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Optimization Strategy of Cultural Legacy Tourism Design Combining Virtual Reality and Genetic Algorithm

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Abstract. With the help of computer-aided technology, this study aims to create an innovative optimization strategy for cultural legacy tourism design by integrating virtual reality (VR) and genetic algorithms (GA). We use VR technology to build an immersive cultural legacy virtual environment for tourists so that they can get a near-real travel experience. Furthermore, combined with GA, the tourist route is intelligently optimized to ensure that tourists can get the best tour effect in a limited time. The experimental data demonstrates that, in comparison to traditional algorithms, the computer-aided fusion approach implemented in this investigation has notably enhanced the response speed, system stability, and recommendation precision. More specifically, our technique decreased the error by 22.55% and increased accuracy by 24.37% when compared to the RF algorithm. This study introduces novel optimization techniques for cultural heritage tourism, significantly enhancing tourist satisfaction and blazing a new trail for safeguarding and preserving cultural heritage.

Keywords: Virtual Reality; Genetic Algorithm; Cultural Legacy; Immersive Experience.
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1 INTRODUCTION

As a witness of human history and a treasure of national culture, cultural legacy bears rich historical information and cultural details. With the vigorous development of global tourism, cultural legacy tourism has gradually become an important factor in attracting tourists. It can not only satisfy people's exploration of history and culture but also inject new vitality into regional economic development. In the rural cultural tourism industry, moving from traditional two-dimensional design environments to more advanced interactive three-dimensional (3D) environments has become an inevitable trend in industry development. Compared with traditional 2D drawings, 3D models can more accurately reflect the spatial form of buildings. BIM not only presents the reality of buildings in a 3D interactive environment but also integrates all relevant information about buildings, such as size, materials, equipment, construction progress, etc. This transformation is not only driven by technological progress, but also by the unique advantages of 3D environments that can greatly improve project efficiency, quality, and user experience. Its structural details and material characteristics can help team members better understand the design intent, and reduce misunderstandings and communication barriers. Through HBIM, Baik [1] conducts three-dimensional digital modelling of heritage culture and integrates relevant information such as historical photos, material files, and restoration records into the model. Emerging technologies such as virtual reality (VR) are increasingly changing the supply and experience of the tourism industry. With the continuous evolution of VR technology, its connotation and application scope are also constantly expanding. In order to provide a systematic and structured overview, Beck et al. [2] classified various VR systems in detail and described their respective technical characteristics and application capabilities. Through virtual reality technology, tourist destinations can construct realistic virtual scenes, allowing tourists to experience the charm of the destination before travelling, thereby attracting more potential tourists. And provide a comprehensive and up-to-date review, in order to provide valuable references for researchers and practitioners both inside and outside the industry. This virtual tourism experience not only provides tourists with a more convenient and economical way of travelling but also provides rare travel opportunities for those who cannot personally reach their destination. Cenni and Vásquez [3] conducted an in-depth analysis of the attractiveness of emerging virtual reality tourism products in their research.

At present, research on the design of tourism AR mainly explores the overall impact of user experience on mobile AR products. However, there has been no further discussion on how to bridge the gap between tourists and products in response to the issue of technological fear. Therefore, the theory of accessibility will be used to explain the level of user acceptance of AR products, in order to analyze the mismatch between users and products in a tourism augmented reality product design model based on accessibility. Durko and Martens [4] conducted reliability and validity analysis and KANO model analysis on the SPSSAU platform to determine the demand attributes of demand indicators. It prioritizes design requirements based on requirement analysis. It has carried out prototype design for essential tourism comfort functions and consultation and help services. The smart tourism service platform is presented in the form of WeChat mini programs, with tourists as the centre, providing information services such as pre-travel information acquisition, product reservation and purchase, travel tour guide guidance, post-travel evaluation sharing, etc., to improve the quality of tourist experience and stimulate market consumption demand. It can assist users in providing scenic area attribute services, such as core scenic area tour guides and prototype design of personal centre functions. This study not only reveals the enormous potential of virtual reality technology in the tourism industry but also provides new ideas on how to better integrate technology with culture. From a postmodern perspective, advanced scholars have explored how virtual reality technology can provide tourists with an immersive travel experience while maintaining cultural authenticity. This concept vividly divides culture into two levels: explicit and implicit. The explicit level is like the top of a model, intuitive and easy for people to perceive and understand [5]. It reviewed the authenticity theory and its application in the tourism field and found that this theory has a certain explanatory power in explaining tourists' perception of the authenticity of tourist destinations. Drawing on the perspective of postmodernism, expand the understanding of authenticity from traditional objective authenticity to a more diverse and subjective level. With the rapid development of VR technology, tourists can experience tourism in virtual environments, which poses new challenges to traditional authenticity theories. In existing research on virtual reality tourism experiences, there is still a lack of understanding of authenticity. The respondents come from different ages, genders, and educational backgrounds, with both active participants in VR tourism experiences and potential users who hold a wait-and-see attitude towards it. The research results found that tourists can interact with other tourists or virtual characters in VR tourism experiences, and this interaction can affect their perception of authenticity. Solely relying on VR technology is insufficient to tackle all the challenges encountered in cultural heritage tourism. Additional refinement is required in the planning of cultural heritage tourism routes and exhibition techniques to enrich the tourist experience. As an optimization search algorithm, GA introduces a novel approach for refining cultural heritage tourism design.

Go, and Kang [6] proposed a comprehensive and forward-looking definition for metaverse tourism. Metaverse tourism has significant advantages in promoting sustainable tourism development. By providing alternative tourism resources and experiences, metaverse tourism can allow tourists to experience tourism experiences similar to the real world in the virtual world. Reduce the pressure of visiting real tourism destinations and protect the natural environment. Metaverse tourism can also provide tourists with a more realistic and vivid travel experience by simulating and replicating the natural environment while reducing the consumption and destruction of natural resources. It is not limited to exploring and experiencing the virtual world, but more importantly, it provides a new mode of combining virtual and reality. This new model allows tourism to no longer be limited by geographical location, time constraints, and natural environment but can be personalized according to the needs and interests of tourists. Tourists can enter the virtual world anytime and anywhere, experiencing the customs of different regions and cultures. This new way of traveling will undoubtedly greatly enrich people's travel experience. In the metaverse, tourists can visit any location and experience any culture without considering geographical limitations, which provides the possibility for unlimited expansion of tourism resources. Mo et al. [7] cleverly utilized VR (Virtual Reality) technology to create an immersive cultural heritage virtual environment for tourists. Through VR technology, tourists can cross the boundaries of time and space, as if they are in ancient historical scenes, conversing with historical figures, and experiencing the unique charm of culture. When conducting in-depth research on the spatial distribution of 5A-level scenic spots in China, we discovered some interesting phenomena. They noticed a clear positive correlation between the density of transportation highways and the distribution density of 5A-level scenic spots. Due to dense transportation routes, the central and eastern regions have a large number of 5A level scenic spots, especially in the Beijing Tianjin Hebei region, the Yangtze River Delta region, and the middle and lower reaches of the Yangtze River and Yellow River. The application of this technology ensures that tourists can enjoy the essence of various cultural heritage attractions in a limited time. Through intelligent planning of tourism routes, we aim to improve tourist satisfaction and make their travels more efficient and enjoyable. This innovative measure not only allows tourists to have a nearly real travel experience at home but also invisibly enhances their interest and understanding of cultural heritage. With the rapid development of technology, the application of new technologies in the tourism industry is undergoing a profound transformation. With the popularization of various tourism application software, traditional tour group mode tourism has gradually shifted towards intelligent tourism. Therefore, the tourism market should pay more attention to people's needs in smart tourism. In today's society, with high-quality development, people's living standards have greatly improved, and people have higher requirements for the quality of tourism travel. At present, major tourism applications still have certain limitations in tourism route planning, and most tourism service providers provide fixed tourism routes for users to choose from. At the same time, the current tourism route planning services have not taken into account the impact of weather and scenic spot congestion on the travel process. Therefore, in response to the above issues, Oncioiu and Priescu [8] studied a tourism path planning method based on dynamic programming algorithms. The research on tourism path planning is a crucial part of smart tourism, and scientifically reasonable tourism routes can bring people a more enjoyable travel experience. By analyzing the current situation of the tourism market and user demand, the path cost function between different states in the dynamic programming algorithm is defined from the dimension of distance and other influencing factors. We have optimized the dynamic programming algorithm and effectively applied it to tourism path planning scenarios, designing a tourism path planning method based on multiple factors for users. Genetic algorithm, as a heuristic search algorithm with global optimization and strong adaptability, can find the optimal solution in complex search spaces. This article elaborates on the computer-aided integration method of VR and GA, as well as their application and optimization capabilities in cultural heritage tourism design. The aim is to significantly improve the quality of cultural heritage tourism design through the integration of this cutting-edge technology.

Not only did it theoretically explore the unique value of combining VR and GA in cultural heritage tourism design, but it also demonstrated its significant advantages in practice. This strategy is not only of great significance for the promotion of cultural heritage tourism but also brings prosperity to the local economy by enhancing the visibility and attractiveness of cultural heritage. At the same time, combined with the optimization function of GA, the system can customize personalized cultural heritage displays and travel routes based on the unique needs of each tourist.

Subsequently, through meticulous experimental validations and data analyses, the article aims to offer robust theoretical backing and practical directives for the continual progress and innovation within cultural heritage tourism.

2 LITERATURE REVIEW

Obsolete or unclear signs, chaotic building layouts, and changing weather conditions are all important factors that make it difficult for people to find a destination. In recent years, more and more universities have begun to introduce virtual campus tours as an innovative solution to address this issue. Virtual campus games can be embedded on the official websites of universities or used as a standalone application. The development of virtual campus tourism applications typically relies on a collection of panoramic video clips. Whether it is the grand exterior of the administrative building, the internal layout of the academic building, or the warm atmosphere of the boarding college, all can be perfectly presented through virtual campus tours. These video clips can capture detailed scenes of various corners of the campus, and users can view the selected campus area 360 degrees without blind spots through simple operations such as sliding, zooming, or rotating [9]. Reality capture technology, as a major breakthrough in the digital age, has opened up new paths for the protection and inheritance of cultural heritage. The 3D model obtained through reality capture technology not only has extremely high realism and detail but also has broad application value. Through 3D modelling, viewers can gain a comprehensive understanding of the history, culture, and architectural style of cultural heritage sites, enhancing their perception and understanding of cultural heritage. Poux et al. [10] explored new methods for interacting with these high-quality 3D reconstructions in real-world scenes. Traditional promotional methods often rely on text and images, while 3D models obtained through reality capture technology can provide a more intuitive and vivid way of presentation. This technology can reconstruct the physical reality of cultural heritage sites with extremely high precision, bringing us unprecedented possibilities. The 3D models obtained through reality capture technology can create highly realistic virtual environments, making users feel as if they are in a cultural heritage site, experiencing its unique charm and charm.

Serbian cultural institutions, as representatives of museums and service institutions, do face multiple challenges, with the most significant being the declining public interest in cultural activities. The main dilemma currently faced is that most people, especially those responsible for cultural institution operations, have not fully recognized the potential and value of digital technology. Specifically, virtual tourism can allow young people to experience the cultural atmosphere of different regions at home, enhancing their interest and curiosity in culture. Augmented reality technology can provide tourists with an immersive cultural experience through mobile phones or head-mounted devices, making them feel like they are in a historical scene [11]. Toji et al. [12] delved into the integration and interaction between intangible cultural heritage policies and virtual reality (VR) technology, as well as how this interaction provides new perspectives and strategies for the inheritance of cultural heritage and the innovative development of the tourism industry. In terms of intelligent optimization of tourism routes, they combine genetic algorithms, using this advanced algorithm technology to ensure that tourists can fully appreciate the essence of intangible cultural heritage within a limited time. In terms of technical effectiveness, compared with the commonly used RF (Random Forest) algorithm, the technology we adopt has significant advantages in accuracy and efficiency. By analyzing the performance forms of intangible cultural heritage and the historical background behind them, it identified multiple participation points where VR technology can play a role. By introducing VR technology and intelligent optimization algorithms, we provide tourists with a brand-new cultural heritage tourism experience. This not only improves tourist satisfaction but also opens up a new path for the protection and inheritance of cultural heritage.

Tsai [13] focuses on interested tourist groups and delves into the impact of non-immersive virtual reality (VR) tourism or virtual tourism on them. After watching the VR exhibition video, participants distributed an online questionnaire to collect their feedback and experience. The research results show that virtual tourism has a significant positive impact on tourist participation, especially in terms of cognition, emotion, and cognitive image. After strict data screening and processing, we obtained 386 valid samples, which provided valuable data support for us to analyze the impact of virtual tourism on tourists deeply. Through a carefully designed experimental process, we have provided participants with AirPano 360 ° VR exhibition videos, an innovative technological means that allows them to experience a travel experience that feels as if they are physically present at home or anywhere. This enhanced cognitive and emotional experience further shapes the cognitive image of tourists towards the destination, forming a more comprehensive and in-depth understanding. The application of virtual and augmented reality technologies in the tourism field is gradually receiving widespread attention and favor, injecting new elements into the tourism experience, and making it more humane, personalized, and immersive. By wearing VR devices, tourists can immerse themselves in visiting scenic spots and historical sites around the world without the need to physically arrive at the site to experience the local customs and historical culture of the destination. Through smartphones, tourists can access information about tourist destinations anytime and anywhere, book tickets, hotels, and transportation, and even participate in interactive tourism activities. At the same time, the application of big data and AI/ML technology has brought revolutionary changes to virtual tourism. In addition, AI/ML technology can also help tourism platforms achieve automated and intelligent services, such as intelligent customer service, intelligent tour guides, etc., further enhancing the tourism experience of tourists. The interaction between these virtual tourism elements is reshaping our travel experience in an unprecedented way [14].

In the era of Tourism 4.0, with the rapid development of technology and the transformation of consumer behaviour patterns, the subjective preferences and experiences of tourists have become the core driving force for the development of scenic spots. Wang and Meng [15] took Jiangsu Province as an example and used an innovative method combining virtual reality (VR) and genetic algorithm to conduct in-depth research on the spatiotemporal characteristics of 5A-level tourist preferences. Based on the different needs and preferences of tourists, we provide personalized tourism products and services, such as customized travel routes and exclusive tour guide services, to enhance tourist satisfaction and loyalty. In the development and operation of scenic spots, attention should be paid to ecological environment protection, maintaining the natural landscape and ecological balance of the scenic spots, and providing tourists with a safe, comfortable, and healthy tourism environment. As a benchmark in China's tourism industry, 5A-level scenic spots not only represent the highest honour of world-class boutique tourism destinations but also continuously pursue excellence in humanized services and attention to detail to meet the growing psychological needs of tourists. In order to better understand and implement the iterative reconstruction process of cultural heritage protection design, the author proposes a research method that combines GA (genetic algorithm) optimization algorithm with iterative reconstruction technology. In the process of model construction, the author adopted high-precision measurement and modelling techniques to ensure the accuracy and authenticity of the model. Genetic algorithm, as an optimization search algorithm that simulates natural selection and genetic mechanisms, can find the optimal solution in complex problem spaces. This optimization process not only improves the accuracy and realism of the model but also lays a solid foundation for subsequent protection and utilization work. Zhao and Bai [16] have carefully constructed a three-dimensional tourism model of cultural heritage through iterative reconstruction techniques. Compared with traditional iterative reconstruction methods, this method places more emphasis on the practicality and manageability of the model. The author continuously improves and optimizes the model through iteration until the expected results are achieved.

3 METHODOLOGY

This section will elaborate on the methodology used in this study, especially how to combine VR technology with GA to realize the optimization of cultural legacy tourism design. With its unique immersive experience, VR technology has brought new display methods and interactive means for cultural legacy tourism. In the reproduction of cultural legacy, VR technology can reproduce the original appearance of historical buildings and monuments through high-precision 3D models and realistic scene rendering. However, the application of VR technology in cultural legacy tourism also faces some challenges. The first is the cost of technology realization. High-precision VR scene production requires a lot of manpower, material resources, and time investment. Secondly, the comfort of user experience, some users may feel dizzy and uncomfortable when using VR devices. In view of these problems, scholars are constantly making technical improvements.

As an optimization algorithm simulating natural selection and genetic mechanisms, GA has obvious advantages in solving complex optimization problems. In the design of cultural legacy tourism, GA is mainly used in the planning of tourism routes and the optimization of cultural legacy display methods. However, there are some problems in the application of GA. For example, the convergence speed and global search ability of the algorithm are greatly influenced by the parameter setting, which needs to be adjusted and optimized for specific problems. For the multi-objective optimization problem, how to balance the relationship between the objectives is also one of the challenges faced by GA.

Although VR and GA have achieved some application results in cultural legacy tourism design, there are still some shortcomings. The application scope of VR technology needs to be further expanded. At present, it is mainly focused on the display of well-known cultural legacy, while less attention is paid to some minority or endangered cultural legacy. The application of GA in optimization problems needs to be further deepened, especially in dealing with multi-objective optimization and constrained optimization problems.

Future research can be carried out from the following aspects: First, expand the application scope of VR technology and include more types of cultural legacy into the scope of VR display; Secondly, the optimization strategy of GA in cultural legacy tourism design is deeply studied to improve its convergence speed and global search ability; The third is to explore the deep integration of VR and GA to provide a more personalized and intelligent cultural legacy tourism experience.

3.1 Selection and Implementation of VR Technology

In this article, Unity3D, a mature VR technology platform on the market, is selected to build a virtual environment of cultural legacy. The platform offers a wide array of development tools and resources, enabling meticulous recreation of cultural heritage's historical characteristics and affording visitors an engaging, immersive experience. During implementation, the first step involves creating a 3D model of the cultural heritage, achieved through scanning physical objects with specialized 3D scanning equipment.

3.2 Principle and Application of GA

Furthermore, the system also integrates their basic information, such as users' personal data, detailed introduction of tourism projects, etc., which provides more comprehensive background data for the model.

By inputting this diversified information into the convolutional neural network, it aims to explore the potential deep characteristics between users and tourism services. These features may not be intuitive, but they have a profound impact on the choice of users and the quality of tourism services in practice. By digging these features deeply, we can understand users' needs more accurately and predict the service effect, thus providing users with a more personalized travel experience.

The core implementation framework of the model is shown in Figure 1. The framework clearly shows the key links such as data input, feature extraction, depth analysis and result output, and provides a systematic and visual method to deeply analyze the interaction between users and tourism services.

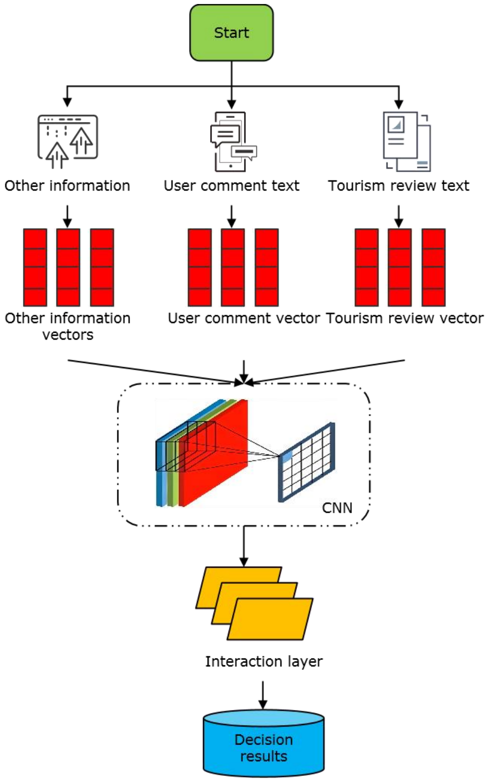

Figure 1: Implementation framework of the model.

GA, an optimization algorithm, mimics the mechanisms of natural selection and genetics. By simulating the biological evolution processes of selection, crossover, and mutation, it strives to identify the most effective solution to a given problem. In our research, we utilize GA for optimizing cultural heritage tourism routes.

We represent a tourist route as a sequence encompassing various scenic spots, with each spot equating to a gene. Initially, we randomly generate a set number of individuals, aka tourist routes, to form the starting population. To evaluate each route's suitability, we employ a fitness function. This function takes into account multiple factors, including route length, scenic spot popularity, and tourist satisfaction.

Subsequently, based on the fitness scores, we select the most promising routes, discarding the less fit ones. In the crossover phase, we randomly pair routes and swap gene segments to create new, potentially superior offspring. This mirrors the hybridization process in nature, aiming to produce stronger, more adapted routes.

The crossover operator is crucial for GA's convergence, ensuring a thorough search process. In our study, we encode GA using floating-point numbers and employ a non-uniform linear crossover method based on a predefined formula:

$$\begin{cases} x_1^{'} = r_1 x_1 + 1 - r_1 x_2 \\ x_2^{'} = r_2 x_2 + 1 - r_2 x_1 \end{cases} \tag{1}$$

Among them, $r_1 \in 0,1$,$r_2 \in 0,1$ are produced at random.

Drawing from experience, it is evident that during the entire evolutionary process, the crossover probability should progressively decrease as the number of evolutionary generations grows, finally settling at a certain value. In this study, the crossover probability is dynamically adjusted using formula (2), with its progression depicted in Figure 2.

$$P_c = \frac{1}{2+0.8\ln G} + \varphi \tag{2}$$

In this context, G represents the evolutionary algebra, while φ denoting the convergence threshold for crossover probability.

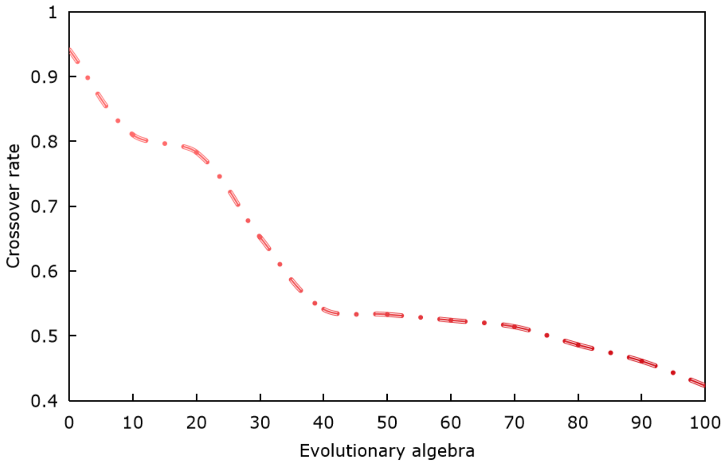

Figure 2: Crossover rate adaptation.

This refined algorithm allows the population to explore a wider range of solutions during the early phases of evolution, securing the algorithm's capacity for a comprehensive search. During the later phases of evolution, it safeguards against slow or non-convergence of the algorithm.

The objective of using GA is to identify the best parameter a_{ij}, σ_{ij} for the fuzzy membership function, ensuring that:

$$\min E = \frac{1}{2}\sum_{i=1}^{n} u - u_i^{\ \ 2} \tag{3}$$

In this context, u denotes the anticipated output, whereas u_i represents the output value generated by the Fuzzy Neural Network Controller (FNNC). The primary learning goal is to minimize E .

GA is used for offline optimization of FNNC's global parameters, followed by real-time adjustments to achieve suboptimal or optimal FNNC performance. The performance index for FNNC training is determined by summing the squared errors between the expected and actual outputs:

$$E_{BTP} = \frac{1}{2}\sum BTP_{set} - BTP\ t^{\ \ 2} \tag{4}$$

In this setting, BTP_{set} stands for the desired output, whereas $BTP\ t$ is the real output generated by the FNNC. The objective of the learning process is to adjust the FNNC weight, labelled as w_{ij} to minimize E_{BTP}.

During the mutation operation, specific genes of certain individuals undergo random modifications to augment the population's diversity. This mimics the natural process of gene mutation in biological evolution, assisting the algorithm in escaping local minima and locating the globally optimal solution. The enhanced GA process is visually represented in Figure 3.

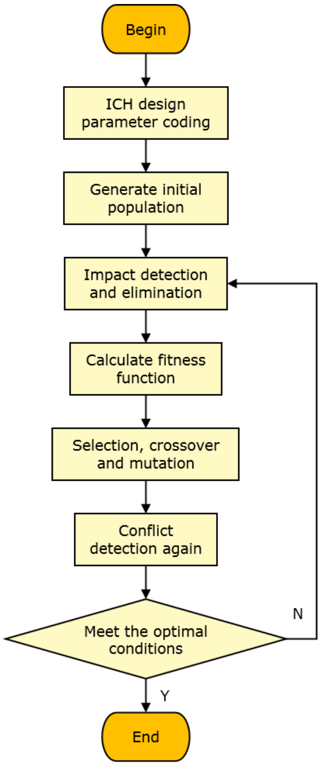

Figure 3: Improved GA process.

Mutation refers to altering one or multiple genes at specific chromosomal positions with a small probability. Akin to the crossover operator, the mutation operator serves to create new individuals. However, unlike crossover, mutation primarily functions as a supporting method in generating novel individuals, yet it remains a crucial operation for maintaining diversity within the population and ensuring GA's local search capabilities. The chosen mutation and crossover probabilities are denoted as P_m having a significant impact on GA's performance. In adaptive GA, P_m is dynamically adjusted based on the formula below:

$$P_m = \begin{cases} \dfrac{k_1\ f_{\max} - f'}{f_{\max} - f_{avg}}, & f \geq f_{avg} \\ k_2, \quad f \leq f_{avg} \end{cases} \tag{5}$$

Here, $f_{\max}$ signifies the peak fitness function value within the population, f_{avg} designates the average fitness function value of the population, $f^{'}$ identifies the greater fitness function value between the two crossover-performing individuals, and f indicates the fitness function value of the individual slated for mutation.

The population resulting from GA crossover mutation serves as the starting point for the simulated annealing algorithm, with the generated solution set functioning as its initial solution. The initial temperature is set to t_0, and the objective function value $f\ x_i$ is computed for the individual population. The current optimal solution undergoes random perturbations to produce a fresh solution $f\ x_i^{'}$. Subsequently, the objective function value of this new solution is determined, along with the increment in the objective function value:

$$\Delta f = f\ x_i^{'}\ - f\ x_i \tag{6}$$

3.3 Combination of VR and GA

In order to realize the combination of VR and GA, it is necessary to define the location and attributes of each scenic spot in the virtual environment. Then, according to the travel route generated by GA, the corresponding travel route can be dynamically generated in the virtual environment. When GA generates a new tourist route, it dynamically adjusts the tourist route in the virtual environment according to this route. In this way, tourists can visit according to the optimized route in the virtual environment.

Based on the biological evolution principle of survival of the fittest, a selection of genes from GN filter genes with high fitness are replicated from their progenitors to create descendant genes. Compute probability λ_i as follows:

$$\lambda_i = \frac{q_i}{q_{\max}} \tag{7}$$

Among them:

$$q_{\max} = \max\ q_i\ ,\ i = 1,2,\cdots,GN \tag{8}$$

The SA algorithm has a chance of accepting solutions inferior to the initial one, whereas GA typically accepts only solutions superior to the original. As a result, the SA algorithm has the potential to escape local optima and converge on the global optimum, whereas GA might result in genetic loss, potentially leading to a failed search. By adaptively adjusting the crossover and mutation rates, which fluctuate based on fitness changes during the iterative process, we can bolster GA's global search capabilities and steer clear of local optimization pitfalls. The crossover and mutation rates are denoted by P_c and P_m, respectively.

$$P_c = \begin{cases} \dfrac{k_1\ f^{'} - f_{\min}}{f_{avg} - f_{\min}} & f^{'} < f_{avg} \\ k_1 & f^{'} \geq f_{avg} \end{cases} \tag{9}$$

$$P_m = \begin{cases} \dfrac{k_2\ f^{'} - f_{\min}}{f_{avg} - f_{\min}} & f^{'} < f_{avg} \\ k_2 & f^{'} \geq f_{avg} \end{cases} \tag{10}$$

Specific crossover techniques, such as single-point or multi-point crossover, can be tailored to the unique characteristics of the problem.

Mutation Process: The newly formed individuals undergo mutation, where certain genes undergo random changes to introduce more diversity within the population. The mutation rate can be adjusted based on requirements.

Iterative Process and Termination Criteria: The fitness evaluation, selection, crossover, and mutation steps are repeated until the algorithm meets its termination criteria, such as attaining a predefined maximum iteration count or discovering a solution that meets the desired accuracy.

Result Output: The final step involves presenting the optimal solution, which corresponds to the most effective tourist route.

4 RESULT ANALYSIS AND DISCUSSION

Experiments are carried out with the image set of Massachusetts Institute of Technology, which contains 2688 colourful natural scene images. These images cover a variety of scenes, such as dense green forests, majestic mountains, rough seas and busy cities, as shown in Figure 4. The richness and diversity of this image set provide us with valuable experimental materials, which enable us to assess the effectiveness of the optimization strategy of cultural legacy tourism design integrating VR and GA more comprehensively. Through the processing and analysis of these different natural scene images, we can get a deeper understanding of the performance of the algorithm in different types of scenes, thus providing strong support for scene adaptation and optimization in practical applications.

Figure 4: Partial experimental image set.

Figure 5 shows the comparison of the response speed between the algorithm used in the optimization strategy of cultural legacy tourism design integrating VR GA and other algorithms. The algorithm presented in this article offers distinct advantages in terms of response speed. When compared to traditional algorithms like Support Vector Machines (SVM) and Random Forests (RF), our algorithm demonstrates superior speed in processing various cultural heritage datasets. This improvement is primarily attributed to the integration of VR technology's intuitive capabilities with the optimization strength of GA, allowing for more efficient cultural heritage image processing, swift generation of corresponding 3D models, and optimized tourist routes.

Firstly, obtain the crowding index of user interest attractions through external data sources, and then analyze and judge the crowding level of that attraction. Assign corresponding change values to achieve the impact of attraction congestion factors on the cost function of paths between different attractions, thereby affecting the optimization process of tourism path planning. The cost function is affected by the congestion of tourist attractions. The introduction is aimed at helping users avoid planning crowded tourist attractions into their travel routes as much as possible during the tourism path planning process, in order to improve user comfort and enhance the travel experience.

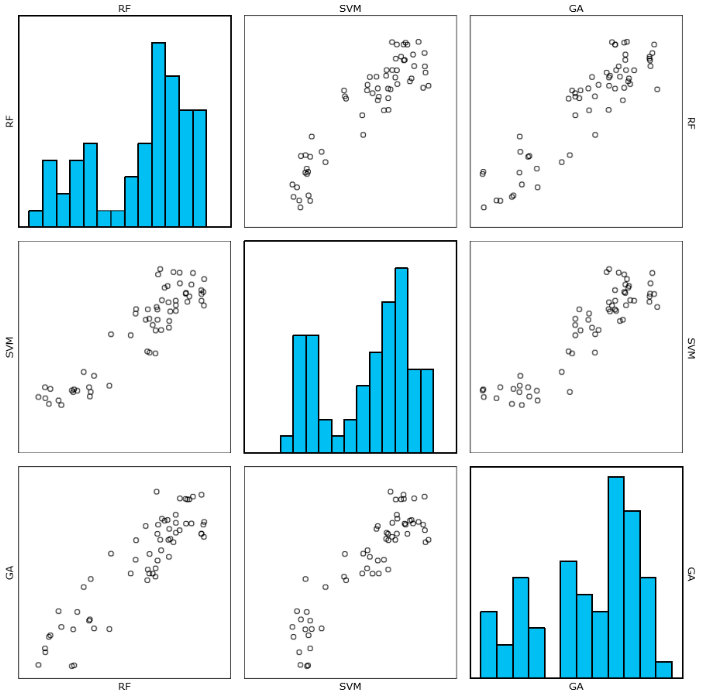

Figure 5: Comparison results of algorithm response speed.

After obtaining the crowding index of the scenic spot, the crowding index of each scenic spot can be analyzed to determine whether it is crowded. When the crowding index is between 1 and 3 levels, it indicates that the attraction is not crowded. When the crowding index is between 4 and 5 levels, it indicates that the attraction is crowded. As shown in Figure 6, our system exhibits high stability under standard conditions, indicating that our method can maintain stable performance under various conditions. Figure 7 shows the error results of different algorithms.

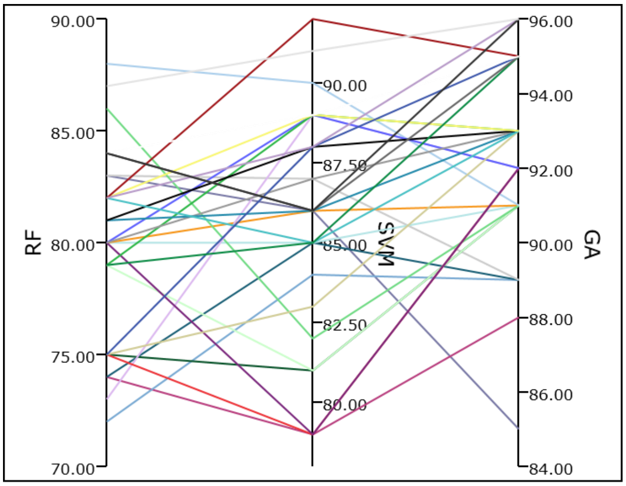

Figure 6: System stability test results.

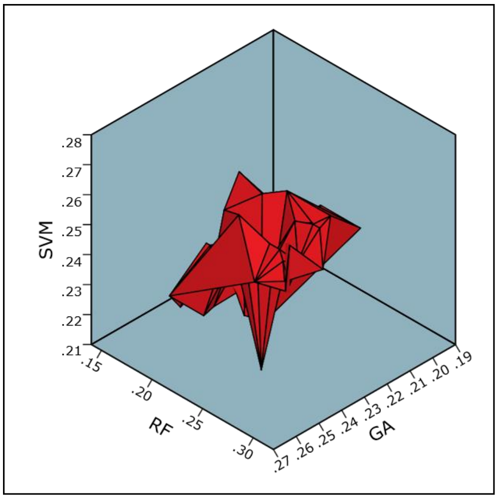

Figure 7: Errors of different algorithms.

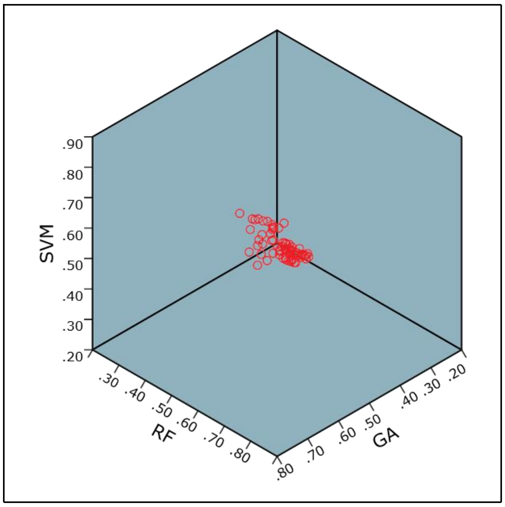

Figure 8: Accuracy of different algorithms.

Figure 8 shows the accuracy results of different algorithms. To sum up, by integrating VR and GA, this study provides an efficient optimization strategy for cultural legacy tourism design. This strategy not only improves response speed and recommendation accuracy but also provides tourists with a more personalized and immersive travel experience. In the future, we will continue to explore how to apply this strategy to more cultural legacy scenes to promote the sustainable development of cultural legacy tourism.

5 CONCLUSIONS

With the help of computer-aided technology, this study puts forward an optimization strategy of cultural legacy tourism design that integrates VR and GA, aiming at improving the quality of tourists' experience and helping the protection and inheritance of cultural legacy. The introduction of deep learning technology has successfully improved the processing speed of the algorithm for cultural legacy images and enabled VR scenes to be built more quickly, thus creating an immersive travel experience for tourists. In addition, the ingenious use of GA further refines the design of cultural legacy tourism routes to better meet the individual needs of tourists.

The experimental data reveals that the strategy outlined in this study possesses evident strengths in terms of response speed, system stability, and recommendation accuracy when juxtaposed with conventional tourism planning techniques. This approach can swiftly adapt to diverse tourist demands, offering steadfast and proficient tourism services. Additionally, through GA's optimization capabilities, the strategy can precisely recommend tourist routes tailored to individual preferences, thereby considerably enhancing tourist satisfaction.

By merging VR and GA, this research not only profoundly enhances the tourist experience but also breathes fresh life into the preservation and perpetuation of cultural heritage. As we look ahead, our research team remains committed to tapping into the full potential of this strategy, striving to make a more profound impact in the realm of cultural heritage tourism.

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