Monitoring wetness of strawberry plants using color imaging and artificial intelligence (AI) for the Strawberry Advisory System (SAS)

Arth Patel, Won Suk "Daniel" Lee, Natalia Peres

Summary

This study aimed to develop a color-imaging and AI-based leaf wetness detection system. This system was placed at multiple locations, and results were compared with manual observations. The results are promising enough to be included in the SAS's strawberry disease risk models.

Hardware Description

Two in-field imaging systems were set up during the 2021-22 strawberry growing season. One at UF Plant Science Research and Education Unit (PSREU), Citra, FL, and the other at UF Gulf Coast Research and Education Center (GCREC), Wimauma, FL. An acrylic sheet painted with flat white paint was used as a reference surface. A WYZE v2 color camera with a resolution of 1920 x 1080 pixels was used to take color images of the reference surface. The camera was installed facing the reference surface and was connected to a single-board computer (Raspberry Pi 4, Raspberry Pi Foundation, Cambridge, UK) using USB cables. The single-board computer was connected to Verizon MiFi 4G wireless cellular modem to upload images to Google Drive. Those images were downloaded to a local computer for analysis and wetness detection. Figures 1 and 2 show the system setup at UF PSREU and GCREC, respectively. The system block diagram is shown in Figure 3.

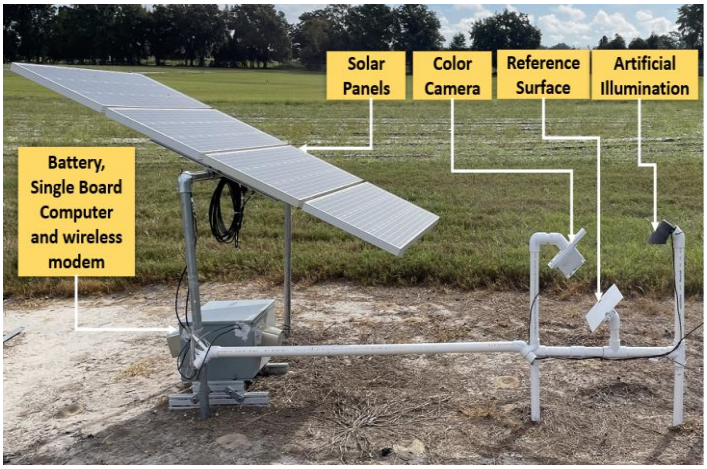

Figure 1. Wetness detection system at UF PSREU, Citra.

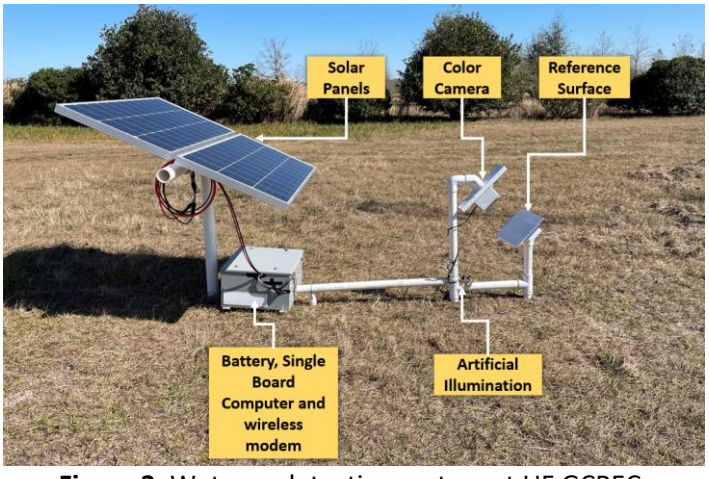

Figure 2. Wetness detection system at UF GCREC, Wimauma.

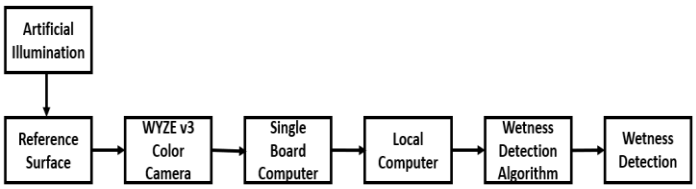

Figure 3. System block diagram

Methods

The data were collected from October 2021 to March 2022 at UF PSREU and from February 2022 to March 2022 at UF GCREC. From the collected images, a dataset was developed. All images of the dataset were manually labeled into wet/dry classes. The dataset was then divided into training and test sets. The training set had 25,000 images and was used to train the deep neural network model, and the trained model was tested on the test dataset. Test set 1, which had images taken at PSREU, had 19,000 images. Test set 2, which had images taken at GCREC, had 2,000 images.

Results

The deep learning method yielded high accuracy data compared with manual observation. Table 1 shows the accuracy of the model when the model's prediction of the images was compared with the manual observation. Table 2 shows the accuracy when compared with the SAS data.

The results are promising when compared to manual observation. The SAS station in Citra used a weather data-based model, and it was located approximately 2 miles away from where this new system was set up, which is one of the reasons for the gap in accuracy in test set 1, as shown in Table 2. Another reason for the gap is that the weather data-based models seem to have limitations in accurately detecting wetness. The SAS station in GCREC uses electronic leaf wetness sensors , this model has good accuracy when compared to leaf wetness sensor data, as shown in test set 2 in Table 2.

In the future, this system can be placed at various locations to take color images of a reference surface every few minutes. Using a pre-trained deep learning model, the device can classify an image into wet/dry categories. The results can be used to measure leaf wetness duration (LWD), an important parameter in strawberry disease risk prediction. These data can be used in SAS for strawberry disease risk factor calculations.

Table 1. Results from the deep learning method for the test-set images, when compared with manual observation labels.

	Test set 1 at PSREU	*Test set 2 at GCREC*
Accuracy	0.962	0.954
Precision	0.946	0.932
Recall	0.962	0.944

Table 2. Results from the deep learning method for the test-set images, when results are compared with SAS data.

	Test set 1 at PSREU	*Test set 2 at GCREC*
Accuracy	0.793	0.922
Precision	0.838	0.876
Recall	0.705	0.913

Contact

Dr. Won Suk "Daniel" Lee
Dept. of Agricultural and Biological Engineering
University of Florida
1741 Museum Road
Gainesville, FL 32611-0570
P: 352-294-6721
E: wslee@ufl.edu