Design of crop harvest time prediction system using thermal imaging

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***Abstract* —Existing research in the field of smart farms has only been studied to increase production by maintaining the optimal growing environment for crops. However, in the case of tomatoes, the harvest time considering the shelf life is very important, so quantified harvest time prediction information is needed. Therefore, this paper designed a system to predict the exact harvest time by measuring the temperature of the fruit directly with a thermal imaging camera rather than the accumulated temperature through the existing greenhouse temperature. A database was built by collecting thermal image data and environmental data, and a system was designed to predict the harvest time of crops through a linear regression algorithm and integrated temperature calculation formula. Through this system, it is possible to predict the exact harvest time of crops, and furthermore, it is possible to control the production time by controlling the smart farm environment, which has the advantage of shipping crops at a high selling price. Therefore, farmers can see the effect of increasing profits through high-quality crops.**

Keywords—Harvest time prediction, precision agriculture, Thermal imaging camera, integrated temperature, machine learning

I. INTRODUCTION

Recently, as the era of the Fourth Industrial Revolution approaches, attempts to incorporate smart technology in various fields are underway both domestically and internationally. Countries around the world are incorporating ICT technology to improve agricultural competitiveness through agricultural technology innovation. Smart farm is a networked facility farming equipped with sensors, information and communication, control, and ICT technologies, and is an alternative that can solve future food problems caused by aging and climate change.[1-3]

Existing smart farm research has focused on increasing the productivity of crops by maintaining the optimal growth environment for crops [4]. However, while increasing the productivity of crops is important, harvesting crops when they are of the highest quality and selling them at a good price is also important for increasing farmers' profits.[5] In particular, tomatoes are a post-ripening fruit vegetable, and the harvest time considering the distribution period for export is very important, so export farms need quantified information to predict the harvest time.[6]

Accordingly, this paper seeks to design a system that predicts the exact harvest time by measuring the temperature of the fruit directly with a thermal imaging camera, rather than the accumulated temperature through the temperature in the existing greenhouse.

II. RELATED RSESEARCH

Figure 1 shows the accumulated temperature to indicate the amount of heat required for crop growth and refers to the accumulated daily average temperature over the number of growing days. When calculating the accumulated temperature, the average daily temperature is selected only at or above the minimum temperature at which the relevant crop can be active. Equation (1) is the formula for calculating the integrated temperature. The standard temperature varies depending on the crop, but the optimal harvest time for tomatoes is when the accumulated temperature reaches 1,000℃.[7-9]

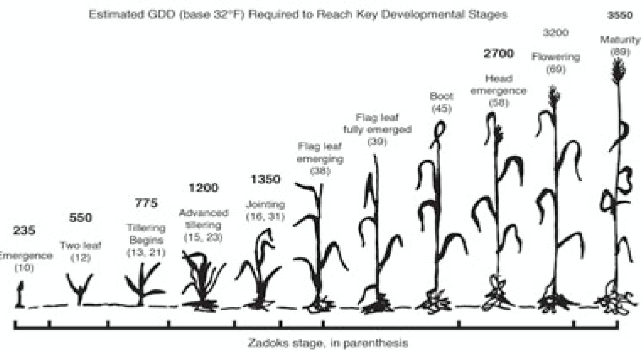

Figure 1. Changes in crop growth according to integrated temperature

$$GDD = \sum\left(\frac{(Tmax+Tmin)}{2}\right) - Tbase \qquad (1)$$

Like the human eye, a general visual camera recognizes an object by receiving light reflected from an object with a detector and converting it into an image. In contrast, thermal imaging cameras create images using heat, rather than visible light. Both heat and light are forms of energy that fall into the electromagnetic spectrum, but cameras that can detect visible light do not have the ability to detect thermal energy, and conversely, cameras that detect thermal energy cannot detect visible light. Thermal imaging cameras accept infrared energy and use the data from the infrared energy to create images through digital or analog video output. In this paper, the temperature of the tomato surface is photographed using a camera equipped with a thermal imaging function, and temperature information is collected.[10]

III. System Design

A system was designed to measure the surface temperature of fruit based on the thermal imaging camera proposed in this paper, and to predict harvest time by analyzing the integrated temperature using the measurement data.

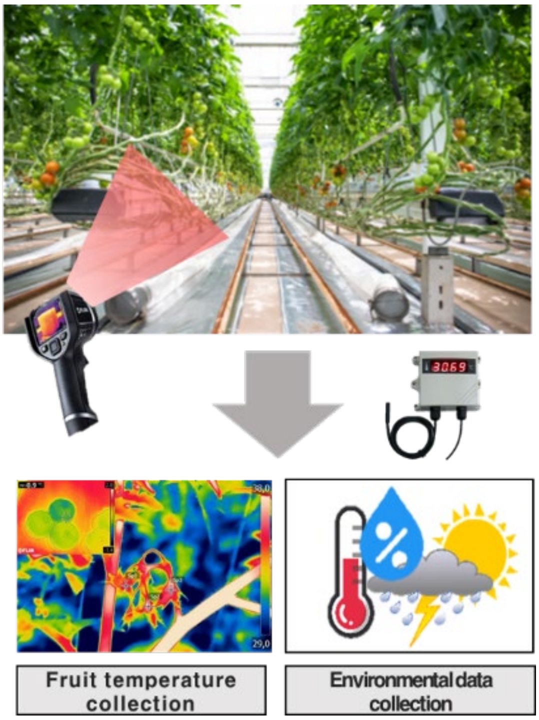

Figure 2. Data collection method for integrated temperature measurement.

Figure 2 shows the method of collecting thermal image data and environmental data to measure integrated temperature. In addition to the environmental data collected from the existing smart farm system, a thermal imaging camera was installed to measure the surface temperature of fruit. Therefore, the integrated temperature is calculated using data that adds not only the environmental temperature in the greenhouse but also the surface temperature of the fruit.

Unlike other systems, the image of the pest consists of three types including the sticky type, a pheromone type, and attracting lamp type. The sticky type is widely used in general systems, and the pheromone type emits pheromones to attract and capture pests. Lastly, the attracting lamp attracts pests with light and provides a good environment for trapping insects at night.

Figure 3 shows the predicted value of crop harvest time by constructing a database based on collected thermal image data and environmental data and analyzing and calculating it using a linear regression model. The sowing time and planting date of the predicted crop are identified and designated as machine learning variables, and the harvest time can be predicted through the integrated harvest temperature value. In this paper, tomato crops were used.

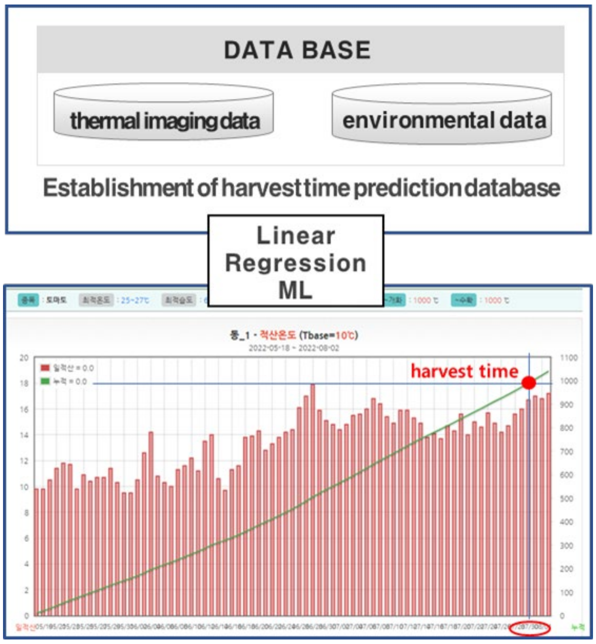

Figure 3. Database construction for data analysis and harvest time prediction results

Since the cumulative temperature prediction of crops is measured in a greenhouse, the temperature is maintained at a constant level, so there is not much change in the data. In addition, it is important to reflect past temperatures in predicting accumulated temperatures and calculating harvest dates. The accumulated temperature was predicted using a decision tree that remembers past information and passes it on as future input information and a random forest algorithm learned in related research.

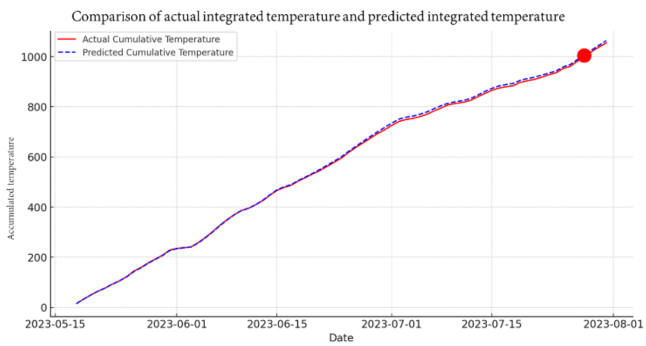

Figure 4. Comparison results between predicted and actual accumulated temperature

Figure 4 visually expresses the prediction accuracy by comparing actual data and predicted data, and it can be seen that the predicted integrated temperature by the model follows the actual integrated temperature relatively well.

The planting season for tomatoes is early March, and the official planting date is May 18. The accumulated temperature has been measured and calculated since May 18, and when the accumulated harvest temperature is reached, it can be considered the appropriate harvest time. The harvest time in this paper can be considered to be possible on August 1st when the cumulative temperature reaches 1,000℃.

IV. CONCLUSION

In this paper, unlike the existing system that predicted the harvest time based on environmental data inside the greenhouse, a system that measures the surface temperature of the fruit using a thermal imaging camera and predicts the harvest time of the crop based on integrated temperature data was designed.

Through this system, the exact harvest time of crops can be predicted, and furthermore, the production time can be controlled by controlling the smart farm environment, which has the advantage of shipping crops at a high selling price. Therefore, farmers can see increased profits through high-quality crops.

In the future, we plan to develop a complex environmental control system in conjunction with the smart farm system so that crops can grow optimally at the desired time.

ACKNOWLEDGMENT

“ This research was supported by the MSIT(Ministry of Science and ICT), Korea, under the Grand Information Technology Research Center support program(IITP-2022-2021-2020-0-01489) supervised by the IITP(Institute for Information & communications Technology Planning & Evaluation)”

REFERENCES

[1] Han Young Jung, \https://www.aitimes.kr/news/articleView.html?idxno=21076 May. 2021

[2] NBS Today, https://www.youtube.com/watch?v=9QvTDy2D0PM, May. 2021

[3] Jae Hyeon Lee, Chang Hwan Son and Hwijong Yi."Multiscale CenterNet for Pest Detection and Counting"The Journal of Korean Institute of Information Technology20,7(2022):111-121.

[4] Jae Soon Kim, Myeong Il Jeong, Seung Won Han, and Ha Kyung Jang, "Analysis of Accumulation Temperature by Growth Development Rate of Several Landscape Plants," in Hortuculture abstracts, (2013): 203-203.

[5] Juhyung Jeong, Eunyoung Lee, Jeonghyeon Lim, Munho Seong, Kabcheol Kim, and Hyeonchung Ok, "Comparative Analysis of Accumulative Temperature and Harvesting Time by Planting Date in Semi-forcing Cultivation of Watermelon," in Hortuculture abstracts, (2019):. 93-93.

[6] In Bog Lee, Jae Hyun Lim, Jin Myeon Park, Han Ik Jang, and Myoung Soon Yiem, "Effect of Elevated Carbon Dioxide and Temperature and Nitrogen Supply on Growth and Yield of Tomato," in Hortuculture abstracts, (2004): 49-49.

[7] Chong Kil Ahn, Young Whan Choi, and Han Ryong Kim, "Production of High Quality Seedlins as Affected by CO_2 and Temperature in Tomato (Lycopersicum esculentum Mill. cv. Momotaro 8)," in Hortuculture abstracts, (2001):. 51-51.

[8] Jihun Kim, Sookhee Kwon, Il Do Ha, and Myung Hwan Na, "Prediction of smart farm tomato harvest time: Comparison of machine learning and deep learning approaches," Journal of the Korean Data And Information Science Society, 33,2, (2022) :283-298

[9] In Hong Jeong, Choong Seon Hong." Fruit Image-based Harvesting Prediction System using Convolution Neural Network" Korean Society of Information Sciences, (2019):1549-1551.

[10] Chang-Hun Lee and Seung-Gook Hwang." A Study on Measuring The Growth Rate of Crops Using Camera Image and Deep Learning"Journal of Korean Institute of Intelligent Systems 32,1(2022):38-43.