Artificial Bee Colony Algorithm

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INTRODUCTION

Nature-inspired computational methodologies and approaches are one of the favorite research topics for both researchers and academic studies in recent years. They're very effective tools for solving complex problems of the real world applications. Most of these algorithms are based on swarm intelligence. Artificial bee colony algorithm is one of the recent and very popular swarm based algorithm mimicking the behavior of the bees. Shortly after introduced, many studies are introduced based on both continuous and discrete optimization problems.

The Artificial Bee Colony (ABC) algorithm is a recently introduced optimization algorithm which simulates the foraging behavior of a bee colony which was proposed by Karaboga (2005) for real-parameter optimization. The algorithm is developed by inspecting the behaviors of reel bees on finding nectar amounts and sharing this information of food sources to other bees in their hive. It's one of the swarm-based algorithms like ants, birds and fishes in which individual units perform collective behavior.

The aim of this study is to present a bibliographical base to the researchers and enlighten them with ABC algorithm. The main topic of this paper is to give an extensive literature survey of the algorithm and its application areas. In the first section swarm intelligence will be studied. After the properties of swarm intelligence, bee based algorithms will be given. Following this section, artificial bee colony algorithm is briefly described and an extensive literature study is given. Further study notes and conclusion finalize the paper.

BACKGROUND

Swarm intelligence is one of the popular research topics which has inspired from nature, mostly living biological systems. The expression was introduced by Gerardo Beni and Jing Wang in 1989, with the context of cellular robotic systems. Some of its natural examples are ant colonies, bacterial growth, animal herding, bird flocking and fish schooling.

Swarm Intelligence

The term swarm is used for an aggregation of animals like fishes, birds and insects such as ants and bees performing collective behavior. The individual agents of these swarms behave without supervision and each of these agents has a stochastic behavior due to her perception in the neighborhood. Swarm intelligence is defined as the collective behavior of decentralized and self-organized swarms. The intelligence of the swarm lies in the networks of interactions among these simple agents, between agents and the environment. Swarm intelligence is becoming increasingly important within researchers because the problems that the natural intelligent swarms can solve (finding food, dividing labor among agents, building nests etc.) have important counterparts in several engineering areas of real world. Two important approaches are ant colony optimization (ACO), based on ant colonies and particle swarm optimization (PSO) based on bird flocking (Karaboga et al., 2012).

Ant colonies and bee hives have the interesting property that large numbers of them seem to conduct their affairs in a very organized way with purposeful behavior that enhances their collective

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survival. Surprisingly these insects seem to utilize very simple rules of interaction. This phenomenon has perplexed a large number of scientists for many years. How is it that "swarms" of creatures with relatively low brain power and communications capabilities can engage in called "collective intelligence" (Fleischer, 2003).

Observations of social insects such as ants and bee hives provide a great deal of insight into their behavior which is the base of the swarm intelligence. Ants and ant colonies have several ways of solving different but related problems. The main mechanism for solving is through the information sharing with pheromones which have a scent that decays over time with the process of evaporation in ants or through dancing in bees. These processes form the basis of what amounts to a clever and mostly simple, communications, information storage and retrieval system (Fleischer, 2003).

Two fundamental concepts, self-organization and division of labor, are necessary and sufficient properties to obtain swarm intelligent behavior such as distributed problem solving systems that self-organize and adapt to the given environment (Karaboga, 2005).

In a swarm system self-organization is the key feature which gives the collective behavior of the simple units. Bonabeau et al. (1999) interpreted the self-organization in swarms with four characteristics:

1. **Positive Feedback:** Promoting the creation of convenient structures. Recruitment and reinforcement such as trail laying and following in some ant species can be shown as example of positive feedback.
2. **Negative Feedback:** Counterbalancing positive feedback and helping to stabilize the collective pattern. In order to avoid the saturation which might occur in terms of available foragers a negative feedback mechanism is needed.
3. **Fluctuations:** Random walks, errors, random task switching among swarm individuals which are vital for creativity. Randomness is often significant for emergent structures since it enables the discovery of new solutions.
4. **Multiple Interactions:** Agents in the swarm use the information coming from the other agents so that the information spreads throughout the network.

Inside a swarm, there are different tasks, which are performed simultaneously by specialized individuals. This kind of phenomenon is called division of labor. Simultaneous task performance by cooperating specialized individuals is believed to be more efficient than the sequential task performance by unspecialized individuals. Division of labor also enables the swarm to respond to changed conditions in the search space. Two fundamental concepts for the collective performance of a swarm, self-organization and division of labor are necessary and sufficient properties to obtain swarm intelligent behavior such as distributed problem-solving systems that self-organize and self-adapt to the given environment (Karaboga, 2005).

Bee Based Algorithms

The self-organization and division of labor features and the satisfaction of principles (proximity principle, quality principle, principle of diverse response, principle of stability and principle of adaptability) given in Millonas (1994) required by swarm intelligence are strongly and clearly can be seen in honey bee colonies. Studies based on bee based swarm intelligence show that many algorithms have been developed depending on different intelligent behaviors of honey bee swarms in the last decade. These studies are mainly based on the dance and communication, task allocation, collective decision, nest site selection, mating, marriage, reproduction, foraging, floral and pheromone laying and navigation behaviors of the swarm. Some known algorithms based on bees are virtual bee, the bees, BeeAdHoc, the marriage in honeybees, the Bee Hive, bee system, bee colony