The Construction of Roof Greening Intelligent Management System Based on Wireless Sensor Network Technology

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Abstract. Roof greening can make up for the problem of urban green deficiency to some extent, add green space for people in urban life, and also alleviate urban ecological problems and heat island effect. With the development of information technology, the development level of modern automation is higher and higher. Information has penetrated into various industries. So it is very important to develop intelligent management system (IMS) of roof greening to use information technology reasonably. At present, roof greening is mainly artificial operation management, and there are many random factors and can not guarantee that roof greening is always the best state. Irrigation system is also very simple. Therefore, this paper proposes the research and construction of IMS of Roof Greening Based on wireless sensor network (WSN) technology. This paper describes the frame design of IMS of roof greening and the overall design of IMS of roof greening. The design factors of WSN are also studied. The plant survival rate of intelligent management and natural growth is studied by field detection. The effect of roof greening on reducing heat island effect is proved by data chart. The experimental results show that the survival rate of plants under the care of intelligent roof greening system is 91.27, while the natural growth survival rate is only 67.32. At the same time, the green roof plays a great role in the heat island effect. When the sun is the strongest at 12:00 noon, the temperature of the green roof is 25 degrees, while the common roof is 32 degrees.

Key words: Roof Greening; Intelligent Management; Management System; Wireless Sensor Technology

1. Introduction
With the rapid development of electronic information industry, information technology has penetrated into various traditional industries. For example, the combination of traditional agriculture and information technology can greatly improve the utilization rate of agricultural resources and labor efficiency [1-2]. WSN is a popular and widely used distributed sensor network in recent years, and it is also a micro network system with great application prospects [3-4]. It obtains the information of each monitored point through the terminal sensor terminals, and feeds back to the monitoring node of the system control center in real time, so as to realize the monitoring and tracking of the environmental data change of each monitoring object [5-6]. Up to now, WSN have been widely used in modern military systems, intelligent transportation, environmental data monitoring, health care, smart home...
and other fields [7-8]. Intelligent management of roof greening can increase green area, improve local ecological environment, reduce heat island effect, regulate air humidity, improve air quality, reduce urban pollution, store rainwater, reduce flood discharge pressure of municipal pipelines, save land, make green roof spaces become stepping stones in urban ecosystem, and improve ecosystem [9-10].

In the research on the architecture of roof greening IMS based on WSN technology, many scholars at home and abroad have made some achievements. Li w pointed out that WSN can be composed of thousands of nodes, and each node needs to use protocol stack to communicate with other nodes. Therefore, the design of protocol stack must not only be energy-saving in communication, but also be stable and efficient in multi node information interaction [11]. Gao X and others pointed out that the current mature urban roof greening system basically guarantees the growth conditions of plants and the functions of waterproof, drainage, water storage, filtration and root isolation, and successfully solves the problems of cumbersome hierarchical installation of roof greening and the incompatibility between upper and lower layers. Different urban roof greening systems are installed for different roofs to ensure convenient installation reducing the cost provides a broad development prospect for the future urban roof greening system and its materials, new technology and other applications [12].

The main content of this paper is to build a roof greening IMS based on WSN technology. This paper expounds the frame design of roof greening IMS, and explains the function of IMS. Then from the network topology design, processing control module design, power supply module design three aspects to improve the overall design of roof greening IMS. It also studies and analyzes the design factors of WSN, and analyzes the design and application of WSN technology from various aspects. This paper also studies the survival rate of intelligent management and natural growth through field detection, data collection and sorting, and understands various data in the plant growth environment. This paper also uses chart analysis method to intuitively prove the effect of roof greening on reducing heat island effect through data chart.

2. Intelligent Management System of Roof Greening

2.1. Framework Design of IMS for Roof Greening
This system is oriented to the roof greening, and aims to design a scientific, efficient, high utilization and sustainable roof greening IMS. The whole system is composed of data acquisition module, wireless communication module, visual control software and other parts, with real-time data acquisition, monitoring, automatic control, alarm, management and other functions. The wireless sensor node of the system is used to collect the environmental data of roof temperature, humidity, light and so on. The data is integrated and transmitted to the gateway of central processing module through the low-power wireless communication module, and then connected to the Internet through the long-distance wireless transmission technology. The roof greening environment can be viewed anytime and anywhere through the mobile phone or computer, it can also set automatic irrigation, pest control and other operations according to the preset scientific data.

2.2. Overall Design of Roof Greening IMS

(1) Network topology design
Combined with the practical application and the structural characteristics of WSN, this paper adopts the star topology network structure, which is a single hop network system structure. All sensor nodes communicate with the central coordination node directly in two directions. Among the three network topologies, star network topology is the simplest one. The system uses four types of sensors: environmental temperature and humidity, soil temperature and humidity, carbon dioxide concentration and light intensity.

(2) Design of processing control module
The processing and computing module is the core part of the whole system. The processing and
control module is used to process the data collected by the wireless sensor module, which is equivalent to the processor of the computer. It undertakes the tasks of task scheduling and distribution, data fusion, transmission gateway and data storage of the whole system. The data collected by the WSN is processed by the calculation processing control module, and then sent to the upper computer through the GPRS communication module. The instructions sent by the upper computer also need to be identified by the calculation processing module, and then the task instructions are sent to each lower module according to the requirements of the upper computer.

(3) Design of power supply module
Power supply system is the heart of the whole system, which provides power guarantee for the efficient operation of the whole system. Because the WSN and processing control module in the lower layer of the system are all working on the roof without shelter, the environmental conditions are relatively bad, and there is no stable power supply, so the battery power supply system based on solar photovoltaic panel is designed in this system. In this system, solar energy is converted into light energy and stored in the battery, which can continuously and stably supply power to the system.

2.3. Design Factors of WSN

(1) High density of network
In order to meet the needs of different applications, WSN must meet the requirements of high density. The network density here refers to the number of nodes within the transmission radius of a single node in a certain area. The formula is as follows:

$$\mu(R) = \frac{(N\pi R^2)}{A}$$

(1)

Where $N$ is the number of discrete sensor nodes in region $A$, and $R$ is the wireless transmission radius. Therefore, the size of the region, the radio frequency coverage of a single node and the number of nodes in the region can be selected reasonably according to the application needs, which directly affects the network density of the design WSN.

(2) Network throughput
Network throughput is the overall evaluation of data transmission capacity of WSN. The relationship between network throughput $\gamma$ and network coverage $A$, data transmission speed $W$, node spacing $L$, number of active nodes $n$ and transmission radius $r$ of ideal spherical wireless transmission model is as follows:

$$\gamma \leq \frac{16AW}{\pi n^2 L r} \frac{1}{\text{bit/s}}$$

(2)

Where $\Delta$ is a constant greater than zero. It can be seen that in the case of a certain network coverage area and node transmission rate, reducing the node transmission radius $r$, selecting reasonable and effective media access control mode and reducing the number of active nodes can improve the network throughput to a certain extent.

(3) Product cost
There are a large number of WSN nodes, and the price of a single node will have a significant impact on the cost of the whole network. If the network cost is too high, it will not be conducive to the promotion of the whole system. Computing processing energy, communication ability and storage ability are the key factors that affect the cost of a single node. Therefore, only by designing simple communication protocol, reducing the cost of system management and maintenance, and improving the self configuration and self repair ability of the system, can the cost of a single node be reduced while meeting the application requirements.

(4) Hardware composition
WSN node is mainly composed of sensor unit, processing unit, wireless transceiver unit and power supply. In addition, according to the needs of the application and the function of the node, the
auxiliary units such as the electric energy generating unit and the mechanical moving device can be used. The sensor unit for sensing and acquiring data consists of two parts: sensor and ADC. The analog signal generated by the sensor is converted into digital signal by ADC and then transmitted to the processing unit. The processing unit includes processor and memory, which is responsible for controlling each part of the node and coordinating itself with other nodes to complete system tasks. The wireless transceiver unit is responsible for the communication with other nodes of WSN. Power supply is usually referred to as micro battery, which provides power for the normal operation of each part of the node. Due to the need of application, the size of WSN node must be small enough, and the weight must be light enough. For nodes that need to work for a long time without legal intervention, the capacity of the battery must be large enough, but the larger the capacity of the battery is, the larger the volume is. Therefore, only by designing efficient power management scheme and network communication protocol to reduce the energy consumption of the node as far as possible, can the node complete the task within the specified time.

(5) Power consumption
In WSN, nodes usually work in unattended environment for a long time, and they can't replace or charge the batteries. Once their batteries are exhausted, the nodes can't work normally or even lose their functions. Therefore, the design of effective power saving and power management scheme is particularly important for the application of WSN. In WSN, sensor nodes are mainly used to collect data, process data and transmit data, so power consumption can be divided into three parts: collection, transmission and data processing. The energy consumption of data collection is related to the application of WSN. The application of interval sampling consumes less energy than that of continuous dynamic monitoring. Moreover, the more complex the monitoring object and the more environmental noise, the more energy it consumes.

3. Experimental Study

3.1. Subjects
This paper mainly studies the construction of roof greening IMS based on WSN technology. This paper studies the WSN technology and combines it with roof greening to manage the growth of roof greening plants, and designs an IMS to provide a suitable environment for roof greening plants and pay attention to the growth and development status in real time.

3.2. Experimental Process Steps
The main content of this paper is to build a roof greening IMS based on WSN technology. This paper expounds the frame design of roof greening IMS, and explains the function of IMS. Then from the network topology design, processing control module design, power supply module design three aspects to improve the overall design of roof greening IMS. It also studies and analyzes the design factors of WSN, and analyzes the design and application of WSN technology from various aspects. This paper also studies the survival rate of intelligent management and natural growth through field detection, data collection and sorting, and understands various data in the plant growth environment. This paper also uses chart analysis method to intuitively prove the effect of roof greening on reducing heat island effect through data chart.

4. Experimental Research and Analysis of Roof Greening IMS

4.1. Intelligent Management of Roof Greening
Roof greening IMS ensures the survival rate of plants different from natural plants by ensuring all kinds of data in the plant growth environment, so as to maximize the value of roof greening and achieve long-term growth and development. In this paper, through the study of intelligent management and natural growth of plant survival rate to prove the advantages of roof greening intelligent
management, and give two groups of living environment data, temperature, humidity and light, the results are shown in Table 1.

**Table 1. Intelligent management of roof greening**

|                | Natural growth | Intelligent management |
|----------------|----------------|------------------------|
| temperature    | 22.64          | 28.5                   |
| humidity       | 55.77          | 75.31                  |
| Light intensity| 62.69          | 80.53                  |
| Survival rate  | 67.32          | 91.27                  |

**Figure 1. Intelligent management of roof greening**

As can be seen from Figure 1, under the care of the roof greening intelligent system, the survival rate of plants is higher than that of natural growth. The survival rate of plants using the IMS is 91.27, while the survival rate of natural growth is only 67.32. This is also due to the different growth environment. Under the control of the intelligent system, the roof greening is in a suitable environment in terms of temperature, humidity and light, Natural plants are affected by various factors.

4.2. *The Effect of Roof Greening*

Roof greening can alleviate the effect of urban heat island to a certain extent. The plants planted in roof greening can absorb carbon dioxide to a certain extent and reduce the roof temperature. To prove the effect of roof greening, this paper, through experiments, detects the houses with and without roof greening, sets up a control group, and conducts measurement and Analysis on the roof temperature. The results are shown in Table 2.

**Table 2. Comparison of roof temperature**

|                | 0 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 |
|----------------|---|---|---|---|----|----|----|----|----|
| temperature    |   |   |   |   |    |    |    |    |    |
| Green roof     | 8 | 12| 13| 18| 25 | 22 | 20 | 14 | 8  |
| Common roof    | 9 | 14| 17| 21| 32 | 27 | 23 | 18 | 10 |
Figure 2. Comparison of roof temperature

From Figure 2, it can be found that the temperature of the roof with greening is significantly lower than that of the ordinary roof, and the greening plays an important role. When the sunlight is strongest at 12 noon, the temperature of the green roof is 25 degrees, while that of the ordinary roof is 32 degrees, which also shows that the roof greening can play a role in the heat island effect.

5. Conclusions

Roof greening plays an important role in enriching the urban landscape, increasing the amount of urban green, reducing the urban heat island effect, conserving rainwater, reducing temperature and so on. It also creates a new green space for leisure, entertainment and ecology, and improves the urban ecological landscape. In this paper, through the research and construction of roof greening IMS based on WSN technology, the role of IMS is described. Then improve the overall design of roof greening IMS, research and analyze the design and application of WSN technology. With the construction and development of roof greening IMS, this innovation will promote the rapid development of multi-disciplinary joint exploration mode guided by demand and application, and provide new opportunities for the development of emerging industries.

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