Magnetotactic Bacteria Optimization Algorithm Based On Four Best-Rand Pairwise Schemes

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ABSTRACT

Magnetotactic bacteria optimization algorithm (MBOA) is an optimization algorithm based on the characteristics of magnetotactic bacteria, which is a kind of polyphyletic group of prokaryotes with the characteristics of magnetotaxis that make them orient and swim along geomagnetic field lines. MBOA mimics the development process of magnetosomes (MTSs) in magnetotactic bacteria to solve problems. In this paper, four improved MBOAs are researched. Four pairwise MTSs regulation schemes based on the best individual and randomly chosen one are proposed in order to study which scheme is more suitable for solving optimization problems. They are tested on fourteen standard function problems and compared with many popular optimization algorithms, including PSO, DE, ABC and their variants. Experimental results show that all the schemes of MBOA are effective for solving most of the benchmark functions, but have different performance on a few benchmark functions. The fourth MBOA scheme has superior performance to the compared methods on many benchmark functions.

Keywords: Best Individual, Magnetosomes Regulation, Magnetotactic Bacteria Optimization Algorithm, Polyphyletic Group, Prokaryotes

INTRODUCTION

Bio-inspired computing (BIC) is a group of computational approaches that extract ideas from biology to develop computational systems. It is a field that develops new computational tools based on or inspired by biology mechanisms for problem solving (De Castro, L.N, 2006). It is one of the important branches of natural computing. As we know, the biology and many
kinds of life systems have been the greatest inspiration sources for a long time in many different fields. In the field of computational intelligence, Evolutionary Computing (Back, T., 1996) is the first group of bio-inspired computing methods which were inspired by evolutionary biology in 1960s.

In recent years, more and more BIC algorithms were developed including Ant Colony Optimization (ACO) (Dorigo, M., Manianiezzo, V., & Colorni, A., 1996) and Particle Swarm Optimization (PSO) (Kennedy, J., & Eberhart, R., 1995), which are known as Swarm Intelligence (SI) (Bonabeau, E., Dorigo, M., & Theraulaz, G., 2000) based on the behaviors of ant colony and bird flocks, respectively. Some other developed SI techniques include Artificial Bee Colony (ABC) (Karaboga, D., & Akay, B., 2009), Biogeography-Based Optimization Algorithm (BBO) (Simon, D., 2008), etc. All of them are also known as population based optimization algorithms. Besides animals on earth can inspire people to design new problems solving methods, researchers have proposed Bacterial Foraging Optimization Algorithm (BFOA) (Müeller, S., Marchetto, J., Airaghi, S., & Koumoutsakos, P., 2002), which was inspired by chemotactic phenomena of bacteria. In nature, there is a special kind of magnetotactic bacteria (MTB) (Faivre, D., & Schuler, D., 2008). They have different biology characteristics from chemotactic bacteria since they can orient and swim along magnetic field lines with the aid of mineral particles inside their bodies. These mineral particles with their enveloping membrane are together called magnetosomes (MTSs). Their chains are called magnetosome chains. Magnetotactic bacteria can orient themselves along geomagnetic field lines (magnetotaxis) in the earth magnetic field (Mitchell J.G., & Kogure K., 2006) since they have magnetosome chains as their compass inside their bodies.

Based on the biology principle of MTB, Mo proposed an original magnetotactic bacteria optimization algorithm (Mo H.W., 2012, Mo H.W., & Xu L.F., 2013). The ability of solving problems of the original MBOA depends on the replacement operation that some worse solutions are replaced by some randomly solutions. The moment mechanism in the original MBOA doesn’t work well, but the original MBOA shows the potential ability of solving optimization problems and has very fast convergence speed.

For the MTB, each cell carries a remanent magnetic moment, the direction of which is determined by the orientation of the magnetosome-chain axis and its magnetic polarity (Michael W, Leida G.A, & Alfonso F.D, et al., 2007). If each cell is to align its magnetosome chain parallel to the other ones, with the same polarity, each cell would yield the most efficient swimming way for living. This behavior is thought to increase the efficiency with which such bacteria find their optimal oxygen concentrations at sedimentwater interfaces or in water columns (Duin-Borkowski R, McCartney M R, & Frankel R.B. et al., 1998). This specific behavior is the inspiration source of the MBOA. For the MBOA, we consider the state that each cell is to align its magnetosome chain parallel to the other ones, with the same polarity, each cell would yield the most efficient swimming way for living as finding the optimal solution. The interaction energy between different chains in different cells makes MTB strive for better living.

In this article, the original MBOA is further improved based on four different schemes. The main idea is to regulate the moments of MTSs based on the combination of the best cell and some other randomly chosen one. All of the improved algorithms work mainly according to three steps: MTSs generation, MTSs regulation, and MTSs replacement. Four schemes are realized at the step of MTSs regulation.

The remainder of this paper is organized as follows: Section MBOA based on four best-rand pairwise schemes describes the basic biology concepts related to MTB and the model of MBOA. In Section simulation results, experiments on fourteen standard functions’ optimization and analysis are provided and results are summarized. Finally is the section Conclusion.
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