# Construction of GIS System of Built Landscape Design Project Based on Internet of Things

Luyao Wang[1], Yiping He[2] and Yanjun Wu[3]

[1]Institute of Art & Design, Shaanxi Fashion Engineering University, Xi'an, Shannxi 712046, China, wly15529565585@163.com
[2]Basic Teach Office, Shaanxi Fashion Engineering University, Xi'an, Shannxi 712046, China, hyptorreska@163.com
[3]School of Urban Construction, Hebei Normal University of Science and Technology, Qinhuangdao, Hebei 066000, China, wyj3845@hevttc.edu.cn

Corresponding author: Yanjun Wu, wyj3845@hevttc.edu.cn

**Abstract.** With the acceleration of urbanization, more and more people live in cities, and building intelligent perception cities urbanization development in the future. In this article, the Internet of Things (IoT) technology is applied to the operation information management system (IMS) of landscape design projects, and a communication model of IoT geographic information system (GIS) based on particle filter algorithm is proposed. The simulation results show that the MSE, RMSE and MAE errors of this method are all low, and the convergence speed of the algorithm is fast; In addition, the stability of the model is high, and it can still reach more than 90% stability in the case of more transaction sets. The work done in this article perfects the theoretical analysis of IMS operation of completed landscape design projects based on IoT, and the relevant conclusions have practical reference significance for the relevant deployment of IMS operation of landscape design projects.

**Keywords:** Internet of Things; Landscape Design; Information Management System
**DOI:** https://doi.org/10.14733/cadaps.2023.S11.24-34

## 1 INTRODUCTION

The continuous evolution and growth of sci & tech, a new network -IoT has emerged to connect everything. IoT has great development potential and occupies an important position. There is a close connection between the development of IoT data and landscape design. For example, by analyzing meteorological data, it is possible to predict the impact of weather changes on plant growth, thereby enabling better plant cultivation and maintenance. The connection between the development of IoT data and landscape design is very close. The development of Internet of Things technology provides more data sources and wider application scenarios for landscape design, which can provide more support and assistance for urban planning and management. CAD can guide landscape design in various ways. Among them, Ali et al. [1] used the scale algorithm to determine the scale and proportion in landscape design. In addition, CAD can also guide landscape design through annotation, such as annotating lines, symbols, text, etc. in landscape design, so that designers can better understand and express the intention of landscape design.

With the growth of communication technology and the popularity of smart phones, convenient communication between people has been basically realized, and the demand for interconnection between things is becoming increasingly hot. IoT application scenarios require low power consumption and wide coverage. As a new industry, IoT involves different fields. Production appliances, product equipment, and most terminal equipment are connected to IoT, which makes modern social production enter a more efficient and intelligent era. Such a brand-new network expression has attracted wide attention for its outstanding performance in various fields. At present, IoT application has become a new economic growth point. However, IoT is prone to network congestion in the gateway during data transmission, resulting in data packet loss and reduced network performance.

IoT is the expansion and generalization of the Internet, and it is also an important carrier of current information transmission, which can strengthen the intelligent perception, identification and management of goods and processes. IoT system collects data of terminal equipment through micro-sensor equipment, and then wireless sensor equipment collects data and transmits it to user terminal in a self-organizing multi-hop network mode, thus realizing the connection among sensor equipment, computer network and users. With the acceleration of urbanization, more and more people live in cities, and building intelligent perception cities urbanization development in the future. IoT technology is improving the city where we live. In landscape design projects, the project management unit has a high management level to ensure the quality of landscape design projects. From a macro perspective, landscape design projects can beautify cities and villages, create a good living environment for people, relieve the pressure of people's work and life, provide places for leisure and relaxation, and enrich people's spare time. People live in time and space, and the information they get is basically related to space. The environment in which everything in the world is located is also a fixed space, and the growth of information technology. With the advent of the network era, GIS, as an important method, tool and technology to acquire, store, analyze and manage geospatial data information, can be applied to any field now, and the design of garden plan can not be separated from GIS . Based on the existing research results, this article studies the IMS operation of the built landscape design project based on IoT:

(1) In this article, IoT technology is applied to IMS of landscape design project, and a communication model of IoT landscape information system based on particle filter algorithm is proposed.

(2) The model uses IoT communication mechanism and algorithm to collect and process sensor data, and builds a smart garden management system, which realizes real-time perception and spatial management of urban smart garden management objects.

## 2 RELATED WORK

Jiang and Zhang [2] CAD also guide landscape design through the setting of annotation styles. For example, annotation styles can be set to control the size, color, position, etc. of annotations, so that designers can better express the intention of landscape design. In addition, CAD can also guide landscape design through text input. For example, special meanings in landscape design can be expressed by inputting special text, or the arrangement of lines, symbols, etc. in landscape design can be guided by inputting text. Kaushik et al. [3] guided landscape design through the management and setting of layers. Control the layers in landscape design through operations such as creating, changing, and deleting layers, in order to better express the intent of landscape design. Through the help of CAD, we can better understand and express the intention of landscape design, thereby better carrying out landscape design. Kim et al. [4] examined the significance of 3D printing technology in landscape design education and practice. It analyzed the literature and examined the current status of 3D printing technology. Case studies were also conducted on middle school students and landscape practitioners to evaluate the implementation of the technology. Liu et al [5] combined the RGB feature decomposition method to extract parameter vectorization features for multi-dimensional nonlinear landscape design. It extracts a parameterized model of multidimensional nonlinear landscape views. Auto CAD network architecture landscape design refers to the process of using Auto CAD software for landscape design, and transmitting and sharing it through the network. Design landscape design plan: According to the requirements of landscape design, design a landscape design plan, including the layout of landscape design, elements of landscape design, materials of landscape design, etc. Ma et al. [6] used Auto CAD software to generate landscape design drawings, including floor plans, elevations, sections, renderings, etc. Nai [7] publishes the generated landscape design drawings online for use by other designers or related personnel. Share landscape design drawings online for use by other designers or related personnel for communication and collaboration. When carrying out landscape design, it is necessary to consider the network transmission speed so that designers and other personnel can obtain design drawings in a timely manner. When carrying out landscape design, it is necessary to consider the security of the drawings to prevent them from being maliciously tampered with or leaked. When designing landscapes, copyright protection needs to be considered to prevent unauthorized use of design drawings by others. In summary, Auto CAD network architecture landscape design is an effective design method that can be transmitted and shared through the network, thereby improving design efficiency and quality. The perception of 3D environment between indoor and outdoor virtual reality environments is a complex issue that involves multiple factors. On the one hand, 3D perception of virtual reality environment is realized by technologies in many fields, such as virtual reality headgear (VR headgear), computer graphics, artificial intelligence, etc. Saorin et al. [8] generated 3D models through computers and presented them in the user's visual system to achieve 3D perception. Shah et al. [9] found that the perception of 3D environment between indoor and outdoor virtual reality environments is also influenced by multiple factors such as user visual ability, environmental lighting conditions, and the resolution of virtual reality headwear devices. The visual ability of users and the lighting conditions of the environment can affect the 3D perception effect of virtual reality environments. The resolution of virtual reality headwear devices can affect the 3D perception quality of the virtual reality environment. Therefore, in order to achieve the perception of the 3D environment between indoor and outdoor virtual reality environments, multiple factors and adopt appropriate technologies and algorithms to improve the 3D perception effect of the virtual reality environment [10]. Zhang et al [11] introduced an intelligent system based on TENG. The latest developments in wearable electronic devices, robot related systems, and smart homes, as well as the future development prospects of sensor fusion technology. Discussed how to apply artificial intelligence to the design of intelligent sensor systems in the 5G and IoT era.

This article studies the IMS of the completed landscape design project based on IoT, applies the IoT technology to the IMS of the landscape design project, and puts forward the communication model of the IoT landscape information system based on particle filter algorithm.

## 3 METHODOLOGY

### 3.1 IoT Technical Characteristics

The main content of urban landscape planning and management is to build an urban landscape system with reasonable structure, rich characteristics and beautiful environment through inductive analysis of urban landscape components and considering various external factors, and form legal urban planning results and planning management documents to control and guide the landscape design process. Various technologies, the growth of IoT is more perfect and its application fields are gradually widened, and great achievements have been made. The digital management model is established in the landscape design project management system, which improves the accuracy of investment management of landscape design projects and reduces the waste of garden resources. The integration of IoT technology has established a flow from purchasing to receiving for garden resources, which has improved the management efficiency of garden resources. The integration of

GIS technology makes the design more intuitive and easy to understand, and avoids the difficulty of understanding the traditional plan list. In the application of IoT large-scale networking, nodes generally choose batteries with limited capacity to supply power, but when nodes need to be configured in a large-scale IoT environment, battery update is very inefficient. Moreover, IoT nodes are gradually becoming smaller in size and lower in use cost. Therefore, the factors to measure network performance should also focus on the energy consumption of nodes. The network topology of urban Internet of Things is shown in Figure 1.

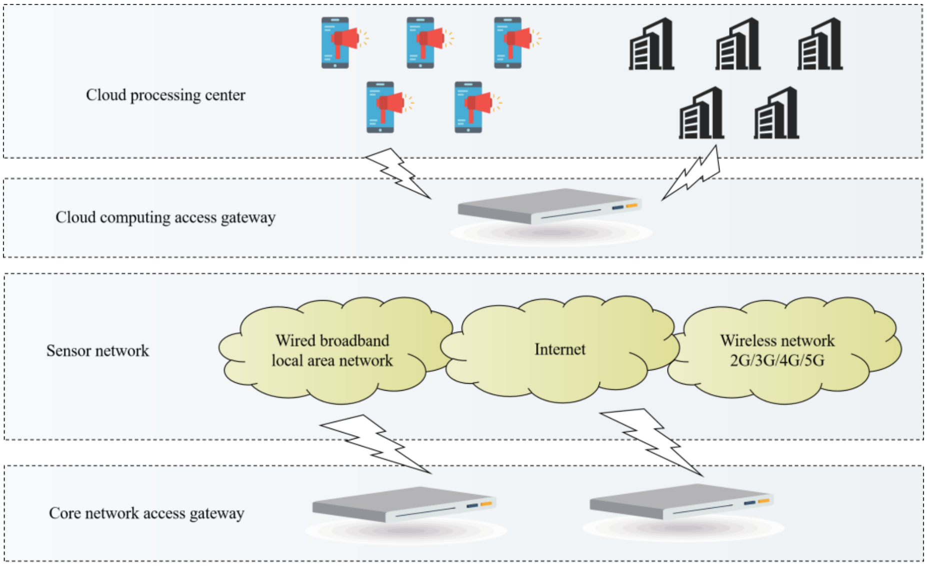


**Figure 1:** Network topology structure of urban IoT.

Landscape design project is to manage the garden resources in a reasonable and overall way, which not only needs to complete the task of garden construction, but also takes into account the landscape effect and ensures economic benefits. The construction unit of landscape design projects usually lacks professional knowledge and project management ability, and its ability to manage investment is relatively weak, so the project management unit assists it in managing investment. Landscape design project design needs technicians to design specific parameters such as step, water spraying intensity, planted tree species and breast-height diameter of seedlings in combination with project experience, so as to make the construction drawing close to the actual project and have more execution. There are many resources that need communication and coordination and overall management in landscape design projects. The maintenance period of landscape design projects is long, and the maintenance stage is also the key stage of project management. Some maintenance personnel have a weak sense of responsibility, lack of awareness of conservation of resources, and some maintenance personnel's comprehensive quality and professional skills need to be improved. The project management unit will usually invest more project personnel in the maintenance stage to check the maintenance work of the maintenance personnel.

## 3.2 Communication Model of IoT Landscape Information System

IoT is different from the traditional Internet in that it has its own characteristics: IoT is based on the Internet and has a wide range of existence; Perception technology has laid the foundation for the widespread use of IoT; Sensors play different roles. Compared with the traditional Internet, IoT has the properties of highly reliable communication, intelligent processing and automatic control.

According to the data rate requirements of different application scenarios, IoT applications can be divided into three categories: high rate, medium rate and low rate. Among them, low-rate services occupy the main part of IoT applications. In the dynamic environment of high-speed change of IoT, its data transmission is mainly based on wireless communication. At present, the main transmission protocols include dedicated short-range communication technology and long-term evolution. In addition, IoT has the following characteristics: (1) The scale of IoT network is large, and there are many data transmissions. The IoT gateway used for data transmission is generally implemented by embedded systems. (2) IoT is a network that connects things and people and things, and it is necessary to ensure that the network is connected at all times. (3) IoT is a geographically distributed and unbalanced network, and the quantity of sensor devices is different in different regions due to different infrastructure and application requirements. Therefore, it is necessary to optimize the deployment of gateways according to the density of sensor devices to avoid wasting gateway resources in places with sparse network distribution. The process of optimizing IoT information system by particle filtering is shown in Figure 2.

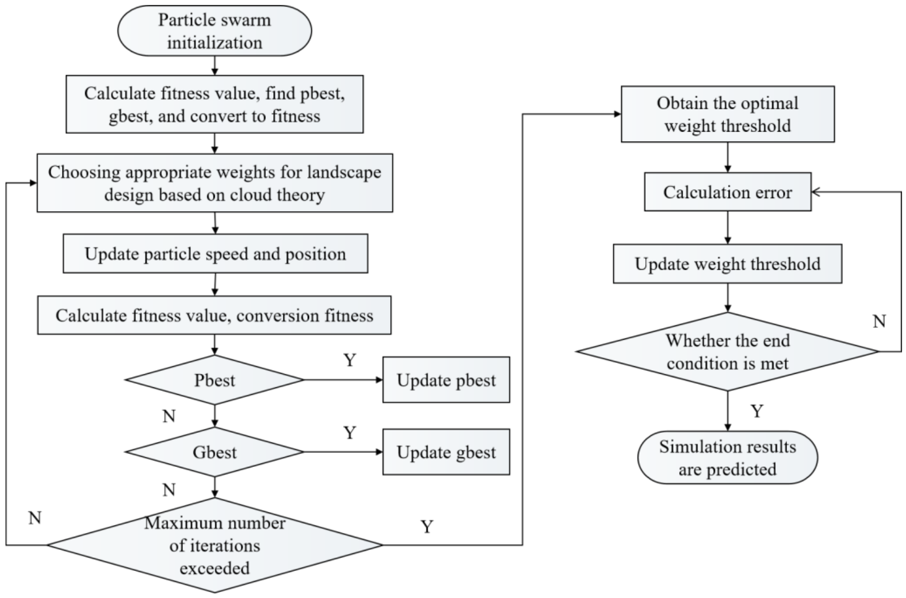


**Figure 2:** Stage of optimizing IoT information system by particle filter.

On-line monitoring refers to the use of sensors to form WSN in a self-organizing or multi-hop manner, and cooperate to perceive, collect and process the information of objects within the coverage of transmission networks. Long-term and independent data stream acquisition is the core advantage of IoT. The online monitoring method based on IoT will greatly improve the convenience and accuracy of ecological data collection and performance evaluation of landscape design projects, and promote the growth of discipline evidence-based design.

$$f\left(\pi(X_t)=\rho \middle| y_{1:t}\right)\approx \omega_t^{(i)} m_{\pi(X_t)^{(i)}}(\rho) \tag{1}$$

Where the attribution function is defined as:

$$\int_{\partial} m_{\eta}(\ell)\delta\ell = \begin{cases} 1, \eta \in \partial \\ 0, other \end{cases} \tag{2}$$

$$\pi\left(\hat{X}_t\right)=\arg\max_{\rho} f\left(\pi\left(X_t\right)=\rho \middle| y_{1:t}\right) \tag{3}$$

For any node $S_i$ within the data collection range, the expected minimum energy consumption is:

$$EMC(i)=\begin{cases}\left(2\lfloor h_0\rfloor\right)E_{elec}B+\dfrac{\varepsilon_{amp}d_{(i,i+h)}^2 B}{\lfloor h_0\rfloor}\\ \left(2\lceil h_0\rceil\right)E_{elec}B+\dfrac{\varepsilon_{amp}d_{(i,i+h)}^2 B}{\lfloor h_0\rfloor}\end{cases} \tag{4}$$

Among them:

$$h_0=\sqrt{\frac{\varepsilon_{amp}}{2E_{elec}}}d_{(i,i+h)} \tag{5}$$

$$\text{support }(\mathrm{X})=\frac{\sigma_x}{|D|}\times 100\,\% \tag{6}$$

Where $|D|$ is the quantity of transactions of data set $D$. If $X$ ,$Y$ is an itemset and satisfies the following formula:

$$X\cap Y=\varnothing \tag{7}$$

$$\text{support}(\mathrm{X}\Rightarrow\mathrm{Y})=\text{support}(\mathrm{X}\cup\mathrm{Y}) \tag{8}$$

$$\text{confidence }(\mathrm{X}\Rightarrow\mathrm{Y})=\frac{\text{support }(\mathrm{X}\cup\mathrm{Y})}{\text{support }(\mathrm{X})}\times 100\,\% \tag{9}$$

Through the system-aided planning and other functions, the three-dimensional simulation system allows planners to dynamically analyze and manage landscape elements such as urban landscape corridors and contour lines, and timely analyze and detect whether there are buildings that exceed the height control requirements, so as to scientifically protect the characteristics and forms of urban landscape. Through continuous, stable and high data precision monitoring, designers can analyze the complex ecological adjustment process, and then make up for the lack of digital simulation in the design stage.

Fuzzy theory maps data from Boolean value $\{0,1\}$ to interval $[0,1]$ through fuzzy function, assuming that fuzzy function $f(x)$ is:

$$f(x)=\begin{cases}f_A(x), x\in A\\ f_B(x), x\in B\\ f_C(x), x\in C\end{cases} \tag{10}$$

$A$, $B$, $C$ are intervals. When $x$ falls in $A$ interval, $x$ is mapped to $f_A(x)$. Similarly, $x$ falls in other intervals and is mapped to corresponding values by other functions. If $x$ is not in this interval, the value is 0. If itemset:

$$t \in L(D) \quad t€L(d) \tag{11}$$

Then scan the newly added transaction database $d$ to get the support quantity of $t$ in $d$. Using the support quantity of $t$ in the original transaction database $D$, calculate the support degree of $t$ in the current transaction database $(D+d)$:

$$\sup(D+d) = (\sup(D) * |D| + \sup(d) * |d|)/|D| + |d| \tag{12}$$

If:

$$\sup(D+d) > \min\_\sup \tag{13}$$

Then the itemset $t$ is put into the frequent itemset of the current transaction database $(D+d)$, otherwise $t$ is not a frequent itemset. If itemset:

$$t€L(D) \quad t \in L(d) \tag{14}$$

Then scan the original transaction database $D$ to get the support quantity of $t$ in $D$. Using the support quantity of $t$ in the newly added transaction database $d$, calculate the support degree of $t$ in the current transaction database $(D+d)$:

$$\sup(D+d) = (\sup(D) * |D| + \sup(d) * |d|)/|D| + |d| \tag{15}$$

If:

$$\sup(D+d) > \min\_\sup \tag{16}$$

Then $t$ is put into the frequent itemset of the current transaction database $t$, otherwise $(D+d)$ is not a frequent itemset.

Using the system's function of maintaining and updating three-dimensional scene data, landscape design models of different development stages of landscape design areas can be made, which can provide reference for future urban landscape planning and management. Moreover, planning managers can also simulate and track the construction and growth of urban form, and adjust the corresponding landscape design scheme in time according to the requirements of different stages of landscape design development.

## 4 RESULT ANALYSIS AND DISCUSSION

The integration of IoT, GIS and other new technologies in the landscape design project management system makes the data collection, storage, transformation and display of landscape design projects more convenient and improves the management efficiency of landscape design projects. The application of 3D GIS technology based on IoT in urban planning has greatly improved the efficiency and level of urban landscape planning and management, and promoted the scientific decision-making of urban management. Landscape design project management system should share data with other information systems, open up data exchange channels, not only output data to other information systems, but also provide data access services for other information systems to avoid "information islands" and build a digital collaborative management platform for landscape design projects. Figure 3 shows the training of the algorithm. Three indicators, MSE (Mean squared error), RMSE (Root mean square error) and MAE (Mean absolute error), were selected to measure the effectiveness of the model, and several experiments were conducted respectively.

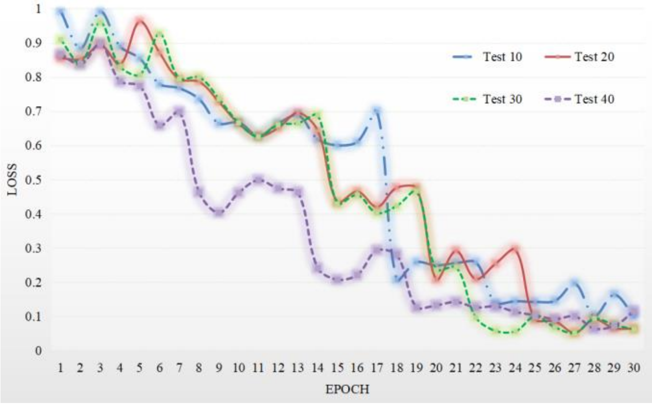


**Figure 3:** Training situation of the algorithm.

The calculation formulas of these indicators are as follows:

$$MSE = \frac{1}{n}\sum_{k=1}^{n}\left(y_k - y'_k\right)^2 \tag{17}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(\left|y_k - y'_k\right|\right)^2} \tag{18}$$

$$MAE = \frac{1}{n}\sum_{k=1}^{n}\left|y_k - y'_k\right| \tag{19}$$

Where $y_k$ is the actual value and $y'_k$ is the model output value. This kind of index expresses the excellent degree of the result of the algorithm relative to the simple model that uses the tie value of the actual result as the output result. The following experiments are conducted, and Figure 4 shows the MSE results of several algorithms. Figure 5 shows the RMSE results of several algorithms. Figure 6 shows the MAE comparison of several algorithms.

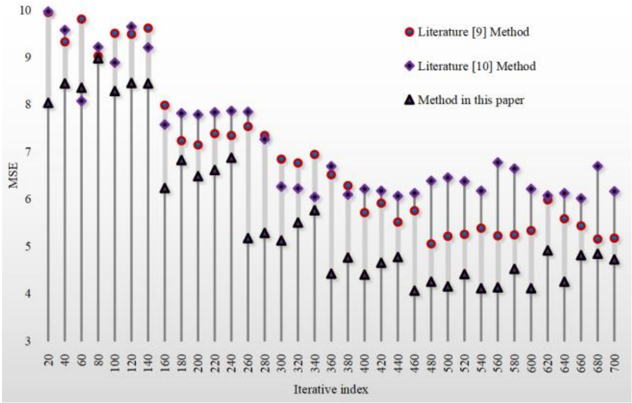


**Figure 4:** MSE comparison results of the algorithm.

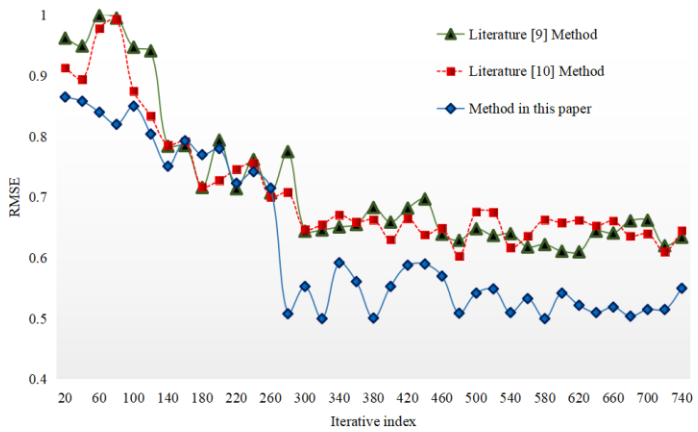


**Figure 5:** RMSE comparison results of the algorithm.

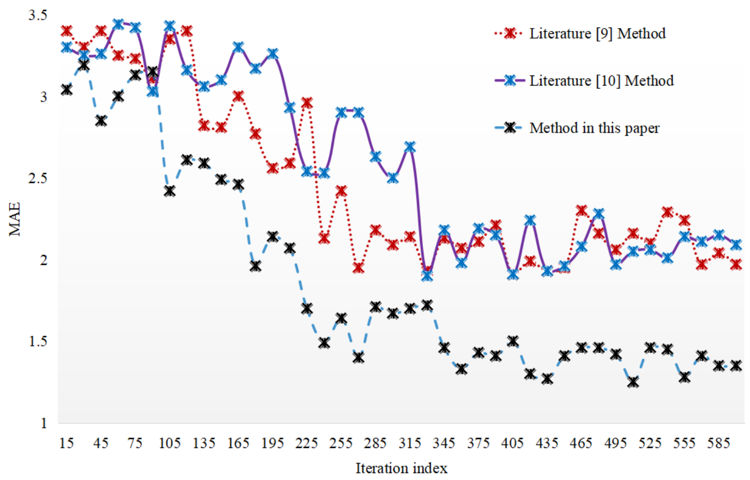


**Figure 6:** MAE comparison results of the algorithm.

From the analysis of test results, it can be seen that compared with the other two methods, the MSE, RMSE and MAE errors of this method are lower, and the convergence speed of the algorithm is faster and the results are considerable. The system provides many functions, such as visual fast 3D modeling, information query, multi-scheme comparison, sunshine analysis, intervisibility analysis, automatic calculation of planning indicators, etc. By providing various 3D simulation effects, the planning effect can be expressed intuitively and accurately, which provides support for planning management decision-making.

The acquisition of information is only the beginning of information management, and the construction of information model is the most effective means of classified storage, analysis and presentation of information. In order to further test the advantages and disadvantages of the models, the stability of several different models is compared experimentally, and the stability comparison of different models is shown in Figure 7.

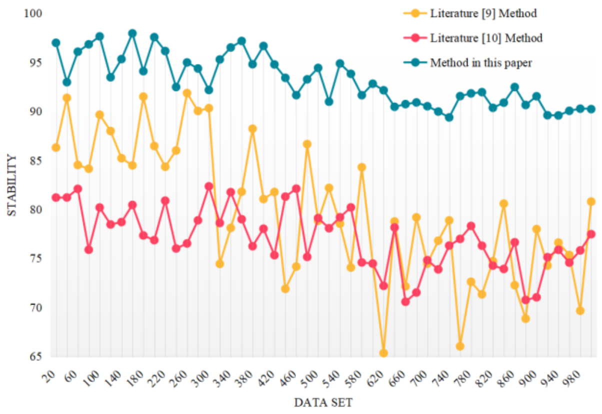


**Figure 7:** Stability comparison of different models.

Many experiments in this section show that the MSE, RMSE and MAE errors of this method are low, and the convergence speed of the algorithm is fast. Generally speaking, the system model can still maintain a high stability, which can basically reach more than 90%, and can effectively provide some technical support for the operation of landscape design projects. The algorithm realizes the real-time perception and spatial management of urban smart garden management objects, which improves the management efficiency. By constructing a three-dimensional urban landscape based on the 3D GIS technology of IoT, a virtual urban environment can be established in the computer, and the urban landscape can be comprehensively examined and evaluated in a dynamic and interactive way, thus providing a basic basis for urban landscape planning and management.

## 5 CONCLUSIONS

With the advent of the network era, GIS, as an important method, tool and technology to acquire, store, analyze and manage geospatial data information, can be applied to any field now, and the design of garden plan cannot be separated from GIS. In this article, IoT technology is applied to IMS of landscape design project operation, and a communication model of IoT landscape information system based on particle filter algorithm is proposed. The simulation results show that the MSE, RMSE and MAE errors of this method are all low, and the convergence speed of the algorithm is fast; In addition, the stability of the system model is high, and it can still reach more than 90% stability in the case of more transaction sets. The model uses IoT communication mechanism and algorithm to collect and process sensor data, and builds a smart garden management system, which realizes real-time perception and spatial management of urban smart garden management objects. With the growth of IoT technology, the intelligent garden management system will be more intelligent and further realize automatic management, thus better serving the growth of urban landscaping.

*Luyao Wang*, https://orcid.org/0009-0005-2664-8969
*Yiping He*, https://orcid.org/0009-0003-8649-4901
*Yanjun Wu*, https://orcid.org/0000-0001-9627-6658

## REFERENCES

[1] Ali, O.; Ishak, M.-K.; Bhatti, M.-K.-L.; Khan, I.; Kim, K.-I.: A Comprehensive Review of Internet of Things: Technology Stack, Middlewares, and Fog/Edge Computing Interface, Sensors, 22(3), 2022, 995. https://doi.org/10.3390/s22030995

[2] Jiang, W.; Zhang, Y.: Application of 3D visualization in landscape design teaching, International Journal of Emerging Technologies in Learning (Online), 14(6), 2019, 53-62. https://doi.org/10.3991/ijet.v14i06.10156

[3] Kaushik, S.; Srinivasan, K.; Sharmila, B.; Devasena, D.; Suresh, M.; Panchal, H.; Srimali, N.: Continuous monitoring of power consumption in urban buildings based on Internet of Things, International Journal of Ambient Energy, 43(1), 2022, 5027-5033. https://doi.org/10.1080/01430750.2021.1931961

[4] Kim, S.; Shin, Y.; Park, J.; Lee, S.-W.; An, K.: Exploring the potential of 3D printing technology in landscape design process, Land, 10(3), 2021, 259. https://doi.org/10.3390/land10030259

[5] Liu, C.; Lin, M.; Rauf, H.-L.; Shareef, S.-S.: Parameter simulation of multidimensional urban landscape design based on nonlinear theory, Nonlinear Engineering, 10(1), 2021, 583-591. https://doi.org/10.1515/nleng-2021-0049

[6] Ma, K.; Mao, Z.; He, D.; Zhang, Y.: Design a network architectural teaching system by auto CAD, Computer-Aided Design and Applications, 17(S2), 2020, 1-10. https://doi.org/10.14733/cadaps.2020.S2.1-10

[7] Nai, R.: The design of smart classroom for modern college English teaching under Internet of Things, Plos one, 17(2), 2022, e0264176. https://doi.org/10.1371/journal.pone.0264176

[8] Saorin, J.-L.; Carbonell, C.-C.; Jaeger, A.-J.; Díaz, D.-M.: Landscape Design Outdoor–Indoor VR Environments User Experience, Land, 12(2), 2023, 376. https://doi.org/10.3390/land12020376

[9] Shah, S.-F.-A.; Iqbal, M.; Aziz, Z.; Rana, T.-A.; Khalid, A.; Cheah, Y.-N.; Arif, M.: The role of machine learning and the internet of things in smart buildings for energy efficiency, Applied Sciences, 12(15), 2022, 7882. https://doi.org/10.3390/app12157882

[10] Shen, X.; Lu, Y.; Zhang, Y.; Liu, X.; Zhang, L.: An Innovative Data Integrity Verification Scheme in the Internet of Things assisted information exchange in transportation systems, Cluster Computing, 25(3), 2022, 1791-1803. https://doi.org/10.1007/s10586-021-03471-5

[11] Zhang, Z.; Wen, F.; Sun, Z.; Guo, X.; He, T.; Lee, C.: Artificial intelligence-enabled sensing technologies in the 5G/internet of things era: from virtual reality/augmented reality to the digital twin, Advanced Intelligent Systems, 4(7), 2022, 2100228. https://doi.org/10.1002/aisy.202100228