Development of Field Monitoring Server System and Its Application in Agriculture

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Abstract. In agricultural field, environmental factors such as temperature, humidity, solar radiation, CO_2, and soil moisture are essential elements which influence on growth rate, productivity of produce, sugar content of fruit, acidity and etc. If we manage the above mentioned environmental factors efficiently, we can achieve improved results in production of agricultural product. For monitoring and managing the growth environments, this paper suggests the Field Monitoring Server System (FMSS) which can operate with solar power. We implemented the Ubiquitous Field Server System (UFSS) in our previous work. Compared with the UFSS, this FMSS enhanced or improved the power consumption, the mobility, and user-friendly environment monitoring methods. The system collects environmental data directly obtained from environment sensors, soil sensor and CCTV camera. To implement a stand-alone system, we applied a solar cell panel to operate this system without power source. To indicate the location of this system, a Global Positioning System (GPS) module is installed on the system. Finally, we confirmed that the FMSS monitors the field conditions by using various facilities and correctly operates without helping external supports.

1 Introduction

The information technologies including wireless sensors, ubiquitous computing and communication devices continuously apply and adapt to agricultural filed for creating newly productive methods [1,2]. The growth of agricultural product demands intensive field data acquisition. When we raise agricultural products, the field data are important factors to decide various methods of cultivation. If we can collect precision field data, the productivity and growth rate of products could be improved. Moreover, in large-scale agriculture, field monitoring is an important work [3,4]. We need effective field monitoring technologies to improve agricultural productivity.

For developing advanced agricultural techniques based on IT, we propose the Field Monitoring Server System (FMSS) that integrates IT devices and solar-power module into a single system. This system collects and monitors the information occurred from given field environments and the system's location.

The rest of this paper is organized as follows: Section 2 explains related works. Section 3 describes the system architecture of the FMSS and then Section 4 presents

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implementation of our system. Finally, we discuss conclusions and future work in Section 5.

2 Related Works

Environment factors, like light, water, temperature, and soil, are the essential elements of agriculture. Some of the researchers have studied agricultural field monitoring.

The Jet Propulsion Lab. in NASA studied the solar environment sensors to monitor temperature, humidity and oxygen of environment and soil. They applied the Sensor Web 3.1 with low power and small size [5].

The phytech Co. in Israel developed a plant growth monitoring system. This system measures the environment status by using sensors adhered to plant and sends information to farmer's home via internet [6].

Fig. 1. A plant growth monitoring system of the phytech co.

Tokyo Univ. in Japan monitored several farmlands in Asia. They collect environmental data and soil information of the farmlands using a stand-alone system [7].

Above researches are not considered the communications of systems or sensors and solar power. They collect environmental data at one spot of field. In large-scale agricultural field, we need to collect environmental data at several spots. Our system adopts Ubiquitous Sensor Network (USN) and the solar battery. Also we develop the FMSS as a stand-alone system integrating sensors, CCTV camera, Solar, database, web server and GPS module.

3 Field Monitoring Server System (FMSS) Architecture

The Field Monitoring Server System (FMSS) can collect real-time environmental field data from various sensors in physical layer and implement the agriculture application services including real-time monitoring at the higher layer, application layer. Figure 2 shows the architecture of the FMSS.

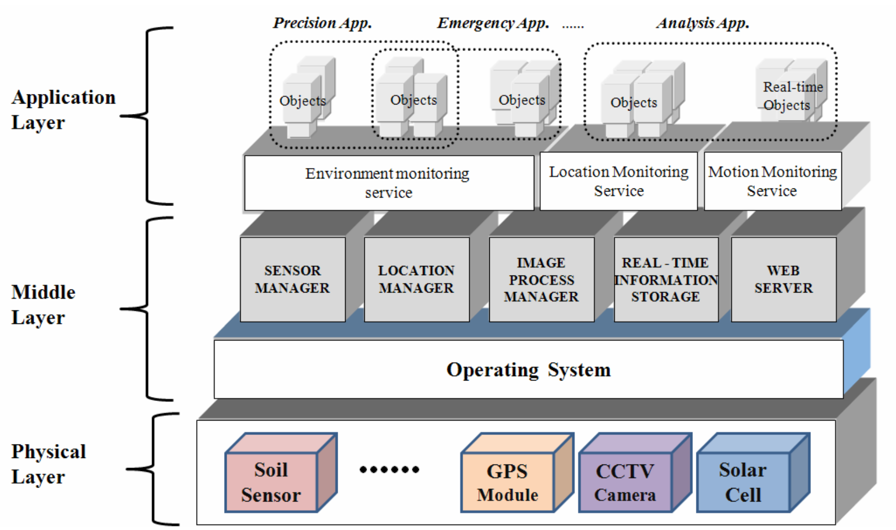

Fig. 2. Field Monitoring Server System's architecture consisting of three layers

Our suggested FMSS consists of three layers. The each layer and components of each layer explains in detail as follows. The physical layer includes various sensors, GPS module, CCTV camera, and solar cell. This system reduces the electric power consumption by using the low-power embedded board consisted of CPU, AD converter, DA converter, Ethernet controller, and wireless LAN. Also the system includes database and web server. Our system is a self-charging stand alone system using solar-electric power.

The middle layer has the soil manager, the location manager, the motion manager, the information storage, and the web server. The sensor manager manages the information from soil sensor and environment sensors. The location manager interacts with GPS module at the device layer. This manager stores and manages location data of the system. The motion manager provides stream data of field status for users. The information storage stores the information of the physical devices to database. The web server provides environment information for users from physical devices via internet.

The application layer provides users with the environment monitoring service, the location monitoring service, and the motion monitoring service. These three layers are integrated into the FMSS. By interacting with each layer, the system provides field environment information to farmers.

We had ever implemented the Ubiquitous Field Server System (UFSS) in previous work [8]. Compared with the UFSS, this FMSS enhanced or improved the power consumption, the mobility, and user-friendly environment monitoring methods. And we have a field test in yard for verifying the system executability.

3.1 Environment Monitoring Service

The environment monitoring service shows data collected from soil and environment sensors in physical layer. First, this service sends the raw data of environment sensors to the sensor manager. The raw data are temperature, humidity, soil Electronic Conductivity (EC) ratio, CO_2 and illumination of field. Then, the sensor manager changes raw data into digital information and stores the information to the information storage. The web server shows this environment information to users. Figure 3 shows procedure of the environment monitoring service.

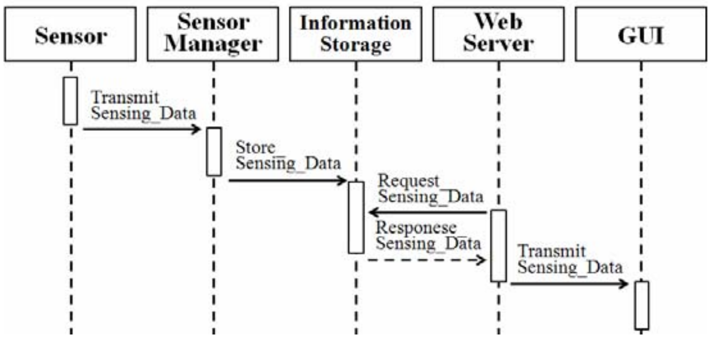

Fig. 3. Procedure of the environment monitoring service

3.2 Location Monitoring Service

This service monitors the system's location in field. First, the GPS Module sends the system's location data to the location manager. Then the sensor manager stores the location data to the information storage. And the web server provides the location of the system for users. Figure 4 explains the procedure of this location monitoring service.

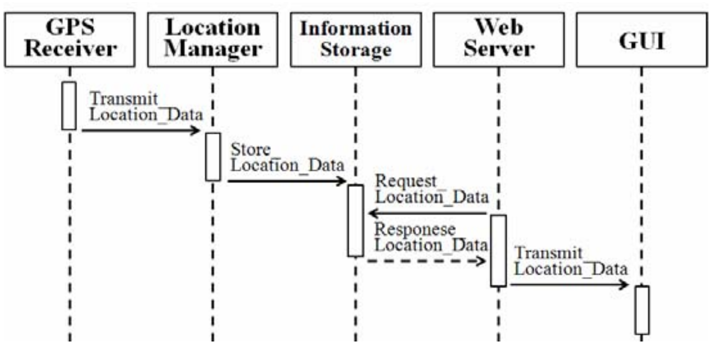

Fig. 4. Procedure of the location monitoring service

3.3 Motion Monitoring Service

This service provides the motion data by using CCTV camera for users. First, the CCTV camera sends stream data to the motion manager. The motion manager stores the stream data to the information storage. The web server shows the stream data to the user via internet. Figure 5 describes the procedure of the motion monitoring service.

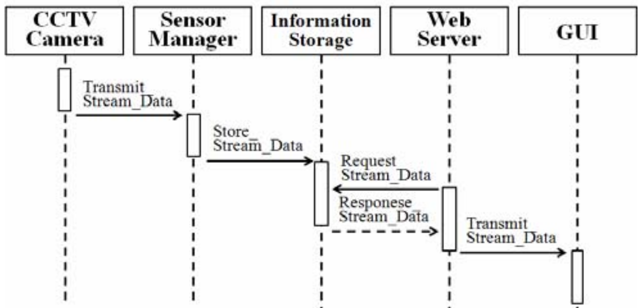

Fig. 5. Procedure of the motion monitoring service

4 Development of the FMSS

In this chapter, we develop the FMSS. Figure 6 shows the whole system model. The FMSS consists of autonomous systems. The system has a solar cell, a storage battery, and a low-power embedded board. The system stores electric power in the daytime and uses it in the nighttime.

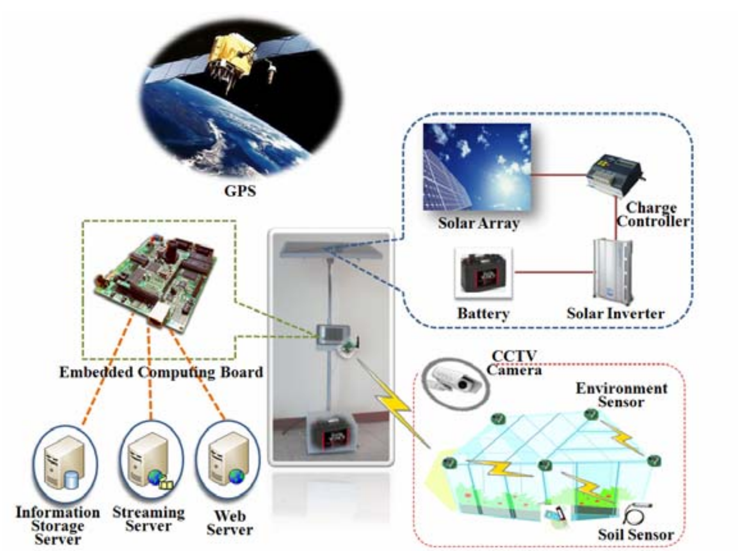

Fig. 6. FMSS model including an embedded board, a GPS, solar-charging devices and sensors

4.1 System Components

This system includes of physical devices and software modules. We explained the software modules in Chapter 3. The physical devices have sensing and information gathering devices. You can see the devices attached in our system in Figure 7.

Fig. 7. Solar cell, soil sensor, network sensor node, GPS module and CCTV camera in the FMSS

Table 1. Power consumption of each module and Power supply of solar battery

Module	Power consumption		
	Voltage	Current	Power
GPS Receiver	DC 5V	0.2A	1W
Embedded Board	DC 9V	500mA	5W
CCTV Camera	DC 9V	400mA	4W
Soil Sensor	DC 5V	10mA	0.05W
Environment Sensor	DC 3V	2.3A	6.9W
TOTAL	DC 12V	1.4A	16.95 W
Module	**Supply Power**		
Solar Cell	Voltage	Current	Power
	DC 26.4V	7.6A	200W
Battery	Voltage	Capacity(20HR)	
	DC 12V	64A	

Table 1 is showing the power consumption of equipped modules and solar power supply in the FMSS. The total power consumption of equipped modules like GPS receiver, embedded board, CCTV camera, soil sensor, and environment sensor is 16.95W. The solar cell supplies with electric power of the maximum 200W in the 25℃ test environment. This is enough to operate the system. And, you can see the main system installed sensors' data receiver, database, and the web server in Figure 8 and a solar battery in Figure 9.

Now, we integrate above components into the system. Figure 10 shows the FMSS's prototype including the software modules. The FMSS can apply various environments such as precision agriculture, livestock monitoring and greenhouse monitoring. For executing field test, we have been deployed the system in wild field.

Fig. 8. Embedded board including environment sensor receiver, database, and the web server

Fig. 9. Soil sensor receiver, solar battery

Fig. 10. Prototype of the FMSS deployed in wild filed

4.2 Implementation Results

Figure 11 is showing the results executed from FMSS's GUI from web server. The (a) in the figure presents the real-time motion from the CCTV camera. The (b) is showing location of the current system via GIS map. We used the GPS data to map the location. (c), (d) and (e) in Figure11 are showing the sensing value from the soil sensor, the sensing value from the environmental sensors and the average temperature, respectively.

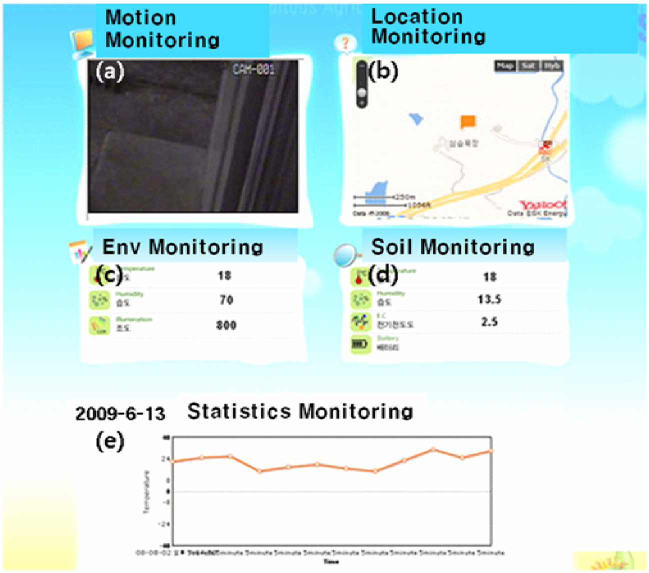

Fig. 11. A GUI for the FMSS's application

Figure 12 is showing the position of the FMSS. We can confirm the system's location or movement through the location monitoring service of the FMSS.

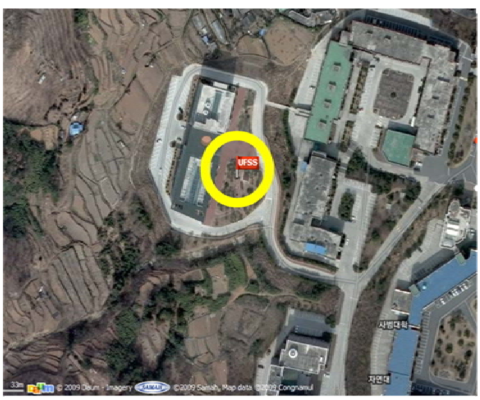

Fig. 12. Location of the FMSS on the map

To confirm the successful operation of the FMSS using solar cell, we performed field test on a sunny day with a mean temperature of 25□ degree. Figure 13 showed a graph of field test result in power consumption. As a final result, a solar cell which charged about 10 hours can support the operation of the FMSS about 24 hours. Hence, our FMSS can operate with the support of solar cell in the field without wired link or additional recharging process.

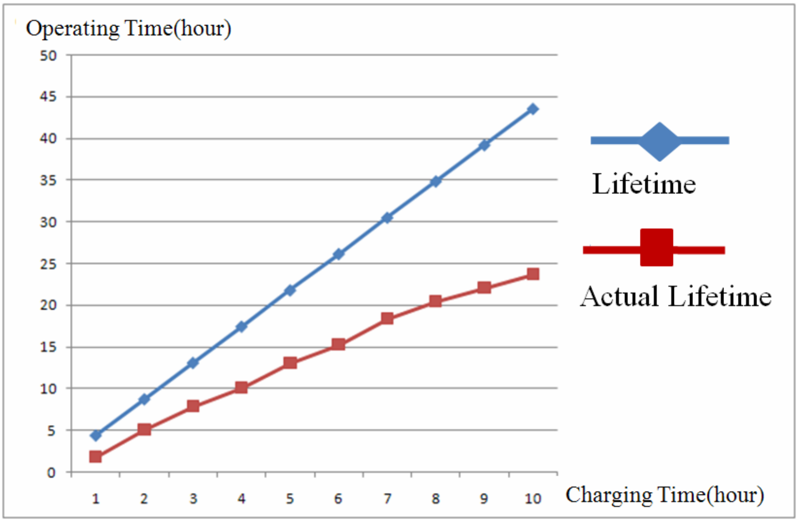

Fig. 13. Comparing estimated lifetime with actual lifetime of the system

5 Conclusions

This paper proposed the Field Monitoring Server System (FMSS) that can collect and monitor the environmental information occurred from given field and the system's location. Also, for verifying the executability of our system, we implemented the FMSS prototype and showed the executing results of the system. From this result, we confirmed that the FMSS monitors the field conditions by using various facilities and correctly operates without helping external supports. Also this FMSS enhanced or improved the power consumption, the mobility, and user-friendly environment monitoring methods. The FMSS can be powerful system to solve fundamental problem in large-scale agricultural area.

In the future, we are to developing an improved monitoring system which operates under CDMA or other technology based USN and applies into the reference point control in GIS field.

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