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Research on Route Planning of River Water Conservancy Projects Based on the Coupling of Su Shi's Natural Aesthetic Evaluation and Genetic Algorithm

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Abstract: Su Shi's construction of his thought on the natural aesthetics of art began with his fundamental stance on nature, which led to the philosophical understanding that "anything that is observable can bring joy." Based on this, in many of his writings, he further expounded the aesthetic principle that the subject should follow when facing nature, that is, "one should not pay attention to objects." Subsequently, Su Shi gradually summarized the natural aesthetic concept of literature and art that literary and artistic creation should "follow the shape of objects" and "develop its own literary principles". The selection of points and route planning rely on the personal experience of the staff. This approach often leads to an insufficiently comprehensive coverage of the inspection, making it difficult to identify potential problems in a timely manner. To this end, by integrating Su Shi's natural aesthetic evaluation system with genetic algorithms, an aesthetic evaluation model for river water conservancy engineering facilities was constructed. The entropy weight-TOPSIS method was used to calculate the risk levels of each inspection object, which were taken as the input data of the path planning model constructed based on the genetic algorithm, and finally the optimized river inspection route was generated.

Keywords: genetic algorithm coupling; planning of river patrol routes; risk level of the inspected object; Su Shi's evaluation of natural aesthetics

1 INTRODUCTION

Su Shi was not only an outstanding eulogue of nature, but also had a unique understanding of its beauty. Constantly summarizing personal and predecessors' artistic practice experiences, in numerous poems, prefaces, inscriptions and letters, a series of exquisite and systematic artistic aesthetic viewpoints have been expounded, though scattered, profoundly. As an artistic creation depicting nature, its essence is the result of the artist's refinement, generalization and concentrated presentation of natural beauty. Nature itself is the source of natural beauty expression. Therefore, the natural aesthetic thoughts reflected in Su Shi's poetry and prose need to be grasped from his relationship with nature and his understanding of natural beauty. Just as he called himself "Zizhan loved mountains and waters", Su Shi was born in Meishan, Sichuan Province, a place with beautiful scenery, and was influenced by the natural environment from an early age. The inspection of river water conservancy engineering facilities is a key link in maintaining the safety of water conservancy operation and also one of the core contents of river management work. How to make quick judgments and decisions during on-site inspections has become an important demand for managers to enhance the inspection functions of water conservancy facilities. Therefore, the introduction of more advanced planning methods will bring significant benefits to the inspection work.

At present, in the selection of inspection points and route planning for river water conservancy facilities, it still largely relies on the experience accumulation of the staff. Such a method is prone to limit the coverage of the inspection and makes it difficult to identify hidden problems in the facilities in a timely manner. By scientifically formulating inspection routes, the coverage of facilities with potential risks and hidden dangers can be expanded, and the overall inspection efficiency can be enhanced. This route planning Problem and the Travelling Salesman Problem (TSP) [1] are research directions that have continuously received attention in computer science. The basic setting is that a salesman starts from any city and needs to travel through all cities without repetition and omission before returning to the starting point. The goal is to seek a path with the shortest total distance.

At present, there are various types of algorithms used to solve TSP (Touch Screen Panel), which can be generally divided into two major categories: exact algorithms and heuristic algorithms. Although the exact algorithm can obtain the theoretical optimal solution, its time complexity rises sharply as the problem scale expands. Therefore, using heuristic methods to solve TSP has become an important research trend at present. In the field of TSP solution, the academic community has accumulated rich achievements. For instance, some studies have reconstructed the basic TSA algorithm [2], effectively addressing the optimization challenge of permutation coding, and proposed DTSA to better cope with TSP. The DSSA algorithm proposed in reference [3] introduces a global perturbation mechanism, which demonstrates strong competitiveness and robustness when solving TSP. Reference [4] developed the FACO algorithm, which outperforms most existing ACO algorithms.

Although there are currently many mature algorithms that can obtain a better or optimal solution of TSP in a relatively short time, these methods still face challenges in terms of efficiency and solution quality, such as increased solution time consumption or being prone to falling into local optima and other predicaments. For this reason, scholars are committed to further enhancing the solution speed and result quality of existing algorithms to meet the growing demand for large-scale path planning.

2 RELATED WORK

In Chapter Three of "The Debate on 'Nature': Su Shi's Finiteness and Immortality", the perspective of discussion is no longer confined to the category of "naturally formed" in Su Shi's artistic philosophy, but instead focuses on another important dimension of his natural aesthetics - the exploration of his aesthetic approach to natural objects and their meaningful connotations [5]. The opening part of this chapter starts with Su Shi's contradictory attitude towards the peony, which is both critical and full of appreciation and love, and then deeply reflects on the intrinsic connection between natural beauty and artistic beauty. Thus, the "creation of nature" in artistic creation and the "aesthetic appreciation of natural objects themselves" jointly constitute two interrelated levels in Su Shi's natural aesthetic system. From a historical perspective, the self-awareness of natural beauty in Western aesthetics began with the Renaissance, while in China, it originated from the spiritual trend of thought full of tension and liberation consciousness during the Wei and Jin Dynasties. This chapter devotes considerable space to the discussions on the issue of natural beauty within the Western aesthetic tradition, covering the theories of natural beauty by Hegel, Kant, and Gu Bin, as well as the philosophical speculations on the "inhuman" discourse in nature by Benjamin, Leotar, and Holderlin [6]. The text emphasizes: "Once we attempt to speak of nature, it no longer exists as a pure material entity but transforms into a representation of it in language." [7] This viewpoint provides a theoretical reference for exploring Su Shi's way of appreciating natural objects. Take the image of "Jieyu Hua" in Tang poetry as an example. Traditionally, the act of flower appreciation was often transformed into an emotional dialogue between scholars and young women. However, in Su Shi's writing, this connotation underwent a change [8, 9]. Research indicates that although the Book of Songs already features the description of "the peach blossoms are in full bloom, their flowers shining brightly", using peach blossoms to symbolize young beauties, Su Shi, with the aid of Buddhist thought, deconstructed the symbolic meanings in traditional peach blossom poems, allowing the "interpretive flower" to return to its pure material nature as a flower. This approach resonates across time and space with the study of "non-human" language in modern Western aesthetics. Overall, systematic research on Su Shi's ecological philosophy in the academic circle is still scarce at present, and the degree of attention is also insufficient. However, Su Shi's ecological philosophy is not only rich in connotation and unique in features, but is also supported by a large number of ecological practices and successful cases, fully demonstrating the universal significance and practical characteristics of his thoughts. Conducting research on Su Shi's ecological philosophy can not only broaden the perspective of his philosophical exploration but also provide a beneficial supplement for the systematic construction of ancient Chinese ecological philosophy. Therefore, Su Shi's ecological philosophy is undoubtedly an academic direction with in-depth exploration value.

A Coupling Model refers to a mathematical architecture in which two or more models perform joint operations through data interaction. In early research, simulation methods were the first to connect physical models with management models. Young and Bredehoeft integrated aquifers, river systems and optimization models through this method. By generalizing physical processes into response functions, they constructed nonlinear equations and iteratively solved them [10]. Subsequent studies applied this simulation method to the analysis of water resource systems composed of multiple reservoirs and a single aquifer [11], thereby simplifying the complexity of spatio-temporal optimized water distribution problems while enhancing the accuracy of the simulation results [12]. The embedding rule is a sequential decision-making process in which a physical model is introduced into an optimization model in the form of constraints or embedded as a state transition equation in dynamic programming. For centralized parameter models that describe physical systems using simplified equations, they are usually used as physically feasible constraint embedding optimization frameworks [13]. The research in Reference [14] is a representative achievement of this approach; however, due to the large scale of the algebraic equations formed by the distributed parameter model and their expansion with the increase of time steps, it is generally difficult to directly adopt such methods. With the advancement of computer technology, scholars such as Yang Jinzhong have carried out systematic work on the embedding coupling of distributed parameter models. To achieve the integration of physical systems and optimization models, the concepts of impulse response function and convolution integral were introduced to express the response mechanism of physical systems to different management strategies [15]. The response function (also known as the algebraic technique function) was introduced into the research on the joint management of river-aquifer systems, promoting further development of this method [16]. Scholars have proposed the concept of hierarchical response function and applied it to the research of related issues such as the exploitation strategies of different groundwater management areas [17]. Another study has used the discrete integral kernel function and its convolution form to describe the response relationship of the river-aquifer system to decision variables, and has conducted field application verification in the South Platte area [18]. With the long-standing problem of delayed route planning in waterway transportation becoming increasingly prominent [19], frequent water transportation activities have led to intensified congestion in some sections, increasing the risk of vessel collisions and the overall safety hazards of transportation. With the continuous development of big data technology, digital twin technology has been gradually introduced into the water environment monitoring system. By collecting real-time data to construct a virtual mapping space, it comprehensively presents the dynamic evolution of the environmental status, thereby providing data support for path planning and safety monitoring [20]. Against this backdrop, this paper innovatively proposes an automated transportation route planning system. This system builds a waterway environment model based on digital twin technology, uses genetic algorithms and coupling algorithms to achieve intelligent route planning, and combines a visual data model to generate the optimal transportation route, with the aim of providing a safe and reliable theoretical framework for waterway transportation planning.

3 TECHNICAL ROUTE OF RIVER WATER CONSERVANCY PROJECT ROUTE PLANNING COUPLED WITH SU SHI'S NATURAL AESTHETIC EVALUATION AND GENETIC ALGORITHM

3.1 Aesthetic Pursuit of the Ecological Realm

Through the aesthetic practice of "capturing the spirit with stones", Su Shi demonstrated his full respect for the intrinsic value of natural objects, emphasizing that in the aesthetic process, one should explore and present the vitality and beauty inherent in nature itself. In the creative concept of "Body and Bamboo Integration", Su Shi takes painting bamboo as an example to illustrate that his aesthetic view is based on a profound understanding of nature, advocating the breaking of the binary opposition between the subject and the object, thereby achieving the integration and unity of people and objects in the process of aesthetics and creation. "Antu Forget" starts from Su Shi's own life practice, embodying the existence form of human beings residing in nature that he pursued. This form is not only symbiosis in an ecological sense but also harmony in an aesthetic sense. Overall, Su Shi regarded natural life as the fundamental basis of his aesthetic activities, and thus advocated for the dissolution of the subjective and object boundaries between humans and nature, integrating the self into the objects of observation, and achieving a sense of peace, freedom and joy in life through harmonious coexistence with nature. This aesthetic orientation has distinct ecological implications.

First of all, the viewpoints put forward by Su Shi mainly cover two aspects: aesthetic appreciation of nature and artistic creation. Secondly, it is advocated that in the process of appreciating natural beauty and engaging in artistic creation, one's personal thoughts and emotions should be integrated, and one's aspirations should be expressed through outdoor scenes. In Su Shi's view, natural beauty is to some extent the product of human practical activities. Only when it possesses certain social attributes can it become an object of aesthetic appreciation. Secondly, what he emphasizes is that poets should purify and refine their own emotions, get rid of utilitarian motives, and observe nature with a clear and selfless mindset, so as to discover and feel the beauty of nature more fully. It should be pointed out that Su Shi attached great importance to the function of art in life and society. He once said, "Because of the poet's meaning, he uses events to satirize, which is somewhat helpful to the country." In his creative works, not only do pieces like "Lychee Sigh" demonstrate a strong concern for reality, reflecting the hardships of the common people and criticizing the darkness of society, but even in his poems themed around mountains and waters such as "Wushan" and "Entering the Gorge", he often consciously interweaves descriptions of the poor lives and arduous labor of the lower-class people, thereby enhancing the ideological depth of his works.

3.2 Technical Route of Natural Aesthetic Evaluation

The problem of route planning for river water conservancy engineering facilities inspection is similar to the traveling salesman problem and is a typical issue in the field of combinatorial optimization. TSP can be described as a merchant starting from any city, visiting each city without repetition or omission, and finally returning to the starting point. Its goal is to find the shortest path that includes all cities. The general assumption of TSP is that the importance weight of each "city" that needs to be passed through is the same. The planning of inspection routes for river water conservancy facilities needs to take into account the risk level of the water conservancy facilities. The higher the risk level, the higher the probability that an inspection is required. Therefore, before solving the TSP, it is first necessary to accurately assess the risk level of water conservancy engineering facilities [21].

This study first determines the risk level of water conservancy engineering facilities through the entropy weight-TOPSIS (Weighted Technique for Order Preference by Similarity to an Ideal Solution) method, and then solves the optimal inspection route through the genetic coupling algorithm. The specific technical route framework is shown in Fig. 1.

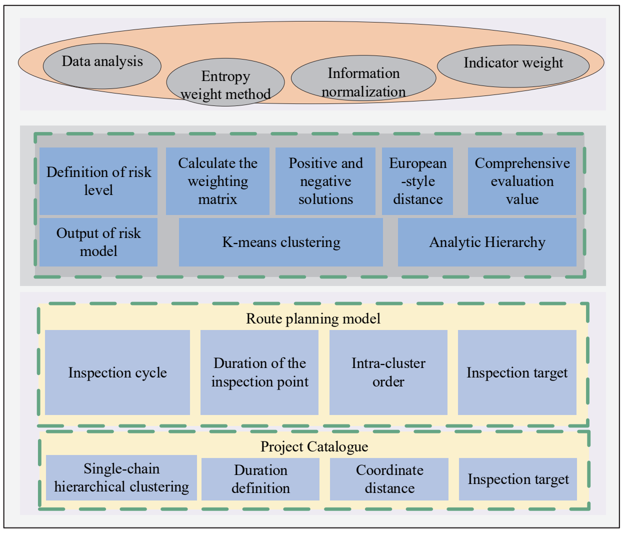

Figure 1 Framework of the technical route

4 MODEL ESTABLISHMENT
4.1 Su Shi's Evaluation Model of Natural Aesthetics

The main method of this risk assessment model for river water conservancy engineering facilities adopts the entropy weight-TOPSIS method to calculate the risk weights and the risk levels of the inspected objects. The Analytic Hierarchy Process (AHP) is used for weight adjustment and fitting to enhance the generalization application effect of the model. Further, the classification results of the risk levels of the river course and its ancillary facilities were calculated using the K-means unsupervised learning method. The Su Shi Natural Aesthetic Evaluation Model for rivers and their ancillary facilities classifies risk levels, defining them as general risk (Level 1), relatively high risk (Level 2), major risk (Level 3), and extremely high risk (Level 4). The definitions of identifiers corresponding to different risk levels are shown in Tab. 1.

Table 1 Definition of risk level identification

Risk level	Identification	Description
General Risk (Level 1	Blue (S_Blue)	The first-tier inspection objects in terms of cluster proportion
"Relatively high risk (Level 2	Yellow (S_Yellow)	The second-tier inspection objects in terms of cluster proportion
Major Risk (Level 3	Orange (S_Orange)	The third-tier inspection objects in terms of cluster proportion
Extremely high risk (Level 4)	Red (S_Red)	The fourth tier of inspection objects in terms of cluster proportion

The Su Shi Natural Aesthetics Evaluation model defines risk-related evaluation indicators based on the historical problem data discovered during the inspection of rivers and their affiliated facilities, calculates the information entropy of each evaluation indicator, determines the indicator weights, and uses the model training data with the spatial positions of river embankments, sluice gates, and pumping stations as modeling features and the risk levels of rivers and their affiliated facilities as labels. Through clustering algorithms, further calculate the risk assessment score, and finally classify the risk levels of the inspected objects through the clustering algorithm, as shown in Tab. 2.

Table 2 Features of the algorithm model and data input

Model characteristics	Data input
The number of months since the last inspection, the frequency of problems found during historical inspections, and the average number of problems found during the previous year's inspection	The number of months since the last inspection of the river course and its affiliated facilities, the frequency of problems found during historical inspections of the river course and its affiliated facilities, and the average number of problems found during the previous year's inspection of the river course and its affiliated facilities
The number of serious and above problems	The number of serious and above-level problems with rivers and their affiliated facilities
The number of more serious problems	The number of serious problems with the river course and its affiliated facilities
Number of general questions	The number of general problems with rivers and their ancillary facilities
The number of days between the number of unresolved issues within the prescribed time and the most recent unresolved issue	The number of unresolved issues of the river course and its affiliated facilities within the prescribed time limit, and the number of days between the most recent unresolved issue of the river course and its affiliated facilities
The total number of cases that have not been completed on time	The total number of overdue unfinished river courses and their affiliated facilities
The number of unprocessed items overdue by 0.5 to 1 year	The number of unfinished projects for rivers and their affiliated facilities that are overdue by 0.5 to 1 year
The number of unprocessed items that have been overdue for 1 to 2 days	The number of uncompleted cases for river channels and their affiliated facilities within 1 to 2 days after the due date
The number of uncompleted cases that have been overdue for more than two years	The number of unfinished river courses and their affiliated facilities that have been overdue for more than two days
The number of serious and above issues that have not been completed within the prescribed time limit	The number of overdue unresolved issues of serious or above problems in rivers and their affiliated facilities
The number of months since the last inspection, the frequency of problems found during historical inspections, and the average number of problems found during the previous year's inspection	The number of months since the last inspection of the river course and its affiliated facilities, the frequency of problems found during historical inspections of the river course and its affiliated facilities, and the average number of problems found during the previous year's inspection of the river course and its affiliated facilities
The number of serious and above problems	The number of serious and above-level problems with rivers and their affiliated facilities

4.2 Inspection Route Planning Model

In the process of this research, considering various factors such as the risk level of water conservancy projects, the frequency of daily inspections, the time required for a single inspection, and the distribution characteristics of engineering facilities in spatial geography comprehensively, the Genetic Algorithm (GA) was introduced to solve the planning problem of river channel inspection paths. Genetic algorithm, as a global optimization search method that simulates the natural evolution mechanism of living organisms, its theoretical basis is derived from Darwin's theory of evolution and the fundamental principles of genetics. By simulating the genetic inheritance and variation operations in nature, it gradually approaches and screens out the optimal solution through multiple generations of iterations. The specific implementation process of applying genetic algorithms in this study is as follows.

a) Population initialization. First, generate the initial population, where each individual corresponds to a possible solution to the problem. These individuals can be constructed by random generation or generated with the assistance of domain prior information. Each gene code represents a parameter value. Set the evolutionary generation counter t, with its initial value set to zero, and randomly generate an initial population $P(t)$ containing M individuals, such as x_1, x_2, x_3, etc. Representative individuals in the population $P(t)$, each individual corresponding to a candidate solution for the problem to be solved.

b) Calculation of fitness values. For each individual, a fitness function is set to evaluate its performance in the solution space, and then the fitness values of all individuals in the population $P(t)$ are calculated.

c) Individual choice. By setting a selection strategy, a portion of individuals with better performance are screened out from the current population as the parent individuals for subsequent reproductive operations.

d) Gene crossover. Two individuals are selected from the chosen parent population, and their genetic codes are cross-recombined according to certain rules to generate new individuals. Crossover strategies can adopt different methods such as single-point crossover, multi-point crossover or uniform crossover.

e) Genetic variation. To enhance population diversity and prevent the algorithm from prematurely falling into local optimum, genetic variation is implemented on new individuals generated through crossover operations. This operation usually randomly alters the numerical values or arrangement order of some genes, and through the aforementioned operation, the next generation population $P(t + 1)$ is obtained.

f) Generation of new populations. Through a series of genetic operations such as selection, crossover and mutation, a new generation of population is formed. This new population retains not only some of the superior individuals from the previous generation but also includes new individuals resulting from crossover and mutation.

g) Iterative optimization. Repeat the steps of selection, crossover, mutation and population update until the preset algorithm termination conditions are met. Common termination conditions include reaching the maximum number of iterations, obtaining a satisfactory solution, or the group fitness reaching a set threshold, etc.

h) Output the result. Output the optimal solution and its fitness value.

In this study, 1,817 rivers, 3,273 embankments, 1,177 sluices, 868 pumping stations and 298 reservoirs within the river patrol range of the river monitoring center of a certain city were taken as the patrol objects. The location distribution of water conservancy facilities within the patrol range is shown in Fig. 2.

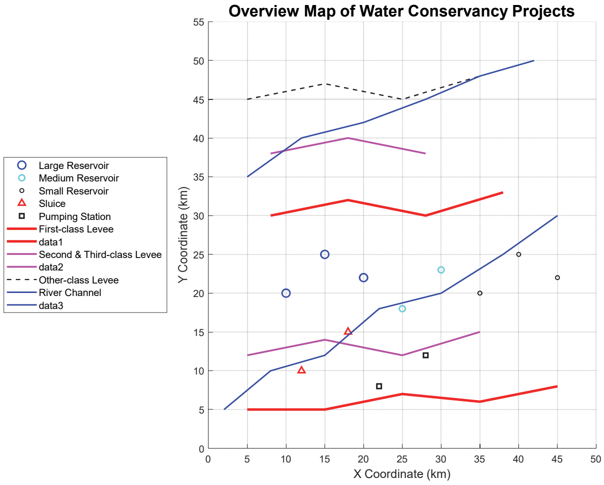

Figure 2 Location distribution of water conservancy facilities within the inspection range

Each month, 3% of the total facilities are selected for inspection, and business attribute analysis is conducted on the data of the above-mentioned water conservancy project facilities and historical problem data. Among them, business attributes are classified into four major dimensions, namely inspection records, problem and hidden danger discovery, problem rectification/completion status, and problem overdue unresolved status. Based on the four major dimensions, 13 evaluation indicators are defined. They are as follows: the number of months since the last inspection, the frequency of problems identified in historical inspections, the average number of problems identified in the previous year's inspections, the number of serious or more severe problems, the number of relatively serious problems, the number of general problems, the number of problems not resolved within the specified time, the number of days since the most recent unresolved problem, the total number of overdue unresolved problems, the number of unresolved cases with a delay of 0.5 to 1 year, the number of unresolved cases with a delay of 1 to 2 years, the number of unfinished cases, the number of unfinished cases overdue for more than 2 years, and the number of overdue unfinished cases with serious or more severe problems. The weights of each indicator are shown in Tab. 3.

In this study, the entropy weight-TOPSIS method was adopted to calculate the risk weights of the above 13 indicators for the pre-set number of four categories. Based on the obtained standardized matrix and the weights of each index, the weighted standardized matrix is calculated. By defining positive and negative ideal solutions (the positive and negative ideal solutions are the maximum and minimum values of each index in the standardized matrix respectively), the Euclidean distances between each evaluation index of the evaluation object and the positive and negative ideal solutions are calculated respectively. Based on the distance between each evaluation object and the positive and negative ideal solutions, that is, the degree of relative proximity, the comprehensive evaluation value is calculated to obtain the risk evaluation score, and then the Analytic Hierarchy Process is used for weight adjustment and fitting, thereby enhancing the generalization application effect of the model. Then, the data centers of each category are calculated through the K-means unsupervised learning method. The K-means algorithm iterates with the goal of minimizing the variance of data points within each category, that is, minimizing the distance between the data points and the center of the category they belong to, to ensure that each data point belongs to the nearest category center. The clustering results corresponding to the four categories and the ranges of their score divisions were obtained, which are respectively: 0-0.044, > 0.044-0.105, > 0.105-0.248, and above 0.248. The calculation results are shown in Tab. 4.

Table 3 Risk weights of indicators

First-level dimension	Indicator	Weight
Inspection record	It has been several months since the last inspection	0.00533
	The frequency of problems discovered during historical inspections	0.02464
	The average number of problems found during the previous year's inspection	0.05145
Discovery of potential problems	The number of serious and above problems	0.08561
	The number of more serious problems	0.05023
	Number of general questions	0.04432
	The number of days between the number of unresolved issues within the prescribed time and the most recent unresolved issue	0.14052
Problem rectification/completion status	The total number of cases that have not been completed on time	0.06424
	The number of unprocessed items overdue by 0.5 to 1 year	0.06489
	The number of unprocessed items overdue for 1 to 2 years	0.09773
Situation where problems have not been resolved within the prescribed time limit	The number of cases that have not been completed for more than 2 years due to the due date and the number of cases with serious or above issues that have not been completed due to the due date	0.09278
	The frequency of problems discovered during historical inspections	0.12847
	The average number of problems found during the previous year's inspection	0.14919

Table 4 Classification of the comprehensive risk score calculation results for various facility objects

Grade	Comprehensive score	Object	Quantity
Level 4	> 0.248	River course	18
		Water gate	2
		Pumping station	3
		River course	93
Level 3	> 0.105~0.248	Water gate	16
		Pumping station	4
		River course	643
Level 2	> 0.044~0.105	Water gate	432
		Pumping station	152
		River course	961
Level 1	0~0.044	Water gate	723
		Pumping station	711

Firstly, by combining factors such as the risk level of water conservancy projects and their geographical spatial distribution, a single-chain hierarchical clustering method is adopted to organize the inspection task package. In the research, relying on the single-chain hierarchical clustering method, the distances between each pair of inspection objects are calculated based on the longitude and latitude coordinate information of each inspection object in the input model data, and the pin-two distance matrix is obtained. The inspection object with the smallest distance in the matrix is selected to be included in the maximum and minimum time threshold judgment. Merge the inspection objects that are less than the minimum threshold to form new objects. Then, accumulate the commuting time of the two inspection objects before the merge, and take the average of the longitude and latitude of the two objects. The new inspection objects obtained will be included in the next round of the inspection package library and participate in the next round of inspection package construction. When the objects to be inspected are merged and fall within the range of the maximum and minimum threshold judgments, an inspection package will be formed. When it exceeds the maximum threshold, mark it and do not perform the merge calculation next time. Based on the already established inspection task package, route planning is carried out with the goal of finding the optimal path, identifying the shortest route to complete the inspection task at the lowest cost or in the shortest time.

When planning the inspection routes for rivers and canals, there may be some constraints, such as the inspection time window and the passage restrictions at the inspection points. Inspection points are represented as nodes in the graph, and inspection paths are represented as edges to construct a graph model. Under the given constraints, the optimal solution is achieved by finding the best combination or arrangement, and the inspection route is constructed using the genetic algorithm to output the sequential route in the inspection package. Based on the already established inspection task package, plan the inspection route and transform it into a travel agency problem to find the optimal path. In the practical application of this project, with the goal of finding the inspection route with the lowest cost or the shortest time, the genetic coupling algorithm was used to solve the above problem. For the 1,110 inspection task packages composed of 5,318 inspection points, the inspection routes were successfully planned. Some of the results are shown in Tab. 5.

Table 5 Inspection route planning results

Path	Path distance	Chinese path
[3525, 3467, 978, 440]	[0.3, 0.4, 0.0]	["Zongyi Yong Water Gate", "Zonger Yong Water Gate", "Left Bank Embankment of Miaonan Village River", "Right Bank Embankment of Miaonan Village River"]
[3121, 139, 4284, 2038]	[0.0, 0.0, 0.0]	["Zini 50-mu Sluice Station - Water Gate Project", 55-mu Right Bank Embankment of the Stream", Zini 50-mu Sluice Station - Pumping Station Project", 55-mu Left Bank Embankment of the Stream
[4682, 3818]	0.1	[Zisha Village Team 5 Pumping Station 'Bangzhu Long Gate
[2864, 3533, 3753, 1298, 281, 2560]	[1.4, 1.6, 1.1, 0.1, 1.6]	"Left Bank Embankment of Zisha Second Stream", West Gate of Zisha Second Stream, West Gate of Zisha Third Stream, Left Bank Embankment of Zisha Third Stream, Right Bank Embankment of Zisha Third Stream "Right Bank Embankment of Zisha Second Stream
[3615,3411,3966]	[0.0, 0.0]	[Old West Entrance Water Gate at the Main Dam Foot 'Middle Main Entrance Water Gate at the Main Dam Foot' East Main Entrance Water Gate at the main Dam Foot
[3074, 2713, 4217, 2440, 455, 1779, 1977, 2608, 2263]	[0.0, 1.6, 0.0, 0.0.1.4, 0.0, 0.3.0.0]	[Zhuzhou Stream Right Embankment 'Zhuzhou Stream Left Embankment ', Beishan Stream Water Gate' Beishan Stream Right Embankment ', Beishan Stream Left Embankment 'Shajiao Branch Stream Left Embankment ', Shajiao Branch Stream Right Embankment ', GuanzhouShajiao Stream Right Embankment ', GuanzhouShajiao Stream Left Embankment Gate]
[4057, 1172, 1763, 3041, 1693, 3960]	[1.4, 0.0, 1.1, 0.0, 2.0]	[a (2) the sluices ´ bamboo, ´ ´ ZhuangChong left south lane, ZhuangChong right dike ´ ´ south lane, ´ ´ rotten pile pit chung right, ´ rotten pile pit chung left, a (3) the sluices ´ bamboo ´]
[3457, 4780, 5030]	[0.3, 0.2]	[" ZhusanXiadu Drainage Station - Water Gate Project ", "ZhusanDouchi Tan Irrigation Station", "Dutou Irrigation Station"]
[3349, 496, 431, 3130, 1944, 2032]	[0.4.0.0, 4.5,0.8.0.0]	Bamboo, bamboo three or four port sluice [´ ´ ´ ´ three rows of drainage right, the left dam ´ ´ bamboo three rows of the canal, ´ Lao mining kraal head sluices ´, dike ´ ´ emerging surge right, emerging chung left dam ´ ´]
[2033, 4799, 3323, 1206]	[0.6, 0.6, 0.3]	[Left embankment of the Second Drainage Channel of ZhuliaoWeir, Drainage Station of ZhusanXiadu, Drainage Gate around the base, Right embankment of the Second Drainage Channel of Zhuliao Weir]
[3122, 1442, 4785, 1286]	[0.0, 0.0, 0.0]	[' Zhujiao Gate Station - Water Gate Project ', 'Left Embankment of Zhujiao Stream', 'Zhujiao Gate Station - Pumping Station Project', 'Right Embankment of Zhujiao Stream']
[321, 335,387,446,317,333]	[1.5, 2.0, 1.5, 2.0, 1.0]	[new surge in brake ´ ´, ´ ´ of eight sand gate, new chung sluices ´ ´ nansha area, ´ ´ sluices, people's livelihood ´ ´, a gate of the people's livelihood new chung second team brake ´ ´]

The training route planning adopts a heuristic method to generate the shortest inspection path. The self-defined parameters of the inspection personnel are initialized in accordance with the above-mentioned dynamic organization of the inspection task package process, including the daily working hours of the personnel, the traveling speed, the inspection time of a single project, and the distance calculation, that is, the longitude and latitude of each pair of water conservancy projects are converted to obtain the surface distance. Hierarchical clustering is used. Finally, output the list of task packages for the shortest inspection route. By using the genetic algorithm to solve the shortest inspection route for this problem, the shortest paths are obtained as follows: "Xinyong Inner Gate", "Xinyong Second Team Gate", "Basha Control Gate", "Xinyong Water Gate of Nansha District", "Minsheng

Water Gate", and "Minsheng First Team Gate". The path length of this shortest route is 8 kilometers. The planning result of this shortest route is shown in Fig. 3.

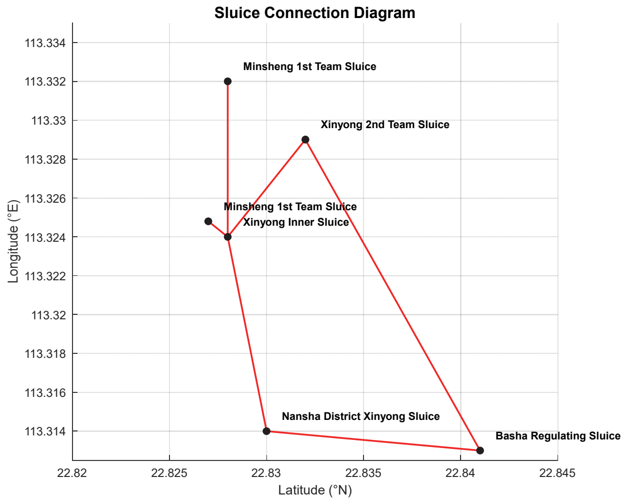

Figure 3 Results of the inspection route planning

5 SIMULATION

This section uses a coupled model to conduct a detailed analysis of two examples of the optimal layout of the final-stage river water conservancy project. Through the optimization examples, the optimization process and results are described in detail, and the feasibility of the method is analyzed. Two forms of drainage index constraints (the drainage constraint based on a single rainstorm and the constraint based on the drainage guarantee rate) are used to optimize river water conservancy projects. To facilitate the analysis of the results, the burial depth H of the drainage pipe is first fixed, and the spacing D of the drainage pipe is optimized based on a single rainstorm. Then, both the burial depth H and the spacing D are optimized simultaneously. Finally, using the long series of data, based on the constraint of the drainage guarantee rate, the optimal layout schemes of the last-level river water conservancy project at 90% and 95% guarantee rates were analyzed respectively. First, analyze the optimization scheme of river water conservancy projects with a fixed burial depth H. Let H = 90 cm. By adjusting the spacing of the last-stage drainage pipes, the investment in the last-stage river water conservancy project that meets the drainage requirements can be minimized. Substituting H = 0.9 m, we get:

$$z=\left(0.4\times 0.9\times 13.1+12\right)\times\frac{667}{D}=\frac{11149.57}{D} \tag{1}$$

In this way, the optimization of the above-mentioned river water conservancy project becomes a unary optimization problem. First, D = 20 m and H = 90 cm are selected and brought into the DRAINMOD model for trial calculation. The results are shown in Fig. 4. Since this result is the drainage process of a single rainstorm (129.5 mm), the drainage control condition must be met-the underground burial depth will reach 50 cm within 3 days. Just look at the groundwater burial depth value on June 28th. When D = 20 m and H = 90 cm, $S6.28$ = 51.98 cm.

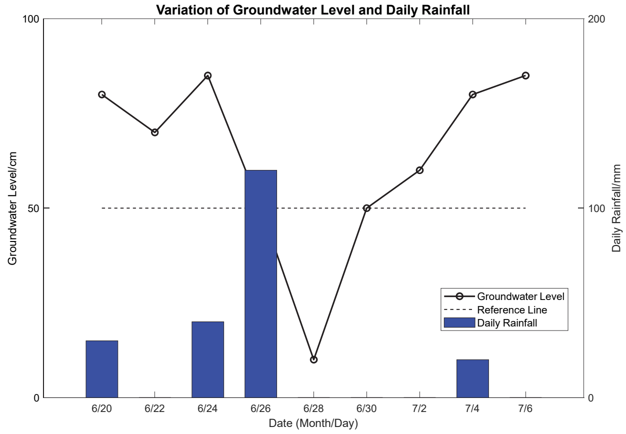

Figure 4 Variation process of groundwater burial depth with D = 20 m and H = 90 cm

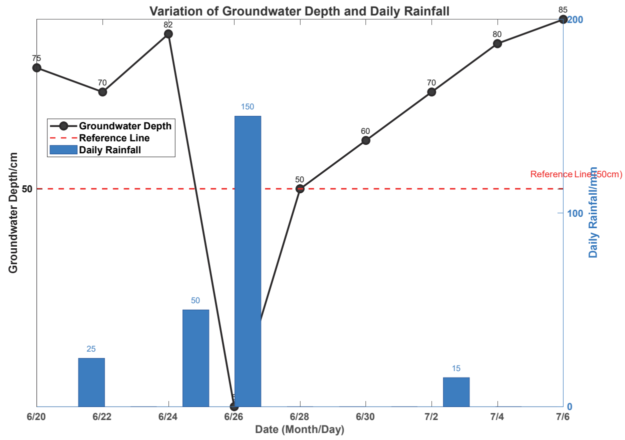

Figure 5 Variation process of groundwater burial depth, with D = 20.60 m and H = 90 cm

The groundwater burial depth value $S6.28$ is a monotonically decreasing function with respect to the drainage pipe spacing D. Therefore, the root of the equation $S6.28(D)$ = 50 cm can be found using the bisection method. After iterative solution, the optimal values obtained are D = 20.60m and $S6.28$ = 50.00 cm. Calculate the investment z for the last-level river water conservancy project of the objective function value as 541.24 yuan per mu. The drainage process of the optimal scheme with a fixed burial depth of H = 90 cm is shown in Fig. 5.

Now, let's analyze the optimization scheme of river water conservancy projects that simultaneously optimize the burial depth H and the burial spacing D. Substituting B = 0.4 m, 0.6 m and 0.7 m, p_1 = 13.1 yuan/m ^{3}, and p_2 = 12 yuan/m, we can obtain:

$$z=\begin{cases}\dfrac{3495.8\times H+804}{D}, 0<H<1.3\\ \dfrac{6116.4\times H+804}{D}, 1.3\le H\le 1.5\end{cases} \tag{2}$$

H represents the intensity of the excitation source of the magnetic field. D, in this equation, participates in the calculation as the denominator and is used for normalization or proportional conversion. To meet the drainage control conditions, the groundwater burial depth will reach 50 cm within three days. Just look at the groundwater burial depth value on June 28th. So, select H and D within a certain range to conduct a trial calculation first and observe the variation law of $S6.28$ with H and D. Through trial calculation, 62 simulated values were obtained and plotted as a contour map 6. Calculate the unit area investment of various final-level drainage system layout schemes and draw the contour map 7.

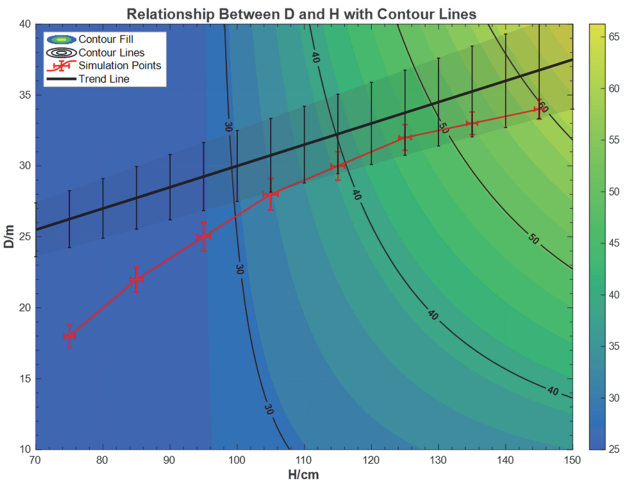

Figure 6 Contour lines of groundwater burial depth (6.28)

It can be seen from Fig. 7 that the objective function satisfying $S6.28$ = 50 cm has a minimum value when the installation depth of the drainage pipe is within the range of 100 to 120 cm. The drainage spacing D values at various burial depths at $S6.28$ = 50 cm were calculated by the bisection method, and the objective function z value was also calculated, as shown in Fig. 8. It can be seen that the objective function value is the smallest when the drainage pipe is buried at 110 cm, with z = 485.20 yuan per mu and D = 24.42 m. The drainage process of the optimal scheme is shown in Fig. 9.

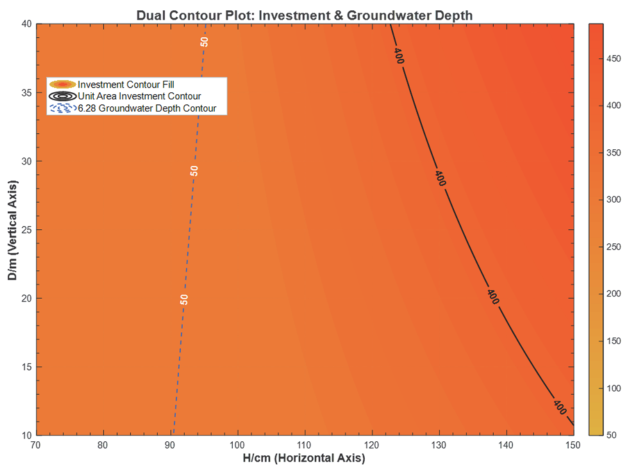

Figure 7 Contour lines of investment per unit area

The investment z obtained from the previous fixed burial depth of 90 cm is 541.24 yuan per mu. Compared with the fixed burial depth of 90 cm, the non-fixed burial depth scheme has a z of 485.20 yuan per mu, reducing the investment by 56.04 yuan per mu (10.4%). The drainage effects of the two schemes are basically the same, and both can reduce the groundwater depth to below 50 cm within three days.

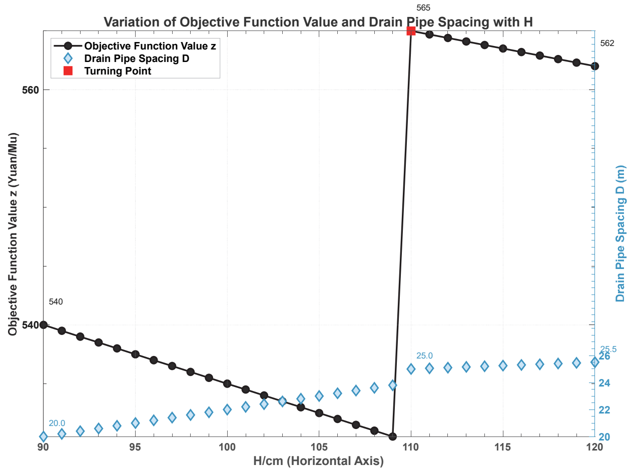

Figure 8 Spacing and investment of each drainage pipe at $S6.28$ = 50 cm

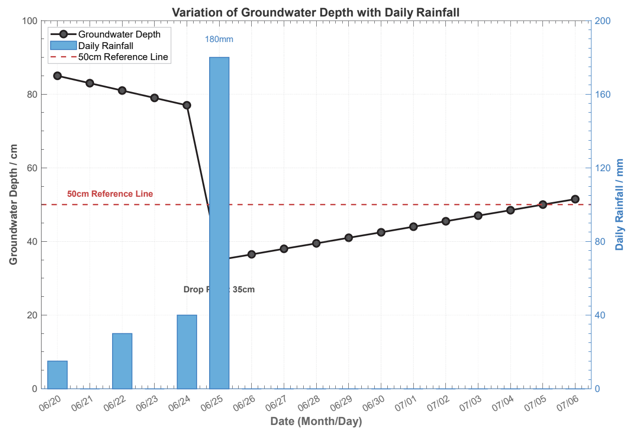

Figure 9 Variation process of groundwater burial depth, with D = 24.42 m and H = 90 cm

Using a long series of data and based on the constraint of a 95% drainage guarantee rate, the optimal layout scheme of the last-level river water conservancy project is analyzed. Based on 66 years of meteorological data, the 95% guarantee rate should be that in 62.7 years of the 66 years (63 years), the groundwater depth dropped to 50cm after three days of heavy rain. Calculate the objective function values of various drainage schemes and draw the contour map 10.

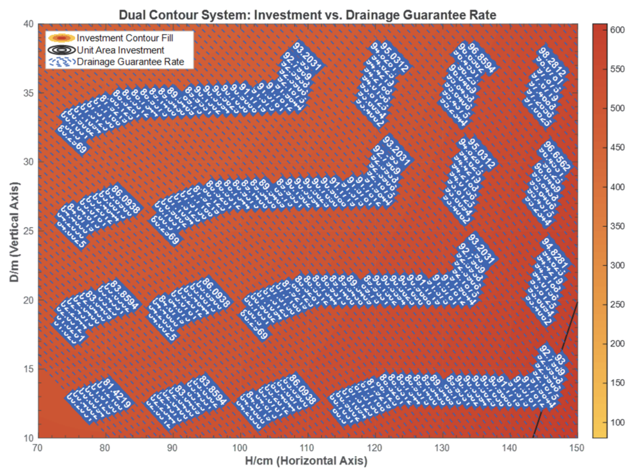

Figure 10 Contour lines of investment per unit area

When the constraint of a 95% drainage guarantee rate is met, the objective function z has a minimum value within the range of 100 cm to 120 cm when the installation depth of the drainage pipe is met. The drainage spacing *D* values at various burial depths when the drainage guarantee rate is 95% (with 63 years meeting the drainage conditions - the water burial depth drops to 50 cm three days after rainfall) are calculated by the binary method, and the objective function z value is calculated, as shown in Fig. 11.

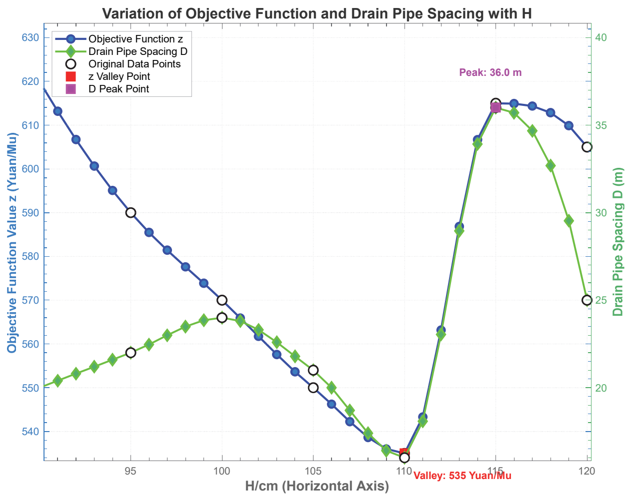

Figure 11 95% drainage guarantee rate, the variation of drainage pipe spacing and investment with the depth of burial

Within the same section of the objective function, the larger the spacing of the drainage pipes, the lower the investment in the final drainage system. However, in terms of drainage effect, the "shallow and dense" installation method is conducive to rapid drainage and the utilization of underground water resources. Designing a drainage system can enhance the water management level of farmland in flood-prone areas and reduce the losses caused by waterlogging in farmland.

6 CONCLUSION

Su Shi's experience of feeling at ease and comfortable in his natural home and returning to the aesthetic perception of nature. Moreover, the sense of home is of great significance in the aesthetic appreciation of nature. Su Shi's contemplation on natural aesthetics as a way of seclusion and accommodation undoubtedly reached a "deep level", making the sense of home in natural aesthetics not only limited to the concern for environmental protection, but also expand to the ultimate concern for the state of life on earth. Based on the method of coupling Su Shi's natural aesthetic evaluation with genetic algorithm, this paper classidivides the risks of water conservancy engineering facilities within the river patrol range of a river monitoring center in a certain city. Through single-chain hierarchical clustering, 1,110 patrol task packages were formed for 5,318 patrol points. Finally, the genetic algorithm results were used to solve the optimal patrol route. In practical applications, based on the optimal inspection route to be solved, the river monitoring center of a certain city has conducted 730 inspections in total, reported 744 problems, and 126 of them have been resolved. This has helped inspection personnel to conduct targeted inspections of high-risk areas and key issues of concern, reducing blind spots in inspections and the frequency of repeated inspections caused by the coupling of routes for different inspection objects. It has reduced the workload of the patrol personnel, which is of positive help to the reduction of burden and improvement of efficiency in the grassroots management and maintenance of rivers, and can provide new attempts and ideas for the traditional river patrol and management work. In future research, attention should also be paid to the water requirements of different plants, and in combination with factors such as terrain undulation and soil type, various aspects should be considered for the planning of irrigation routes in farmland. This will further enhance work efficiency and save the utilization of water resources.

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