

Chapter 5

Magnetotactic Bacteria Optimization Algorithm (MBOA) for Function Optimization: MBOA Based on Four Best- Rand Pairwise Schemes

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ABSTRACT

Magnetotactic bacteria is a kind of prokaryotes with the characteristics of magnetotaxis. Magnetotactic bacteria optimization algorithm (MBOA) is an optimization algorithm based on the characteristics of magnetotaxis. It mimics the development process of magnetosomes (MTSs) in magnetotactic bacteria. In this chapter, four pairwise MTSs regulation schemes based on the best individual and randomly chosen one are proposed to study which scheme is more suitable for solving optimization problems. They are tested on 14 functions 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 test functions but have different performance on a few test functions. The fourth MBOA scheme has superior performance to the compared methods on many test functions. In this scheme, the algorithm searches around the current best individual to enhance the convergence of MBOA and the individual can migrate to the current best individual to enhance the diversity of the MBOA.

INTRODUCTION

Bio-inspired computing (BIC) has been extensively studied for solving the optimization problems. 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 the past two decades, many BIC algorithms were developed including Ant Colony Optimization (ACO) (Dorigo, M., Manianiezzo, V., & Coloni, 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) (Müller, S., Marchetto, J., Airaghi, S., & Koumoutsakos, P., 2002), which was inspired by chemotactic phenomena of bacteria. In recent years, many new optimization algorithms inspired by nature were proposed, such as Invasive Weed Optimization Algorithm (IWOA) (Mehrabian, A. R. & Lucas, C., 2006), Monkey Search (MS) (Mucherino, A. & Seref, O. 2007), Artificial Glowworm Swarm Optimization (AGSO) (Krishnanand, K. N. & Ghose, D., 2009), Firefly Algorithm (FA) (Yin, Tan., 2015), Brain storm optimization algorithm (Shi, Y. H., 2011), Chemical-Reaction Optimization (Lam, A.Y.S. & Li, V.O.K, 2010). Most of them were inspired by biology and few of them were inspired by physical and chemical phenomenon.

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 sediment water 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

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