

Construction of User Portrait System for Online Shopping of Cultural and Tourism Products Based on Generalized Regression Neural Network

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Abstract. In response to the development dilemma of product similarity and singularity in the cultural and tourism market, the system constructs a user portrait system which is based on Generalized Regression Neural Network (GRNN). It aims to improve the accuracy of user portrait for online shopping of cultural and tourism products, and make judgments on the visualization, intelligence, digitization, and development trends of cultural and tourism network services. The study summarizes four types of user demand elements through traditional questionnaires and AHP analytic hierarchy process. It forms a hierarchical model for user portrait system analysis. The study integrates user online shopping process data into the design and analysis process, and combines GRNN to intelligently analyze the target users, makes the analysis results of the software more objective and reasonable. It provides reference and decision-making for the cultural and tourism market, platform, product development, and service optimization.

Keywords. Generalized Regression Neural Network (GRNN), Online shopping users, Cultural and Tourism Products, User profile, Analytic Hierarchy Process

1. Introduction

With the rapid recovery of the tourism industry, the continuous improvement of the network economy, e-commerce, and Internet of Things technology, the cultural and tourism product market has begun to expand from traditional markets to internet platforms, serving the local cultural industries, agricultural products, surrounding and characteristic product markets. However, the singularity and similarity of cultural and tourism products have put the further development of cultural and tourism products and surrounding markets into difficulties. The design of the user portrait analysis system for online shopping cultural and tourism products aims to integrate user shopping behavior and perspectives into the design process. Based on the characteristics of cultural and tourism products and its user's data, the system is determined by the Analytic Hierarchy Process (AHP). In the construction of the cultural and tourism product user portrait system, intelligent data analysis and mining are used to achieve intuitive portrayal of cultural and tourism product users, providing cultural and tourism products prediction of the current status and development trends of online platforms and services.

2. Research Status

2.1. Related research and objective

Cooper proposed User Portrait, which aims to highly extract user information and summarize user features by assigning tags (Cooper, 2004). Currently, user portrait technology is relatively mature, but research topics and application scenarios still need to be expanded (Zhang Haitao, 2019). The application scenarios of user portrait vary, and their construction dimensions are also different. Online health community user portraits aimed to identify user emotional expression features (Wang Shuai, 2022); The portrait of a collaborative innovation research team is constructed through a team performance evaluation system, reflecting the collaborative innovation ability (Liu Xingbing, 2021).

With the high-quality development of cultural and tourism industry, the cultural and tourism product market is more prosperity in China. People are enthusiastic about purchasing cultural tourism products offline during the tourism process, but the widespread application of digital technologies such as artificial intelligence, virtual reality, and augmented reality has accelerated the development of online and digital cultural tourism products. The dissemination and resource sharing of cultural products are more convenient, and more tourists use online shopping to purchase, mail, and share characteristic products during or after tourism. Online services usually use this type of data for user preference and demand analysis. Compared to other online products, the number of online shopping users for cultural and tourism products is relatively small. It is hard to accurately depict user characteristics due to insufficient information (Zhang Tao, 2020). The offline purchase is the main channel because of the characteristics of the tourism products. As an extension of the experience and promotion channel, if the online purchase path lacks timely user preferences and shopping feedback, it cannot assist in improving the online shopping experience, platform and products, and providing personalized services. The research aims to construct a user portrait system, providing visual analysis results and predictions for different stakeholders.

2.2. Application of GRNN

The judgment of user portrait should be based on Generalized Regression Neural Network (GRNN), quantifying the input and output of subjective feelings. Traditional user research and design processes can provide algorithm design teams with a sensory to rational process experience. It helps models apply to user experiments and achieve more objective and comprehensive portrait results. GRNN plays an important role in the analysis systems for cultural and tourism products. It is a form of data analysis model through the intelligent analysis application process.

2.3. The Purpose of Applying AHP Analytic Hierarchy Process

With the arrival of the digital and intelligent era, more tourism groups, including the elderly, are able to independently order online cultural and tourism products. Departments and groups related to the cultural and tourism industry need to pay immediate attention to the trend of cultural and tourism consumptions. They also concern the current status of cultural and creative consumption. They need to evaluate feedback on ordering channels and the preferences for using digital ordering platforms. The user

portrait system is also an analysis and comparison system for consumers. It is designed to summarize, analyze, and compare information data, behavioral data, user preference data, and user transaction data from different consumer groups. However, the result is not good due to the small amount of data information and the particularity of the products. The Analytic Hierarchy Process (AHP) is introduced to classify and extract the demand element based on research. By distinguishing the weight of elements and combining with GRNN, it provides objective feedback on the characteristics, preferences, consumption trends, and digital cultural and tourism status of the consumptions.

3. Methodology and Research Framework

Based on the target online users, it formed the construction method of the cultural and tourism product user portrait system. The research proposes to extract elements from the user’s behavior. It conducts hierarchical analysis of different elements, mining user preferences, and generating user portrait based on user’s preferences. It aims to apply the constructed portrait to personalized recommendations or improve the services through comparison. The system can also solve problems such as homogenization of the cultural and tourism product market, lack of big data support, and lack of relevant analysis support for development. The study combines objective descriptions of online shopping behavior with a summary of the characteristics and preferences of the consumers. It provides a basis for design researchers to deeply develop the cultural and tourism market and products. Based on cultural and tourism questionnaire surveys and the methods of AHP, a more accurate analysis element model is constructed to refine element weights. The model also addresses the objective constraints of limited data information and difficulty in precise characterization. It promotes the development of digital cultural and tourism products and the construction of online service. The research framework is shown in figure 1. Based on the demand model, it collects uses relevant elements. The data processing is uniformly through input and correction of information variables. The portrait data is based on GRNN, and features are extracted from the data. Based on user sequences, user tags are constructed to analyze and compare the user portraits.

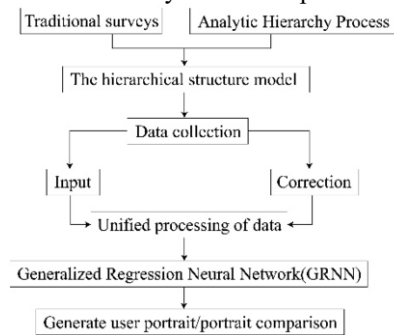


Figure 1. The research framework

4. Methodology and research framework

Firstly, the research analyzes the purpose of establishing user portraits, and combines traditional research to structure a conceptual model based on data. It includes basic

information, behavior, preferences, and transactions. Secondly, it needs to determine the main label attributes of the target user group. Finally, the research combined with the AHP to further analyze the weights of different labels, in order to more comprehensively express different user characteristics and provide comparative analysis modules. Element research shows that the user group exhibits significant differences in gender, age, purchasing influence, online shopping activity, and cultural and creative interest themes.

4.1. Demand Research and Element Indicator Analysis

At the theoretical level, the core content of user portrait construction is the label indicator system. In existing research, user portrait indicators are generally summarized into seven categories of characteristics: user basic information, emotions, psychology, behavior, social interaction, consumption ability, and preferences. This study mainly focuses on tourists in the Jiangsu region, conducting a questionnaire survey and interview on the online shopping needs of cultural and tourism product audiences. 412 valid questionnaires and 17 in-depth interview records were collected. The basic information of the survey shows that tourists have a wide geographical distribution, but local short distance travel users from Anhui, Zhejiang, and Jiangsu account for 76% of the surveyed population. The proportion of women is 58%, slightly higher than men. The travel groups mainly consist of couples, family members, and middle-aged and elderly people. The occupational distribution is relatively broad, with retirees, students, enterprises and institutions, and study tour ranking in the top five. The demand for cultural and tourism products shows that although most tourists purchase items during their travels, a considerable number of people still choose to repurchase or search for similar tourism products online after the trip. It is used for sharing, giving, and enjoying in the future. Age has a significant impact on users' online shopping activities. Middle-aged and elderly users over 55 years old have a stronger willingness to repurchase and share, but they are not proficient in operating online platforms and will repurchase through WeChat groups, contact shopping guides online, etc.

Based on research, feature extraction is carried out. The key feature requirements are the basic value of cultural and tourism products, network security, service experience, and sharing needs. Based on research records and correlation analysis, filter out meaningless secondary indicators to obtain the hierarchical structure of target audience portrait feature indicators for online shopping cultural and tourism products (See Table 3 for details), including 4 primary indicators and 25 secondary indicators. This indicator is used to construct portrait labels. The basic information features such as age, region, gender, and occupation can be directly generated, or classified and discussed through algorithm paths to form further user comparison profiles. Other indicators of basic information features, such as practicality, health, brand, and price, reflect the real needs of users for cultural and tourism products. The service experience reflects the themes of users' attention. It is necessary to analyze the process, behavior, results, and feedback generated by users' online shopping to determine the label attributes. Security features are the foundation of user online shopping behavior, and label attributes need to be processed and determined. By combining sharing needs to reveal users' confidence, enthusiasm, activity, and influence in online shopping, it is also necessary to process the text to obtain user profile label attributes.

4.2. Weight of User Profile Elements

4.2.1 Building a hierarchical model

AHP is a decision-making method proposed by Saaty in the 1970s, which systematically and hierarchically analyzes complex problems (T. L. Saaty, 1980). The study combines the above research and AHP hierarchical analysis of the hierarchical weights of user portrait elements to construct a hierarchical model for analyzing system of cultural and tourism products. Among them, the audience's online shopping needs are the target A layer, and the basic value (B1), security (B2), sharing (B3), and online shopping experience needs (B4) are the first level indicators B layer. Then, the second level indicators below each B layer are the element C layer. Unlike other online cultural and tourism product user analysis, as shown in Table 2, the study developed a hierarchical structure model based on AHP.

4.2.2 Constructing a judgment matrix

To be more objective, it is compared the importance of corresponding indicator elements with the previous indicators. The secondary indicators are compared with a scale of number from one to nine, as shown in Table 1. After taking the scale values, each element is assigned a value to form a comparison matrix for secondary indicators.

$$A = [a_{ij}] = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

Table1. Definition of Importance Level Scale

Scale a_{ij}	Implication
1	Indicates that i and j are equally important compared to each other
3	Compared the factors i and j, the former is slightly more important than the latter
5	Compared the factors i and j, the former is more important than the latter
7	Compared the factors i and j, the former is much more important than the latter
9	Compared the factors i and j, the former is extremely important compared to the latter
2,4,6,8	Represents the intermediate value of the adjacent judgments mentioned above

4.2.3 Hierarchy sorting and consistency testing

It aims to solve the maximum eigenvalues and eigenvectors of the matrix corresponding to user needs and normalize them.

$$\lambda_{max} = \sum_{i=1}^n \frac{[B_1 W]_i}{n w_i} \quad (2)$$

$$w_i = \frac{1}{n} \sum_{j=1}^n \frac{a_{ij}}{\sum_{k=1}^n a_{kj}} \quad (3)$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (4)$$

The maximum eigenvalue of the judgment matrix B_1 is determined by formula (2). W represents the weight of each element in the primary and secondary indicator.

Perform consistency check on the matrix, with $CR=CI/RI$. RI refers to the average random consistency indicator. When $CR<0.1$, it is considered that the judgment matrix meets the consistency condition, otherwise it needs to be corrected. According to the solving process, the CR of the judgment matrix B_1 is $0.0037<0.1$. The consistency of corresponding indicators under other target layers is also less than 0.1. These indicate a low degree of deviation of the matrix and good consistency in the solution results.

4.2.4 Constructing a weight analysis system for feature indicators

Solve the weight of the target user's online shopping needs, and take the comprehensive weight to compare the results. According to the weight of the two levels indicators (Table 2), the importance order of online shopping needs of tourism product users is: B1 basic needs, B4 network service needs, B2 security needs, and B3 sharing needs. According to the weight values of the secondary indicators, it can be seen that users have a high demand for elements such as cultural connotations and regional characteristics, packaging, applicability to special groups, reliable sharing link, convenient sharing, mode of payment, clear browsing information and authenticity, reliable online shopping touchpoints, and after-sales guarantee. Users have a relatively low demand for low prices, brands, personal information security, uniqueness and promotional activities, collectible or additional purchases (temporarily not purchased) and transportation safety indicators.

Table 2. Hierarchy of user profile feature indicators

Target layer	Primary indicators	Weight	Secondary indicators	Weight	Comprehensive weight
the demand for online shopping of cultural and tourism product	B1 basic value requirement	0.385	C1 low price	0.0710	0.0273
			C2 health	0.2500	0.0963
			C3 cultural connotation/regional characteristics	0.2976	0.1146
			C4 package	0.3241	0.1248
			C5 brand	0.0357	0.0137
			C6 practicality (taste, purpose, etc.)	0.1429	0.0550
			C7 suitable for special groups (children/pregnant women/elderly)	0.2727	0.1050
	B2 security requirements	0.230	C8 personal information security	0.4000	0.0920
			C9 comment Area Privacy	0.1000	0.0230
			C10 share link source reliability	0.5000	0.1150
			C11 convenient sharing	0.3737	0.2877
	B3 sharing needs	0.077	C12 cost-effective	0.2727	0.0210
			C13 regional cultural characteristics	0.1818	0.0140
			C14 promotional activities	0.0909	0.0070
			C15 uniqueness	0.0909	0.0070
			C16 platform reliability	0.0882	0.0272
	B4 service experience requirements	0.308	C17 transport Safety	0.0588	0.0181
			C18 convenient search	0.0882	0.0272
			C19 display product	0.0882	0.0272

popularity and reviews		
C20 can be collected/added for purchase (temporarily not purchased)	0.0294	0.0091
C21 mode of payment	0.1471	0.0453
C22 clear display information/ authenticity	0.2059	0.0634
C23 reliable online shopping contacts	0.1176	0.0362
C24 after sales guarantee	0.1764	0.0543

4.3. Intelligent User Portrait Analysis Solution

After constructing an indicator hierarchy based on the AHP method, it can be used for intelligent analysis software design, digital processing of data, and visual output. The user portrait analysis system combines demand weighting to intelligently translate behavioral and characteristic indicators of users. It analyzes and compares the cultural and tourism products consumers. The system could input, modify, intelligently analyze and compare different data, including behavior data, user preference data, and user transaction data. It aims to analyze the characteristics of cultural and tourism product consumer groups more accurately based on limited data, optimize the cultural and tourism industry and digital media services. The system can also combine user ordering, evaluation, and feedback to provide cultural and creative consumption suggestions for users, achieve more intelligent data processing, enhance user experience and sharing needs. At the same time, it also provides solutions such as data storage, viewing historical data, parameter correction, generating portrait, comparing user portraits, and generating profile charts.

The user portrait system interface is mainly divided into four parts: parameter selection and setting area, parameter control correction area, portrait generation area, and comparison parameter setting and portrait generation area.

Parameter selection and setting area: Various parameters can be selected to generate personalized user portraits, and parameters can also be added through the "Other" option.

Parameter control correction area: Based on the actual guiding significance of the data, set parameter control correction areas to facilitate data improvement, refinement, and parameter adjustment based on the development of cultural and tourism.

Portrait generation area: As shown in Figure 2, it can generate user images and intelligently analyze results.

Comparison parameter setting and image generation area: The comparison parameter setting interface allows for the selection of various parameter indicators and provides a "Comparison parameter summary" box for parameter addition, deletion, and confirmation, as well as the generation of comparison images.

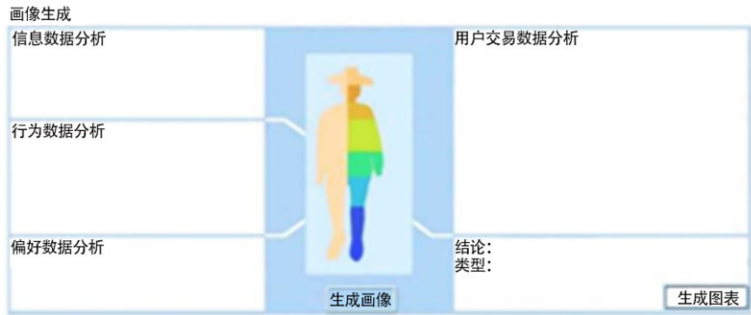


Figure 2. The Portrait Generation Module for the Conceptual Model of User Portrait System

5. Building an Intelligent User Portrait Model Based on GRNN

When constructing an intelligent user portrait model, a large amount of user data is analyzed. The model is applied to analyze the demand, interest, and feature information of consumer groups for cultural and tourism products. The general steps for building an intelligent user portrait model include six steps: data collection, data processing, intelligent algorithm selection, model training and optimization, user portrait generation and analysis, and model evaluation and improvement. Intelligent models can help the cultural and tourism market better understand target users, provide personalized recommendations, personalized services, and precise marketing.

5.1. The Application of GRNN Neural Network Model

Generalized Regression Neural Network (GRNN) is a highly parallel oriented basis network with fast learning speed and strong nonlinear mapping ability. Its structure is shown in Figure 3, consisting of four layers of network: input layer, pattern layer, summation layer, and output layer. In response to the issues of user information data, user behavior data, user preference data, and user transaction data in this study, such as the large number of detail variables, the high correlation of internal detail factors in each type of data, and the complex relationship between user portrait and various input factors, a generalized regression neural network is used to construct user portrait. For example, in user information data, user age, occupation, online shopping platform, gender, education level, type of cultural and tourism product browsing, etc. are used as inputs. In user behavior data, browsing frequency, duration, whether to add a purchase, external contacts, comment content and so on are used as inputs. In user preference data, product type, brand preference, sharing frequency, login method, and geographical location of the product are used as inputs. The user transaction data uses correlation rate, promotion conversion rate, churn rate and so on as input data. Respectively corresponding to $X_1, X_2, \dots, X_n, X_1, X_2, \dots, X_n$, after neural network model training, its output is $\bar{Y} = [Y_1, Y_2, \dots, Y_n]^T$, displayed as a portrait model.

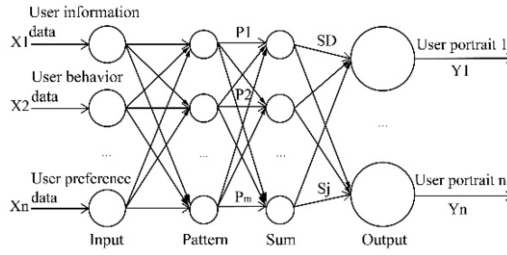


Figure 3. The Topological Structure of GRNN Neural Networks

5.2. GRNN Neural Network Algorithm

GRNN is a feedforward neural network in which each layer is assigned to a specific computational function for nonlinear regression during data processing.

The first layer is the input layer. It is responsible for receiving information. It directly transfers the data to the pattern layer when the input layer receives the input vector X . The second layer is the pattern layer. After inputting the data to the pattern layer, the pattern layer neurons recombine and process the data. It stores the connection weight of the i -th neuron in the i -th Gaussian function P_m , the neuron transfer function used by this stored procedure is as follows:

$$P_i = \exp \left[-\frac{(X - X_i)^T (X - X_i)}{2\sigma^2} \right], i = 1, 2, \dots, m \quad (5)$$

In the formula, X is the network input variable; X_i is the training vector corresponding to the i -th neuron in the pattern layer; σ is the smoothing factor.

The third layer is the summation layer. The neurons in the pattern layer generate an output vector P_m , and feedback the results to the third layer summation layer. In the summation layer, perform arithmetic summation and weighted summation on the output vectors of each neuron in the pattern layer, as follows:

(1) Simple arithmetic summation

$$S_D = \sum_{i=1}^m P_i \quad (6)$$

(2) Weighted summation

$$S_j = \sum_{i=1}^m y_{ij} P_i, j = 1, 2, \dots, n \quad (7)$$

In the equation, y_{ij} is the j -th element in the i -th output sample.

The fourth layer is the output layer. The network output y_i is equal to the quotient of S_j divided by S_D . The formula is as follows:

$$y_i = \frac{S_j}{S_D}, j = 1, 2, \dots, n \quad (8)$$

5.3. Display of User Portrait System

After analyzing and processing user data through intelligent algorithms, the user portrait is output, as shown in Figure 4. The obtained user portrait information is displayed in a visual and easy way to help the cultural and tourism market better know the target audience, formulate precise strategies and decisions, better meet user needs and improve

user experience. These results can also be expanded and modified according to different data sources and analysis purposes.

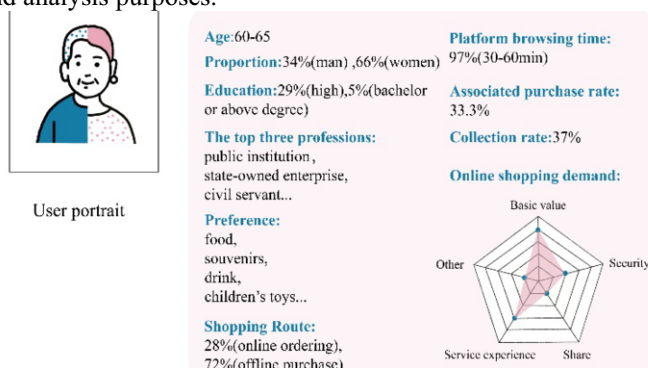


Figure 4. User portrait

6. Conclusion

The cultural and tourism product portrait system based on GRNN aims to build a visual and intelligent platform. Its results reflect the effectiveness, service quality, and attractiveness of cultural and tourism product information. It constructs intelligent data analysis on different groups. The user portrait system uses labels, motivation, and online shopping behavior of different descriptions of crowd roles to provide reference for different stakeholders. It can also perform relatively efficient intelligent analysis on the limited data of the target audience. The system could effectively assist in the development of cultural and tourism products, the improvement of network services, and the sustainable development of building the cultural and tourism market.

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