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A Study on Data Collector and Shared Platform in Smart Greenhouse for Precision Agriculture

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ABSTRACT

Due to the recent increase in consumer demand for high-quality agricultural and fishery products and interest in safety, it is necessary to improve the quality and productivity of agricultural and fishery products. One way to solve this problem is the precision farming technology of smart greenhouses, which increases the productivity of crops while reducing energy. To realize precision agriculture, it is necessary to derive optimal growth environment data for crops in greenhouse. In addition to farms that use hydroponic cultivation methods, there are farmers who harvest crops through soil cultivation at agricultural sites, so to derive optimal growth environment data for farmers, including both hydroponic and soil cultivation, a data collector was developed to provide wired and wireless communication depending on the situation of greenhouses while allowing the linkage of legacy equipment of existing farms. It also established a data sharing platform to store, analyze, and share collected data. Data collected from data collectors installed in smart greenhouses will be delivered to data sharing platforms through cloud communication, and data sharing platforms will be able to derive an optimized environment through comparative analysis by providing users with greenhouse monitoring functions and sharing data collected from nearby farms. Based on this, it is expected that the data will be developed into forecasting growth of crops, forecasting production, and forecasting insect pests in the future.

KEYWORDS: Smart agriculture, Precision agriculture, Data collector, Platform, IoT

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1. Introduction

Recently, people's anxiety about safety has been mounting due to increased natural disasters and environmental pollution caused by climate change [1].

It is also necessary to improve the quality and productivity of agricultural and fishery products due to increased consumer demand for high-quality agricultural and fishery products and interest in the safety of agricultural and fishery products [2].

Currently, smart agriculture is attracting worldwide attention as a solution to the continuing problems of agriculture, such as increased food demand due to population growth, a shortage of manpower due to small numbers of farms and aging, marginal distribution of agriculture and expansion of advanced agricultural technology [3-5].

Precision agricultural technology, one of the cutting-edge technologies for smart farming, is a technology that uses certain sensors and software to accurately provide what is needed to optimize crop productivity and sustainability and is capable of simultaneously monitoring crop conditions [6].

To realize precision farming in ICT-based smart greenhouses, which can increase crop productivity while reducing energy, the optimal growth environment data for crops in the greenhouse must be derived, and one of the ways to address this process is to create a platform for collecting and sharing greenhouse environment data through data collectors.

Related platform research for precision farming involves developing and testing low-cost sensor/controller network platforms based on the Internet of Things, integrating machine-to-machine and person-to-machine interface protocols, and collecting and analyzing data through edge computing technology to provide optimized environmental data for hydroponic cultivation [7].

However, in addition to farmers who use hydroponic cultivation methods, there are also farmers who harvest crops through soil cultivation.

In this paper, we introduced the precision agriculture in Chapter 2 and explained the data collection process and shared platform transmission flow chart through the data collector through the data collector installed in the smart greenhouse to derive the optimal environment data including both hydroponic and soil cultivation, and we established a system to create files on the gateway server or cloud server through wired or wirelessly connected communication network and then transfer the data to the shared platform.

The definitions of hardware conceptual diagrams and communication protocols for data collectors and of databases and functions for building data sharing platforms are introduced in Chapter 3.

The results of the test application and data analysis of the developed data collector and data sharing platform are also introduced in Chapter 4.

According to the results of the experiments derived from this paper, it is expected that the data utilization model will be derived through the data sharing platform to help farmers improve productivity and utilize the technology and product development of smart greenhouse-related companies, and it is also expected to contribute to the development of precision agricultural technologies such as various analysis and prediction of smart agriculture in the future by utilizing the data collected on the platform.

2. Background

2.1 Precision Agriculture

Precision agriculture is the technology for observing, measuring and responding to changes in crops.

Aim to increase production and profitability to achieve maximum crop yield with the lowest investment, and contribute to the broad goal of improving the sustainability and environmental quality of agricultural production by using intensive data and information collection and processing in time and space [8-10].

It is also a technically more objective data-based analysis and predictable technology that has created a variety of agriculture-related technology fields through continuous research, as it utilizes quantified data by environmental variables and stages of soil and cultivation using various sensors through collection and analysis[11].

To collect data, IoT sensor nodes are installed throughout the smart greenhouse, which communicate directly or through the gateway to the cloud server [12].

In this paper, as shown in Figure 1. environmental information and control information measured within smart greenhouses are transmitted to the cloud through data collector, stored on data sharing platform, and utilized and shared data collected from smart agricultural information sharing system built on data sharing platform to realize precision farming.

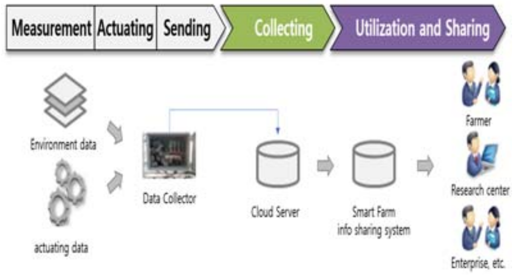

Figure 1. Data Collecting Flow

3. Implementation

3.1 Data collector

The hardware concept diagram of the data collector in smart greenhouses for precision farming is shown in Figure 2.

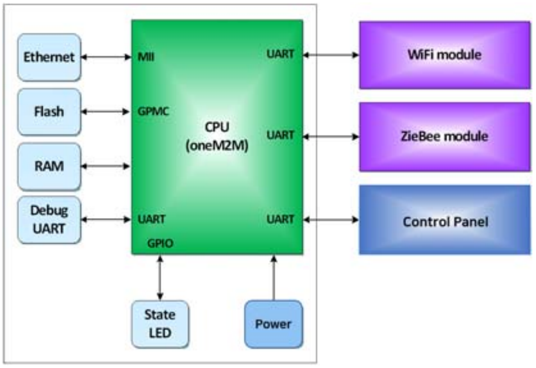

Figure 2. Data Collector H/W Concept Diagram

In order to enable linkage of existing legacy equipment used by farms operating smart farming, data collection and transmission of greenhouse data are performed through application of OneM2M platform technology, and various ICT devices and legacy communications (Ethernet, RS-485, RS-422, RS-232, WiFi, and ZigBee) used by farms are designed to enable immediate linkage after setting environmental values.

The data collector basically uses the Internet network (TCP / IP communication) for data transmission to the cloud server, and the communication with the ICT facility equipment in the smart greenhouse basically uses the wired communication, RS-485 MODBUS RTU communication.

One environment The module is configured so that wired and wireless communication can be used in parallel.

Here, RS-485 MODBUS RTU communication method is an extension of RS-422 and RS-232 which means the standard specification of the serial communication protocol and has an increased transmission distance of 1.2 km compared to the existing RS-232 [13].

MODBUS is a Master/Slave-based protocol, and MODBUS RTU, one of the types of MODBUS, uses a serial communication network, and the representative standard used for serial communication is RS-485. It is possible to communicate with several slaves from the master of the RS-485 MODBUS RTU configured in this way, and the connected repeaters are controlled according to the frame (command) sent from the master (data collector) [14-15].

In addition, the JSON format conversion management system was introduced to analyze the collected data and send it as standard.

Communication protocols are defined for data collection in smart greenhouses of data collectors, and protocols for RS-485-based MODBUS RTU communication are shown in Table 1.

Table 1. RS-485 based Modbus RTU protocol

Type	ID (8bit)	CMD (8bit)	Start Address (16bit)		Stop Address (16bit)		CRC16 (16bit)	
Data Type: Byte			hi	lo	hi	lo	hi	lo
Request (hex)	01	03	00	00	00	1C	44	03
Request (decimal)	1	3	0		28		17411	

3.2 Data Sharing Platform

A list of data base tables for building a data sharing platform defined tables such as collection information and scenario information based on in- and outside-collect environment information in smart greenhouses, as shown in Table 2.

In addition, functional definition tables were defined for the definition of common code query, menu information, etc. and sequence tables were defined for the definition of menus, bulletin boards, monitoring indices, etc. Finally, an index table was defined to define the index values according to the collection information and set values from the ICT equipment installed in the greenhouse.

Thus, the data sharing platform was built to provide users with greenhouse environmental control and monitoring functions, and data analysis functions as a result of data collection, as shown in Figure 3.

In the data analysis screen, the collected data can be compared to each farm, and the chart is printed based on the collected data when the sensor data items such as comparison standard temperature, humidity, geothermal temperature, geothermal humidity, and CO2 are selected.

Based on these data, we will update production forecasting capabilities for precision farming based on the data analyzed later.

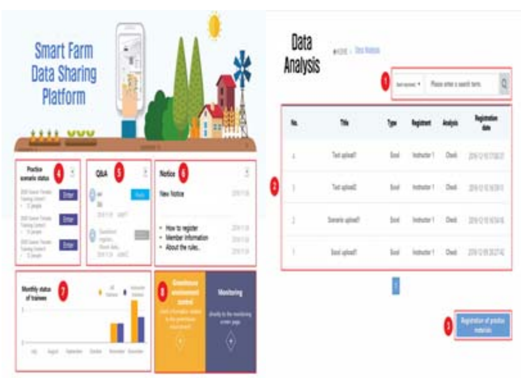

Figure 3. Data Sharing Platform

4. Experimental Prototype

For the experiment of the developed data collector, the farmers who grow and harvest tomatoes using hydroponic and soil cultivation methods were selected among the pilot farms. Figure 4. shows the configuration of the data collector installation on the experimental farm

Table 2. Data Sharing Platform DB Table

Table List			
No.	Function	Table ID	Table Name
1	Set Greenhouse Control	TB_3WAY_VALVE_SET	SET 3WAY VALVE
2	Set Greenhouse Control	TB_ACAH_SET	SET AIRCONDITIONER
3	Set Greenhouse Control	TB_ACAH_STEP_SET	SET AIRCONDITIONER LEVEL
4	Collecting Info	TB_ACQ_AUTO_BASE_INFO	COLLECTING ENVIRONMENT BASE INFO
5	Collecting info	TB_ACQ_EXT_ENV_INFO	COLLECTING EXTERNAL ENVIRONMENT INFO
6	Collecting Info	TB_ACQ_GAD_INFO	COLLECTING GROWTH INFO
7	Collecting info	TB_ACQ_INT_ENV_INFO	COLLECTING INTERNAL ENVIRONMENT INFO
Etc.			

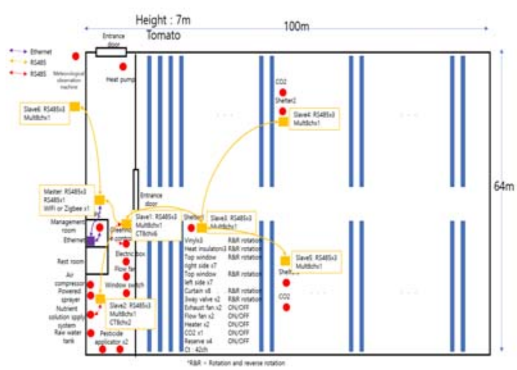

Figure 4. Set Data Collector Configuration

Management PCs and data collectors outside smart greenhouses are connected by Ethernet communications, and sensing data from each sensor node is transmitted from repeaters installed in each greenhouse.

The communication method used for delivery used the protocols of RS-485 MODBUS RTU.

The collection cycle for data collection was measured in 10-minute increments, and the collected data is communicated to the data sharing platform via the cloud.

Figure 5. Data Analysis Using a Data Sharing Platform

The collected data can be retrieved from the data-sharing platform as shown in Figure 5. and a weekly analysis of the chart from August 20 to August 26 resulted in an average temperature of 28.2°C and humidity of 73.4%.

If the data collected by the farmers who installed the data collector are analyzed and uploaded to the shared platform, it will be possible to derive the optimal data for crop growth by comparing data from each farm, which is expected to realize the precision farming required to optimize the productivity and sustainability of the crops.

5. Conclusions

In this paper, the data collector developed through the study of the data collector and shared platform in smart greenhouse for precision farming was selected by farmers using hydroponic and soil cultivation methods and the technology to deliver the data collected from each greenhouse sensor after installation to the shared platform through cloud communication.

The developed data collector is equipped with OneM2M platform technology to enable interworking of existing legacy equipment and is configured to use RS-485 MODBUS RTU as a base and wired and wireless communication depending on the greenhouse environment.

In addition, it is expected that by sharing the data collected from neighboring farmers through the established data sharing platform, it will be possible to derive an optimized environment for crop growth through comparative analysis, and based on this data, it will be able to develop into forecasting the growth of crops, forecasting production, and forecasting of pests.

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정밀 농업을 위한 스마트 온실에서의 데이터 수집기 및 공유플랫폼 연구

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요 약

최근 소비자의 고품질 농수산물에 대한 수요 증가와 안전성에 대한 관심으로 인해 농수산물의 품질향상 및 생산성 제고가 필요하다. 이를 해결하기 위한 방법 중 하나로써 작물의 생산성을 높이면서 에너지는 절감시키는 스마트 온실의 정밀농업 기술이 있다. 이러한 정밀농업을 실현시키기 위해서는 온실 내 작물의 최적 생장 환경 데이터 도출이 필요하다. 농업현장에서는 수경재배방식을 이용하는 농가 이외에도 토양재배를 통해 작물을 수확하는 농가들이 존재하기 때문에 이러한 재배 방식의 다양성을 고려하여 수경재배와 토양재배를 모두 포함한 농가들의 최적의 생장 환경 데이터를 도출하고자, 기존 농가의 레거시 장비 연동이 가능하면서 온실의 상황에 따라 유무선 통신을 제공하는 데이터 수집기를 개발하였다. 또한 수집된 데이터를 저장하고 분석, 공유하기 위한 데이터 공유 플랫폼을 구축하였다. 스마트 온실에 설치된 데이터 수집기로부터 수집된 데이터는 클라우드 통신을 통해 데이터 공유 플랫폼으로 전달되며, 데이터 공유 플랫폼에서는 사용자에게 온실 모니터링 기능 제공 및 주변 농가들로부터 수집된 데이터를 공유함으로써 비교분석을 통해 최적화된 환경을 도출해 낼 수 있을 것으로 기대되며 이를 기반으로 향후 작물의 생육 예측이나 생산량 예측 및 병해충 예찰 등으로 발전해 나갈 수 있을 것으로 기대된다.

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