Niche Genetic Algorithm Based on Sexual Reproduction and Multimodal Function Optimization Problem

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ABSTRACT

In this paper, a genetic algorithm with sexual reproduction and niche selection technology is proposed. Simple genetic algorithm has been successfully applied to many evolutionary optimization problems. But there is a problem of premature convergence for complex multimodal functions. To solve it, the frame and realization of niche genetic algorithm based on sexual reproduction are presented. Age and sexual structures are given to the individuals referring the sexual reproduction and “niche” phenomena, importing the niche selection technology. During age and sexual operators, different evolutionary parameters are given to the individuals with different age and sexual structures. As a result, this genetic algorithm can combat premature convergence and keep the diversity of population. The testing for Rastrigin function and Shubert function proves that the niche genetic algorithm based on sexual reproduction is effective.

Keywords: Genetic Algorithm, Optimization Problem, Rastrigin Function, Sexual Reproduction, Shubert Function

INTRODUCTION

Genetic algorithm is a probability search algorithm, enlightened by Darwin’s evolution theory and Mendel’s genetics, simulates the creature’s genetic and evolutionary process. It has been drawn wide attention since Michigan University’s professor John Holland proposed the conception of Simple Genetic Algorithm(SGA) in 1970s. According to the struggle for existence principles, produced new generations and evolved to the optimal solution through a
series of genetic manipulation such as selection, crossover and mutation by leveraging colony searching technology. Compared with other optimizing methods, genetic algorithm described the researching problem in the form of string, simply used fitness function for optimization, without the need of derivative or other auxiliary information, especially for dealing with complex and nonlinear problems, which traditional search methods were difficult to solve, can be widely used in combinatorial optimization, machine learning, adaptive control and image processing and other fields.

Although genetic algorithm has been successfully applied to many fields, but a lot of practice and research show that the simple genetic algorithm has poor search ability and premature convergence defects, especially in dealing with multimodal function, this problem has become more prominent. It can only find a few optimal solutions, and sometimes gets a local optimal solution, but we often want to optimize the algorithm to identify the optimal solution for all. The same problem solving many times may help us to find multiple solutions, but the solution results are random, we cannot guarantee to find all global optimal values. Some theoretical studies have proved that traditional simple genetic algorithm did not converge to the global optimum (Rudolph, 1994). To overcome this problem, many researchers improved the genetic algorithm from the encoding, genetic operators, population patterns, the producing way of next generations and other aspects (Schraudolph & Belew, 1992; Chen & Wang, 2009; Lis & Eiben, 1997; Kuo & Hwang, 1996; Zhang, Wang, Luo, & Cong, 2010; Song, Qu, & Han, 2003). Although the global convergence rate and optimizing efficiency has been improved in some degrees, it needs further research and development. Simple genetic algorithm simulates the genetic evolution process relatively simple, less considering the individual characteristics of age, gender, reproduction. Niche Genetic Algorithm (NGA) (Huang & Chen, 2004; Xie, 2005) has good performance when be used in solving the premature convergence defects. Therefore, this article drew lessons from the sexual reproduction, introduced niche technology in the genetic algorithm, proposed the Niche Genetic Algorithm Based on Sexual Reproduction (NGABAR).

NICHE GENETIC ALGORITHM BASED ON SEXUAL REPRODUCTION

Algorithm Structure

Niche refers to a specific living environment in biology (Lei et al., 2005). Generally, the same species always live together to produce offspring in the biological evolution process, “feather flock together, people in groups” is a niche phenomenon. They are also survived in particular geographic areas, such as tropical fish cannot survive in colder areas and polar bears cannot survive in the tropics. This offers the possibility of new species formation and maintains infinite diversity of the biosphere. Draw lessons from sexual reproduction, niche and the individual fertility changes with age, we construct the new genetic algorithm. Genetic individuals were divided into males and females, males have strong optimizing and exploring abilities in the larger space, females quickly in a small area for local optimization. Male and female individuals have been given the age parameters. According to the law of higher organisms experienced growth period, mature period and decline phase, the male and female individuals run crossing operation for heterosexual cross-breeding. This algorithm is not easy to fall into local convergence, has a strong ability to jump out of local minima, and converged quickly. The local research and global research abilities are all strong.

The algorithm structure was described as follows:

First, randomly generated initial population and initialized, set the initial age of each individual;
while (algorithm terminal conditions not satisfied) do
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