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Social Insects Shaping Our Future

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Abstract

Social insects like ants, bees, wasps are mysterious creatures for the complex society they build. Inspite of their anatomical simplicity, they have survived and almost dominated Earth for some 130 million years. Recent researches on their behavior has inspired the development of some novel computer programs which promise to solve some of the very complicated problems of the modern society.

Introduction

Social insects like ants, termites, many bees, and some wasps have a real family life which is very complex. They live in communities, and the members of a community depend on one another. Interestingly their body organization is very simple with a very primitive brain. They arrived on Earth in the Mid Cretaceous period at around 110 to 130 million years ago and are still thriving without much difficulty[1]. Infact there are around 22,000 species of ants, 20,000 species of bees and more than 100,000 species of Wasps. The wide diversity of these social insects is a testimony to their success. But why are they so successful?

Researches on social insects like ants and bees have revealed that they have a very meager intelligence. But their colonies can solve problems unthinkable for an individual insect, such as finding the shortest path to the best food source, allocating workers to different tasks, or defending a territory from neighbours[2]. Interestingly an average colony of ants has more than a lakh ant. Yet no one is in charge of the colony. The famous "queen" ant has no role but to act as a breeder. Rest members alter their duties according to the requirement.

Scientists believe that the preponderance of these groups of insects is because of the three qualities that they are endowed with-

a) Ability to adapt to the changing environment.
b) Robustness i.e.; performing the task even if some individuals of the colony fails.
c) Ability to self organize, independent of any centralized control. The underlying factor that controls this unique action is called *'Stigmergy'* or self communication through environment.

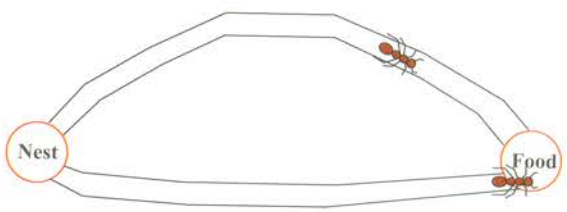
Social Insects and Our Future

New findings on the behavior of ants and honeybees are giving surprising results which can even be applied to solve complicated problems of the modern society. Taking cue from these findings, MNC giants like Southwest Airlines, Unilever, Mcgraw Hill, Hewitt Packard have tried to implement them in their organizations. According to them, these principles have not only helped them to run their operations more efficiently, but also to save millions of dollars annually. Such is the impact of these new findings that experts predict that the social insects' intelligence is going to shape our lives and make it better in the days to come.

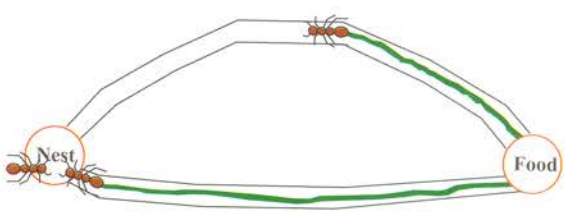
As such it will be pertinent to go through some of the findings that have been observed in these insects which can revolutionize our lives.

Ability to Find the Shortest Path from the Food Source to the Nest

It has been observed experimentally that ants chose the shortest path to reach the food from the nest, even though there may be more than one path[4].



Scientists predict that this can only be possible by the application of the principle of self organization. Ants form and maintain a line to their food source by laying a trail of pheromone, i.e. a chemical to which can be sensed by other members of the same species. They deposit a certain amount of pheromone while walking, and each ant prefers to follow a direction rich in



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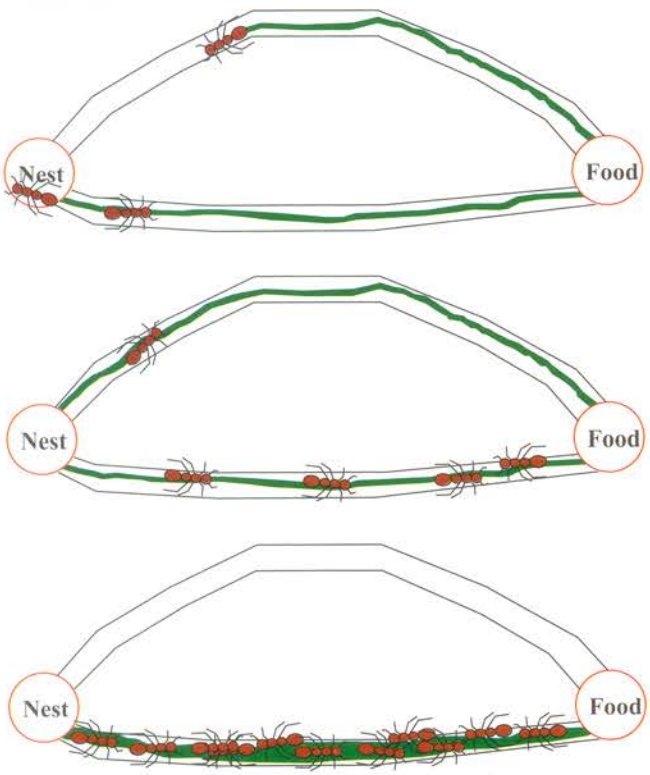
pheromone. This enables the ant colony to quickly find the shortest route. The first ants to return should normally be those on the shortest route, so this will be the first to be doubly marked by pheromone (once in each direction). Thus other ants will be more attracted to this route than to longer ones not yet doubly marked, which means it will become even more strongly marked with pheromone. Soon nearly all the ants will choose this route. The volatility of the pheromone assures that no trail remains on the route which is longer and as such no ant will chose that route.



Software based on this new routing algorithm is popularly known as *'AntNet'*. In the AntNet algorithm, routing is determined by means of very complex interactions of forward and backward network exploration agents ("ants"). The idea behind this sub-division of agents is to allow the backward ants to utilize the useful information gathered by the forward ants on their trip from source to destination. 'AntNet', exhibits a number of interesting properties: it works in a fully distributed way, is highly adaptive to network and traffic changes, uses lightweight mobile agents (called ants) for active path sampling, is robust to agent failures, provides multipath routing, and automatically takes care of data load spreading. 'AntNet's performance has been extensively tested in simulation, considering different networks and traffic patterns, and has been compared to several state-of-the-art routing algorithms. Interestingly 'AntNet' has largely outperformed all its competitors, showing excellent adaptivity and robustness. 'AntNet' has been also tested in small physical networks, confirming the good performance in real-world tests[5].

Congestion Free Telecommunication

The unique feature of the pheromone and the associated ant behavior has inspired researchers from the telecom wing of Hewitt Packard to develop a modified computer program called ***Ant - Based Control*** **(ABC)**, that works on the similar principle as AntNet. In this program, only one class of ants are launched from the sources to various destinations at regular time interval which get destroyed on reaching the node. The quickest to be destroyed represents the uncongested route. Once a successful search is made, the information is then deposited in the nodes via digital pheromones which then influence the subsequent behavior that is related to the task. In due course of time, the behavior get temporarily stored that may be used again in future, if the need arise. Reinforcement by similar agents about an uncongested path attracts the phone calls to follow the trail and pass through the uncongested route. Conversely when this path gets congested, the path is abandoned by lesser reinforcement and a new uncongested path is discovered by the agents. As a result a congestion free telecommunication system could be developed, even when the traffic is high. Encouraged by the results, other MNCs like British Telecom, MCI World Com, France Telecom have started implementing the program in their telecommunication network.

No Traffic Jam

A modified version of 'AntNet' software has been done for dynamic routing of traffic in a city where in a simulated environment vehicles are guided through different roads based on the load of traffic. In order to streamline the process, artificial ants are created which

move in a virtual street network. This model is supplemented with actual data from the traffic by the cars themselves through the use of satellite navigation. This enables the agents (artificial ants) to divert the traffic from congested routes and improves the traveling time. The simulation environment makes it possible to see the effect in different cities or in accident or emergency circumstances, where because of a disaster, multiple roads become unavailable or are heavily congested, and most of the drivers are get confused.

Extension of the above program can be applied even for air trafficking. Southwest Airlines, a leading airline in USA, has already implemented this technology to solve its cargo handling problem and have gained more than 10 million dollars in a single year.

Current research in this field have shown that the above system could be used for Wireless communication network and even for guiding unmanned military robots in warfare.

Flexibility in Task Allocation

Contrary to the popular notion, a lot of flexibility has been found among these insects. For instance, an ant may perform several kinds of job. When the colony discovers a new food source, an ant which was doing housekeeping duty may suddenly become a forager. Or if the colony's territory size expands or contracts, patroller ants change the nature of their scrutiny pattern. Similar kind of behavior can be seen in case of Honeybees where the nurse bees can even go for foraging if the situation demands so.

This principle has been the inspiration behind the development of software programs that will allow for switching between a set of activities, if needed.

Similarly, when the ant carries food to the nest, they follow a relay mechanism. Interestingly the distance up to which a single ant will carry the food is not fixed. This seemingly simple activity has encouraged Human Resource managers of companies like McGraw-Hill, Blockbuster Music etc. to dismantle the zone division concept in their factory line production process. Moreover keeping in mind the differential ability of the workers, it has been found that allotting the best and the fastest workers at the end of the chain process have increased the overall productivity by 30%.

No Top Down Approach, Only Best Idea Flourish

As has been already mentioned, there are no supervisors in the society of social insects. It has been found in bees that they make decisions by seeking a diversity of options that has been presented by scout bees through their waggle dance. Then a free competition among different options is weighed and finally an effective mechanism is devised to narrow down the choices to choose the best option.

Similar kind of management skill has been applied in a major credit card company called Capital One where every member has been empowered to give a good idea, irrespective of the hierarchy. Once any idea comes forth, it is analyzed thoroughly and necessary addendum is made by experts, if required, before implementation. To make this system more effective, some companies are encouraging their employees to post their ideas online where everyone can study it. The idea that gets the highest number of votes is taken up. In return the originator of the idea is suitably rewarded.

Though this approach does not match with the conventional management practice, but the approach has already started showing some very encouraging results. Scientists have found that these insects' approach towards exploiting a new food source vary from one species to another and the underlying reasons, if deciphered properly, may give valuable lessons to the managers regarding potential market exploitation.

Conclusion

Swarm intelligence boasts a number of advantages due to the use of mobile agents and stigmergy. These are:

1. Scalability: Population of the agents can be adapted according to the network size.
2. Fault tolerance: Swarm intelligent processes do not rely on a centralized control mechanism. Therefore the loss of a few nodes or links does not result in catastrophic failure, but rather leads to graceful, scalable degradation.
3. Adaptation: Agents can change, die or reproduce, according to network changes.
4. Speed: Changes in the network can be propagated very fast.
5. Modularity: Agents act independently of other network layers.
6. Autonomy: Little or no human supervision is required.
7. Parallelism: Agent's operations are inherently parallel.

Notwithstanding the number of interesting applications presented, a number of open problems need to be addressed and solved before that of ant algorithms becomes a mature field. For example, it would be interesting to give an answer to the following questions:

How do we define "artificial ants"? How complex should they be? Should they all be identical? What basic capabilities should they be given? Should they be able to learn? Should they be purely reactive? How local should their environment knowledge be? Should they be able to communicate directly? If yes, what type of information should they communicate?

Even though the field of Ant based algorithms is in its nascent stage, yet researchers predict that as more studies are conducted on these insects, we may get some unthinkable results that may change our outlook and our future lives. Perhaps these insects remind us of the old proverb: "Nature is the best teacher".

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