Chapter 39
Studies of Computational Intelligence Based on the Behaviour of Cockroaches

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ABSTRACT

In this chapter, the author expands the notion of computational intelligence using the behavior of cockroaches. An introduction to cockroach as swarm intelligence emerging research area and literature review of its growing concept is explained in the beginning. The chapter also covers the ideas of hybrid cockroach optimization system. Next, the author studies the applicability of cockroach swarm optimization. Thereafter, the author presents the details of theoretical algorithm and an experimental result of integration of robot to some cockroaches to make collective decisions. Then, the author proposes his algorithm for traversing the shortest distance of city warehouses. Then, a few comparative statistical results of the progress of the present work on cockroach intelligence are shown. Finally, conclusive remarks are given. At last, the author hopes that even researchers with little experience in swarm intelligence will be enabled to apply the proposed algorithm in their own application areas.

1. INTRODUCTION

Swarm intelligence (SI) as an emerging research area, has attracted many researchers' attention since the concept was proposed in 1980s. It has now become an interdisciplinary frontier and focus of many disciplines including artificial intelligence, economics, sociology, biology, etc. It has been observed a long time ago that some species survive in the cruel nature taking the advantage of the power of swarms, rather than the wisdom of individuals. The individuals in such swarm are not highly intelligent, yet they complete the complex tasks through cooperation and division of labour and show high intelligence as a whole swarm which is highly self-organized and self-adaptive.

The growing complication of real life problems has encouraged computer scientists to investigate for proficient problem-solving techniques. The behavior of ants, termites, bird's fishes, bees slime,

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moulds, and other creatures have enthused swarm intelligence investigators to create new optimization algorithms. Decentralized control and self-organization for those creatures are extraordinary features of swarm-based systems. Such decentralized consensus building behaviors are observed in a variety of social organisms, including ants (Pratt et al. 2002), honeybees (Britton et al., 2002) and cockroaches (Ame et al. 2006) and have inspired much research on the development of self-organized task allocation strategies for multi-robot systems.

During the past decade, a number of new computational intelligence (CI) algorithms have been proposed. Unfortunately, they spread in a number of unrelated publishing directions which may hamper the use of such published resources. Those provide the author with motivation to analyze the existing research for categorizing and synthesizing it in a meaningful manner. The mission of this chapter is really important since those algorithms are going to be a new revolution in computer science. The author hopes that it will stimulate the readers to make novel contributions or to even start a new paradigm based on nature phenomena.

Swarm intelligence is a soft bionic of the nature swarms, i.e. it simulates the social structures and interactions of the swarm rather than the structure of an individual in traditional artificial intelligence. The individuals can be regarded as agents with simple and single abilities. Some of them have the ability to evolve themselves when dealing with certain problems to make better compatibility (Wang et al. 2005). A swarm intelligence system usually consists of a group of simple individuals autonomously controlled by a plain set of rules and local interactions. These individuals are not necessarily unwise, but are relatively simple compared to the global intelligence achieved through the system. Some intelligent behaviors never observed in a single individual will soon emerge when several individuals begin cooperate or compete. The swarm can complete the tasks that a complex individual can do while having high robustness and flexibility and low cost. Swarm intelligence takes the full advantage of the swarm without the need of centralized control and global model, and provides a great solution for large-scale sophisticated problems.

The idea computational intelligence may come from observing the behavior of creatures. Ant colony Optimization (ACO) was presented by studying the behavior of ants, and Particle Swarm Optimization (PSO) was presented by of examining the movements of flocking gulls. Through inspecting the behavior of the cockroach, Cockroach Swarm Optimization (CSO) is proposed in this chapter. Cockroach optimization is a new development under SI paradigm; cockroach optimization algorithms are inspired by collective cockroach social behavior. The artificial structure can be viewed as the model for modeling the common behavior of cockroaches. CSO somehow belongs to the swarm intelligence.

A cockroach is an invertebrate walking animal in the phylum of arthropods. It has six legs, and each leg is composed of multiple segments: coxa, trochanter, femur, tibia and tarsus (foot). The upper leg segments generally point upwards and the lower segments downwards. The legs project out from the trunk like a salamander. They are oriented around its trunk in a way that the two front legs point forwards while the four rear legs typically point backwards to maintain stability in walking. Such orientation can be beneficial in climbing over an obstacle; i.e., a cockroach can easily move its front legs forward to reach the top of an obstacle while the rear legs power its motion by raising its trunk up and pushing it forward. As a result, it can climb over the obstacle (Wei et al. 2004). Moreover, front legs are also used to detect stimulus coming from the front while rear legs perceive stimulus from the back.

Cockroaches can move and run swiftly and smoothly no matter what terrains to transverse. Their movement smoothness, flexible self-control, and regulation ability have aroused researchers' deep interests to seek the secret of the movement. Cockroach's control over its agile movement far exceeds