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Swarm Intelligence (SI)-Paradigm of Artificial Intelligence (AI)

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Abstract | **Review Article**

This paper gives you the overview of the subfield of artificial intelligence which is called as "SWARM INTELLIGENCE". This is so called because it is named after the inspiration taken from the working behavior of the swarms. The term "swarm" denotes the group or aggregation of insects or animals or birds which works together so as to complete the difficult tasks in an efficient manner which are not possible to be completed as an individual entity. This working behavior of swarms has influenced the researchers to solve their problems in robotics, telecommunications, computer science, networking and various other technical fields. Apart from it, algorithms have been proposed to solve various complex problems which are having resemblance to swarm intelligence, in their working behavior. In this paper, a brief description of the working of these algorithms is given.

Keywords: Swarm, swarm intelligence, stigmergy, pheromone, paradigm.

1. INTRODUCTION

Since it is described that, problem solution which is inspired by the collective behavior of swarms is defined as swarm intelligence [1]. Thus, such an intelligent and autonomous systems are required that are able to solve complex tasks with self-organizing nodes that are not having central control (means distributed approach). Swarms are broadly categorized into:

1. Ants,
2. Honey bees,
3. Termites,
4. Particle.

1.1 Ant Swarms

Ants as individuals are not smart or intelligent enough to do their daily tasks of finding food source or finding shortest path to that location if source is found, dividing their work into short tasks and assigning these tasks to multiple ants so as to complete a task as a whole. Foraging is one of the examples that can describe the behavior of ants, and their working as colony. In the foraging process,

a) Ants are free to move in any direction in search of their food location.
b) Once they found a destination, they come back to their actual starting position by leaving a chemical substance which is volatile and attractive in nature and is called as pheromone.
c) For coming back to actual location, an ant may follow any direct or indirect path.
d) All other colony members will follow the same path where they found pheromone.
e) Now, in order to move through the shortest path, path that will constitute more number of ants to follow the same path in same interval of time will be the shortest path.
f) And for this shortest path obviously the concentration of the pheromone will be more as more number of ants will follow the same route leaving the chemical substance behind them.
g) As the concentration of that route will increase since more number of ants will follow it, thus the path that is comparatively longer will soon disappear. This is because of the volatile nature of the pheromone and of least concentration of the substance over that path.

1.2 Honey Bee Swarms

Honey bees are one another swarms' type that seems very helpful in solving the complex tasks by their working manner in an efficient, effective and intelligent way. They have tendency to do typical tasks by dividing them into smaller tasks. Their daily tasks involves forging, storing, retrieving and distributing honey and pollens , communication and most precisely their ability of adaptation for the change in the environment. Several

algorithms have been designed which work in the same manner as that of the working behavior of the honey bees. The concept of forging in honey bees can be explained as:

In the hive there are two types of bees named as:

i. Worker bees (scouts), and ii) forager bees.

The tasks that are to be performed by the worker bees are maintenance and management activities like collecting and storing food, removing the dead bees from the hive, keeping proper ventilation and guarding the hive etc. the foraging process involves:

a) First of all, the scout bees are sent to various directions randomly so as to find the food source.
b) Scouts move from one flower patch to another so as to find promising food source that may have the quality rated above the pre-defined quality threshold deposit their nectar or pollen.
c) After finding this, the scout bees move to the dance floor to perform a kind of dance so as to indicate the type of quality food detected to other bees.
d) This kind of dance that scout bees perform on the dance floor for communication to other bees is known as waggle dance.
e) This dance basically helps the other bees to know the direction of patch, distance of patch, and quality rating.
f) After getting this information, forager bees are sent to that patch.
g) Higher the quality of food at the patch more will be the number of bees at that patch.

Thus, in this way bee colony is able to get good quality of food effectively and efficiently.

1.3 Particle Swarms

In particle swarm method, the way by which the researchers got influenced is the working criteria of the birds and their ability to find their food. The foraging process in particle swarm can be described as:

a) It is supposed that the flock of birds is searching for food in some particular area.
b) And there is only a single piece of food in that area.
c) Now, to get the exact location where the food actually laying, each bird will flew in the direction in which the bird nearest to the food is flying.
d) An algorithm is being designed in such a way that locally and globally best positions of the birds are being calculated. And velocity after each iteration is modified.

In this way, the bird swarms (particle swarms) are helpful in order to find solution to the complex problems.

1.4 Termite Swarms

Termites are known for building hills by using pebbles. And the way they collect the pebbles, the way they do it effectively by using shortest path method by the use of pheromone substance has major influence on the researchers to use an algorithm based on this intelligence. The process is as described:

a) Each termite moves on the way where it finds the pheromone substance in order to collect the pebbles.
b) But if no pheromone is detected by the termite then, it will follow a random path so as to search a pebble by its own.
c) During the way to search a pebble, if it caught any pebble it will took it up.
d) A termite can carry on one pebble at a time.
e) And during its path again if it found any other pebble, then it will drop the already carrying pebble at that new location and infuse that pebble with pheromone so that other termite can detect it easily.
f) And this pebble will act as the building site of the hill of pebbles. That means all other termites will get a location to drop their own pebbles at that location so as to build a hill there.

2. APPLICATIONS

Since there are many algorithms that can completely fit into the working of various areas of working of several technical fields. Thus according to those several principles of working, we are having with applications in which Swarm Intelligence is useful. Some of the fields are as follows, Robotics, data Mining, Communication networks, Fuzzy Systems, Military Applications, Traffic Patterns and many more resembling fields that can have their solution with the help of this Swarm Intelligence.

3. ALGORITHMS

Algorithm is a kind of procedure or formula that is to be followed step by step so as to calculate or process a particular problem.

Various algorithms were designed that have their working similar to the working behavior of the above given swarm types. Few of the algorithms are listed below as:

a) PSO (Particle Swarm Optimization),
b) ACO (Ant Colony Optimization),
c) BFO (Bacterial Foraging Optimization),
d) PPSO (Perceptive Particle Swarm Optimization).

3.1 Particle Swarm Optimization

Particle Swarm Optimization (PSO) [1] was inspired by the behavior of the birds that fly around and search space, for the best location. Each particle either directly or indirectly communicates with the one another for the directions. Each particle moves through

the multi-dimensional space sampling an objective function at various positions. Best solution is extracted out and is plotted.

And is seeded with an initial velocity. The velocity of the particle is continuously updated so that it may experience the best position of itself or best position that is experienced by its neighbor in the swarm. The performance of the particle can be evaluated with the help of fitness function. The technique might have the problem of adjusting the parameters but is easy to implement.

3.2 Ant Colony Optimization

As it is explained in the 1.1 section of this paper, that ants used to communicate through the use of chemical towards it so that the ants of the swarm might follow the same path only. This all process of communication via the use of chemical substance is termed as trail-laying and trail-following. The algorithm based on this concept, uses a technique of positive feedback in which the concentration of the pheromone goes on increasing with the number of ants passing through the same route and the path that have lesser number of ants or least concentration of pheromone will disappear soon.

3.3 Bacterial Foraging Optimization

Bacterial Foraging Optimization algorithm is a kind of evolutionary computation algorithm. It is based on the foraging behavior of Escherichia Coli (E. coli) bacteria that resides in human intestine. This method is used for locating, handling and ingesting the food in the intestine. During its foraging phase, it can exhibit two different states: tumbling or swimming. The modification in the orientation of the bacterium is due to the fact of tumbling action possessed by the bacterium. And the swimming action is responsible for the movement of the bacterium in the current direction.

After a certain number of complete swims, the best half of the population undergoes the reproduction and eliminating the rest of the population. In order to escape local optima, an elimination- dispersion event is carried out where some bacteria are liquidated at random with a very small probability and the new replacements are initialized at random locations of the search space.

3.4 Perceptive Particle Swarm Optimization

Conventional particle swarm optimization relies on exchanging information through social interaction among individuals. However for real-world problems involving control of physical agents (i.e., robot control), such detailed social interaction is not always possible. Recently, the perceptive particle swarm optimization (PPSO) algorithm was proposed to mimic behaviors of social animals more closely through both social interaction and environmental interaction for applications such as robot control. In this study, we investigate the PPSO algorithm on complex function optimization problems and its ability to cope with noisy environments.

4. CONCLUSION

In this paper, I have discussed several types of swarms that can influence the working behavior of researchers. Nature has inspired problem solving techniques have been found to be an intelligent and efficient way for this. Apart from it, this paper is giving a reference to few of the commonly known algorithms of swarm intelligence. The working steps of these algorithms are mentioned that how the ants as a collective team behave efficiently in order to process complex tasks that are not possible to be carried out as an individual. Swarm intelligence has also been used for minimizing functions and for training in neural networks efficiently. Swarm intelligence is used in various other areas like in digital circuits, data mining and telecommunications.

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