

**The 11th Asian-Australasian Conference on Precision Agriculture (ACPA 11)
October 14-16, 2025, Chiayi, Taiwan**

A LOW-COST MULTI-VIEW IMAGE TO 3D RECONSTRUCTION FOR PLANT PHENOTYPING

Shao-Yang Chang¹, Chung-Han Chen¹, Hang Ren², Yohei Koide², Chen-Kang Huang^{1, 3*}

¹ Department of Biomechatronics Engineering, National Taiwan University, Taiwan.

² Research Faculty of Agriculture, Hokkaido University, Japan.

³ Center for Intelligent Agriculture Education and Research, National Taiwan University, Taiwan

*Corresponding Author: ckhuang94530@ntu.edu.tw

ABSTRACT

Current 3D plant phenotyping approaches often rely on LiDAR or multi-camera systems, which are costly, require complex calibration, and lack scalability. This study introduces a simple and cost-effective pipeline for 3D plant reconstruction using Hunyuan3D-2.5, a multi-view generative model. Plant samples were photographed directly using a mobile phone, and raw images were processed with a custom Python background-removal pipeline that enhanced plant contours and removed environmental noise. The cleaned multi-view images were then reconstructed into accurate 3D plant meshes through Hunyuan3D-2.5. Subsequent measurements of branch numbers, stem angles, and plant height were conducted in Blender. The proposed workflow significantly reduces equipment costs while delivering reproducible, high-quality 3D reconstructions, offering an accessible solution for small-scale laboratories and scalable potential for field-based plant phenotyping.

Keywords: 3D plant phenotyping, Hunyuan3D-2.5, multi-view reconstruction, blender measurement

INTRODUCTION

3D plant phenotyping is increasingly important for studying plant morphology and growth dynamics. Conventional approaches such as LiDAR or multi-camera rigs provide accurate reconstructions but face limitations including high cost, complex calibration, and poor scalability, restricting their practical use in large-scale studies. Recent advances in generative modeling and image-based reconstruction enable the development of low-cost, accurate pipelines. This study aimed to develop and validate a practical phenotyping workflow using Hunyuan3D-2.5, a multi-view reconstruction model, combined with a simple imaging setup and open-source tools (Guo, Huang, & Zhao, 2025; Paulus, 2019). Specifically, the objectives were to establish a standardized and affordable image acquisition system, fine-tune the model for plant-specific reconstructions, and evaluate the reconstructed model for phenotyping tasks in Blender.

MATERIALS AND METHODS

The imaging procedure was designed as a mobile-based acquisition process to reduce equipment requirements and simplify operation. Each plant was photographed from multiple angles using a smartphone with a 48-megapixel camera under consistent indoor lighting to minimize shadows and maintain uniform image quality. Raw images were processed with a custom Python pipeline implemented in OpenCV to enhance object contours and remove background. Specifically, we applied an unsharp-mask filter for edge enhancement, computed vegetation priors using HSV color thresholds together with the Excess-Green (ExG) index to obtain an initial foreground mask and then refined the mask with OpenCV's GrabCut algorithm to produce an alpha-matted cutout with light feathering for boundary preservation. The cleaned multi-view images were then uploaded to a custom web interface and reconstructed into textured 3D meshes using the Hunyuan3D-2.5 multi-view generative model. The reconstructed meshes were exported in standard 3D formats and imported into Blender, where automated Python scripts measured branch counts, stem and leaf angles, and overall plant height. To ensure reliability, measurements derived from the 3D models were validated against manual readings obtained directly from physical plant samples.

RESULTS & DISCUSSION

Smartphone-based imaging successfully generated high-quality multi-view datasets, which were reconstructed into detailed 3D meshes using Hunyuan3D-2.5 (Figure. 2). The reconstructed models preserved plant geometry, enabling accurate measurements in Blender. Quantitative validation against manual readings demonstrated strong agreement: plant height differences averaged 1.8 cm (1.4%), stem/leaf angle errors averaged 2.1° (3.2%), and branch count errors remained within ± 2 counts (<5%). Overall, the mean absolute percentage error across all traits was 3.6%, consistently below the 5% threshold (Table 1). These results highlight the reliability of the proposed workflow. Minor discrepancies were mainly due to leaf overlap and incomplete segmentation, yet measurement fidelity remained robust. Compared to LiDAR or photogrammetry pipelines, the proposed method reduced equipment cost by over 90% and significantly simplified operation, making it highly suitable for small-scale laboratories while showing promise for field-scale adoption. (Paulus, 2019).



Figure 2. Reconstructed 3D plant model generated by Hunyuan3D-2.5.

	Plant height (cm)	Leaf and stem angle (°)	Branches
Manual measurement 1	137	65	25
3D model 1	135	63	23
Manual measurement 2	134	38	21
3D model 2	136	43	21
Manual measurement 3	129	50	20
3D model 3	130	52	21

Table 1. Comparison between manual and 3D model measurements

CONCLUSION

This study demonstrates a low-cost and accessible smartphone-based workflow for 3D plant phenotyping using Hunyuan3D-2.5. By integrating mobile imaging, automated background removal, and mesh-based measurement in Blender, the pipeline eliminated the need for specialized hardware while maintaining scientific rigor. Validation showed that reconstructed models achieved measurement accuracy within 3% of manual readings, with average errors consistently below 5% across plant height, branch counts, and stem/leaf angles. Such precision confirms the method's reproducibility and reliability for phenotyping tasks. Beyond cost reduction and operational simplicity, the workflow enables broader accessibility to research groups with limited resources. With further optimization, particularly for outdoor lighting conditions and real-time segmentation, the approach holds strong potential to scale toward field-based, high-throughput phenotyping applications.

ACKNOWLEDGEMENTS

This research was supported by the Ministry of Agriculture under grant 114AS-1.6.1-AS-28.

REFERENCES

- Guo, C., Huang, J., & Zhao, Z. 2025. Hunyuan3D 2.0: Scaling diffusion models for high-resolution textured 3D assets generation. *arXiv preprint arXiv:2501.12202*.
- Paulus, S. 2019. Measuring crops in 3D: Using geometry for plant phenotyping. *Plant Methods* 15(103): 1–14.