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

DEVELOPMENT OF 3D PHENOTYPIC ANALYSIS TECHNOLOGY FOR PRECISION MONITORING OF STRAWBERRIES

Seong-Hwan Lee[1], Woo-Joo Choi[1], Dokyun Jung[1], Ki-Su Park[1], Yeong-Jin Kim[1], Wonjin Kim[2],Jihyeon Yang[2],Myongkyoon Yang[2, 3*]

[1]Department of Agricultural Machinery Engineering, Jeonbuk National University, Jeonju 54896, Republic of Korea.
[2]Department of Bioindustrial Machinery Engineering, Jeonbuk National University, Jeonju 54896, Republic of Korea.
[3]Institute of Agricultural Machinery & ICT Convergence, Jeonbuk National University, Jeonju 54896, Republic of Korea.

*Corresponding Author: yangmk@jbnu.ac.kr

Strawberries exhibit high overall production volume but low productivity per unit area, primarily due to diseases that occur during cultivation. These yield losses can be mitigated through precision monitoring technologies based on phenotypic analysis. To enhance monitoring accuracy, 3D phenotyping techniques are essential. This study aims to automate such 3D phenotyping by constructing a 3D segmentation model capable of identifying plant organs. Strawberry plants were imaged from all angles using a smartphone (Galaxy S21+, Samsung, Republic of Korea). The captured images were processed using a COLMAP-based algorithm for key point extraction and image alignment. The aligned views were then input into the Gaussian Splatting algorithm to generate a 3D model. The resulting model was preprocessed through spatial scaling and noise removal, and annotated with three key classes: Leaf, Leaf Stem, and Runner. Subsequently, a 3D segmentation model was trained using the mmdetection3d library. The model was evaluated using Accuracy, Precision, Recall, F1-Score, and mIoU. Results confirmed that the model was able to accurately recognize major strawberry organs, demonstrating its potential to support precision monitoring based on 3D phenotypic analysis.

Keywords: 3D segmentation, Gaussian Splatting, MM3detection, Strawberry

INTRODUCTION

Strawberry is an economically important horticultural crop worldwide; however, its yield per unit area is relatively low compared with other crops due to pests and physiological disorders during cultivation. Such losses can be mitigated through precision monitoring based on plant phenotyping. Recently, three-dimensional (3D) phenotyping has been introduced to overcome the limitations of conventional two-dimensional image-based analysis and to improve monitoring accuracy (Li et al., 2025).

This study aimed to establish an automated monitoring approach by developing a 3D segmentation model for strawberries and evaluating its performance.

MATERIALS AND METHODS

Strawberry images were captured from multiple angles using a smartphone (Galaxy S21+, Samsung, Republic of Korea). The images were processed with COLMAP to extract keypoints and perform image registration. Subsequently, a 3D model was generated using the Gaussian Splatting algorithm. The reconstructed model was scaled, denoised, and annotated into four classes: Leaf, Leaf stem, Runner, and Background. Finally, a segmentation model was trained using the mmdetection3d Python library.

RESULTS & DISCUSSION

As shown in Figure 1, the 3D models reconstructed by Gaussian Splatting provided visually detailed and high-quality representations of plant structures. However, the quantitative evaluation (Table 1) indicated poor performance, with a mean Intersection over Union (mIoU) close to 0.1. Class imbalance and biased predictions were observed, likely caused by limited training data and discrepancies between Gaussian Splatting-derived point clouds and the original training distribution. These findings highlight the need for dataset expansion, tailored preprocessing, and adaptive training strategies to improve segmentation performance in future research.

Fig.1 3D strawberry model reconstructed by Gaussian Splatting

Table 1 Segmentation performance metrics

Classification	Sample A	Sample B
accuracy	0.449	0.357
mIOU	0.112	0.089

CONCLUSIONS

This study developed a 3D segmentation model for automated precision monitoring of strawberries and evaluated the use of Gaussian Splatting-based datasets. Although the performance was low due to limited training data, the results demonstrate the feasibility of applying advanced 3D reconstruction methods in crop phenotyping. Future work will focus on expanding the dataset and optimizing the model to achieve practical improvements in segmentation accuracy.

ACKNOWLEDGEMENTS

This work was supported by Korea Institute of Planning and Evaluation for Technology in Food, Agriculture and Forestry(IPET) and Korea Smart Farm R&D Foundation(KosFarm) through Smart Farm Innovation Technology Development Program, funded by Ministry of Agriculture, Food and Rural Affairs(MAFRA) and Ministry of Science and ICT(MSIT), Rural Development Administration(RDA)(RS-2024-00399854)

REFERENCES

Kerbl, B., Kopanas, G., Leimkühler, T., & Drettakis, G. (2023). 3D Gaussian splatting for real-time radiance field rendering. *ACM Trans. Graph.*, *42*(4), 139-1.

Li, Z., Wang, S., Su, Y., & Yu, D. 2025. A Method for Measuring Strawberry Leaf Area Based on Three-Dimensional Point Cloud Instance Segmentation. *IEEE Access*. vol. 13, pp. 25339-25349