

## Research Article

# Research on the Development Model of Rural Tourism Based on Multiobjective Planning and Intelligent Optimization Algorithm

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In order to improve the effect of rural tourism development, this study combines multiobjective planning and intelligent optimization algorithms to analyze the development mode of rural tourism and further deals with the problem of multisensor target tracking under unknown input interference conditions by designing a tourism network consensus algorithm. The algorithm adopts a distributed multisensor fusion structure combined with consensus estimation, and each sensor first performs two-level information filtering estimation and unknown input parameter estimation locally. The experimental research results show that the rural tourism development model based on multiobjective planning and intelligent optimization algorithm proposed in this study can play an important role in the development of rural tourism.

## 1. Introduction

Tourism products have the characteristics of different places, changes, and differences, and it is more convenient and efficient to publicize and promote through the mode of Internet interconnection. In the era of micromedia, the public began to use mobile terminals to obtain relevant consultation, exchange experiences, and reservations for scenic spots through the Internet in the process of tourism selection, which changed the traditional tourism marketing model. The rural tourism marketing model in the micromedia era is that the majority of tourists choose the information of the tourism destination through the Internet. Tourists choose their favorite rural tourism destinations according to their personal preferences. Moreover, managers and operators of rural tourism strengthen interaction and communication with each other and with tourists through the Internet. Tourists can post comments through WeChat and Weibo, which can subtly enhance the popularity and reputation of tourism companies. The connection between tourists and operators can promote the development of the rural tourism

industry, thereby driving the development of the local tourism economy.

The sinking tourism market represented by rural areas has broadened the growth space of online consumption and has become a new bright spot in the growth of Internet consumption. In the era of micromedia, rural tourists can publish their itinerary or travel strategies through WeChat, Weibo, and other methods for rural tourism routes, accommodation, travel experience, etc. Taking Weibo as an example and browsing the Weibo of a tourist attraction, we can see the comments of netizens on the relevant tourist attractions, tourist accommodation, or travel itinerary planning, strategies, and suggestions and opinions from senior tourists. Moreover, novel business models have driven the transformation of traditional consumption patterns.

The combination of operators of modern tourism enterprises and advanced Internet technology has changed the traditional mode of operation. Operators no longer distribute travel information through the traditional methods of distributing leaflets or mass information but publish tourism information through WeChat and Weibo public

accounts and update it to meet the comprehensive and personalized tourism needs of rural tourists. For managers and tourism operators of rural tourism destinations, the use of Internet technology to release and publicize the latest tourism routes, contact information, and tourism products not only saves the cost of publicity but also expands the scope of information dissemination, especially The promotion of tourism packages is carried out on a regular basis according to the needs of the public, which further enhances the influence of rural tourism. For example, in the parent-child interaction in the farm, combining the Internet of Things technology and tourists' favorite "sweep" function, tourists can experience farming activities such as picking melons and fruits, making tofu, and making cheese while recognizing animals and plants. The user purchase provides a vivid experience interface, which combines education and entertainment, and shopping in tourism, which is conducive to the sustainable development of rural tourism. In the era of micromedia, rural tourism has accelerated the development of the tourism industry and promoted the vigorous development of the rural economy. On the other hand, it promoted the construction of rural network infrastructure.

Based on the above analysis, this study combines multiobjective planning and intelligent optimization algorithm to analyze the development mode of rural tourism, so as to improve the analysis effect of rural tourism development path.

## 2. Related Work

The rapid development of science, technology, and economy has greatly reduced the demand for mass tourism products such as traditional sightseeing tourism products [1]. Literature [2] classifies the development mode of rural tourism into five categories: demand-pull, supply-push, intermediary-influence, support-effect, and mixed-drive. Literature [3] believes that government promotion is the main driving force in the early stage of rural tourism development; with the development of rural tourism, market driving force has gradually become the main driving force, and the government mainly plays the role of supervision. Literature [4] believes that relying on natural landscapes to develop rural tourism is suitable to adopt pastoral agricultural tourism mode and return to nature tourism mode and farmhouse tourism mode. Literature [5] believes that the three development models based on regional tourism resources, oriented by the development and management of the main body, and relied on the type of tourism product projects are the main models of rural tourism development in Beautiful China. Literature [6] found that the development mode of rural tourism is mainly scenic based, urban based, and primitive ecological (the old and young, borderless, and poor areas). Literature [7] believes that there are two rural tourism development modes in the Erhai Lake area: the mode of participation of community residents guided by grassroots organizations and the mode of community residents leading. Literature [8] believes that according to the main body of management, the main models of rural tourism development can be divided into government led, enterprise led, collective led, and individual led.

Tourism is an information-intensive and information-dependent industry, and tourism informatization has become one of the hotspots in tourism research. Literature [9] proposes that policy selection, personnel training, network security, and technology adoption are the needs of tourism informatization. Literature [9] proposes that policy selection, personnel training, network security, and technology adoption are the basic issues that need to be considered in tourism informatization. Literature [10] analyzed the limitations of the traditional tourism value chain and the impact of tourism informatization on the tourism value chain in the context of tourism informatization and reconstructed the new tourism value chain. Reference [11] analyzes the problems encountered in the process of tourism informatization and proposes solutions. Literature [12] proposes a networked system and development countermeasures for urban tourism information consulting services. Literature [13] proposes measures such as developing rural tourism mobile SMS mode, strengthening website construction, improving infrastructure construction, raising public awareness, strengthening talent training and introduction, and promulgating relevant policies and regulations for rural tourism informatization construction. Literature [14] analyzed the constraints and opportunities of rural tourism informatization construction in Yunnan and proposed countermeasures and platform construction measures for rural tourism informatization construction. Literature [15] discussed the influence mechanism and main manifestations of informatization on the development of tourism industry, aiming at establishing office automation network, business management network, public service network, and comprehensive tourism information database and pointed out that informatization can transform the tourism industry development model, enhance the competitiveness of the tourism industry, and optimize the tourism development environment. Reference [16] discusses the development mode of the intelligent management system of tourist attractions. Literature [14] proposed digital tourism service, pointing out that digital tourism is a tourism information service system based on the network environment, and it is a space centered on "3S" technology, database technology, decision support system, network technology, electronics, and virtual reality technology. The information technology system is the combination of economy, tourism, and information science and technology. Literature [17] constructed the overall framework of the digital tourism system and proposed the realization idea of the tourism application information system. Literature [18] studies the multimedia tourism intelligent navigation system, designs, and develops the tourism intelligent navigation system platform, which has the functions of online virtual tour, tourism itinerary planning, autonomous navigation, and rescue. Literature [19] starts from the realization method and realization of intelligent tourism. The concept of smart tourism is described from the perspective of goals, but the essence of smart tourism is insufficiently explored. Literature [20] believes that smart tourism has not changed the basic characteristics and inherent requirements of the development of the tourism industry and the whole chain of

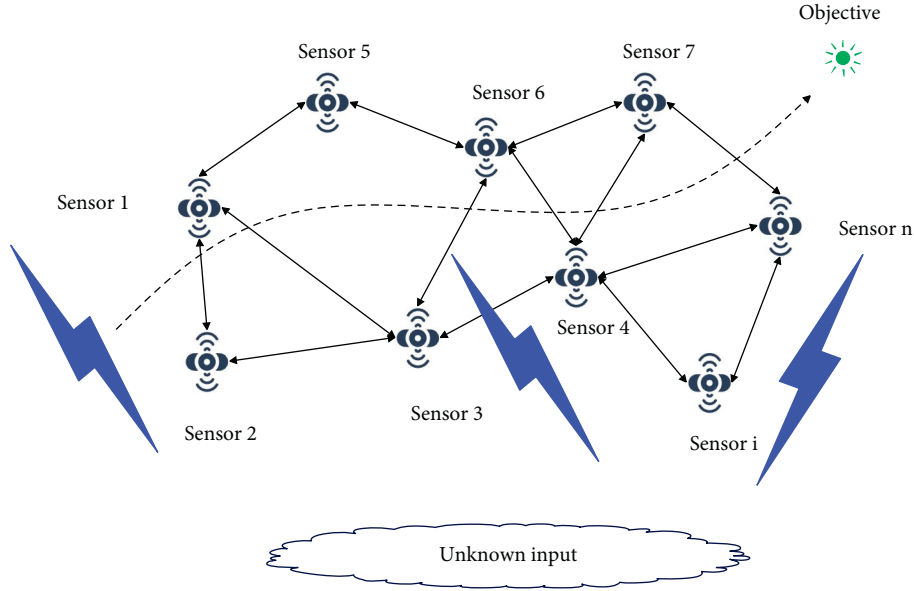


FIGURE 1: Target tracking with multiple sensors affected by unknown inputs.

tourism services to generate wisdom effect and create wisdom value.

### 3. Multiobjective Programming and Intelligent Optimization Algorithms

A multisensor target tracking scenario affected by unknown inputs is shown in Figure 1. Each sensor node in the multisensor network is equipped with a detection function module, a communication function module, and a data processing function module. The detection function module of the node has the functions of real-time detection of targets and acquisition of target observation information. The communication function module has the function of transmitting the observation information of the sensor itself or the estimated information processed by the data processing module to its neighbor nodes; at the same time, it has the function of receiving the data information of the neighbor nodes. The data processing module has the functions of local data processing and consensus data fusion. Therefore, this study designs the detection function module of all nodes in the sensor network to detect the target measurement information. The target state estimation, sensor bias estimation, and unknown parameter estimation are obtained by filtering estimation locally through the information processing module. Then, through the communication function module, the state estimation and unknown parameter estimation of itself are exchanged and transmitted with the information of the neighbor nodes. Then, in the data processing module, the estimated information of the network consensus is fused, the system deviation is further corrected, and the information is repeatedly exchanged for consensus fusion to finally obtain the global consistency estimation of the target state.

Based on the above description, considering a sensor consisting of  $n$  sensors, this section proposes the following multisensor discrete system model:

$$\mathbf{x}_{k+1} = \mathbf{A}_k \mathbf{x}_k + \boldsymbol{\zeta}_k, \quad (1)$$

$$\mathbf{b}_{k+1}^i = \mathbf{B}_k^i \mathbf{b}_k^i + \mathbf{D}_k^i \boldsymbol{\mu}_k + \boldsymbol{\omega}_k^i, \quad (2)$$

$$\mathbf{y}_{k+1}^i = \mathbf{H}_{k+1}^i \mathbf{x}_{k+1} + \mathbf{N}_{k+1}^i \mathbf{b}_{k+1}^i + \mathbf{v}_{k+1}^i. \quad (3)$$

Among them,  $\mathbf{x}_k \in \mathfrak{R}^n$  is the target state quantity at time  $k$ ,  $\boldsymbol{\mu}_k \in \mathfrak{R}^q$  is the unknown input,  $\mathbf{y}_k^i \in \mathfrak{R}^m$  is the observation quantity of the  $i$ -th sensor system at time  $k$ , and  $\mathbf{b}_k^i \in \mathfrak{R}^p$  is the deviation of the  $i$ th sensor system at time  $k$ .  $\mathbf{A}_k, \mathbf{B}_k^i, \mathbf{N}_k^i, \mathbf{H}_k^i$  is a known transition matrix of appropriate dimension. We assume that  $m^i > p^i > q^i$ ,  $\mathbf{D}_k^i$  is a column full rank matrix. The noises  $\boldsymbol{\zeta}_k, \boldsymbol{\omega}_k^i$  and  $\mathbf{v}_k^i$  are uncorrelated zero-mean white noises, and the noises of each sensor are also uncorrelated with each other, satisfying  $E\{\boldsymbol{\zeta}_k \boldsymbol{\zeta}_k^T\} = \mathbf{F}_k \boldsymbol{\delta}_{k-1}$ ,  $E\{\mathbf{v}_k^i \mathbf{v}_k^{iT}\} = \mathbf{R}_k^i \boldsymbol{\delta}_{k-1}$ ,  $E\{\boldsymbol{\omega}_k^i \boldsymbol{\omega}_k^{iT}\} = \mathbf{S}_k^i \boldsymbol{\delta}_{k-1} \cdot \mathbf{F}_k \mathbf{R}_k^i$  and  $\mathbf{S}_k^i$  are their respective covariance matrices.

The information filtering vector and its information matrix transformation formula are as follows:

$$\mathbf{Y} = \mathbf{P}^{-1} = \frac{\mathbf{P}}{\mathbb{1}}, \quad \mathbf{y} = \mathbf{Y}\mathbf{x}. \quad (4)$$

Among them, “ $\backslash$ ” represents the left division operator, “ $\mathbf{y}$ ” represents the information vector, “ $\mathbf{Y}$ ” is the information matrix, “ $\mathbf{x}$ ” represents the filter estimated value, and “ $\mathbf{P}$ ” is the estimated error covariance.

Then, according to formula (4), the matrix inverse transformation can be performed to predict the stateless deviation information vector  $\bar{\mathbf{y}}_{k+1k}^{b,i}$  and its information matrix  $\bar{\mathbf{Y}}_{k+1k}^{b,i}$ . Similarly, it is easy to obtain the predicted state information vector  $\mathbf{y}_{k+1k}^{x,i}$  and its information matrix  $\mathbf{Y}_{k+1k}^{x,i}$  by inverse transformation.

**Theorem 1.** The algorithm updates the stateless bias information vector  $\tilde{\mathbf{y}}_{k+1|k+1}^{b,i}$  and its information matrix  $\tilde{\mathbf{Y}}_{k+1|k+1}^{b,i}$  as follows:

$$\begin{aligned}\tilde{\mathbf{Y}}_{k+1|k+1}^{b,i} &= \tilde{\mathbf{Y}}_{k+1|k}^{b,i} + \tilde{\mathbf{I}}_{k+1}^{b,i}, \\ \tilde{\mathbf{y}}_{k+1|k+1}^{b,i} &= \tilde{\mathbf{y}}_{k+1|k}^{b,i} + \tilde{\mathbf{i}}_{k+1}^{b,i}.\end{aligned}\quad (5)$$

Among them,  $\tilde{\mathbf{b}}_{k+1|k}^i = \bar{\mathbf{B}}_k^i (\tilde{\mathbf{Y}}_{k|k}^{b,i} / \tilde{\mathbf{y}}_{k|k}^{b,i}) + \mathbf{D}_k^i \Pi_k^i \mathbf{y}_{k+1}^i + \Theta_k^i \tilde{\mathbf{i}}_{k+1}^{b,i} = \mathbf{N}_{k+1}^{iT} \mathbf{R}_{k+1}^{i-1} \mathbf{y}_{k+1}^i$ ,  $\tilde{\mathbf{I}}_{k+1}^{b,i} = \mathbf{N}_{k+1}^{iT} \mathbf{R}_{k+1}^{i-1} \mathbf{N}_{k+1}^i$ . The algorithm updates the state information vector  $\mathbf{y}_{k+1|k+1}^{x,i}$  and its information matrix  $\mathbf{Y}_{k+1|k+1}^{x,i}$  as follows:

$$\begin{aligned}\mathbf{Y}_{k+1|k+1}^{x,i} &= \mathbf{Y}_{k+1|k}^{x,i} + \mathbf{I}_{k+1}^{x,i}, \\ \mathbf{y}_{k+1|k+1}^{x,i} &= \mathbf{y}_{k+1|k}^{x,i} + \mathbf{i}_{k+1}^{x,i}.\end{aligned}\quad (6)$$

Among them,  $\tilde{\mathbf{x}}_{k|k}^i = \mathbf{Y}_{k|k}^{x,i} / \mathbf{y}_{k|k}^{x,i}$ ,  $\tilde{\mathbf{G}}_{k+1}^i = L^i (\mathbf{N}_{k+1}^i (\tilde{\mathbf{Y}}_{k+1|k}^{b,i} / \mathbb{1})) (\mathbf{N}_{k+1}^{iT} + \mathbf{R}_{k+1}^i) L^{iT}$ ,  $\tilde{\mathbf{i}}_{k+1}^{x,i} = \mathbf{S}_{k+1|k}^{iT} \tilde{\mathbf{G}}_{k+1}^{i-1} \tilde{\mathbf{r}}_{k+1}^i$ .

The prediction and update information vector  $\mathbf{y}_{k+1|k+1}^{\beta,i}$  and information matrix  $\mathbf{Y}_{k+1|k+1}^{\beta,i}$  of  $\beta$  are expressed as follows:

$$\mathbf{y}_{k+1|k+1}^{\beta,i} = \mathbf{y}_{k+1|k}^{\beta,i} + \mathbf{i}_{k+1}^{\beta,i}, \frac{n!}{r!(n-r)!} \quad (7)$$

$$\mathbf{\beta}_{k+1|k+1}^i = \mathbf{Y}_{k+1|k+1}^{\beta,i} \setminus \mathbf{Y}_{k+1|k+1}^{\beta,i}. \quad (8)$$

$$\mathbf{Y}_{k+1|k+1}^{\beta,i} = \mathbf{Y}_{k+1|k}^{\beta,i} + \mathbf{I}_{k+1}^{\beta,i} = \tilde{\mathbf{y}}_{k+1|k+1}^{b,i}. \quad (9)$$

Among them, the value of  $\mathbf{Y}_{k+1|k}^{\beta,i} = \tilde{\mathbf{y}}_{k+1|k}^{b,i}$ ,  $\mathbf{y}_{k+1|k}^{\beta,i} = \mathbf{Y}_{k+1|k}^{\beta,i} \beta_{k+1|k}^i$ ,  $\mathbf{I}_{k+1}^{\beta,i} = \tilde{\mathbf{I}}_{k+1}^{b,i} = \mathbf{N}_{k+1}^i \mathbf{R}_{k+1}^{i-1} \mathbf{N}_{k+1}^i$ ,  $\mathbf{i}_{k+1}^{\beta,i} = -\mathbf{N}_{k+1}^{iT} \mathbf{R}_{k+1}^{i-1} \mathbf{H}_{k+1}^i \beta_{k+1|k}^i = \Gamma_{k+1}^i + (\mathbf{Q}_k^{bxi} - \Gamma_{k+1}^i \mathbf{Q}_k^x) \mathbf{Y}_{k+1|k}^{x,i} \Gamma_{k+1}^i$ ,  $\mathbf{i}_{k+1}^{\beta,i} = \mathbf{I}_{k+1}^{\beta,i} \tilde{\mathbf{x}}_{k+1|k}^i$  is the same as the formula.

*Proof.* It can be expressed as follows:

$$\begin{aligned}\tilde{\mathbf{K}}_{k+1}^{b,i} &= \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} (\tilde{\mathbf{G}}_{k+1}^i)^{-1} \\ &= \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} \left( L^i \left( \mathbf{N}_{k+1}^i \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} + \mathbf{R}_{k+1}^i \right) L^{iT} \right)^{-1} \\ &= \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} \left( L^i \left( \mathbf{N}_{k+1}^i \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} + \mathbf{R}_{k+1}^i \right) L^{iT} \right)^{-1} (L^i \mathbf{R}_{k+1}^i L^{iT}) (L^i \mathbf{R}_{k+1}^i L^{iT})^{-1} \\ &= \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} (L^i \mathbf{R}_{k+1}^i L^{iT})^{-1} - \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} \left( L^i \left( \mathbf{N}_{k+1}^i \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} + \mathbf{R}_{k+1}^i \right) L^{iT} \right)^{-1} \\ &\quad \left( L^i \left( \mathbf{N}_{k+1}^i \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} \right) L^{iT} \right) (L^i \mathbf{R}_{k+1}^i L^{iT})^{-1} \\ &= \left( \mathbb{1} - \tilde{\mathbf{K}}_{k+1}^{b,i} L^i \mathbf{N}_{k+1}^i \right) \tilde{\mathbf{P}}_{k+1|k}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} (L^i \mathbf{R}_{k+1}^i L^{iT})^{-1} \\ &= \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \mathbf{N}_{k+1}^{iT} L^{iT} (L^i \mathbf{R}_{k+1}^i L^{iT})^{-1} \\ &= \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \mathbf{N}_{k+1}^{iT} \mathbf{R}_{k+1}^{i-1} (L^i)^{-1}.\end{aligned}\quad (10)$$

Then, there is

$$\mathbb{1} - \tilde{\mathbf{K}}_{k+1}^{b,i} L^i \mathbf{N}_{k+1}^i = \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1}. \quad (11)$$

Then, it can be expressed as follows:

$$\begin{aligned}
\tilde{\mathbf{b}}_{k+1|k+1}^i &= \tilde{\mathbf{b}}_{k+1|k}^i + \tilde{\mathbf{K}}_{k+1}^{b,i} \tilde{\mathbf{r}}_{k+1}^i \\
&= \left( \mathbb{I} - \tilde{\mathbf{K}}_{k+1}^{b,i} L^i N_{k+1}^i \right) \tilde{\mathbf{b}}_{k+1|k}^i + \tilde{\mathbf{K}}_{k+1}^{b,i} L^i \mathbf{y}_{k+1}^i \\
&= \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} \tilde{\mathbf{b}}_{k+1|k}^i + \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \mathbf{N}_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} L^{i,-1} L^i \mathbf{y}_{k+1}^i \\
\left( \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \right)^{-1} \tilde{\mathbf{b}}_{k+1|k+1}^i &= \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} \tilde{\mathbf{b}}_{k+1|k}^i + N_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} L^{i,-1} L^i \mathbf{y}_{k+1}^i \\
&= \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} \tilde{\mathbf{b}}_{k+1|k}^i + N_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} \mathbf{y}_{k+1}^i.
\end{aligned} \tag{12}$$

It is easy to obtain  $\tilde{\mathbf{y}}_{k+1|k}^{b,i}$  according to the definition of the information matrix. By connecting the above formula, formula (4) can be proved.

By taking formula (7) into it, we get

$$\tilde{\mathbf{P}}_{k+1|k+1}^{b,i} = \tilde{\mathbf{P}}_{k+1|k}^{b,i} - \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} N_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} N_{k+1}^i \tilde{\mathbf{P}}_{k+1|k}^{b,i}. \tag{13}$$

By inverse matrix transformation of this formula, we can get

$$\begin{aligned}
\left( \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \right)^{-1} &= \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} + N_{k+1}^{i,T} L^i \left( L^i \mathbf{R}_{k+1}^i L^{i,T} \right)^{-1} L^i N_{k+1}^i \\
&= \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} + N_{k+1}^{i,T} L^i \left( L^{i,T} \right)^{-1} \mathbf{R}_{k+1}^{i,-1} L^{i,-1} L^i N_{k+1}^i \\
&= \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} + N_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} N_{k+1}^i.
\end{aligned} \tag{14}$$

Then, formula (3) is proved.

Substituting formula (8) into it, we get

$$\begin{aligned}
\beta_{k+1|k+1}^i &= \beta_{k+1|k}^i - \tilde{\mathbf{K}}_{k+1}^{b,i} \mathbf{S}_{k+1|k}^i \\
&= \left( \mathbb{I} - \tilde{\mathbf{K}}_{k+1}^{b,i} L^i N_{k+1}^i \right) \beta_{k+1|k}^i - \tilde{\mathbf{K}}_{k+1}^{b,i} L^i \mathbf{H}_{k+1}^i \\
&= \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} \beta_{k+1|k}^i - \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \mathbf{N}_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} \mathbf{H}_{k+1}^i.
\end{aligned} \tag{15}$$

Then,

$\left( \tilde{\mathbf{P}}_{k+1|k+1}^{b,i} \right)^{-1} \beta_{k+1|k+1}^i = \left( \tilde{\mathbf{P}}_{k+1|k}^{b,i} \right)^{-1} \beta_{k+1|k}^i - N_{k+1}^{i,T} \mathbf{R}_{k+1}^{i,-1} \mathbf{H}_{k+1}^i$ , and formula (9) is proved.

In order to improve the tracking accuracy, this study designs parameter estimation for unknown input. The unknown parameters in the system are estimated in turn using the bias estimates derived in the previous section. The bias dynamic equation of the multisensor network in formula (2) can be rewritten as follows:

$$\begin{aligned}
\mathbf{D}_k^i \boldsymbol{\mu}_k &= \mathbf{b}_{k+1}^i - \mathbf{B}_k^i \mathbf{b}_k^i - \omega_k^i \\
&= \hat{\mathbf{b}}_{k+1|k+1}^i - \mathbf{B}_k^i \hat{\mathbf{b}}_{k|k}^i + \left( \hat{\mathbf{b}}_{k+1|k+1}^i - \mathbf{B}_k^i \hat{\mathbf{b}}_{k|k}^i - \omega_k^i \right) \\
&= \bar{\mathbf{b}}_k^i + \phi_k^i.
\end{aligned} \tag{16}$$

Among them,  $\bar{\mathbf{b}}_k^i \triangleq \hat{\mathbf{b}}_{k+1|k+1}^i - \mathbf{B}_k^i \hat{\mathbf{b}}_{k|k}^i$ ,  $\phi_k^i \triangleq \hat{\mathbf{b}}_{k+1|k+1}^i - \mathbf{B}_k^i \hat{\mathbf{b}}_{k|k}^i - \omega_k^i$ ,  $\hat{\mathbf{b}}_{k+1|k+1}^i \triangleq \hat{\mathbf{b}}_{k+1}^i - \hat{\mathbf{b}}_{k+1|k+1}^i$ . It is easy to know  $E(\phi_k^i) = 0$ . The deviation equations of sensor node  $i$  and its neighbor

nodes can be expressed in the form of equation (13). Therefore, these equations can be combined, and formula (13) can be expressed as follows:

$$\mathbf{D}_k \boldsymbol{\mu}_k = \mathbf{B}_k + \phi_k. \tag{17}$$

Among them,  $\mathbf{D}_k \triangleq \text{col}\{\mathbf{D}_k^j: j \in J_i\}$ ,  $\mathbf{B}_k \triangleq \text{col}\{\bar{\mathbf{b}}_k^j: j \in J_i\}$ ,  $\phi_k \triangleq \text{col}\{\phi_k^j: j \in J_i\}$ .

Further, according to the principle of least squares estimation, equation (14) can be transformed into the following equation, so as to obtain the estimation of the unknown input parameters of the  $i$ -th sensor node:

$$\begin{aligned}
\hat{\boldsymbol{\mu}}_k^i &= \left( \mathbb{D}_k^T \mathbb{D}_k \right)^{-1} \mathbb{D}_k^T \mathbf{B}_k, \\
\mathbf{Y}_k^{\mu,i} &= \mathbb{D}_k^T \mathbb{D}_k.
\end{aligned} \tag{18}$$

Then, there is  $\mathbf{y}_k^{\mu,i} = \mathbb{D}_k^T \mathbb{B}_k$ .

Although each sensor network has different biases, sensor networks are all affected by unknown inputs. Therefore, it is advisable to design a network to achieve consistent consensus on unknown inputs, so that unknown parameters can be accurately estimated.

The multisensor communication network topology is usually represented by the adjacency matrix in graph theory, and the communication connection of the nodes in the sensor network is often represented by the adjacency matrix. The topology of the sensor network is represented by defining an undirected graph  $G = (V, E)$ . Among them,  $V$  is the node set in the multisensor network,  $V = \{1, 2, \dots, n\}$ , and each element in the set corresponds to a sensor.  $E$  represents the set of edges in the graph  $G$ , the elements in  $E \subseteq V \times V$ ,  $E$  are called edges, which are represented as unordered pairs of elements in  $V$ , and an edge represents two-way communication between the two sensors. The number of edges associated with  $V_i$  is called the degree of a point  $V_i$ , and the degree of a graph is equal to the sum of the degrees of the points.  $A_i = \{j \in V, (j, i) \in E\}$  represents the set of neighbor nodes that can communicate with sensor  $i$ , and  $n$  represents the number of sensor nodes.

For graph  $G = (V, E)$ ,  $|V| = n$ ,  $|E| = m$ , the  $n \times n$ -order matrix  $J = [a_{ij}]_{i,j=1}^n$  is an adjacency matrix, which is expressed as follows:

$$a_{ij} \begin{cases} 1 & \text{if } (j, i) \notin E \\ 0 & \text{otherwise} \end{cases}. \tag{19}$$

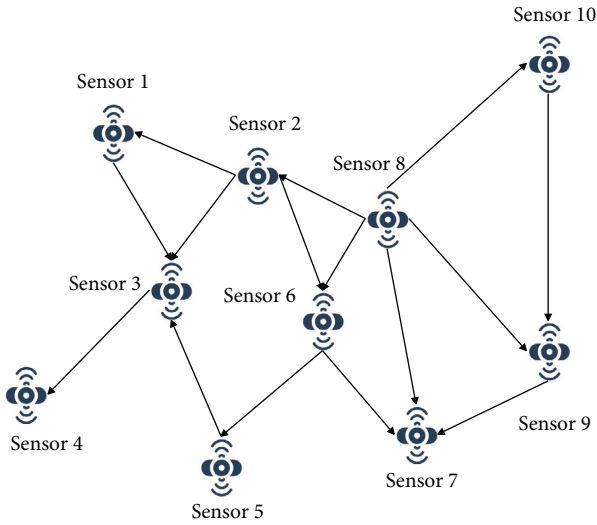


FIGURE 2: Sensor network communication topology.

Among them,  $a_{ij} = 1$  refers to the existence of a communication link between sensor  $i$  and sensor  $j$  and  $a_{ij} = 0$  refers to the absence of communication between sensor  $i$  and sensor  $j$ . According to the adjacency matrix, the connection and communication of the sensor network can be well represented, and it has a wide range of applications in multisensor fusion algorithms.

During the operation of the entire network, the node set  $V$  and the edge set  $E$  of the network change dynamically, that is to say, the connection relationship between nodes is allowed to change during the operation of the sensor network, and nodes can be directly added or removed. However, due to the limited communication capability of each sensor, it is impossible to send its own information to every other node in one communication cycle. Taking 10 sensors as an example, Figure 2 shows the network communication topology diagram composed of 10 sensors.

The adjacency matrix corresponding to the sensor network in Figure 2 is shown in formula (17):

$$J = \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \end{bmatrix}. \quad (20)$$

Since the sensor bias is not only affected by the unknown input but also includes the sensor's own bias, the bias of each sensor is unique to itself, and consistency filtering cannot be performed. However, the unknown input received by the

sensor network is consistent, so it can achieve a consistent consensus on the unknown parameters.

According to the network topology, the matrix  $\text{Time}_{i*j}$  is defined in this study to represent the minimum number of times that the information of node  $i$  is transmitted to node  $j$ , that is, the shortest path of information transmission. The matrix  $\text{Time}_{i*j}$  is an  $n * n$  matrix, and the matrix element  $\text{Time}_{ij}$  represents the minimum number of transfers required to transmit information from the  $i$ -th node to the  $j$ -th node. Taking Figure 2 as an example, the shortest path to transmit information from sensor 1 to sensor 9 is as follows: sensor 1 -> sensor 2 -> sensor 8 -> sensor 9. Since it is passed 3 times,  $\text{Time}_{1*9} = 3$ . For different network communication topologies, the matrix  $\text{Time}_{i*j}$  will also be different. It can be seen that according to the matrix  $\text{Time}_{i*j}$ , the communication situation of each sensor can be known, and it can be seen which nodes can obtain the most global information in the least number of iterations. The matrix  $\text{Time}_{i*j}$  of the multisensor network shown in Figure 2 can be expressed as formula (17):

$$\text{Time}_{i*j} = \begin{bmatrix} 0 & 1 & 1 & 2 & 2 & 2 & 3 & 2 & 3 & 3 \\ 1 & 0 & 1 & 2 & 2 & 1 & 2 & 1 & 2 & 2 \\ 1 & 1 & 0 & 1 & 1 & 2 & 3 & 2 & 3 & 3 \\ 2 & 2 & 1 & 0 & 2 & 3 & 4 & 3 & 4 & 4 \\ 2 & 2 & 1 & 2 & 0 & 1 & 2 & 2 & 3 & 3 \\ 2 & 1 & 2 & 3 & 1 & 0 & 1 & 1 & 2 & 2 \\ 3 & 2 & 3 & 4 & 2 & 1 & 0 & 1 & 1 & 2 \\ 2 & 1 & 2 & 3 & 2 & 1 & 1 & 0 & 1 & 1 \\ 3 & 2 & 3 & 4 & 3 & 2 & 1 & 1 & 0 & 1 \\ 3 & 2 & 3 & 4 & 3 & 2 & 2 & 1 & 1 & 0 \end{bmatrix}. \quad (21)$$

This study defines  $\rho$  as a set, where  $\rho(i) = \sum_{j=1}^n \text{Time}_{ij}$  is the sum of the minimum number of iterations for node  $i$  to receive information from all other nodes. Within the limited number of iterations, the smaller the sum of the minimum number of iterations for a node to receive information from other nodes, the more information the node obtains from other nodes. Therefore, the communication volume of a node is designed in this study to represent the amount of information obtained by the node, which is inversely proportional to  $\rho(i)$ . The smaller  $\rho(i)$  is, the greater the communication volume is, and the more information is obtained.

This study defines  $\Delta$  to represent the node traffic, and its expression is as follows:

$$\Delta(i) = \frac{1}{\rho(i)}. \quad (22)$$

A sensor with more neighbor nodes potentially has more information throughput, and its status in the sensor network is equivalent to a core node. This study defines  $\Omega_{\max}$  as the sensor with the most neighbor nodes, which represents the node that exchanges the most information in the sensor network. Then, this study designs the consistency weight

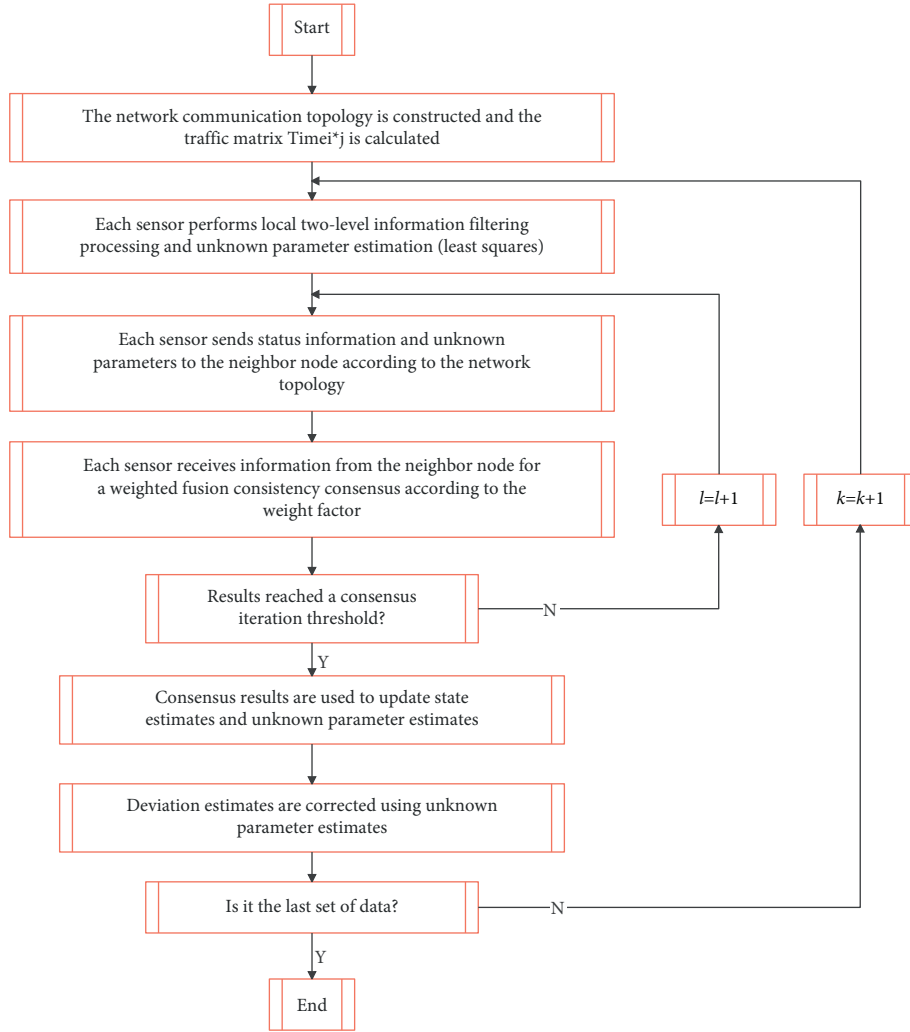


FIGURE 3: Block diagram of the algorithm flow.

factor according to the traffic of the node, so that the greater the traffic of the node, the higher the importance of the node, and the estimated value of the node is closer to the global optimal estimated value of all the information in the sensor.

Consistency estimation theory means that in a multi-sensor network, the arbitrary initial state of each node for any sensor has

$$\lim_{t \rightarrow \infty} \|x_i(t) - x_j(t)\| = 0. \quad (23)$$

That is, all sensors eventually reach a common consistent state, and all sensors have the same estimated state of the target.

In a sensor network, the basis for judging the good performance of the system is the unbiased estimation of the mean initial state of the node as the target state. If each sensor is in an initial state, each node of the sensor network can quickly reach the average consistency of the initial value; it is considered that for the target in any fixed time state, the entire network has achieved consistent tracking of the target. In the discrete-time case, the most commonly used mathematical model for consensus estimation is expressed as follows:

$$x_i(k+1) = x_i(k) + \varepsilon \sum_{j \in N_i} w_{ij} (x_j(k) - x_i(k)) \quad i \in V. \quad (24)$$

Among them,  $\varepsilon$  represents the iteration step size, and the value range is as follows:

$$0 < \varepsilon < \frac{1}{\theta} \quad \theta = \max_i \left( \sum_{i \neq j} a_{ij} \right). \quad (25)$$

In an undirected graph,  $w_{ij}$  represents the weight that sensor  $i$  assigns to sensor  $j$ .

Since the sensor nodes exchange information with each other, the greater the communication volume of a node, the more times the node communicates with other sensors, and the greater the impact on other sensors in the process of network consensus. Therefore, when designing the data fusion weight factor, the relative situation between nodes should be considered, and the consistency weight factor should be designed by corresponding to the relative size of the communication between the two sensor nodes. The consistency weight factor is determined by the traffic between node  $i$  and node  $j$ . According to the average consensus



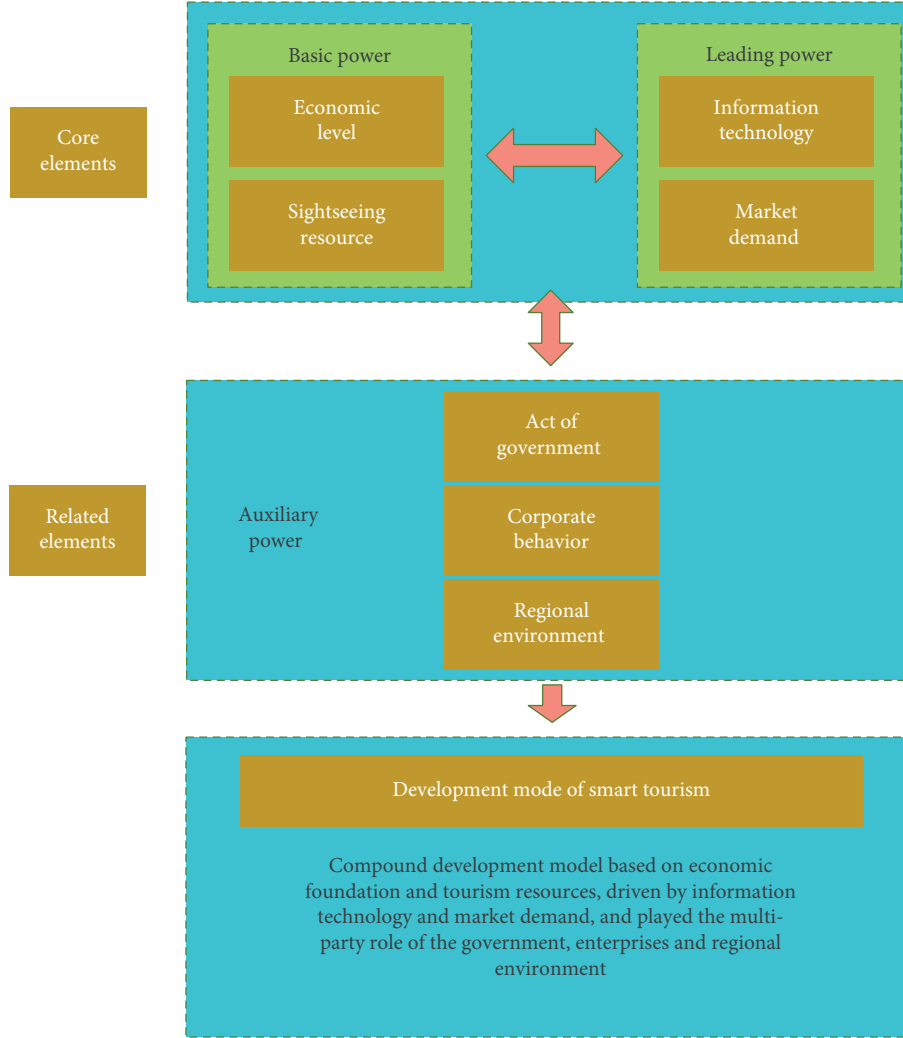


FIGURE 4: Dynamic mechanism of rural smart tourism development.

fusion criterion,  $\mathbf{U}(l) = [\mathbf{u}_{ij}(l)]$  denotes the linear weighting matrix of the state estimation iteration  $l$  step, and  $\mathbf{u}_{ij}$  denotes the weight of node  $j$  at sensor node  $i$ . The initial design weight factor is determined in the form of  $\Delta(j)/\Delta(i)$ . The greater the traffic  $\Delta(j)$  of the neighbor node  $j$ , the greater the weight factor, and the local information will make more corrections to its own information according to the weight factor. Then, the estimation accuracy of the node with small communication traffic will be corrected at a faster speed than the estimation accuracy of the node with large communication traffic. In order to ensure that the consistency weight factor does not modify the local too much and cause the information to be cluttered in the iterative process, this study defines the following weighting matrix rules:

$$\begin{cases} \mathbf{u}_{ij}(l+1) = \frac{\Delta(j)}{\Delta(i)} * \frac{\min_{j=1,2,\dots,n}\{\Delta(f)\}}{\max_{f=1,2,\dots,n}\{\Delta(f)\}} * \Omega_{\max} & j \in J_i \\ \mathbf{u}_{ij}(l+1) = 0 & j \notin J_i \end{cases} \quad (26)$$

The second half of this formula is to ensure that  $\mathbf{u}_{ij} \in (0, 1)$  enables the network to converge.

According to formulas (1)–(3), after sensor  $i$  performs  $l$  consistent fusion, its state estimation and unknown parameter weighting coefficient matrix is  $\mathbf{U}(l)$ , and its corresponding global optimal information vector and information matrix are as follows:

$$\begin{cases} \mathbf{y}_{k|k}^{x,i}(l+1) = \mathbf{y}_{k|k}^{x,i}(l) + \sum_{j \in J_i} \mathbf{u}_{ij}(l) (\mathbf{y}_{k|k}^{x,j}(l) - \mathbf{y}_{k|k}^{x,i}(l)) \\ \mathbf{Y}_{k|k}^{x,i}(l+1) = \mathbf{Y}_{k|k}^{x,i}(l) + \sum_{j \in J_i} \mathbf{u}_{ij}(l) (\mathbf{Y}_{k|k}^{x,j}(l) - \mathbf{Y}_{k|k}^{x,i}(l)) \\ \mathbf{y}_k^{\mu,i}(l+1) = \mathbf{y}_k^{\mu,i}(l) + \sum_{j \in J_i} \mathbf{u}_{ij}(l) (\mathbf{y}_k^{\mu,j}(l) - \mathbf{y}_k^{\mu,i}(l)) \\ \mathbf{Y}_k^{\mu,i}(l+1) = \mathbf{Y}_k^{\mu,i}(l) + \sum_{j \in J_i} \mathbf{u}_{ij}(l) (\mathbf{Y}_k^{\mu,j}(l) - \mathbf{Y}_k^{\mu,i}(l)) \end{cases} \quad (27)$$

Then, the global optimal state estimation and unknown parameter estimation can be expressed as follows:



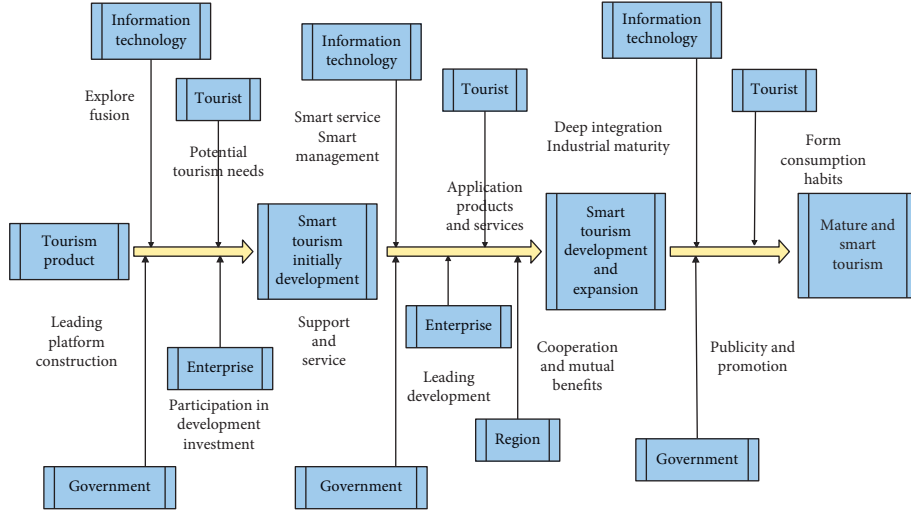


FIGURE 5: Rural smart tourism development model.

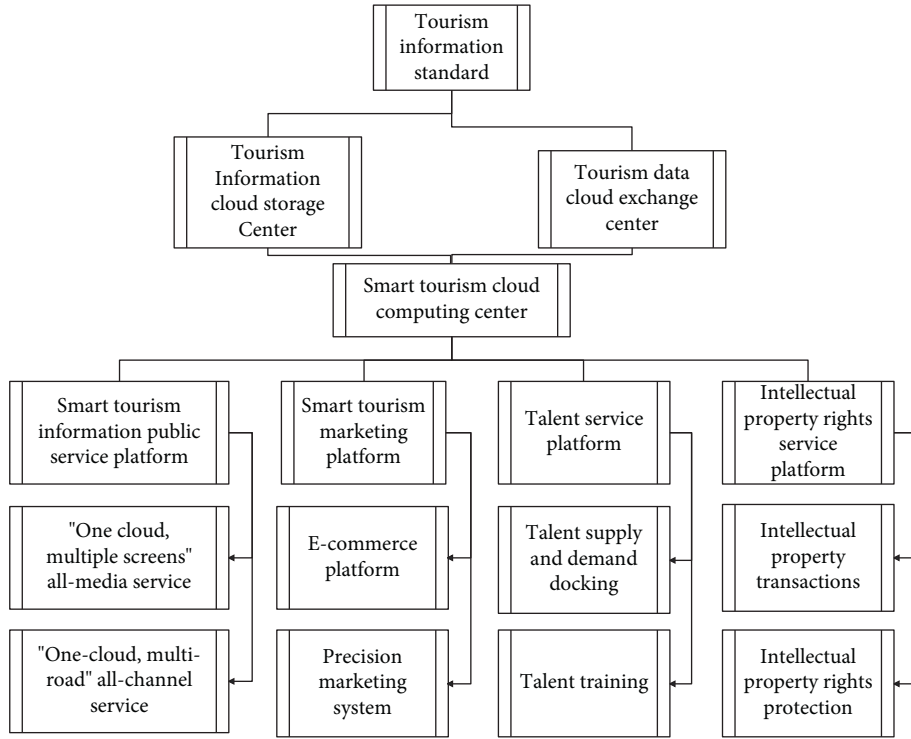


FIGURE 6: Construction system of rural smart tourism public service platform.

$$\begin{aligned} \hat{\mathbf{x}}_{k|k}^i(l+1) &= \mathbf{Y}_{k|k}^{r,i}(l+1) \setminus \mathbf{y}_{k|k}^{xi}(l+1), \\ \hat{\boldsymbol{\mu}}_k^i(l+1) &= \mathbf{Y}_k^{\mu,i}(l+1) \setminus \mathbf{y}_k^{\mu,i}(l+1). \end{aligned} \quad (28)$$

The distributed consistent data fusion algorithm continuously improves the state estimation accuracy of each sensor through iteration. The fused state estimation is fed back to each sensor to continue to use the unknown parameter estimation to correct the deviation, so that the state of the sensor and the estimation accuracy of the deviation are improved in both aspects. This iterative update method makes the neighbor nodes with high traffic have higher

weights, and each sensor collects the neighbor information iteratively, so that the updated value of each sensor is more accurate. By repeating this cycle, eventually, the state estimates of all sensors will gradually reach an agreement.

After the unknown input global estimate  $\hat{\boldsymbol{\mu}}_k^i$  obtained through the consensus estimation of the network consensus, it is put into the local to correct the local bias estimate. According to formula (2), the following deviation estimate can be obtained:

$$\hat{\mathbf{b}}_{k+1|k+1}^i = \mathbf{B}_k^i \hat{\mathbf{b}}_{k|k}^i + \mathbf{D}_k^i \hat{\boldsymbol{\mu}}_k^i. \quad (29)$$

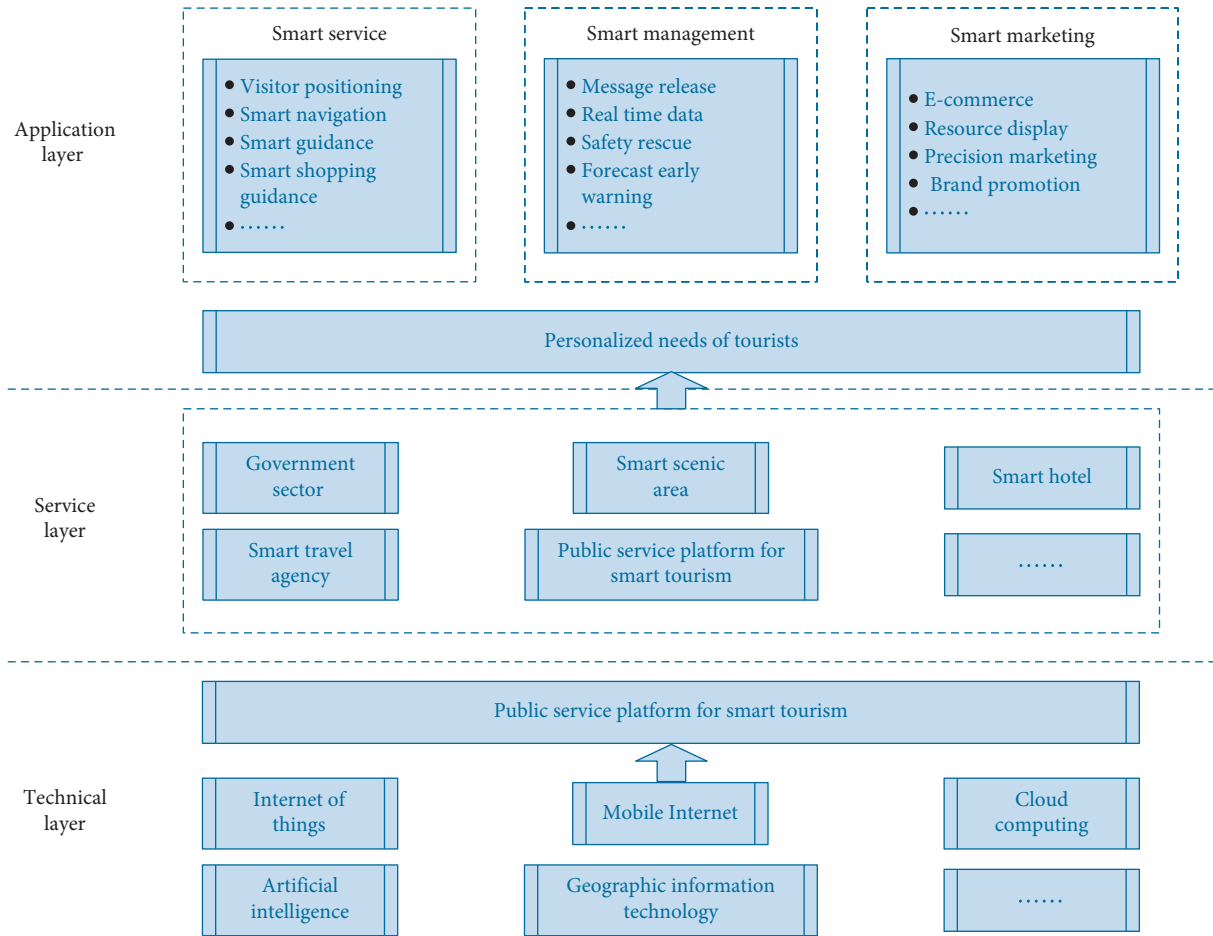


FIGURE 7: Diagram of rural smart tourism system.

TABLE 1: Planning effect of rural tourism development model.

Number	Tourism plan	Number	Tourism plan	Number	Tourism plan
1	93.23	25	91.06	49	89.62
2	90.53	26	87.98	50	90.28
3	93.45	27	89.13	51	89.44
4	89.50	28	92.36	52	89.13
5	90.85	29	91.95	53	89.17
6	89.54	30	93.77	54	90.75
7	88.82	31	91.73	55	92.97
8	87.15	32	93.28	56	93.18
9	90.20	33	90.00	57	88.62
10	93.50	34	92.11	58	91.29
11	91.36	35	87.32	59	87.23
12	87.54	36	92.26	60	88.27
13	91.27	37	87.93	61	92.20
14	89.55	38	89.44	62	93.19
15	93.50	39	90.42	63	92.70
16	88.32	40	87.43	64	91.18
17	91.05	41	88.46	65	92.09
18	93.55	42	91.01	66	93.79
19	92.74	43	87.38	67	89.78
20	92.80	44	91.00	68	90.04
21	89.17	45	91.79	69	91.99
22	87.31	46	93.25	70	90.11
23	92.76	47	89.50	71	93.79
24	90.10	48	89.18	72	90.73

So far, the estimated value  $\hat{\mathbf{b}}_{k+1|k+1}^i, \hat{\mathbf{x}}_{k+1|k+1}^i, \hat{\mu}_k^i$  can be output as the final estimation result after the  $k$ th sampling, as shown in Figure 3.  $\square$

#### 4. Research on the Development Model of Rural Tourism Based on Multiobjective Planning and Intelligent Optimization Algorithm

Combined with the previous intelligent optimization algorithm and multiobjective planning sensor algorithm, the rural tourism development model of this study is constructed. According to the analysis of the driving factors of rural smart tourism development, it can be seen that the core factors promoting the development of rural smart tourism are information technology, market demand, economic level, and tourism resources, and the relevant factors are government behavior, corporate behavior, and regional environment. The economic level provides financial guarantee, and tourism resources provide resource attractiveness, both of which are the basis for the development of smart tourism. The application of information technology and the update of market demand are the leading factors to promote the development of smart tourism in Changshu, and the government, enterprises, and regional environment are the external driving forces. The particularity of the

TABLE 2: The effect of rural tourism development model.

Number	Tourism development	Number	Tourism development	Number	Tourism development
1	76.29	25	75.31	49	72.97
2	84.52	26	79.43	50	76.88
3	81.33	27	83.50	51	74.14
4	83.42	28	80.22	52	74.71
5	70.91	29	84.58	53	77.00
6	81.87	30	83.86	54	70.10
7	78.94	31	74.90	55	84.82
8	75.27	32	82.70	56	83.50
9	76.10	33	77.07	57	78.17
10	83.00	34	73.28	58	74.10
11	76.52	35	81.92	59	79.30
12	73.31	36	70.34	60	84.69
13	74.61	37	72.93	61	84.70
14	74.63	38	75.48	62	77.33
15	81.99	39	76.82	63	69.56
16	74.17	40	69.74	64	77.66
17	70.66	41	79.08	65	73.33
18	78.26	42	84.40	66	83.97
19	79.86	43	76.51	67	81.27
20	83.85	44	79.99	68	75.35
21	81.86	45	79.33	69	75.55
22	80.39	46	79.08	70	81.25
23	75.48	47	83.79	71	76.78
24	77.28	48	75.10	72	79.92

development conditions of smart tourism determines that the mode of regional smart tourism development is based on the economic foundation and tourism resources. Moreover, it is driven by information technology and market demand and is a compound development model, in which the government, enterprises, and the regional environment play multiple roles, as shown in Figure 4.

This study analyzes the development model of rural smart tourism. Under the action of dynamic factors, the development of smart tourism is divided into three stages, as shown in Figure 5.

The construction system of the smart tourism public service platform is shown in Figure 6.

Rural smart tourism will go through the initial stage and the development stage. Under the interaction of driving factors such as tourism resources, economic level, market demand, information technology, government behavior, corporate behavior, and regional environment, through multiple efforts and joint development, a mature smart tourism system will be built. It specifically covers the technical layer, service layer, and application layer and realizes the whole process, all media, and all time and space services of tourism information. Moreover, it realizes the optimal utilization of rural tourism resources, promotes the optimization and upgrading of the tourism industry and improves the quality of rural tourism. At the same time, the smart tourism system can be promoted as the framework system of rural smart tourism, providing reference for the development of other rural smart tourism. Figure 7 shows the smart tourism system diagram.

Through the above research, a good rural smart tourism development model is constructed. Next, the effectiveness of

the smart tourism development model proposed in this study is verified. This study combines the intelligent simulation method to verify the effect of the rural tourism development model and count the effect of tourism planning and the evaluation of the effect of the rural tourism development model. The statistical test results are listed in Tables 1 and 2.

From the above research, we can see that the rural tourism development model based on multiobjective planning and intelligent optimization algorithm proposed in this study can play an important role in the development of rural tourism.

## 5. Conclusion

In the process of the development of the rural tourism industry, in the context of the micromedia era, whether it is rural tourists making Internet financial payments or operators publishing information through the Internet platform, Internet technology plays a very important role in it. Moreover, the development of rural tourism has forced the construction of network infrastructure to a certain extent. On the other hand, rural tourism e-commerce has become a new business operation model that provides online payment, financial trade, and comprehensive services. This study combines multiobjective planning and intelligent optimization algorithm to analyze the development mode of rural tourism, so as to improve the analysis effect of rural tourism development path. The experimental research results show that the rural tourism development model based on multiobjective planning and intelligent optimization algorithm proposed in this study can play an important role in the development of rural tourism.

## Data Availability

The labeled dataset used to support the findings of this study is 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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