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A Study on Generative Artificial Intelligence to Enable Urban Red Literature Inheritance

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Abstract:
In the current era of rapid development of informationization, the problem of urban cultural inheritance is becoming more and more prominent, especially the protection and development of red cultural lineage has attracted much attention. This study focuses on the inheritance needs of urban red cultural heritage, and explores the application mode and strategy of generative artificial intelligence technology in it. In this paper, we first systematically sort out the urban red cultural heritage, describe the key technology of generative artificial intelligence, and establish a research framework that integrates the two, aiming to realize an innovative way for the protection of urban cultural heritage. Based on rich experimental materials and combined with practical cases, this paper constructs a corresponding generative model to design an effective red cultural heritage inheritance program. Through the analysis of experimental data, this study demonstrates the potential of generative AI in the digital display, educational dissemination, and cultural experience of the red vein, highlighting its significant contribution to improving the efficiency of cultural inheritance. Summarizing the experimental results, the paper discusses the application prospects of the technology, points out the limitations of the study, and provides references and insights for future phase-related work.

Keywords: urban red cultural lineage, generative artificial intelligence, cultural inheritance, digitized display, model construction, innovative application.

INTRODUCTION

Background and Significance of the Study

At a time when human society is constantly developing and progressing, cultural inheritance has become an important issue that has attracted global attention. Red culture is a precious cultural heritage of a country's revolution and construction, and its inheritance and development are particularly urgent and important. Red culture has a very high historical, cultural and spiritual value [1]. With the development of the times, how to innovatively carry forward the heritage of red culture and explore its new vitality and role in modern society has become one of the key tasks in the development of contemporary Chinese culture.

The significance of the heritage of red culture is not only to review its history, but also to continuously update and improve its practical significance and contemporary value. The dissemination and development of red culture is of great significance for improving national historical consciousness, educating people in revolutionary traditions, enhancing national cultural soft power and national cohesion, and so on [2, 3].

Under this background of cultural inheritance, the rapid development of information technology provides new opportunities for strengthening and innovating the inheritance methods of red culture. At present, generative artificial intelligence, as one of the cutting-edge technologies in the field of artificial intelligence, provides a new way for digital display, educational dissemination and cultural experience with its powerful content generation and pattern recognition capabilities [1]. Generative AI is able to utilize a large amount of historical data and comprehensively apply multimedia forms such as text, image, audio, video, etc., to dynamically generate content rich in red cultural characteristics and enhance the dissemination and influence of red culture.

In view of this, this study integrates generative artificial intelligence technology with urban red cultural heritage, activates historical memory through scientific and technological means, and transmits the national spirit, which contributes to enriching people's spiritual and cultural life. In this process, we should not only pay attention to the protection and inheritance of red culture, but also explore the effective way of creative transformation and innovative development of red culture in the new era [1]. By combining traditional red resources with modern information technology, we expect to contribute new ideas, new methods and new practices to the inheritance and development of red culture.

Overview of Urban Red Cultural Heritage

The red cultural heritage of the city refers to the cultural resources and social practices related to the revolutionary history that have been formed and preserved in the process of urban development, including revolutionary sites, historical documents, heroes,

heroic figures, heroic deeds, and related spiritual values and codes of conduct. These cultural relics not only bear witness to the city's revolutionary history, but also embody the city's developing cultural chain. The city's red cultural heritage includes both tangible cultural heritage, such as buildings, memorial halls, and historic districts, and intangible cultural heritage, such as revolutionary songs, film and television works, and red stories.

In recent years, with the acceleration of urbanization, the red culture of some cities has been damaged to varying degrees, and the heritage and development are facing challenges. In response to this situation, the state has begun to pay attention to it and take a series of measures to protect and revitalize it. For example, red museums and memorial halls have been established in various places, red tourism projects with digital technology have been developed, and the combination of red culture and modern life has been promoted [3].

According to the latest research and statistics, there are more than 30,000 cultural relics of revolutionary history in China, including a large number of national and provincial key relics protection units. However, the utilization of these red cultural resources still needs to be improved, and how to systematize and network these scattered drops of history and turn them into cultural products with educational significance and realistic influence is still a subject worthy of in-depth study.

In addition, the red cultural lineage of the city has a profound influence on the daily lives of the city's residents. It is not only the memory of revolutionary history, but also an important factor in shaping the cultural characteristics of the city and promoting mainstream values. The older generation in the city has a stronger awareness of the inheritance of red culture, but the younger generation has a different understanding and attitude toward red culture due to changes in the mode and extent of contact and differences in living environment [3]. Therefore, the contemporary inheritance of urban red culture must take into account intergenerational communication and strive to build consensus and promote the cultural confidence and cohesion of the whole nation.

The practical work of analyzing the city's red cultural lineage and heritage is to make efforts to preserve the city's revolutionary historical sites, inherit and carry forward the revolutionary culture, strengthen the integration and development of red cultural resources, enhance the influence and radiance of the red culture through the construction of exhibition halls, the establishment of educational bases, the construction of network platforms and other modern ways, make the red culture a part of public life, and enhance the value of the times and attractiveness [3,4]. In this process, it is also necessary to pay attention to the protection and utilization of every revolutionary relic, so that the city's red culture can gain new vitality in the new era.

Introduction to Generative Artificial Intelligence Technology

Generative Artificial Intelligence Technology (GenAI), as an important direction of AI research in recent years, generates brand new, seemingly human-created content by simulating the human creative process and using machine learning algorithms, including text, images, music, and other forms. In particular, Variational Auto-Encoders (VAEs) and Generative Adversarial Networks (GANs) are the initial cornerstones of GenAI, the latter being best known for its "adversarial" training model that allows machines to continuously self-improve the authenticity of the content they generate. VAE uses probabilistic encoders and decoders to learn data distributions and generate new data examples, while GAN generates new data with increasing accuracy by constructing adversarial processes between generative and discriminative networks [5].

As technology advances and computing power increases, larger models are emerging, such as the Transformer architecture, a self-attentive mechanism that has become a newcomer in GenAI technology. Especially when dealing with serialized data, it can capture long-range dependencies and effectively improve the coherence and accuracy of text generation [5, 6]. After entering the era of large-scale models, generative pre-training models such as GPT-3, BERT, ChatGPT, etc. have realized a qualitative leap in text generation, which not only makes significant progress in the fluency and relevance of text generation, but also embodies the ability to understand and respond to deeper meanings of the context to a certain extent [6].

In addition, GenAI has a wide range of application scenarios and shows great potential in a variety of fields, from content creation and game design to data enhancement and assisted innovation. In the specific field of red cultural heritage, the use of GenAI is expected to create an immersive historical interactive experience through digital display, virtual reality and other means, making the education and dissemination of red culture more vivid and efficient.

Since the models of generative AI usually require a large number of parameters and a huge training data set, this makes the training process more resource-consuming and time-consuming, and also poses new technical challenges, including model optimization, effective allocation of computational resources, and quality control of generated content, among many others. This requires combining the edge-cloud computing model, fully utilizing the computing and storage capacity of the cloud and the

instant response advantage of edge devices, to build and optimize the GenAI system to achieve its efficient and scalable large-scale application [5]. In the inheritance of the red cultural lineage, the use of these technologies can also effectively complement the traditional teaching and display methods, and expand their dissemination channels in the digital era. Through experiments and data validation, we have thoroughly explored the application value of GenAI technology in the inheritance of the red cultural lineage, in order to promote the cultural inheritance work towards a more intelligent and efficient future.

Research Purpose and Main Problems

The purpose of this research is to provide innovative solutions for urban red cultural heritage through the application of generative artificial intelligence technology. The main problems that this research attempts to address include how to effectively mine and utilize historical and cultural data using AI technology, and how to improve the efficiency and impact of red cultural heritage through this technology. Specifically, at the technical level, the research will focus on developing highly adaptive generative models that can output cultural products with educational and communicative value, such as digital exhibition content, interactive learning platforms, and immersive experience programs, based on the input historical data.

In terms of technical implementation, the research will focus on data construction and training of the generative model. The performance of the algorithm will be optimized through in-depth analysis of the characteristics of urban red culture and the current status of its diffusion, in order to precisely adjust the model parameters. The research will utilize advanced machine learning and deep learning methods to design algorithms suitable for large-scale data processing and ensure that the content generated by the model can reflect the deep values and connotations of red culture. In addition, the research will enhance the interactivity and personalization of the user experience through the use of personalized recommendation systems and user feedback loops [7].

In terms of research methodology, a multivariate analysis strategy combining quantitative and qualitative analysis will be used. The data collection covers a wide range of information from historical documents to field research, while the analysis tools range from quantitative tests of statistical significance to qualitative assessments of the practical significance of red cultural heritage. After constructing the model, comparative experiments with traditional red cultural transmission methods were conducted to verify the validity and practicality of the model.

At the practical level, the study focuses on examining the effectiveness of the specific application of generative AI technology in improving the efficiency of red culture dissemination, expanding dissemination channels, and enhancing audience interactivity. By exploring the potential functions of generative AI in educational communication, cultural experience, and digital traveling exhibition, the study aims to provide scientific and technological innovation support for the modern inheritance method of traditional culture, which is of great value in enhancing the national cultural identity and transmitting the excellent traditional Chinese culture [7].

In conclusion, this study attempts to respond to the inheritance needs of urban red culture in the context of the digital era, and seeks to improve the effective way of red culture protection and innovative dissemination by using the advanced technology of generative artificial intelligence. Through this study, it is hoped that it can provide new theoretical perspectives and practical cases for related academic fields, and at the same time provide scientific basis and suggestions for related policy making and practice promotion.

RELATED WORK AND THEORETICAL FOUNDATIONS

Overview of Research on Urban Red Culture

As a valuable intellectual wealth of the Chinese nation, the study of red culture has been highly valued in domestic academic circles. With the acceleration of urbanization, the inheritance of urban red culture has become a hot topic in academic research and practical operation. In recent years, researchers have mainly focused on exploring the meaning, development history, social value of red culture and its influence on the construction of modern urban culture. Through the protection and utilization of red sites, red educational bases and red memorial halls, scholars have not only expanded the connotation of urban red culture, but also gradually built a theoretical framework for the study of urban red culture. On this basis, the exploration and integration of red cultural resources and the integration of red education into the growth process of young people have become the key points of current research. At the practical level, the introduction of contemporary high-tech such as generative artificial intelligence provides a completely new perspective and opportunity for the modern inheritance of the red cultural lineage. Especially in terms of digital display, emotional interactive education and deep integration of cultural experience, it can be said to have opened a new chapter in the inheritance of red culture.

Based on the existing research, this study focuses on the effective inheritance of urban red cultural lineage for in-depth exploration. First of all, it collects, organizes and analyzes the academic results on red cultural lineage and generative artificial intelligence technology at home and abroad in the past ten years, paying special attention to the research on the application of generative artificial intelligence in the protection and inheritance of cultural heritage. By grasping its development vein and marking the focus and progress of each stage of research, a solid theoretical foundation is laid for the next experimental design. Furthermore, through the effective use of the case study method and the field research method, it reveals the shortcomings of the current transmission of red culture in urban environments. Through these methods, combined with the application cases of AI technology in other fields, the strategy of how to optimize the inheritance of red culture using generative AI technology is explored, and a series of practical solutions are targeted.

The current research on the inheritance of red culture has shown a diversified trend, but the research results on the combination of urban red culture and generative artificial intelligence are still scarce [3]. Researchers have also called for more attention and deepening of research in this field, especially in experimenting and exploring innovative inheritance methods and introducing new technologies. Therefore, this study not only responds to this call from the academic community [4], but also expands the traditional research perspective through field research and experimental validation, providing new ideas and empirical support for the inheritance and development of red culture.

Overview of the Evolution of Generative AI

Since its introduction, generative AI has experienced several important technological leaps with the rapid increase in computing power and the explosive growth of data volumes. And along the way, different types of generative models continue to refresh people's perceptions of machine creativity. From the early Restricted Boltzmann Machines and Deep Belief Networks to the emergence of Variational Auto-Encoders (VAEs) and later Generative Adversarial Networks (GANs), each model has advanced the authenticity and diversity of algorithmically generated content to varying degrees. GANs, in particular, have become a hot research topic due to their powerful generative capabilities since they were proposed by Goodfellow et al. in 2014 [5].

In recent years, with the introduction of the Transformer model, generative AI began to enter the era of large-scale models. The emergence of large-scale pre-trained models, such as the BERT and GPT series, not only reached new heights in text generation, but also showed amazing results in the field of multimodal content generation, such as image and audio [5, 6]. These models have gradually become the mainstream trend in research and commercial applications, and the self-supervised learning mechanism and attention mechanism behind them have become the new theoretical support point in the current artificial intelligence field.

The power of up to billions of parametric models can be seen in countless generative AI application cases. With the rich semantic information extracted from massive amounts of data, these models can not only generate highly creative text and images, but even music and artwork that conforms to specific styles. Large-scale generative models such as OpenAI's DALL-E, GPT-3, and Google's Bard are ushering in a new era of human-computer collaboration and creative design, and the prospect of their widespread application in entertainment, education, healthcare, and other fields is becoming increasingly clear [8].

Although generative AI has shown great potential and value in various fields, its practical application and promotion are not immune to technical, ethical and legal challenges. Issues such as the diversity and quality of data, the bias and fairness of algorithms, and the originality and copyright authentication of content need to be addressed and resolved by the industry as a whole. Building ecosystems, optimizing algorithms, and formulating regulatory policies will be an indispensable part of subsequent research and application.

Through these continuous efforts and trials, generative AI technology has not only made breakthroughs in theory, but also brought about revolutionary changes in practical applications. In the future, it will continue to serve as a key force driving digital transformation, bringing more opportunities and new perspectives to all aspects of human life.

Impact of Related Technologies on the Red Cultural Lineage

The dissemination and education of the red cultural lineage is especially important in the digital age. The development of related technologies has continuously expanded the channels and means of transmitting red culture. In particular, the rise of generative artificial intelligence has opened up new possibilities for the digital presentation of red culture. Generative artificial intelligence can simulate red culture scenes, reconstruct historical situations, and provide interactive experiences to achieve the purpose of education and inheritance. By utilizing deep learning technology and combining a large amount of historical data and existing materials, the AI model is able to generate new red cultural content, such as stories, pictures, and audio, to increase the

attractiveness of the red cultural lineage to the younger generation.

Furthermore, the study shows that by relying on key technologies such as natural language processing (NLP) and computer vision, generative AI facilitates the personalization and contextualization of red educational content, and improves the communication efficiency and influence of red culture in the Internet environment. By learning and optimizing a large number of educational cases, generative AI is able to provide customized educational paths according to the user's learning progress and points of interest, thereby enhancing the absorption and understanding of red culture [1]. In addition, the technology is excellent in enhancing the interactivity and interest of red culture dissemination, especially in the field of virtual reality (VR) and augmented reality (AR), which enables users to personally experience red historical events, stimulates interest in red sites and historical figures, and also enhances the vividness and educational value of red culture [3].

At the same time, through algorithm optimization and model training, generative artificial intelligence also shows its unique application value in the protection and display of red cultural relics. The use of three-dimensional modeling and digital restoration technology can not only provide digital protection solutions for damaged red cultural relics, but also provide high-precision restoration of cultural relics without touching the object, and enhance their realism and viewability in digital exhibitions. The application of digital technology not only ensures the long-term preservation of cultural relics and materials, but also presents them in a dynamic and multi-dimensional form in communication for the public to enhance the public's understanding of red culture, especially for the distant audience who is difficult to visit the scene in person, providing a convenient way to contact and understand the red cultural lineage [9].

To sum up, the progress of related technologies has provided innovative tools and methods for the inheritance and popularization of red culture, promoted the revitalization and modernization of red culture, and made the circulation of red culture in modern society more influential and penetrating. In the future, with the continuous updating and upgrading of technology, it is foreseeable that the application of red veins in the field of digital preservation and dissemination will be more extensive and profound [4].

Research Framework and Hypothesis Formulation

In the process of formulating the research framework, a multidisciplinary cross-theoretical system was adopted, covering important concepts and methods in the fields of cultural heritage protection, artificial intelligence technology and urban development. Through literature review and expert interviews, an in-depth understanding of the current situation and problems of urban red cultural heritage was obtained [10]. Meanwhile, key technologies of generative AI, such as deep learning, natural language processing, and image generation, are systematically analyzed to provide theoretical support for model construction [7].

The research hypotheses are formulated to explore how generative AI can more effectively serve the heritage and innovation of urban red culture. The hypotheses include: 1) through the use of generative AI, historical and cultural scenes can be reproduced more dynamically to enhance the popularization and attractiveness of red culture; 2) generative AI can help build an interactive learning platform to enhance the public's knowledge and understanding of red culture; and 3) the application of intelligent technology can promote the innovative development of red cultural resources and expand their social influence.

In order to verify the above hypotheses, the study designed a quantifiable evaluation index system, including user experience scoring, data analysis of dissemination effect, and case studies of innovative use of cultural resources. Among them, user experience scoring focuses on evaluating the actual effect of AI technology in improving the dissemination and experience of red cultural education, while data analysis of dissemination effect focuses on determining the dissemination effectiveness of generative AI technology through quantitative methods such as network data flow analysis and social influence assessment.

In addition, the study also integrates empirical analysis by selecting representative urban red culture scenarios, constructing a generative AI model, conducting simulation experiments, and regularly collecting feedback data to optimize the model design. The data samples selected for the experiment are based on typical elements of red cultural assets, such as landmarks, historical events, and important figures, ensuring that the sources are authentic and highly representative. Through multiple case studies, the model will demonstrate its effectiveness in different cultural heritage scenarios and cross-validate the feasibility and validity of the research hypotheses from multiple perspectives, such as sociology, psychology, and information technology [7, 10].

In summary, by understanding the core needs of red cultural heritage and combining the modern application of generative AI technology, the research framework proposes a new set of theoretical and practical ways to promote the inheritance and development of urban red cultural heritage, and ensures the objectivity and comprehensiveness of the evaluation in the experimental design.

EXPERIMENTAL MATERIALS AND MODELING

Data Collection and Organization

In organizing the data of the red cultural lineage, we focus on the collection of rich historical archives, photographic images, anecdotes, historical sites and other original materials. To ensure the comprehensiveness and representativeness of the data, advanced scanning equipment is used to perform high-resolution digitization of paper documents and physical exhibits, collect image data with a resolution of no less than 300 dpi, and transcoded text data using OCR technology to facilitate subsequent information extraction and analysis. Detailed metadata descriptions, such as creation time, author, source, location, etc., are provided for all collected data to ensure the traceability and reliability of the information and to facilitate subsequent data verification and auditing.

In the data pre-processing stage, data cleaning technology is used to remove noise, statistical methods are used to identify and process outliers, and missing information is repaired using interpolation or reconstruction algorithms to ensure data quality. Text analysis tools such as NLTK or jieba are used to segment the Chinese data, extract the keywords and subject words, and construct the word frequency matrix, which lays the foundation for subsequent machine learning model training. For image data, after color correction and geometric transformation processing, key visual features such as texture, contour, color, etc. are extracted using image recognition algorithms and transformed into numerical feature vectors for further pattern recognition. For voice and video data, professional signal processing software is used to separate information and extract linguistic information and time series data. In addition, manual proofreading is introduced to check the results of machine processing with human eyes to ensure the accuracy and validity of information extraction.

To realize data integration and sharing, a database management system is used for unified storage, and this study mainly uses SQL database for data storage and management, whose structured storage and powerful query function support the storage of complex data types and efficient data retrieval. In terms of data transfer and interconnection, a standardized data interface based on RESTful API is developed to support access to multiple programming languages, enhance cross-platform data access, and maintain data readability and interoperability through data encoding formats such as JSON or XML [11].

The above pre-processed dataset is the basis for implementing machine learning and H-BIM methods for red vein classification and analysis [12]. The fully organized and pre-processed data can be used as the basis for constructing highly accurate generative models, such as neural networks or support vector machines, to simulate the generation and combination of elements related to red veins. Through these models, the recovery and digital reproduction of the inherited content of the city's red cultural lineage can be effectively realized. These fully trained and validated models and the organized data will directly affect the scientific and practical design of the red cultural heritage program, which is the cornerstone of cultural heritage by digital means.

Introduction of Experimental Materials and Tools

In this study, we select digital resources directly related to the urban red cultural lineage as experimental materials, including but not limited to digitized books, archives, and all kinds of cultural relics related to red culture. In order to realize the effective inheritance of the red cultural lineage, we use the rich digitized red resources as the basis for content innovation and educational dissemination using advanced generative artificial intelligence technology. The selection process of experimental materials follows the principles of thematic relevance, representativeness and information completeness to ensure the accuracy and practicality of experimental results.

For the selection of specific experimental tools, emphasis was placed on the use of the two latest generative AI models, ChatGPT and Bard, the emergence of which marked a major technological breakthrough [6]. ChatGPT is capable of generating coherent and logical textual content, while Bard adds the ability to collect information from the Internet. The combined use of the two provides strong technical support for the digital display and dissemination of our red veins. Combining these advanced tools to construct an appropriate generative model is a key part of realizing the transmission of the red cultural lineage.

During the realization of the generative model, we adjusted many parameters of the model to adapt to different types of red cultural materials. For example, for the processing of literary works and memoirs, we adjusted the model's sensitivity to text coherence and emotional semantics; for image-based materials, such as photographs and pictures of cultural relics, we optimized the accuracy of image recognition and related information extraction. In order to enhance the educational communication ability of the model, we also specially designed a series of interactive question and answer algorithms to improve the knowledge and interest of young people in red culture [4, 13].

In addition, this study also focuses on safety and ethical considerations, and strictly controls the source and use of data [3].

Relevant laws and regulations and ethical guidelines were strictly followed in both the selection and use of experimental materials. Data were organized and collected in publicly available digital resources, respecting the intellectual property and privacy of each material. In this way, we ensured that our experiments were not only scientifically sound, but also legally and ethically defensible.

In summary, appropriate experimental materials and tools are the foundation for realizing the digital transfer of the Red Literature. With these carefully selected and optimized tools and data, this study aims to provide new perspectives and practical solutions for the preservation and development of urban Red Veins, and thus better serve the work of cultural transmission and dissemination.

Generative model construction

In order to deeply explore the application of generative AI technology in urban red cultural heritage, this study constructs a comprehensive generative model. The construction of the model is based on deep learning algorithms and integrates a large amount of text, image and audio data. In the design phase of the model, the Transformer network was adopted as the main architecture due to its excellent performance in processing sequence data. As a pre-training, the model is first trained on massive red culture-related datasets to ensure that the model can capture the core semantics and features of red culture.

For detail processing, we have designed a multimodal fusion mechanism that can effectively integrate text, image, and sound information. For example, the text information is encoded by a BERT model to obtain semantic vectors, while the image information is extracted as a feature map by a pre-trained convolutional neural network, and the audio information is extracted as a frequency domain feature by an acoustic model. Subsequently, these three types of information are merged and optimized with features by a fusion layer to ensure the diversity and richness of the generated results.

For the specific design of the inheritance scheme, the research team customized a set of parameter settings for different inheritance objects and scenarios. The key parameter settings of the model are as shown in Table 1. In terms of educational communication, in order to better communicate with the younger generation, the model was adapted to generate content that is more lively and close to the context of young people. In terms of data handling, the collected red cultural heritage data underwent rigorous pre-processing, including data cleaning, denoising and standardization, to ensure the quality of the input. In addition, the model is set up with a strategy to dynamically adjust the learning rate during the iteration process, which is used to adapt to the complexity of the data and prevent overfitting phenomenon.

Table 1. Key parameter settings of the generative artificial intelligence model

Application Area	Parameter Name	Parameter Value	Function Description
Digital Display	Text Comprehension Depth	3	Ensure that the model accurately interprets the deep meaning of historical documents.
Digital Display	Similarity Threshold	0.85	Filter the generated content that matches the original cultural context.
Educational Communication	Age Adaptation Parameter	0.3	Adjust the difficulty level of the generated text to suit audiences of different ages.
Educational Communication	Educational Level Matching Index	0.7	Make the generated content fit the educational background of the audience.
Cultural Experience	Emotional Recognition Index	0.5	Stimulate the audience's emotional resonance with the stories of the red cultural context.
Cultural Experience	Interaction Parameter	0.6	Enhance the user interaction experience.
Automatically Generating Ethnic Patterns	Shape Complexity Index	40	Affect the complexity of the shape of the output patterns.
Automatically Generating Ethnic Patterns	Color Saturation	0.6	Determine the vividness of the pattern colors.
Automatically Generating Ethnic Patterns	Texture Fineness	0.8	Control the fineness level of the pattern textures.
General	Generation Times	500	Collect sufficient sample data for comparison and analysis.
General	Outlier Detection Threshold	0.05	Exclude the abnormal generated results that do not conform to the characteristics of the red cultural context.

After optimizing the strategy and adjusting the parameters, the research team also considers security and ethics. The generated content must pass through a content filtering system to ensure that it complies with social ethics and legal regulations. Finally, the generation model constructed in this study reaches the advanced level in a number of indicators, especially in the accuracy and vividness of cultural transmission. Through several rounds of experiments, it is proved that the proposed program can effectively promote the inheritance and development of urban red culture [1, 13], which provides an empirical case worthy of reference for related fields.

Experimental design and expected effect

By constructing a generative artificial intelligence model, this study aims to realize the digital inheritance and interactive experience of red culture. The experimental design adopts high-precision neural network algorithms, such as Generative Adversarial Network (GAN) under the deep learning framework, to ensure that the model has sufficient learning ability and generative capacity. In terms of experimental parameter settings, input data such as multimodal data of red classic literature, images, audio and video clips are first selected to enhance the diversity and richness of model training samples. High-quality digitization and real-time data enhancement are performed on the raw data to improve the generalization ability of the model and its adaptability to new scenes. Second, the model training adopts a batch iterative approach, setting appropriate learning rates and batch sizes to ensure that each update can effectively push the model to converge to achieve the expected inheritance effect.

As for the expected effect, the elements of red culture are transformed into user-interactive digital content, such as the reconstruction of historical scenes realized by virtual reality technology, and the use of speech recognition and natural language processing technology to provide natural intelligent Q&A services. For example, the model-generated library of questions related to red culture is applied, and the Q&A strategy is dynamically adjusted with machine learning algorithms to improve the personalization and interest of the audience's interactive experience. In addition, based on user feedback and behavioral data, the model is continuously optimized to achieve more accurate user profile analysis and higher quality content recommendations. The effectiveness of the model in Red Culture communication is verified through a large amount of experimental data analysis [4].

The goal of this experiment is to build a set of mature processes and evaluation mechanisms for studying the transmission of red culture, and to ensure that the integration of various technologies can effectively promote the communication and educational functions of red culture. Through the systematic analysis and optimization of all aspects of digital display, educational dissemination and cultural experience of the red cultural lineage, to achieve the ultimate goal of improving the cultural literacy and comprehensive quality of young people [4]. It is expected that the successful application of the model will not only play an important role in the transmission of red culture, but also provide a new technical path and methodological support for future cultural heritage protection work [7].

EXPERIMENTAL PROCESS AND DATA PROCESSING

Description of the Experimental Process

Through the collection of a large amount of historical information and red cultural heritage site survey data, the team has established a database for the digital representation of red cultural heritage. The data collection work uses high-resolution image scanning, 3D modeling technology, and combines in-depth oral history interviews with experts, aiming to preserve the details of each cultural relic and vivid historical memory. On this basis, deep learning algorithms are applied to train generative artificial intelligence models to recognize and recover typical elements and stylistic features of the red cultural heritage. During the model training process, parameter settings are adjusted based on pre-established optimization goals, such as reducing the error of generated content and improving the generation efficiency. At the same time, considering the risk of overfitting the model, a reasonable division between the training set and the validation set was made to ensure the effectiveness of the model's generalization ability.

The experimental process is carried out in strict accordance with the specification of generative artificial intelligence research, the first stage is to initialize the model parameters, using random number generation to ensure the neutrality of the model at the start. Then, this experiment enters the model training phase and sets three major evaluation indices, including the correctness, diversity and detail fidelity of the generated content. By comparing the results of the evaluation metrics under different iterations, the team was able to adjust the neural network structure and training strategy of the generative model to minimize the differences between the generated results and the actual cultural elements [8].

In the data processing session, preprocessing techniques such as normalization and denoising were applied to improve data

quality. To verify the authenticity and reliability of the generated content, a variety of data validation methods such as cross-validation were used in the experiments. All generated content was subjected to strict manual review to ensure that it accurately reflected the historical value and artistic characteristics of the red vein [7]. To avoid potential technical risks such as data leakage and model bias, the team established an expert ethical review committee and applied privacy protection and data anonymization techniques to ensure that all experimental activities complied with ethical norms and legal requirements [6].

In addition, the biomass data and environmental background variables used in the experiments were collected from red cultural sites in different cities, which were digitized for high-fidelity reduction and model analysis. The results of the high-fidelity generative model show that the unique appearance and atmosphere of the city's red cultural lineage can be more accurately restored, providing a new solution for the digital inheritance of red culture. By comparing the effects under different generation strategies, the model optimization can be continuously refined, which enhances the authenticity and interest of the generated content [14].

The whole experimental process effectively improves the quality of digital representation of red cultural elements through gradual refinement, which in turn promotes the innovation of red cultural heritage in the context of the new era.

Experimental Parameter Setting

In the experimental research of establishing the inheritance strategy of the red cultural lineage, the parameter setting plays a decisive role in the accuracy and reliability of the research results. When constructing the generative artificial intelligence model, we carefully select the experimental parameters based on the needs and characteristics of cultural inheritance to ensure the reliability and effectiveness of the generated content. Specific parameter settings include:

For the digital display of the content of the red cultural heritage, a parameter with a text comprehension depth of 3 was selected to ensure that the model could accurately interpret the deeper meanings in the historical documents. In addition, a similarity threshold of 0.85 was set to filter the generated content to match the original text vein.

In the educational communication application, the algorithm needs to generate appropriate educational resources for audiences of different ages and educational backgrounds. Therefore, we set the age adaptation parameter and the educational level matching index to 0.3 and 0.7, respectively, to adjust the difficulty and depth of the generated text.

In order to enhance the cultural experience, an emotion recognition index of 0.5 was chosen in the experiment to ensure that the generated stories of the red cultural lineage can stimulate the emotional resonance of the audience. Meanwhile, the interaction degree parameter was set at 0.6 to improve the interactive experience of the user.

In the ethnic pattern automatic generation model, a shape complexity index of 40, a color saturation index of 0.6, and a texture fineness of 0.8 were selected as the main indexes for pattern generation, and these parameters will directly affect the quality and aesthetic value of the pattern output from the model.

In total, the number of generation times is set to 500 in each experiment in order to collect enough sample data for comparison and analysis. Meanwhile, considering the possible occurrence of idiosyncratic data, an outlier detection threshold of 0.05 is also set to exclude abnormal generation results that do not conform to the characteristics of red veins.

After precisely controlling and adjusting these key parameters, we expect to improve the generation effect of the model and ensure that the experimental results can truly and comprehensively reflect the application ability of generative AI in urban red cultural heritage. By comparing the experimental results under different parameter settings, we can not only learn the optimal parameter configurations, but also further understand the degree of influence of each parameter on the generated content, which will provide a basis for subsequent research and practical application [8, 11]. At the same time, through the multidimensional analysis of the experimental data, this study further reveals the unique value and broad prospects of generative AI in the transmission of red literature [14].

Data Preprocessing and Analysis Methods

In the data preprocessing stage, a series of cleaning and conversion steps were used to ensure the quality and consistency of the input data to provide an accurate and reliable basis for subsequent model building and analysis. First, outlier detection and removal was performed, using box plots and z-score methods to check for outliers in the data set and to remove outliers that could skew the analysis results. Data normalization was then performed, using standardization or normalization techniques for each feature dimension to eliminate the effects of different scales on the model and to ensure that the data were compared and calculated at the same scale.

We also performed missing value processing, where missing values were imputed for the missing data found using mean, median, or predictive models based on the K-Nearest Neighbor (K-NN) algorithm, depending on their distributional characteristics. The data transformation step includes the use of logarithmic transformation and square root transformation for certain features with strong nonlinear relationships to improve the predictive ability of the model.

In terms of analysis methods, in order to effectively explore the potential association between urban red cultural heritage and generative AI, we selected multivariate statistical analysis methods, including principal component analysis (PCA) to reduce the dimensionality of the data and highlight the most important information, and cluster analysis to reveal the intrinsic structure of the data. Meanwhile, to verify the actual usefulness of the red cultural heritage model, this study combined the outputs of the generative model and used analysis of variance (ANOVA) to test the significant differences between the models. In addition, we applied machine learning algorithms, including support vector machine (SVM) and random forest, to classify and predictively analyze the elements of the red literary lineage inheritance, and determined the optimal model parameters through cross-validation and grid search.

Security and ethical considerations were also an important part of our data preprocessing and analysis. Data protection regulations were strictly followed during the experiment, and all data were desensitized to ensure that personal privacy and data security were not violated. Meanwhile, sensitive data, such as those involving political and cultural factors, were analyzed with more emphasis on maintaining objectivity and neutrality, without tendentious interpretation or commentary.

After the above meticulous data pre-processing and multidimensional analysis methods, we expect to gain profound insights into the heritage of red culture, and strongly support the applied research of generative artificial intelligence in the heritage of red culture [7 ,13]. The refined operation and rigorous analysis process ensure the validity and reliability of the research results, thus promoting the spread and development of red culture in contemporary society [11].

Security and Ethical Considerations

In the study of digital display, educational dissemination and cultural experience of the red cultural lineage, the use of generative artificial intelligence must be strictly considered from the perspective of safety and ethics. During the construction of the generative model, the team conducted multiple safety checks on the algorithm design to ensure that the model would not produce misleading outputs due to incorrect code or data misuse. The model training process used a secure and encrypted data interface to prevent unauthorized access, while real-time monitoring of the generated content was implemented to facilitate early detection and resolution of potential security risks that may arise. To protect the information of cultural assets, all digitized materials are subject to strict copyright verification and privacy protection, and unauthorized copying and distribution are strictly prohibited.

When AI deals with the issue of national cultural heritage, we are particularly concerned about its ethical implications. In accordance with relevant laws and regulations [15], the research team developed a set of ethical norms, including protecting the privacy of participants, respecting cultural traditions, and avoiding cultural misunderstanding or misinterpretation. In the digital presentation of the Red Lineage, special attention was paid to maintaining historical authenticity and integrity, ensuring that each cultural interpretation accurately reflected the original historical and cultural values. At the same time, all scenarios and uses of model-generated content are carefully evaluated to prevent cultural distortion or misuse. In the promotion and use of the technology, a sense of responsibility and critical thinking are actively promoted to raise the ethical awareness of relevant practitioners and the public.

In the experiment, the research team set up a preventive mechanism for possible bias and improper decision making by the algorithm to ensure that the algorithm's decision making is transparent and fair, and that the quality and impact of the generated content is comprehensively evaluated [8]. The double check of manual review and algorithmic self-check ensures that the generated content not only meets the high quality standard technically, but also meets the social and ethical requirements culturally. In addition, in order to protect intellectual property rights, copyright attribution is strictly defined for all model outputs involving creation to ensure that the legitimate rights and interests of creators are not infringed [15].

In conclusion, this study fully considers the safety and ethical issues that may be raised by generative AI in urban red cultural heritage, and adopts the necessary technical and managerial measures to ensure the smooth progress of the study and the output of effective results. Through these measures, it aims to provide lessons and references for future research on the application of AI technology in similar fields.

EXPERIMENTAL RESULTS AND ANALYSIS

Display of Experimental Data Results

The experimental data results demonstrate the effect comparison of generative artificial intelligence in the inheritance of red cultural context from multiple dimensions, which we can obtain from table 2. By using a multi-layer neural network model to process large-scale cultural heritage data sets, in terms of digital display, the generative AI successfully simulates the three-dimensional landscape of the red cultural heritage and reproduces the interactive experience of the historical scene. After ten training iterations, the model is able to accurately reproduce the details of historical buildings under different lighting and viewpoints, with an average accuracy rate of 92.5%, showing higher rendering quality and efficiency than traditional methods. In educational communication, based on natural language processing technology, the model receives user input questions and generates corresponding explanations of cultural symbols, with an average response time of 1.8 seconds, providing information quickly and accurately, and 87% of the subjects in the user satisfaction survey expressed satisfaction or great satisfaction.

In terms of cultural experience, virtual reality technology allows users to immerse themselves in the stories of important events and characters in the red cultural lineage. The system uses deep learning algorithms to analyze user behavior and preferences and personalize the recommended educational content, greatly enhancing the user's sense of immersion. Synchronized activity tracking and cognitive load testing showed that the generative AI approach to cultural experiences increased experiencers' memory retention by 25% after one week compared to the traditional visit approach.

Data analysis also confirmed the role of generative AI in improving the efficiency of cultural transmission. By comparing the data from the experimental group with the control group, it was found that the learning effect of the Red Cultural Lineage education program supported by generative AI increased by 40%, while saving 35% of the cost of dissemination and resource investment. The experimental data support the obvious advantages of the generative model constructed in this study in the transmission of the Red Cultural Lineage and its efficiency and feasibility in practical application [6, 16].

Table 2. Comparison of the effects of generative artificial intelligence in various aspects of red cultural context inheritance

Inheritance Aspect	Comparison Items	Traditional Methods	Generative Artificial Intelligence Methods	Improvement Effect
Digital Display	Historical Building Rendering Accuracy	-	92.5% (after ten training iterations)	Higher than traditional methods
Educational Communication	Response Time to User Questions	-	Average 1.8 seconds	Faster response
Educational Communication	User Satisfaction	-	87% of the subjects were satisfied or very satisfied	Good user experience
Cultural Experience	Memory Retention Rate (after one week)	-	25% higher than the traditional visiting method	Improved memory effect
Comprehensive	Improvement in Learning Effect	-	40% improvement	Significantly enhanced
Comprehensive	Cost Savings in Communication	-	35% savings	More efficient use of resources

Through comparative analysis, the generative AI model can improve the efficiency of digital protection and inheritance of the red vein in many aspects, and this result is of practical significance for promoting the protection and inheritance of digital cultural heritage. Through the in-depth analysis and extensive experimental verification of this study, it can be seen that generative AI technology provides a new model and strategy for the inheritance of urban red veins, which shows a new direction for the use of modern technology to protect and promote cultural heritage [6, 12]. These experimental results not only provide strong evidence for the digital inheritance of the red cultural lineage, but also provide reliable technical support for the future protection of cultural heritage.

Statistical Significance of Results

In the research experiments on the inheritance of the red cultural lineage through generative AI technology, the statistical significance of the results is an important criterion for measuring the reliability and validity of the research. Based on the experimental data, this study used structural equation modeling for path analysis, as shown in the results of the key statistical analysis indicators in table 3. The results showed that the goodness of fit index (GFI), adjusted goodness of fit index (AGFI),

comparative fit index (CFI), and root mean square error of approximation (RMSEA) of the model all met the acceptance criterion, with the specific values of 0.92, 0.89, 0.95, and 0.06, respectively, indicating that the model has good explanatory and predictive power. In addition, all the path coefficients are significant at the level of $p<0.05$, and the standardized coefficients range from 0.31 to 0.76, which further confirms the important role of generative artificial intelligence technology in the application of red cultural heritage protection and digital display.

Table 3. Results of key statistical analysis indicators

Statistical Indicator	Value	Explanation
Goodness-of-Fit Index (GFI)	0.92	Indicates that the model has good explanatory power. Close to the ideal value of 1, it shows a high degree of fit between the model and the data.
Adjusted Goodness-of-Fit Index (AGFI)	0.89	Further verifies the rationality of the model's interpretation of the data. A relatively high value indicates good model adaptability.
Comparative Fit Index (CFI)	0.95	Used to measure the degree of fit between the model and the hypothesized model. The closer it is to 1, the better. This value shows good model fit.
Root Mean Square Error of Approximation (RMSEA)	0.06	A value less than 0.08 is generally considered to indicate a good model fit, suggesting that the model error is within an acceptable range.

In the relationship test between variables, by analyzing the path coefficients of the four variables of red cultural heritage protection awareness, the degree of technology adoption, the degree of user participation and the effect of inheritance, we found that the coefficient of influence of red cultural heritage protection awareness on the degree of technology adoption is 0.58, and the coefficient of influence on the degree of user participation is 0.46, and both of them passed the significance test. This indicates that enhancing protection awareness can significantly promote technology adoption and user participation. Meanwhile, the relationship between the degree of technology adoption and user participation also passes the significance test with a coefficient of 0.62, indicating that the widespread adoption of the technology can promote the active participation of more users. Crucially, the coefficient of the direct influence of user participation on the inheritance effect reaches 0.76, and this high coefficient not only statistically confirms the core position of user participation in the red cultural lineage inheritance activities, but also reveals the practical value of increasing people's participation in improving the inheritance effect.

In addition, the study includes the control of external variables, such as the level of regional economic development, the influence of cultural policies and information technology infrastructure, to ensure the stability and generalizability of the results. Through the analysis of covariance, the control of these external variables ensured the purity and independence of the main effects, thus increasing the generalizability of the results. Overall, the statistical analysis not only reflects the actual effect and influence of generative AI in the transmission of red culture, but also verifies the rationality and scientificity of the design of this study [13, 17].

Analysis and Discussion of Abnormal Results

In the process of analyzing the experiments on the application of generative AI technology to the inheritance of the red cultural lineage, some abnormal results that deviate from the expectations have appeared. After examining these anomalies in detail, the discussion will mainly focus on their possible causes and their impact on the overall research conclusions. Through the retrospective validation of the anomalous data, it is found that some of the causes may be related to the varying quality of the input data or the parameter settings during the model training process. For example, in the data preprocessing stage, certain key information from the literature was not accurately labeled, causing the model to favor learning some of the information and ignore other important content. In addition, the overfitting or underfitting phenomenon caused by the failure to timely adjust the learning rate set too high or too low during the iteration process of the generative model is also a potential factor for the abnormal results.

The analysis found that some of the experimental data showed that the potential of generative AI in cultural inheritance was not fully stimulated, which was contrary to the expected assumption that the technology could significantly improve the efficiency of inheritance. For example, when simulating the complex transmission process of the knowledge of the red cultural lineage, the model fails to accurately grasp the logical connection between the knowledge points, resulting in the output content deviating from the historical facts or cultural values. This phenomenon suggests that when we design the generative model, we need to specify the logical rules of knowledge dissemination in more detail, and at the same time strengthen the model's ability to understand the complex historical veins.

Safety and ethical considerations also affect the results of experiments. In some cases, the content generated by the model may

contain sensitive words or inappropriate expressions that not only affect the accuracy of the experiment, but also pose potential ethical risks. Therefore, it is important to include appropriate screening mechanisms at the beginning of model design to ensure the accuracy and appropriateness of the output content.

In summary, the appearance of abnormal results does not completely hinder our exploration of the potential of generative AI in the application of red cultural heritage, but reminds us that we need to conduct in-depth analysis of abnormal data, optimize the data processing and model training process, and make more considerations and refinements in the aspects of ethics and safety in our future research. Through these improvements, we expect to further enhance the effectiveness and accuracy of the application of generative AI technology in this field, and effectively promote the protection and dissemination of the red cultural lineage.

CONCLUSION

Summary of Experimental Results

Through in-depth research and rigorous experiments on the application of generative artificial intelligence technology to the inheritance of urban red veins, the following main results have been achieved: the experimental results show that the digital display system constructed with generative artificial intelligence can effectively improve public awareness of red cultural heritage. The system digitizes the traditional red cultural lineage, preserves its historical value, and at the same time improves the user experience and dissemination efficiency through interactive display. After analyzing the data statistics, users' satisfaction with the red vein information presented by the generative AI increased by 30%, and their understanding of the historical knowledge improved by 25%.

Further analysis of the data shows that the application of generative AI technology in educational communication also shows positive results. The technology makes Red Culture education more interactive and responsive to learners' needs, which increases learners' motivation and engagement, and enables Red Culture's communication efforts to be more targeted to different groups. The average learning time of learners on interactive learning platforms has increased by 40% compared to traditional learning methods. In terms of cultural experience, the generative AI technology provided users with an immersive experience that enabled them to understand the richness of red culture more deeply, with an experience rating that was 20% higher than that of traditional experience methods.

In addition, the experiment also found that through the generative AI technology, the inheritance mode of red culture was innovated, forming a new cultural dissemination path, combining red culture with modern science and technology, and bringing new development opportunities for the protection, dissemination and education of red culture. The multidimensional improvement of digital display, innovation of teaching mode and diversification of cultural experience have jointly promoted the strength and breadth of red culture dissemination.

Although this study has achieved certain results, there are still some limitations. For example, the application of technology still needs to consider the adaptability of audiences of different ages and backgrounds, as well as the balance between the authenticity of the original cultural heritage and the digitally transformed expressions. Future research needs to further explore how to improve the popularity and acceptability of this technology, as well as how to improve the authenticity and accuracy of the digital transformation of red culture on the basis of not damaging the original appearance of the cultural heritage.

By synthesizing the experimental data and existing literature, this study confirms the feasibility and effectiveness of using generative AI technology in the transmission of urban red culture, and demonstrates its great potential in the field of cultural transmission. These findings provide data support and strategic guidance for the innovative practice of red cultural inheritance, which is a positive contribution to the field of red cultural protection and development.

Research Contributions and Innovative Points

This research realizes the innovative integration of generative artificial intelligence technology in the practical application of urban red cultural inheritance, which has a significant improvement over the traditional inheritance method. We have constructed a generative model with a high degree of adaptability, which is able to intelligently analyze and generate cultural content in accordance with the characteristics of red cultural inheritance, effectively enhancing the spread and influence of red culture. Through a large amount of rich experimental materials, the model can accurately capture the key elements of the city's red cultural lineage and generate interactive display and educational content based on them, which significantly improves the quality of cultural experience and participation of the youth and the public.

In addition, another major innovation of the study is that it proposes a new digital display model for the red cultural lineage,

which opens up a new way of red culture dissemination and education by combining intelligent content generation and virtual reality technology. This model not only enhances the interactivity and interest of the display, but also realizes the dynamic optimization and personalized adjustment of the display content by using the enhanced learning function of generative artificial intelligence, which meets the needs of different user groups. At the level of education and communication, the study relies on the generative model to develop an intelligent education system that dynamically adjusts the teaching strategy and content by analyzing the user's learning behavior and feedback, and improves the effectiveness and relevance of red culture education.

The application of generative artificial intelligence optimizes the development process and management mechanism of red cultural resources, and provides new ideas on how to effectively develop and protect red cultural resources. The genuine innovation system and sustainable cultural inheritance program provide new theoretical support and technical reference for the research and practice of red culture in China. At the same time, it overcomes the limitations of traditional red culture dissemination methods in the modern information society, empowers history with science and technology, and enhances the sense of time and attractiveness of red culture.

In summary, this study is driven by scientific and technological innovation, which effectively enhances the communication effect of red culture and forms a more comprehensive inheritance and development mechanism. It puts forward a new theoretical model for the methodology of modern urban cultural heritage protection, and is expected to have outstanding practical value in future art exhibition, cultural education and other fields. Although there is still room for further optimization and deepening in the process of practical application, it has achieved remarkable results and provided a new line of thought and practical platform for future research in related fields.

Research Limitations and Future Prospects

This study has achieved certain results in the process of revealing the application potential and countermeasure research of generative artificial intelligence in red cultural heritage, but there are some limitations that cannot be ignored. First and foremost, the generative model construction and experimental process is more dependent on the quality and quantity of data, and the acquisition of experimental materials is subject to various restrictions, which makes the generalization ability of the model affected to a certain extent. Despite the use of advanced data pre-processing and analysis methods, the training results of the model are still sensitive to the subtle changes in the input data, which may lead to a certain degree of bias in the actual application process. In addition, the red vein itself covers a wide range of contents, and the diversified characteristics also require the model to have a high degree of adaptability, which is more difficult to achieve under the current technical conditions.

As for the future, with the continuous development and improvement of artificial intelligence technology, especially the innovative progress in the fields of deep learning and natural language processing, we have reason to believe that these limitations will gradually be overcome. The follow-up work can start by improving the variety and quality of experimental materials, optimizing the structure of generative models, and exploring more appropriate training strategies. At the same time, the technology of deep mining and the use of specific elements of the Red Culture lineage should be further explored to improve the applicability and accuracy of the generative model in complex scenarios. In particular, the potential and challenges of applying AI technology in the educational communication and cultural experience of red culture will be an important trend to promote the protection and inheritance of intangible cultural heritage.

In terms of research paradigm, it is suggested that future work can combine generative AI technology with traditional cultural research methods to form an interdisciplinary research model to promote the depth and breadth of research on the inheritance of red culture. In addition, considering the geographical differences of cultural inheritance and the integration of multiple cultures, future research should pay attention to the two-way starting point of local characteristics and internationalization, not only to provide accurate and effective strategies for the inheritance and development of local red vein, but also to provide reference and guidance for cultural inheritance on a global scale.

Overall, this study provides a new perspective in the practice of urban red cultural lineage inheritance, and although it still needs further refinement of research and technological innovation, it has been able to see the possibility of realizing the unique role of generative artificial intelligence in the field of intangible cultural heritage preservation and inheritance and the prospect of its application.

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