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PAPER

Rural Tourism Management Cloud Service Platform Based on Interactive Mobile Embedded Systems

Shanshan Luo(✉)

Department of Tourism Management, Shanxi Vocational College of Tourism, Taiyuan, Shanxi Province, China

luoshansn@163.com

ABSTRACT

Aiming to address the issues of low data execution efficiency and slow storage speed on traditional tourism cloud service platforms, a rural tourism management cloud service platform based on an embedded system is proposed. The embedded device components, such as the ARM processor, NOR Flash memory, and RTL network chip, are utilized to optimize the hardware structure of the cloud service platform. This optimization aims to enhance data processing and storage efficiency, as well as improve the reliability and durability of system operation. The unstructured feature grasping algorithm is employed to gather rural tourism resource data for target demand characterization. Associated algorithms are then utilized to develop data analysis, service recommendation, and tourism management modules, creating a comprehensive tourism cloud service platform. Additionally, the shortest path algorithm is used to enhance database storage speed, improve business docking efficiency, establish a big data monitoring center, comprehensively monitor changes in the scenic area and related industries, and enhance platform service efficiency. It has been proven through experiments that the latency of the tourism management cloud service platform, based on the embedded system, is reduced by almost 46.7% compared to the traditional approach, and the throughput is increased to 0.69 b/s. The practical application effect is positive, as it contributes to the development of tourism resources and the economic growth of rural areas. It also brings about economic and social benefits.

KEYWORDS

embedded system, rural tourism management, cloud service platform, big data analysis

1 INTRODUCTION

Under the backdrop of the current rapid development of information technology, social production and life are increasingly moving towards informatization and intelligence. With the improvement of social and economic levels, people's demand for tourism, entertainment, and other resources is increasing, which greatly promotes the positive development of tourism. However, due to the imbalance in the allocation of resources between urban and rural areas, rural tourism resources have not been

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effectively developed. Furthermore, the lack of technical support for information technology makes it challenging to drive regional economic development. Therefore, the establishment of a cloud service platform for rural tourism resources holds significant economic and social value. Literature [1] presents a smart tourism information system designed using virtual display technology. It includes a detailed analysis of the system's logical and data layers, optimization of key functional technologies within sub-modules, and the provision of personalized tourism services. However, the method focuses on image display functionality with weak data processing capabilities. In the literature [2], a data mining algorithm is proposed based on the three dimensions of rural tourism scale superiority and aggregation for resource mining. It utilizes an interest-degree function for rule matching to enhance user satisfaction. However, the data command response rate of this method is poor, and it is challenging to manage the parallel processing of massive data. Literature [3] proposes a cloud computing virtualization technology for a tourism information service platform. It utilizes the J2EE framework and the Map-Reduce algorithm combined with the Java programming language to optimize the structure of the service platform. The operational process is complex, the cost is high, and it relies on computer storage space. This platform can be applied when the data capacity is small but the performance of information storage and processing is poor. Given the aforementioned issues, a rural tourism management cloud service platform based on an embedded system with independent operational capability is being investigated. The technical feasibility of implementing the platform is being explored through an examination of the hardware structure and software design.

2 HARDWARE DESIGN OF RURAL TOURISM MANAGEMENT CLOUD SERVICE PLATFORM BASED ON EMBEDDED SYSTEM

An embedded system is essentially a computer at its core, capable of operating independently of the system device. It is equipped with an external processor, memory, and network communication devices, enabling it to perform extensive data processing and storage tasks. Embedded systems are known for their excellent real-time performance, reliability, and flexibility (see Figure 1).

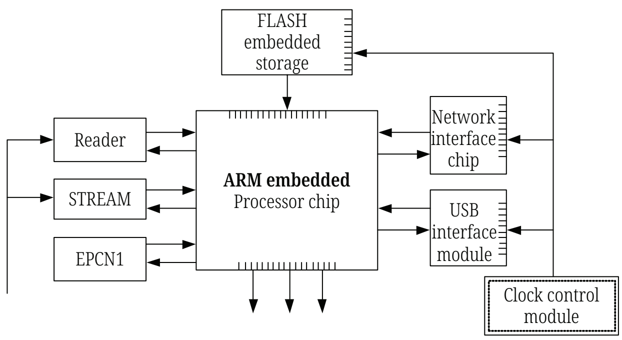


Fig. 1. Embedded system hardware structure

2.1 ARM embedded processor

The ARM10E microprocessor supports a DSP instruction set, a 32-bit ARM instruction set, and a 16-bit Thumb instruction set. It is capable of supporting a 32-bit high-speed AMBA bus interface and a VFP10 floating-point processing co-processor. Additionally, it supports data cache and instruction cache. The ARM10E microprocessor is compatible with various mainstream embedded operating systems, including Windows, Linux, and Palm OS. Higher instruction and data processing capabilities, with a main frequency of up to 400 MIPS, including embedded parallel read and write components [4]. Suitable for high-speed digital signal processing requirements, the efficiency of instruction execution is very high.

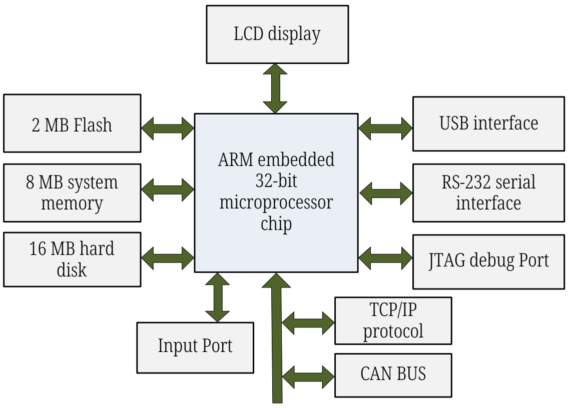


Fig. 2. ARM embedded processor architecture

2.2 NOR flash embedded memory

The S70GL02GS11FHI010 is a synchronous dynamic random access memory that utilizes a differential clock signal to minimize interference, thereby enhancing data storage frequency. It operates at a high speed [5]. It can support an operating temperature range from –20°C to 90°C and requires a minimum supply voltage of 4 V. It adopts the NOR Flash architecture, which provides fast page access of 25 ns and a corresponding random access time of 110 ns. It allows up to 256 words or 512 bytes to be programmed in a single operation, which results in higher operating density and lower power consumption. Supports a variety of interface standards, such as serial peripheral interface (SPI), parallel interface, and others. Equipped with 2 GB of storage capacity, this device supports fast data reading and writing operations. It boasts good data reliability and durability, supports multiple programming operations, facilitates faster information interaction, and is ideal for long-term data storage needs.

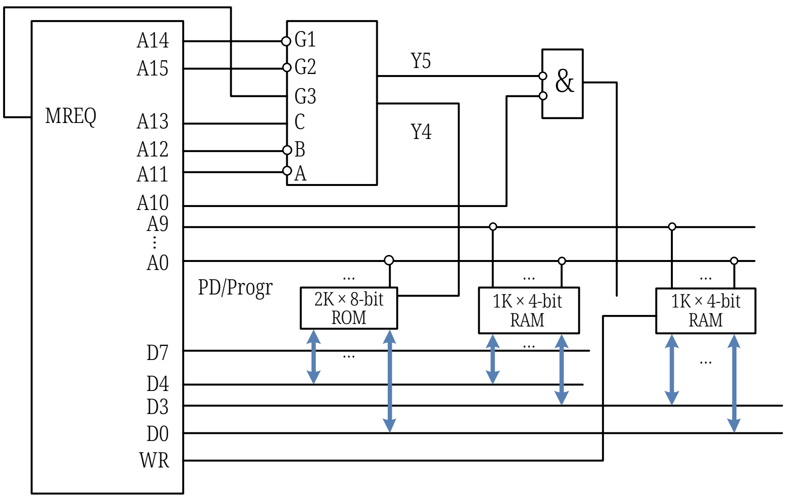


Fig. 3. Circuit diagram of NOR Flash embedded memory

2.3 RTL network interface

The RTL network interface supports Ethernet II and IE, as well as other Ethernet connections (see Figure 4). It can be connected to the control chip and memory chip through the external bus, enabling the ARM embedded processor to control the network and send and receive data. Integrated physical layer interface capacity of 10/100 M, with 16 K bytes of internal send/receive cache, read/write time of 10 ns I/O, support for 8/16-bit two host operating modes, support for I/O ports, and SDRAM interface interconnections [6]. It can be connected with multiple models of serial and parallel interfaces to match and reduce the burden of the processor chip operation. This makes the processor more adaptable to a higher degree, and the embedded chip's device power supply interface connection is more convenient. The interface connection with embedded chips and equipment power supplies is more convenient [7].

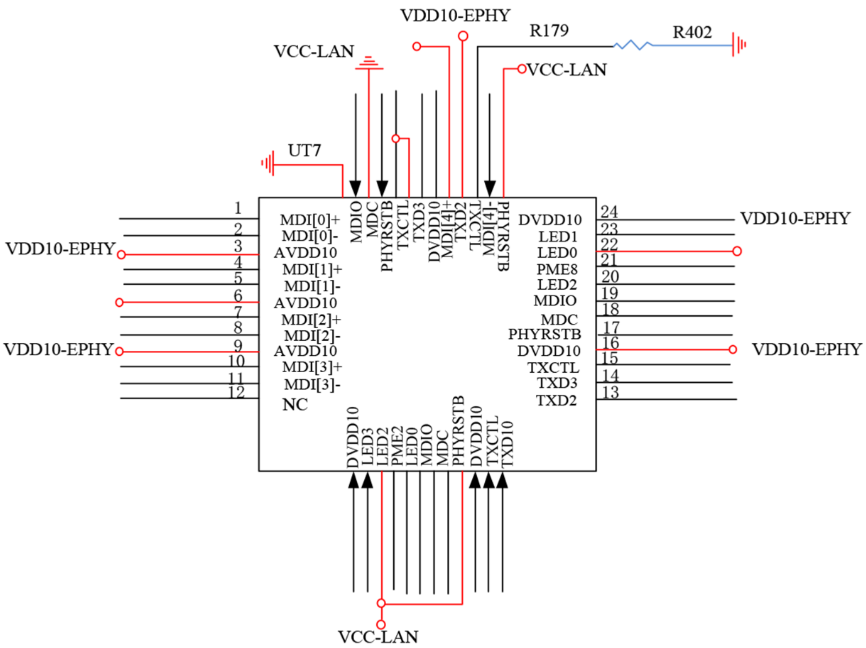


Fig. 4. RTL network interface

3 SOFTWARE DESIGN OF RURAL TOURISM MANAGEMENT CLOUD SERVICE PLATFORM

3.1 Data collection

By utilizing drone aerial photography and 3D laser scanning technology, rural tourist attractions are surveyed on-site [8]. Every coordinate point of the scenic spot is thoroughly scanned to determine its geographic location, altitude, vegetation coverage, and other relevant information. Use the computer to create a three-dimensional model of the scenic spot as the foundation for the management and planning model of the cloud service platform. Mobilize extensive historical tourism data on the scenic spot, including visitor flow, seasonal distribution, traffic patterns, and other non-structural data, and analyze potential opportunities based on characteristic relationships.

$$Popular(x) = N(x) / N_{\max} \tag{1}$$

In the formula, *Popular*(x) represents the probability data of a certain type of tourism resource feature randomly captured, $N(x)$, N_{max} respectively representing the demand for tourism information data and the maximum demand that the platform can meet. The likelihood characterization data are structurally assessed based on heat and satisfy the following conditional relationships:

$$x_i = \sum_{i=1}^{n} R_x(p_1, p_2, \ldots, p_n) \tag{2}$$

In the formula, R_x is the weight of heat structural evaluation, p_1, p_2,..., p_n are the probabilities of correlation between this type of data and seasonal heat fluctuations in passenger flow. Consistency processing of similar feature data:

$$\cos(x_i) = \frac{\sum_{n}^{i=1} Popular(p)_1 \cdot Popular(p)_2}{\sqrt{\sum_{n}^{i=1} Popular(p)_1^2 \cdot Popular(p)_2^2}} \tag{3}$$

Integrate the calculation results based on feature categories and input them into the cloud service platform database for classification and storage.

3.2 Cloud service platform framework

The rural smart tourism cloud service platform is designed to meet the diverse application needs of managers, tourists, and other users. The platform's overall architecture is divided into the cloud data center, functional blocks, and terminal application layer. The schematic diagram of the cloud service platform's overall architecture is as follows (see Figure 5):

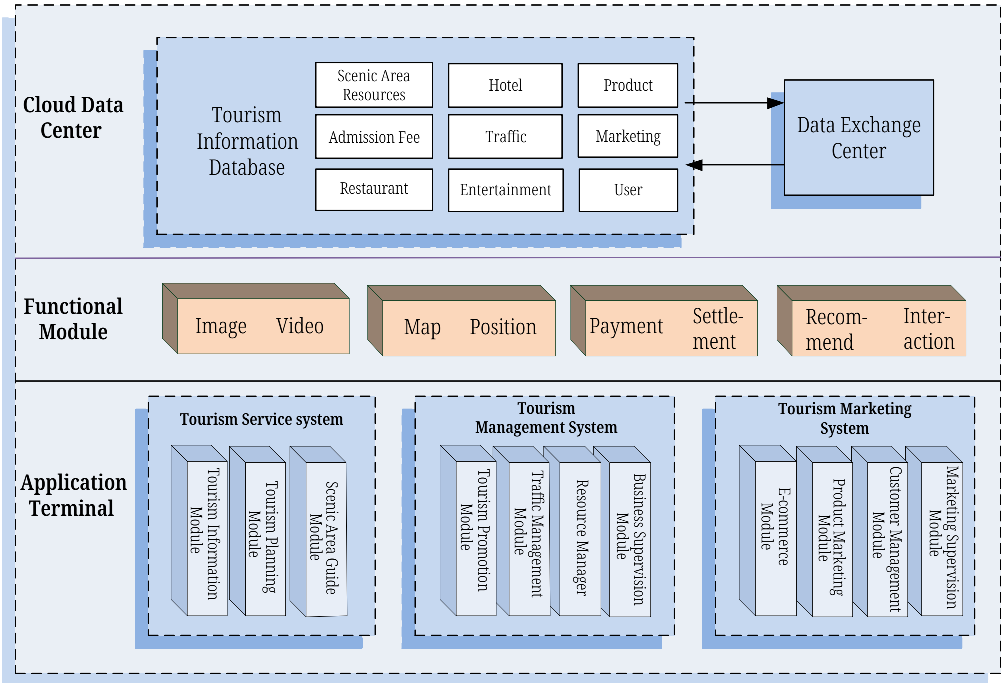


Fig. 5. Overall architecture of rural tourism cloud service platform

1. Cloud data center. Based on the storage, processing, and analysis of scenic spot tourism data, management and application terminal information transmission can be achieved by meeting tourists' demand instructions for data exchange [9].
2. Function block. It serves as the connecting module between the cloud data center and the application terminal layer. It integrates scenic tourism resource data and map frequency information, enabling the comprehensive development of resources and offering comprehensive integrated services for customer terminals.
3. Application terminal. Analyze the personalized demand characteristics of the application service object, develop terminal application functions, set up interactive access windows for tourists and administrators, and provide reliable services for tourists by searching for target information with keywords using the access protocol.

3.3 Functional module design

1. Data analysis module. Analyze the seasonal distribution of passenger flow in the tourism area by using the number of visitors as the primary indicator [10]. Calculate the passenger flow for each month, the change in visiting time, and the seasonal distribution intensity of tourists in the scenic area using the following formula:

$$Q = \sqrt{\sum_{12}^{i=1} (x_i - 8.33)^2 / 12} \tag{4}$$

In the formula, Q is the seasonal distribution intensity index of tourists in the scenic area, x_i indicates the proportion of monthly passenger flow to the annual passenger flow data and the larger the intensity index obtained, the stronger the seasonal changes in the flow of visitors to the scenic area and the greater the impact of the time factor. The smaller the intensity index, the more uniform the distribution of tourism time, and the less affected by the time factor [11]. Combined with the number of tourists per unit in the tourist area and the associated density to assess the scale of tourism in the scenic area:

$$n_k = k(k-1) \tag{5}$$

$$w(n_k) = [k^*(k-1)] / 2 \tag{6}$$

In the formula, n_k represents the passenger flow proportion parameter of the tourist attraction node, while k is the actual passenger flow data of this node. Convert n_k into $w(n_k)$ a diagram representing the traffic network in the scenic area for tourism.

$$M = 2\sum_{k}^{i=1} m_i w(n_k) / (\mathrm{k}^*(\mathrm{k}-1)) \tag{7}$$

In the formula, M represents the network density of passenger traffic connections at each node in the tourism area, with a value of [0, 1], m_i is the density ratio of unit passenger flow to annual passenger flow for that month. In an ideal state, the relationship between network density and unit monthly passenger flow satisfies the following relationship:

$$m_i w(n_k) = \sum_{k}^{j=1} m_i(n_k, n_j) \tag{8}$$

Calculate the seasonal distribution of tourist data in scenic spots using the formula provided. Conduct parameter analysis to enable a cloud service platform for passenger flow consultation and adjustment planning for scenic spot ticket sales functions.

2. Service recommendation module. Using the association rule algorithm to mine the relationship between scenic spot nodes and passenger flow intentions, we utilize the passenger flow network as the basis for analysis. The key location nodes within the scenic spot are set as the focal points for analysis, and the centrality relationship between the peripheral radiation resources and the central attraction is calculated.

$$C_{around(i)} = \sum_{n}^{a} \sum_{n}^{b} d_{ab}(\mathrm{i}) \tag{9}$$

In the formula, $C_{around(i)}$ represents the intermediate centrality of radiation resources around the center point, a, b represent the distance from the surrounding nodes to the center point, respectively, d_{ab} represent the shortest linear distance between a and b. Obtain the closeness centrality of the absolute point through the proximity test formula:

$$C_{around(i)}^{-1} = \sum_{i=1}^{n} d_n(\mathrm{i}) \tag{10}$$

Perform normalization calculation to obtain standardized correlation centrality:

$$\bar{C}_{around(i)} = \frac{2C_{around(i)}^{-1}}{(n^2 - 3n + 2)} \tag{11}$$

Convert the associated parameters into the central potential of cloud computing network space, expressed as formula (9):

$$C_{w\left(C_{around(i)}\right)} = \frac{\sum_{i=1}^{n} \left(\bar{C}_{around(i)\max} - C_{around(i)}^{-1} \right)}{(n-1)} \tag{12}$$

In the formula, $\bar{C}_{around(i)\max}$ represents the maximum normalized correlation value of radiation around the absolute center point. Calculate the radiation and attraction capacity of the central point of the scenic area network using the formula above. Explore the correlation between the surrounding resources and develop a platform recommendation service function model. This model includes both automatic and manual services in two sub-districts. The algorithm model for the automatic recommendation rule design is illustrated in Figure 6:

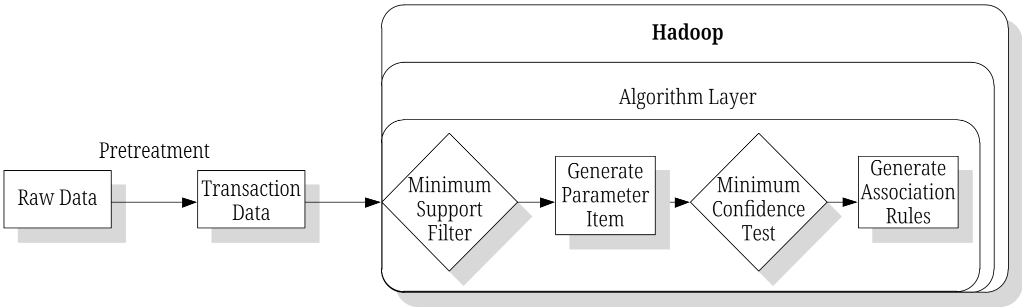


Fig. 6. Automated service recommendation module

The automatic recommendation module recognizes and extracts the raw data of user requirements, utilizes Hadoop for minimum support screening to generate parameter items, obtains association rules after conducting the minimum confidence test, and mines the necessary recommendation information [12].

The online service manual module consists of a three-layer structure: service layer, logic layer, and storage layer, as illustrated in Figure 7. The management terminal receives user requests in the service layer, processes data through the logic layer, analyzes the user's personalized correlation recommendation, accesses the storage layer to request data, and transmits it to the service layer to complete the user recommendation [13].

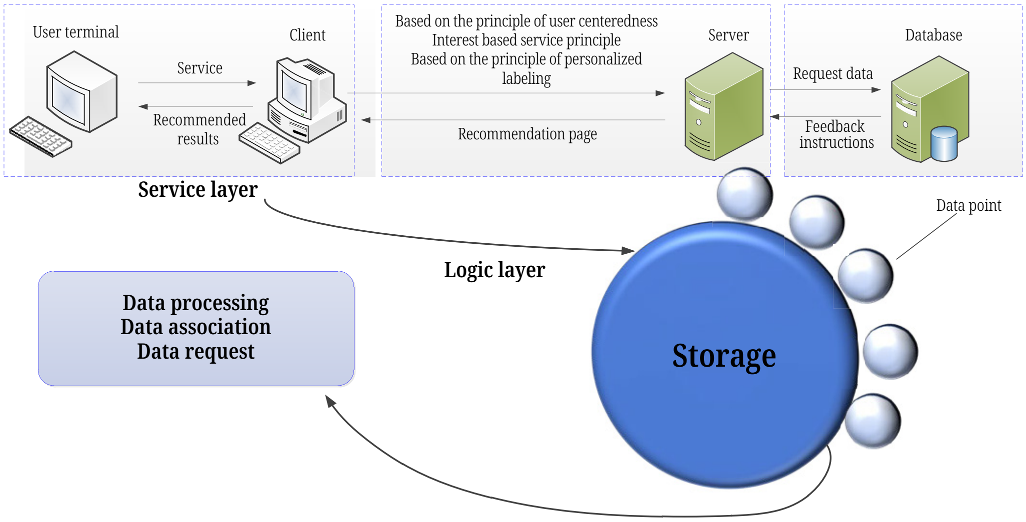


Fig. 7. Manual online recommendation module

3. Tourism management module. The tourism management module is designed for scenic spot managers and visitors, offering interactive interfaces, data display, information dissemination, attraction maintenance, and comprehensive, multi-faceted service capabilities. Visitors can access comprehensive information about rural tourist attractions, including accommodation, transportation, entertainment, shopping, livelihood, and other details. Managers can engage with relevant stakeholders to facilitate business contacts, enhance multi-channel publicity and promotion of tourist attractions, gather feedback from tourists, and continually improve scenic area management [14]. The functional block diagram of the management module is as follows (see Figure 8):

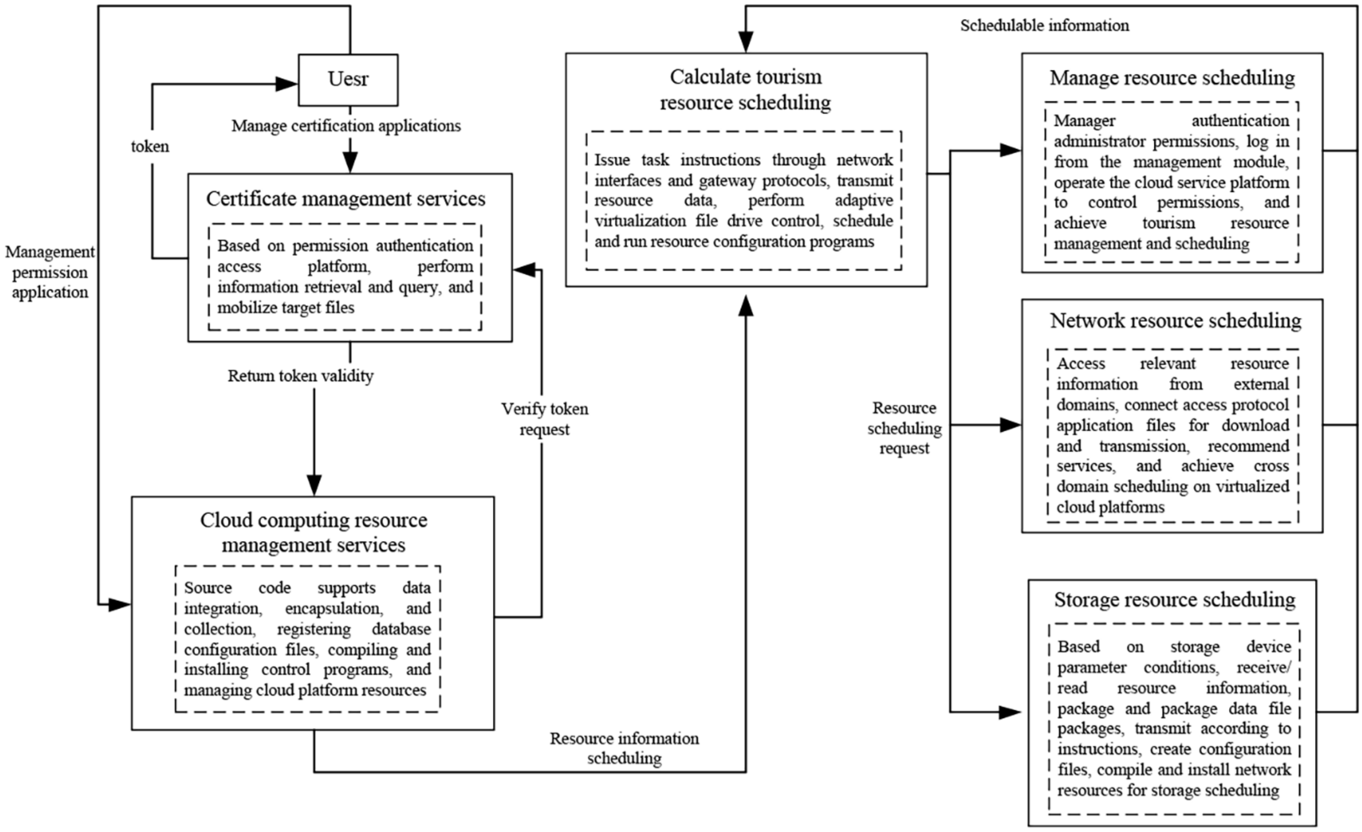


Fig. 8. Flowchart for the realization of tourism management functions

4 IMPLEMENTATION OF TOURISM MANAGEMENT CLOUD SERVICE PLATFORM TECHNOLOGY

4.1 Database storage optimization

The cloud service platform uploads tourism resource data and stores it in embedded memory. To enhance data storage and read and write efficiency, as well as improve cloud platform service performance, the Floyd algorithm is utilized to optimize the data storage path. Firstly, an initial data storage path matrix is established.

$$path[o][e] = 0 \tag{13}$$

In the formula, o, e represent the spatial coordinate positions of the starting point and target point for data transmission in the system, respectively. Iterating the path matrix:

$$D^{(0)} = cos\,t^{(0)}[o][e] \tag{14}$$

In the formula, $D^{(0)}$ is the initialization path iteration matrix, $t^{(0)}$ represents the shortest path factor. The formula for calculating the path optimization matrix using weighted calculation is:

$$\Delta cost = \begin{bmatrix} 0 & 10 & \infty & 30 & 100 \\ \infty & 0 & 50 & \infty & \infty \\ \infty & \infty & 0 & \infty & 10 \\ \infty & \infty & 20 & 0 & \infty \\ \infty & \infty & \infty & 60 & 0 \end{bmatrix} \tag{15}$$

Calculate the weighted matrix formula and substitute the result into formula (14), When the value of t meets $path[o][e] = t$, Indicates that this path is the shortest storage path.

Based on the hardware structure characteristics of the embedded system, the cloud service platform offers extensive data storage space, supports large-scale data parallel processing, and enables simultaneous multi-label, multi-entity storage. It flexibly manages resources based on various criteria, such as the time of addition, file size, storage path, and other identification characteristics for multi-identification, classification, and storage. The platform boasts robust storage and business processing capabilities [15].

4.2 Service business docking

Through the rural tourism management cloud service platform, users can log in to query, download, and share resource information using visitor rights. The demand instructions issued by the client reach the management control area, where the administrator searches the database for information based on access rights to meet customer service needs [16].

1. Tourism information query business. Users access the platform service page to find detailed attractions, purchase tickets, view maps, explore tour routes, access transportation information, and seek support through keyword search.
2. Tourism consulting, an interactive business. Scenic management aims to establish a consulting platform where tourists can log in and verify their identity. This platform allows tourists to ask customer service questions about the scenic area, catering to their individual needs [17]. The goal is to facilitate a positive interaction between tourists and management, encouraging the exchange of ideas and continual improvement in the management of the scenic spots.
3. Scenic area planning for businesses. Rural tourism accommodations, food, and transportation are not as convenient as in the city. There is a need to thoroughly investigate the scenic area's clothing, food, housing, and transportation resources and upload them to a cloud service platform to support resource planning.
4. Scenic management and operation business. Managers use permission authentication to access service platform resources. They analyze data such as passenger flow, traffic flow, traffic congestion rate, per capita tour length, and other relevant factors to make timely adjustments to operational strategies and optimize the management of the scenic area.
5. Rural tourism promotion business. Utilize network channels effectively to disseminate information related to scenic areas and activity planning. This will enhance the visibility of rural tourism resources, attract social resources to rural tourism destinations, and stimulate rural economic development [18].

The business docking process is shown in Figure 9.

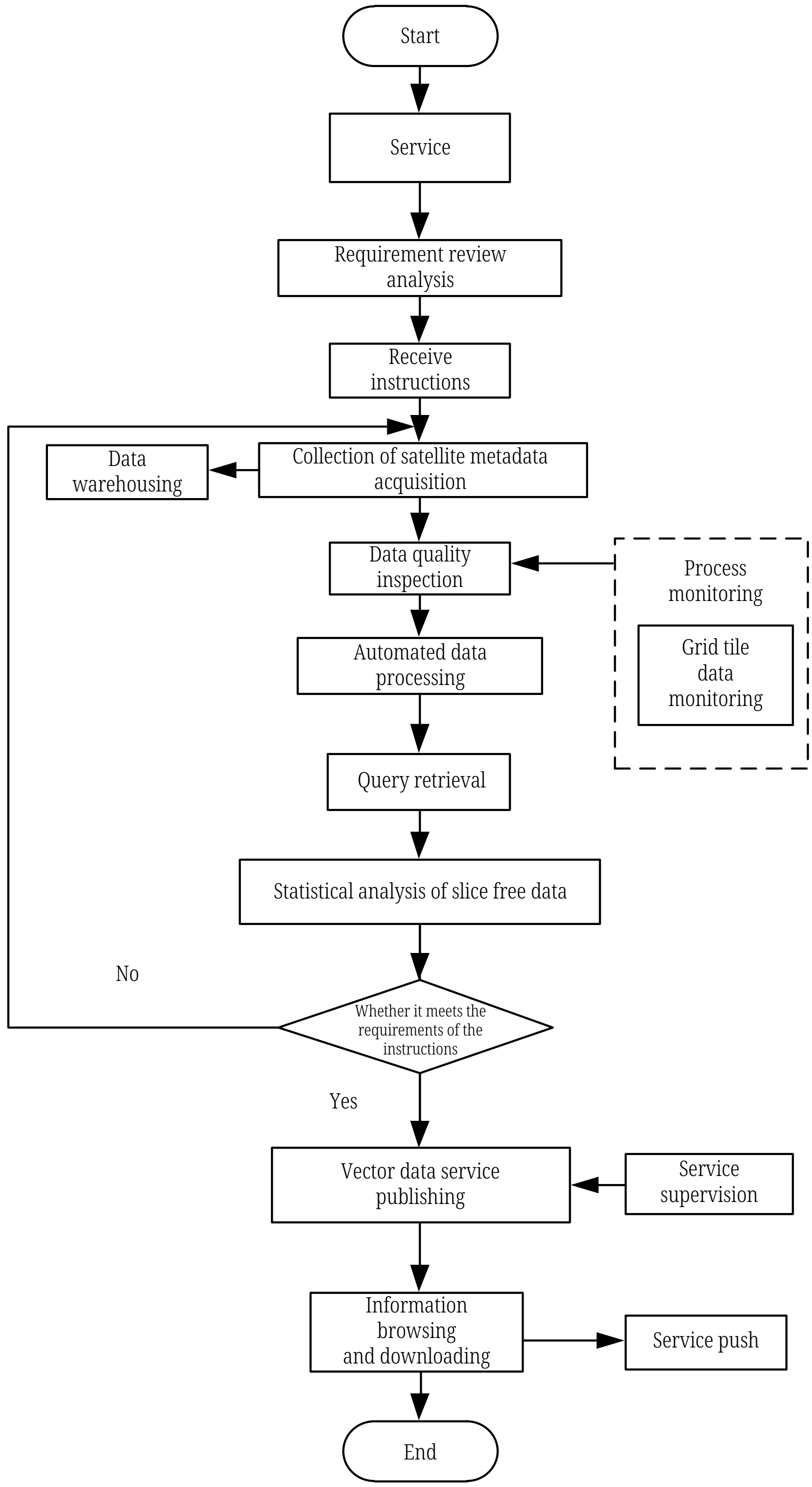


Fig. 9. Cloud service platform business interfacing process

4.3 Big data monitoring center

The functional relationship of the big data monitoring center is shown Figure 10.

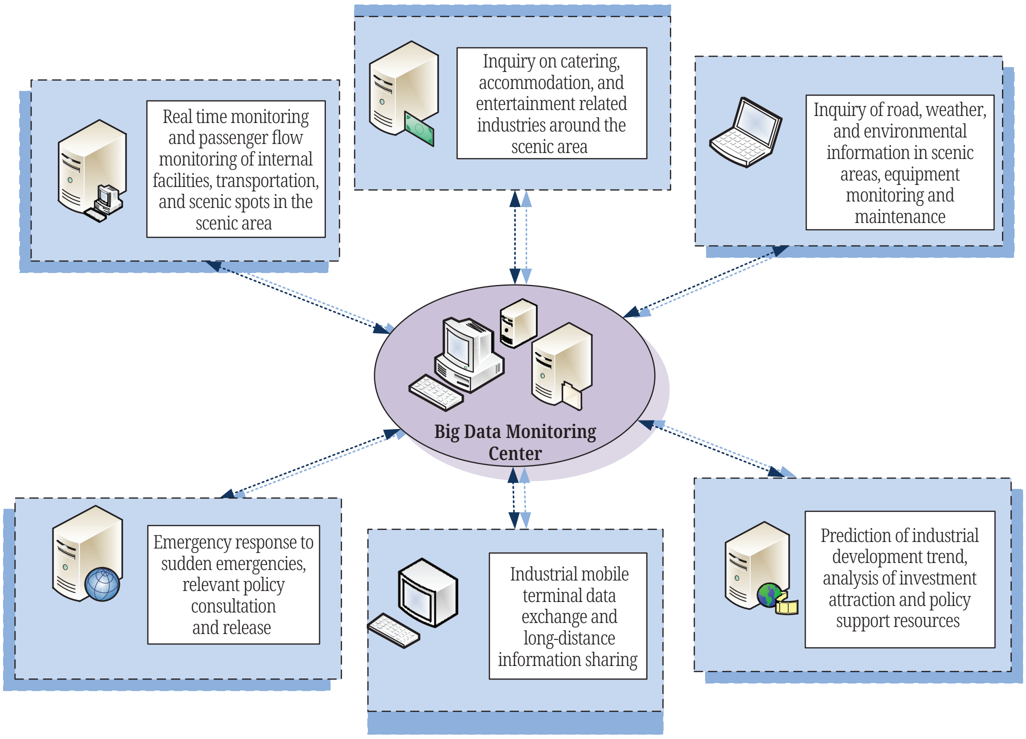


Fig. 10. Schematic diagram of big data monitoring network structure

1. Real-time monitoring of attractions and transportation within the scenic area. This is done through data sharing, real-time monitoring of tourist information within the scenic area.
2. Inquiring about information related to industries such as catering and lodging around scenic spots. This is done by monitoring the changes in passenger flow in related places, such as the number of hotel guests and price fluctuations [19].
3. Emergency handling of emergencies. This done through setting up a dedicated response board to promptly monitor and by addressing emergencies in the scenic area to prevent human and financial losses.
4. Analysis of the regional industrial situation. Based on the historical tourism resource data, along with relevant policies aimed at attracting investment and considering time and weather changes, it is essential to analyze and make decisions regarding future tourism resources in the short term [20].

5 EXPERIMENTAL RESEARCH

To verify the practical application feasibility of the studied embedded system-based rural tourism management cloud service platform, non-structural tourism resource information from a rural tourist attraction in North China is collected. Simulation experiments are conducted using the control variable method. Based on the hardware system above, the configuration parameters for developing a cloud service platform experimental setup are presented in Table 1.

Table 1. Experimental configuration parameters

Development Platform	Eclipse 4.2
Programming language	Html, Css, Java, JavaScript
Design tool	Power Designer 16.5
System OS	Windows XP, Windows 7
Plugins	Google Web Toolkit SDK 2.5.1
Frame	Struts 2, Spring 3.2

5.1 Platform I/O read and write response time monitoring comparison

Cloud platform I/O read and write time will increase with the increase in platform operation time. However, the system network interface can support different models, which will affect the platform's I/O read and write efficiency. The embedded system adopts an RTL network interface, supporting serial and parallel multi-interface connection forms. This setup enables the interconnection of the I/O interface and SDRAM interface, ultimately improving the cloud platform's I/O read and write response rate. Experimental monitoring of cloud platform I/O read and write response time comparison results are shown in Figure 11.

As depicted in the Figure 11, the cloud platform examined in this study exhibits an I/O read response time of 236.7 ms when operating for 10,000 ms, which is 139.4 ms less than the response time of the traditional data mining algorithm platform. Furthermore, the I/O read response time is 315.9 ms when running for 50,000 ms, whereas traditional methods consistently exceed 380 ms. In terms of I/O write response time, the monitoring data indicates that the embedded system cloud platform has the highest response time of 328.3 ms, while the data mining cloud platform shows a response time as high as 491.2 ms. This suggests that as the platform running time increases, the I/O read and write response time of the traditional method slows down significantly, with an increase of about 91.3 ms. In contrast, the response time of the embedded system platform increases by 41.7 ms.

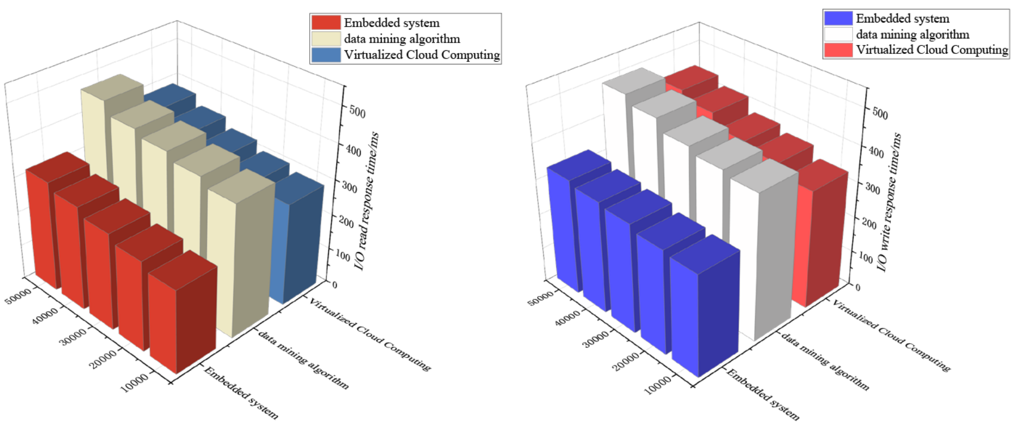


Fig. 11. Cloud platform read-write response time

5.2 Comparative analysis of task execution delay time

Respectively, 200 kb, 400 kb, 600 kb, 800 kb, and 1000 kb of sample data volume were extracted for resource scheduling. The computer issued commands to access the embedded system's information receiving network interface, initiated command reading, monitored the timing of various systems to complete the tasks, and recorded the delay time caused by the execution. The monitoring time comparison results are illustrated in Figure 12.

From the results in Figure 12, it can be seen that the embedded system-based rural tourism management cloud service platform has the shortest running delay time of 12 ns when dealing with a data volume of 200kb. When the data volume reaches a maximum of 1,000kb, the delay time generated by the task execution is 81 ns. This is because the ARM embedded processor supports a 32-bit high-speed bus interface, enabling faster platform access and feedback data, thus reducing the probability of generating operation delays. In contrast, the traditional cloud platform struggles to support high-speed network communication interfaces, resulting in slow parallel data processing execution speeds. The cloud platform based on data mining algorithms executes tasks with a latency time as high as 152 ns, while the virtualized cloud computing management platform operates with a latency time of 138 ns. The embedded cloud service system researched in this paper effectively reduces the latency time of the system. Task execution is faster by nearly 46.7% compared to the traditional method.

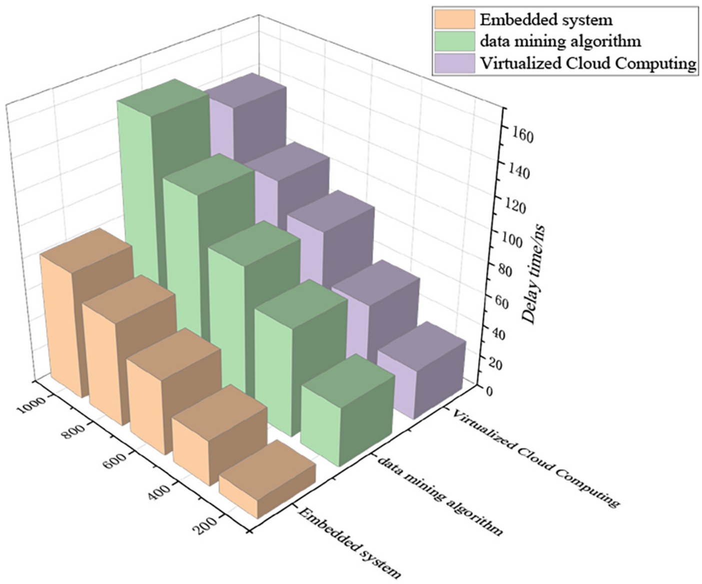
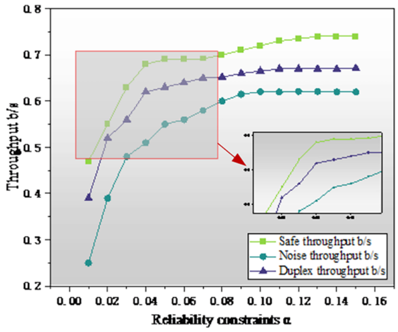


Fig. 12. Cloud service platform task execution delay time

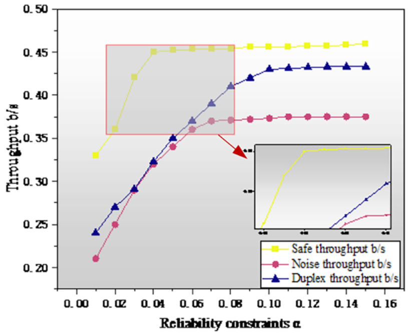
5.3 Comparison of data throughput of cloud platforms

During the operation of the cloud platform, the reliability constraints of 0.01–0.15α is applied to the transmitted data to calculate the network throughput of the cloud platform operation in the presence of noise injection, duplex interference, and security.

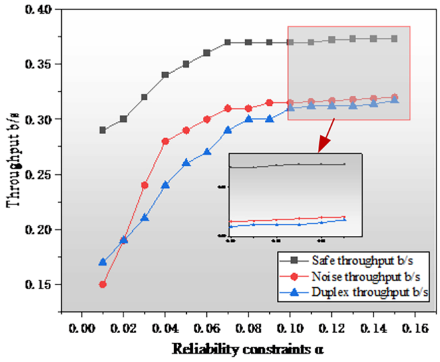
As depicted in the Figure 13, noise interference has a significant impact on the platform network throughput. When the reliability constraint reaches 0.05, the platform throughput growth reaches a critical value. This paper investigates cloud platform security throughput, which reaches 0.69 b/s. In the presence of noise interference, the throughput is also 0.55 b/s. However, with the increase in the constraint index, the growth in throughput was found to be insignificant. A data mining platform with a constraint index of 0.04 shows that the throughput gap reaches its maximum. There is a noise interference throughput and security throughput gap of 0.13 b/s. In the virtualization cloud platform, the constraint index reaches the maximum of 0.15, and the security throughput is 0.373 b/s. In the case of duplex interference, the throughput is only 0.317 b/s. The statement suggests that the throughput of the embedded system-based cloud platform is higher. Less affected by noise interference, the stability of the platform operation posture is significantly improved.



(a)Embedded system



(b)Data mining algorithm



(c)Virtualized cloud computing

Fig. 13. Cloud platform network throughput monitoring

5.4 Analysis of cloud platform data storage volume

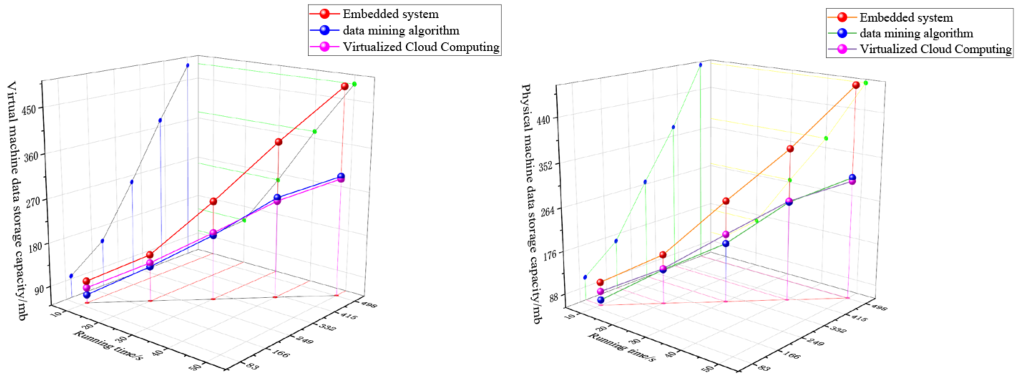


Fig. 14. Cloud service platform data storage volume

As shown in Figure 14, the embedded system cloud service platform analyzed in this study has a virtual machine data storage capacity of 482 MB and a physical machine data storage capacity of 493 MB after running for 50 seconds. In contrast, the traditional management platform utilizing data mining algorithms has a virtual machine and physical machine data storage capacity of less than 320 MB. Furthermore, the virtual machine storage capacity of the management cloud platform based on virtualized cloud computing is 297 MB, while the simultaneous physical machine storage capacity is also 304 MB.

Due to the embedded system with independent Flash memory, the storage space is larger. It is equipped with a parallel network interface, allowing for simultaneous massive data transmission and storage. Compared to traditional service platforms, it offers a scalable storage space with significantly increased data storage capacity. The storage efficiency is higher, making it more practical than traditional cloud management platforms.

6 CONCLUSION

Aiming to address the issues of low data execution efficiency and slow storage speed on tourism cloud service platforms, a rural tourism management cloud service platform based on an embedded system is proposed. The following conclusions have been drawn:

1. The new components, such as the ARM embedded processor, NOR Flash embedded memory, and RTL network chip, are utilized to optimize the hardware structure of the cloud service platform. This optimization aims to enhance data processing and storage efficiency while ensuring good reliability and durability.
2. According to the targeted demand for characterizing rural tourism resources, analyzing design data, providing service recommendations, managing tourism, and other multifunctional modules, a comprehensive tourism cloud service platform is being developed to fully explore rural tourism resources.
3. Optimize the database storage function by implementing the shortest path algorithm. Establish a big data monitoring center to comprehensively monitor changes in scenic spots and related industries in the surrounding area, aiming to enhance platform service efficiency effectively.

Through the experiment, it has been proven that the tourism management cloud service platform, based on an embedded system, has effectively improved execution time and storage speed. It has shown a positive practical application effect. It is hoped that the research results of this paper can provide valuable references for the design and optimization of intelligent cloud platform systems in related fields.

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8 AUTHOR

Shanshan Luo studied at Datong University and received her bachelor's degree in 2011. She studied at Shanxi University and obtained her master's degree in Tourism Management in 2014. From 2014 to the present, she has been working in Shanxi Vocational College of Tourism, Taiyuan 030031, China. She has published five papers. Her research focuses on rural tourism and cultural tourism.