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Application of artificial intelligence algorithm in mathematical modelling and solving

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Abstract

To help people solve unsolved problems in everyday life and solve the complexity of life, this paper proposes an artificial intelligence algorithm and establishes a mathematical model for simulation experiments. The results show that the artificial intelligence algorithm can search the optimal solution in a short time, with a success rate of 95.87%. Under the same conditions, relative to other algorithms, it can not only improve the success rate of the optimal solution, but also the search solution has very significant advantages.

Keywords: artificial intelligence algorithm, mathematical modeling, application**AMS 2010 codes:** 93A30

1 Introduction

In the 1960s, the mathematics modelling competition entered the Western National University. In 1985, in the early 1980s and in early 1985, China introduced mathematical modelling into the university class. The National College Student Mathematics Modeling Competition (CMCM) began in 1994, hosted by the Ministry of Education and the China Industrial and Applied Mathematics Society, for 1 year. The scale of this competition has developed at an average annual rate of >25%. After >20 years of development, most colleges in China have opened various forms of mathematical modelling courses, and cultivated students using mathematical methods, solving practical problems.

The mathematical model is mainly to use mathematical symbols, formats, procedures, graphics, and so on to provide new methods and ideas to solve practical problems. This application knowledge is abstract from the actual topics, and the process of extracting the mathematical model is called mathematical modelling. Mathematical modelling is an application of mathematics, returning mathematics theory, which enhances one's logical thinking and open thinking. Mathematical modelling plays more and more in various fields. It involves various disciplines and various fields. In recent years, with the rapid development of computer technology and

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artificial intelligence technology, the computer approach has been widely used in mathematical modelling, and the proposal of intelligent algorithms has played a crucial role in the development of mathematical modelling. There are numerous intelligent algorithms in mathematical modelling, such as artificial neural network methods, analogue annealing algorithms, genetic algorithms and grey systems. These methods have a common feature: self-learning, self-organising, adaptive, simple, universal, robustness, adapting to parallel processing. There is a wide range of applications in parallel search, Lenovo memory, pattern identification and knowledge automatic acquisition [1].

The intelligent algorithm is an inspiration of nature's wisdom to abstract summary of some structures and laws in nature, and the general name of a class of algorithms designed. The intelligent algorithm basically has the characteristics of autonomous learning and adaptive. When calculating, the purpose of solving a problem can be achieved by adjusting the individual structure or algorithm parameters. The implementation of the algorithm must be done by means of intelligent individuals, so that these individuals can interchange with other individuals, and also obtain certain knowledge from the environment, combining some optimised strategies. In the process itself, one can continue to update knowledge and improve one's own structure, while gradually approaching the goal. In general, the intelligent algorithm is more suitable to solve high dimensions of complex problems. Conversely, it is used to solve some simple problems, which may complicate problems. Different intelligent algorithms are obtained based on different simulation principles and mechanisms.

Some group intelligence algorithms, such as particle group algorithms, ant colony algorithms, and artificial neural networks, have been solved by simulating a natural phenomenon or biological evolutionary process, with high self-organised and parallelism. They have shown powerful features of vitality and further development potential in artificial intelligence, machine learning, data mining and other fields. Ant colony algorithm is a group intelligence algorithm obtained by the inspiration of real ant foraging behaviour. The definition of its structures was first done by Bachici M et al. In 1999, Bachici M 2004 defined it in his writings [2].

A more generalised description is given. The Ant-Miner algorithm proposed by Y Mohamadou et al. simplifies the rules found to improve the understandability and prediction accuracy of the classification rules [3]. In recent years, the ant colony classification algorithm has been used by a lot of researchers, and they have put forward a variety of improvements in research on the disadvantages of Ant-Miner in their studies. In the heuristic strategy of the ant colony algorithm, Chen Y et al. proposed a density-based heuristic assessment strategy [4]. Hetmaniok E et al. proposed an evaluation strategy based on an ant-selected assessment strategy, which is more effective [5]. Jidong et al. proposed a simple and effective heuristic function that can partially solve the algorithm premature maturity problem caused by the heuristic function [6]. In addition, many scholars, such as Taghinezhad E et al., have conducted research and proposed an improved algorithm that can produce a disorderly classification rule [7].

2 Ship route planning mathematical modelling

Since different intelligent algorithms have their respective advantages, this topic is based on ship route, and two different types of planning programmes are developed based on artificial intelligence algorithms, constructing the corresponding mathematical model and deriving the optimal route.

① Directions planning problem description and hypothesis

For an existing ship team, by analysing the historical data analysis, it is possible to predict the ship route, freight, and operating levels during shipping. On the basis of technical feasibility, construct the marine route planning target function. In this study, the route planning target function first presented the following functions: determine the research cycle of the ship route plan, set the route planning of the ship type, which is available, the available routes have a total of K , and the road is more traditionally a traditional multi-port cargo direct route. In all routes, the number of ports is N , uniform number $1 - m$, and the order is constant during the route planning,

and cannot be changed. According to historical data in the original ship route, the shipping demand between the ports between the ports is predicted from the transportation costs. The research cycle of the route plan is analysed accordingly for the optimal speed of each ship type, and the number of ships in the route is determined. In the process of design, the stability of operating costs is guaranteed, while controlling shipping costs are not affected by voyage truck.

In response to the problems and assumptions presented above, the operating profit in the ship route is the target function of the route planning, and the number of target functions of the corresponding route ship is established. The specific content is as follows:

$$\max x = \sum_{i=1}^K \sum_{j=1}^n \sum_{l=1}^n a_{ij} D_{ij} - \sum_{i=1}^G \sum_{j=1}^L D_{ij} b_{ij} - \sum_{i=1}^L E_i F_i \quad (1)$$

where x indicates the target function of this route design, which is used to control the operating profit of the ship. a_{ij} and b_{ij} represent decision variables in the route plan, i and j represent two port nodes in the route plan, E_i indicates the number of idleness of the ship, and D_{ij} represents the operating cost of I and J two nodes in the route. D_{ij} indicates a shipping cost of a ship in the route, which contains fixed expenditure costs and changes costs. The above function is used as the mathematical model planning of the ship route route, and the corresponding solving algorithm is obtained to obtain the optimal solution of the route plan [8].

② Environmental construction and route of ship navigation, constraint conditions description

Before establishing a mathematical model for a ship route, one must first analyse the environment of ship sailing. There are currently many ship navigation environments, such as contour line methods and network methods. This article selects more network methods, currently using more. After using a network method to construct a ship navigation environment, it is set that the starting position of the ship navigation is S . The destination location is g , and it passes multiple points, which are expressed as: $R_1, R_2, \dots, R_{N-1}$, then the ship sail The line can be described as:

$$R_k = \{S, r_1, r_2, \dots, r_{N-1}, G\}, \quad (2)$$

During ship navigation, some constraints are required, such as the shortest ship navigation line ($L_{\min}$), the longest ship navigation line ($L_{\max}$), and the largest ship navigation node ($n_{\max}$), so this article also chooses these as ship routes. The planned constraints are as follows:

$$\begin{cases} l_i \geq l_{\min} \\ L = \sum_{i=1}^N l_i \leq L_{\max} \\ N \leq N_{\max} \end{cases} \quad (3)$$

In the formula, l_i represents the planned ship route.

2.1 Mathematical model of ship route planning

According to the environment of the ship sail, the constraints can establish the following ship route planning mathematical model:

$$f_k = \min \sum_{i=1}^N (\omega_1 l_i + \omega_2 f_{TAi}) \quad (4)$$

In the formula, ω_1 and ω_2 indicate the weight and f_{TAi} represents the threat price.

Since the ship is threatened by a watellite, an obstacle during the navigation process, the ship's navigation threat cost is the sum of the threats of the entire route path. In order to reduce the computational complexity,

divide the ship navigation path into three segments, calculate each of the threat index, then ask for a threat, as follows:

$$f_{TAi} = \frac{l_i}{3} \sum_{j=1}^M \left[f_j \left(\frac{l_i}{4} \right) + f_j \left(\frac{l_i}{2} \right) + f_j \left(\frac{3l_i}{4} \right) \right] \quad (5)$$

3 Ship route planning problem for artificial intelligence algorithm

For the ship route planning mathematical model for the design of the above ①, the original solution method is optimised to obtain the optimal solution; the design is more in line with the solution process, and the specific process is shown in Figure 1 [9].

Fig. 1 Mathematical solution process of ship routes.

Design constraints. The filter consists of a constraint conditional throttle and a constraint condition queue. In the constraint condition filter, each of the conditions that have an impact on the ship route planning results has its own serial number. This constraint condition filter is mainly a linear function mode, and the setting $G_i * H_i$ is a constraint condition during the solution; u represents the sequence number of the constraint condition filter, then G_{i+1} can be obtained as -1 and H_{i+1} takes the value of U , pass the formula. The process of this filter is shown below:

$$G_i * H_i - \sum_{i=1}^{n+1} G_i * H_i \quad (6)$$

Using the above formula to complete the constraint condition filtering process, the value range of the constraint conditions during the planning process is determined by this calculation result, and the prerequisite for the last route is acquired. Set the stereo table area in the ocean as R , where the feasible route is p , according to the set

constraint conditions, the optimal route solution can be expressed as:

$$P_{\max} = \sum_{i=1}^n R + \sum_{i=1}^{n+1} G_i * H_i \quad (7)$$

Use this formula to obtain the optimal solution of setting the target function in this study, and also implement the optimisation process of the method for solving the math model of the route.

For the ship route planning mathematical model for the above ②, the genetic algorithm has a global optimised artificial intelligence algorithm, which is simpler, very easy to achieve and has good convergence and stability. Successful applications were obtained in many fields. However, the standard genetic algorithm is the same as other artificial intelligence algorithms, such as particle group algorithms. There are some shortcomings, such as lack of climbing capacity in the later period, resulting in an increase in the probability of local optimal solutions. For this purpose, the corresponding improvement is carried out, introducing the adaptive cross probability and variation probability; then the cross probability and variation probability update are as follows:

$$P_c = \begin{cases} P_{c1} - \frac{(P_{c1}-P_{c2})(f'-f_{avg})}{f_{\max}-f_{avg}}, & f' \geq f_{avg} \\ P_{c1}, & f' < f_{avg} \end{cases} \quad (8)$$

$$P_m = \begin{cases} P_{m1} - \frac{(P_{m1}-P_{m2})(f_{\max}-f)}{f_{\max}-f_{avg}}, & f \geq f_{avg} \\ P_{m1}, & f < f_{avg} \end{cases} \quad (9)$$

3.1 Individual coding method

When the genetic algorithm is used to solve the problem of ship route planning, the individual coding method of marine route planning is first solved. Since each individual represents a ship route planning plan, this paper uses the encoding method as shown in Figure 2. The coding sequence of the first body is: $\{x_{i1}, x_{i2}, \dots, x_{im}\}$, which is the number of nodes in the ship route planning path [10, 11].

Fig. 2 Individual code schematic.

3.2 Adaptation function design

Since the ship's route planning adaptation function is mainly used to evaluate the advantages and disadvantages of the individual, it is closely related to the math model of the ship route, so the adaptation function of the individual's personal expedition can be expressed as:

$$fitness = \frac{1}{\sum_{i=1}^N (\omega_1 l_i + \omega_2 f_{TAi})} \quad (10)$$

3.3 Ship route planning steps for artificial intelligence algorithms

1. Set the parameters of the genetic algorithm, such as the maximum number of iterations, population individual planning, and set the size of the ship route navigation area, as well as the starting point position, destination location.

2. Set the corresponding constraints of ship route navigation planning, and establish a mathematical model of ship route navigation planning, design the adaptation function of genetic algorithm.
3. A random manner produces initial groups, and each individual represents a vast planning of a ship route.
4. Calculate the individual adaptivity value according to the adaptivity function, and evaluate the pros and consumption of the viable plan for ship route navigation plan according to the calculation results.
5. Select a part of the preferred individual to enter the next generation population based on the evaluation results.
6. Select some of the individual individuals to cross, variation operation, select better individual to enter the next-generation population.
7. Evolution algebra, and compare with the maximum evolutionary algebra. If you exceed the maximum evolutionary generation, stop the math model of the ship's route navigation plan, and output the optimal ship route navigation planning plan, or return to step (4).

4 Simulation test

4.1 Test scenario

In order to analyse the ship route planning effect of artificial intelligence algorithm, the ship navigation area is $1,000 \text{ km} \times 1,000 \text{ km}$. The starting point position of the ship navigation is (0, 0), the destination location is (1,200, 1,200), and the parameter of the genetic algorithm is set as: Population individual 20, maximum evolutionary generation 500, using C++ programming simulation experiments for ship route planning simulation experiments [12].

4.2 Results and analysis

In order to make the ship route planning effect of the above ② artificial intelligence algorithm more comparable, the ship route planning method of the fish group algorithm is selected, and the ship route planning method of the ant colony algorithm is a compared experiment. Choose a ship route planning success rate, the optimal ship route planning path length and find the number of iterations of the optimal ship route planning scheme as performance evaluation indicators, as shown in Table 1.

Table 1 Comparison of ship route planning performance of different methods

Planning method	The success rate	Optimal road length
Fish algorithm	90.21	1807
Ant colony algorithm	93.65	1793
Algorithm 1	94.53	1756
Algorithm 2	95.87	1708

As can be seen from Table 1, the success rate of the ship route of the above ② method is 95.87%, which is much higher than the other three algorithms. At the same time, it has greatly reduced the number of iterations to find the best ship route planning plan, and speed up the optimal ship route planning programme. It can also be seen from Table 1 that the optimal ship route planning path in this paper is also shorter than the comparison method, which reduces the planning cost of the optimal ship route, with a higher practical application range.

5 Conclusion

Due to different advantages and disadvantages of different intelligent algorithms, in the actual mathematical modelling process, a few intelligent algorithms can be compared, which can be effectively solved, and the reliability of the model can be obtained. With artificial intelligence constantly developing, more and more issues require a comprehensive way to solve; intelligent algorithms have also played an increasingly important role in mathematical modelling.

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