DOI:10.18686/ahe.v7i28.10618

Optimization Research Based on Improved Genetic Algorithm

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Abstract: Genetic algorithm itself has the characteristics of openness and parallel processing. Promoting its efficiency in optimizing recognition, widely applied in fields such as engineering, science, economics and computer science. However, the structural analysis time of traditional genetic algorithms is long and "premature" , the problem of low efficiency in designing and facing large-scale data still exists. In view of this, the article deeply analyzes the current shortcomings of genetic algorithms, and proposes suggestions to improve genetic algorithms with moderate functions, promote the integration of other optimization algorithms into genetic algorithms, and use big data technology to optimize genetic algorithms. Improvements are made to address the above issues, in order to provide useful references for optimizing genetic algorithms.
Keywords: Genetic algorithm; Evolution process; Improvement path; Local optimal solution

1. The Characteristics and Significance of Genetic Algorithms

1.1 Characteristics of genetic algorithm

As one of the widely used algorithms in current society, genetic algorithm has the following characteristic. Firstly, compared to traditional optimization algorithms, genetic algorithm does not seek the optimal solution by iterating a single initial value, but rather solves the problem through a set of solution strings. This solution has the characteristics of large coverage and global optimization. Secondly, genetic algorithms can simultaneously process multiple data and implement parallelization algorithms to reduce the risk of falling into local optima. Thirdly, genetic algorithms can use fitness function values to calculate the optimal solution of individuals, making their own available range relatively wide and not constrained by continuous differentiability. Fourthly, genetic algorithm conducts search through probability transition rules to further avoid local optimal solution problems. Fifth, genetic algorithms have self-organizing, adaptive, and self-learning habits. Specifically, in the process of genetic algorithms using evolutionary processes to obtain information and self-organize their search, individuals with stronger fitness have a higher probability of survival, resulting in gene structures that are more adaptable to the environment. Sixth, the genetic algorithm itself can use dynamic adaptive techniques such as fuzzy adaptive method to automatically adjust the algorithm control parameters and coding accuracy during the evolution process, in order to ensure the accuracy of the optimal solution.

1.2 The significance of genetic algorithms

With the rapid iterative development of technology, the demand for optimization algorithms in various fields is gradually increasing, making improving genetic algorithms one of the key directions of academic research. In the simulation calculation process of genetic algorithm, the final effect achieved by the optimization algorithm largely depends on the selection of algorithm parameters. Therefore, in the optimization research process of improving genetic algorithms, the most direct way is to improve parameter adjustment, crossover, mutation, and other operations. By adjusting the algorithm parameters, genetic algorithms can be better adapted to different fields, thereby improving the algorithm's solving ability. Moreover, the crossover and mutation operations of genetic algorithms can directly affect the search space of the algorithm. In this regard, the above two operations can be improved to expand the search range of the algorithm, increase algorithm diversity, and avoid the occurrence of local optimal solutions, thereby improving the optimization effect. In summary, improving genetic algorithms can promote their application in practical problems in the field of robotics and meet the needs of the new era industry for optimization algorithms.

2. The Problems of Traditional Genetic Algorithms

2.1 Traditional genetic algorithm takes a long time for structural analysis

The structural analysis of traditional genetic algorithms is mainly calculated through chromosome coding. Chromosomal coding refers to the transformation of DNA fragments that require structural analysis into specific DNA sequences that can represent the problem using special methods such as enzyme digestion, chemical synthesis, etc. When comparing the transformed DNA sequence with the gene fragment for structural analysis using methods such as the principle of complementary base pairing, if one or more gene fragments have different combinations on the base, these different base combinations can be regarded as information about the problem solution, namely chromosome coding. Due to the use of different encoding methods, different genetic algorithms selectively analyze chromosome encoding. For the same problem, using the same gene encoding may result in different results, so multiple structural analyses must be performed during structural analysis to obtain the optimal solution. This process results in longer structural analysis time and slower computational efficiency in traditional genetic algorithms.

2.2 Traditional genetic algorithms have "premature" design

Genetic algorithms are widely used in the field of engineering optimization. However, when dealing with many practical problems, traditional genetic algorithms have a "premature" design, which leads to the algorithm being unable to converge or slow in convergence speed. Researchers from the University of Bonn in Germany have found that the phenomenon of "premature" is more prominent in the process of using genetic algorithms to handle non smooth functions. In practical applications, the "premature" design of traditional genetic algorithms is common, and as the complexity of algorithm design and data size expand, the "premature" phenomenon is more likely to occur. After testing three typical non smooth functions, it was found that three of them had a severe degree of "premature", and traditional genetic algorithms would automatically select individuals with lower mutation rates for mutation. After introducing evolutionary factors into traditional genetic algorithms, the "premature" phenomenon of three non smooth functions has been alleviated, but there is still a significant "premature" phenomenon. This indicates that the "premature" design of traditional genetic algorithms is difficult to avoid.

2.3 Traditional genetic algorithms face low efficiency in large-scale data processing

Encoding and decoding are the two most important steps in genetic algorithms. Encoding is the process of converting data from input variables to output variables. Decoding is the process of converting output variables into input variables. The most important step in the encoding and decoding process is to convert input data into output variables, that is, to transform big data into small data and to transform small data into big data. However, due to the continuous crossover and mutation required by genetic algorithms during the search process, a large amount of computational resources are required. The characteristic of large-scale data is the presence of a large number of duplicate features, which makes traditional genetic algorithms prone to errors and leads to low efficiency when facing large-scale data.

3. The Improvement Path of Genetic Algorithm

3.1 Improve genetic algorithm with moderate function

The fitness function is an important way to measure all solutions in the search space, which greatly affects the search ability and convergence speed of genetic algorithms. Therefore, relevant technical departments and researchers can further improve genetic algorithms by utilizing moderate functions and applying them to structural analysis. Firstly, the moderate function is associated with the crossover and mutation operations in genetic algorithms to avoid blindness in random selection and take into account the information of multiple solutions. Secondly, the fitness function can not only measure the quality of solutions, but also the similarity between solutions, overcoming the shortcomings of a single function to a certain extent. Finally, the fitness function endows genetic algorithms with a global optimization property, which can avoid local search and improve convergence speed.

3.2 Promote the integration of other optimization algorithms into genetic algorithms

With the rapid iterative development of technology, traditional genetic algorithms cannot meet the requirements of the times. In the future, it is necessary to explore the improvement path of genetic algorithms from the following four aspects. Firstly, optimize the operation of genetic algorithms. The relevant technical department needs to select and cross operate individual diversity in the population, and set the crossover probability to 50% (or randomly select half of the individuals in each population), which is conducive to avoiding the occurrence of "premature" phenomenon. Secondly, relevant technical departments should also use random variation to achieve differences between individuals in the population. If there are a large number of infeasible individuals in the population, random variation analysis can be conducted on such individuals. Thirdly, organically combine genetic algorithm with other optimization algorithms. The relevant technical departments need to integrate other optimization algorithms such as evolutionary strategies, simulated annealing methods, and dynamic programming methods into genetic algorithms with the aim of improving the efficiency and performance of genetic algorithms, expanding the application fields of genetic algorithms, and alleviating the "premature" problem of genetic algorithms. Fourthly, relevant researchers should also use methods such as variational Bayes and non parametric statistics to analyze the characteristics and mutation rate of non smooth functions, in order to help improve genetic algorithms.

3.3 Optimize genetic algorithms using big data technology

With the rapid development of big data technology, relevant technology departments and R&D personnel need to fully utilize the screening and aggregation technology of big data to intelligently classify and store large-scale data based on features and categories, avoiding repetitive work and accelerating computational efficiency. Moreover, relevant technology departments and R&D personnel should use big data analysis and storage technology to analyze large-scale data, adjust and modify the parameters required in genetic algorithm design, which can more accurately and quickly optimize large-scale data, optimize genetic algorithms, and obtain the optimal solution. On this basis, relevant technology departments and R&D personnel can also use key core technologies such as artificial intelligence and supercomputers as auxiliary tools to further optimize genetic algorithms and accelerate work and computational efficiency when facing large-scale data.

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