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*Research Article*

# Development Potential of the Internet of Things-Based Forest Recreation under the Background of Informatization

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There are few studies on forest smart tourism currently, and most smart tourist service models are only studied and analyzed theoretically. Based on this, the Internet of Things (IoT), mobile communications technology, and smart tourism related ideas are discussed in depth in this study, followed by the construction of a forest smart tourist service model. The forest smart tourism evolutionary game model is then built based on the benefit relationships of various tourist sectors. Finally, the effect of the forest smart tourist service model and the forest smart tourism service evolutionary game model is evaluated using simulation experiments. The findings show that (a) daily passenger flow data from scenic spots in June was scattered, but the overall estimate gives that the daily passenger flow was more than 800; (b) daily passenger flow data from scenic spots in December was scattered, but overall estimate shows that the daily passenger flow was less than 300; and (c) the average profit value of the game model was 3.5, 3, and 6, respectively, under various circumstances. To summarize, the model provided in this paper is reliable and appropriate for optimizing forest smart tourist services. Through the constructed model, this work seeks to give theoretical reference for further boosting the development potential of forest recreation.

## 1. Introduction

Gordon Phillips described smart tourist in the early twenty-first century as “the use of a sustainable strategy to design and produce tourism products and businesses” [1]. Smart tourism is defined by the United Nations World Tourism Organization (UNWTO) as “clean, green, ethical, and high-quality service,” but it ignores the significant changes and new demand caused by technological aspects in the tourism industry [2]. As a result, the British Smart Tourist Organization coined the terms “digital tourism” and “smart tourism” to characterize the phenomena of using and implementing information technology in the tourism sector [3]. Later, smart tourism is described as tourism that integrates tourism resources with information and communication technology based on the advancement of mobile communication technology [4]. To highlight the practical support of “smart tourism” for “smart city,” smart tourism is described as the use of mobile digital connection technologies to establish a more intelligent, meaningful, and sustainable interaction between tourists/visitors and the city [5]. In a nutshell, smart tourism entails gathering important data in a destination and then converting that data into practical experience and an economic tourist value [6].

In China, smart tourism came into being after the “smart city” was proposed in 2011 [7]. At first, smart tourism was defined as the use of all types of information technology in the tourism experience, with a highly organized and systematic integration of tourism and information resources [8, 9]. Subsequently, smart tourism is considered to provide tourists with ubiquitous tourism information services [10]. On this basis, the smart tourism system is defined as where tourists can entertain, buy, eat, and live independently through smart terminals [11]. Further, smart tourism is considered to use cloud computing, the Internet of Things (IoT), artificial intelligence, and other technical means through intelligent terminals to enjoy a variety of information services [12].

It is found that there is little existing research on forest smart tourism, and most smart tourism service models are only analyzed in the theoretical stage. Above this, the forest smart tourism service model is designed by virtue of IoT and mobile communication technology, and the forest smart tourism service game model is built. Then, experiments are set up to verify the effect of the model. The application of game theory to construct a model promoting the operation advantages of the smart tourist business is the novelty of this research work. This effort intends to strengthen the theoretical framework related to the smart tourism industry. It also gives a scientific basis and theoretical support for future tourist development planning.

## 2. Methods

*2.1. IoT.* IoT is a network designed for intelligent identification, positioning, tracking, monitoring, and management. It facilitates information sharing and communication by connecting objects to the Internet using information sensing equipment that adheres to the agreed-upon protocol [13]. According to this principle, experts and scholars at home and abroad divide IoT into 3 layers including the perception layer, network layer, and application layer; or 4 layers including perception and identification layer, network construction layer, management service layer, and comprehensive application layer [14]. Compared with various existing communication and network services, IoT and its application layer have the following characteristics shown in Figure 1.

The Internet of Things (IoT) technology involves the placement of a sensor recognition device on an object to enable communication between objects or between humans and objects. Using IoT in tourism can assist in obtaining dynamic information in a quick and accurate manner. IoT's massive data processing platform allows for 3A (anytime, anywhere, and anything) connection throughout the whole tourist sector. As a result, the physical environment and information technology are integrated, allowing for information cross-penetration and interconnectedness [15]. The connectivity dimensions and information flow in IoT are shown in Figure 2.

*2.2. Mobile Communications-Related Technology.* Mobile communications are the communications between moving bodies and fixed bodies [16]. The moving body can be people, cars, trains, ships, and other objects in the moving state [17]. Mobile communications system is composed of the space system and the ground system. The primary purpose of mobile communications in smart tourism is to enable wireless connections between various tourism information elements within the system, between the system and the external environment, and between remote devices, and it is the core infrastructure that supports the construction and growth of smart tourism [18]. With the development and popularization of mobile terminal equipment (smart phone and PDA), mobile communications technology transforms from computer users-cantered to terminal individuals namely tourists-cantered, tourists can obtain comprehensive real-time and dynamic tourism information through text, voice, and video. Mobile communications technology provides tourists with real-time, dynamic, and high-quality information services. It plays a key role in the construction of smart tourism and promotes tourism management and services to develop in a more refined and high-quality direction [19].

*2.2.1. Smart Tourism Service*

(1) Definition of smart tourism. The so-called smart tourism service refers to the tourism enterprise group with tourists as the core factor and uses big data, IoT, cloud computing, artificial intelligence, virtual reality, and other information technology to collect, mine, and compute tourism data. Through the accumulation of intelligent data, they actively find the real needs of tourists and then provide personalized service plans for tourists [20].

(2) Characteristics of smart tourism. Smart tourism services are distinguished by their complex adaptability. Complex adaptive systems (CAS) capture and reflect the overall complex changes of the system, the interaction between macro and micro, and the evolution mechanism from simple to complex via adaptive interactions between actors [21]. CAS theory is used to obtain the nonlinear and dynamic complex characteristics of smart tourism services as shown in Figure 3.

(3) Main participants in smart tourism service. Smart tourism service includes the whole-domain space resources, the whole-industry element supply, the whole-process service value cocreation, and multi-dimensional multilevel experience [22]. In the process, each participant has a complex network link relationship. Smart tourism service has typical ecological characteristics. It is oriented on the demands of tourists and makes extensive use of information technology to achieve efficient resource allocation and integration, encouraging tourism service innovation [23, 24]. The network structure of the smart tourist service is depicted in Figure 4.

(4) Elements constituting smart tourism service. Scenic locations, tourism resources, and tourism facilities are all examples of smart tourist service features. Tourism facilities are all to appeal tourists and draw economic benefits. Tourism resources are natural, historical, and realistic objective existences that are appealing to tourists. Tourism resources may be separated into natural and cultural resources based on their formation conditions [25].

(5) Food, accommodation, transportation, travel, shopping, and entertainment are the six main

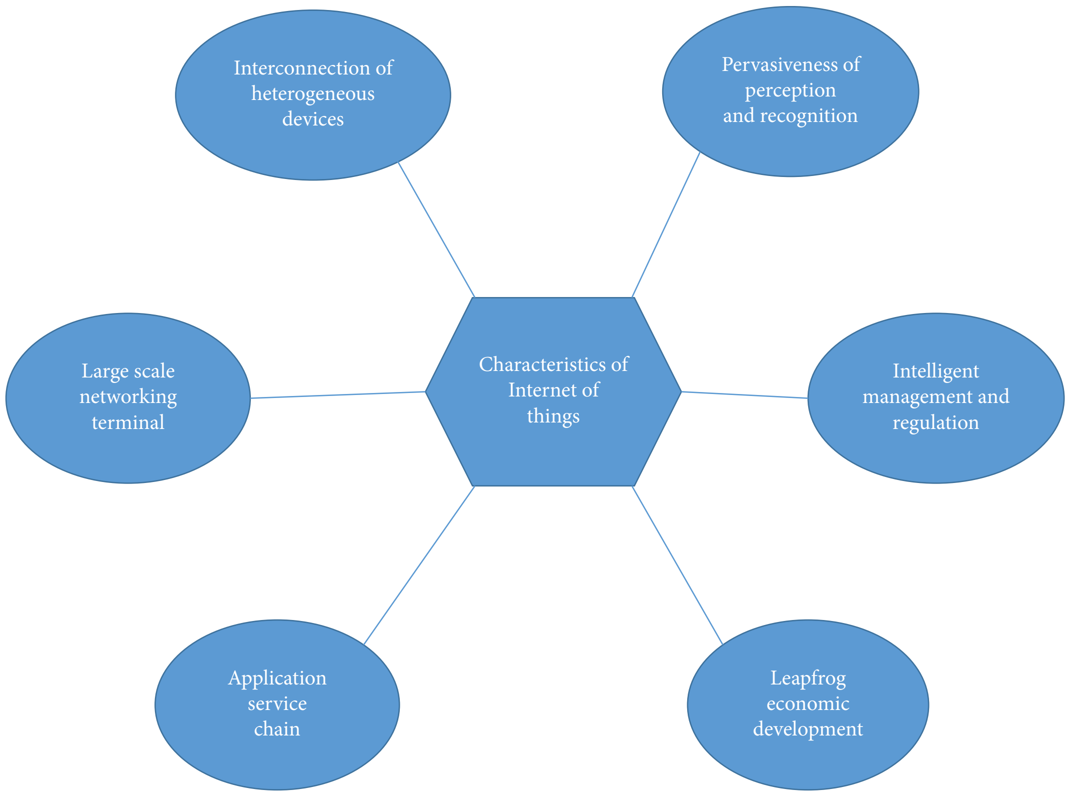


Figure 1: Characteristics of IoT.

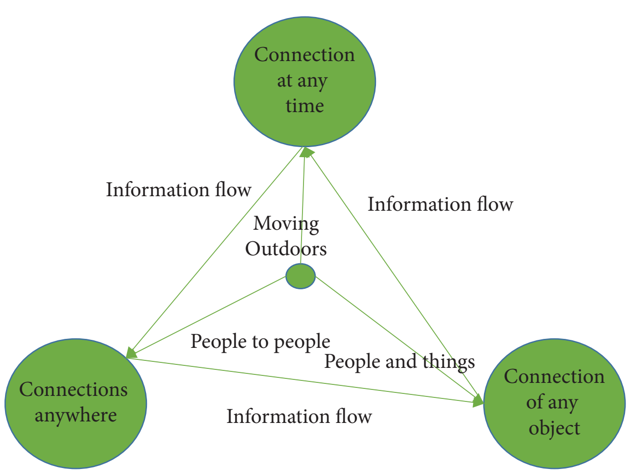


Figure 2: The connection dimensions and information flow in IoT.

elements of tourism in traditional sense [26]. Four elements of sports, recuperation, learning, and perception have been introduced to tourism because of its growth and development. The relationship between the elements is shown in Figure 5.

(6) Of them, food, accommodation, and transport are the most basic elements; travel, shopping, and entertainment are to meet the needs of people to visit, play, and entertain; sports and recuperation are to meet people's needs for health; and learning and perception are to meet the needs of work [27].

(7) Extended tourism elements: the "eight categories" of tourism relate to the various industries engaged in tourism, such as recreation, reception, marketing, transportation, construction, production, commercial, and tourist intelligence. The tourist industry chain is made up of the related industries and factors. To generate a community of interests and strengthen collaborative service capability, tourism development must completely integrate all service elements, tourism resources, and relevant industries.

(8) Smart tourism environment: the smart tourism environment mainly includes social and cultural environment, economic and technological environment, legal and policy environment, and natural and ecological environment.

*2.2.2. Establishment of the Smart Tourism Service Model.* The demand for forest smart tourism can be divided into four stages: Travel Dream ⟶ Travel Plan ⟶ Booking and Payment ⟶ Comment/Share, forming the DPB-S (dream, plan, and book-share) cycle of smart tourism demand [28]. Focusing on the demand of smart tourism, the model is constructed from two dimensions: vertical service process and horizontal service interaction.

*(1) Forest smart tourism service model.* Based on the analysis of smart tourism demand, the smart tourism service process is divided into five stages namely: tourism service demand

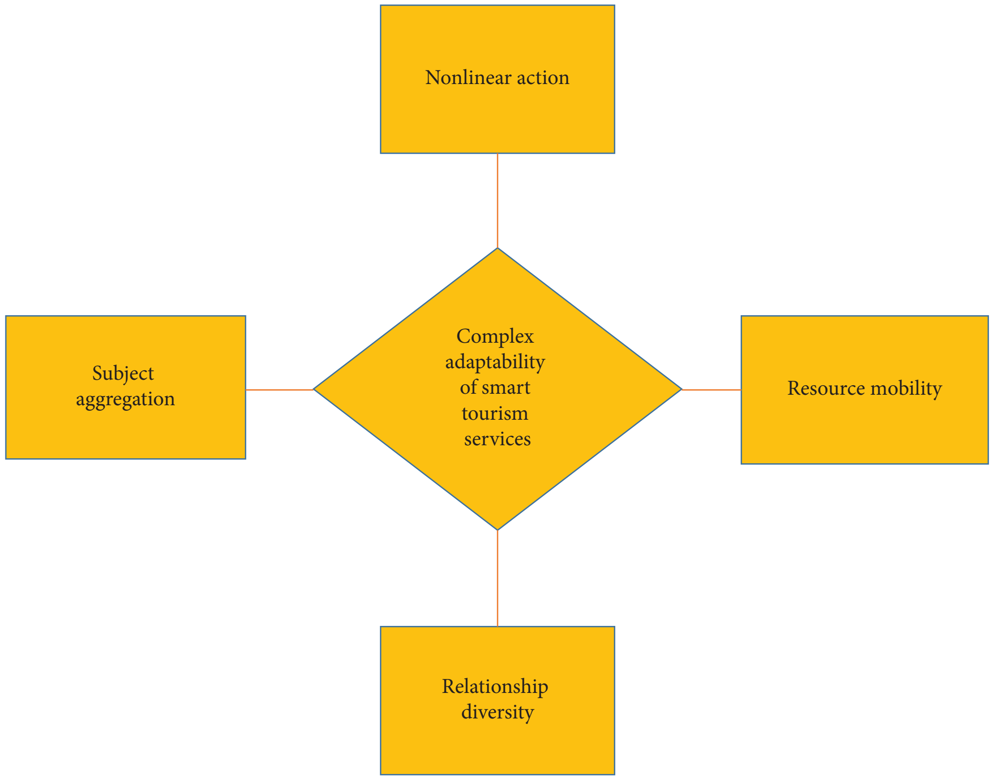


Figure 3: Complex adaptability of the smart tourism service.

mapping ⟶ tourism service resource integration ⟶ tourism service scheme formation ⟶ tourism service scheme selection and implementation ⟶ tourism service evaluation and feedback, as shown in Figure 6. From Figure 6, information flow, element flow, service flow, and transaction flow together form an ecological cycle.

*(2) Functions of the forest smart tourism service model.* According to Figure 6, the functions of the forest smart tourism service model should include (1) to improve the information quality of forest recreation; (2) to guide the forest recreation demand; and (3) to innovate the smart service supply mode.

*(3) Simulation experiment*. The model was introduced into a forest scenic spot and the tourist flow in June and December was counted. The MatLab platform was used to perform regression fitting on the data.

*2.2.3. Game Model of the Forest Smart Tourism Service.* The three primary participants in the process of the smart tourism service are tourists, tourism agents (TAs), and tourism factor providers (TFPs) [29]. To be more precise and in collaboration with tourism factor providers, TA employs a variety of marketing methods to attract tourists. The network platform (NP) also plays a role in TA, serving as a major component in advancing the upgrading of smart tourist services [30].

*(1) The establishment of the model.* $M$ represents the cooperation between TA and NP; $M_1$ and $M_2$ represent the deep and simple cooperation between them, respectively; $D$ represents the cooperation between TFP and NP; $D_1$ and $D_2$ represent the deep and simple cooperation between them, respectively; $U_M$ represents the benefits of simple cooperation between TA and NP, while $U_D$ represents the benefits of simple cooperation between TFP and NP; $X$ represents excess revenue sharing under tripartite cooperation, with NP as the core; $Y$ represents excess revenue sharing with deep cooperation between TFP and NP and simple cooperation between TA and NP; $Z$ represents excess revenue sharing with deep cooperation between TA and NP and simple cooperation between NP and TFP; $C_M$ represents the cost of deep cooperation between TA and NP, while $C_D$ represents the cost of deep cooperation between TFP and NP. The cost of simple cooperation is not considered here (in order to attract TA and TFP, NPs often offer large discounts in the early stage). $\alpha$ represents the revenue sharing proportion of TFP in deep cooperation with NP, $0 < \alpha < 1$; $\beta$ represents the revenue sharing proportion of TA in the deep cooperation with NP, $0 < \beta < 1$, $0 < \alpha + \beta < 1$; $C_M < U_M + \beta X$, $C_D < U_D + \alpha X$, $Y < \alpha X$, $Z < \beta X$.

In the initial stage, it is assumed that the probability of simple cooperation between TA and NP is $x$ $(0 < x < 1)$, and the probability of deep cooperation between them is $1-x$, the probability of simple cooperation between TFP and NP is $y$ $(0 < y < 1)$, and the probability of deep cooperation between them is $1-y$. Then, according to relevant game theories, the

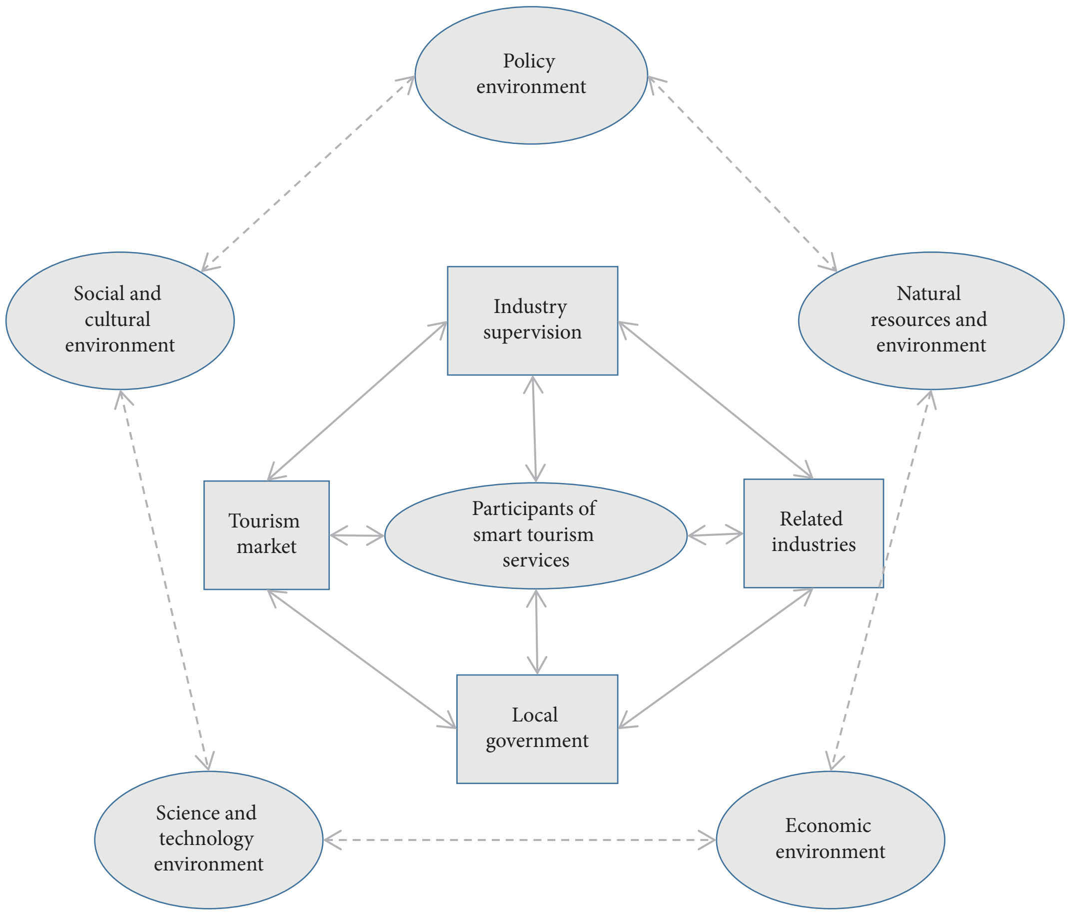


Figure 4: The smart tourism service network.

expected benefits of TFP in deep and simple cooperation with NP are as follows:

$$\begin{aligned} u_{1D1} &= x\left(U_D + \alpha X - C_D\right) + (1-x)\left(U_D + Y - C_D\right), \\ u_{1D2} &= xU_D + (1-x)U_D = U_D. \end{aligned} \tag{1}$$

The average expected income with TFP performing strategy selection with probability $y$ and $1-y$ is expressed as follows:

$$u_1 = u_{1D1}y + u_{1D2}(1-y). \tag{2}$$

The replication dynamic equation of TFP in deep cooperation with NPs can be constructed as follows:

$$F(y) = \frac{d_y}{d_t} = y\left(u_{1D1} - \overline{u}\right) = y(1-y)\left[x(\alpha X - Y) + Y - C_D\right]. \tag{3}$$

The expected benefits of deep and simple cooperation between TA are as follows:

$$\begin{aligned} U_{2M1} &= y\left(U_M + \beta X - C_M\right) + (1-y)\left(U_M + Z - C_M\right), \\ U_{2M2} &= yU_M + (1-y)U_M = U_M. \end{aligned} \tag{4}$$

The average expected income of TA performing strategy selection with probability of $x$ and *1-x* is as follows:

$$\overline{u_2} = U_{2M1}x + U_{2M2}(1-x). \tag{5}$$

The replication dynamic equation of the deep cooperation between TA and NP can be constructed as follows:

$$F(x) = \frac{d_x}{d_t} = x\left(U_{2M1} - \overline{u}\right) = x(1-x)\left[y(\beta X - Z) + Z - C_M\right]. \tag{6}$$

Above, the replication dynamic equation of the game model in the forest smart tourism service process is expressed as follows:

$$\begin{cases} F(y) = \dfrac{d_y}{d_t} = y(1-y)\left[x(\alpha X - Y) + Y - C_D\right] \\ F(x) = \dfrac{d_x}{d_t} = x(1-x)\left[y(\beta X - Z) + Z - C_M\right] \end{cases}. \tag{7}$$

*(2) Stability analysis*. The derivative of the replication dynamic equation of TFP is determined initially to examine the stability of the replication dynamic equation of TFP.

$$\frac{d_{F(y)}}{d_y} = (1-2y)\left[x(\alpha X - Y) + Y - C_D\right]. \tag{8}$$

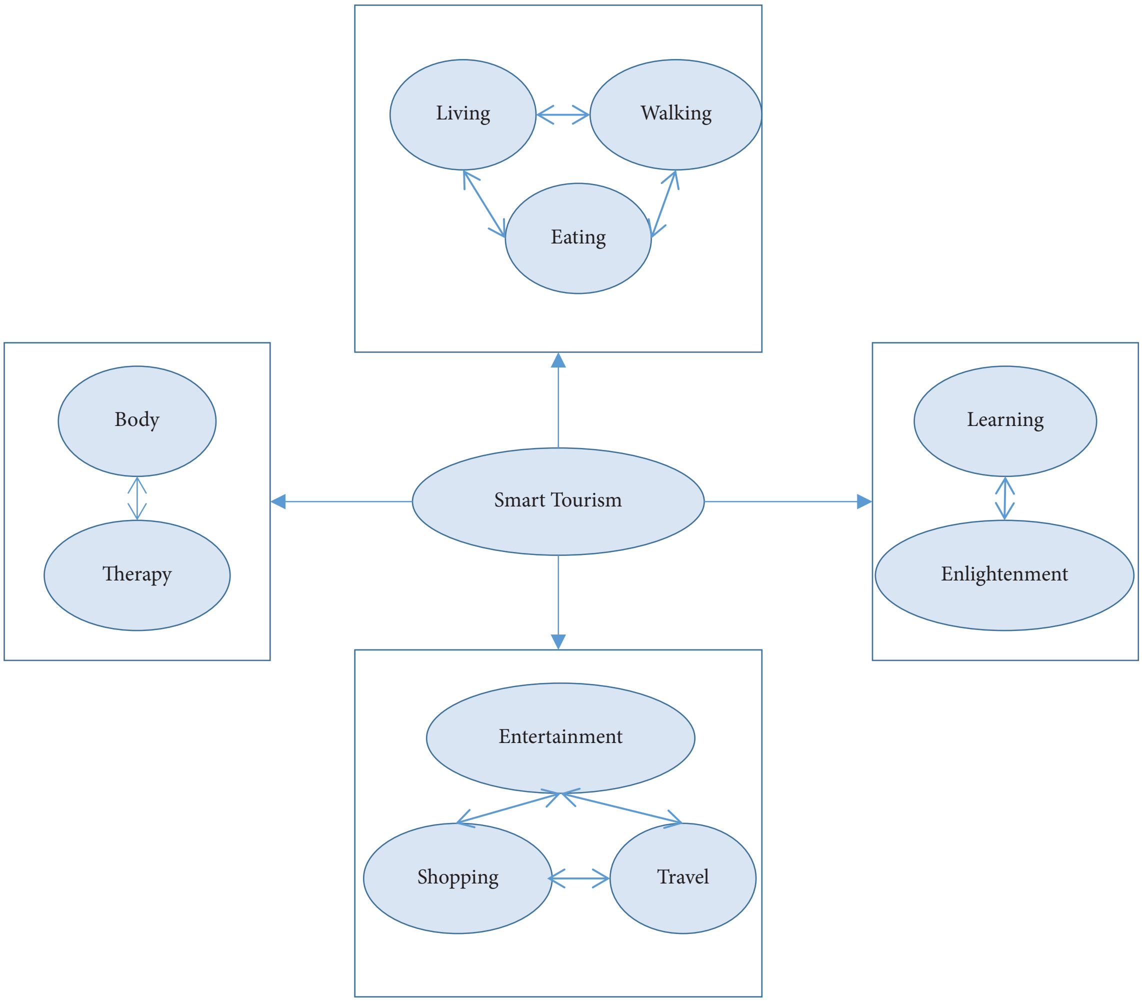


Figure 5: Tourism elements.

Therefore, the stability of the equation is analyzed in three cases.

(i) $0 < [C_D - Y/\alpha X - Y] < 1$, since $Y < \alpha X$, then $Y < C_D < \alpha X$, that is, the cost of deep cooperation between TFP and NP is greater than the benefits, but less than the revenue sharing of deep cooperation among the three. When $x = [C_D - Y/\alpha X - Y]$, all $y$s are stable; when $x > [C_D - Y/\alpha X - Y]$, $y = 0$ or $y = 1$ are two stable states of $y$. According to the stability theorem of differential equations and the properties of evolutionary stability strategy, $y$ is an evolutionary strategy when $\mathrm{d}_{F(y)}/\mathrm{d}_y < 0$. It is known that $y = 1$ is an evolutionary stable strategy, that is, in this case, after long-term evolution, TFPs choose a deep cooperation strategy with NPs. When $x < [C_D - Y/\alpha X - Y]$, $y = 0$ or $y = 1$ are two stable states of $y$. According to the stability theorem of differential equations and the properties of evolutionary stability strategy, $y$ is an evolutionary strategy when $\mathrm{d}_{F(y)}/\mathrm{d}_y < 0$. It is known that $y = 0$ is an evolutionary stable strategy, that is, in this case, after long-term evolution, TFPs choose a simple cooperation strategy with NPs.

(ii) $[C_D - Y/\alpha X - Y] > 1$, since $Y < \alpha X$, then $Y < CD$, $\alpha X < C_D$, that is, the cost of deep cooperation between TFP and NP is greater than the revenue sharing of deep cooperation among the three, and $[x(\alpha X - Y) + Y - C_D] < 0$, therefore, $y = 0$ is an evolutionary stable strategy, that is, in this case, after long-term evolution, TFPs choose a simple cooperation strategy with NPs.

(iii) $[C_D - Y/\alpha X - Y] < 0$, since $Y < \alpha X$, then $\alpha X > Y > C_D$, that is, the cost of deep cooperation between TFP with NP is less than the benefits, and $[x(\alpha X - Y) + Y - C_D] > 0$, therefore, $y = 1$ is an evolutionary stable strategy, that is, in this case, after long-term evolution, TFPs choose a deep cooperation strategy with the NPs.

*(3) Simulation experiment*. Based on MATLAB simulation software, PDTool-Box_MatLabmaster software package was used to simulate the numerical results. The parameter value

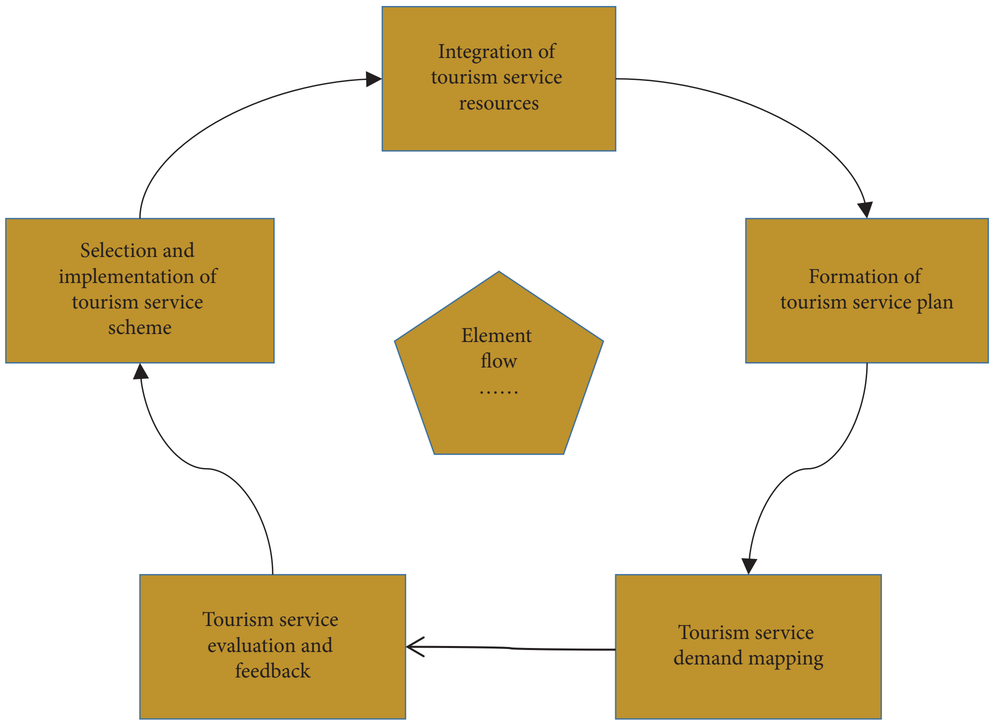


FIGURE 6: The flowchart of the smart tourism service.

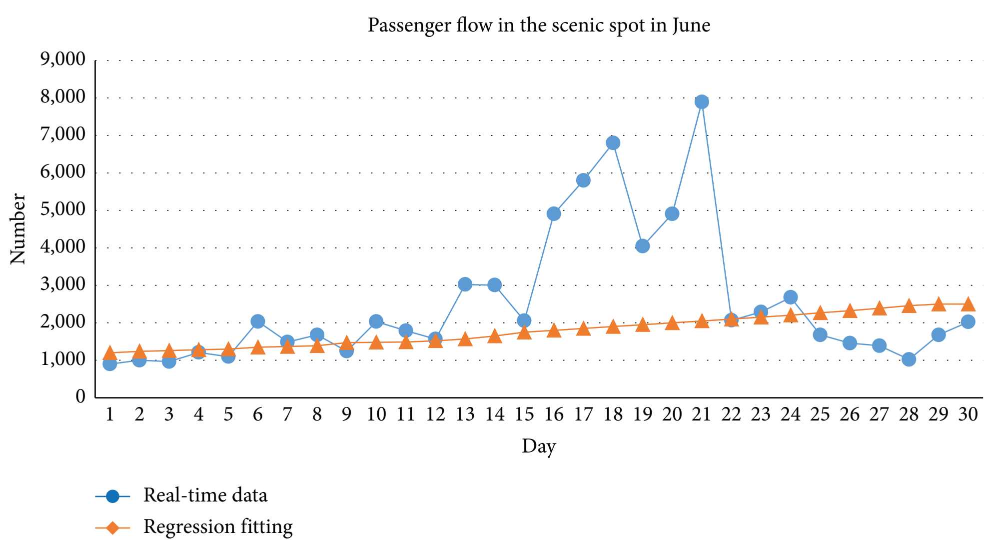


FIGURE 7: Data analysis of tourist flow in summer.

must meet the basic assumptions and constraints described in the previous section.

## 3. Results and Analysis

*3.1. The Performance of the Forest Smart Tourism Service Model.* The summer passenger flow based on the forest smart tourism service model is shown in Figure 7 as following.

Figure 7 shows that the daily passenger flow data of the scenic spot in June were scattered, but overall, the daily passenger flow was more than 800. In addition, through data fitting on the MatLab platform, it was found that although the overall change of passenger flow in June was slow, it was always in a rising trend. Thus, the effect of this model was preliminarily verified.

The winter passenger flow based on the forest smart tourism service model is shown in Figure 8 as following, Figure 8 shows the passenger flow of this scenic spot in winter.

In December, the daily passenger flow statistics for the scenic spot was dispersed, as shown in Figure 8. Despite the effects of the weather, the scenic spot had a daily passenger

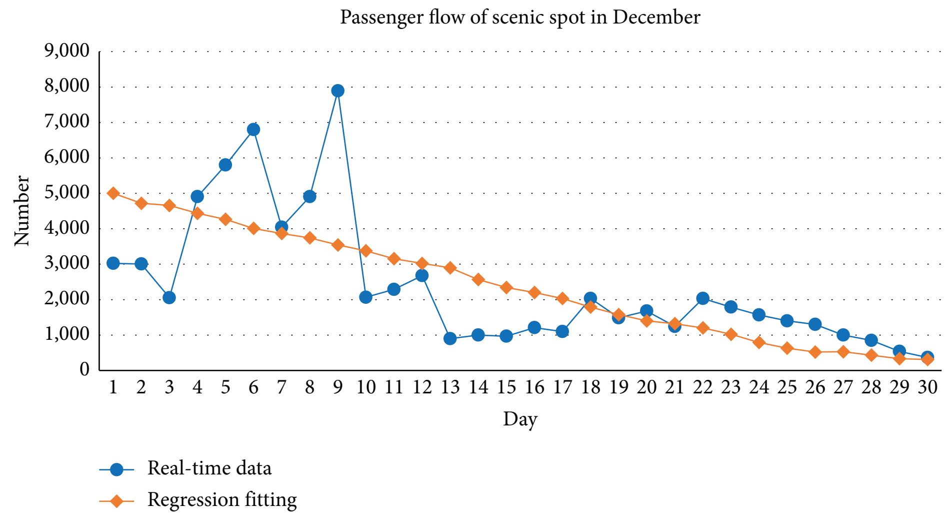


Figure 8: Data analysis of tourist flow in winter.

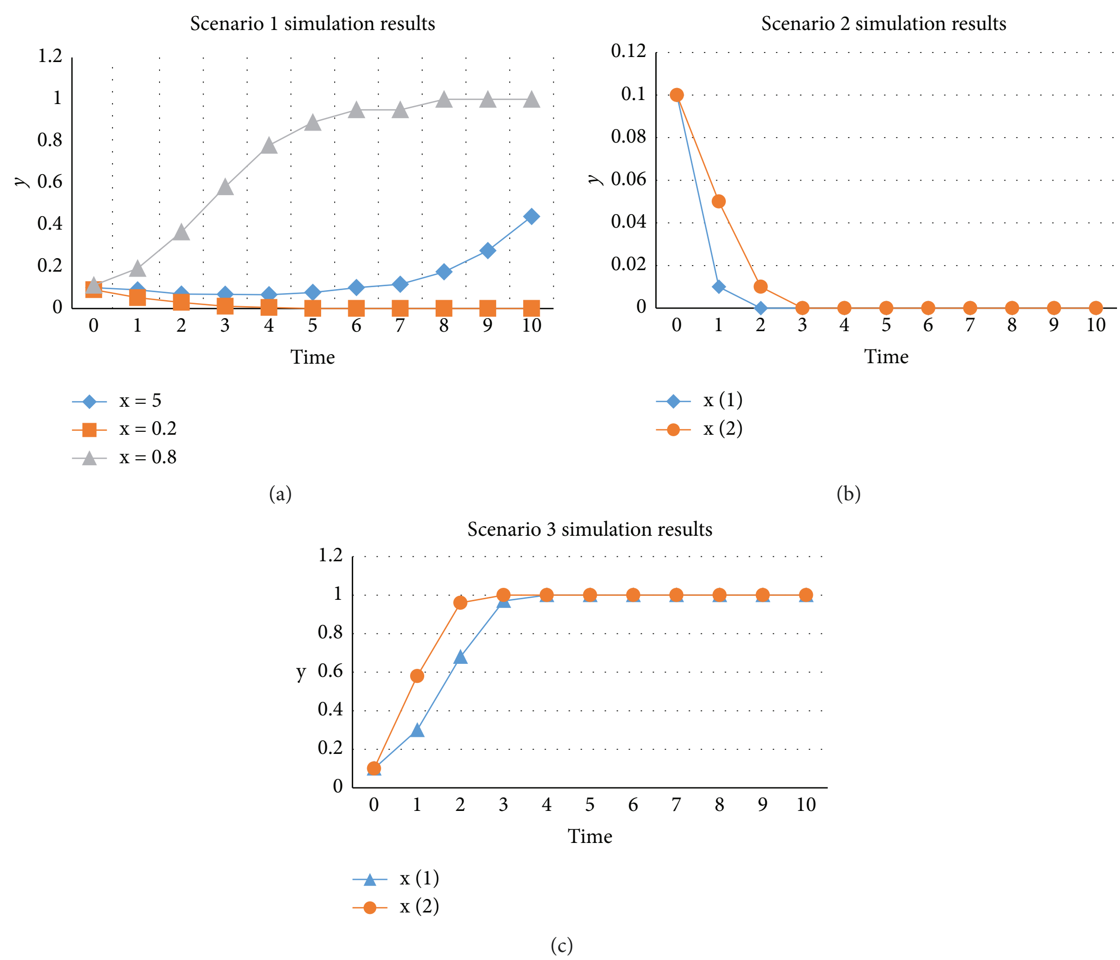


Figure 9: Performance of the game models in different situations, (a) simulation results in case 1; (b) simulation results in case 2; (c) simulation results in case 3.

flow of more than 300 people. Furthermore, using the MatLab platform to fit data, it was discovered that, while the overall change in passenger flow at the scenic spot in December exhibited a decreasing trend, the decline was small. The above data further demonstrated the reliability and consistency of the model in this work.

*3.2. Game Model of the Forest Smart Tourism Service.* According to the game model of forest smart tourism service, different parameters are set to conduct simulation experiments on the model under three scenarios, and the results are shown in Figure 9.

Figure 9 shows that for Case 1, when $x = 5$, the game model does not converge quickly, and any value of $y$ is stable; when $x = 0.2$, $y$ rapidly converges to 0, and the profit value of TFP is 3; when $x = 0.8$, $y$ rapidly converges to 1, and the profit value of TFP is 4. For Case 2, when all parameters meet relevant conditions, the value of $x$ has no influence on the convergence of $y$ but only on the convergence speed. The former converges to 0 faster, and the profit value of the TFP is 3. For Case 3, when all parameters meet relevant conditions, the value of $x$ has no influence on the convergence of $y$ but only on the convergence speed. The latter converges to 1 faster, and the profit value of TFP is 6.

## 4. Conclusion

The forest smart tourist service model described in this paper, is based on IoT and mobile communications technologies. First, the relevant theories are examined. Secondly, the forest smart tourism service model and the forest smart tourism game model are constructed. And finally, the performance of the model is verified by experiments. The resulting findings show that: (1) the model presented in this work can play a good role in data analysis in both peak and low tourist seasons; (2) according to the benefit relationship between various sectors of tourism, the game model of the forest smart tourism service can give different optimal revenue strategies in different situations. The deficiency of this work is that the game model is only analyzed with theoretical assumptions and is not applied to actual tourism projects. In the future, the model will be constantly improved and introduced into practical applications. This work aims to improve the service quality of smart tourism, and to provide theoretical method support and decision-making reference for the sustainable development of the tourism industry.

## 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.

## Acknowledgments

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