Survey Paper on Swarm Intelligence

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ABSTRACT
In this paper we are discussing regarding the Swarm Intelligence and there some of the examples. Anything in group is said to a swarm. Intelligent behaviour from a large number of Simple Individuals is called as Swarm Intelligence. It is a collective Behaviour from the local interactions of the individuals with the each other. Individual co-ordinate from the decentralized control and self-organization. We can find swarm in colonies of ants, school of fishes, flocks of birds etc. In this paper we are seeing the examples of Swarm and their behaviour. we also see the various Swarm Intelligence models such as the Ant colony Optimization where is describes about the movement of ants, their behaviour, and how do it overcome the obstacles, in birds we see about the Particle swarm optimization it is based on the swarm intelligence and how the positions has to be placed based on the three principles. Next is the Bee colony optimization that deals with the behaviour of the bees, their interactions, also describes about the Movement and how they work in Swarm. Some of the techniques and algorithms are discussed in this paper.

Keywords
Swarm, Swarm Intelligence, Stigmergy, Pheromone

1. INTRODUCTION
Swarm Intelligence (SI) is a group of homogeneous individual agents, interact among themselves and with the environment. A Swarm is a collection of homogeneous, individual agents which interacts among them locally within the environment without centralization. "Swarm Intelligence" concept was first introduced by G. Beni, Hackwood and J. Wang in 1989. The context of cellular robotics systems was strictly used [6] [10][33]. This field of study focuses on the collective behaviour those results from the local interactions of the people with each other and with their surrounding conditions [1]. There is an arise to the smart systems which is able to perform complex tasks in various fields like robotics, computer science and software applications. SI is a simple local behaviour which leads to global intelligent behaviour. SI represents the idea to control and monitor complex systems interacting among the entities. Distributed forms of control can be more efficient, effective and scalable. The main aim of Swarm Intelligence is to increase the performance and robustness [6][9]. Swarm algorithms are fast, robust solution to solve complex problems. SI is a new branch of artificial intelligence that is used as collective behaviour of swarms in nature, such as colonies of ants, flocking of birds, honey bees. Agents are simple with limited capabilities; by interacting with other agents of their own kind they achieve the task. The agent follows very simple rules. The social interactions among individual swarms can be either direct or indirect. Direct interactions here the agents interact with each other through audio or video. Example is birds where they interact with each other through sound (audio) and bees interact with each other through waggle dance. Indirect interactions here the agents interact with the environment i.e., one agent changes the environment and other agents respond to the change. This indirect type of communication is called as stigmergy which is interaction through environment [7]. For example, the pheromone trail lay by the ants during the search of food. SI algorithms are inspired by nature to solve real life problems. Social collective behaviour of swarms helps to solve the real life problems by observing how swarms have survived to take challenges to solve complex problems in nature [8][12]. The swarm system is characterized in terms of individuals, interactions and environment.

Many researchers were motivated about the collective behaviour of ants, bees, birds etc. Different set of computer instructions (algorithms) were built based on the smart systems which could solve various problems. Colonies of ants, schools of fish, flock of birds, herds of land animals are some of the natural examples of swarm which has limited intellectual capabilities which presents a smart and efficient problem solving techniques. Ants are capable of searching their food in shortest path and they communicate through environment by chemical substances called as pheromone. They cannot directly communicate with each other; indirect communication is called as Stigmergy. Honey Bees which is capable of finding better quality of food than other swarms. Scout bees go in search of food from their source and when they find quality food, they perform waggle dance and convey information about the food quality and the direction to the food source [2]. Birds have very high immense vision power they go in search of food source. Some birds smell the best quality of food source and spread the information to all other birds hence they have good communication and co operation within themselves.

2. ANTS
Ants are considered to be one of the best natural examples of swarm. Ants follow indirect interactions. Ants live in colonies and are "almost blind" individuals, they lay pheromone (i.e., volatile chemical substance) on the way from the nest when they go in search of food source. The term "pheromone" was introduced by P. Karlson and M.Luscher in 1959, based on Greek word Pherin which means transport and hormone means to stimulate. There are different types of pheromones used by social insects; they are alarm pheromone and food trail pheromone. Alarm pheromone is used when crushed ants produces an alert to nearby ants to escape from dangerous predators to protect their colonies. The intensity of pheromone on the way is higher the probability in search of food [7]. Food trail pheromone is whenever the ant goes in search of the food it leaves the chemical pheromone on its way, in its environment. Ants are small tiny creatures which has limited intellectual abilities which are not smart enough to perform their daily tasks to find shortest path for food source. Ants

divide their works within themselves assigning tasks. These tasks can be performed by ant colonies in an efficient manner. Individual ants are simple and tiny creatures when they are in colonies only they are capable of performing tasks quickly and more efficiently to change their environment [1] [11][12].

2.1 Ant Colony Optimization

Ant colony optimization (ACO) 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 source [3][11]. ACO algorithm is used to solve complex problems like optimization problems, sequential ordering problems, scheduling problems, graph colouring, assembly line balancing, vehicle routing problems. Multi objectives areas used are data mining, telecommunication networking and bioinformatics [7]. ACO is widely used in swarm intelligence it is a class of algorithms which inspires the foraging behaviour of ants. ACO is almost same as motivated behaviours in order to solve optimization problems. Since it has been introduced there are several different versions to the original optimization algorithms. So we limit our focus to Ant Systems (AS), the original ACO algorithms were introduced. Pheromone levels are updated by all the ants which build a solution to the iteration which is the main characteristics of AS [4]. Foraging behaviour of ants is the best example for explaining the ability of ant colonies.

Foraging behaviour of ants is as follows:

1. Individual ants go in search of food; they wander randomly around colonies in search of food source as shown in figure 1.
2. Ants cannot directly communicate with each other; indirect communication is called as stigmergy.
3. When the 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 they keep evaporating.
4. Ants are capable of sensing this pheromone and the route is attracted by other ants, they move on the same track. And each ant leaves their chemical substances and thickness the 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 ant has found shortest paths for the same food source, then that shortest path can be followed by many other ants and this route becomes more attractive as increase in the concentration of pheromone.
6. If there is any obstacle in the route then it will move randomly in the beginning but later they will find the shortest path [5].

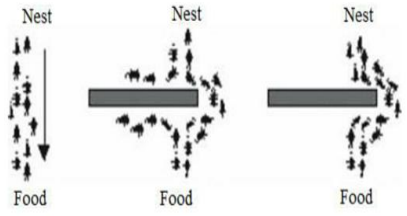


Figure 1: Ant's stigmergic behavior in finding the shortest path between the food and nest.

There are two concepts that is been demonstrated

1. Self organizing 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 chooses the negative feedback i.e., it explore the new route.[34][35]

2.1.1 Algorithm for ant colony optimization

1. Procedure ACO metheuristics
2. Schedule activities
3. Construct ants solutions
4. Update pheromones
5. Daemon actions is optional
6. End schedule activities
7. End procedure[34]

Application of ACO is it is used in a scheduling problems, travelling salesman is developed and used in routing telecommunication network. The main advantage is it can be used in a dynamic applications like adapts to the new changes in the environment such as new distance. And disadvantages of ACO is theoretical analysis is difficult and research is experimental not theoretical. [35]

3. HONEY BEES

Honey bees are one of the examples of swarm. Honey bee swarms are dynamic and intelligent; they are capable of dividing various tasks among other bees. The activities that the bees perform are foraging, storing, retrieving and distributing honey, collecting pollen, communication and adapting themselves to the changes in the environment in the collective manner without any central control. Foraging in bees is different than that of ants. Bees organize their colonies very well that there is no need of hibernation for it. Bees are always social and live together in colonies. Bees produce honey by collecting the pollen and nectar from the flowers and store it in the honey combs

Bees in nature are very organized, there are three groups of bees they are employed bees and unemployed bees. Unemployed bees are onlooker and scouts bees. Employed bees are usually the experienced bees and they go in search of food source. These bees' moves randomly from one flower to another and keep exploring other flowers in order to find the best food until they are tired. Once the employed bees find the food source with the rich of food, they come back and communicate to the onlooker bees through waggle dance within the hive [36]. Scout bees look for different sources or targets, this bees search their source which are flowers based on various constraint and after finding the appropriate sources they have to display it to the other bees in the hive, so they return to the hive and there is something called as dance floor in the hive where these scout bees do waggle dance, by this dance they can communicate to other bees about the location of the food source. The worker bees decide the best path of the source based on the dance. And all the worker bees go to the appropriate location which is flower and they collect the nectar from it and reach to the hive in the same path taken, by this way they come back to the hive and gives the nectar to the food stores bees which collects the nectar from the worker bees and then they process the nectar and then they store it in

the comb, the selection of the food source is based on the quantity of the food and can also be the distance. This behaviour of bees can be used for many optimization problems and also for the best path technique. [13][14]

3.1 Bee Colony Optimization

Based on the behaviour of bees the BCO is designed. In the BCO there are many agents which works collectively to solve the problem in the optimization method.BCO is a little different from the actual bee colony. Initially before BCO there were two algorithms that are ecological algorithm and bee system algorithm which was based on the collective intelligence of bees behaviour and latter is of the genetic algorithm.BCO can be related to the travelling salesman problem. Yonezava and Kikuchi were the first to describe the collective intelligence of bees. Lucic and Teodorovic used the principles of the collective intelligence to solve the optimization problem. BCO can also be called as the population algorithm because it finds the optimal solution. One of its applications is Ride matching problem can be solved using BCO. It is met heuristic and it is motivated by the foraging behaviour of bees. BCO is not used widely to solve real life problems. BCO has two vital process that is recruiting and information exchange [30].

3.1.1 Algorithm for bee colony optimization

The Bees Algorithm is based on the foraging behaviour of the bees. This finds the optimal solution.

1. Population of the bees is initialized.
2. Populations fitness has to be calculated.
3. While (condition (stopping criteria) not met)
4. Select certain spots to search.
5. Select more bees for the new spot and calculate the fitness.
6. Determine the fittest bees.
7. Other bees have to be assigned randomly for the search.
8. End While. [14][15]

4. BIRDS

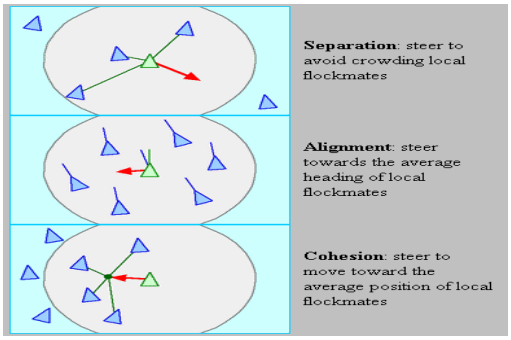
A flock is a group of birds or mammals assembled or herded together. Boids was developed by Craig Reynolds in 1986. Boids is an artificial life program which simulates the flocking behaviour of birds. The name "boid" means "bird-oid" object which refers to "bird-like" object. Boids are similar to particle systems but have orientation and geometrical in shape which is used for rendering. Boids is a behavioural based motion. [21][22] Age, Sex and Body size plays a major role in the formation of the V-shaped pattern. In a group of birds of adults and young birds, juveniles usually do not lead the group since they are unable to maintain high speed in lead position and hence would slow down. The entire flock down according to the study of Swedish researchers published in January 2004 issue of journal behaviour Ecology.

Researchers also decided that pelicans that fly in group formation beat their wings less often and have lower heart rates than those birds that fly alone. In this way the birds that fly in v-formation conserve less energy during their long and difficult journey and to avoid predators. This v-formation also helps in communication and coordination within the flock, allowing birds to improve orientation and follow their route more directly. From the swarm behaviour is a collective motion of large number of self-entities. From the mathematical model perspective, it is emergent behaviour arising from the simple rules that are followed by the individual.

There are two theories why birds fly in v-shape. The first theory is when the birds lift the wings to fly; the air flowing off their wing tips gives birds in the back of V an extra lift. This reduces the amount of energy the birds need to fly. Once the course of migration the birds take a turn leading the front of V, the most difficult position. When the bird is tired of leading it falls to the rear of the V, where there is a least mind resistance. This rotation through various positions in the v maximizes the use of each bird's energy, allowing the flocks to fly for longer period without taking break. In the second theory, line of sight as the flocks flies through the air. This becomes easier for the birds to keep track of each member of the flocks.

The simple mathematical model of animal swarms follows three rules. They are

1. Neighbours move in the same directions.
2. Closely remain to their neighbours.
3. In all direction they avoid collisions. [21][23]



The movement of Boids can be in order or disorder. Disorder means splitting groups and wild behaviour. Splitting flocks and reuniting after avoiding obstacles are few unexpected behaviours and these can be considered as newly formed or newly independent. Boids simulation specifies each individual bird behaviour.

4.1 Particle Swarm Optimisation

Particle swarm optimization is a method which works on the basis of swarm intelligence. Particle swarm optimization was introduced by Doctor Kennedy and E Berhart in 1995. PSO was developed from swarm intelligence and the research is based on birds and fish behaviour. While searching for food the birds get scattered or they go together in search of food while searching for food source from one place to another, there is always a bird that can smell the best food source easily and go in search of that source i.e., the bird is perceptible of the food source and supply the information to all other birds. Birds have good communication, co operation and positive thinkers. The particle without quality and volume will serve as individuals and their behaviours are controlled by each particle to show their complexity. PSO is an experience based thinking optimization which is based on swarm intelligence. [16]

PSO will be mainly concentrated on the following:

1. The math's basic theory- it analyze the stability of the condition where the particle can move stably.
2. Particle swarm topology- Research on the topology of new pattern of particle swarm which can perform

the function better. Different particle swarms are based on the intimation of different society's foe neighbouring topology. In order to enable PSO and to have best property and perform research on the suitable ranges of different topologies the algorithms should select the proper topology.

3. Blending with other intelligent optimization algorithm- it means merging the PSO advantages with the other intelligent optimization algorithm advantages to create the compound algorithm that has practical value.
4. Develop the application area of algorithm- it is important to explore the developing area since the PSO algorithm has been used widely.[16][17]

4.1.1 Algorithm for boids

Boids program structure:

1. Initialize position( )
2. Loop
3. Draw boids( )
4. Move all boids to new position( )
5. End loop

All the boids are initialized at a starting position and initialization is done at random locations. All the boids will fly towards the middle of the screen when simulation starts. One frame of animation is drawn with all boids being in their current positions. Moving all boids to new position involves simple vector operations on boids positions.

Consider vector A1, A2, A3 for Boid c

For each boid c

1. A1=rule1(c)
2. A2=rule2(c)
3. A3=rule3(c)
4. c.velocity =c.velocity+A1+A2+A3
5. c.position =c.position+c.velocity
6. end

5. CONCLUSION

In this paper, the main ideas and principles of swarm, 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 examples of swarm are the colonies of ants, flocks of birds, schools of fishes. 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, algorithm. Particle Swarm Optimization it 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 together and there interaction with each other. These swarm examples all solve complex problem.

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