Swarm Intelligence

SNEHA[1] and WAJAHAT[2]
JB Institute of Technology, Dehradun

Abstract
In this paper we will be discussing about the swarm intelligence and some of its examples. A swarm is a group of simple agents that interact among themselves and with their environment. There is no particular controlling agent that is responsible for the behavior that arises among the group. These agents that work in groups can be colonies of ants, school of fishes, bird flocks etc. We can call them as swarm. In this paper we will be discussing some examples of swarm and their behavior. We will also discuss various swarm intelligence models for example Ant Colony Optimization and Particle Swarm Optimization that is related to behavior of ants and birds respectively.

Keywords: Swarm, swarm Intelligence, Stigmery, Pheromone, Boids.

1 INTRODUCTION

The term "Swarm intelligence" was first given by G.Beni, Hack wood and J.Wang in 1989. [4][6][11].Swarm intelligence can be defined as the emergent collective intelligence of groups of simple agents. It is a collective behavior of decentralized, self-organizing systems. It is a distributed system that comprises of autonomous agents which interact with each other to reach a particular goal.This field focuses on the collection of results that arises among people when they interact locally. [1].Recently swarm-based algorithms have grown as family of naturally population based algorithms that provide fast and low cost solutions to various complex problems.[12][13]. Swarm intelligence is actually a new branch of artificial intelligence, in which the agents of same kind interact with each other to complete a particular task. Swarm intelligence is used as a collective behavior of swarms such as colonies of ants, flocks of birds, honeybees etc.Agents or individual swarms that perform a particular task interact either directly or indirectly among themselves. Direct interactions can be through audio or video. For example birds interact among themselves through sound (audio) and bees through their waggle dance (video).In indirect interaction if one agent changes the environment, the others also respond to that change and that indirect interaction is called stigmergy, which means interaction through environment.[5]. It is seen in ants through the pheromone trail laid by them.Thus based on such intelligent behavior of swarms many algorithms have been formulated. Some techniques and algorithms are discussed in this paper.

2 ANTS

Ants have been surviving since tens of millions of years ago, through different environments, and it was possible only due to their sociality.[19].Ants are considered as one of the best examples of swarm. Ants interact indirectly with each other by laying pheromone (i.e. a volatile chemical substance). Pheromone term was introduced by P. Karlson and M. Luscher in 1959, based on a Greek word Pherin which means transport and hormone means to stimulate. There are two different types of pheromone stimulated by ants, one is the alarm pheromone that is used to signal other ants if there is any danger on the way and other is the food trail pheromone that is stimulated by ants on their way in search of food. Higher the intensity of pheromone on the way more the chances of food on that way.[5].Ants work together by dividing the task among themselves . These tasks can be more efficiently done by ant colonies.[1][7][8].

3 ANT COLONY OPTIMIZATION

Ant colony optimization is the first example of successful swarm intelligence model introduced by M. Dorigo et al.[14][15][16]. It is actually based on social behavior of ant colonies and is used to find optimal path in search of food. Ant colony optimization (ACO) is widely used in swarm intelligence as a class of algorithms that inspires foraging behavior of ants. Foraging explains the capabilities of ant colonies.[2]. Foraging is done by ant colonies as follows:-

1:- We can find many individual ants moving here and there in search of food. Thus these tiny agents keep moving around the colonies searching food.

2:- As ants cannot communicate directly, they follow the indirect path that is known as stigmery.

3:- When these ants find the food source they return back to their nest and while returning they deposit a chemical substance known as pheromone.

4:- The pheromone that is deposited by agents on their way back is volatile in nature so it keeps on evaporating. Other ants are able to sense it and get inclined in the direction of pheromone.

5:- When many ants follow the same track they also leave pheromone on that track and thus the pheromone gets thickened and it becomes easier for other ants to find the food source.

6:- If the agents could find the shorter path then that path will be followed by many other agents and it

becomes more attractive as the pheromone level is much higher on that path.

7:- If any obstacle comes in between the path, the ants at first will move randomly but will be able to find shortest path.

8:- Thus the longer route will get disappeared within some time because the pheromone which was deposited at first by the ants is volatile in nature.

9:- Hence finally the ants will be able to find the shortest route for food.[3].
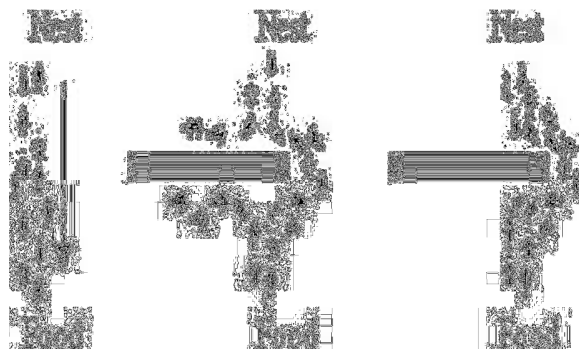
Diag.1:- Ants finding the food source.

4 BIRDS

Groups of mammals or birds assembled together are called a flock. An artificial life program which stimulates the flocking nature of birds is called a Boid. Boid was developed by Craig Reynolds in 1986, which simulates the flocking nature of birds. Boids is basically a kind of motion that is dependent on behavior of birds.[23][24].

Those birds that fly in V- shaped formation conserve less energy during their difficult journey and this helps them to avoid the predators or enemies. V- Shaped pattern formation of birds is dependent on the age, sex and body size. V- Shaped orientation of birds also help them to communicate and maintain coordination within the flock.There are basically two theories that are related to flying of birds in V- Shape.Firstly when the bird flies and the air that flows off their wing tips gives bird an extra lift or pushes the bird upwards and thus eases the bird's flight. Thus bird doesn't need to work hard and this reduces the amount of energy during their flight.When the birds fly in V-Shape there is not any particular bird that is leading their flock, because the bird which is leading the flock often gets tired as it is the most difficult position. So the bird falls to the rear of the flock where it doesn't have to use most of its mind and then the turn of other members in that flock comes one by one. So in this way the flocks of birds keep moving for longer time by maximizing each bird's energy.Secondly it becomes easier for every member of the flock to keep track of every other member while flying in the V-Shape.Birds flocking behavior was stimulated on computer by Craig Reynolds in 1986.Craig Reynolds proposed 3 simple flocking rules for implementation of a simulated flocking behavior of birds:

1:- Flock centering:- which means that each bird in the flock will remain close to the nearest bird in the flock by which they can stay close to the centroid of flock mates.

2:- Avoiding collision:- Based on their relative position the flock members avoid collision with neighbouring flock mates.

3:- Matching of velocity:- birds in the same flock try to match their velocity.[20].

These three flocking rules that are given by Craig Reynolds are known as cohesion, seperation and alignment rules in literature.[21][22].

5 PARTICLE SWARM OPTIMIZATION

E Berhart and Kennedy introduced Particle Swarm Optimization (PSO) in 1995. It is based on birds and fish behaviour. While searching for food the birds fly here and there or get scattered. In the flock of birds there is always a bird that can smell good and has the ability to find that food source better easily. When that bird reaches that food source it communicates the information to rest of the members of its flock as birds have good communication and are positive thinkers. PSO is an experience based on thinking optimization that is based on swarm optimization.[9].PSO mainly follows:

1:- The Math's basic theory: - It is analysis of the condition where particle can move stably. Particles are the population members, which are described as the swarm position in n- dimensional solution space.

2:- Particle Swarm topology: - It is research on the topology of new pattern of particle swarm which functions better.

3:- Merging with other intelligent optimization algorithm: - Blending the PSO advantages with the advantages of other intelligent algorithms to create an algorithm that gives a practical value.

4:- Develop application area of PSO algorithm:- It is important to develop application areas of PSO algorithm as it is widely used.[9][10].

Diag.2:- Birds flying in V-shape.

6 CONCLUSION

In this paper, the basic idea of swarm and swarm intelligence is given describing the two swarm optimization techniques. We gave a brief idea about Ant Colony Optimization that is related to behavior of ants and their interactions. We also described Particle Swarm Optimization that describes behavior of birds and their movement.

7 REFERENCES

[1] , Frederick Ducatelle, Gianni A. Di Caro, Luca M.Gambardella, "Dalle Molle": Principles and applications of swarm intelligence for adaptive routing in telecommunications networks Institute for Artificial Intelligence Studies (IDSIA) Galleria 2, 6928 Manno, Switzerland e-mail: {Frederick, gianni,luca}@idsia.ch

[2] Haitham Bou Ammar, Karl Tuyls, and Michael Kaisers: Evolutionary Dynamics of Ant Colony Optimization, Maastricht University, P.O. Box 616, 6200 MD Maastricht, The Netherlands.

[3] Yassiah Bissiri, W. Scott Dunbar and Allan Hall Department of Mining and Mineral Process Engineering University of British Columbia, Vancouver, B.C., Canada Swarm –Based Truck-Shovel Dispatching System in Open Pit Mine Operations

[4]http://www.slideshare.net/smashingrohit/swarm- intelligence-an-introduction.

[5] Beekman M, Sword G A, and Simpson S J: 2008, Biological foundations of swarm intelligence, In C. Blum and D. Merkle (eds.) Swarm Intelligence. Introduction and Applications, Springer, Berlin, Germany, pp. 3-41.

[6] Harvard Rykkelid: Swarm-based information retrieval Automatic knowledge-acquisition using MAS, SI and the Internet

[7] http://www.slideshare.net/idforjoydutta/ant-colony- optimization-23180597?related=2

[8] Swarm Intelligence: Concepts, Models and Applications Technical Report 2012-585 Hazem Ahmed Janice Glasgow School of Computing Queen's University Kingston, Ontario, Canada K7L3N6 {hazem, janice}@cs.queensu.ca

[9] Analysis of Particle Swarm Optimization Algorithm Qinghai Bai College of Computer Science and Technology Inner Mongolia University for Nationalities Tongliao 028043, China Tel: 86-475-239-5155 E-mail: baiqh68@163.com.

[10] Angeline P J. (1999). Using selection to improve Particle Swarm Optimization. Proceedings of the 1999 Congress on Evolutionary Computation. Piscataway. NJ: IEEE Press, 1999:84-89.

[11] Beni.G, Wang.J, Swarm Intelligence in cellular robotic systems, precede NATO advanced workshop on robots & biological systems, Italy June 26-30 in 1989.

[12] B. K. Panigrahi, Y. Shi, and M.-H. Lim (eds.): Handbook of Swarm Intelligence. Series: Adaptation, Learning, and Optimization, Vol 7, Springer-Verlag Berlin Heidelberg, 2011. ISBN 978-3-642-17389-9.

[13] C. Blum and D. Merkle (eds.). Swarm Intelligence – Introduction and Applications. Natural Computing. Springer, Berlin, 2008.

[14] . M. Dorigo, V. Maniezzo, and A. Colorni, Positive feedback as a search strategy, Tech. Report 91-016, Dipartimento di Elettronica, Politecnico di Milano, Italy, 1991

[15] . M. Dorigo, Optimization, learning and natural algorithms (in Italian), Ph.D. Thesis, Dipartimento diElettronica, Politecnico di Milano, Italy, 1992.

[16] . A. Colorni, M. Dorigo, V. Maniezzo, and M. Trubian. Ant System for Job-shop Scheduling. Belgian Journal of Operations Research, Statistics and Computer Sci-ence, 34(1):39-53, 1994.

[17] M. Bakhouya and J. Gaber, An Immune Inspired-based Optimization Algorithm: Application to the Traveling Salesman Problem, Advanced Modeling and Optimization, Vol.9, No. 1, pp. 105-116, 2007.

[18] K.N. Krishnanand and D. Ghose, Glowworm swarm optimization for searching higher dimensional spaces. In: C. P. Lim, L. C. Jain, and S. Dehuri (eds.) Innovations in Swarm Intelligence. Springer, Heidelberg, 2009.

[19] L. Keller and E. Gordon, The Lives of Ants, Oxford University Press, Oxford 2009.

[20] C. W. Reynolds, Flocks, herds, and schools: a distributed behavioural model, Computer Graphics (ACM SIGGRAPH '87 Conference Proceedings), Vol. 21, No. 4, pp. 25–34, July 1987.

[21] R. Olfati-Saber, Flocking for multi-agent dynamic systems: Algorithms and theory, IEEE Trans. Automatic Control, Vol. 51, No. 3, pp. 401–420, 2006.

[22] V. Gazi and K. M. Passino, Swarm Stability and Optimization, Springer 1st edition, 2011. ISBN: 978-3-642-18040-8

[23] http://www.slideshare.net/SwapnilGaul/particle-swarm-optimization-and-its-applications-in- electromagnetics?related=2

[24] Reynolds, Craig (1987). "Flocks, herds and schools: A distributed behavioural model.". SIGGRAPH '87: