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Design of Scalable Sensor and Actuator Interface Module for Smart Farm

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Abstract

In this paper, we describe the structure of sensor-actuator interface module which can be used for overcoming of limitations regardless of sensor/actuator data type in aspects of compatibility and scalability. The sensor-actuator interface module can be added or removed depending on change of circumstances. And, it can be configured dynamically by modularization of device-drivers. The communication between main controller and sensor-actuator interfaces module can be applied by using MODBUS protocol. It is designed to gather data from digital or analog sensors and to control supply power, speed and direction of the driver such as on/off and PWM control. With this, we expect that our modular architecture with high compatibility and scalability can be easily applied to various smart farm system.

Keywords: *Actuator, Data converter, Modbus interface, Sensor, Smart farm*

1. Introduction

With the development of ICT technology, it has been attempted to integrate technology to improve productivity and management efficiency in various industrial fields such as automobile, health, factory, and city. According to the main statistics of the Ministry of Agriculture and Food and Rural Affairs in 2016 [1], the rural population was 51% of the total population in 1975 in Korea, but it decreased to 19% in 2015. In terms of age distribution, the ratio of ages 60 and over in the 1975s was 8%, but it increased to 50% in 2015. Smart farm system applying ICT technology has been suggested as a solution of the decrease of rural population and aggravation of agricultural productivity. Based on this social and economic phenomenon, IoT sensor-based greenhouse environment control techniques and monitoring studies are progressed [2][3][4]. Recently, a lot of research is underway not only in agriculture but also in animal husbandry and fisheries [5][6]. Although many companies make their efforts for the development of smart farm, it is not unable to enter the market place due to the high initial investment cost and the equipment installation fee which is a significant barrier to apply the system by the customer. Since most smart farm devices have their own system structure to control specific sensors or actuators, the system is vulnerable. so, if maintenance, repair, or remediation work is interrupted, the entire system may not be supported anymore. In addition,

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incompatibility problems can be occurred since hardware and software are developed separately [7]. Therefore, it is necessary to find the solution for technical constraints of interoperability and sensor-actuator scalability. In order to solve this problem, this paper proposes a sensor-actuator interface structure which can be used for the data collection and processing without regard to the sensor and actuator interface, and its data format. The proposed sensor-actuator interface is designed by based on 32-bit processor and converts the sensor value and actuator command via the internal communication protocol and transmits it to the main controller.

In the chapter 2, we describe the structure of the extensible sensor-actuator interface module and describe its flow structure for design and message processing. The conclusions and future research directions will be presented in the chapter 3.

2. Structure of sensor-actuator interface module and its design

2.1. Module structure

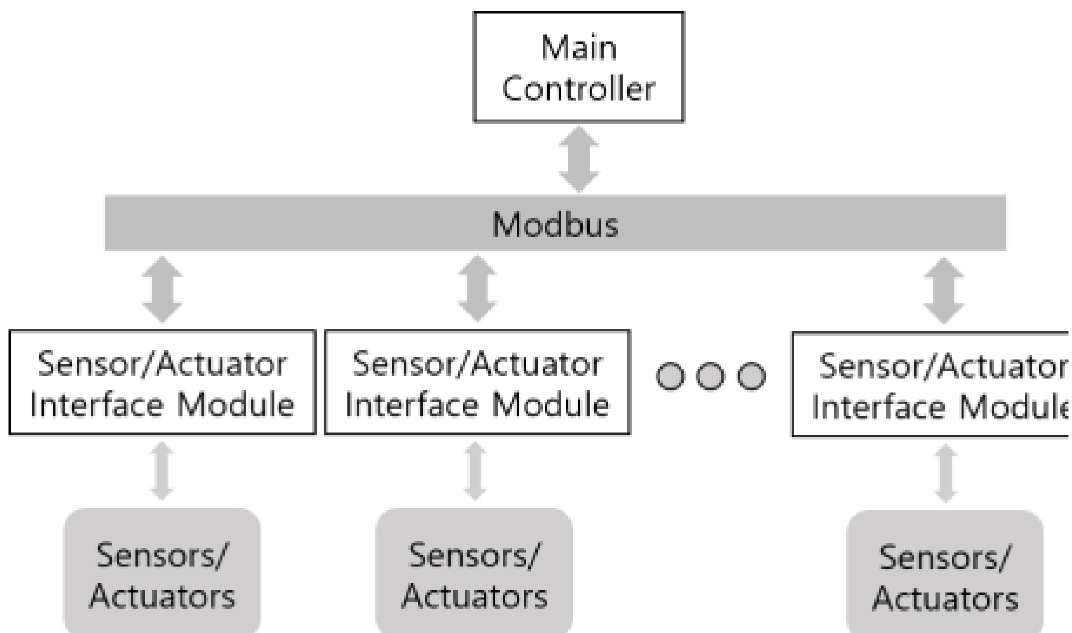

Figure 1. Architecture of sensor-actuator interface module

Currently, the development of standard for smart farm is ongoing, but there is still in progress not completely developed yet [8]. Therefore, depending on the developer, the data format for communication among the device-network and the device-sensor/actuator may be different. these different data structure types make not to be able to integrate each smart farm devices. To solve this problem, the sensor-actuator interface should support various types of the input and output to have different data formats.

The STM32 Microcontroller is used for the development of the sensor-driver interface module [9], and it is designed to be connected to the main controller via Modbus as shown in [Figure 1]. So, the main controller and module can be connected in parallel.

Being able to support various sensors and actuators depending on its data type, this module is designed to support total 16-ports by the configuring 8 inputs and 8 outputs. There are 8 input ports capable of analog/digital sensor input for sensors. And also, there are 8 output ports capable of the direction/speed control output, speed control output, On/Off/direction control output, and on/off control output for actuators. The sensor-actuator interface module supports the voltage and current signal interfaces to handle various types of sensor data. Because it is designed as the module type structure, modules can be added or removed according to the number or type of sensors and actuators needed, so it is able to improve the scalable and compatible

In this process, the collection of the sensor data and the control of actuator are controlled via the Modbus [10] protocol which is used for the communication between the main controller and the sensor-actuator interface. Each devices can be controlled by using the internally standardized message type regardless of the sensor signal or the control signal of the actuator in the main controller

2.2. Software structure

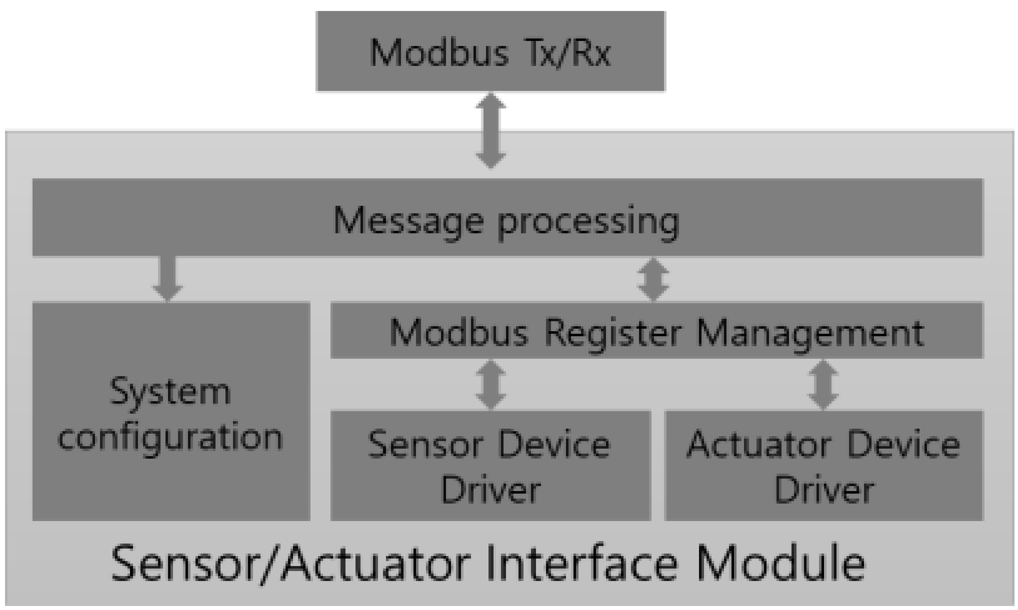

Figure 2. SW architecture of sensor-actuator interface module

The software structure of the sensor-actuator interface module is shown in [Figure 2]. The structure of sensor-driver interface can be divided into the message processing unit that communicates between the main control unit and the sensor-actuator interface module through the Modbus, and a control part that periodically controls the operation of each actuators according to the setting. Both the message processor and the device controller refer to the Holding register and operate asynchronously.

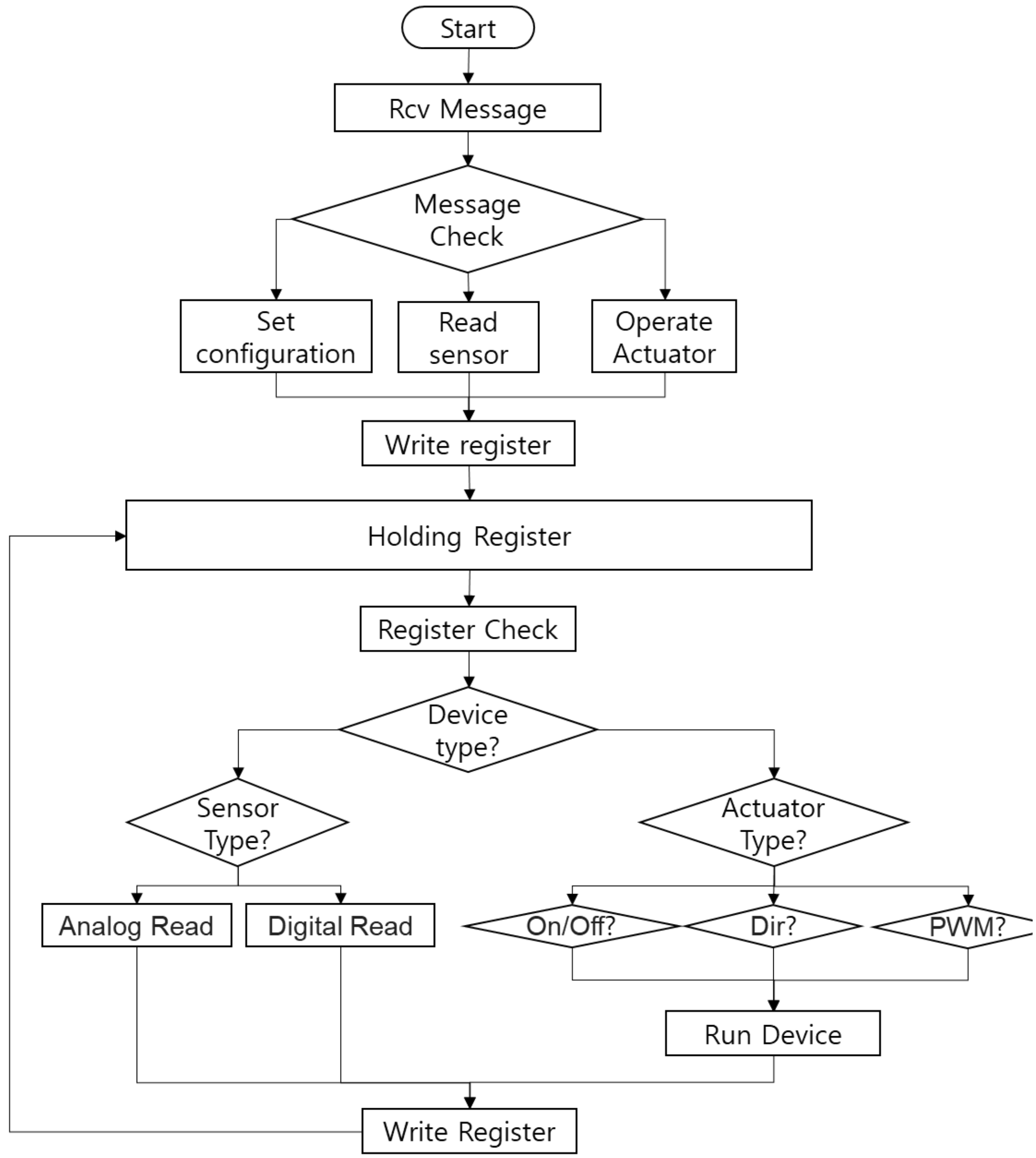

Figure 3. Flow diagram of sensor-actuator interface software

The software flow diagram of the sensor-actuator interface module is shown in [Figure 3]. Based on the Holding Register, the up side shows the message processing and the down side shows the process of the device control.

The message processor is used for the communication with the main controller using the Modbus protocol, and are processing the message transferred from the main controller, and are writing information such as setting, sensor reading, and actuator operation to the Holding Register.

The device control unit refers to the register set through the message processing process and executes the command. The device controller can read the sensor value or control the actuator by referring to the set command after the message process. To be able to control depending on the configuration and command setting, holding registers are periodically checked in the control part and the actuators are controlled by its device type. The result is written to the Holding Register again. and the sensor data and the latest actuator control status are transmitted in forms of the internal communication protocol to the main control unit. Through this process, the device control unit can perform sensor data transmission and actuator control at the request of the main control unit.

3. Conclusion

In this paper, we propose an extensible sensor-actuator interface for smart farm. The proposed sensor-actuator interface can support the various type of inputs such as analog and digital sensors and also support outputs for control of actuators such as power, direction, and speed control. In addition, as each module is operated independently by connecting the main controller with the internal bus, it is ensuring higher compatibility and expandability than the existing system. By using the sensor-actuator interface proposed in this paper, it is possible to easily replace or add sensors and actuators which is equipped on existing smart farm system. Ultimately, without the parchment of a new smart farm system, additional maintenance and upgrades are possible by transplanting of sensors and actuators of existing smart farm facilities. This makes it easy to maintain and manage smart farm facilities in terms of time and cost. It is also expected to contribute to the expansion of smart farm equipment market. We plan to develop a more general and stable system through further research.

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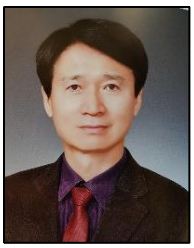

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