Strawberry Plant Wetness Detection Using Color Imaging and Artificial Intelligence for the Strawberry Advisory System (SAS)

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Summary

Solar-powered imaging units and AI models achieved 97% accuracy in detecting wetness in strawberry fields. The system reduced false positives compared to weather-station sensors, providing growers with more reliable inputs for the Strawberry Advisory System (SAS) and improving fungicide spray timing. A time-series deep learning approach (ConvLSTM) was used to track droplet formation and evaporation over image sequences, enabling more accurate detection under changing field conditions.

Background

Leaf wetness is a critical factor in strawberry disease development, particularly Botrytis fruit rot and Anthracnose. Traditional weather-station leaf wetness sensors often fail to capture canopy-level conditions, leading to mismatches with disease forecasts. This project aimed to test a robust, solar-powered imaging system integrated with AI models to improve detection accuracy and enhance the Strawberry Advisory System (SAS).

Methods

Field experiments were conducted at five sites: Citra, Dover, Wimauma (UF/IFAS GCREC), Plant City (Fancy Farms), and Floral City (Ferris Farms). Each unit consisted of a Raspberry Pi 3, RGB camera, LED lights, solar panel with battery, and a white acrylic reference plate (5 × 7.5 inches). Images were captured every 15 minutes, generating over 18,000 sequences. The deep learning model combined ResNet-18 with a Convolutional Long Short-Term Memory (ConvLSTM) architecture, using contrast enhancement, attention modules, Convolutional Block Attention Module (CBAM), and focal loss. Performance was benchmarked against Convolutional Neural Network (CNN) only models and infrared imaging methods.

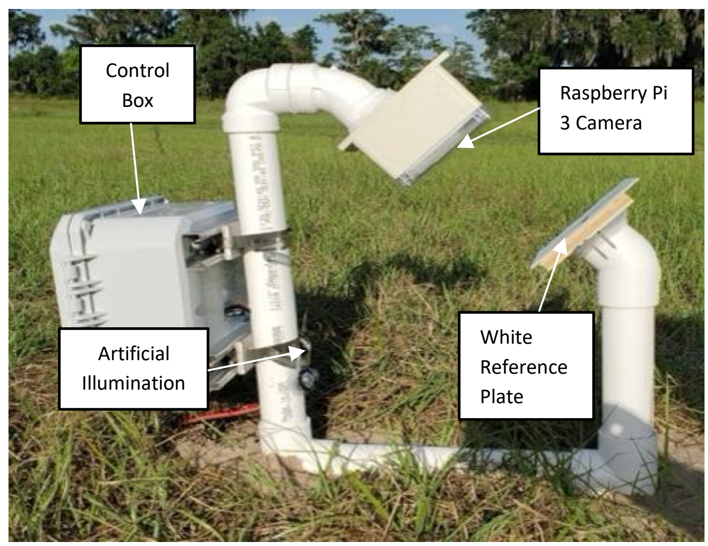

Figure 1. Wetness detection system at Ferris Farms, Farms, Floral City, FL.

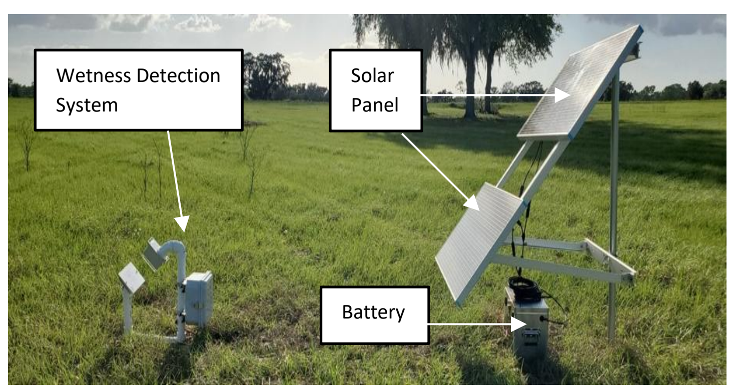

Figure 2. Power supply for the wetness detection system with solar panels and a battery.

Results

The ConvLSTM model achieved 97.4% validation accuracy, with specificity of 97.9% and sensitivity of 95%. This outperformed CNN-only and RGB+ Infrared methods, which showed ~95% accuracy. False positives were reduced by 15–20% when tested within the SAS framework. Most misclassifications occurred with very fine droplets (< 0.0394 inches) or blurred images.

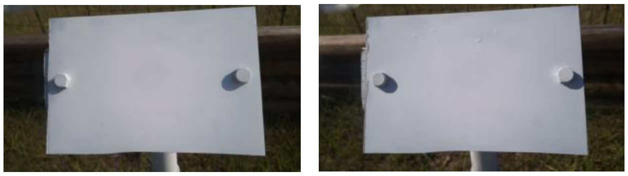

Figure 3. Correctly classified as Dry (left) and Wet (right).

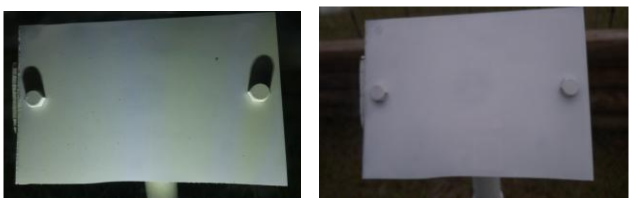

Figure 4. Misclassified as wet due to dust (left) and blurry image (right).

Table 1. Comparison of model performance across different approaches.

Model	Training	Validation
RGB + Infrared cameras with CNN (Patel et al., 2022)	96%	94%
CNN with Time-of-day Classification (Kondaparthi et al., 2024)	95.3%	92.9%
CNN+ConvLSTM (This study)	98.9%	97.4%

Takeaways

- The CNN+ConvLSTM system was compatible with SAS for near-real-time disease advisories.
- This research introduced a hybrid deep learning model that combines a CNN and an LSTM to analyze time-series image data. The model achieved a 97.4% peak validation accuracy in detecting leaf wetness, surpassing previous static-image models.
- By capturing the temporal patterns of droplet formation and evaporation, the system offered a more reliable and accurate method for detecting leaf wetness compared to the traditional flat-plate sensors used by advisory systems like the SAS.
- The complete detection system was fully solar-powered, allowing for scalable and long-term deployment in off-grid agricultural locations without connecting to main power.

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