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A Study on the Implementation of Raspberry Pi Based Educational Smart Farm

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Abstract

This study presents a paper on the implementation of a Raspberry Pi-based educational smart farm system. It confirms that in a real smart farm environment, the control of temperature, humidity, soil moisture, and light intensity can be smoothly managed. It also includes remote monitoring and control of sensor information through a web service. Additionally, information about intruders collected by the Pi camera is transmitted to the administrator. Although the cost of existing smart farms varies depending on the location, material, and type of installation, it costs 400 million won for polytunnel and 1.5 billion won for glass greenhouses when constructing 0.5ha (1,500 pyeong) on average. Nevertheless, among the problems of smart farms, there are lax locks, malfunctions to automation, and errors in smart farm sensors (power problems, etc.). We believe that this study can protect crops at low cost if it is complementarily used to improve the security and reliability of expensive smart farms. The cost of using this study is about 100,000 won, so it can be used inexpensively even when applied to the area. In addition, in the case of plant cultivators, cultivators with remote control functions are sold for more than 1 million won, so they can be used as low-cost plant cultivators.

Keywords: *Smart Farm, IoT, Raspberry Pi, Sensor*

1. INTRODUCTION

A smart farm uses Information and Communication Technology (ICT) to observe and manage the growing environment of crops remotely and automatically, without the constraints of time and space. It has revolutionarily improved the agricultural environment by not only increasing crop yields but also reducing labor hours. Unpredictable and unpreventable factors in farming include frequent weather changes such as typhoons, monsoons, droughts, cold waves, and the spread of pests and diseases that significantly harm crop production and quality. Smart farms, by using enclosed spaces isolated from the external environment, can control pests and diseases and automatically regulate temperature, humidity, and sunlight exposure. This significantly mitigates the problems associated with climate change and natural disasters. Furthermore, smart farms can produce crops in places previously unsuitable for plant cultivation, such as basements, by using LED lights instead of natural sunlight. The automation and remote control technologies in agriculture have not only increased the value of agricultural products but also improved farmers' incomes, offering them more leisure time and better control over production and market supply and demand. In South Korea, the aging

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agricultural workforce and labor shortage have led to a decrease in agricultural production, making smart farming an increasingly important technology in the market. South Korean smart farm technology, while holding 70% competitiveness compared to technologically advanced countries like the U.S. and Europe, is expected to double the current smart farm market by 2026 (Information Communication Newspaper, March 2023).

The global smart farm market size has grown 66% from 12.4 billion US dollars in 2020 to 20.6 billion US dollars in 2023, and is projected to reach 34.1 billion US dollars by 2026 (BG Research), with an annual growth rate of approximately 10.2% (Grand View Research). This study implemented a Raspberry Pi-based educational smart farm, optimizing the nurturing environment within the smart farm and providing remote control and monitoring through a web service. This process confirmed the practical applicability of Raspberry Pi-based smart farms in real environments [1-3].

2. SMART FARM DESIGN FOR EDUCATION

The Raspberry Pi-based educational smart farm used in this study employs the Raspberry Pi 3B model, along with LED lights, a CDS (light sensor), a temperature and humidity sensor (DHC11), a DC motor (fan), a heater (connected to a relay), soil sensors, a water pump, a servo motor (for window control), and a Pi camera. Figure 1 shows that a web server (Raspberry Pi) collects Analyst Data (Brightness, Temperature, Soil moisture, Humidity) and provides it as smart farm environment information. The manager sees the environmental information of the smart farm and operates a water pump to hydrate the soil and control the temperature with a heater. Among the components of the web page, LEDs, Windows, and Fan move the slider bar so that the manager can adjust the intensity of light, the angle of the window, and the intensity of operation of the fan, respectively.

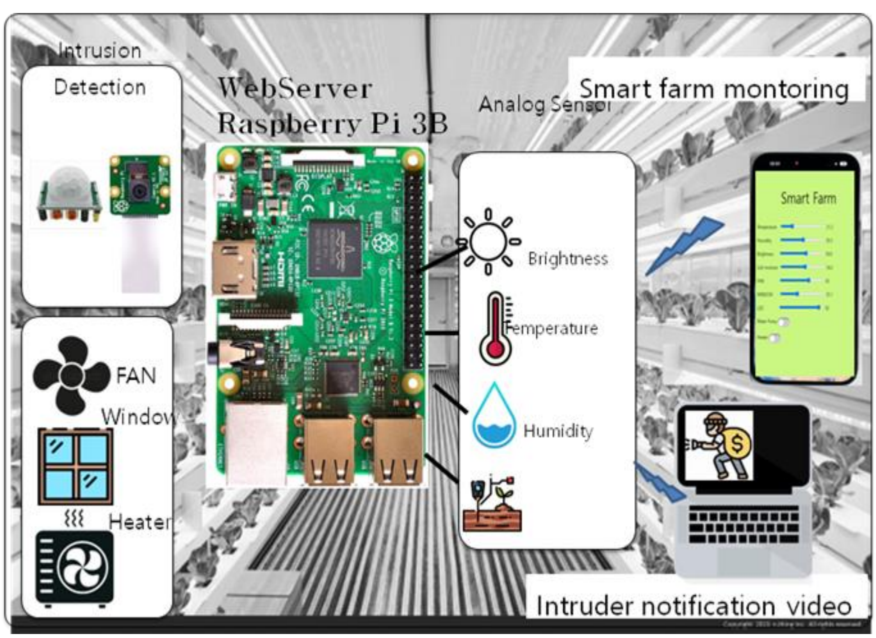


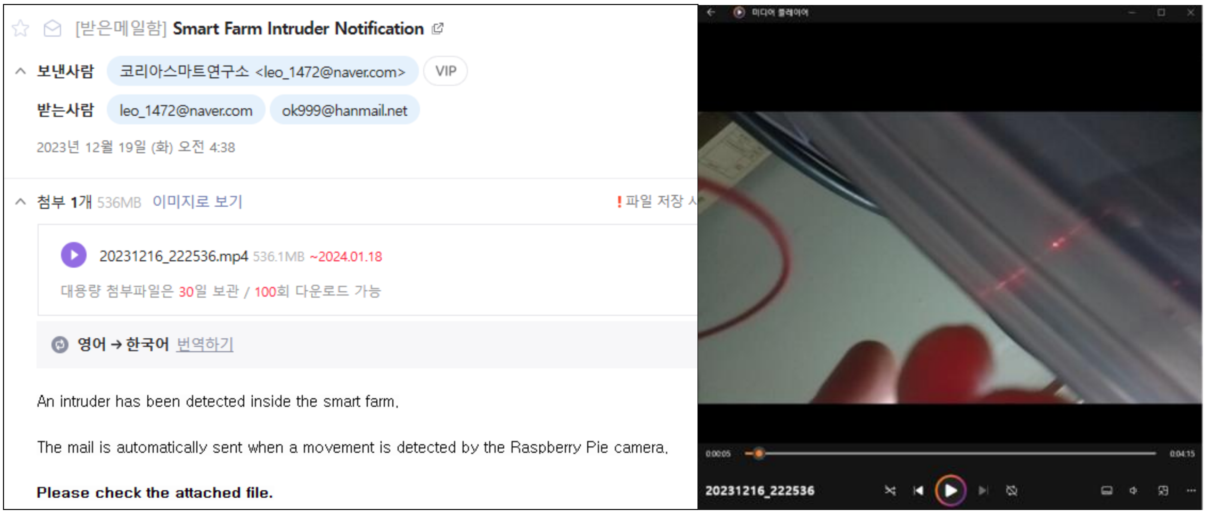
Figure 1. Education smart farm configuration chart

2.1 Raspberry Pi Based Smart Farm Security

In the security source code of Figure 2, the Pi camera monitors the environment inside the smart farm, and when an intruder (Motion) is detected in the smart farm, the camera photographs the intrusion behavior. The file name is saved in H246 format using datetime.now(), converts the image into an mp4 format file, and sends an e-mail to the administrator to notify the intruder. Figure 3(a) is a screen that takes a video of the intruder on the smart farm and sends it to the administrator email, and Figure 3(b) is the video attached to the administrator' email.

```
try:
        while True:
                if GPIO.input(sensor):
                        print "Motion Detected."
                        #LED ON
                        GPIO.output(led, True)
                        #If motion is detected, move the camera for operation check.
                        #call("echo 0=35% > /dev/servoblaster", shell=True)
                        #time.sleep(1)
                        #call("echo 0=75% > /dev/servoblaster", shell=True)
                        #time.sleep(1)
                        #Create a file name using datetime.
                        basename = "video"
                        suffix = datetime.datetime.now().strftime("%y%m%d_%H%M%S")
                        filename = "_".join([basename, suffix])

                        #Single Image Capture
                        #call("raspistill -w 1280 -h 720 -vf -hf -o /home/pi/Videos/"+filename+".png", shell=True)

                        #Start recording the video. 1000ms=1sec.
                        call("raspivid -t 10000 -w 1280 -h 720 -vf -hf -o /home/pi/Videos/"+filename+".h264", shell=True)
                        #Convert h264 format to mp4.
                        call("MP4Box -add /home/pi/Videos/"+filename+".h264 /home/pi/Videos/mp4/"+filename+".mp4", shell=True)

                        sendMail()
                        time.sleep(30)

                #LED OFF
                GPIO.output(led, False)
                time.sleep(1)
```

Figure2. Intruder detection code in education smart farm



(a) Smart Farm Intrusion Notification Email **(b) Saved intrusion video**

Figure 3. Intruder notification video

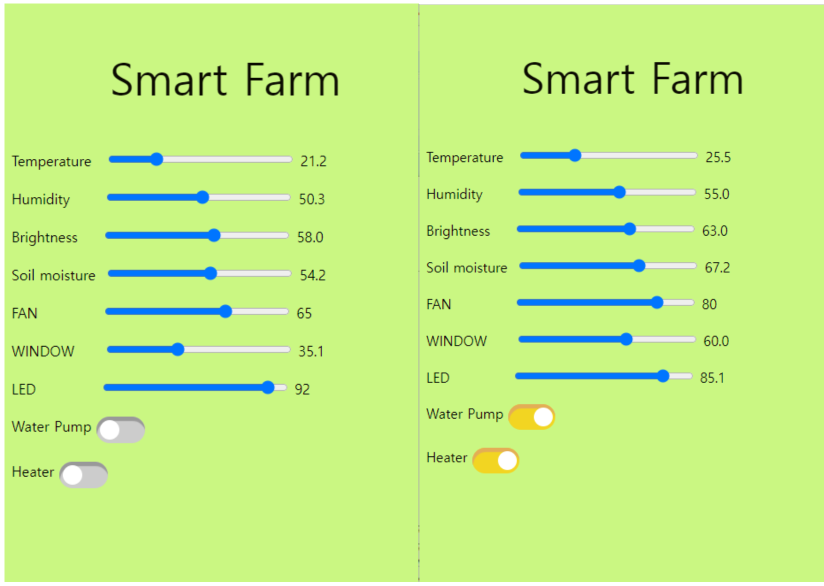
To verify the suitability of the implemented smart farm for indoor environment control, a web server was set up using Raspberry Pi, displaying sensor information in HTML and allowing control. The figure 4 shows the use of temperature and humidity sensors, CDS (light sensor), and soil sensors for measuring the smart farm's indoor environment. These sensors' data are used to control windows (ventilation), LED lights, water pumps, and heaters. The LED lights and windows can be controlled gradually by adjusting their values, while the water pump and heater are set to operate on an ON/OFF basis.

3. EXPERIMENT AND APPLICATION

To verify the real-world applicability of the Raspberry Pi based educational smart farm presented in this paper, a web server (Flask) was established on the Raspberry Pi, and a test was conducted to allow users to control it using mobile devices. and light intensity of the smart farm in real-time, as shown in the figure 4 (a).

Figure 4(b) shows a slight increase in temperature, humidity, illuminance, and soil moisture content in the smart farm, and the FAN is stronger and the window is more open at an angle of about 60 degrees. The LED brightness was increased to 85.1 and the wether pump and heater were activated.

If necessary, users can adjust the brightness of the LEDs and regulate the temperature using the DC motor's propeller and the relay-connected heater by clicking on a slider bar. The windows and LEDs are gradually operated by moving the slider bar, changing the angle and light intensity slightly [5, 6].



(a) smart farm information1 (b) smart farm information2

Figure 4. Education smart farm interface

3.1 Utilization plan

The cost of setting up traditional smart farms varies depending on location, materials, and types of installation, but on average, it costs about 400 million won for a 0.5ha polyhouse and 1.5 billion won. for a glasshouse. Despite these costs, smart farms have issues such as weak locking mechanisms, concerns over automation (malfunctions), and sensor errors (power issues). This research can be used complementarily to improve security and reliability of high-cost smart farms, allowing for cost-effective crop protection. The use of this research, with an estimated cost of about 100,000 won, can be affordably applied to the corresponding area. Additionally, plant cultivators with remote control functions, as shown in Figure 5, are being sold at more than 10 times the price, making them an affordable option for plant cultivation [4].

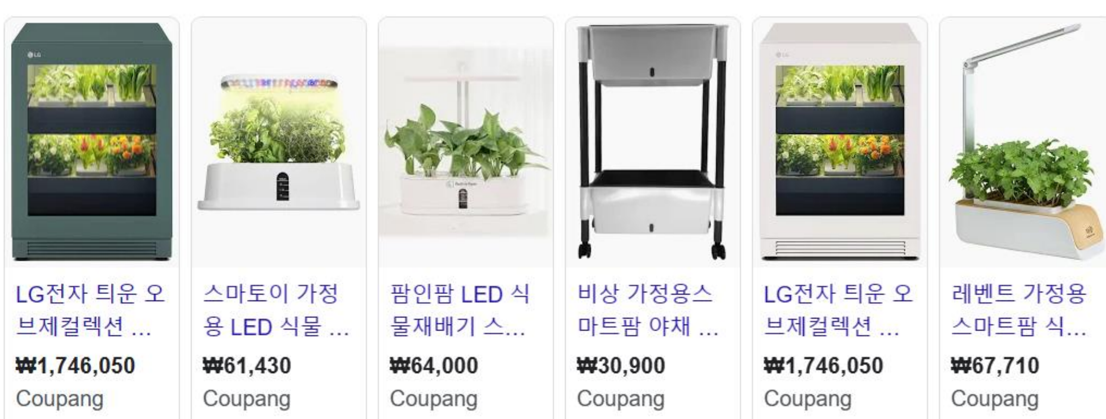


Figure 5. Plant growers searched on google

4. CONCLUSIONS

This paper presents a study that implemented an educational smart farm using Raspberry Pi, allowing for a convenient and inexpensive way to educate about real-world smart farms on a smaller scale. The smart farm measures environmental information, regulates temperature and humidity, and supplies moisture to the soil. Remote control and monitoring were made possible by providing sensor information through a web server, enhancing the convenience and affordability of the system [7]. This technology can be applied to precision agriculture, maximizing the production of high-quality crops with minimal inputs (fertilizers, pesticides, etc.) by monitoring the conditions and environment of farmland and crops.

5. REFERENCES

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