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IoT-based Smart Home Farm System

Joonhwan Shim
School of Electrical and Electronics Engineering, Korea Maritime and Ocean University, Busan, KOREA

ABSTRACT: *Recently, in South Korea, smart home farm systems for growing companion plants of hobby purposes have been gaining attention among urban residents who find it difficult to operate weekend farms. In particular, as the number of single-person households increases, the number of households that grow companion plants to relieve loneliness and emptiness have been also increasing. In order to improve the quality of life of these modern people, this study designed and manufactured a smart home farm system that automatically manages the growth environment of companion plants using Internet of Things (IoT) technology. This system supplies water and light sources based on real-time data through various sensor information to increase the effectiveness of the plant growth process, and can improve the efficiency of plant cultivation and crop growth through remote monitoring and control functions using mobile technology. Through this smart farm system, users can conveniently and simply manage companion plants, and minimize the effort and time required for plant cultivation.*

KEYWORDS: *IoT, smart farm, companion plant, remote control and monitoring*

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I. INTRODUCTION

Since the 2020 COVID-19 pandemic, the time spent by household members at home has increased in South Korea, and as telecommuting has become more common, the number of households cultivating companion plants as a personal hobby has increased. In particular, the demand for companion plants grown by individuals at home has increased further due to the increase in single-person households in South Korea. These single-person households are receiving much attention because companion plants provide emotional stability and reduce loneliness, and companion plants also have a great effect on interior design that makes the living environment more pleasant[1-4].

In Korea, more than 50% of households live in apartments, so it is not easy to grow companion plants in a small apartment. The timing of watering will vary depending on the plant, but if it does not receive water for a certain period of time, it will wither[5-6]. If there are multiple members in the household, when the member who is growing the plant is unable to take care of the plant, the other members can ask for care. However, if you are a single-person household and are away from home for a long time when something comes up, you will not be able to take care of it, making it difficult for the companion plant to grow normally. To solve these difficulties, home smart farms have been introduced for several years now. And home smart farms are currently gaining popularity in the market because it allows even beginners to easily grow companion plants and gives the joy of growth[7-8].

In fact, it is very difficult for modern people to provide water at the right time and create an environment (temperature, humidity, sunlight, etc.) suitable for plant cultivation in their busy daily lives. Therefore, a home smart farm system helps busy modern people easily grow companion plants[9-10]. In this study, we fabricated a home smart farm that can automatically manage the environment of companion plants, such as water, temperature, humidity, and sunlight, by utilizing IoT technology of smart farms, and monitor and manage various variables related to the growth of companion plants[11-15]. This smart farm was designed and manufactured using 3D printing for its exterior, and is divided into an IoT sensor section and a control section based on Arduino. Using a temperature and humidity sensor, a light sensor, and a soil humidity sensor, it monitors the crop growth environment in real time and collects data to manage information for efficient plant cultivation. Based on the collected data, it is composed of a smart farm system that uses LEDs to add insufficient light, a servo motor to operate a blower for air circulation, and a water pump to automatically water the plants.

II. EXPERIMENTAL SETUP

IoT technology is applied to plant cultivation to provide intelligent, digital, and automated management throughout the entire cultivation process. The IoT system applied to plant cultivation collects important information such as water, temperature, humidity, and sunlight required for plant cultivation through various sensors, and provides a control system that can monitor and adjust the plant growth environment in real time through a wireless network. In this paper, we focused on two major points to satisfy the most important needs of people who grow plants at home by utilizing smart farm IoT technology. The first is a system that has the basic growth and management performance required for plant control while being inexpensive, and the second is convenience so that it can be used anywhere, such as at home or in the office. In terms of the first cost, the smart farm system sold by large companies has various functions and excellent performance, but its price is very high, making it difficult for individuals to purchase it when purchasing a smart farm for home due to its high price. Therefore, this system can build a low-cost system that can be attached to each plant one by one by configuring the temperature and humidity sensor, light sensor, soil moisture sensor, automatic water replenishment, and LED lighting functions that are considered essential for the home into one system. The second convenience aspect is that the size of the system is minimized so that each flower pot can be attached and detached one by one, allowing efficient use of the plant growing space and easy installation when moving the plants to another space. Also, unlike other smart farm products, we have made it possible to check the plant's necessary growth conditions, lighting, temperature, humidity, and other environmental conditions in real time by simply registering as a Plus Friend using the KakaoTalk Plus Friend function, which is highly accessible to most users, without the need for a separate application when receiving the plant environment and controlling it remotely. The proposed smart farm components can be largely classified into three categories. First, collecting the plant's environmental information from various sensors, second, sending various control signals based on this information, and third, displaying various information on an LCD and transmitting the information to a smartphone via Wi-Fi. Figure 1 shows the proposed home smart farm system that utilizes IoT technology based on Arduino.

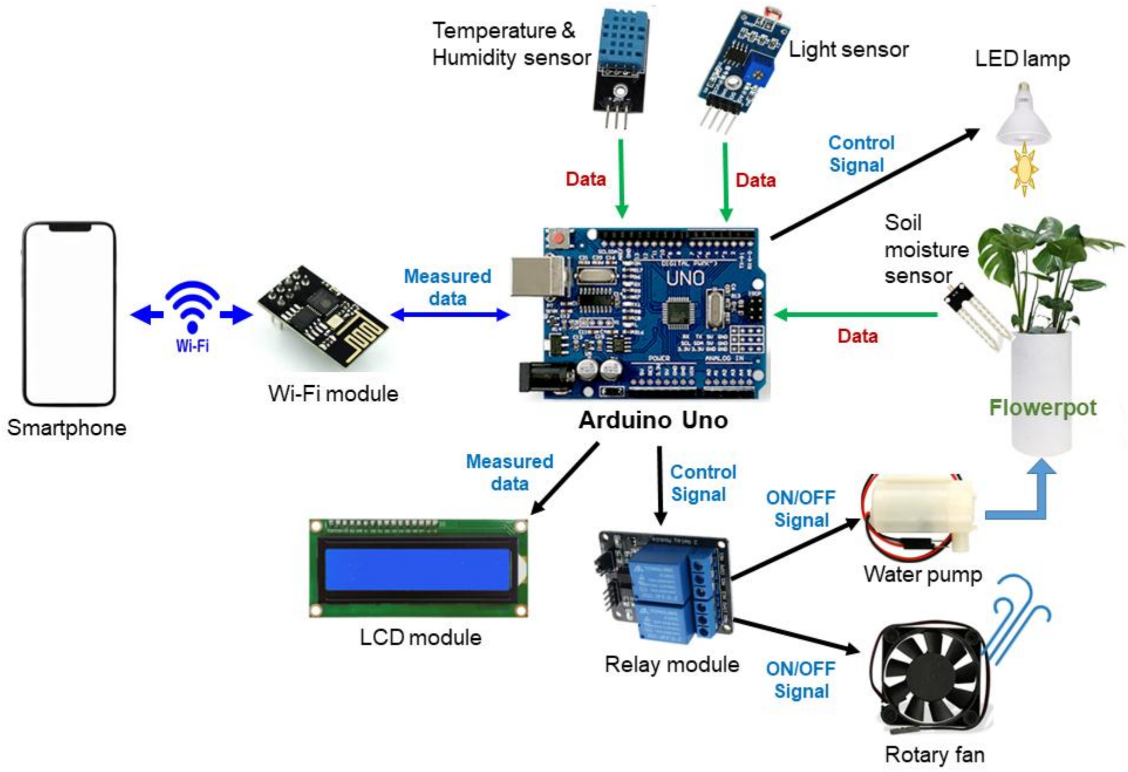

Fig. 1 The proposed home smart farm system

Plant Cultivation IoT System

IoT systems are essential for home smart farms, allowing growers to create a controlled and efficient cultivation environment. They provide precise monitoring, control, and data-driven insights to optimize crop growth in a controlled environment.

Plant Environmental Monitoring

The temperature and humidity sensor continuously monitors the temperature and humidity inside the room. This data ensures that the growing conditions are maintained within the optimal range for plant growth. The soil moisture sensor monitors the moisture in the soil inside the flower pot and supplies water by operating the water pump according to the amount of moisture needed by the plant. The light sensor monitors the amount of light in the room and provides the amount of light needed for plant growth in conjunction with the LED lighting to promote photosynthesis. Since proper ventilation is important for plants, the rotating fan is operated by setting the airflow at a certain time to ensure that the plants have the proper airflow.

Plant Status Monitoring

The LCD display shows the plant's environmental information in real time, allowing the grower to check the plant's environmental status at any time. In addition, a cloud-based platform was built using MySQL, PHP, and APACHE HTTP server so that the plant's environmental information can be checked anytime, anywhere with a smartphone.

III. RESULTS AND DISCUSSION

Figure 2 shows the fabricated IoT smart farm system. If you look at the LCD, you will see the alphabets ‘H’, ‘T’, ‘L’ and specific values next to them. These represent humidity, temperature, and illuminance, respectively, and the data collected using the sensors in the hardware are displayed as relative humidity, Celsius temperature, and Lux values, respectively, to show the surrounding environment information. In addition, ‘W’ represents soil moisture. However, unlike other environmental information, soil moisture is not displayed as a specific unit value, but as “LESS” or “FULL.” When it is “LESS,” it means that there is insufficient moisture, so the water pump operates to supply water. When it is “FULL,” water is not supplied because there is still sufficient moisture. Using this LCD, you can grasp the surrounding environment information without any other tools, and through this, you can control the environment in which plants can grow well.

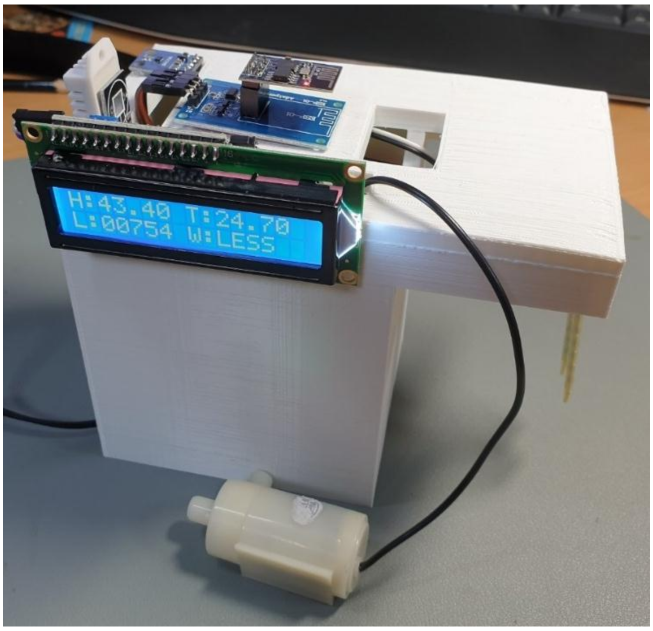

Fig. 2 The fabricated IoT smart farm system

IDE is an integrated development environment used to control MySQL, PHP, and APACHE HTTP server. For this purpose, we used the cloud IDE, which is written in Korean and thus easier to use. First, install MySQL on the cloud IDE and run it. Then, after connecting to MySQL, grant access to the root host in order to connect to another IP address. After that, create a database and its tables so that environment information can be stored. Figure 3 shows the created smart farm database and the sf1 and sf2 tables. At the sf1 table, you can see the temp1, humi1, lux1, and water1 fields, which contain environmental information on temperature, humidity, illuminance, and soil moisture, respectively.

```
mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| mysql              |
| performance_schema |
| phpmyadmin         |
| smartfarm          |
| sys                |
+--------------------+
6 rows in set (0.00 sec)

mysql> use smartfarm;
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> DESCRIBE sf1;
+--------+------------+------+-----+---------+-------+
| Field  | Type       | Null | Key | Default | Extra |
+--------+------------+------+-----+---------+-------+
| temp1  | float      | NO   | PRI | NULL    |       |
| humi1  | float      | NO   |     | NULL    |       |
| lux1   | int(11)    | NO   |     | NULL    |       |
| water1 | varchar(4) | NO   |     | NULL    |       |
+--------+------------+------+-----+---------+-------+
4 rows in set (0.00 sec)

mysql> DESCRIBE sf2;
+--------+------------+------+-----+---------+-------+
| Field  | Type       | Null | Key | Default | Extra |
+--------+------------+------+-----+---------+-------+
| temp2  | float      | NO   | PRI | NULL    |       |
| humi2  | float      | NO   |     | NULL    |       |
| lux2   | int(11)    | NO   |     | NULL    |       |
| water2 | varchar(4) | NO   |     | NULL    |       |
+--------+------------+------+-----+---------+-------+
4 rows in set (0.00 sec)
```

Fig. 3 The created database of IoT smart farm

In order to verify whether the fabricated smart farm system operates normally in flower pots of various sizes, its function was tested in flower pots of different sizes, as shown in Figure 4. In order to check whether the IoT sensors detect the environmental information of the plants well, various changes were made to the indoor environment. By artificially changing the indoor temperature and humidity, we checked whether the temperature and humidity sensors were operating well, and by changing the indoor lighting, we verified whether the LED lamps operated normally by detecting the change in lighting. As shown in Figure 5, we verified whether the information about these various surrounding environments and the status of the plants could be checked in real time anytime, anywhere through the KakaoTalk Plus Friend service on a smartphone.

(a) Small plant **(b) Large plant**

Fig. 4 Performance testing of smart farm system according to flower pot size

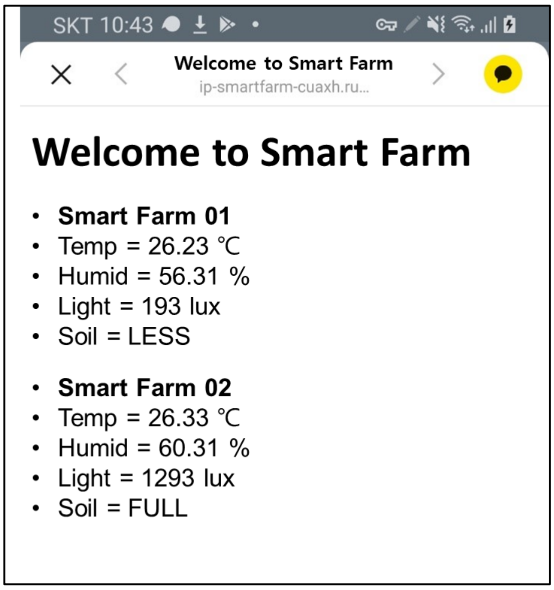

Fig. 5 KakaoTalk Plus Friend service on a smartphone

IV. CONCLUSION

The main purpose of the developed home smart farm system is to reduce the production cost so that people who grow companion plants can easily produce it, and to provide convenience by installing it anytime and anywhere and checking the growth environment of the plants. The developed smart farm can be produced at a low cost of less than $30 per plant, and does not require a separate application to receive information about the plant growth environment and control it remotely. It was produced so that the growth conditions of the plants and the surrounding environment can be easily checked in real time by utilizing the KakaoTalk Plus Friend function that most people use on their smartphones. In addition, the developed Arduino-based IoT smart farm does not require difficult coding or assembly, so even people without related knowledge can easily install and use it as long as they have the manual and materials.

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