Research Article

Construction of Tourism Area Capacity Early Warning System Based on Internet of Things Technology

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In order to make up for the shortage of smart tourism construction highlighted by public tourism safety accidents due to the bearing capacity of scenic spots, this paper proposes a tourism area capacity early warning system based on the Internet of Things technology. By combining the main characteristics of a park and a place, this paper determines the composition of its tourism capacity and the corresponding calculation methods. At the same time, in order to control the number of tourists in peak hours within a reasonable range, the peak constraint method is proposed to improve the traditional algorithm of daily space capacity; then this paper calculates the tourism capacity of a park and a place by combining the relevant data obtained by investigation and observation methods. The experimental results show that according to the given number, the instantaneous tourism capacity of a park can be accurately calculated as 11841 person times/day and the daily tourism capacity as 21313 person times/day. The instantaneous tourism capacity of a certain place is 1066 person times/day, and the daily tourism capacity is 9594 person times/day. The construction of the early warning system of the tourism area based on the Internet of Things can effectively solve the problems such as public tourism safety accidents caused by the problem of carrying capacity. It will play an important role in the customized services of tourists, the innovation of scenic spot business processes, and the integration of tourism enterprise resources and provide data support for the early warning system.

1. Introduction

With the continuous improvement of people’s living standards, people are pursuing high-quality spiritual life while meeting material needs. As a service-oriented industry, tourism has become an urgent need for people to pursue self-realization [1]. People's requirements for the service level of tourism have become higher and higher, which has prompted the transformation of tourism to meet the needs of the market. With the rapid development of tourism, the number of tourists has increased dramatically. Many scenic spots are often overcrowded and crowded in the peak tourism season, which not only greatly reduces the quality of tourists’ experience, but also poses a great threat to the ecological environment and sustainable development of the tourism destination [2].

Tourism is an information intensive industry. With the continuous innovation and development of cloud computing, the Internet of Things, artificial intelligence, and other new technologies, tourism has a new demand for information construction [3]. From the perspective of tourism destination, it is necessary to realize the integrated marketing of tourism resources with the help of information management platform to provide comprehensive and intelligent services for tourists; from the perspective of tourists, personalized and intelligent services are needed to achieve a smooth tour of the scenic spot [4]. As the core combination of tourism, how to improve the management level of tourists in scenic spots has become one of the urgent problems to be solved in the information construction of scenic spots [5, 6]. In view of the existing problems, the concept of smart tourism is introduced to build a more modern progressiveness smart
regional tourism early warning system, in order to provide reference for the construction of smart tourism. Figure 1 shows the tourist flow warning platform of tourist attractions.

2. Literature Review

As an important part of scenic spot management, the level of tourism management directly affects the satisfaction of tourists and then affects the image building of scenic spots. Due to the different emphases of the research, scholars’ understanding of tourism management is also different. Hu and Hou believe that tourist management is a process in which tourist destination managers use modern management means to achieve tourist satisfaction and tourist destination satisfaction through tourist responsibility management and tourist experience management [7]. Sorka and Wojciechowska-Solis believe that tourist management is the organization and management of the whole process of tourists’ activities in the scenic spot, taking tourists as the management object. It is a part of scenic spot management [8]. Suklabaidya and Aggarwal believe that tourist management is the organization and management of the whole process of tourist behavior by tourism management departments or institutions using information, technology, education, and other means. Through the regulation and management of tourist capacity, behavior, safety, etc., the attraction of tourism resources and environment is strengthened, so as to improve the quality of tourist experience and satisfaction and achieve the sustainable development of tourism destinations [9]. Rivera believes that tourist management means that the scenic spot managers take tourists as the management object to organize and manage the activities of tourists in the scenic spot in the whole process, so as to ensure the long-term and stable development of tourism activities in the scenic spot [5]. According to the concept of tourist management, it can be seen that tourist management in scenic spots is a management activity with tourists as the management object, tourist behavior and its influencing factors as the management content, and the maximization of comprehensive benefits of tourist destinations as the management objective [10, 11]. According to different emphases of tourist management, tourist management modes can be divided into three types: environment oriented, tourist oriented, and environment tourist oriented. The main goal of environmental orientation is to protect the environment of tourism destination by controlling the number of tourists and standardizing the behavior of tourists [12]; the tourist-oriented management mode is to take tourists as the center and improve tourist satisfaction as the goal; the environment tourist-oriented management mode is to meet the needs of tourists to the greatest extent on the premise of protecting resources and environment, so as to achieve the sustainable development of tourism destinations.

In view of the above problems, although tourism management departments and tourism scholars at home and abroad attach great importance to the issue of tourism environmental capacity in tourism planning and give calculation formulas in theory, the application value is limited because researchers blindly pursue the fixed number of scenic spot tourism environmental capacity and simply apply various calculation formulas of tourism environmental capacity. In fact, tourism environmental capacity has certain dynamic characteristics [13]. Therefore, it is of more practical significance to explore the tools and methods of tourism environmental capacity management with practical application.
value. With the development and application of emerging science and technology, weakening the calculation and research of theoretical capacity and paying attention to the research of capacity regulation mechanism will certainly become the direction of tourism environmental capacity research [14].

3. Research Methods

3.1. Calculation of Tourism Capacity

3.1.1. Peak Constraint Method

(1) Peak Constraint Index. At present, scholars have found that there is a certain proportion between the number of tourists received by the scenic spot and the maximum number of tourists during peak hours for scenic spots with certain regularity of daily passenger flow. Through the analysis of the data obtained from the field survey, it is found that there is also a certain proportional relationship between the number of daily tourists received by a park and the maximum number of tourists in peak hours (see Table 1). The correlation test is carried out by Spss20.0, and the result is \( r = 0.9343 \) (0.7). The results show that there is a significant correlation between the number of visitors received in a park and the maximum number of visitors in peak hours; that is, the proportional relationship between the number of visitors waiting in a park and the maximum number of visitors in peak hours is established. Therefore, this paper proposes that the peak constraint index \( g \) represents the ratio between the daily number of tourists \( m \) received by the scenic spot and the maximum number of tourists \( m \) during peak hours. If the peak constraint index \( g \) is stable, the total daily number of tourists received by the scenic spot can be determined by this value and the instantaneous spatial capacity of the scenic spot [15]. Due to the limited access to daily visitor volume data, this paper mainly theoretically verifies the stability of the peak constraint index \( G \).

(2) Theoretical Verification of Exponential Stability with Peak Constraint. In this paper, the stability of peak constrained index \( g \) is theoretically verified by some assumptions and Bernoulli’s law of large numbers in probability [16].

In this paper, the time when tourists enter the scenic spot is regarded as a random variable \( \alpha \), and the probability of tourists entering the scenic spot at time \( x \) is recorded as \( f_1(x) = p(\alpha \leq x) \), where \( f_1(x) \) is the distribution function of random variable \( \alpha \). Assuming that the time when \( m \) tourists enter the scenic spot in a day follows the same distribution function, and the time when each tourist enters the scenic spot is independent of each other, when \( m \) is infinite, according to Bernoulli’s law of large numbers, the number of tourists entering the scenic spot before time \( x \) can be approximately \( M \times f_1(x) \). In the same way, the time when tourists leave the scenic spot is regarded as a random variable \( \beta \), and the probability of tourists leaving the scenic spot at time \( x \) is recorded as \( f_2(x) = p(\beta \leq x) \), where \( f_2(x) \) is the distribution function of random variable \( \beta \). Assuming that the time when \( m \) tourists leave the scenic spot in a day obey the same distribution, and the time when each tourist leaves the scenic spot is independent of each other, when \( m \) is infinite, the total number of tourists leaving before time \( x \) can be approximately \( M \times f_2(x) \). Therefore, the number of tourists in the scenic spot at time \( x \) can be expressed by \( M \times f_1(x) - M \times f_2(x) \), and the ratio \( G(x) \) of the number of tourists in the scenic spot at time \( x \) to the total number of tourists received can also be obtained, that is, \( G(x) = M[f_1(x) - f_2(x)] = 1/[f_1(x) - f_2(x)] \). It can be seen from this that within a certain range of \( m \), if the rules for tourists to enter and leave the scenic spot remain the same, and the peak time of tourists remains the same, it can be considered that the peak constraint index \( g \) is relatively stable.

At present, for a park, the time for tourists to enter and leave the scenic spot has a certain regularity, and the peak time of tourists also shows a certain regularity. In addition, as the development of the scenic spot is quite mature, the factors that may change the daily behavior of passenger flow, such as resource type, functional zoning, location traffic, tourist routes, and opening hours, are basically stable. Therefore, for a park, the peak constraint index \( g \) is relatively stable.

(3) Peak Constraint Method. In order to limit the number of tourists in the peak period to the instantaneous spatial capacity of the scenic spot, this paper improves the algorithm based on the previous spatial capacity based on the peak constraint index \( G \) and puts forward a new method: the peak constraint method, \( C = CO \times G \) [17]. At present, the applicable algorithms for instantaneous space capacity include “area method,” “trail method,” and “bayonet method.” In combination with the fact that the physical space that visitors can visit in a park is mainly planar, this paper uses “area method” to calculate the instantaneous space capacity of the scenic spot [18]. At the same time, according to previous experience, tourists’ demands for basic space standards are different in different space places, but the existing “area method” usually takes the scenic spot as a class of space to calculate, without considering this factor. Therefore, this paper also needs to fully consider the impact of different types of space in a park on the calculation results of space capacity. The specific formula is as follows. The tourable physical space of a park can be divided into indoor architectural space of main scenic spots, indoor architectural space of other scenic spots, outdoor human landscape tourable space, and outdoor natural landscape tourable space.

\[
C = \frac{\sum_{i=1}^{n} S_i}{A_i},
\]

\[
C = C \times G = \frac{\sum_{i=1}^{n} S_i \times M}{m},
\]

where \( M \) is the daily number of tourists received by the scenic spot; \( m \) is the maximum number of tourists in peak
hours; \( n \) refers to the number of physical space types that different tourists can visit; \( S_i \) refers to the area of physical space that class \( i \) tourists can visit; \( A_i \) refers to the basic space standard of physical space that class \( i \) tourists can visit; and \( G \) refers to the peak constraint index, which is the ratio of the daily number of tourists \( m \) received by the scenic spot to the maximum number of tourists \( m \) during peak hours [19].

### 3.1.2. Calculation Method of Tourism Capacity

#### (1) Calculation of Space Capacity. Since there is no obvious regularity in the time when tourists go in and out of a place every day, and most of the time, especially on holidays, the number of tourists in the building will be in a relatively large state from the opening time to the closing time of the scenic spot. At the same time, considering that the accessible physical space in a certain place is planar, this paper mainly adopts the “area method” commonly used by scholars, combined with the daily average turnover rate of scenic spots, to calculate its instantaneous space capacity and daily space capacity. The specific formula is as follows.

\[
C = \frac{A}{A_0},
\]

\[
C = C \times Z = \frac{A}{A_0} \times \frac{T}{t},
\]

where \( A \) refers to the area of physical space that tourists can visit; \( A_0 \) refers to the basic space standard of tourists; \( T \) refers to the effective opening hours of the scenic spot every day; \( t \) refers to the average visiting time of each tourist in the scenic area; and \( Z \) refers to the daily average turnover rate of the whole scenic spot, that is, the integer part of \( T/t \).

#### (2) Measurement of Psychological Capacity. Generally, scholars will use the “area method” to approximate the psychological capacity by taking the personal occupied area when the average satisfaction of tourists is the largest as the basic space standard [20]. However, since the psychological factors of tourists are considered to some extent when calculating the spatial capacity, it is not appropriate to use the spatial capacity algorithm to approximate the psychological capacity. According to previous studies, with the increase of the number of tourists, the sense of crowding of tourists will gradually increase, and after exceeding a certain number, the negative impact of the sense of crowding on the satisfaction of tourists will gradually become significant and enhanced [21]. Therefore, this paper can explore the impact of tourists’ perception of crowding on the tourist experience, build a tourist satisfaction model, and determine the instantaneous psychological capacity. Daily psychological capacity is mainly calculated based on the instantaneous psychological capacity and daily turnover rate of the scenic spot. The specific formula is as follows.

\[
C = C_p \times Z = C_p \times \frac{T}{t},
\]

where \( C_p \) refers to the instantaneous psychological capacity, which is mainly calculated by constructing the tourist satisfaction model; \( T \) refers to the effective opening hours of the scenic spot every day; \( t \) refers to the average travel time of each visitor in the scenic area; and \( Z \) refers to the daily average turnover rate of the whole scenic spot, that is, the integer part of \( T/t \) [22].

#### (3) Determination of Final Capacity. Since the tourism capacity of a certain place is only considered from the psychological capacity and spatial capacity, in order to ensure the tourist experience, according to the barrel theory, the minimum value of different capacity values should be taken as the actual tourism capacity of a certain place.

\[
C = \min \{ C_{\text{Spatial capacity}} \times C_{\text{Mental capacity}} \}.
\]

### 3.2. Sample Statistics. The sample statistics of visitors to a park are shown in Table 2. It can be seen from the table that the number of male and female respondents is basically the same in terms of gender; in terms of age, the group aged 15-24 has the most respondents, followed by the group aged 25-44 and over; in terms of occupation, the number of students is the most because a park is implementing the free ticket policy, and students, especially college students, will have more free time to visit; in terms of educational background, the interviewees generally have high school education or above, and their overall quality is high, which is conducive to improving the accuracy of the questionnaire. In terms of income, the group with less than 2000 yuan has the largest number, followed by the group with 4001-6000 yuan.

Generally speaking, the different nature, place, and population density of the tourist destination will affect the tourists’ perception and satisfaction with the crowding of a certain space. At present, domestic scholars have achieved good results by using questionnaires to obtain basic spatial standards for different tourism spaces in tourism destinations. Therefore, according to the previous research results and the standard values of some standards and norms, this paper can obtain a reasonable basic space standard through a questionnaire survey of tourists.

### Table 1: Daily total number of tourists and daily maximum number of tourists in the scenic spot at different times.

| Date    | 11.23  | 11.24  | 11.25  | 11.26  | 11.27  | 11.28  | 11.29  |
|---------|--------|--------|--------|--------|--------|--------|--------|
| M/N     | 1.71   | 1.78   | 1.75   | 1.76   | 2.18   | 1.68   | 1.73   |
| Daily number of visitors \( M \) | 14234 person | 13542 person | 15741 person | 14281 person | 17542 person | 21563 person | 21954 person |
| Maximum number of tourists \( m \) | 8312 person | 7601 person | 9012 person | 8114 person | 8034 person | 12841 person | 13254 person |

Note: The table data is based on actual survey results and is used to illustrate the calculation of tourism capacity.
From November 23 to 29, 2020, the author conducted a survey on the tourist space standards and collected 497 valid questionnaires. The survey results are shown in Table 3.

Statistical items can reflect tourists’ subjective perception of per capita space. The minimum area interval takes the maximum value, the maximum area interval takes the minimum value, and other area intervals take the average value. Different space standards can be obtained based on the weight method: basic space standards for indoor building space of major scenic spots:

\[ S_1 = 0.25 \times 4.23\% + 0.625 \times 15.90\% + 1.625 \times 47.08\% + 3.125 \times 18.31\% + 4 \times 14.49\% = 2.03 \text{ m}^2. \]  

(7)

Basic space standards for interior space of buildings in other scenic spots:

\[ S_2 = 0.25 \times 48.09\% + 0.625 \times 20.32\% + 1.625 \times 16.30\% + 3.125 \times 12.27\% + 4 \times 3.02\% = 1.02 \text{ m}^2. \]  

(8)

Basic space standards for outdoor human landscape tourable space:

\[ S_3 = 1 \times 1.61\% + 2.5 \times 39.44\% + 6.5 \times 42.86\% + 12.5 \times 12.27\% + 16 \times 3.82\% = 5.93 \text{ m}^2. \]  

(9)

Basic space standards for outdoor natural landscape tourable space:

\[ S_4 = 1 \times 27.97\% + 2.5 \times 39.64\% + 6.5 \times 18.31\% + 12.5 \times 11.67\% + 16 \times 2.41\% = 4.35 \text{ m}^2. \]  

(10)

Therefore, the basic space standard for indoor space of buildings in major scenic spots is 2 m², that of buildings in other scenic spots is 1 m², that of outdoor human landscape is 6 m², and that of outdoor natural landscape is 4 m².

According to the data processing obtained from the survey, the indoor space area of the main scenic spot buildings is 2827 m², and the basic space standard is 2 m²; the area of
The indoor space of buildings in other scenic spots is 5052 m², and the basic space standard is 2 m²; the area of outdoor natural landscape sightseeing space is 29143 m², and the basic space standard is 2 m²; the area of outdoor human landscape sightseeing space is 2076 m², and the basic space standard is 2 m² (see Tables 4 and 5). In order to accurately reflect the general trend of data changes, this paper takes the average value as the peak constraint index G, that is, the value of G is 1.80. By substituting the above data into formulas (1) and (2), the instantaneous space capacity of a park is 11841 person times/day, and the daily space capacity is 21313 person times/day.

3.3. Calculation of Tourism Capacity. The building area of a certain place is 3321 m². According to the field measurement, the actual area of accessible space is about 2132 m². At the same time, according to the investigation, the basic space standard in the building is 2 m²; the area of outdoor human landscape sightseeing space is 2076 m², and the basic space standard is 2 m² (see Tables 4 and 5). In order to accurately reflect the general trend of data changes, this paper takes the average value as the peak constraint index G, that is, the value of G is 1.80. By substituting the above data into formulas (1) and (2), the instantaneous space capacity of a certain place is 11841 person times/day, and the daily space capacity is 21313 person times/day.
1066 person times/day, and the daily space capacity is 9594 person times/day.

Based on the impact of tourists’ perception of crowding on the tourist experience, this paper constructs a satisfaction model to measure the psychological capacity of main scenic spot \( a \). In order to ensure the tourists’ experience, and in combination with the assignment of tourists’ perception of crowding, it can be seen that 3 is the critical value of tourists’ satisfaction, and the per capita tourists’ satisfaction score cannot be lower than 3. When \( y \) is taken as 3, it is substituted into

\[
y = -0.00001x^2 + 0.00711x + 2.82311. \tag{11}
\]

Finally, \( X \) is 685, so the instantaneous psychological capacity of a place is 685 person times/day. At the same time, by substituting the instantaneous psychological capacity value into formula (5), the daily psychological capacity of a place can be calculated to be 6165 person times/day.

4. Result Analysis

According to the above calculation, the instantaneous space capacity of a certain place is 1066 person times/day, the daily space capacity is 9594 person times/day, the instantaneous psychological capacity is 685 person times/day, and the daily psychological capacity is 6165 person times/day. Based on formula (11), the instantaneous tourism capacity of a certain place is finally determined to be 1066 person times/day, and the daily tourism capacity is 9594 person times/day. Finally, the tourism capacity calculation results of scenic spot A and scenic spot B are shown in Figure 2.

Through the analysis of the characteristics of a park, it is considered that the spatial capacity can best reflect the actual tourism capacity of the scenic spot. At the same time, through the analysis of the general algorithm of spatial capacity, it is found that the existing methods cannot ensure that the number of tourists in a park can be maintained within the instantaneous spatial capacity during the peak period. Therefore, the peak constraint method is proposed to improve the daily spatial capacity algorithm of a park. Finally, the instantaneous tourism capacity of a park is 11841 person times/day, and the daily tourism capacity is 21313 person times/day. By analyzing the characteristics of a certain place, it is considered that the spatial capacity and psychological capacity can accurately reflect the actual tourism capacity of the scenic spot. Finally, combined with the barrel theory, it is determined that the instantaneous tourism capacity of a certain place is 1066 person times/day, and the daily tourism capacity is 9594 person times/day.

5. Conclusion

With the development of tourism informatization, the personalized demand of tourists has become increasingly strong, especially the research on the capacity early warning system of scenic spots. With the change of tourists’ consumption behavior, tourists’ demands for tourism information services have become increasingly strong. The capacity early warning system of scenic spots will play an important role in the customized services of tourists, the innovation of scenic spot business processes, and the integration of tourism enterprise resources. This paper predicts and monitors the tourist quality, which provides a basis for the scenic spot to alleviate congestion and improve the tourist quality. The construction of tourism area early warning system can effectively solve the problems such as public tourism safety accidents caused by the problem of carrying capacity and will play an important role in the customized services of tourists, the innovation of scenic area business processes, and the integration of tourism enterprise resources.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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