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**SPEAKER BIODATA FORM**

Title: Professor

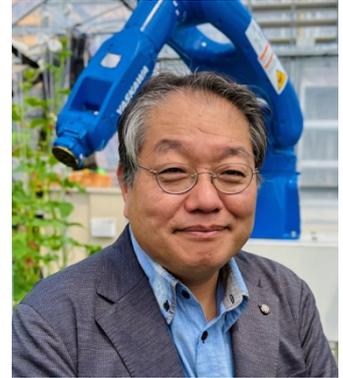
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Brief career highlights (less than 250 words):

His fields of researches are data-driven agriculture, field-type machinery in agriculture, and computational mechanics based on inelastic constitutive models and their applications to biosystems engineering fields. He is working on research projects to enhance agricultural production and machinery design. He has written more than 280 research papers (including international and domestic journals and international conference proceedings), contributed to writing 10 books as a chapter author, and edited several books and conference proceedings. He has delivered more than 90 presentations as keynote, invited and special lectures.

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## POTENTIAL OF PLANT PHENOTYPING FOR DATA-DRIVEN GREENHOUSE HORTICULTURE

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### ABSTRACT

We are trying to investigate the use of various features extracted from plant images for the purpose of environmental control in greenhouses according to the growth conditions of plants. A measurement robot was utilized in order to collect plant images. Plant growth features (apical buds, flowers, fruits, etc.) were extracted by using a deep learning-based detector. In addition, we also introduced a 3D reconstruction technology to obtain the plant shape features such as plant height, internode length, and leaf width. We also examined whether the acquired plant growth characteristics could be used to optimize the operation of the environmental control system.

**Keywords:** Multi-functional environmental control, plant growth feature extraction, deep learning, sensing robot,

### INTRODUCTION

Japanese agriculture is currently facing a severe labor shortage due to an aging population and declining birth rates, with the average age of farmers reaching 68.4 years old in 2022. To address this pressing issue, the realization of data-driven agriculture has become an urgent necessity. In particular, we are conducting research aimed at improving productivity and reducing labor in greenhouse horticulture. We use the open-source Ubiquitous Environmental Control System (UECS) proposed by Hoshi et al. (2004). UECS can manage facilities in greenhouses by connecting monitoring and control nodes via network. Twenty years after its release, this system has now been put to practical use in small and medium-sized greenhouses.

On the other hand, a plant phenotyping is identified as an optimal technique for evaluating plant responses to environmental factors such as light intensity, water, CO<sub>2</sub> concentration, and temperature). Plant phenotypes (shape, color, texture, nutrient content, taste, and functionality), are significantly influenced by both genetic factors (crop variety, growth stage) and environmental factors. Now, various types and scales of high-throughput plant phenotyping platforms are utilized in the world.

In this study, we try to propose integrating a plant phenotyping node into the UECS. By utilizing AI and image analysis, the node is able to obtain real-time plant growth features that can be used for automated cultivation management. This integration will accelerate the shift to data-driven greenhouse horticulture, ultimately leading to improved production efficiency and labor savings.

## UTILIZATION OF PLANT PHENOTYPING DATA TO ENVIRONMENTAL CONTROL

Plant phenotyping research requires the development of technology to measure and extract plant traits quickly and comprehensively. In addition to developing a plant growth image measurement system with a robot, we have also developed a feature extraction method using a deep learning to evaluate the plant growth status (Pham et al., 2024). The method could collect growth features of cucumber plants such as apical buds, flowers, and fruits. By using zoomed plant images captured by a PTZ (pan tilt zoom) camera on the robot, the accuracy was significantly improved. Next, 3D plant models were reconstructed by 3D Gaussian Splatting from a series of cucumber plant images taken from various positions by the robot (Pham et al., 2025). Specifically, first, using an image processing library called COLMAP, SfM (Structure from Motion) was applied to the input image (true value) to obtain camera information (position, orientation, etc.) and 3D point cloud data. Next, using this data as the initial values, machine learning was used to correct the point cloud data so as to minimize the difference with the input image, thereby reconstructing a highly accurate 3D model. Because this 3D model contains depth information, it was relatively easy to remove objects behind the target plant body and extract only the leaf surface information of the target plant. Further, 3D growth features (plant height, internode length, leaf width and length, etc.) were also extracted from 3D model. The accuracy was comparable to that of the actual measurement values.

On the other hand, the environmental measurement and control system for a greenhouse was developed by the UECS. In order to improve the usability of the control program, we adopted a low-code programming architecture with a web interface. The validity of the developed system was evaluated by a real cultivation test in greenhouse. As the result, It was confirmed to operate stably throughout the entire cultivation period. To improve cultivation management and reduce labor, we are considering introducing a plant phenotyping node into the UECS network. The plant growth features mentioned above can provide as valuable information for understanding changes in a plant's growth status. For example, by grasping leaf area and fruit number, we can estimate irrigation conditions. This node transmits the collected growth features to the environmental control node by using the UECS-CCM (Common Correspondence Message), which can then be provided to appropriately adjust the operating parameters of the environmental control facilities.

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## REFERENCES

- Hoshi, T., Y. Hayashi, and H. Uchino. 2004. Development of a Decentralized, Autonomous Greenhouse Environment Control System in a Ubiquitous Computing and Internet Environment. Proceedings of AFITA/WCCA2004. Thailand, 490–496.
- Pham, D. T., N. A. Amin, D. Yasutake, Y. Hirai, T. Ozaki, M. Koga, K. Hidaka, K. Masaharu, H. B. Vo, and T. Okayasu. 2024. Development of plant phenotyping system using Pan Tilt Zoom camera and verification of its validity. COMPAG. 227, 10.1016/j.compag.2024.109579.
- Pham, D. T., T. Iwakuma, Z. Jiang, S. Sar, D. Yasutake, T. Ozaki, M. Koga, Y. Hirai, M. Mitsuoka, M. R. A. Mamun, K. Nomura, H. B. Vo, and T. Okayasu. 2025. Smart Agric. Technol. 12, 10.1016/j.atech.2025.101063.