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Model-based morphometrics for plant phenotyping

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Currently, high-resolution point cloud data can be acquired easily and cost-effectively. For example, a pipeline using Structure from Motion (SfM) and Multi-View Stereo (MVS), which is a promising technique to reconstruct a 3D surface as point cloud data from a series of 2D images taken from different angles, has been implemented in several libraries and software products. In this study, we developed a workflow for measuring and quantifying the canopy growth of soybean cultivars to compare growth speed based on point cloud data acquired from the SfM and MVS pipeline. First, we took multi-view 2D images of soybean plants growing in a field with a digital camera (EOS 60D, Canon, Tokyo). The images of plants in a single plot were taken from ca. 40 different directions. From these multi-veiw 2D images, point cloud data of soybean canopies were reconstructed by using the SfM and MVS pipeline. Second, we segmented the point cloud of plants and their leaves for each plot from the reconstructed data. Finally, we fitted several models to the point cloud data for estimating phenotypic values of plant organs constituting canopy architecture (e.g. leaf area, leaf shape, curvature). For example, we reconstructed 3D surfaces of leaves from the point cloud data with the penalized B-spline surface fitting by regarding a leaf as a 2D closed surface embedded in the Euclidean space $\mathbb{R}^3$. When field conditions were not desirable (e.g. wind, change in light conditions) for acquiring corresponding points among multi-view images, however, incomplete point cloud data were reconstructed.

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