Bringing phenotyping to the farm: an evaluation of 3d reconstruction of plants in outdoor environement.

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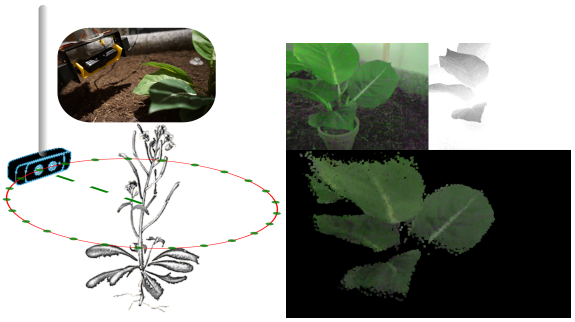

Figure 1. (Left) Scanning device and illustration of a circular scan path. (Right) Color and RGB inputs from the SoftKinetic camera merged in a colored point cloud.

Recent reviews have pointed out that data collection and trait extraction is the major bottleneck in plant phenotyping. Several platforms, like PhenoTiki [3], provides Open Source components for an affordable acquisition of plant images. Recent years also emphasized the importance of 3d geometric features to characterize the morphology of plants [1]. We describe the hardware and software components for the acquisition of 3d images and a precise analysis of the plant morphology. The platform distinguishes itself from existing work in that it is designed as an affordable and modular solution that can be used both in the lab and in the field, in either static or mobile configuration. In addition, the plant images are captured with an off-the-shelf camera that combines color from an RGB sensor with depth information from a time-of-flight (TOF) sensor (DepthSense by SoftKinetic).

To reach parts of plants that are occluded in a single view, the camera is mounted on a mobile 5 DOF arm (3 translations and pan/tilt rotations) and several views (typically 100) on a circular path are combined to get a full reconstruction of the plant. An iterative closest point algorithm is used to align clouds taken from nearby poses. Based on the reconstructed plant, the organs of the plant are segmented and analyzed using either the point cloud representation or graph based algorithms [2].

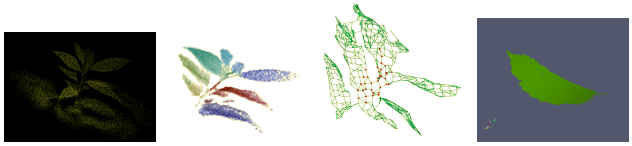

Figure 2. Example representation for plant reconstruction and morphological analysis: Point cloud, segmented point cloud using K-means, graph representation with the plant shoot identified as the nodes with high betweenness centrality index, surface estimation of a leaf from its triangular mesh.

TOF cameras are known to be limited by the low resolution of the sensor. We propose to overcome this limitation by a dense sampling along the scan path. The accuracy of our measurements is evaluated by estimating the area of a plant leaves for which 2d scans of the leaves are available and is compared to the accuracy of available high resolution platforms.

The design files for the hardware as well as the algorithms are made available under an Open Source license. A large diffusion of inexpensive 3d phenotyping devices could be helpful in building databases that reflect the large diversity of morphologies encountered in various environments. A prototype is currently installed on a rooftop for a longitudinal acquisition of plant morphology during its growth.

References

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