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Automatizing MiniRhizotron Image Acquisition

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Minirhizotron (MR) imaging systems are key instruments to study the hidden half of plants and ecosystems, i.e. roots, mycorrhiza and their interactions with pathogens, fauna etc. in the rhizosphere. However, despite scarce data on the 'hidden half' of plants and ecosystems, e.g. needed for better understanding species' ecophysiology, breeding resource efficient crops or determining soil C input, the technological advances remained yet limited.

We designed and build an automatic, modular MR camera system for permanent operation in situ, combining state-of-the-art imaging sensors (UHD VIS and certain near infrared (NIR) wavebands) with mechatronic automation to allow for effective and precise imaging of MR tubes. The system consists of a MR camera 'carrier system' (i.e. for camera positioning, scheduling and processing of images, interconnectivity) for 7 cm diameter, up to 2 m long, MR tubes installed in situ (fields to forests), and two interchangeable camera modules to be used with the carrier system. The first module is a cost-effective UHD RGB module and the second module combines VIS and selected multispectral (NIR) wavebands--potentially allowing for advanced image processing such as root classification (age, branching order etc.) and approximation of selected soil properties (soil water content, C contents etc.).

The presented technology has the potential to benefit society both indirectly via improving the capacity of the research community to study root and rhizosphere systems (e.g. in a C budgeting, or plant breeding context), and is, beside automatic image analysis, a prerequisite for making root development information available to stakeholders in real time (e.g. to farmers for precision irrigation). Additional benefits of an automatic MR system such as precise stitching (for creating 'panoramic' images) and creation of 'super resolution' images are discussed.