Hydration imaging with THz Quantum Cascade Lasers: Towards Precision Agriculture

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To reduce the water-footprint in agriculture, there has been a recent push towards precision irrigation management with a sharp rise in photonics-based hydration sensing in plants in non-contact, non-invasive manner. Here we explore video-rate hydration imaging of leaves with pulsed laser feedback interferometry (LFI) with terahertz (THz) quantum cascade lasers [1]. Conventional hydration sensing techniques typically use single spot measurement treating this single point as the whole leaf, while this approach can image the whole leaf rapidly. Pulsed THz LFI provides a set of images with high spatial and temporal resolution, wide dynamic range, immunity to background radiation, while generating concurrently amplitude and phase information of the target [2]. This allows the production of a time series map of changes in reflectivity and absorption of the leaf as the hydration level changes. Concurrent monitoring of leaf weight combined with machine learning techniques [3] allows us to correlate the THz LFI amplitude and phase images with weight change due to water loss in the leaf. This provided new insights into the plant physiology as well as a tool for monitoring the plant health.

[1] A.D. Rakic, *Appl. Phys. Rev.* **6**, 021320 (2019).

[2] Y.L. Lim, *Opt. Express.* **27**, 10221 (2019)

[3] M. Kashyap, *Proc. SPIE 12139*, 121390J-1 (2022)

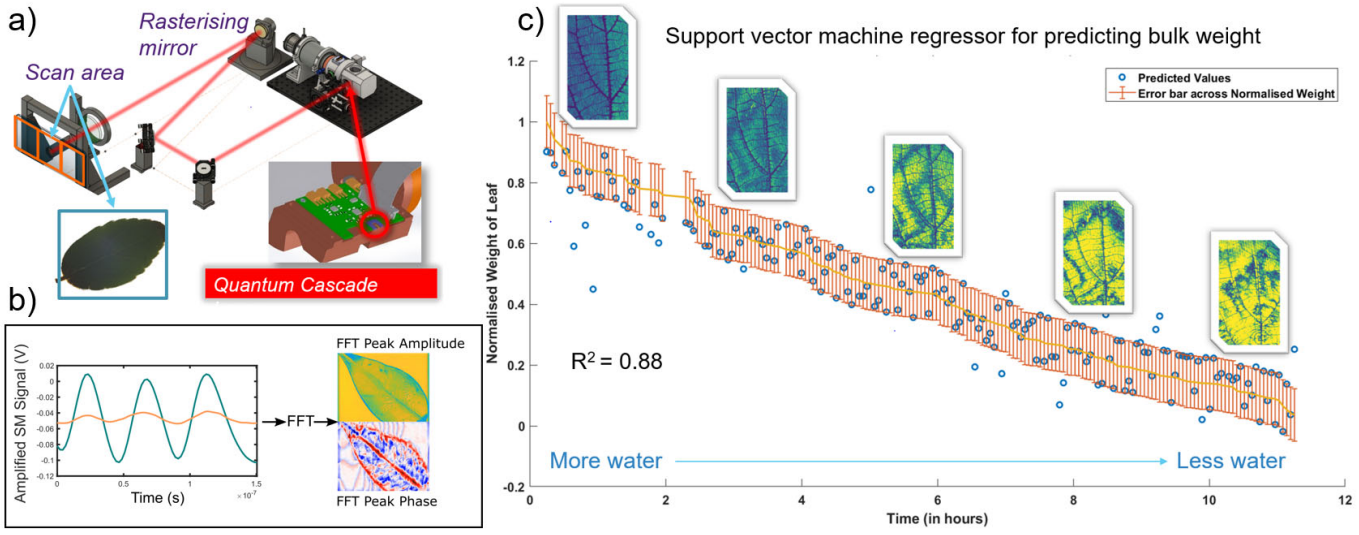

Figure 1: a) THz QCL LFI imaging setup showing fast scanning imaging mode. b) Processing steps of the LFI interferogram into image pixels. c) Change in leaf weight due to dehydration vs predicted values from a support vector machine regressor from same time point THz LFI images.