists of related fields in recent years. The classical example of a swarm is bees swarming around their hive; nevertheless the metaphor can easily be extended to other systems with a similar architecture. An ant colony can be thought of as a swarm whose individual agents are ants. Similarly a flock of birds is a swarm of birds. Swarm intelligence has a twofold objective. First, it aims to understand the fundamental principles that are the responsible for the collective-level intelligence sometimes exhibited by large groups of animals. Second, it aims to define engineering methodologies for the design and construction of large groups of man-made entities that collectively solve practical problems.

Artificial Swarm Intelligence Systems
The design and construction of artificial swarm intelligence systems have been heavily inspired by the behavior of natural swarms. The first efforts toward the development of artificial swarm intelligence systems began in the 1990s with pioneering works in robotics, data mining, and optimization. In fact, these domains are still the application areas of most artificial swarm intelligence systems.

Ant Colony Optimization
The ants' pheromone trail laying and trail following behavior inspired the development of ant colony optimization (ACO). Some aspects of the real behavior of ants that allows them to find shortest paths in nature are simulated in ACO algorithms in order to tackle optimization

problems. In nature, real ants form pheromone trails; in ACO, artificial ants construct candidate solutions to the problem instance under consideration. Solution construction is a stochastic process biased by artificial pheromone trails and possibly by available heuristic information based on the input data of the instance being solved. Pheromones are simulated as numerical information associated with appropriately defined solution components. A positive feedback process implemented by iterative modifications of the artificial pheromone trails is key for all ACO algorithms. In ACO algorithms, pheromone trails can be thought of as a function of the ants' search experience. The goal of positive feedback is to bias the colony towards the most promising solutions. The ACO metaheuristic (Dorigo and Di Caro, 1999; Dorigo et al., 1999) is an algorithmic framework that allows the implementation of the aforementioned ideas for the approximate solution of optimization problems. Such a framework needs to be instantiated into an algorithm in order to tackle a specific problem. The framework is flexible enough to accommodate specialized problem-solving techniques.

Algorithm 1: Basic structure of an ant colony optimization algorithm:

Repeat

Construct Solutions

Daemon Actions / Optional */*

Update Pheromones

Until Stopping criterion is satisfied

Particle Swarm Optimization

Particle swarm optimization (PSO) is a population-based stochastic optimization technique primarily used to tackle continuous optimization problems. A continuous optimization problem is defined as follows. PSO has roots in computer graphics, social psychology, and natural swarm intelligence. Examples of such objects are fire, smoke, water and clouds. In these systems, particles are independent of each other and their movements are governed by a set of rules. PSO is a direct search method, which means that it works only with ordinal relations between objective function values and does not use the actual values to model, directly or indirectly, higher order properties of the objective function. In a PSO algorithm, simple agents, called particles, move in the solution space.

Algorithm 2: Basic structure of a particle swarm optimization algorithm:

Initialize Swarm

Repeat

Evaluate Swarm

Update Positions

Until Stopping criterion is satisfied

Swarm Robotics

Robotics has been pivotal in the development of the swarm intelligence field. In fact, it was in a robotics paper that the term swarm intelligence was first used. Swarm intelligence applied to the multi-robot domain is called swarm robotics. It is sometimes defined as the study of how large number of relatively simple physically embodied agents can be designed such that a desired collective behavior emerges from the local interactions among agents and between the agents and the environment. In swarm robotics, some mechanisms involved in robot control and the benchmark tasks robots solve, have been inspired by studies of real swarm-forming animals. Research in swarm robotics is not only focused on tasks that can be solved collectively by robots. There are also practical problems that need to be tackled in a swarm robotics system. For example, robots that are part of a swarm may need to know when one of their peers stops working properly, or they may need to know how many robots compose the swarm. Some of these problems have been tackled using nature-inspired as well as purely engineered approaches.

Optimization Technique:

Ant colony optimization (ACO:

Ant colony optimization (ACO) takes inspiration from the foraging behavior of some ant species. These ants deposit pheromone on the ground in order to mark some favorable path that should be followed by other members of the colony. Ant colony optimization exploits a similar mechanism for solving optimization problems.

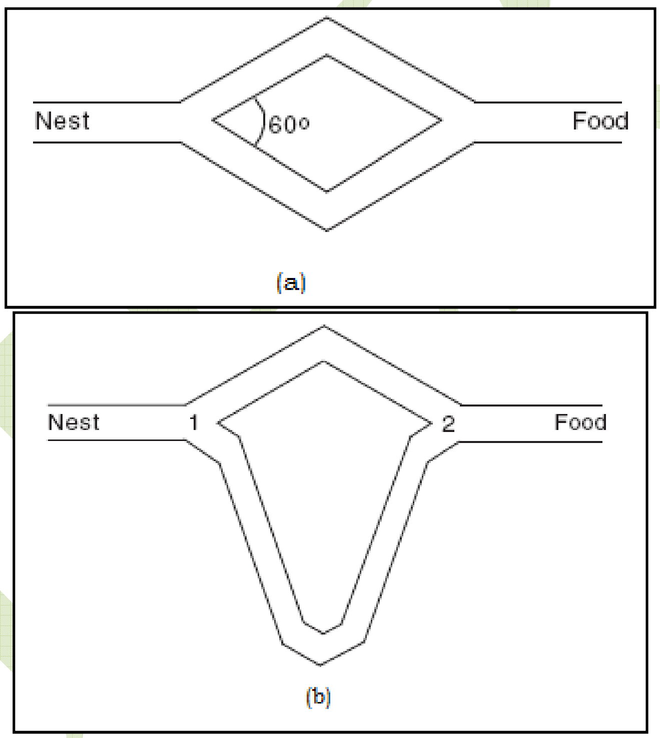

Fig. 1: Experimental setup for the double bridge (a) Branches with equal length (b) Branches with different Lengths. In many ant species, ants walking to and from a food source deposit on the ground a substance called pheromone. Other ants perceive the presence of pheromone and tend to follow paths where pheromone concentration is higher. Through this mechanism, ants are able to transport food to their nest in a remarkably effective way.

Algorithm 3: The Ant Colony Optimization Metaheuristic:

Set parameters, initialize pheromone trails
While termination condition not met do
ConstructAntSolutions

ApplyLocalSearch (optional)
Update Pheromones
end while

Ant colony optimization (ACO) has been formalized intoa metaheuristic for combinatorial optimization problems by Dorigo and co-workers. A metaheuristic is a set of algorithmic concepts that can be used to define heuristic methods applicable to a wide set of different problems. In other words, a metaheuristic is a general-purpose algorithmic framework that can be applied to different optimization problems with relatively few modifications.

***APPLICATIONS OF ANT COLONY OPTIMIZATION*:**

Dynamic Nature in term of nodes behavior, traffic and channel and network condition. Due to the mobility node and the changing in environmental condition as a result of the movement, the channel and therefore link qualities might be extremely dynamic thus, the communication techniques need to be flexible and to be adaptive to the dynamics of the specific networking environment. One of the most powerful biological approaches is Artificial Immune System (AIS) which effectively identifies the changing in environmental condition

Table 1: Evaluation of Bio-Inspired Network to Conventional Network Disaster System

Criteria	**Bio-inspired Networks**	**Conventional System**
Performance	Good performance even when the task is weakly defined	Attain a saturation boundary in their performance
Flexibility	Strength through flexibility	begin with a fixed size or population in mind therefore are not very flexible
Scalability	It is not a really problem for bioinspired network	Scalable in certain degree and limitation
Decision making	Try to find the optimal and best available solution	Limitation in understating the program to make an optimal decision

OUTLOOK AND CONCLUSIONS

As we have discussed, nowadays hundreds of researchers worldwide are applying ACO to classic NP-hard optimization problems, while only a few works concern variations that include dynamic and stochastic aspects as well as multiple objectives. The study of how best to apply

ACO to such variations will certainly be one of the major research directions in the near future. A better understanding of the theoretical properties of ACO algorithm is certainly another research direction that will be pursued in the future.

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