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A Study on the Automatic Control Architecture with Conditional Results in Smartfarm System

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Abstract

With the advance of Information and Communications Technology (ICT), IoT technology is getting a great impact on human activities. As the gradual decline in agricultural labor due to the decreasing populations and aging in a rural area, development of agricultural technologies, a smart farm, based on ICT is considered as an alternative to improve productivity and food quality regardless of plant items. In this paper, we present a two-level architecture for a smartfarm automation suitable for an agriculture growth environment using collected conditional data in the intelligent smartfarm system. Using this architecture, it is possible to control many actuators automatically by deriving the conditional results from environment sensor data in a greenhouse. And, it can be extended to a high-level correlation function with consideration of operating status, soil quality, and regional characteristics and also provide scalability to the automation of fish-farming and livestock systems.

Keywords: *Smartfarm, Automation architecture, Conditional analysis, Correlation analysis, Hierarchical structure*[1]

1. Introduction

Currently, rural areas in Korea are struggling due to a changing in the distribution of population and dramatic climate changes. Especially, the changing population which causes a bad impact on the food productivity due to rapidly becoming a trend that people have moved to urban areas while aged people remain on their hometown emerges as a major issue. Moreover, the agricultural land has been also declining, and also causing a food self-sufficiency decline as well. In the circumstances, the smartfarm can be a good alternative to be utilized for enabling farmers to cultivate crops more conveniently and to increase productivity by providing and improving growing conditions. Additionally, the technology prevents diseases and can be applied to a variety of areas including animal farming, fishery, and etc. This being so, there have been numerous research studies conducted on the smartfarm technology which includes actuator control with sensor data in the greenhouse.

A smartfarm monitoring network is established to support remote control of actuator inside the greenhouse. The remote control is possible to be implemented by monitoring the growth environment that has been extracted from sensors in the greenhouse without spatio-temporal constraints [1]. In addition, as a study of designing integrated environmental monitoring system, actuators could be controlled based on the acquired environment data by establishing the sensor network in the greenhouse [2]. A fussy algorithm has been so for the determination of the

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operation of a cooling system in the greenhouse [3]. The work of hybrid algorithm has been in to use for the development and the production of intelligent agricultural products has been conducted [4]. According to for the usage of IoT technology's ability to monitor the environment, the server and the user must build a system that is able to send out the current environment's state and condition and allow cloud-based collection, analysis, and forecasting system [5]. Also, an IoT based system for the transmission of environmental data to the server and user has been built and a cloud-based environment data collecting, analyzing, and prediction system also has been developed [6]. A study for supporting integrated system for being able to communicate among different sensors for the intellectualization has been conducted and its intellectualization study also has been conducted [7]. A three-layer smartfarm architecture with data collection, network, and cloud back-end architecture has been designed [8], and a way to allocate channels has been also designed to prevent radio interference [9]. Focused on controlling actuators in the greenhouse by using IoT-based data collection and analysis, the standardization of system configuration and interface among heterogeneous devices is underway to support its scalability [10][11]. However, these researches only focus on individual crop types and their cultivation environment characteristics, and implementation of the smartfarm system according to specific network interfaces. Therefore, it is disallowing the linkage of structured smartfarm data and the systematic control structure is also unavailable.

In this paper, an advanced control method for the smartfarm system, a two-level architecture with analysis of the associated conditional data for controlling actuators in the greenhouse, will be introduced and the automation of smartfarm system will be also presented. In section 2, two main contents will be introduced and described; one is the two-level architecture and the other is a data structure and workflow for the correlation among sensor data and actuator status. Concluding in section 3, future work will be discussed.

2. Smartfarm complex control structure

Existing automatic smartfarm systems are not supporting a systematical automatic function for harvesting crops, but instead providing for individual characteristics of crops because it is developed for the specific one. This has led us to consider more widely usable system to design. Designing a complex control structure for the smartfarm should be considered of the relation among the devices installed in the greenhouse. Through the mode configuration and numerical setting of sensors installed in the farm, the automatic control function can be provided systematically and is able to provide an optimum growth condition. In this chapter, we propose the two-level architecture for automatic control of smartfarm system and propose its workflow on a conditional analysis control level considering the relation characteristics among sensor data and actuator status.

2.1 Two-Level Control Architecture

In order for controlling various actuators according to environment data in the smartfarm, the optimized method should be derived by analyzing associated parameters and relevance among sensors and actuators as shown in Fig. 1, which illustrates the two-level control architecture for smartfarm automation system to control actuators in the greenhouse. The conditional analysis control level provides the calculated result according to pre-defined conditions based on the measured value from sensors in sensor lists. This calculated result from the processing of conditional analysis control level is used for driving actuators with a combination of environment variables.

In other words, the condition result by the processing of conditional analysis control level is the value for controlling an individual actuator by using environment data in the farm but not related to heuristic configurations for each crop. In order to drive a ventilation fan, for instance, the value of sub-items such as the humidity, carbon dioxide, and the number of ventilations should be logically considered with scheduling information. It is just supporting analysis control structure on the current environmental data in the smartfarm, but not impacted by the soil or geographical characteristics and specific cultivation method. The correlated analysis control level has an intelligent structure in order to support the result from the conditional analysis control level as well as an integrated result by association with additional sub-parameters for the actuator control. Therefore, various methods such as regional characteristic, heuristic configuration, statistical data processing, AI, and Bigdata technologies can be used. However, in most cases, because basic automation for smartfarm can be achieved by only using the conditional analysis control level, in this paper, we describe the structure of smartfarm automation focused on the conditional analysis control level.

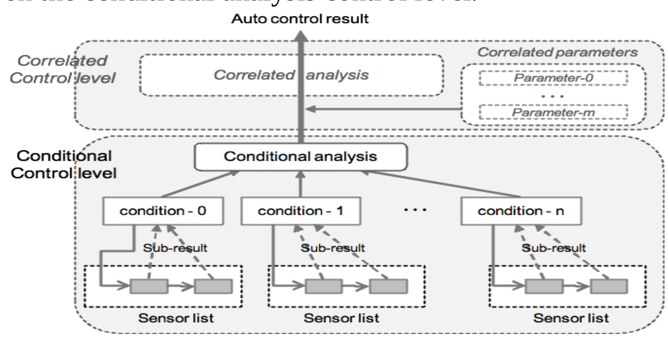

Figure 1. Structure of two-level control processing for Smartfarm control

In the conditional analysis control level, there are sub-items of environment parameters depending on its target smartfarm system as shown in Table 1.

Table 1. Detailed control environment parameters on conditional analysis control level

Control level	Sub-items	Contents
Condition analysis control level	Light environment	Light intensity (Wavelengths of photosynthetically active radiation): the strength or amount of light Light quality (Spectrometry): Wavelength, Spectral distribution of light Light duration (Photoperiod): The number of continuous hours of light in each 24-hour period
	Ventilation	Rate of air circulation, Number of air change
	Air conditioning	Min. temperature, Optimum temperature for crop, Max. temperature Cooling technique, Circulation type water curtain system
	CO2	Optimum photosynthesis, Gasification of solid/liquid carbon dioxide
	Watering, Nutrient supplement	Soil water, Nutriculture (Nitrogen, Phosphoric acid, Kalium)
	Blight monitoring	Temperature, Humidity, Moisture

2.2 Items in conditional analysis control level

Items in conditional control analysis level consist of actuator control and sensor related parameters. In detail, the control data includes the settings of speed, direction, and duration of active actuators, and sensor list which includes each sensor' identifier, mode and others. Each driver can be enabled and the control parameters for actuator is derived by referring the max./min. value of sensors and deviation value from the pre-configured sensor value. The configuration format is presented as a form of JSON data as shown in Table 2, for example.

Table 2. Items for conditional control analysis

```
{
"enable" : 0 or 1
"actid" : Actuator ID
"speed": Speed or on/off
"direction": forward/reverse
"duration": Actuator duration time(ms)
"number" : number of sensors
"sensorlist" :
[
{
        "sid" : Sensor ID
        "logic" : logic operation
        "subnum" : Sensor sub-number
        "mode" : Sensor condition mode
        "mvalue" : Median value
        "hyst" : Hysteresis value
},
   .....
]
}
```

A thread can be used for conditional analysis control level for system resource efficiency. To control a specific actuator, various sensor values in the sensor list can be referred. The operation and control messages are processed in network thread and configuration thread. To prevent from race condition of shared resources, the critical section should be decided, and the use of the mutual exclusion (MUTEX), signal/wait, and semaphore can be considered.

2.3 Processing flow of condition analysis control

The condition analysis control processing is operable to use thread object and the setlist is processed continuously. There is the related sensor list for each condition analysis control list. And the result is given by calculated values depending on the condition mode of each sensor as shown in Fig. 2. The automatic control function for each actuator control unit may have different control functions for various types of associated sensors values. Therefore, after the control result according to the pre-configured sensor condition mode is calculated, it is used for controlling the actuator through the comprehensive analysis and processing algorithm based on its priority and relevance. And, to avoid producing the redundant command generation, and the additional traffic consumption or resource usage, a generated command by the condition analysis control process is applied to the system to control actuators automatically depending on the comparison values with the current status of the actuator. The message processing for scheduling configuration is processed when the request is transmitted via the network, or there can be internal request for reservation scheduling. The transmitted message is extracted and analyzed. A message is delivered as the form of JSON type. Depending on the pared JSON objects and values, the auto-control can be processed.

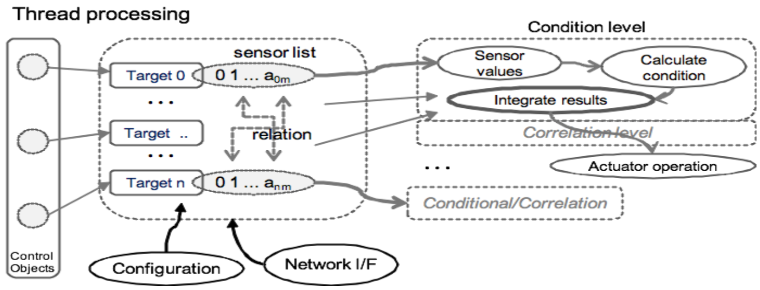

Figure 2. Condition control analysis and process diagram

The result of the conditional control analysis process is classified into required settings, and the unnecessary items are filtered as an error and he previous item values are used as they are. With this procedure, it demonstrates the efficiency by processing the only required items without having to redirect all items. The items in condition analysis control processing can be divided into two parts; one is required, the others are optional. If the required item is empty, then the error message will be generated and therefore the previously configured value is filled.

3. Conclusion

In this paper, we propose the two-level architecture, the conditional analysis control level and the correlated analysis control level, to derive the control command based on the analyzed environmental data collected from various sensors. To configure the sub-items of environment parameter for processing conditional control level, we also present the structure of conditional control with considering the equal-level structure and collected data. Using this architecture, it is possible to control and manage smartfarm system in base level, which supports processing function of data structure items for actuator control by using conditional analysis results from sensor monitoring values on the multitask system. This research can be a motivation to establish a structure for standardization of smartfarm system. For our future work, it needs further research to establish detailed structure and processing flow of correlation analysis control level to provide intelligent control ability on smartfarm system.

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