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GrasVIQ: An Image Analysis Framework for Automatic Quantification of Veins in Grass Leaves

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Leaf veins facilitate transport and provide mechanical support to the leaf and have critical implications for the performance and productivity of the plant and the ecosystem. Computational image analysis programs have been developed to extract and quantify vein traits from the reticulate venation of dicots, but a dedicated program for the parallel venation of monocots, particularly grasses, has yet to be developed. To address the need for high throughput vein phenotyping in grass species, like Oryza sativa (rice) and Zea mays (maize), we developed the Grass Vein Image Quantification (GrasVIQ) framework which automatically segments and quantifies vein from images of cleared leaf pieces using classical computer vision techniques. Using image datasets from inbred lines and auxin mutants in maize, we demonstrate that GrasVIQ can perform high throughput quantification of vein traits, including vein density, vein width, and interveinal distance, with a precision on par with manual quantification. Further, we show that the framework can be used to recognize quantitative traits, identify previously undetected phenotypes, and measure vein patterning defects, which is advantageous for both basic and translational research. We envision GrasVIQ to be adapted for vein phenomics in maize and other grass species.