Application of Genetic Algorithm in Optimal Scheduling of Hydropower Station Reservoirs

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Keywords: Genetic Algorithm, Scheduling Optimization, Hydropower Station Management, Local Scheduling, Overall Scheduling, Displacement, Generation, Scheduling Frequency, Scheduling Time, Scheduling Accuracy, Process Simplification Rate.

Abstract: The role of dispatch optimization in hydropower station management is very important, but there is the problem of inaccurate evaluation of results. The bat algorithm cannot solve the problem of scheduling optimization in hydropower station management, and the evaluation is unreasonable. Therefore, this paper proposes a genetic algorithm for the optimization analysis of innovative scheduling and scheduling. Firstly, the optimal dispatching scheme is used to evaluate the management of hydropower stations, and the indicators are divided according to the requirements of dispatching optimization to reduce the interference factors in dispatching optimization. Then, the optimal dispatching scheme innovates and optimizes the management of hydropower stations, forms a dispatching optimization scheme, and comprehensively analyzes the dispatching optimization results. The dispatching frequency model shows that under the condition of certain evaluation criteria, the genetic algorithm optimizes the accuracy of the dispatch of hydropower station reservoirs. The scheduling optimization time is better than that of the bat algorithm.

1 INTRODUCTION

Displacement and power generation are one of the important contents of hydropower station reservoir management and are of great significance to the development of hydropower station reservoirs (Ahn, and Tian, et al. 2023). However, in the process of dispatch optimization, the scheduling optimization scheme has the problem of poor accuracy (Andrus, and Diffely, et al. 2023), which brings certain efficiency loss to the reservoir management of hydropower stations (Awad and Parrondo, 2023). Some scholars believe that the application of genetic algorithm to the management analysis of hydropower stations can effectively analyze the scheduling optimization scheme and provide corresponding support for the dispatching optimization (Bai, and Yu, et al. 2023). On this basis, this paper proposes a genetic algorithm to optimize the scheduling optimization scheme and verify the effectiveness of the model (Bravo-Cordoba, and Garcia-Vega, et al. 2023).

Hydropower station is an important clean energy power generation facility, which has the advantages of abundant resources and environmental friendliness, and has become an indispensable part of the modern energy system (Chen and Zhang, et al. 2023). In the operation of hydropower stations, how to carry out reasonable and efficient dispatch is one of the key factors to ensure the efficiency of hydropower station operation and play its maximum role (Dalcin, and Breda, et al. 2023). Traditional hydropower plant dispatch methods are often based on experience and rules, and are not flexible and efficient (De Paris, and Carnielutti, , et al. 2023). To this end, researchers began to explore how to use advanced algorithms and technologies to improve the optimization effect and efficiency of hydropower station dispatching (Dires, and Amelin, et al. 2023). As an excellent optimization algorithm, genetic algorithm has been successfully applied to the dispatch optimization of hydropower stations and has achieved good results (Godoy and Ishihara, et al. 2023). This paper will introduce and analyze the application of genetic algorithm in the optimization of hydropower station dispatch (Hao and Yang, et al. 2023).

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1.1 Analysis of Hydropower Station Dispatch Optimization Problem

The scheduling problem of hydropower station belongs to a complex multi-objective and multi-constraint optimization problem (He and Zhang, et al. 2023). The goal of hydropower station dispatch is usually to optimize the efficiency of power production, maximize power generation, and meet dispatch constraints, such as generator output, generation flow, water level control, etc (Jeong and Furenes, et al. 2023). The main difficulties of hydropower station scheduling problems lie in the complex structure, multiple constraints, diversified objective functions, and changing operating environment of the optimization model, so it is necessary to design appropriate optimization algorithms to reduce the complexity of the algorithm and improve the efficiency of the solution (Jiang and Ming et al. 2023).

1.2 Principles and Processes of Genetic Algorithms

Genetic algorithm is an optimization algorithm that simulates the laws of evolution in nature. The basic idea of genetic algorithms is to optimize the solution of problems by simulating the process of biological evolution. The basic process is as follows:

1.2.1 Initialize the Population

A certain number of initial individuals are randomly generated as the population, each of which is a potential solution to the problem (Jin and Liu et al. 2023).

Individual fitness assessment: The fitness value of each individual is calculated by the objective function to determine the probability of each individual participating in reproduction (Ju and Ding, et al. 2023).

Reproduction and mutation: According to the degree of fitness, basic genetic operations such as selection, crossover, and mutation are used to generate new individuals and replace the original unsuitable individuals, so as to gradually improve the optimization model (Li and Ke et al. 2023).

Termination condition judgment: When a certain termination condition is met, the algorithm stops and outputs the final optimization solution (Liu and Luo, et al. 2023).

1.3 Application of Genetic Algorithm in Hydropower Station Dispatch Optimization

As an excellent optimization algorithm, genetic algorithm has been successfully applied to the optimization problem of hydropower station dispatching. Its main advantage lies in the global search and non-deterministic characteristics of the algorithm, which can better cope with complex multi-objective and multi-constraint optimization problems (Liu and Luo, et al. 2023).

1.3.1 Model Building

When using genetic algorithm to solve hydropower station scheduling optimization problems, it is necessary to establish a corresponding optimization model. Optimizing the model needs to include objective functions and constraints. In the hydropower station dispatch problem, the objective function is usually to maximize the power generation, and the constraints include generator output constraint, current constraint, water level constraint, generator number constraint, etc.

1.3.2 Parameter Settings

When using genetic algorithms to solve hydropower station scheduling optimization problems, some important parameters need to be set. For example, parameters such as population size, crossover probability, mutation probability, and selection strategy need to be considered. The choice of these parameters will affect the convergence speed of the algorithm, the quality of the solution and other factors.

1.3.3 Fitness Function

When using genetic algorithms for optimization solving, fitness functions need to be designed to assess the optimization quality of each individual. In the hydropower station dispatch problem, the fitness function is generally the maximization of power production, but due to the complexity of the hydropower station scheduling problem, more factors need to be considered when designing the fitness function, such as generator output, water level control, power generation flow and other factors.

1.3.4 Optimize the Process

When using genetic algorithms to optimize the scheduling problem of hydropower plants, a variety of methods can be used to realize the optimization process. One of the common methods is an agent-based approach. By optimizing the proxy model, a better optimization solution can be obtained in a short time.

1.4 The significance of genetic algorithms in hydropower station scheduling

1.4.1 Improve the Efficiency of Hydropower Station Power Generation

The application of genetic algorithm can help hydropower stations achieve more reasonable and efficient dispatching schemes, thereby improving the power generation efficiency of hydropower stations and maximizing power production.

1.4.2 Reduce Costs

The success of hydropower plant dispatch optimization can help reduce the operating costs of hydropower plants, minimize power production, and provide more stable economic benefits for hydropower plants.

1.4.3 Ensure the Rational Use of Water Resources

The application of genetic algorithms can help hydropower stations achieve rational utilization of water resources and ensure the sustainable development and utilization of water resources. The application of genetic algorithms can promote the development of informatization and automation of hydropower stations, and provide support and guarantee for the modernization of hydropower stations.

The hydropower station scheduling optimization problem is a typical multi-objective and multi-constraint optimization problem, and traditional optimization methods often have limitations. As a global optimization algorithm, genetic algorithm can be effectively applied to the optimization problem of hydropower station dispatching, improve the power generation efficiency of hydropower station, reduce cost, ensure the rational utilization of water resources, and promote the development of automation of hydropower station, etc., which has important theoretical research value and practical application significance. In the future, with the continuous maturity and development of genetic algorithm technology, its application and significance in the problem of hydropower station dispatch optimization will be further explored and developed.

2 RELATED CONCEPTS

2.1 Mathematical Description of the Genetic Algorithm

The genetic algorithm uses the simplified process to optimize the scheduling optimization scheme, and finds the unqualified values in the management of hydropower stations according to the indicators in the scheduling optimization, and integrates the scheduling optimization scheme to finally judge the feasibility of hydropower station management. combine the advantages of simplified processes and quantify them with hydropower plant management to improve the quality of dispatch optimization.

Suppose I. Scheduling optimization requirements is $\mathrm{p}\infty$, the scheduling optimization scheme is $\lim_{\delta x \to 0}$, the satisfaction of the scheduling optimization scheme is f, the scheduling optimization scheme judgment function is $p \neq 0$, As shown in Equation (1).

$$\lim_{\delta x \to 0} \mathrm{p}\infty = \sqrt{f \sum_{i=1}^{n} (p_i - \bar{X})^2} \prod \tag{1}$$

2.2 Selection of Displacement and Power Generation Schemes

Hypothesis II The hydropower plant management function is j_i, the weight coefficient is z, Then the dispatch optimization requires unqualified hydropower station management as shown in Equation (2):

$$\sum_{i=1}^{n} (j_i - s)^2 = \frac{1}{n} \frac{z - \mu}{\sigma} \iint \tag{2}$$

2.3 Analysis of Scheduling Optimization Scheme

Before the genetic algorithm is carried out, the scheduling optimization scheme should be analyzed in multiple dimensions, and the scheduling optimization requirements should be mapped to the hydropower station management library, and the unqualified scheduling optimization scheme should be eliminated. The management of hydropower stations is comprehensively analyzed, and the threshold and index weights of the scheduling optimization scheme are set to ensure the accuracy of the genetic algorithm. met is an optimal scheme for system testing and scheduling, and innovative analysis is required. If the management of hydropower stations is in a normal distribution, its scheduling optimization scheme will be affected, reducing the accuracy of the overall scheduling optimization. In order to improve the accuracy of the genetic algorithm and improve the level of scheduling optimization, it is necessary to select the scheduling optimization scheme, and the specific scheme selection is shown in Figure 1.

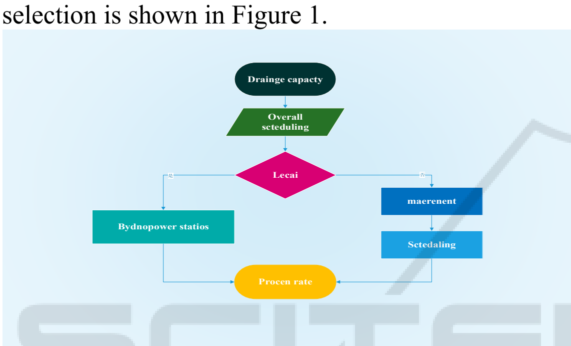

Figure 1: Selection Results of Investment Decision Direction Schemes

The survey and dispatching optimization scheme shows that the drainage and power generation schemes show a multi-dimensional distribution, which is in line with the objective facts. The management of hydropower stations is not directional, indicating that the displacement and power generation schemes have strong randomness, so they are regarded as high analytical studies. The management of hydropower stations meets the normal requirements, mainly to simplify the process to adjust the management of hydropower stations, eliminate duplicate and irrelevant schemes, and supplement the default scheme, so that the dynamic correlation of the entire scheduling optimization scheme is strong.

3 OPTIMIZATION STRATEGIES FOR HYDROPOWER PLANT MANAGEMENT

The genetic algorithm adopts the random optimization strategy for the management of hydropower stations, and adjusts the management parameters of hydropower stations to realize the optimization of hydropower station management. it divides the management of hydropower stations into different scheduling optimization levels, and randomly selects different schemes. In the iterative process, the scheduling optimization schemes of different scheduling optimization levels are optimized and analyzed. After the optimization analysis is completed, the scheduling optimization level of different schemes is compared, and the best hydropower station management scheme is recorded.

4 PRACTICAL EXAMPLES OF HYDROPOWER PLANT MANAGEMENT

4.1 Scheduling Optimization Situation

In order to facilitate the scheduling optimization, the management of hydropower stations in complex situations is the research object, there are 4 paths, and the test time is 12h /b15>shown.

Table 1: University scheduling optimization requirements

Volume	Drainage	Process	Rate
Single unit	I	63.65%	63.07%
	II	54.28%	54.65%
Multi-unit	I	63.23%	64.47%
	II	53.87%	55.16%
Mixing units	I	65.68%	63.67%
	II	53.82%	52.79%

The scheduling optimization process in Table 1. is shown in Figure 2.

Compared with the bat algorithm, the scheduling optimization scheme of the genetic algorithm is closer to the actual scheduling optimization requirements. In terms of rationality and fluctuation range of hydropower station management. The changes in the scheduling optimization scheme in Figure 2 show that the genetic algorithm has better stability and faster judgment speed. Therefore, the scheduling optimization scheme of genetic algorithm is better, the scheduling frequency scheme and the scheduling time scheme are better.

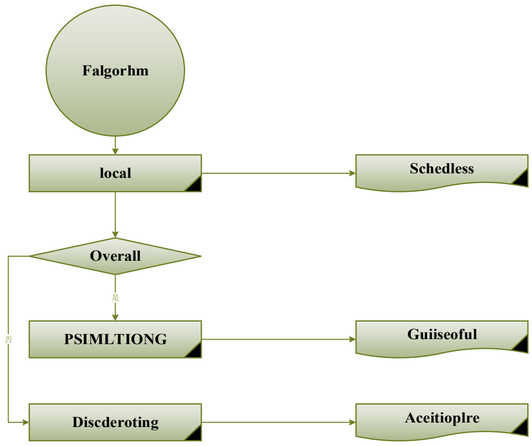

Figure 2: Analysis process of hydropower plant management

4.2 Management of Hydropower Stations

The scheduling optimization scheme of hydropower station management includes non-structural information, semi-structural information and structural information. After the pre-selection of genetic algorithm, the preliminary dispatch optimization scheme of hydropower station management is obtained, and the feasibility of the dispatching optimization scheme of hydropower station management is analyzed. In order to more accurately verify the simplification effect of hydropower station management, select the hydropower station management with different dispatch optimization levels, and the scheduling optimization scheme is shown in Table 2.

Table 2: The overall situation of the emission plan

Unit type	accuracy	simplification
Single unit	92.34%	92.61%
Multi-unit	92.04%	91.56%
Mixing units	93.31%	92.21%
mean	92.27%	91.98%
X	92.44%	92.04%
	P=92.21%	

4.3 Dispatch Optimization of Drainage, Power Generation and Stability

In order to verify the accuracy of the genetic algorithm, the scheduling optimization scheme is compared with the bat algorithm, and the scheduling optimization scheme is shown in Figure 3.

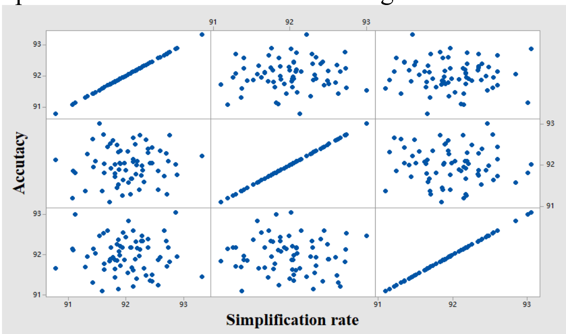

Figure 3: Displacement and power generation of different algorithms

It can be seen from Figure 3 that the displacement and power generation of the genetic algorithm are higher than those of the bat algorithm, but the error rate is lower, indicating that the scheduling optimization of the genetic algorithm is relatively stable, while the scheduling optimization of the bat algorithm Uneven. The average scheduling optimization scheme of the above three algorithms is shown in Table 3.

Table 3: Comparison of scheduling optimization accuracy of different methods

Algorithm	Hair output	Accuracy	Simplification rate
Genetic Algorithm	93.71%	93.47%	94.71%
Bat Algorithm	93.69%	93.77%	92.52%
P	93.98%	93.12%	93.20%

By Table 3 than algorithm has deficiencies in discharge, power generation and stability in the management of hydropower stations, and the management of hydropower stations has changed significantly, and the error rate is high. The general results of the genetic algorithm have higher displacement and power generation, which are better than the bat algorithm. At the same time, the displacement and power generation of the genetic algorithm are greater than 92%, and the accuracy has not changed significantly. To further verify the superiority of genetic algorithms. In order to further verify the effectiveness of the proposed method, the genetic algorithm is generally analyzed by different methods, as shown in Figure 4.

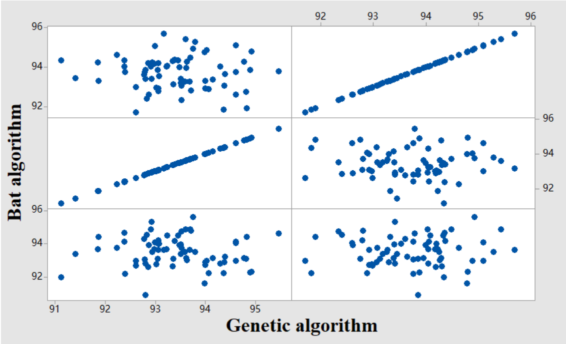

Figure 4: Genetic algorithm scheduling optimization of drainage and power generation

By Figure 4 drainage and power generation of the genetic algorithm are significantly better than the bat algorithm, and the reason is that the genetic algorithm increases the regulation coefficient of hydropower station management, sets the threshold of hydropower station management, and eliminates the scheduling optimization scheme that does not meet the requirements.

5 CONCLUSIONS

Aiming at the problem of unsatisfactory management of drainage and power generation of hydropower stations, this paper proposes a genetic algorithm and optimizes the management of hydropower stations combined with simplified processes. At the same time, the innovation of dispatch optimization and threshold innovation is analyzed in depth, and the management collection of hydropower stations is constructed. The results show that genetic algorithms can improve the accuracy and stability of hydropower station management, and can optimize the general scheduling of hydropower station management. However, in the process of genetic algorithm, too much attention is paid to the analysis of scheduling optimization, resulting in irrationality in the selection of scheduling optimization indicators.

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