Research article

Landscape design of urban culture transmission based on the regional information security of Internet of Things

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A B S T R A C T

In the context of the rapid development of Internet of Things technology, urban cultural communication and information security have become a new focus in the field of landscape design. This paper innovatively discusses the landscape design of urban cultural communication based on Internet of Things regional information security, aiming at building a safe and culturally rich urban landscape environment. Taking the unique regional culture of Zhangjiajie as an example, this study evaluated the cultural communication effect of landscape design under information security guarantee through in-depth case analysis and field investigation, combined with Internet of Things information security technology. The results show that the cluster head node strategy has significant advantages in resisting physical capture attacks, especially when the number of sensor nodes captured is less than 2000, the information loss rate is less than 0.1. This discovery not only improves the level of information security in the Internet of Things environment, but also provides technical support for the effective dissemination of urban culture. In addition, through the detailed analysis and evaluation of landscape, this study further reveals the important role of landscape design in regional cultural inheritance. To sum up, this study not only provides a new perspective for urban landscape design, but also provides practical guidance for the protection and dissemination of urban culture in the era of Internet of Things.

1. Introduction

With the rapid development of Internet of Things technology, urban cultural communication and information security have become a new focus in the field of landscape design. In the digital era, cities are not only a space for human habitation, but also an important place for cultural exchange and information transmission. Urban culture is an important embodiment of urban soft power, which not only affects the quality of life of residents, but also is a key factor in attracting tourists and investors. However, with the wide application of Internet of Things technology, urban cultural communication is facing unprecedented information security challenges. Security issues such as information leakage and data tampering not only threaten personal privacy, but also damage the authenticity and integrity of urban culture. Therefore, this paper aims to analyze how to achieve the safe transmission of urban culture through landscape design under the environment of Internet of Things. Specific research questions include: How to use iot technology to ensure information security in landscape design? How can landscape design effectively promote the spread of urban culture? And how to evaluate the cultural communication effect of landscape design under information security guarantee? Previous studies have mainly focused on the aesthetic and functional aspects of landscape design, and less on the combination of information security and cultural

communication. The contribution of this paper is to combine the information security technology of the Internet of Things with landscape design. Taking the unique regional culture of Zhangjiajie as an example, through in-depth case analysis and field investigation, this paper evaluates the impact of landscape design on urban cultural transmission under the guarantee of information security. This particular approach is proposed because the introduction of the Internet of Things technology provides new possibilities to solve this problem. By combining the information security technology of the Internet of Things, the role of landscape design in cultural communication is enhanced while ensuring data security, so as to achieve the safe and effective communication of urban culture.

With the rapid development of Internet of Things (IoT) technology, the security of urban landscape design and cultural communication has become a research hotspot. Nijhuis S [1] discussed landscape design as a research methodology and emphasized the importance of design practice in theoretical research. Liu C [2] used nonlinear theory to simulate the parameters of multi-dimensional urban landscape design, demonstrating the possibility of combining theory with practice. In terms of information security, Jason R C [3] and Serkov A [4] discussed the concept of security risk assessment and information security in iot systems respectively, pointing out the challenges faced by iot security. Hassan W H [5] reviewed the current research on iot security, emphasizing the urgency of security issues. Dhillon HS [6] explored the challenges of IoT in wide-area wireless communication, while Ze A [7] and Lv Z [8] explored the management and security of smart cities from the perspective of data-driven city management and artificial intelligence (AI) -enhanced iot security, respectively. Although the existing literature has provided abundant research results in landscape design, Internet of Things security and urban cultural communication, there are still few landscape design studies that combine these fields, especially on urban cultural communication under the premise of information security. Combining the information security technology of the Internet of Things with landscape design to achieve the effective transmission of urban culture is not enough research in this field. Therefore, this paper combines the information security technology of the Internet of Things with landscape design, adopts the cluster head node strategy to resist physical capture attacks, improves the level of information security in the Internet of Things environment, and provides technical support for the effective dissemination of urban culture. In addition, through the integration of eco-design theory and traditional techniques with local materials, this paper shows how to create a region-specific urban landscape that beautifies the urban environment and enhances visitors' experience and awareness of local culture. These achievements fill the research gap in the existing literature on how to ensure information security while carrying out urban cultural communication landscape design, and provide a new perspective and practical guidance for future urban landscape design and cultural communication.

2. Method on landscape design of urban culture transmission based on the regional information security of Internet of Things

Current research is mainly focused on the technological development of the Internet of Things and the strategy of urban cultural transmission, however, how to effectively integrate these two fields while ensuring information security has not been systematically studied. The unique feature of this paper is that it will focus on the application of information security technology in urban cultural communication, which makes up the gap of this comprehensive application in the existing literature.

2.1. IoT information security systems

The architecture of the Internet of Things can be divided into three layers: perception layer, network layer and application layer [9, 10]. The bottom layer is the perception layer, which is mainly used to collect information. To defend against physical capture attacks, the cluster head node policy is adopted. When the sensor node is captured, the cluster head node immediately detects the anomaly and cuts off communication with the node through a preset security protocol to prevent data leakage. In addition, the cluster head node also has the data encryption function to encrypt the transmitted data, even if the data is intercepted, the attacker can not interpret its content.

The middle layer is the network layer, which mainly solves the problem of long-distance transmission of information in the perception layer. This layer uses a multi-layer defense mechanism, including intrusion detection system and defense system. Intrusion detection system monitors network traffic in real time, and finds potential attack behavior in time through pattern recognition and anomaly detection technology. Intrusion prevention systems take further steps to isolate suspicious traffic and reset malicious connections to stop the spread of attacks. In addition, Virtual Private Network (VPN) technology has been introduced to ensure the secure transmission of data over public networks through encrypted tunnels.

The application layer is the remote terminal layer of the Internet of Things, which mainly solves the problem of information processing and human-machine interface. Among them, the information security problem involved in the perception layer used for information collection is that the node information of the acquisition terminal may be illegally damaged and attacked during transmission, and security protection measures must be strengthened to ensure the integrity and confidentiality of the perception node [11–14]. This layer implements strict access control and identity authentication mechanisms. Role-Based Access Control (RBAC) ensures that only authorized users can access specific data and services. At the same time, Multi-Factor Authentication (MFA) technology is used to improve the security of the system by combining multiple authentication methods such as password and biometrics.

2.2. Research methods of regional cultural transmission

For the spread of urban culture, two methods are used here:
Field research method, this method is to understand the local customs, regional culture, cultural image positioning and typical

communication activities through interviews with locals and people who came from other places to obtain first-hand information. Ensure the objectivity and reliability of these materials. This research method explores the interviewees' aesthetic pursuits, lifestyles, values and other perspectives, and draws certain conclusions [15]. In Zhangjiajie area, this paper organized several field trips to visit the local cultural heritage sites, folk villages and tourist attractions.

Case study method, a detailed interpretation of a city, analysis of its various aspects of regional culture, and find ways to express regional culture [16–18]. This paper firstly collects the historical data and current information of cultural communication in Zhangjiajie. Through comparative analysis, we identify how these cultural elements are transmitted through sensor networks, mobile applications and social media in the iot environment. Finally, through the study of examples, summarize and summarize the research results of urban landscape design based on regional culture, and further deepen the theoretical system and method of regional expression of urban scenic spots.

3. Experiment on landscape design of urban culture transmission based on the regional information security of Internet of Things

3.1. Algorithm process of the regional information of Internet of Things

The geographic information being queried has a database Y, and the inquirer has private data x. He hopes to find a certain meaning value represented by x in the queried information database, or find a certain meaning value closest to x [19–21]. For the protection of regional information security and the transmission of culture, the Y part of the database of the queried regional information cannot be copied, and the inquirer does not want the queried regional information to record its privacy input. Based on the above requirements, the following algorithm is designed:

(1) The inquirer decomposes the information x he inquired into $x = x_1, x_2, ..., x_n$ and constructs a vector

$$\vec{x} = (1, -2x_1, -2x_2, ..., -2x_n) \tag{1}$$

(2) The inquirer uses a random number generator to generate an n+1-order invertible matrix A, and record $\vec{x}A^{-1}$ into the geographic information being inquired.

(3) For the geographic information database Y, record the number of records as y_i and i = 1, 2, ..., n, and then divide each record y_i in the same way according to the mathematical method used by the inquirer $y_i = y_{i1}, y_{i2}, ..., y_{in}$.

(4) The queried information constructs a vector for each y_i , i = 1,2, ... , n

$$\vec{y}_i = \left(\sum_{k=1}^{k=n} y_{ik}^2, y_{i1}, y_{i2}, ..., y_{in} \right) \tag{2}$$

Use a random number generator to generate a random number a_i , i = 1,2, ... , n, multiply each of them to get

$$\vec{y}_i = a_i \vec{y}_i = \left(a_i \sum_{k=1}^{k=n} y_{ik}^2, ba_i y_{i1}, ba_i y_{i2}, ..., ba_i y_{in} \right) \tag{3}$$

After transposition, it is multiplied by the random matrix A generated in the second step, and then sent to the information to be queried, where the superscript M is the transposition symbol of the matrix [22,23].

(5) The queried information is calculated by adding random numbers a_i.

$$A \left(b \vec{y}_i \right)^M = A \left(ba_i \vec{y}_i \right)^M \Big/ a_i \tag{4}$$

And then calculate

$$z_i = \left(\vec{x}A^{-1} \right) \cdot \left(A \left(b \vec{y}_i \right)^M \right) = \vec{x} \left(b \vec{y}_i \right)^M = b \left(\sum_{k=1}^{k=n} y_{ik}^2 - 2x_1 y_{i1} - ... - 2x_n y_{in} \right) \tag{5}$$

(6) When all y_i are involved in the calculation, the queried information z_i will be compared with a certain range D, and send all z_i and $A \left(b \vec{y}_i \right)^M$ that are less than the range value t(t < n) to the inquirer, and the inquirer will make the final choice.

(7) The inquirer uses the invertible matrix A and the random number b for t $A \left(b \vec{y}_i \right)^M$ in the range of t to calculate

$$\left[A^{-1} \cdot A \left(b \overrightarrow{y}_i \right)^M \Big/ b \right]^M = \overrightarrow{y}_i \tag{6}$$

Get t y_i, i = 1, 2, …, n that are closest to the input x in the queried information database.

(8) The inquirer uses $x = x_1, x_2, …, x_n$ and the random number b to calculate the received t z_i.

$$d_i{}^2 = \overrightarrow{x} \left(b \overrightarrow{y}_i \right)^M \Big/ b + \sum_{i=1}^{i=n} (x_i - y_i)^2 \tag{7}$$

Get the difference d_i , i = 1 , 2 , … , n between these t y_i and the input x of the inquirer, i = 1, 2, …, n, and the inquirer will make a final choice based on the difference value d_i among these t y_i by analyzing and comparing.

In the urban cultural communication landscape design under the background of regional information security in the Internet of Things, the algorithm realizes the protection of the privacy of the enquirer and the secure access to the geographic information database through a series of mathematical transformations and random number generation: The algorithm adopts the method of matrix transformation and random number generation, and has certain scalability in theory. The assumptions of scalability are as follows: The number of records in database Y can be increased indefinitely and the random number generator can quickly generate A high-order invertible matrix A and random numbers to meet the query needs.

However, as the number of database records increases, the computational complexity and spatial complexity of the algorithm will increase accordingly. Therefore, the scalability of the system is limited by the hardware resources. The computational complexity mainly depends on the number of matrix operations and random number generation. In the worst case, every query requires processing of every record in the database. The spatial complexity is mainly related to storing matrix A, random numbers and processed data. As the size of the database increases, so does the amount of storage required.

3.2. BP neural network model

BP neural network mainly imitates the reaction process of human brain neurons to external excitation signals, and builds a multilayer perceptron model, usually using a three-layer structure: input layer, hidden layer and output layer [24–27]. When performing BP neural network modeling and design, a nonlinear sigmoid function is used as the transfer function between the hidden layer and the output layer nodes. The expression of the sigmoid function is as follows:

$$f(u) = \frac{1}{1 - e^{-u}} \tag{8}$$

Among them, u is the value of the weighted summation of the output of each layer. The neural network algorithm defines the objective function:

$$J = \frac{1}{2} \sum_{p=1}^{N} \sum_{k=1}^{n} \left(y_k^p - y_k'^p \right)^2 \tag{9}$$

They are the network output and expected output target value when the output node k acts on the sample p, n is the dimension of the output variable, and N is the number of training sample [28,29].

3.3. Application of regional culture in landscape design

(1) The carrier of regional cultural elements in landscape design-design symbols

Semiotics was originally developed by Western scholars based on linguistics and logic. It is a general theoretical discipline for studying signs. The characteristics of design signs include cognition, universality, restriction and uniqueness, and the conception of signs in landscape design. Combinations include borrowing, deconstruction, exaggeration and communion. Understanding such symbols can help us understand the regional culture and also help us reflect the elements in the landscape design [30].

(2) Application of Regional Cultural Characteristics in Landscape Design

To carry out landscape design, we must first extract regional cultural elements. Using methods such as borrowing, transformation, and innovation can help visitors experience tradition, experience the region, and understand culture from multiple angles and ways. Secondly, we must pay attention to the use of some regional symbols, combining intuition and indirectness, and combining sensibility and cultural heritage to form a unique visual language [31].

(3) Expression Carrier of Regional Cultural Symbols

To understand the regional culture of a city, you can start with its landscape materials, local architecture, native flowers and trees,

folk customs, and folk art. Landscape materials can carry local emotions and memories. Local architecture reflects local regional characteristics. Flowers, grass and trees also contain a lot of humanity. Folk art and folk customs reflect the local cultural atmosphere [32–34].

(4) Expression Way of Regional Culture in Landscape Design

First of all, we must preserve the regional culture and minimize the destructiveness. In the inheritance of urban culture, we must not only superficially, but also dig deeper [35]. Repair and remediation are also very important to regional culture. The cultural relics usually preserved are already incomplete. Therefore, modern technology can be used to make it more perfect and innovate.

4. Comprehensive analysis on landscape design of urban culture transmission based on the regional information security of Internet of Things

4.1. Information security analysis

This research introduces a security gateway node as the root CA, manages the certificate and key to the gateway node and cluster head node, adopts a sub-regional management model, and divides it into non-overlapping hexagonal network regions, each region has one Cluster head node and several common sensor nodes,as shown in Fig. 1.
Fig. 1 shows the ratio of the number of captured nodes to the affected links. Even if key nodes such as gateway nodes and cluster head nodes are controlled by an attacker, they will not reveal important information such as communication keys and pairing keys. At the same time, during inter-regional communication, two-way authentication must be performed first, which can effectively prevent malicious nodes and establish a trust relationship between nodes. Fig. 1 shows the relationship between the number of nodes captured and the proportion of links affected. d represents the side length of the hexagonal area. Under the condition that the number of nodes captured is the same, the larger the area is, the greater the proportion of links affected, that is, the easier it is to be attacked.
Then compare different schemes against random attacks, as shown in Fig. 2.
Fig. 2 is a comparison diagram of this research scheme, the E-G scheme and the q-composite scheme against random attacks. It can be seen that this scheme has better ability to resist random attacks. When the number of nodes acquired by the adversary is equal, the communication link of this scheme will suffer the least proportion of influence.
In addition, because there is no common key space between the hexagonal grids, the information is isolated and a lot of unnecessary loss is avoided. Table 1 shows the relationship between the number of key spaces required and the number of regions. It can be seen that the larger the number of key spaces required, the greater the number of regions. When the number of required key spaces reaches a critical point, the number of regions is max.

4.2. Landscape design evaluation

Zhangjiajie City is located in the northwest of Hunan Province, in the middle and upper reaches of the Lishui River, and is situated in the hinterland of the Wuling Mountains. It is the birthplace and central area of the revolutionary base areas of Hunan, Hubei, Chongqing, and Guizhou. Due to its tourism development, it is a window for opening up in Hunan, a living room for welcoming guests, a leader in global tourism, and a beautiful business card of China. It is known as the "expanding bonsai and shrinking fairyland",and the details are shown in Fig. 3. The beautiful scenery of Zhangjiajie Scenic Area in Hunan Province is well presented in Fig. 3. In 2022, the gross domestic product of Zhangjiajie City was 59.24 billion yuan, an increase of 2.3 % compared to the previous year.
The complex and diverse geological formations in Zhangjiajie have created a unique local landscape. There are mainly mountains,
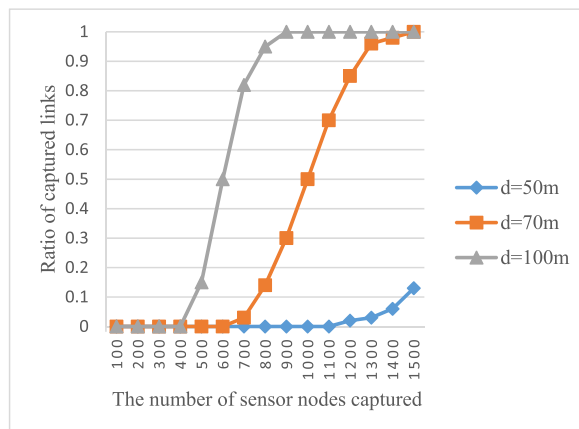

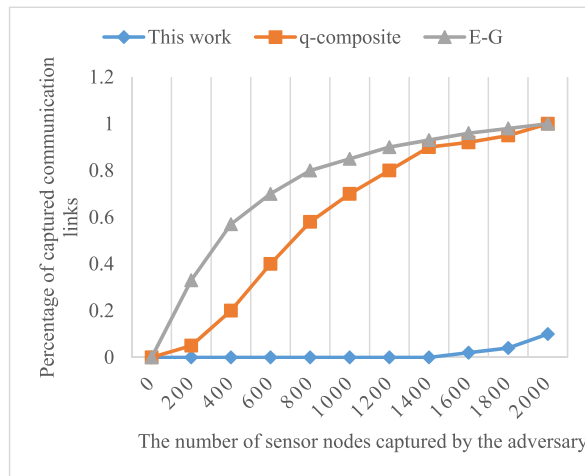**Fig. 1.** The ratio of the number of nodes captured to the link affected.

Fig. 2. Comparison of anti-random attacks.

Table 1
Total key space required.

Number of key spaces required	Number of regions
1	1
2	10
3	15
4	21
5	13

karst areas, hills and plains, with mountainous areas accounting for 76 % of the total area. Among them, the most distinctive is the quartz sandstone peak forest landform, which is rare in the world. The urban terrain is high in the northwest and slopes southeast along the Li River.

Zhangjiajie is located in the middle north latitude and belongs to the monsoon humid climate of the prototype of the subtropical mountains. It has sufficient light and heat, abundant rainfall, long frost free period, short severe cold period, and distinct four seasons. The average sunshine, temperature, and precipitation over the years are about 1440 h, 16°, and 1400 mm, respectively. The average frost free period over the years is between 216 and 269 days.

Zhangjiajie has a moderate climate, located in the middle north latitude, and belongs to the subtropical mountain prototype monsoon humid climate. Therefore, the rainfall is abundant (with an average annual precipitation of 1400 mm), the sunlight is abundant, the frost free period is long, the severe cold period is short, and the annual average temperature is around 16.6 °C. The extreme temperature in August of summer is around 37.2 °C, and the average temperature in the coldest month of winter is 4.3 °C (with January being the coldest, the extreme temperature ranges from zero to 4.5 °C). The altitude of Zhangjiajie urban area is 183 m, and the average altitude of the scenic area is 1000 m. Due to this difference, the temperature difference between day and night can reach 10 °C.

For this kind of landscape, relevant professionals will score according to the information and the advantages and disadvantages of various aspects. As shown in Fig. 4., it is divided into five levels according to the different scores, namely special level, fourth level, third level, second level and level.

In Fig. 4, the regional interpretation of these landscapes should follow the theory of ecological design, meet the functional needs of contemporary scenic spots, and adapt to the development of modern economic society. Under this premise, we extracted traditional prototypes, explored traditional technologies and local materials, and exercised modern materials and technologies to make innovative use of them to create urban scenic landscapes with regional characteristics.

4.3. Cultural communication analysis

In the process of dissemination of regional culture, there are mainly the following three types:

(1) Group Transmission

As the main body of dissemination, the local people in Zhangjiajie have a strong sense of group for Zhangjiajie culture, regardless of whether their profession is related to the Zhangjiajie Scenic Area. Group communication will form group consciousness, and after the formation of group consciousness, it will in turn affect group communication. As a group with a common sense of belonging,

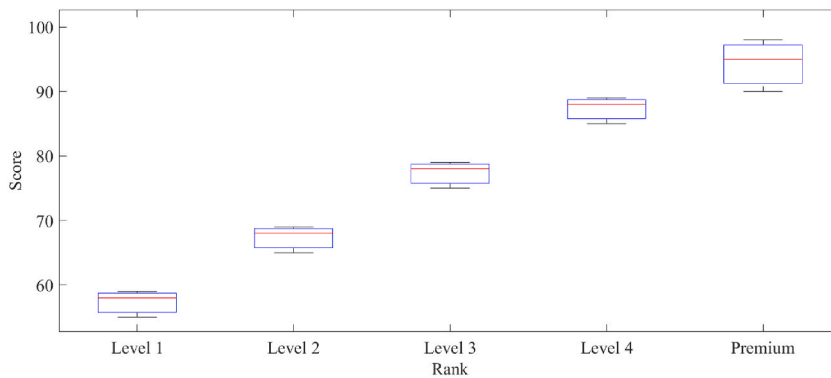**Fig. 3.** Scenic area in Zhangjiajie, Hunan.

Fig. 4. Scores of different levels of landscape.

Zhangjiajie people respect and recognize the traditional Zhangjiajie culture, so that they form a common group consciousness. Under the influence of this group consciousness, the communication effect within the group will continue to strengthen.

(2) Organizational Dissemination

In the process of spreading this kind of regional culture, the carriers of organizations are mainly divided into official and non-governmental organizations. Taking Zhangjiejie as an example, the municipal ethnic department closely cooperates with the cultural department to guide performance shows such as "Charming Xiangxi", "Tianmen Fox Immortal", and "Zhangjiajie Eternal Love" to perfectly integrate ethnic cultural heritage such as Sangzhi folk songs, waving dance, and Maogusi dance with modern stage

technology, creating a well-known tourism ethnic cultural brand. There are 5 ethnic cultural performance shows with different styles in the city, with more than 3000 performers and mass actors, and an average audience of more than 15000 people per night. More than 60 % of tourists have watched ethnic cultural performance programs. It fully showcases the ethnic customs of Zhangjiajie City to the whole country and even the world, allowing the flower of ethnic culture to bloom endlessly in scenic areas. Zhangjiajie Charming Xiangxi Tourism Development Co., Ltd., and Zhangjiajie Tianmen Fox Immortal Cultural Tourism Industry Co., Ltd., have respectively been approved as the third and sixth batches of national cultural industry demonstration bases. These tourism policies have greatly promoted the development of the local economy.

(3) Interpersonal Communication

For individuals, the locals of Zhangjiajie have been deeply influenced and nurtured by the local culture since they were born, so that this group has formed roughly the same values. Whether they are active or passive, they will learn about the history, culture, customs and other aspects of Zhangjiajie. In all aspects, under the collectivism of identity, passively cultivate the love and recognition of local culture, and actively participate in the dissemination of culture.

5. Disscusion

(1) Results

Through comparative analysis (as shown in Figs. 1 and 2), this paper proves the superiority of the proposed research scheme in resisting random attacks. Compared with the E-G scheme and Q-composite scheme, the scheme in this paper shows a smaller impact on the proportion of communication links affected. Similarly, in the real world, the results of the defense against random attacks are deficient, unstable and susceptible to influence compared with this scheme. This finding has important implications for ensuring information security in the Internet of Things environment, especially in urban cultural communication, where the secure transmission of information is the key to guaranteeing cultural authenticity and integrity. In addition, since there is no common key space between hexagonal grids, information isolation effectively avoids a large amount of unnecessary information loss, which is further verified in Table 1, indicating that there is a positive correlation between the demand for key space and the number of regions, which is of great significance for the effective management and protection of regional information security.

In terms of landscape design evaluation, Zhangjiajie City, as a case study, its unique natural landscape and suitable climate conditions provide rich resources for urban cultural dissemination. By adopting eco-design theory and exploring traditional techniques and local materials, urban landscapes with regional characteristics can be created, which not only beautifies the urban environment, but also enhances visitors' experience and awareness of Zhangjiajie culture.

(2) Implications

The analysis of cultural communication reveals three main forms of cultural communication in Zhangjiajie: collective communication, organizational communication and interpersonal communication. Collective communication strengthens cultural identity and inheritance through community activities, organizational communication expands the scope of cultural influence through systematic activities of official and unofficial organizations, while interpersonal communication enhances the emotional connection and authenticity of cultural communication in daily interactions, making the folk culture of Zhangjiajie vividly displayed to domestic and foreign tourists. Together, these forms of communication not only strengthen the local community's identity and inheritance of Zhangjiajie culture, but also spread the culture of Zhangjiajie to a wider audience through official and unofficial organization activities and interactions between individuals. In particular, through ethnic cultural performances and other activities, Zhangjiajie's folk culture is effectively displayed to tourists from all over the country and even the world. This study not only proposes an effective information security management scheme to protect data security in the process of urban cultural transmission, but also demonstrates the importance of regional characteristic ecological landscape design and cultural transmission through the case analysis of Zhangjiajie. These findings highlight the need to preserve and disseminate local culture in the context of globalization and the importance of using scientific and technological means to ensure information security.

6. Conclusion

Based on the regional information security system of the Internet of Things, this paper carries out the landscape design of urban cultural communication. It is found that the security protection ability of information system can be significantly improved and the leakage of sensitive information can be effectively prevented by constructing the security node, implementing the sub-area management model and dividing the non-overlapping hexagonal network area. At the same time, ecological theory and traditional technology are integrated into landscape design, which enhances the spreading power of urban culture and regional characteristics. Taking Zhangjiajie as an example, this paper analyzes the multi-dimensional path of cultural transmission that promotes the identification and inheritance of local culture. The contribution of this paper is to propose effective information security management strategies for the Internet of Things, and emphasize the close connection between regional cultural communication and landscape design through case studies, as well as the importance of protecting and disseminating local culture in the context of globalization. However, the shortcoming of this study is that it does not further analyze the adaptability of cultural transmission in different regions.

Future research can further combine emerging technologies to improve the efficiency and effectiveness of information security management.

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Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Weiting Li: Writing – original draft, Software, Methodology. **Zhi Yang:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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