Research Article

Evaluation Method of Resource Development Effect of Cultural Industry Based on Wireless Sensor Technology

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To overcome the problems of low evaluation accuracy and efficiency existing in traditional resource development efficiency evaluation methods, this paper proposes a new evaluation method of cultural industry tourism resource development effect based on wireless sensor technology. The method takes into account the data of cultural industry resource development collected by the wireless sensors and transmits it to the computer system by wireless transmission technology. Based on the collected development data, the evaluation index system is constructed and the index weight is calculated. Furthermore, the multiobjective weighted function is employed to calculate the development effect evaluation score and complete the evaluation of cultural industry resources development effect. Experimental results show that the proposed method can successfully improve the evaluation accuracy and efficiency, and the highest evaluation accuracy is stable at 98%. Therefore, this method has high reliability.

1. Introduction

Cultural industry resources are dynamic, nonexclusive, and renewable spiritual wealth. The essence of the development of the cultural industry is the value realization process of cultural resources transforming into cultural products and services. However, the advantage of cultural resources cannot be naturally transformed into the advantage of the industry [1]. The strength of innovation and inspiration is the key to determine the number of cultural resources and the success of development and utilization. Therefore, it is important to examine the development and utilization of cultural resources with a new concept under the current situation of vigorously developing cultural industry in China [2].

How to recognize cultural resources, sort out and classify them, and scientifically divide them at the level of industrial development is the premise and basis for the development and protection of cultural resources in the process of cultural industry development. People’s understanding of cultural resources must be based on the understanding of culture. Corresponding to the diversity of cultural understanding, people’s understanding of cultural resources is also very different, because the elements of cultural resources are very broad, including not only science and technology, education, and other factors but also the whole social and cultural network, as well as the traditional and foreign cultural factors in real life [3]. Generally speaking, all the achievements of civilization with cultural significance and the activities, objects, events, and even some celebrities and famous cities with certain cultural significance created in the process of human development are all cultural resources of some form.

In terms of form, cultural resources can be divided into tangible cultural resources (such as historical relics, characteristic residential buildings, historical and cultural cities, towns, characteristic costumes, and national and folk crafts) and intangible cultural resources (such as language, literature, and art, painting, music and dance, myths and legends, customs, and national festivals). In terms of content, cultural resources can be divided into historical cultural resources, national cultural resources, religious cultural resources, and
regional cultural resources (such as urban culture and rural culture). From the perspective of cultural industry development, cultural resources can be divided into exploitable resources and undevelopable resources [4].

However, this division is not the ultimate goal, the important thing is to clarify the content of cultural resources and the characteristics of cultural resources in contemporary times, to better develop cultural resources. In the process of the development of cultural industry resources, the evaluation of the development effect of cultural industry resources can effectively improve the effectiveness of the development of cultural industry resources. Therefore, many scholars have studied the evaluation method of the development effect of cultural industry resources.

Wu et al. [5] proposed the evaluation method of cultural industry resource development effect based on the classification method. This method first normalizes the data of cultural industry resource development and establishes the resource development efficiency curve. Based on the results of the curve, the reciprocal of the curve was used as the evaluation criterion to divide the development effect, and the effect classification evaluation method was established to evaluate the effect of cultural industry resource development. However, the evaluation index of this method was too single to comprehensively evaluate the development effect. Chena et al. [6] introduced the evaluation method of cultural industry resource development effect based on the cloud model. Firstly, the evaluation index set of cultural industry resource development effects was selected and established, and then the weight cloud and evaluation cloud of each evaluation index was constructed. Finally, based on the cloud algorithm, the evaluation effect of cultural industry resource development was calculated. However, this method has the problem of low evaluation accuracy. Song and colleagues [7] developed the evaluation method based on impression space. Firstly, the concept of impression space was used as the evaluation index of the development effect of cultural industry resources. Secondly, it analyzed the impact of development type, development mode, development process, and other characteristics on the evaluation standard of cultural industry resources development effect. They introduced the local characteristics of resource development, analyzed the layout characteristics of resource development, and completed the evaluation of the cultural industry resource development effect. Lu et al. [8] employed a two steps data envelopment analysis model to evaluate the profitability and marketability of 22 Taiwanese cultural and creative companies. The network-based ranking approach was applied to identify benchmark inputs/outputs and the strengths and weaknesses of each company. Xu et al. [9] used a fuzzy comprehensive evaluation method for analyzing oilfield companies. Membership functions were established to get the evaluation set of each index and the conclusions about the development performance of the oilfield were drawn from these evaluation sets. However, the evaluation effect of this method is low, which cannot meet the needs of evaluation.

To solve the problems of low evaluation accuracy and efficiency existing in the traditional methods, this paper proposed a novel evaluation method of cultural industry resource development effect based on wireless sensors technology. The multiobjective optimization function was used to calculate the development effect evaluation score and complete the evaluation of cultural industry resources development effect. Experimental results showed that the proposed method can successfully improve the evaluation accuracy and efficiency, and the highest evaluation accuracy achieved is 98%.

The rest of the paper is organized as follows. Section 2 describes the methodology of the proposed evaluation approach. Section 3 illustrates the proposed evaluation method. In Section 3, different results are given for model evaluation. Finally, the conclusion is given in Section 4.

2. Methodology

2.1. Data Acquisition. The data acquisition wireless sensors system is comprised of three different modules. The structure of the wireless sensor system is shown in Figure 1. The main modules of the wireless sensor are as follows:

(i) Data acquisition module: it is mainly composed of various sensors for measuring parameters, and the measured cultural industry resource development parameters are sent to the data processing module through the serial port after A/D conversion [8].

(ii) Data processing module: the data processing module adopts 32 ARM7 microprocessor LPC2210 as the processor of ZigBee wireless sensor data management, which is an important part of the data processing module. LPC2210 has 16kB RAM, 76 general I/O ports, 12 independent external interrupt pins, and an 8-channel 10-bit A/D converter. With the help of LPC2210’s powerful data processing and abundant pin functions, after the data of the data acquisition module is processed and packaged, the data is transmitted to the radio frequency module via the SPI port for wireless transmission [9].

(iii) Communication module: the data communication module is comprised of an RFID system. We have focused on ZigBee technology for wireless communications. ZigBee has advantages for accurate localization and easy transmission.

Due to the huge amount of resource data in the cultural industry, when wireless sensor technology is used for data collection and transmission, it is necessary to ensure that the energy consumption of wireless sensor nodes is minimized [10]. The CMCH algorithm is used to calculate the energy consumption of data sending and receiving. When a node sends data if the sending distance is less than $d_0$, the free space model is adopted; otherwise, the multipath attenuation model is adopted. The energy consumption calculation formulas of nodes transmitting and receiving data of $l$ bit length are given in equations (1) and (2), respectively.
\[
E_{Tx}(l, d) = \begin{cases} 
1E_c + l\varepsilon_a d^2, \\
1E_c + l\varepsilon_{mp} l^4,
\end{cases}
\] (1)

\[
E_{Rx}(l) = lE_c,
\] (2)

where \(d\) represents the data transmission distance, \(E_c\) represents the circuit energy consumption of wireless transmitting or receiving data of unit length, and \(\varepsilon_a\) and \(\varepsilon_{mp}\) are the amplifier power parameters of the free space model and multipath attenuation model, respectively.

\(E_{DA}\) is used to represent the energy consumption of data acquisition per unit length [11], and the energy consumption of \(p\) data acquisition nodes with all lengths of \(l\) is

\[
E_{DA}(p, l) = pE_{DA}.
\] (3)

Through the control of wireless sensor energy consumption, it can effectively achieve the collection of cultural industry resource development data.

2.2. Evaluation on the Development Effect of Cultural Industry Resources

2.2.1. Evaluation Index System. To evaluate the development effect of cultural industry resources, it is necessary to first build an evaluation index system based on the collected data of cultural industry resources development, with reference to the principles of scientific, feasible, complete, concise, hierarchical, stable, independent, and easy to obtain development effect of evaluation [12]. The evaluation index of cultural industry resource development effect is divided into three levels: target level \(A\), criterion level \(B\), and index level \(C\) [13]. The criterion layer is composed of four parts: the development system of cultural industry \(B_1\), the development system of cultural resources \(B_2\), the resource-based system of cultural industry \(B_3\), and the implementation system \(B_4\) of sustainable development of the cultural industry. The index layer is composed of the quantity and development speed of the cultural industry. The structure of the proposed index system is shown in Table 1.

2.2.2. Index Weight. Index weights are used to determine how much weight each component will be assigned in the index. For the comprehensive evaluation of the development effect of cultural industry resources, the uncertainty of index weight has a decisive impact on the evaluation results [14]. Among many methods to determine the weight of indicators, a large number of practical studies show that the analytic hierarchy process is one of the most widely used methods. It can quantitatively analyze the qualitative results, determine the weight of indicators by using the AHP method, divide various factors in complex problems into orderly levels [15], and then invite 11 relevant experts to compare and score layer by layer by using the pairwise comparison method. AHP provides a rational framework for a needed decision by quantifying its criteria and alternative options, and for relating those elements to the overall goal.

AHP is unique because it can quantify criteria and alternatives.

By comparing with the values given in Table 2, we can get the discriminant matrix between the four criteria layers. Similarly, we can get the discriminant moment between the index layers. Through the operation of the judgment matrix, we can get the index weight, as shown in Table 3.

2.2.3. Consistency Detection. It is not difficult to get their respective eigenvectors \(\lambda_{max}\) in the five evaluation matrices composed of the four kinds of indexes in the criterion layer and internal indexes \(B_1, B_2, B_3\), and \(B_4\). To test the consistency of the matrix, it is necessary to calculate its consistency index:

\[
I_C = \frac{(\lambda_{max} - n)}{(n - 1)}.
\] (4)

When \(I_C = 0\), the judgment matrix has complete consistency [16]. The larger \(\lambda_{max} - n\), \(I_C\), the worse will be the consistency of the judgment matrix. Thus, the average random consistency index of the judgment matrix is shown in Table 4.

When \(R_C = I_C/I_R < 0.1\) (where \(R_C\) is the consistency detection value; \(I_R\) is the average random consistency index), the judgment matrix has satisfactory consistency, that is to prove that the data is valid; otherwise, the judgment matrix needs to be adjusted [17]. The main characteristic values and consistency test values of each index are shown in Table 5.

It can be seen from Table 5 that the average \(R_C\) is much lower than 0.1. Therefore, it can be examined that the above matrix is consistent and its indicators and other data are feasible.

2.2.4. Effect Evaluation. Based on the current status of the development of cultural industry resources and related data in recent years, combined with the evaluation of similar domestic cultural industry resource development effects [18], the expert group determined the evaluation level of each single-level indicator and solicited the opinions of some professionals. The final feedback was given to the expert group [19], combined with the opinions of the expert group and professionals in various industries; the grading scores shown in Table 6 were obtained.

Each index of the evaluation of the development effect of cultural industry resources reflects the development situation of cultural industry resources from different angles [20, 21], so the comprehensive scoring function adopts the multiobjective weighting function, and its expression is as follows:

\[
P = \sum_{i=1}^{n} \left( \sum_{j=1}^{n} I_j \times R_j \right) \times W_i,
\] (5)

where \(P\) is the comprehensive evaluation value of the development effect of cultural industry resources, \(I_j\) is the core value of the \(j\) index, \(R_j\) is the weight of the index, and \(W_i\) is the weight of the four systems at the criterion level.
To clearly distinguish the development effect of cultural industry resources, after repeated discussion with relevant experts, the rating standard and score of cultural industry resources development effect are finally transformed and corresponding, and the results are shown in Table 7.

According to the score calculation results, corresponding to the evaluation standard of cultural industry resource development effect, the evaluation of cultural industry resource development effect can be completed.

### 3. Experimental Results and Verification

To verify the practical application performance of the proposed evaluation method of cultural industry resource development effect based on wireless sensor technology, a comparative simulation experiment was carried out. To reduce the experimental error and improve the reliability of the experimental results, the environmental parameters and experimental scheme are strictly defined before the
experiment. The experimental environment parameters are shown in Table 8.

(i) Experimental scheme: taking the evaluation accuracy and efficiency as the experimental comparison indexes, the method in this paper is compared with the methods given in [5] and [6].

(ii) Evaluation accuracy: evaluation accuracy refers to the degree of conformity between the evaluation results of different methods and the actual development effect. The higher the evaluation accuracy is, the stronger the effectiveness of the evaluation method is.

| Score | Meaning |
|-------|---------|
| 1     | The two elements are of equal importance |
| 3     | Compared with the two elements, A is slightly more important than B |
| 5     | Compared with the two elements, A is more important than B |
| 7     | Compared with two elements, A is highly important than B |
| 9     | Compared with the two elements, A is extremely important than B |
| 2, 4, 6, 8 | They represent the intermediate value of the above judgment |
| Reciprocal | The order of A and B before and after the exchange is the inverse |

| Table 2: Meaning of pairwise comparison scores. |

| Table 3: Weights of the evaluation index system for the development effect of cultural industry resources. |

| Criterion layer B | Criteria layer weight \( W \) | Index layer C | Index layer weight \( W \) |
|-------------------|-----------------|-------------|-----------------|
| Cultural industry development system \( B_1 \) | 0.167140 | Quantity of cultural industry \( C_{11} \) | 0.125899 |
| | | The development speed of the cultural industry \( C_{12} \) | 0.331386 |
| | | The efficiency of cultural industry development \( C_{13} \) | 0.234325 |
| | | Benefits of cultural industry resources development \( C_{14} \) | 0.308389 |
| Cultural resources development system \( B_2 \) | 0.118186 | The resource growth rate of the cultural industry \( C_{21} \) | 0.065509 |
| | | Resource density of cultural industry \( C_{22} \) | 0.053740 |
| | | Share of cultural industry resources \( C_{23} \) | 0.142265 |
| | | Utilization rate of cultural industry resources \( C_{24} \) | 0.205970 |
| | | Development rate of cultural industry resources \( C_{25} \) | 0.063825 |
| | | Resource level of cultural industry \( C_{26} \) | 0.277216 |
| | | Awareness of sustainable development of cultural industry resources \( C_{27} \) | 0.0191475 |
| Resource-based system of cultural industry \( B_3 \) | 0.261589 | Diversity of cultural industry resources \( C_{31} \) | 0.0160520 |
| | | Resource coverage of the cultural industry \( C_{32} \) | 0.106088 |
| | | Abundance of cultural industry resources \( C_{33} \) | 0.183750 |
| | | Current situation of cultural industry resources development \( C_{34} \) | 0.075016 |
| | | Development and protection of cultural industry resources \( C_{35} \) | 0.196597 |
| | | Protection degree of cultural industry resources \( C_{36} \) | 0.278030 |
| Implementation system of sustainable development of cultural industry \( B_4 \) | 0.453081 | Investment of development funds \( C_{41} \) | 0.354523 |
| | | Technical level of resource development \( C_{42} \) | 0.354523 |
| | | Policy support \( C_{43} \) | 0.130781 |
| | | Human resource investment \( C_{44} \) | 0.160174 |

| Table 4: Average random consistency index of matrices of orders 1–9. |

| Order number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|--------------|---|---|---|---|---|---|---|---|---|
| \( I_R \)    | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |
(iii) Evaluation efficiency: evaluation efficiency refers to the evaluation time of different methods. The shorter the evaluation time is, the higher the evaluation efficiency of evaluation methods is.

3.1. Evaluation Accuracy. The comparative results of the evaluation accuracy of the three methods are shown in Figure 2.

It can be seen from the comparison results of evaluation accuracy in Figure 2 that the evaluation accuracy of the method
in this paper is always stable at 98% in the process of multiple comparison experiments, while the evaluation accuracy of the method in [5] always fluctuates around 50%–70% and that of the method in [6] fluctuates the most, with the fluctuation range of 20%–70%. Therefore, this method has high evaluation accuracy and high stability.

3.2. Evaluation Efficiency. The comparative results of the evaluation efficiency of this method with the methods given in [5] and [6] are shown in Table 9.

Analysis of the evaluation time results shown in Table 2 shows that the average evaluation time of this method is much lower than that of the two literature comparison methods. The average evaluation time of this method is 2.73 min, that of the method in [5] is 8.663 min, and that of the method in [6] is 11.734 min, respectively. Therefore, this method can complete the evaluation of cultural industry resources development effect in a short time.

4. Conclusion

To improve the accuracy and efficiency of the evaluation of the development effect of cultural industry resources, the evaluation method of the development effect of cultural industry resources based on wireless sensor technology was proposed. The performance of the proposed method was verified theoretically and experimentally. This method has higher evaluation precision and lower evaluation time when evaluating the effect of cultural industry resources development. Specifically, compared with the method based on classification, the evaluation accuracy was significantly improved, and the highest evaluation accuracy obtained is 98%. Compared with the method based on the cloud model, the average evaluation time is 2.73 min. Therefore, it fully shows that the proposed evaluation method based on wireless sensor technology can better meet the requirements of cultural industry resource development effect evaluation.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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