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Application of multi-objective comprehensive optimization model of soil and water conservation based on genetic algorithm

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Abstract: Soil and water conservation as the focus of the development of urban construction, in the development of modern economic and technological innovation, international scholars applying artificial intelligence to construct the integrated optimization model of soil and water conservation, in order to provide effective reference for solving the problem of soil erosion, avoid the destruction of their homes by human beings rely on, really realize the goal of sustainable development. As a basic part of artificial intelligence research, genetic algorithm plays an active role in solving IP problems in combinatorial optimization. Therefore, on the basis of understanding the genetic algorithm and the research status of soil and water conservation, this paper mainly discusses the application effect of the multi-objective comprehensive optimization model of soil and water conservation with the genetic algorithm as the core. The final experimental results prove that the comprehensive optimization model constructed by RAGA accelerated genetic algorithm proposed in this paper can comprehensively improve the multi-parameter optimization ability, and has reliability and applicability characteristics in practice, which provides an effective basis for the soil and water conservation work of urban construction and development in the new era.

Keywords: Genetic algorithm; Soil and water conservation can be divided into many objective optimization problems; The optimization model

1. Introduction

According to our country in recent years the application of multi-objective integrated optimization model of soil and water conservation construction Angle analysis, now the main use of computer aided method, linear programming and multi-objective programming method solve the problem of xiao river basin comprehensive harness of soil and water conservation, is one of the most representative east goal programming method, can get rid of the limitation of traditional simplification goal, And ensure that each planning goal convergence. Nowadays, multi-objective planning method has been widely used in soil and water conservation projects. For example, some scholars use SETM to find the optimal solution of multiple parameters and choose the method of multi-objective comprehensive programming for research. The whole operation process is to use the basic and theory of trial calculation and iterative calculation to scientifically deal with the problems of local optimal parameters and early convergence that may be generated by SETM method. Combined with the above problems to effectively prevent model calculation, enter into the early convergence of local optimal problems, the multi-objective programming theory and accelerated genetic algorithm into the integration, the construction of a new theoretical model, to achieve the main content of Liu Yudong objective comprehensive optimization algorithm research. From the perspective of practical application, this new model method has strong convergence and can find the optimal solution globally.[1-3]

Genetic algorithm was first proposed by American scholars in the 1970s. It is designed and analyzed mainly in combination with the evolution law of organisms in nature, and effectively simulates the natural selection and genetic mechanism of Darwinian biological evolution. It is a

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method to find the optimal solution by simulating natural evolution. Through the integration of mathematical equations and computer simulation operation, the problem solving process is transformed into the process of crossover and mutation of chromosome genes in biological evolution. When calculating and analyzing complex combinatorial optimization problems, the routine optimization algorithm can be used to quickly obtain optimization results. Nowadays, this kind of algorithm has been widely used in artificial life, adaptive control, signal processing, machine learning, combinatorial optimization and other aspects. The specific simulation process is shown in Table 1 below:[4-6]

Table 1 Simulation process of genetic algorithm

Biological evolution	Genetic algorithm (ga)
Individual	One solution to the problem
Individual competitiveness	To adapt to the function
The survival of the fittest	The solution with the largest adaptation value has the greatest probability of being retained
Chromosome	Solution of the coding
Gene	Elements of code
Group	A selected group of solutions
Population	A set of solutions selected according to an adaptation function
Cross	The process of producing offspring from both parents in a certain way
Variation	The process by which some component of a code is changed

From the perspective of practical application, genetic algorithm has the following advantages: First, the algorithm will regard the coding of decision variables as operational objects, and directly interact with the objects for effective operation, which can not only simulate multiple processes such as biological genes and genetic evolution, but also expand the application scope of genetic algorithm. Secondly, this kind of algorithm will regard the value of the objective function as the search information, and does not involve the process of derivative and differentiation of the value of the objective function. It only needs to use the value of the fitness function to measure the excellence of the individual. Thirdly, this kind of algorithm will abide by probabilistic rules rather than deterministic rules, so the actual search will be more flexible, and parameters will have little influence on the search results. Finally, the algorithm has strong scalability and can be mixed with other technologies, providing an effective basis for the development of modern scientific research. However, genetic algorithm also has some problems, such as irregularities and inaccuracies during coding. Because a single genetic algorithm code cannot constrain the representation optimization problem, it is necessary to put forward a threshold for the infeasible solution, which will inevitably increase the computation time and work amount. The efficiency of the algorithm is usually lower than that of other traditional methods, and premature convergence is very easy to occur, as shown in Figure 1 below:[7]

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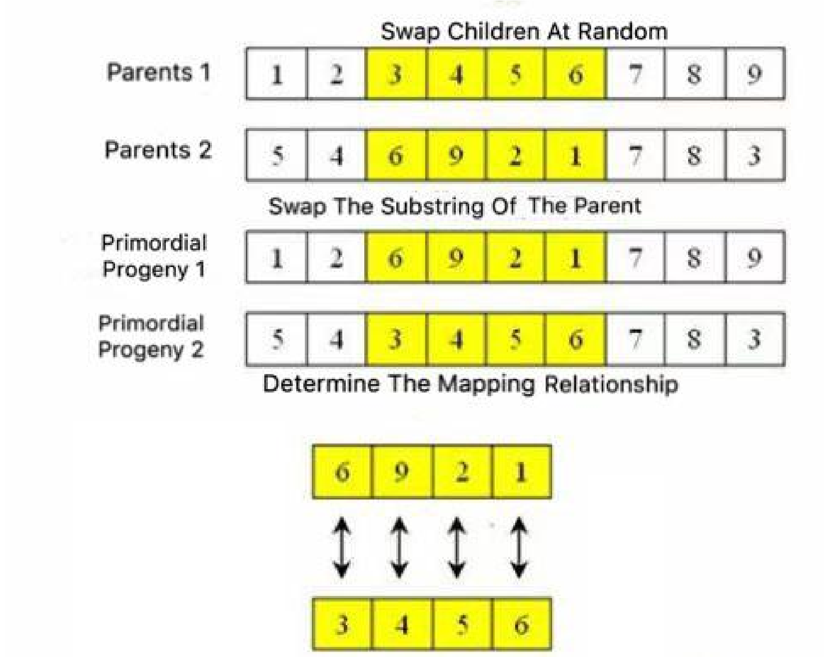

FIG. 1 Schematic diagram of premature convergence of genetic algorithm

Therefore, on the basis of understanding the application calculation results of multi-objective comprehensive optimization model of soil and water conservation in recent years, this study mainly discusses the application effect of genetic algorithm and its improved algorithm, so as to provide effective basis for the soil and water conservation work of urban construction and development.[8]

2. Method

2.1 Genetic Algorithm

This kind of algorithm first appeared in the early 1960s, is by the University of Michigan professor J.Holland's students in the doctoral dissertation proposed, mainly discusses the application of genetic algorithm in the game. Due to the lack of guiding theory and computational tools in early research, relevant research has not received much attention. In the mid-1970s, Professor J.Halland et al. conducted research and analysis based on the important pattern theory of genetic algorithm, and introduced the basic theory and application method of genetic algorithm in the book, which provided an effective basis for the development of genetic algorithm in the new era. In the 1980s, genetic algorithm entered the boom period, mainly used in robotics, image processing, production planning and many other fields. The actual structure is shown in Figure 2 below:[9-11]

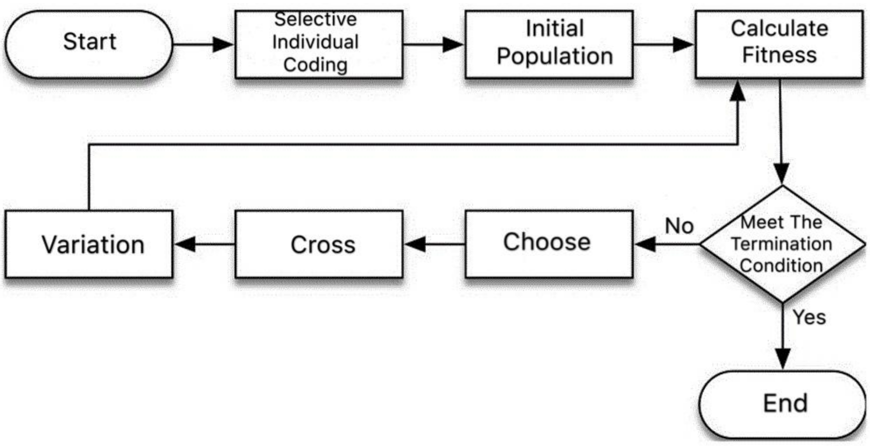

FIG. 2 Structure of genetic algorithm

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This paper mainly studies the application effect of accelerated genetic algorithm in the multi-objective comprehensive optimization model of soil and water conservation. The process of standardized genetic algorithm is shown in Figure 3 below:

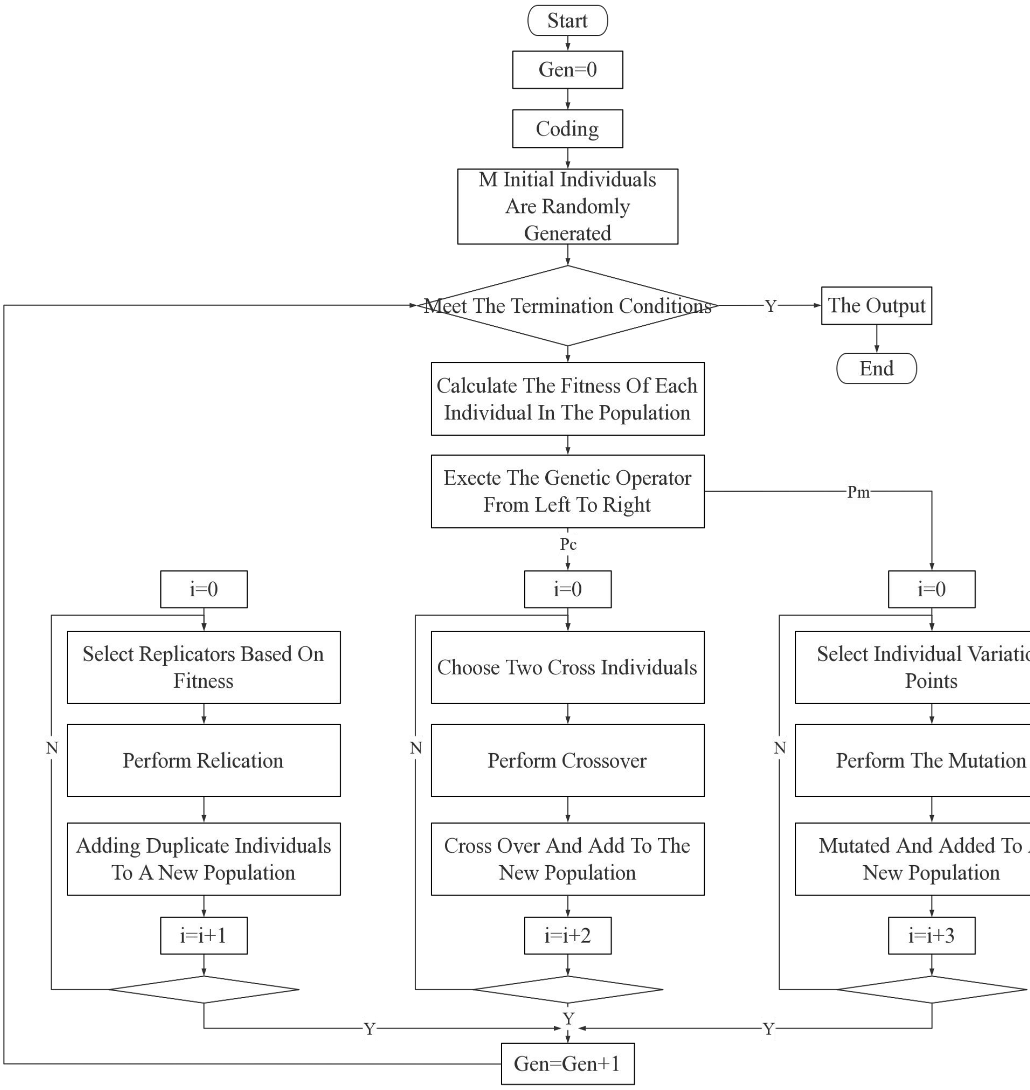

Figure 3. Flow chart of standardized genetic algorithm

2.2 Multi-objective optimization problem

Nowadays, many control decision-making problems need to consider the optimization results of multiple objectives, but the solution of multi-objective optimization problems has been a major difficulty in scientific research, usually it is difficult to calculate the optimal solution, can only get Pareto solution. Nowadays, science scholars put forward a series of used in practice to explore the methods to solve this kind of algorithm, such as ant colony algorithm, particle swarm optimization and genetic algorithm, although these algorithms in engineering optimization and process control and so on obtained the excellent result, but in solving multi-objective function optimization problem still exists many problems. For example, the genetic algorithm studied in this paper has the characteristics of global convergence, randomness and rapidity. However, after running to a certain extent, because the feedback information in the system cannot be effectively used, a large number of meaningless redundant iterations will appear. The complexity of the actual algorithm is too high to guarantee the optimization of the solution. Ant colony algorithm has the characteristics of high solving efficiency, positive feedback mechanism and parallelism, but the global search ability is low, and it is easy to fall into the phenomenon of local solution in the process of calculation and

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analysis. Therefore, this paper proposes to use the improved genetic algorithm to solve the multi-objective comprehensive optimization problem of soil and water conservation, and the specific definition is as follows:[12-15]

$$\begin{cases} \mathrm{Min}(\mathrm{f}_1(x), f_2(x), ..., f_m(x))^T \\ s.t. S(x) = (s_1(x), s_2(x), ..., s_k(x))^T \geq 0, \\ a \leq x \leq b \end{cases}$$

In the above formula, $x = (x_1, x_2, ..., x_n)$ represents the decision vector, $(f_1(x), f_2(x), ..., f_m(x))^T$ represents the multi-objective optimization function vector, $S(x) = (s_1(x), s_2(x), ..., s_k(x))^T \geq 0$ represents the constraint condition, $a \leq x \leq b$ represents the boundary condition, and conforms to the condition $a = (a_1, a_2, ..., a_n), b = (b_1, b_2, ..., b_n)$, while the decision component conforms to the condition $x_i \in [a, b], i = 1,2, ..., n$. In the moving target optimization problem, each target usually has a limiting relation. The optimization of a certain target will inevitably reduce the performance of other targets, and the optimal decision is not unique, but there is a set of optimal decisions.

2.3 Optimization Model

First, you choose to deal with the target function. In this paper, we study on fully considering the experimental area of natural economy law of development and management situation of soil and water conservation conditions, through the system to understand related data and previous experts accumulated experience, and constructing related to river basin planning system, which includes three contents, first is to point to economic net income biggest target, the second is refers to the maximum grain yield target, The last is the minimum target of soil loss. The calculation formula of each target is as follows:

$$\begin{aligned} f_1(X)_{Max} &= 135x_1 + 82x_2 + 60x_3 + 471x_4 + 377x_5 \\ &+ 250x_6 + 462x_7 + 351x_8 + 280x_9 + 165x_{10} + 142x_{11} + \\ &630x_{12} + 618x_{13} + 347x_{16} + 355x_{17} + 346x_{18} + 842x_{25} + \\ &16x_{26} + 21x_{27} + 75x_{28} + 220x_{29} + 185x_{30} \end{aligned} \quad (1)$$

$$\begin{aligned} f_2(X)_{Max} &= 355x_1 + 270x_2 + 250x_3 + 1120x_4 + \\ &940x_5 + 780x_6 + 510x_7 + 450x_8 + 260x_9 + 220x_{10} + \\ &170x_{11} \end{aligned} \quad (2)$$

$$\begin{aligned} f_3(X)_{Max} &= 0.342(\ x_1 + x_4 + x_7\ ) + 0.0128x_2 + 0.031(\ x_3 + x_5\ ) + 0.1325x_6 \\ &+ 0.160x_8 + 0.138x_9 + 0.076(\ x_{10} + x_{12}\ ) + 0.166(\ x_{11} + x_{13}\ ) + \\ &0.27(\ x_{16} + x_{17} + x_{18} + x_{19} + x_{20} + x_{21} + x_{22} + x_{23} + x_{24}) \end{aligned}$$

In the above formula, f1 (X) max represents the maximum target of economic net income, f2 (X) max represents the maximum target of grain yield, and f3 (X) min represents the minimum target of soil erosion. In combination with the multi-objective comprehensive optimization principle of genetic algorithm, the above three formulas are summed linearly weighted, and the following formula can be obtained:

$$F_{Min} = \sum_{i=1}^{3} T_i \cdot f_i(X)_{Max} = T_1 f_1(x)_{Max} + T_2 f_2(x)_{Max} + T_3 f_3(x)_{Min}$$

Secondly, the decision variables and constraints should be defined. According to the analysis of the statistical results of decision variables shown in Table 2 below, four constraints should be mainly considered when constructing the multi-objective comprehensive optimization model: first,

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land constraints; Second, productivity development; Third, balance constraints; Fourth, development of animal husbandry.

Table 2 Statistical results of decision variables

The decision variables	Meaning of expression	The decision variables	Meaning of expression	The decision variables	Meaning of expression
X_1	Class I wheat area	X_{11}	Area of multi-grain terraced fields in Class III	X_{21}	Area of forest used in Class IV
X_2	Cultivated wheat area in Class II	X_{12}	Cash crop area under cultivation in Class II	X_{22}	Shrub area of class II land
X_3	Type III terraced wheat area	X_{13}	Area of cash crops in Class III terraced fields	X_{23}	Area of shrub in class III
X_4	Area of maize in Class I field	X_{14}	Artificial pasture area of Class II ground ladder	X_{24}	Area of shrub in class IV
X_5	Corn cultivation area in Class II	X_{15}	The artificial pasture area of Class III ground ladder	X_{25}	The number of cows
X_6	Type III terraced corn area	X_{16}	Economic forest area of Class II land	X_{26}	Number of chicken
X_7	Soybean area in Class I land	X_{17}	Economic forest area of Class III land	X_{27}	Duck duck number
X_8	Cultivated soybean area in Class II	X_{18}	Economic forest area of Class IV land	X_{28}	The number of sheep
X_9	Type III terraced soybean area	X_{19}	Area of timber forest for Class II	X_{29}	Number of pigs
X_{10}	Area of mixed grain cultivated in Class II	X_{20}	Area of Class III timber forest	X_{30}	Large livestock quantity

Finally, we deal with the constraint equation. There are many restrictive conditions for the comprehensive optimization of the model. In the process of calculation and analysis, due to the large differences in unit and dimension, the constraint conditions should be preprocessed to meet the requirements of the model. Among them, the most common method is the penalty function method, which defines a penalty term for the target function, so as to judge whether the variable is in the constraint set. The specific calculation process is as follows:

$$F'_{Max} = T_1 f_1(x)_{Max} + T_2 f_2(x)_{Max} + T_3 f_3(x)_{Min} - \sum_{i=1}^{m} h_i g_i(x)$$

In the above formula, higi (x) represents the multiplication term. When this value is equal to zero, it means that the constraint conditions meet the requirements. If this value is any other real number, then it proves that there is a degree of dispersion between the constraint and the condition; F prime stands for optimization criterion function.

3. Result analysis

In this paper, MATLAB5.3 software is applied to calculate and analyze 30 parameter variables of the accelerated genetic algorithm. Assume that the initial calculated population of the model is

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600, the crossover probability is 0.84, and the compilation probability is 0.80. After identifying 20 final excellent individuals, the global optimization analysis is carried out, and the final results are shown in Table 3 below:

Table 3 Experimental results

Parameters of the variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Scheme 1 optimization results	3116.2	670.1	927.7	2273.2	832.7	676.7	922.5	782.4	677.0	360.5
Scheme 2 optimization results	2480.5	752.5	845.1	3516.1	813.5	672.5	846.1	657.6	768.2	330.3
Parameters of the variable	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}
Scheme 1 optimization results	521.7	615.2	249.1	677.4	847.6	647.2	304.6	114.6	312.6	277.6
Scheme 2 optimization results	565.2	687.4	217.2	850.2	625.1	920.7	412.5	136.2	351.2	245.5
Parameters of the variable	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}	X_{26}	X_{27}	X_{28}	X_{29}	X_{30}
Scheme 1 optimization results	96.1	622.1	236.2	118.4	347.6	977.6	350.1	485	1082.4	485
Scheme 2 optimization results	125.7	150.4	308.4	112.5	480.4	1018.2	644.6	485	1030.2	485

According to the analysis of the research results, the multi-objective comprehensive optimization model studied in this paper can not only ensure the rationalization of agricultural land application, but also improve the content of organic matter in soil and strengthen the fertility of soil by combining key technical measures under the restriction of multiple conditions. From the perspective of data change, agricultural land decreased from the original 7% 17:00 300,000,000 to 66.25%, and the local forest coverage increased from the original 5.7% to 16.22. The actual coverage area increased, which not only met the requirements of soil and water conservation engineering construction and management, but also comprehensively improved the local ecological environment. At the same time, strengthening the construction and management of agricultural joint irrigation association can not only guarantee the rationality of economic construction and development, but also effectively control the adverse consequences of soil and water loss, ensure that the local woodland cover system is more perfect, and meet the requirements of rational development and utilization of land resources. In addition, farming and animal husbandry also increased from the original 0.80% to 14.00%, and the quality of pasture improved. The income of local residents has increased nearly 3.5 times, and the amount of grain per person has increased from 1,182.50 kg to 3,844.70 kg. Thus, it is proved that under the constraint conditions required in this paper, the selected scheme 2 has more economic advantages than scheme 1, and meets the sustainable requirements of current urban construction and development.

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4. Conclusion

To sum up, therefore, in the future urban construction and development, Chinese scholars should continue to explore the application of multi-objective comprehensive optimization model of soil and water conservation, integrate the artificial intelligence technology theory represented by genetic algorithm, and pay attention to adjusting the constraints of practical research to ensure the maximum of the overall economic effect of the watershed. This provides an effective basis for the construction and development of sustainable and innovative social environment. At the same time, we should strengthen the training of professional and technical personnel, actively study the research results obtained by foreign scholars, and continue to optimize the soil and water conservation research measures and solutions in our country, to lay the foundation for the realization of sustainable development goals.

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