Living Optics

Identifying Fungal Diseases in Strawberries Plants and Fruit

Strawberry plants and fruit are susceptible to a variety of fungal diseases which can significantly impact their health and crop yield. Certain diseases, such as Botrytis Fruit Rot, if left unmanaged can reduce yields by 50%.

Whilst traditional RGB methods fall short in identifying diseases early, hyperspectral imaging captures detailed spectral information across tens or hundreds of wavelengths, revealing subtle biochemical and physiological changes long before visible symptoms appear. This capability makes hyperspectral imaging a powerful tool for farmers to deploy in the field.

The Need for Early Identification

Several fungal diseases can infect the entire strawberry plant. These diseases can cause various symptoms on leaves, stems and flowers, and fruits such as:

- **Leaves:** wilting, curling, spots, discoloration, lesions, necrotic tissue
- **Stems and Flowers:** lesions, necrotic tissue
- **Fruit:** hardened and seedy appearance, mould coating, sunken spots

Leaves are often the first and most visible place for fungal infection symptoms to appear. Being able to detect these symptoms early, particularly when yet not visible to the human eye, is critical for effective interventions.

Snapshot hyperspectral imaging for plant monitoring

The Living Optics Hyperspectral Imaging Camera captures 96 spectral bands across the visible and near-infrared region for every pixel in the scene. Unlike traditional RGB imaging, hyperspectral imaging (HSI) can detect subtle changes in light absorption and reflection to identify plant stress before symptoms appear. A widely used metric in remote sensing, the Normalized Difference Vegetation Index (NDVI) is a quick way to assess plant health. HSI data can be used to generate NDVI maps in real-time, which allow farmers to:

- Set custom thresholds to **trigger alerts**
- Flag areas for **targeted treatment**
- **Monitor health to assess progression of diseases** over time

Two proof-of-concepts have been explored to demonstrate the Living Optics camera's potential to assess early and symptomatic disease detection tasks.

Use Case 1:
Plant Stress Detection

In this use case, the camera is mounted on a tripod and a video is captured whilst walking along a row of strawberry plants. Recording at 30 frames per second (FPS) under sunlight, NDVI maps can be generated in real-time. These maps enable the visualisation of photosynthetic activity across the plant canopy.

One advantage of this method is the rapid identification of stress hotspots. By flagging areas of stress, it gives agronomists a clear insight on where to concentrate inspection and treatment efforts.

Fig. 1a

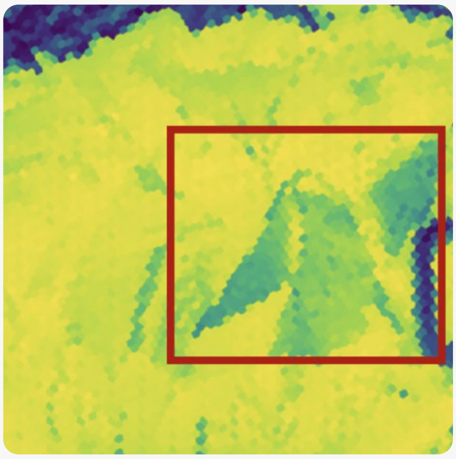


Fig. 1b

In the example, an NDVI map **(Fig 1b.)** is generated from the strawberry plant canopy **(Fig 1a.).** The red box highlights reduced photosynthetic activity, indicating plant stress. Upon further inspection, the area corresponded to wilting leaves, an early indicator that sometimes could signal the onset of a fungal infection.

Use Case 2:
Detection of Powdery Mildew on Strawberry Fruit

The presence of powdery mildew impacts the commercial value of strawberry crops and particularly when not detected early, it can lead to substantial economic losses.

This case study focuses on the detection of powdery mildew on strawberry fruit, where symptoms range from hardened, desiccated immature berries to mature berries that appear seedy and powdery, often supporting spore-producing fungal colonies.

Hyperspectral detection workflow:

1. **Creation of a Spectral Library:**
   Reference reflectance spectra were collected using the Living Optics camera from healthy and infected fruit samples. These spectra serve as a baseline for distinguishing infected areas based on their unique spectral signature.

   Below are shown the samples strawberries captured under slightly different lighting conditions **(Fig 2a.):** in the lab under halogen lighting and out in the field under sunlight. A white reference was also collected to remove the effects of different lighting conditions, allowing to obtain the unique spectral signatures of the fruits **(Fig 2b.).**

Fig. 2a

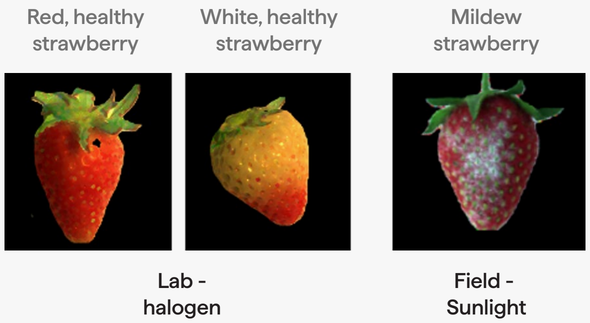
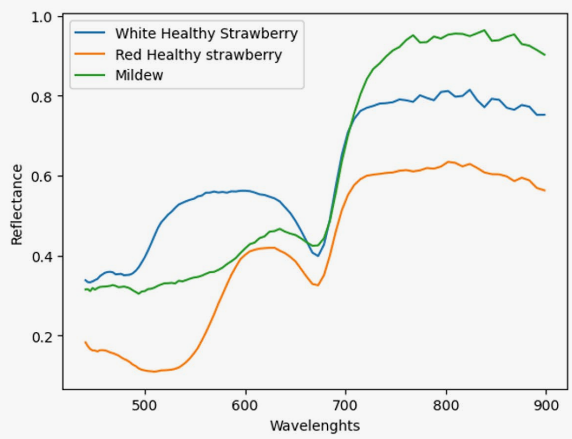
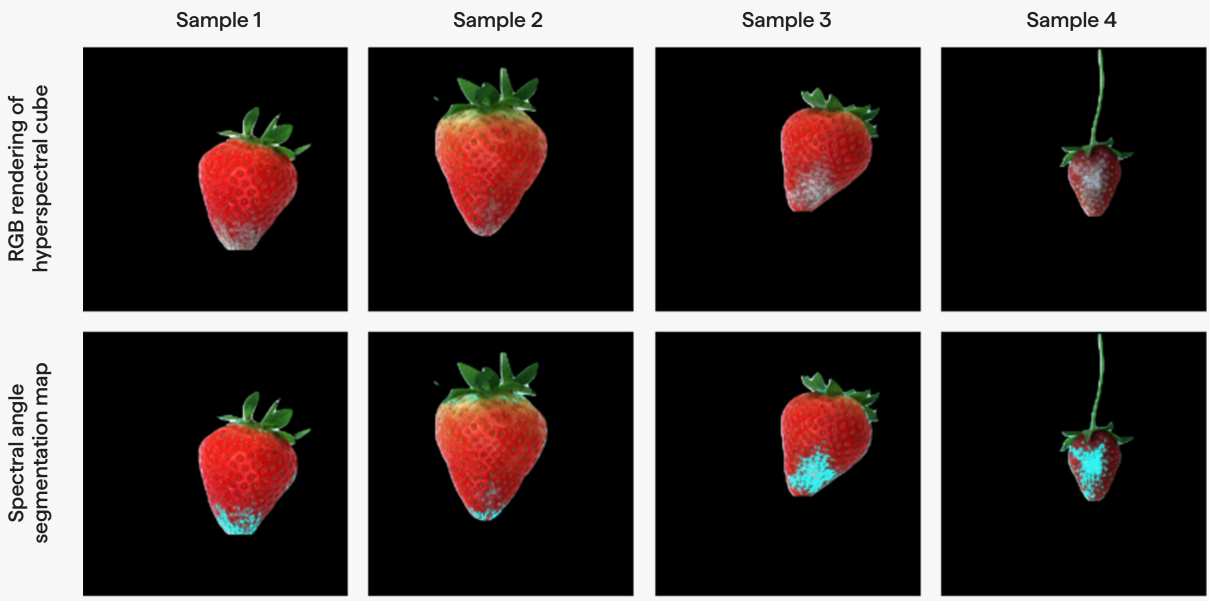


Fig. 2b



2. **Run a Spectral Classifier:**
   A spectral angle map (SAM) was computed using the infected fruit sample as target spectra. The map was used to query different hyperspectral images of strawberries to highlight areas on the fruit affected by powdery mildew. By comparing the spectral signatures of each pixel against the reference spectra, the classifier is used to segment infected regions, as shown in the figure below for four different strawberry samples.



Enabling Automated Early Detection with the Living Optics Camera

Fungal diseases pose a significant risk to strawberry growers, impacting plant health, reducing yield and market quality. Early detection is essential to enable time critical interventions.

This case study demonstrates how the Living Optics **snapshot hyperspectral imaging camera** can be used to detect subtle spectral changes in infected plant and fruit tissues. By leveraging tools like **NDVI** or **custom band ratios,** and **spectral classifiers,** growers can monitor photosynthetic activity, flag stress areas, and **identify powdery mildew on fruit.**

To make the process more efficient and cover larger areas of crop, the camera can be integrated with mobile platforms. This automation allows for continuous, real-time monitoring enabling a scalable solution for growers.