

Chapter XX

Artificial Life Optimization Algorithm and Applications

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ABSTRACT

This chapter describes a hybrid artificial life optimization algorithm (ALRT) based on emergent colonization to compute the solutions of global function optimization problem. In the ALRT, the emergent colony is a fundamental mechanism to search the optimum solution and can be accomplished through the metabolism, movement and reproduction among artificial organisms which appear at the optimum locations in the artificial world. In this case, the optimum locations mean the optimum solutions in the optimization problem. Hence, the ALRT focuses on the searching for the optimum solution in the location of emergent colonies and can achieve more accurate global optimum. The optimization results using different types of test functions are presented to demonstrate the described approach successfully achieves optimum performance. The algorithm is also applied to the test function optimization and optimum design of short journal bearing as a practical application. The optimized results are compared with those of genetic algorithm and successive quadratic programming to identify the optimizing ability.

INTRODUCTION

Firstly, we describe an optimization algorithm (ALA) to compute the global solutions of function optimization problem based on artificial life algorithm. Emergent colonies which are a fundamental mechanism use to search the optimum solution can be accomplished through the metabolism, movement and reproduction among artificial organisms which appear at the optimum locations in the artificial world (AWorld). In this case, the optimum locations mean the optimum solutions in the optimization problem. Then, the ALA focuses on searching for the optimum solution in the location of emergent colonies and can lead to a more accurate global optimum. The ALA has a demerit that after it congregates at the neighborhood of optimum solutions, not only the convergent speed becomes very slow, but also the solution accuracy is poor. Moreover, to decide the locations where a waste

of metabolism in random movement and the offspring in the reproduction having an important influence on the efficiency are the remaining problems must be improved in ALA.

Secondly, we describe an enhanced hybrid algorithm (ALRT) which introduces the random tabu search method into the ALA to solve the remaining location problems mentioned above. This technique can improve the convergent speed and accuracy, and can be applied to enhance the distinguished efficiency in the multivariable and the multi-modal problems. The hybrid algorithm is not only faster than the conventional ALA, but also gives a more accurate solution. In addition, ALRT can find all global optimum solutions. The optimization results using different types of test functions are presented to demonstrate the ability of the described approach in achieving good performance successfully.

Finally, ALRT is applied to the test function optimization and optimum design of short journal bearing as practical application. The results are compared with those of conventional methods such as ALA, genetic algorithm and successive quadratic programming, and the optimizing ability is identified.

BACKGROUND

There are two types of modeling approaches for studying natural phenomena; namely, the top-down approach involving a complicated, centralized controller that makes decisions based on access to all aspects of the global state; and the bottom-up approach, which is based on parallel, distributed networks of relatively simple, low-level agents that simultaneously interact with each other. Most traditional artificial intelligence (AI) research focuses on the former approach (Kim & Cho, 2006).

Artificial life (ALife), as a scientific term, was first stated in 1987 by Langton, who has contributed significantly to ALife. *ALife is the study of man-made systems that exhibit behavior characteristics of natural living systems* (Langton, 1989; Assad & Packard, 1992). The research motive of ALife was originated from the intent to understand the true meaning of life through the synthesis of life that makes it superior to the existing life in nature. ALife includes computational simulations such as virtual places where animated characters interact with the environment and with other virtual beings of the same or distinct categories.

A general property of ALife is that the whole system's behavior is represented only directly, and arises out of interactions of individuals with each other. In this context, known as the philosophy of decentralized architecture, ALife shares important similarities with some new trends such as connectionism (Haykin, 1998), multi-agent AI (Ferber, 1999) and evolutionary computation (EC) (Goldberg, 1989). Technologies in ALife research include cellular automata, the Lindenmayer system (L-system), genetic algorithm (GAs), and neural networks (NNs).

The two most important characteristics of ALife are *emergence* and *dynamic interaction* with the environment. Namely, the micro-interaction with each other in the ALife's group results in emergent colonization in the whole system. It is the concept of emergence that highlights the nature of ALife research. Emergence is exhibited by a collection of interacting entities whose global behaviors cannot be reduced to a simple aggregate of the individual contributions of the entities. Conventional methods of AI have to struggle to reveal and explain emergence because they are generally reductionist. That is, they reduce systems to constituent subsystems and then study them in isolation (the top-down approach). In contrast, ALife adopts the bottom-up approach which starts with a collection of entities exhibiting simple and well-understood behavior and then synthesizes more complex systems (Kim & Cho, 2006).

The concrete study method using the above characteristics consists of mainly two steps. First, the essence of ALife system, which shows the behavior characteristics of living organisms in the natural world such as growth, adaptation, multiplication, self-preserving, self-control, and evolution, which is realized through several theoretical models. Second, the ALife organisms which are called real living organisms are created in the computer through simulation. This process can be defined as the informationization process. Therefore, the research object of ALife is not the physical system of life itself but the function as the information. In the ALA for the function optimization, the emergent colonization is accomplished through the metabolism and the reproduction in the artificial world. The optimum solutions are found on the emergently colonized region (Yang & Lee, 2000).

According to Bedau (2003), there are three branches of ALife. *Soft ALife* creates simulations or other purely

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