

SWARM INTELLIGENCE

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Abstract--*In this paper we are discussing about “Swarm Intelligence”. Anything in group is said to swarm. Intelligent behaviour from large number of Individuals is called as Swarm Intelligence. Swarm intelligence is a cumulative behaviour of the intelligence of concurrently interacting natural/artificial agents. Swarm Intelligence is a computational and behavioural metaphor for solving distributed problems inspired from biological examples provided by social insects like ants, termites, bees, and wasps and by swarm, herd, flock, and shoal phenomena in vertebrates such as fish shoals and bird flocks. Ant colony Optimization describes the movement of ants, their behaviour, and how do it overcome the obstacles, in birds we can see about the Particle swarm optimization it is based on the swarm intelligence and how the positions has to be placed based on the principles. Next is Bee colony optimization that deals with behaviour of the bees, their interactions, also describes about the Movement and how they work in Swarm.*

Keywords

Swarm Intelligence, ant colony optimization, particle colony optimization, bee colony optimization

I. INTRODUCTION

A swarm is vast number of homogenous, simple agents interacting locally among themselves, and with no central control to allow a global interest behaviour to emerge. The Swarm-based algorithms have emerged recently as nature- inspired, population-based algorithms that are capable of producing low cost, fast, and robust solutions to several complex problems. Swarm Intelligence (SI) can therefore be defined as a relatively new branch of Artificial Intelligence (AI) that is used to model the collective behaviour of social swarms in nature, like ant colonies, honey bees, and bird flocks. Although these agents (insects or swarm individuals) are relatively unrefined with limited capabilities on their own, they are interacting together with certain behavioural patterns to cooperatively achieve tasks necessary for their survival.

In past , biologists and natural scientists have been studying behaviours of social insects because of the amazing efficiency of these natural swarm systems. In the late-80s, computer scientists proposed the scientific insights of these natural swarm to the field of Artificial Intelligence. In 1989, the Swarm Intelligence was first introduced by G. Beni and J. Wang in the global optimization framework as a set of procedures for controlling robotic swarm. By the late-90s, the two most popular swarm intelligence algorithms started to go beyond a pure scientific interest and to enter the realm of real-world applications. It is perhaps worth mentioning here that a number of years lately, in 2005, Artificial Bee Colony Algorithm was proposed by D. Karabago as a new member of the family of swarm intelligence algorithms.

To put it in a simple way, swarm intelligence can be described as the cumulative behaviour emerged from social insects working under very few rules. Self-organization is the important theme with limited restrictions from interactions among agents. Many famous examples of swarm intelligence come from the world of animals, like birds flock, fish school and bugs swarm. The social communications among individual agent help them to adapt to the environment more efficiently since more information are gathered from the whole swarm. This paper aims to introduce several well-known and interesting algorithms based on meta heuristic derived from nature and their applications in solving problems.

II. SWARM INTELLIGENCE OVERVIEW

Swarm Intelligence is, intrinsically, a bottom-up approach. Bottom-up approach is carried out by programming big number of independent entities with relatively simple sets of rules. Brought together,

constructive behaviour emerges, as it does in Swarm Intelligence Optimization and Its Applications 459 insects that create complex social behaviour and structures from the combined efforts of individuals with extremely limited intelligence. In contrast, the top-down approach is based on the classic centralized method (e.g., the Client/Server approach), where in central coordination should take place. SI can be implied to fully distributed systems that consist of several autonomous agents working together with local communication and minimal perception capabilities to complete one or more tasks. Collective behaviour demonstrated by social insects (ants, bees, termites, etc.) often emerges from a small set of simple low-level communications between individuals, and between individuals and the environment.

The following example illustrates the concept of emergence. To solve a given task, for example, to sort elements scattered on the ground, one can write an algorithm (procedure) wherein a centralized part distributes the task to achieve between a set of distributed agents. The centralized program, based on the global goal and plans, the current input, and the current state, collects agent results, analyses them, and decides the actions to be executed next. Swarm Intelligence is a way to control multiple agent systems. The swarm type approach to emergent strategy deals with large numbers of homogeneous agents, each of which has fairly limited capabilities on its own. However, when many such simple agents are brought together, globally interesting behaviour can emerge as a result of the local interactions of the agents and the interactions between the agents and the environment. A key research issue in such a scenario is determining the proper design of the local control laws that will allow the collection of agents to solve the given problem [5].

III. ANT COLONY OPTIMIZATION (ACO)

Ant colony optimization was proposed by Macro Darigo in 1991 in his PhD thesis the first algorithm was to search for optimal path based on the behaviour of ants finding the shortest path in search of food. ACO algorithm is used to solve problems like optimization problems, sequential ordering problems, scheduling problems, graph colouring, assembly line balancing, vehicle routing problems. ACO is widely used in swarm intelligence it is a class of algorithms which inspires foraging behaviour of ants. ACO is almost same as motivated behaviours in order to solve the optimization problems. Since it has been introduced there are several different versions to original optimization algorithm. So we limit our focus to Ant Systems, the original ACO algorithms were introduced. Pheromone levels are updated by all ants which build a solution to the iteration which is the main characteristics of AS. Foraging behaviour of ants is the best example for explaining the ability of ant colonies [3].

Foraging behaviour of ants is as follows:

- 1. Individual ants go in search of food; they wander randomly around the colonies in search of food source.
- 2. Ants can't directly communicate with each other; indirect communication is called as stigmergy.
- 3. When ants find their food source they immediately come back near the nest on its way back it leaves a chemical substances called as pheromone. These pheromones are volatile in nature and they keep evaporating.
- 4. Ants are capable of sensing pheromone and the route is attracted by other ants, they move on the same track. And each ant leaves their chemical substances and thickness track so that if any other ants are in the source then they can follow the pheromone thickness and find their food source.
- 5. If other ants have found shortest paths for the same food source, then that shortest path can be followed by other ants and this route becomes more attractive as increase in the concentration of pheromone.
- 6. If there is any difficulty in the route then it will move randomly in the beginning but later they will find the shortest path.

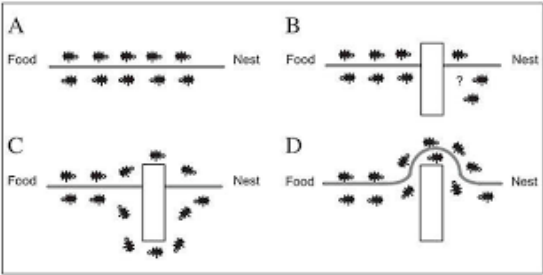


Fig: Ant's stigmergic behaviour in finding the shortest path between the food and nest.

There are two concepts that is been demonstrated

1. Self-organize behaviour of the ant by the positive feedback process as the count of the ant already passed in the ant's choosing a route increasing.
2. Food pheromone trail is a chemical substance, there is a high possibility that a chemical substance can evaporate, then ant select the negative feedback i.e., it explore the new route.

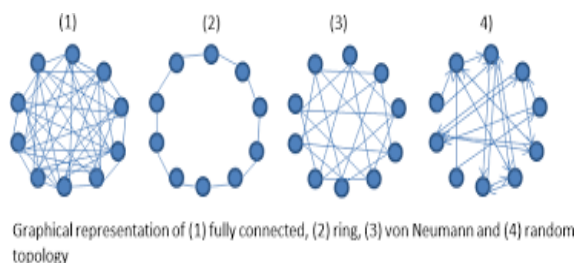
Algorithms

1. Procedure ACO meta heuristics
2. Schedule activities
3. Construct ants solutions
4. Update pheromones
5. Daemon actions is optional
6. End schedule activities
7. End procedure

Application of ACO used in scheduling problems, travelling salesman is developed and used in routing telecommunication network. The big advantage is it can be used in a dynamic applications like adapts to the new changes in the environment such as new distance. And drawback of ACO is theoretical analysis is difficult and research is experimental not theoretical.

IV. PARTICLE SWARM OPTIMIZATION (PSO) MODEL

The second example of a successful swarm intelligence model is Particle Swarm Optimization (PSO), which was introduced by Russell Eberhart, who is electrical engineer, and James Kennedy, social psychologist, in 1995. PSO was originally used to solve non-linear continuous optimization problems, but most recently it has been used in many practical, real-life application problems. For example, PSO(Particle Swarm Optimization) has been successfully implied to track dynamic systems, evolve weights and structure of neural networks, analyse human tremor, register 3D-to-3D biomedical image, control reactive power and voltage, even learning to play games and music compositions. PSO (Particle Swarm Optimization) draws inspiration from the sociological behaviour associated with bird flocking. It is a natural observation that birds can fly in big groups with no collision for extended long distances, making use of their effort to maintain an optimum distance between themselves and their neighbours. This section presents some details about the birds in nature and their capabilities, as well as their sociological flocking behaviour [4].



V. BEE COLONY OPTIMIZATION

Just like ants, bees have similar food collecting behaviours. Instead of pheromones, bee's colony optimization algorithms rely on the foraging behaviour of honey bees. At the first stage, some bees are sent out to look for promising food sources. After a good food source is located, bees return back to colony and perform a waggle dance to spread information about the source.

Three pieces of information are included:

1. Distance,
2. Direction,
3. Quality of food source.

The better the quality of food sources, the more bees will be attracted.

ALGORITHM

Bees Algorithm is based on foraging behaviour of the bees. This finds the optimal solution [3].

1. Population of the bees is initialized.
2. Population fitness has to be calculated.

3. While (condition (stopping criteria) not met)
4. Select certain spots to search.
5. Select more bees for a new spot and calculate the fitness.
6. Determine the fittest bees.
7. Other bees have to be assigned randomly for searching.
8. End While.

VI. CONCLUSION

In this paper, the main idea of swarm intelligence is presented with the particular focus on three most popular and successful SI optimization techniques: Ant Colony Optimization, bee colony optimization and Particle Swarm Optimization. The colonies of ants, flocks of birds, schools of fishes are some examples of the swarm. We also describe about the various Swarm Intelligence models such as the Ant Colony Optimization model that deals with the behaviour of the ants, their interactions and algorithm. Particle Swarm Optimization describes the behaviour and the principles of movements of birds in swarm. The Bee colony deals with the behaviour of bees how do they work in group and there interaction with each other. These swarm examples all solve complex problem.

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