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Design and development of UECS-based environmental monitoring and
control platform without coding

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Abstract

Data-driven agriculture has been increasingly adopted to achieve labor-saving, energy efficiency, and resource optimization in agricultural operations. Among small- and medium-scale horticultures, the Ubiquitous Environment Control System (UECS) proposed in 2004 is attracting again due to low cost of introduction. The UECS is an autonomous and distributed open-source environmental monitoring and control platform for greenhouse horticulture. A computer called a node is used in each environmental monitoring and control apparatus. Users can flexibly design node configurations according to their needs and farming scales. However, constructing nodes typically requires a certain level of programming knowledge and skills, and thus it has been a barrier for users. In general, the user only needs to propose the environmental control logic for plant cultivation management, and programming is not necessarily required. This study aims to design and develop a new platform that allows the use of UECS based environmental monitoring and control nodes without coding. Specifically, a system was developed for the environmental control node that can operate the environmental control apparatus by combining meteorological information received via UECS-CCM (UECS Common Correspondence Messages). This allows users to intuitively change the operation of the environmental control apparatus without coding. By implementing no-code control logic for irrigation equipment, CO₂ generators, heaters, etc., it was demonstrated that this apparatus can be properly managed. This system is a highly flexible environmental control system that can be used even by producers with no programming knowledge and skills, and it is expected to be popularized in small and medium-scale greenhouse horticulture management organizations.

Keywords: UECS (Ubiquitous Environment System), data-driven horticulture, complex environmental control, open-source, node

INTRODUCTION

Japan's declining birth rate and aging population directly contribute to reduced agricultural workforce and fragmented farmland issues. To address these social challenges through agricultural industrialization, we developed the UECS standard for implementing cost-effective data-driven equipment.

MATERIALS AND METHODS

The UECS comprises measurement nodes (custom M302N circuit boards measuring air temperature, humidity, solar radiation, and CO₂ concentration) and control nodes (M304 circuit boards with Arduino MEGA2560) communicating via CCM for environmental regulation (Figs.

1 and 2). The no-coding program contains 30 relay entries (RX), 10 transmission entries (X), and 10 conditional entries (OPE), where RX entries specify control periods and rules based on environmental data, and OPE records process CCM TYPEs to trigger corresponding RX outputs. No-code control logic was implemented for irrigation, CO₂ generation, and heating systems, with heating device relay outputs verified without physical activation due to seasonal considerations.

RESULTS & DISCUSSION

Environmental control nodes were successfully fabricated for irrigation, CO₂ generating, and heating systems using M304 platforms (Table 1). All systems demonstrated satisfactory performance without operational anomalies. However, user interface improvements were identified. Union (OR) and intersection (AND) operations for multiple control conditions enabled comprehensive environmental management through single nodes, demonstrating integrated multi-parameter control within a unified framework.

CONCLUSIONS

This research developed a no-code system for UECS-compatible environmental control nodes. The system validated remote configuration and parameter modification capabilities, providing advantages for centralized management in distributed horticultural facilities. However, the node using the Arduino proved insufficient for sophisticated applications because of the limitations in processing speed and memory capacity. Future development will focus on higher-performance CPU architectures for advanced no-code UECS node development.

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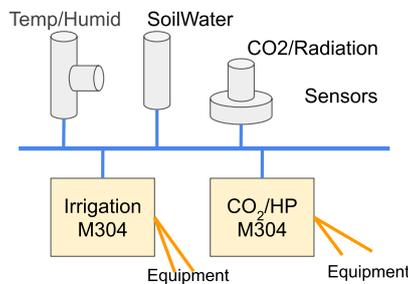


Figure.1 UECS node's network

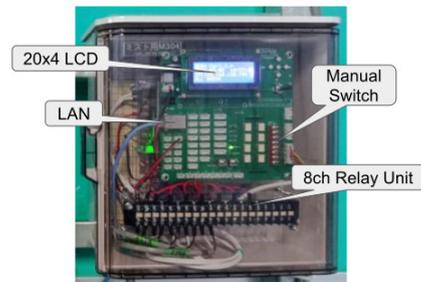


Figure.2 M304 structure

Table 1:Environmental Conditions vs Output

Expected Output	Environmental Conditions
Irrigation Control	cond.1 : Day & SoilWater < X_{w1} cond.2 : Day & Radiation > X_{w2}
CO ₂ Generation	Day & Windows close & CO ₂ < X_{CO2}
Heater Control	Temp < X_t & Window close