



A Survey on Bio-inspired Methods for Resource Discovery

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Abstract: In the past, people exposed a variety of the motivating insect or creature behaviours in the nature. A congregate of birds sweeps across the sky. A group of ants hunt for food. A group of fish swims, turns, flees together... - we label this category of group activity as swarm behaviour. Recently biologists and computer scientists in the field of artificial life have studied how to model biological swarms to understand how such social animals interact, achieve goals, and evolve. Biologically inspired computing is an area of computer science which uses the advantageous properties of biological systems. It is the amalgamation of computational intelligence and collective intelligence. Biologically inspired mechanisms have already proved successful in achieving major advances in a wide range of problems in computing and communication systems.

Keywords: Bio-inspired Methods, ACO, Honey Bee Foraging, Migration of Elephants

I. INTRODUCTION

The main intention of this survey is to introduce and to overview the emerging area of bio-inspired algorithms. We try to classify the field of biologically inspired approaches to resource discovery. Selected examples are presented in more detail. Bio-inspired algorithms can effectively be used for optimization problems, exploration and mapping, and pattern recognition. Based on a number of selected examples, we will see that some insects/animals behaviour of foraging food can be extended to discovering the resources in a grid environment. The survey was conducted based on the foraging behaviour of Ant, Honey Bee and Elephant.

II. CLASSIFICATION AND CATEGORIZATION

Basically, the following application domains of bio-inspired solutions to problems related to computing and communications can be distinguished:

- Bio-inspired computing represents a class of algorithms focusing on efficient computing, e.g. for optimization processes and pattern recognition.
- Bio-inspired systems constitute a class of system architectures for massively distributed and collaborative systems, e.g. for distributed sensing and exploration.
- Bio-inspired networking is a class of strategies for efficient and scalable networking under uncertain conditions, e.g. for autonomic organization in massively distributed systems.

Looking from biological principles, several application domains can be distinguished. Following table summarizes

the biological domains that are, together with specific examples of successful application to computing and networking.

TABLE I
 Application of biological principles

| Biological principle | Application of fields in Computing |
|--|---|
| Swarm Intelligence and Social Insects[1] | distributed search and optimization; routing in computer networks, task and resource allocation |
| Fire fly Synchronization [2] | robust and fully distributed clock synchronization |
| Artificial Immune System [3] | network security; anomaly and misbehaviour detection |
| Epidemic Spreading [4] | content distribution in computer networks , analysis of worm and virus spreading in the Internet |
| Cellular Signalling Networks [5] | coordination and control in massively distributed systems; programming of network-centric operating sensor and actor networks |

III. ANT COLONY OPTIMIZATION

Ant Colony Algorithm [6] was first proposed by Italy researcher Marco Dorigo. His inspiration came from ants behaviours of discovery path when searching food in nature.

- The principle of choosing path: Ants belong to social insects. Its individual behaviour is very simple, but group behaviours are complicated. A swarm of ants cooperate with each other, then they can find the shortest



path from the nest to the food resource, but a single ant cannot do this.

- The principle of avoiding obstacles: Ants can adopt changes in circumstance. For example, when there are obstacles on their moving route, they can quickly find a new route to continue.
- The manner of transmission information: Ants transmit information with each other through leaving behind pheromones on their route. Each ant scatters the most pheromones when they found food or ant nest at first time, then scatters less and less pheromones when they go far away.

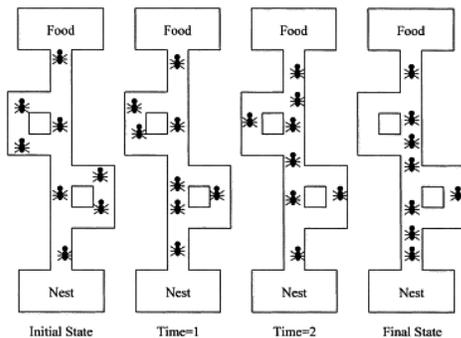


Fig. 1 Dynamics of pheromone trail — ants converge to the most ‘popular’ trails [10]

Ant Colony Algorithm, which has properties of robustness and commonality, is proposed based on the behaviours of ants in nature. Ant Colony can find the shortest path from source to destination and communicate with each other through pheromones. The more ants move on the shortest path, the larger pheromones are on the shortest path. Ant is to choose path which has large pheromones. As a result, more and more ants choose to move on this path. That means the resources which are scheduled frequently equivalent to the path which more ants are move on. We lead pheromones into resources. When ants meet pheromones, they can detect how much pheromones are on the path, and can be guided the direction of advance through pheromones. Meanwhile, pheromones can volatilize as time goes on. Then, the remnants of Pheromones Concentrations can be affected by the path length and the number of ants on the path, while the pheromones concentrations guide the direction of ants. Any Colony System updates pheromones according to the positive feedback characteristic of ants. Any Colony System is given some intelligent features, such as perspective, local optimization and returning back along the same path.

IV. HONEY BEE FORAGING

Honeybee forages [7] around the hive in search of resources. Usually this resource constitutes food in the form of pollinating flowers. Honeybees perform two distinct dance routines that coincide with two different distance

approximations made by the foraging bee. These two dances, the Round dance and the Waggle dance, communicate to the other the approximate distance from the hive to the new resource. Only the Waggle dance communicates direction. The Round dance is performed by the returning bee usually in complete darkness, vertically on a honeycomb. The circuitous motion attracts other foragers, which then learn that the resource is within approximately 50 meters of the hive. No direction is given by this routine. As a result, the newest foragers leave to search in all directions surrounding the hive. Behaviourally, this dance is energetically favorable due to the short distances travelled.

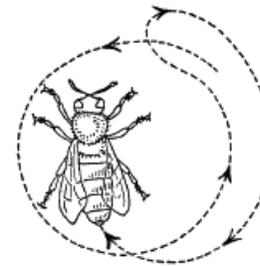


Fig. 2 The round dance [11]

In contrast, the Waggle dance is energetically unfavorable to the individual, but beneficial to the hive. The Waggle dance is performed primarily when the resource is further than 50 meters. The returning forager either performs the dance on a vertical surface or a horizontal one. To determine distance and direction, the bee orientates itself relative to the sun. Any deviation from this point gives the angle the new foragers should pursue. If vertical, the bee orientates itself to gravity. Perpendicular to the ground becomes the reference point (i.e. the sun). Deviations from such relay direction accordingly. Distance is communicated by the length of the abdomen shake that forms the middle of a figure eight dance.

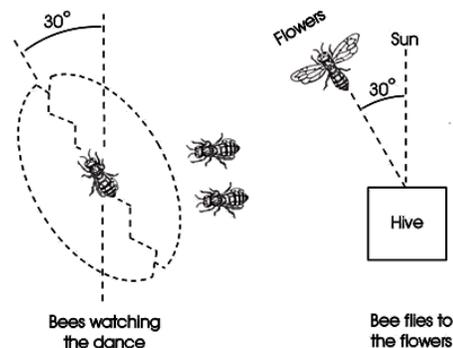


Fig. 3 The waggle dance [12]



Kirchner et al. determined that the Round dance does not convey direction. By tipping several hives onto their horizontal axis and placed a resource 10 meters away, the reference heading was experimentally altered. Regardless of the hive orientation, the number of successful returning foragers was constant (1998). Once the distance crossed 50 meters, the success rate decreased for hives orientated horizontally, indicating direction is dependent on hive orientation for the waggle dance to be effective.

V. MIGRATION OF ELEPHANTS

Elephants are incredibly social creatures that have lasting memories, and can communicate over long distances through low range sound waves. They show a range of cognitive abilities and social behaviour. The African elephant is the largest living land mammal. There are two kinds of elephants: African and Asian elephants. African elephants are larger than Asian elephants. African elephants inhabit a diverse array of habitats. The elephants migrate [9] and normally follow the same migratory routes every year. The migration occurs typically at the commencement of dry season. The animals move toward more suitable locations near rivers and water sources. The environmental conditions considerably affect the migration distances. The distance being covered during migration by African elephants is more than 100 km in dry seasons. Asian elephants residing in the dense forests of southern India, travels between 20 and 50 km during migration. However, when the rainy season appears, elephant herds go back to native regions to feed on the lush green vegetation. Thus, the migration of elephants allows time for the re-growth of plants in fatigued scraping areas.

VI. COMPARISON OF BEHAVIOUR OF ANIMALS/INSECTS

The following table compares different foraging behaviours of animals/insects.

TABLE III
 Comparison of bio – inspired algorithms

| Parameters | Ant | Honey Bee | Elephants |
|--|--|--|---|
| Labour Type | Division of labour | Division of labour | Leader leads |
| Positive Feedback | the deposit of pheromone | Waggle dancing for a longer duration | low range sound waves |
| Negative Feedback | dissipation of the route by evaporation | Waggle dancing for a shorter duration | Nil |
| Criterion for food source selection | wander randomly through a path : trails and attractiveness | wander randomly – from hive to destination | Past Information of older female elephant |

| | | | |
|--|---|---|--|
| Ply : Selected Food Source to Hive/Nest | Pheromone Strength | Memory | Memory |
| Traversal | Traverse from one node to nearby node | Uses a defined path from hive to flower patch | Follow the same migratory routes annually |
| Time Taken | Time taken to explore all sources will be very less | Time to learn successful discovery will be high due to random selection | Not Applicable. It uses previous knowledge |

VII. CONCLUSION

In summary, the foraging behaviors of animals/insects discussed are efficient for resource discovery issues in distributed and autonomic computing.

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