SPEAKER BIODATA FORM

Title: Application of image processing and AI for cabbage cultivation monitoring

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Brief career highlights (less than 250 words):

Dr. Sun-Ok Chung is a Professor in the Department of Smart Agricultural Systems at Chungnam National University, Republic of Korea. He received his B.S. and M.S. degrees in Agricultural Machinery from Seoul National University in 1995 and 1997, respectively, and earned his Ph.D. in Department of Biological Engineering at the University of Missouri, Columbia, USA. His doctoral research focused on the development of an on-the-go soil strength profile sensor.

His research encompasses agricultural field machinery, precision agriculture technologies, and sensing and control systems for bio-production environments. He has demonstrated exemplary leadership in his field, served as President of the Korean Society of Precision Agriculture (2023–2025), President of the Korean Society of Artificial Intelligence in Agriculture, the Secretary General and the Chair-person for 2nd and 5th Asian Conference of Precision Agriculture, respectively. He is currently serving as a member of Executive Committee of ACPA, President of the Korean Smart-pet Technology Association (2025-present), Vice-president of the Korean Society of Bio-Environmental Control (2023–present), and Vice-president of the Korean Society for Agricultural Machinery (2024-present).

APPLICATION OF IMAGE PROCESSING AND ARTIFICIAL INTELIGENCE (AI) FOR CABBAGE CULTIVATION MONITORING

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ABSTRACT

Cabbage requires precise monitoring for during cultivation, e.g., transplanting performance, water stress, growth status, and yield estimation. This study presents image processing and artificial intelligence (AI) techniques to enhance automation for cabbage production operations. High-resolution multispectral and thermal images were acquired using UAVs and ground-based platforms. Seedling detection during transplanting operation was implemented using a YOLOv8 model with a CSPDarknet53 backbone and FPN for multi-scale feature extraction, supported by transfer learning on annotated datasets. Growth monitoring and yield estimation employed RGB imagery and 3D point clouds derived via structure-from-motion and multi-view stereo, with canopy and height features input into an artificial neural network (ANN) optimized using Adam. Cabbage water stress was assessed using normalized vegetation index (NDVI), green normalized vegetation index (GNDVI), and crop water stress index (CWSI), with partial least squares regression (PSLR) used for sensor fusion and stress identification. The approach demonstrated high accuracy in seedling detection (mAP: 90.1–93.6%), volume estimation (R^2 = 0.93), and ware stress monitoring under field conditions. This approach substantially would reduce labor and enhance decision-making precision.

Keywords: Precision agriculture, cabbage, UAV, deep learning, growth monitoring, yield estimation.

INTRODUCTION

Cabbage (*Brassica rapa* subsp. *pekinensis*) is a high-value crop extensively cultivated in temperate regions such as the Republic of Korea (Jeong and Park, 2025). Monitoring cabbage development and stress indicators would play a critical role for yield optimization, but remains labor-intensive and error-prone with traditional methods. Advances in image processing and artificial intelligence (AI) now offer efficient alternatives for crop monitoring in precision agriculture. Data collected from multiple sensor types, deployed across various platforms (e.g., ground-based systems and unmanned aerial vehicles [UAVs]), facilitate comprehensive analysis of plant phenotypic traits, canopy architecture, and physiological status (Nethala et al., 2024). Deep learning models further support robust feature extraction, classification, and anomaly detection from complex image datasets. Integrating these technologies provides a scalable, accurate, and labor-saving framework for real-time decision-making in cabbage farming, supporting sustainable and efficient production practices. This study presented an application of image processing and AI techniques in monitoring cabbage cultivation.

MATERIALS AND METHODS

Field data collection was conducted in Hongcheon, Gangwon-do, Republic of Korea, over a 70 m × 30 m farmer's cabbage field. A custom mobile sensing platform was mounted 1.8 m above the crop canopy. It integrated RGB, multispectral, and thermal sensors, along with a GNSS receiver for geo-referencing and a microcontroller-supported control system. Aerial data were collected using a UAV equipped with multispectral and thermal cameras, flown at a 30 m altitude. Predefined flight paths ensured consistent overlap for accurate spatial dataset generation, supporting comprehensive monitoring of cabbage health and growth. Cabbage detection was performed using YOLOv8 with a CSPDarknet backbone and PANet neck (Alif et al., 2024), fine-tuned on 640×640 pixels cabbage images using transfer learning from a COCO-pretrained model. Adam optimizer (learning rate 0.001) and data augmentation techniques enhanced generalization. For volume estimation, canopy area and plant height were extracted from RGB orthomosaics and normalized point clouds, respectively, and processed via a feedforward artificial neural network (ANN) model. Water stress detection used multispectral and thermal sensor data to calculate normalized vegetation index (NDVI), green normalized vegetation index (GNDVI), and crop water stress index (CWSI), and PLSR models integrated multispectral and thermal metrics for water stress identification. GPS timestamps ensured sensor data synchronization.

RESULTS & DISCUSSION

The cabbage counting model based on YOLO v8 achieved mean average precision (mAP) scores between 90.1% and 93.6% at an Intersection over Union (IoU) threshold of 0.5, confirming robust detection accuracy across varied lighting and occlusion conditions. Frame processing speeds of 14–18 frames per seconds enabled real-time applications. Volume estimation using ANNs reached an R^2 of 0.93 and RMSE of 1.98 cm³, better than single-feature models. Integrating UAV and ground-based thermal imagery provided accurate water stress maps, aiding in precise irrigation management.

CONCLUSIONS

Image processing and AI improved cabbage monitoring by enabling precise analytics and reducing labor. Future work will expand to other crops, incorporating hyperspectral data, and enhancing real-time analytics for broader deployment in precision agriculture.

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