Large Scale Greenhouse Environment Monitoring Systems in Japan and other Countries

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***Abstract*—The development of the large scale green house environment monitoring system in Japan and other countries are discussed in this paper. By inspecting the previous work of this topic, it is concluded that the production efficiency of the agriculture can be greatly improved and huge profit potentials are expected in future with wireless sensor networks using mobile and static nodes as well as various information analysis techniques.**

***Index Terms*—sensors, wireless network, greenhouse**

I. BACKGROUND

With the rapid development of science and technology and the wide application of high and new technology in agricultural production, facilities agriculture is becoming an innovative industry of agriculture in the world. Its development has injected new blood into traditional agriculture, which has brought strong impetus and prospects for modern agriculture [1-3]. In 1990s, large scale multi-span greenhouses and supporting cultivation techniques were used worldwide. With the national and local financial support, world's facilities agriculture has developed to a considerable scale of industry to produce super season, anti season facilities horticultural crops and achieve high efficiency and quality of the target. The greenhouse area, which is the main body of vegetable cultivation, has exceeded 20 million hectares now. Among them, multi-span plastic greenhouse, glass greenhouse and sunlight greenhouse are the main facilities.

The development of facilities technology makes people quickly realize that large greenhouse facilities have the advantages of high land use rate, relatively stable indoor environment, energy saving, easy operation and mechanized production, etc. In recent years, newly built greenhouses in developed countries are all large modern ones. For example, the size of the greenhouse in Holland is above 1 hm2; the ones in Japan have been developed with a single area of more than 5000 hm2, and a large number of newly built single buildings in the United States are greenhouse with the size of 20 hm2 and so forth. Technically, the European and American countries, such as Holland, have large scale and high degree of automation. These countries also continue to launch new types of large greenhouses. The temperature, humidity, light, moisture, fertilizer and CO2 in the greenhouse are controlled by computer. The United States, Japan, Austria and other countries have set up at least ten "plant plants" that represent the most advanced level in the world. They are fully-closed, artificial light, and all the production procedures are controlled by computer, robot or manipulator, completely free from the constraints of natural conditions.

The development of facilities agriculture in China is relatively late, most of which are developed on the basis of copy for foreign technology. There is no complete and systematic research on the scale, type and related technology of facilities, as well as unified and scientific technical standards. For instance, the management of facilities and cultivation technology is not standard, various facilities are not matched, the overall level of scientific and technological content is low, and it is difficult to realize the overall benefit function of facilities agriculture and the production of large scale. With the large-scale greenhouse facilities, the cultivation and management technology has being developed towards the trend of the automatic collection of greenhouse information and the intelligent control trend based on the crop growth model, the greenhouse comprehensive environmental factor analysis model and the agricultural expert system. However, most of the operations of soil cultivation, sowing, irrigation, fertilization and environmental monitoring in the production process of facilities are also carried out artificially. Not only the working environment is poor and the production efficiency is low, but the work quality is poor, and the labor intensity is too much as well. Therefore, it is urgent to form a complete set of standardized technical system from the selection, cultivation, management and collection of the facilities in China, and through the automatic measurement of the production process, the automatic monitoring of diseases and pests, the automatic control of the environmental parameters and the computer programming technology.

Although the research and application of the greenhouse planting environment monitoring technology is still in the rapid development stage, such as data collection, processing, transmission, storage, intelligent decision analysis and intelligent production and cultivation management, the static sensor node technology is only suitable for large-scale deployment in the monitoring area. Due to the fact that the function of one single node is weak, if the information collection and processing capability needs to be strengthened, the whole

wireless sensor network construction cost will be very expensive. One alternative is to deploy some powerful and mobile sensor nodes in a wireless sensor network. Whenever a particular event requires information collection and processing, the mobile sensor nodes are sent to those points for further processing and to reduce the cost of deployment effectively. If some areas are not covered by sensors, mobile sensor nodes can move to the empty area to achieve the goal of covering holes.

Under the support of the sensor network technology, which is composed of static and mobile nodes, the cost of the original monitoring system can be greatly reduced, while the efficiency and flexibility of the network can be greatly improved. The level and accuracy of the monitoring information can be further increased and improved, and the overall performance of the monitoring system will be developed by leaps and bounds. Therefore, it is reasonable to study the node technology of mobile sensor network in large greenhouse environment, study the key technologies of the monitoring system for large greenhouse planting environment, and make it a "performance multiplier" for the transformation or expansion of the traditional greenhouse monitoring system. This is a great effort to develop the agricultural automation monitoring technology.

II. Previous Work in Japan and Other Countries

In recent years, the greenhouse area in China has been enlarged, and the level of facilities and equipment are improved. Now the direction of monitoring automation is moving forward. At present, some universities and research institutes in China have carried out research on remote control technology of greenhouse facilities, and have made a series of research results.

The intelligent remote greenhouse environment controller developed by the China National Agricultural Information Engineering Technology Research Center can monitor the temperature and humidity of the air, soil and leaf surface temperature, water content, light intensity, CO2 concentration and carry out statistical analysis. Through expert system and computer network, the greenhouse irrigation, fertilizer and pesticide can be realized. Intelligent decision-making and remote distributed control for spraying, ventilation and other processes have been focused on. These sets of devices, including data measurement, storage, remote control and automatic alarm, enable agricultural experts to see plant growth through the network and monitor remote monitoring in the office.

The greenhouse environment monitoring system developed by China Agricultural University consists of three parts: the main control computer, the greenhouse machine and the outdoor weather station. The main control computer control room can manage the whole system in a unified way to complete the setting of various system parameters, the functions of recording, querying, printing, realizing the control algorithm and generate control commands used. Each independent facility has a greenhouse with built-in temperature / humidity, CO2 and other sensors, control equipment and camera lens. It can transmit the crop growth in the greenhouse to the office site in real time, and monitor the indoor and outdoor environment conditions and plants through telephone lines, digital signal transmission lines and Internet. The growth situation can be transmitted to the computer screen of the agricultural experts so to guide the production according to the information provided, and realize the monitoring and control of the greenhouse environment.

In the existing monitoring systems, the remote monitoring system (OpenPLANET) developed by the Japanese four power group is mainly composed of monitoring control LAN, information acquisition unit, data recording unit, decentralized controller, OP server and so on, which can realize the group management of greenhouse. The FieldServer (live server) system in Japan is a multi-sensor data acquisition device based on embedded system which can connect a variety of sensors and integrate the micro camera internally. It can collect environment information such as temperature, humidity and image video information at the same time, and send the data to the center service through the TCP / IP protocol. FieldServer can be powered by batteries and has the characteristics of small size, strong function and less power consumption, and is easy to set up in the field.

The British Wireless Systems Company had also developed a series of wireless communication devices, such as wireless frost and intrusion alarm systems suitable for widely distributed garden greenhouses or storage rooms, portable radio TV systems, remote wireless sprinklers, heating and ventilation control, etc. Holland, Israel and other countries also have large scale modern greenhouse and corresponding automatic monitoring system. The prominent characteristics of the greenhouse development in these countries are the high level of facilities, the strong ability to control the environment and the ability to control the benefits, from breeding, transplantation, cultivation and post processing to circulation, all of which have reached the matching of technology and equipment and formed the industrialization.

Recently, emerging wireless sensor networks provide a cheap and powerful way to monitor agricultural planting environment. It consists of many small and low power sensor nodes, and nodes form network through self-organization and multi-hop. Each sensor node usually consists of a sensing device, a wireless transceiver, a microprocessor with micro memory, and a corresponding power supply unit. The sensor is responsible for perceiving the environment data in the monitoring area, and completing the collection and conversion of the information. The processor unit is responsible for controlling the specific operation of the whole sensor node, processing the data collected by the sensing unit and the data from other nodes in the network. Meanwhile, it also carries out a short time and a small amount of data storage; the transceiver is responsible for communicating with other nodes and exchanging control information and data; the power supply unit is responsible for providing the energy needed for other modules to run. These sensor

nodes are arranged in a certain way in a large number of areas to be monitored to form a wireless sensor network to collect and process environmental information. According to their mobility, these sensor nodes can be classified into two types: static and mobile. Although the static sensor nodes are suitable for large-scale deployment in the monitoring area, the construction cost of the whole wireless sensor network will be very expensive because of the weak function of the single node, such as the need to strengthen its information acquisition and processing capabilities. One alternative is to deploy some powerful and mobile sensor nodes in a wireless sensor network. Whenever a particular event requires information collection and processing, the mobile sensor nodes are sent to those points for further processing. To reduce the cost of deployment effectively, if some areas are not covered by sensors, mobile sensor nodes can move to the empty area to achieve the goal of covering holes.

In traditional agriculture, the way people obtain farmland information is mainly through artificial measurement. The acquisition process needs to consume a lot of manpower and time. The environment parameters and crop growth conditions need to be held in stages and localations. With the development of artificial intelligence and precision agriculture, intelligent network technology, such as intelligent sensing chip and mobile embedded system, has been more and more applied in modern agriculture. It has become a reality to monitor the conditions of water, temperature and CO2 in crop growth environment through various sensors and Internet technology.

III. Conclusion

The use of wireless sensor networks with mobile and static nodes can effectively reduce the impact of human consumption and human activities on the farmland environment and obtain accurate crop environment and crop growth information on a larger area of knowledge and knowledge of wind, atmosphere, rainfall, evaporation, and nitrogen, phosphorus, potassium and other nutrient elements and soil PH values. Through various information collections, it helps enterprises to find problems in time, manages production accurately and improves production efficiency greatly.

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