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Data-Based Monitoring System for Smart Kitchen Farm

Ye Dong Yoon, Woo Sung Jang, So Young Moon, *R. Young Chul Kim

M.S, Department of Software and Communication Engineering, Hongik University, Korea
Dr, Department of Software and Communication Engineering, Hongik University, Korea
Post Dr, Department of Software and Communication Engineering, Hongik University, Korea
** Professor, Department of Software and Communication Engineering, Hongik University, Korea*

E-mail {uriel2001, whit2, bob}@ hongik.ac.kr
{yedong}@mail.hongik.ac.kr

Abstract

Pandemic situations such as COVID-19 can occur supply chain crisis. Under the supply chain crisis, delivering farm products from the farm to the city is also very challenging. Therefore it is essential to prepare food sufficiency people who live in a city. We firmly insist on food self-production/consumption systems in each home. However, since it is impossible to grow high-quality crops without expertise knowledge. Therefore expert system is essential to grow high-quality crops in home. To address this problem, we propose a smart kitchen farm as a data-based monitoring system and platform with ICT convergence technology. Our proposed approach 1) collects data and makes judgments based on expert knowledge for home users, 2) increases product quality of the smart kitchen farms by predicting abnormal/normal crops, and 3) controls each personal home cultivation environment through data-based monitoring within the smart central server. We expect people can cultivate high-quality crops in thir kitchens through this system without expert knowledge about cultivation.

Keywords: *Data Based Decision Making, Plant Disease Detection, Expert System, Data Collection*

1. Introduction

Under COVID-19 the England shows how a supply chain crisis can cause food insufficiency [1]. There are many countries exist which have a poor degree of food self-sufficiency. These countries can be in danger of hunger under a supply chain crisis [2]. To secure our food security, we insist on our system of making urban farming as Cuba did to create sustainable city life [3].

Recently, as ICT convergence technology spreads in rural start-ups for smart farms is increasing as one of the means to solve many pending issues in domestic agriculture [4]. The Rural Development Administration are developing a Korean smart greenhouse model with accumulated know-how and item cultivation conditions to suit the characteristics of domestic horticulture industry centered on small and medium-sized vinyl greenhouse es [5].

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Corresponding Author: bob@ hongik.ac.kr
Tel: +82-44-860-2477, Fax: +82-44-865-0460
Professor, Department of Software and Communication Engineering, Hongik University, Korea

However, this model is limited to large-scale producers at the corporate or farm level. This cannot fulfill the requirements of smart kitchen farm users who aim for self-sufficiency after the COVID-19 crisis. The city householders never have experience to cultivate any crops. To solve this problem, we propose a data-based monitoring system with A.I to classify disease of plant. The proposed approach controls plant growth on local own devices with information collected through remote terminal devices (RTU).

2. Related Works

2.1 Heterogeneous Smart Farm Data Collection Based on Model Transformation Techniques

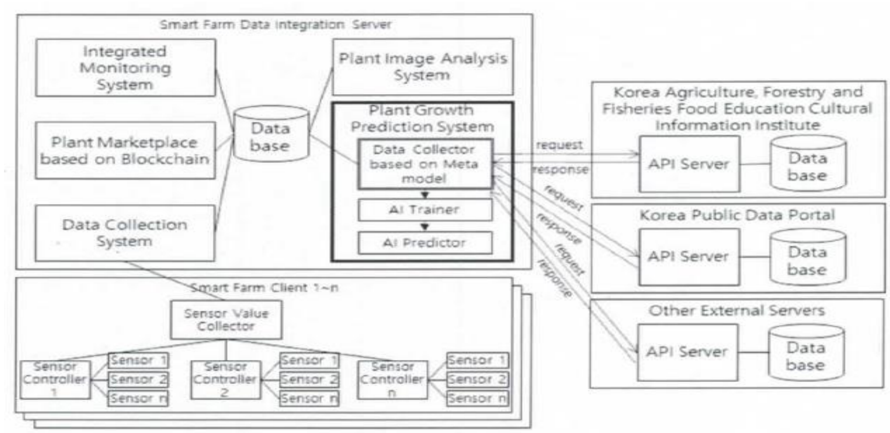

Figure 1. Heterogeneous smart farm data collection based on model conversion technique

Figure 1 shows a heterogeneous smart farm data collection method based on a model conversion technique [6]. Information such as public data, smart farm crop data, and environmental sensor data is integrated and processed and managed by applying meta-model-based model conversion techniques. Smart farm big data stored in heterogeneous databases can be automatically collected and made into AI learning data.

2.2 Convolutional Neural Network (CNN)

CNN is a convolutional neural network, a type of deep learning that can be learned while maintaining spatial information of an image [7]. Therefore, it is used to find patterns in images.

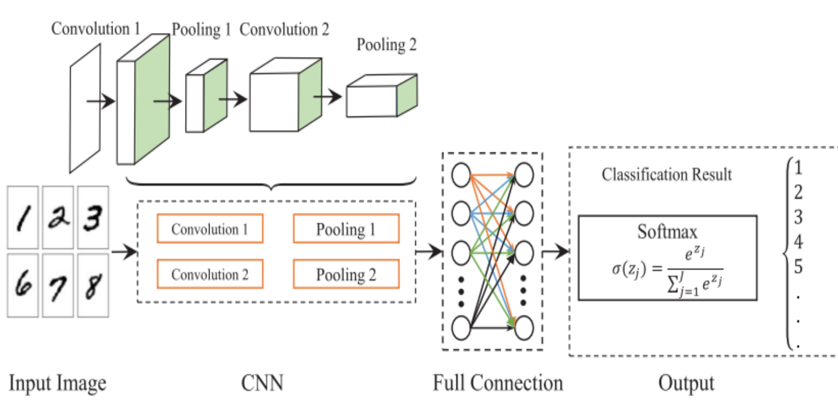

Figure 2. CNN model

Figure 2 shows the detailed process of CNN model. It is composed of several layers of convolution layer and pooling layer to extract the characteristics of the image. The Convolution Layer is an essential element that reflects the activation function after applying a filter to the input data. The extracted feature classifies the image by entering the classification function through a fully connected layer for image classification. Since the characteristics of the image are extracted in the learning process, there is no need to create the characteristics for learning.

2.3 Hydroponics

Hydroponics is the way to grow crops without soil [8]. It can reduce water usage compared with conventional agriculture. Hydroponics have variable techniques. Each technique has common that roots of crop exposed to the culture solution.

LG Tiiun is a representative commercially available kit of hydroponic system for home [9]. But it is not enough for home. Tiium is expensive, the number of crops that can be grown is limited and occur operating noise. Because The product uses a water pump to circulate culture solution

But our approach using a Fogponics. Fogponics supply aerosolized culture solution to root. Our approach using ultrasonic module to aerosolize the culture solution. It doesn't occur operating noise. Therefore, this approach is suitable for home

3. Our Data-Based Monitoring System for the Smart Kitchen Farm

3.1 Overall System Structure

Our system classifies the crop has disease or not and identify what the disease is. To classify it the system divided with central server and local devices. Local devices made with RTU to collect data and send it to central server and controller to control

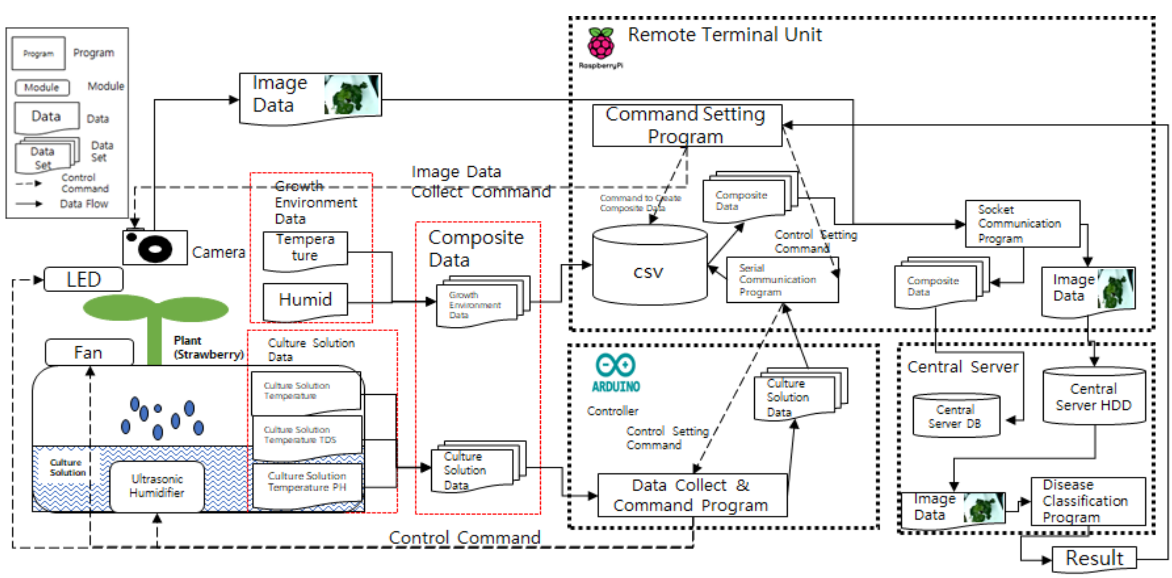

Figure 3. A Data-based monitoring system for smart kitchen farms

Figure 3 shows the overall structure of a data-based monitoring system for smart kitchen farms. Humid and Temperature data from sensor is stored in RTU. Images are sent to central server without stored in RTU. The RTU receive culture solution data from the Controller. The culture solution data transmitted from the controller and the growth environment data collected by the RTU are combined and stored in the form of a file (*.csv). The stored file is periodically delivered to the central server.

3.2 Deep Learning-Based Abnormal/Normal Crop Learning Method

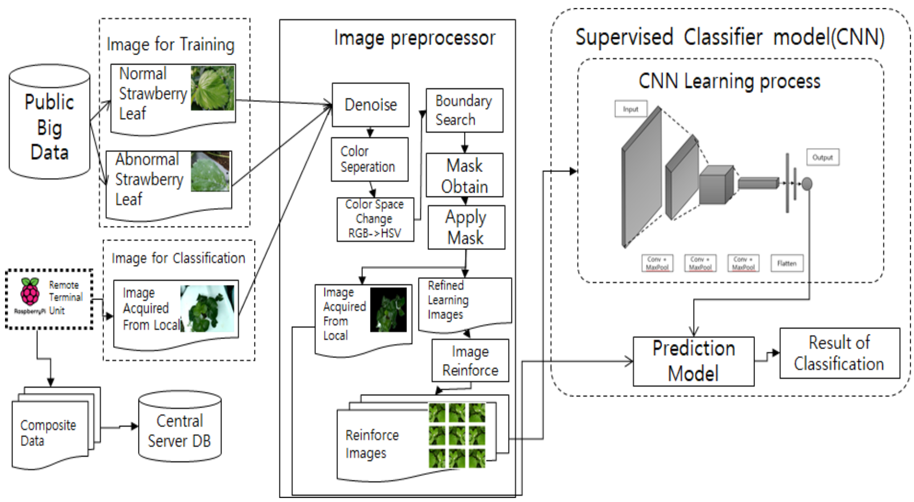

Figure 4. Abnormal/normal crop learning and classification

3.2.1 Preprocessing crop images

The crop image preprocessing method is shown in the image preprocessing part of Figure 4. We preprocess image information in the central server. Preprocessed image use as inputs for a classifier. Then the classifier classifies whether there is a disease in the image and what kind of disease it has. Preprocessing is performed to improve the quality of the images. Central server Preprocess image before classify image or training A.I with images. Through preprocess images quality is enhanced for classification. Because after the preprocess image remove background which can cause noise for classify.

3.2.2 CNN Learning for Abnormal/Normal Crop

Figure 4 is a CNN-based abnormal/normal crop learning method. Refined public data are trained on normal and abnormal leaves using CNN models. Create predictive models through learning. After purifying the image transmitted from the RTU, it is input into the prediction model to classify the disease status and type of the image.

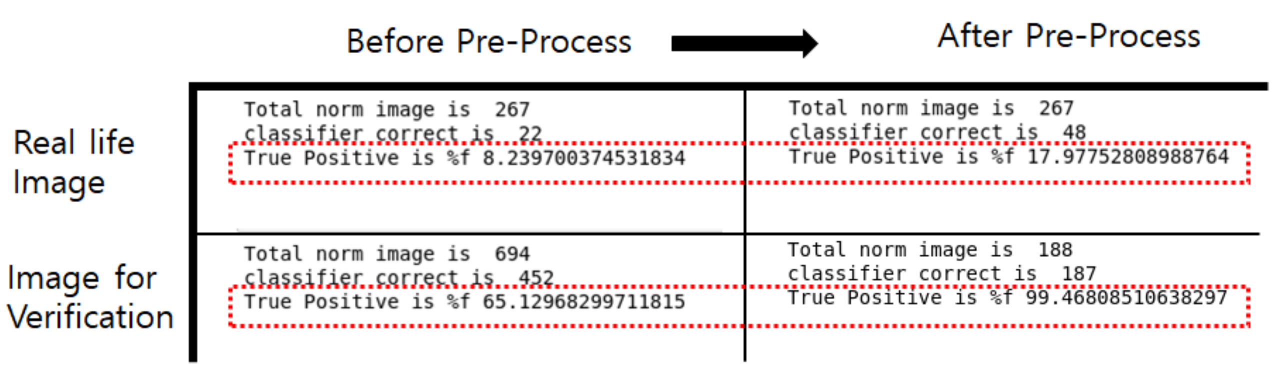

Figure 5. Classifier performance increases after preprocessing

Through this, the positive effect as shown in Figure 5 can be obtained. The accuracy of the classifier increases because only the parts that need to be classified remain.

The image file after purification is smaller in size than the original image data so that storage space may be efficiently used. The size of the smaller image data reduces the load of the central server by reducing the amount of computation required for classification.

In addition, the portion of the image excluding the region of interest is removed, reducing the likelihood of causing privacy infringement problems of data collected at home.

4. A DATA-BASED MONITORING SYSTEM FOR HOME SMART FARMS

The Remote Terminal Unit (RTU): The RTU device uses Raspberry Pi4. RTU displays crop image to the user locally. The RTU communicates with both the central server and the controller. Data collected by the control unit is transmitted through serial communication with the control unit, an order is issued to the control unit, and is performed through socket communication. The data collected by the control unit and the RTU is transmitted to the central server and requests a judgment from the central server.

The RTU receives commands to be issued to the control unit through direct input from the user or communication with the central server and transmits them to the control unit. Temperature and humidity sensors (dht22) are attached to measure temperature and humidity inside the greenhouse, and webcams are connected to receive image data. An environment was prepared for pre-processing the image by covering it with a white cloth around the crop (strawberry).

The Controller: An Arduino is used as the controller. The controller receive command from connected RTU and control Led, Fan, Ultrasonic Humidifier. LED to control light for grow, fan for ventilation, and ultrasonic for supply nutrient to crop. The controller transmits data collected from sensors to the RTU. The sensors collect data from culture solution. Sensors collect culture solution temperature, TDS, and PH.

The Central Server: The central server receives and stores composite data and image transmitted from the RTU through socket communication. The composite data is stored in the central server DB, and the image data is stored as a file with the date and time of the received year as the name. Use Python, OpenCV libraries for image preprocessing. It uses the Tensorflow, Keras library for CNN learning. A.I was trained with public image data of strawberry from AI Hub [10] and Kaggle [11] to classify disease of leaves.

The Crop Farming environment:

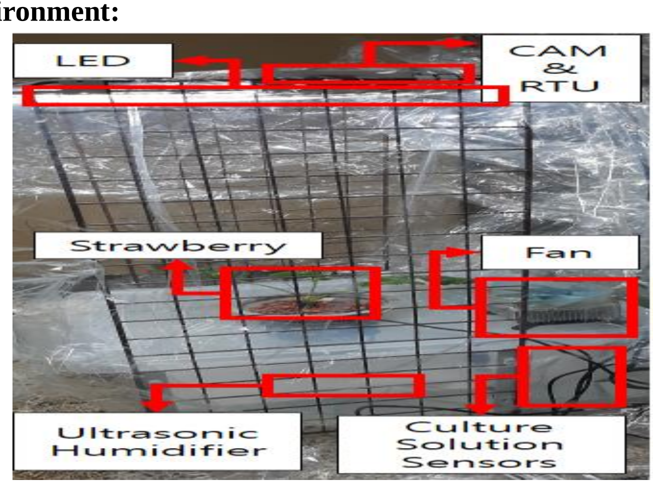

Figure 6. Implemented crop cultivation environment

Figure 6 shows the implemented crop cultivation environment. Vinyl was used to maintain a constant temperature and humidity.

Our Smart Kitchen Farm System: It is a data-based monitoring system for smart kitchen farm. RTU can show Real-time image of crop and collected environment data.

Figure 7. Real-time crop monitoring

Figure 7 shows an image acquired in real-time for a user.

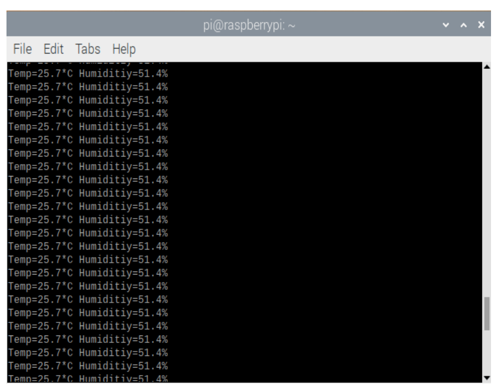

Figure 8. Real-time environment data

Figure 8 shows the sensor data acquired in real-time to the user.

5. RESULTS

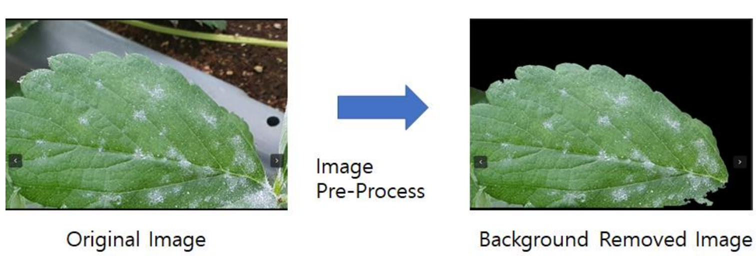

Figure 9. Image preprocessing and results

Figure 9 shows an image preprocessing result. The original image(left) was changed to a preprocessed image(right).

Figure 10. Normal crop image classified success

Figure 10 shows a crop image classified normal. The pre-process was applied and classify image as normal leaf.

Figure 11. Abnormal crop image classified success

Figure 11 shows a preprocessed image classified have a disease. The pre-process was applied and classify image is powdery mildew.

6. CONCLUSION

We propose a monitoring system for smart kitchen farms. The system 1) makes judgments and collects data based on expertise for home users, 2) increases the productivity of smart kitchen farms by predicting abnormal/normal crops, and 3) performs data-based monitoring within the smart kitchen farm central server. The expert system to help make decisions is expected to help not only smart kitchen farm Users but also can help people who don't have expert knowledge such as farmer, gardener, and forestry workers. As a future study, we consider improving the accuracy of disease classification by improving the learning model of the central server and expanding functions such as pest detection and growth disorder analysis in the video. Also, we consider making our systems can cultivate high-value crops such as herb or medicinal crops to help people who need the crop regularly.

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