Making plants' inner qualities visible

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The hyperspectral camera is mounted under the wing of the airplane used for research. Credit: Fraunhofer IFF

A photographic airplane circles above an Australian vineyard in large arcs. An onboard camera takes pictures of the grapevines in regular intervals – anything but ordinary photos, though. Instead, this camera "looks" directly inside plants and delivers valuable information on their constituents to viticulturists. This enables viticulturists to systematically modify their cultivation in order to increase the yield of their grapevines by using hybrids with valuable properties – a real challenge under the

basic conditions in Australia: The soil is dry and salty and summer temperatures are often extremely high.

This look at a grapevine's "inner qualities" is made possible by special software that processes data from a hyperspectral camera, which records images of many adjacent wavelengths. Researchers at the Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg developed the software and the mathematical models it contains. "Every molecule absorbs light in a very specific wavelength range," explains project manager Prof. Udo Seiffert. "The camera chip we use covers a large area of the relevant wavelength spectrum and, together with appropriate software, is able to scan the biochemical composition of every single recorded pixel precisely." The camera thus delivers an overview of every constituent present in a plant in any significant concentration – a kind of hyperspectral "fingerprint".

A camera delivers an overview of phytoconstituents

The raw data have to be processed appropriately in order to make them usable for clients. "Our data processing is based on mathematical modeling. On the basis of these algorithms, the software recognizes characteristic absorption properties of defined target constituents and filters them out of the raw data," explains Seiffert. Initially, the researchers have to calibrate the software for the particular application so that it "knows" what constituents it should display. To do so, they photograph reference plants with their camera in order to obtain the fingerprint of the constituents. Then, the photographed tops of the plants are sent to a laboratory in order to analyze the concentrations of the constituents that are relevant to the user. Afterward, the laboratory results are entered into the mathematical model together with the hyperspectral fingerprint. The special thing about the software is its ability to correlate information autonomously and to save this knowledge. "Picture it somewhat like learning vocabulary," explains

Seiffert. Once the software has learned the correlation, it automatically filters the relevant constituents out of the hyperspectral camera images the next time. Then, a laboratory analysis is no longer needed for other series of measurements.

Looking inside plants creates effective new options for farmers to increase crop yield. For instance, certain metabolites – products of metabolism – provide information on the quality of a plant's nutrition. Farmers can concentrate on cultivating those plants that thrive particularly well under the prevalent climatic conditions, thus enabling them to irrigate their fields less, for instance. Diseases such as fungal infections can also be detected faster thanks to hyperspectral technology. An infested plant activates defense mechanisms before an infection becomes outwardly visible – by dead leaves, stalks or mildew. Theses mechanisms indicate that the plant has detected and is combatting the infection. Previously, such tests required lengthy experiments in greenhouses. Not least, aerial photos can be used to detect sources of infection in a field quickly.

The first series of measurements with the project partner, the Australian Plant Phenomics Facility at the University of Adelaide, have concluded – the results are promising. At present, another use of the camera down under is in the planning stage. A demonstrator of the system's use in greenhouses and laboratories will be on display at Booth E72 in Hall 9 at the BIOTECHNICA in Hannover from October 8 to 10, 2013.

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