PReEMPT - A New and Unique Method for Very Early Detection of Powdery Mildew Infection Using an AI-Based Hyperparameter-Tuned Convolutional Neural Network and Full-Spectrum Camera

Vinay, Achuth (School: Clovis North High School)
Gupta, Arnav (School: Clovis North High School)

Powdery mildew is one of the most widespread and damaging agricultural diseases in the world. As the nation's leading agricultural region, Fresno, California's 9 billion annual crop revenue is increasingly threatened by powdery mildew. Farmers currently rely on visible disease symptoms for diagnosis, which appear 7-14 days after infection. By then, the disease is already established, necessitating increased fungicide use, and reducing yields by 50% or more. To enable earlier intervention, a novel machine learning based detection system, the Powdery Mildew Recognition and Early Detection Machine Learning Prediction Tool (PReEMPT), was developed. A standard digital camera was converted to capture the full light spectrum from 300 to 1,100 nm. Full spectrum images of infected and noninfected Spring Bouquet (Viburnum tinus) plants were collected over a 0–7-day period and used to train a convolutional neural network from scratch. This technique exploits the subtle spectral signature shifts caused by powdery mildew, which disrupts internal leaf structure and reduces reflectance prior to the appearance of visual symptoms. The PReEMPT model identified powdery mildew as early as 24 hours after infection, with a validation accuracy of 94.39%. The newly developed PReEMPT Identifier Program (PIP) and mobile PIP app accurately classified healthy and infected plants across all images collected from 0-7 days, with correct detection as early as 1 day after infection. By utilizing PIP, supported by a fully functional, field-ready app, farmers can establish more effective and safer disease management practices, reducing fungicide use, protecting workers, optimizing yields, and increasing profits.

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