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Plant-cell morphology mapped by greyscale-level granulometry

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Legland D *et al.*

Parametric mapping of cellular morphology in plant tissue sections by gray level granulometry.

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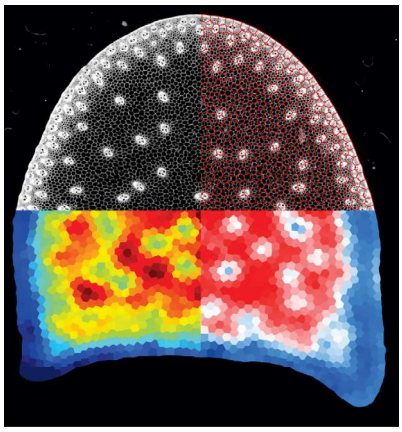

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Global workflow-steps for parametric mapping computation. Original image in greyscale levels. Automated region-of-interest contouring. Curve plots of the geometric mean sizes of cells in each region (from blue to red). Mapped representation of the first explanatory axis in the principal component analysis (negative values in blue, positive values in red).

Contact

David Legland

UR BIA

david.legland@inrae.fr

Context

The cellular morphology of plant organs is strongly related to other physical properties such as the size, shape, mechanical properties or chemical composition of the plant or plant organ. Cellular morphology often varies depending on type of tissue or position in a specific tissue. A common challenge in quantitative plant histology is to quantify not only the cellular morphology but also how it varies within the image or the plant organ. Image texture analysis is a fundamental part of the image analysis toolbox that has proven invaluable for describing plant cell morphology when individual cells are hard to isolate. As a rule, it is applied at whole-image scale, which narrows the scope for analysis of spatial heterogeneity.

Results

We developed a method that generates a parametric map of cellular morphology in images of plant tissues by working up from macroscopy or microscopy images. The workflow starts by segmenting the image into a huge number of tessellated regions of interest using a centroidal Voronoi diagram, which produces a set of hexagonal regions contouring the plant organ, and then using grey-scale mathematical morphology to extract quantified image texture features from each region. The resulting granulometric curves can be interpreted either through multivariate data analysis (principal component analysis) or by computing descriptive-metric statistics such as the average size or localized heterogeneity of the cells. The parameters are computed for each region-of-interest, making it possible to graph a visual map of the variations in image texture. We have employed this methodized workflow to map cell morphology on macroscopy-scale image cross-sections of plant-stem internodes. The resulting parametric maps give a graphed picture of the in-stem variations in cellular morphology, making it possible to connect these variations in cellular morphology to the in-stem pattern of tissue distribution.

Future outlook

The results inform understanding how the cellular morphology is related to genotypic and/or environmental variations, and to clarify the relationships between cellular morphology and other key plant tissue descriptors, such as chemical composition of the cell walls. The method yields quantitative data, so results can readily be integrated to produce representative statistical models of a single plant tissue or organ. The workflow is essentially generic, so it can be applied to other types of images, including images from foods that present a clear visual texture.