Virtual Broccoli Farmland Implementation by Drone-based Phenotyping and Cross-scale Data Fusion

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Abstract

Broccoli head plays an important role in the vegetable market. Obtaining their growth status in the field in a timely manner is essential to make proper crop management decisions and thus has the potential to maximize profits. However, limited by the efficiency and human cost, it is not cost-effective for manually individual investigation of the entire farmland. The recent utilization of drone-based aerial phenotyping has provided an efficient means of conducting individual investigations. However, the presence of occlusion prevents access to the invisible portions. In this study, we proposed a cross-scale data fusion approach to restore and visualize the invisible parts of each individual broccoli head in the entire farmland. Firstly, we developed a close-range phenotyping pipeline in order to acquire a comprehensive and high-quality database of 3D broccoli heads. Then, we enhanced the aerial phenotyping pipeline to acquire the morphological characteristics of individual broccoli. Based on the aforementioned pipelines, the closest model was identified from the close-range database for each individual broccoli head from aerial pipeline. Subsequently, we reintegrated them into the aerial field models following the geometric transformations. Finally, a 3D virtual visualization of a farmland was presented. Although the proposed template matching approach did not strictly reflect the actual conditions in the field, it offers a potential solution for addressing the invisible parts beneath the canopy. Additionally, it serves as a fundamental technique for the development of digital twins and smart agriculture in the future.