Development of machine learning algorithms for plant leaf segmentation and disease status classification based on chlorophyll fluorescence images

Background

Heliospectra AB is a global leader in smart LED light technology, light control systems and related services for greenhouse and controlled plant growth environments. The main offering to the market is a wireless lighting system which consists of energy efficient and controllable LED lamps with lighting spectra targeting various applications in commercial horticulture, and a control system, tailored for this market, with control functions optimizing lamp use for improved efficiency, quality, and reproducibility. Some of the control functions are using sensor data of the ambient light environment and we have algorithms that are using radiation forecasts for the present day.

Heliospectra and Chalmers are working on improving the lighting control system by integrating other types of sensors, collect more data, and develop more smart algorithms. There is great potential and novelty in developing lighting control strategies based on sensors that can directly monitor plant performance and well-being. Heliospectra and Chalmers have conducted research on this topic, lighting control with biological feedback, for many years, using sensors that measures an optical signal that is emitted by the plants and that provides insight into the status of the photosynthetic machinery. This signal is called chlorophyll fluorescence and we are measuring the signal from a distance, on canopy level. The research has led to the development of a point sensor that can be used for (1) light intensity control, (2) growth tracking and control, and (3) abiotic stress detection. For biotic stressors (pest and diseases), we have found that a sensor with spatial resolution, a fluorescence camera, is more capable of early stress detection than a point sensor. That is where this project comes into play.

We have collected time series fluorescence images of strawberry plants treated with the fungi powdery mildew and conducted analysis that shows that the so-called dynamic fluorescence step response (DFR) is affected by the infection at an early stage. The DFR analysis is based on system identification and the difference is noticeable when analysing single leaves but not when analysing the whole canopy. Infected leaves, with and without visual symptoms tend to have a shorter peak time and higher peak value, and the variations are bigger within plants that are infected. We are interested in developing a method for early disease detection using fluorescence camera data and machine learning tools. In the first step, machine learning is being used for leaf segmentation (for example using Mask-RCNN), and in the second step it is being used to classify leaves as sick or
healthy (for example using SVM).

Suggested activities:

1. Investigate suitable method for leaf segmentation
2. Develop method for leaf segmentation (neural network)
3. Develop method for health status classification (SVM)
4. Combine the two methods into an algorithm for disease detection and show proof of concept

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