RMIT UNIVERSITY
School of Science, Engineering & Technology

ORLAR
AUSTRALIAN GOODNESS GROWN IN VIETNAM

INNOVATION X

A DIGITAL TWIN FRAMEWORK FOR PRECISION LIGHTING IN INDOOR FARMS USING ROBOTIC AND IOT SYSTEMS

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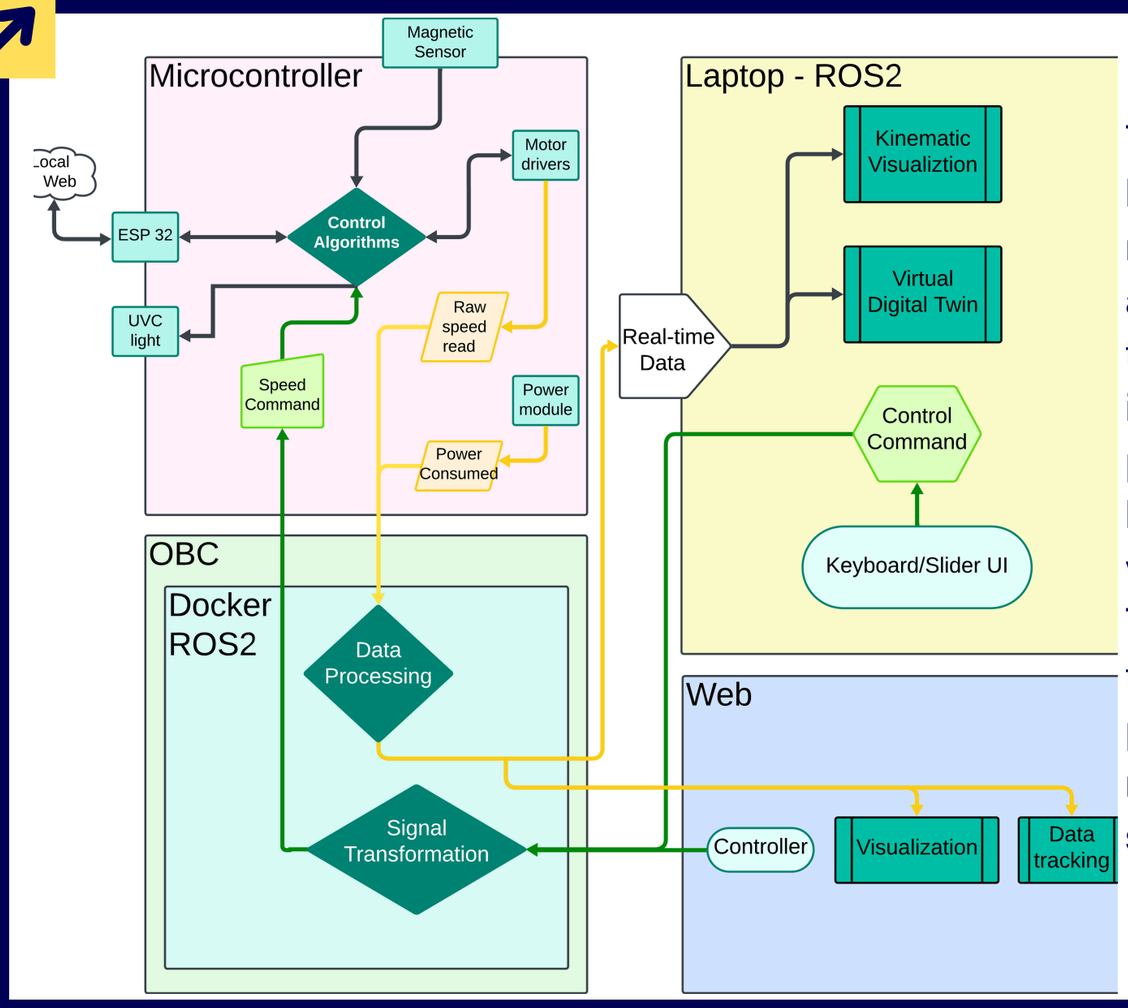
BACKGROUND & MOTIVATION

Indoor farming offers sustainable food production but faces challenges in labor shortages, disease detection, and safety risks. Manual inspection of thousands of plants is time-consuming and inconsistent, while powdery mildew often escapes early detection. UV-C treatment is effective but hazardous to workers, especially during night shifts. To optimize yield, safety, and cost-efficiency, Orlar Vietnam requires an automated system capable of precise monitoring, disease treatment, and real-time farm management.

OBJECTIVE

- Automated navigation
- Safe UV-C treatment
- Real-time digital twin monitoring
- Remote control and data tracking



METHODLOGY

The system integrates microcontroller control, onboard computing, laptop-based ROS2, and web interfaces to achieve real-time robot operation and monitoring. At the microcontroller level, the ESP32 executes control algorithms, reads speed and sensor data, manages motor drivers, and transmits speed commands. The onboard computer (OBC), running ROS2 in Docker, processes raw inputs, performs signal transformation, and publishes data as ROS2-compatible topics, creating a link between hardware and high-level control. On the laptop, ROS2 provides kinematic visualisation and a virtual digital twin for real-time monitoring and validation. The web interface extends access by supporting visualisation, controller functions, and data tracking. This enables operators to remotely monitor performance and system metrics. Together, these four layers provide a robust framework for efficient robot control, visualisation, and remote supervision.

FEATURE

- Global remote control
- Digital Twin implementation
- Safety integration
- Power efficiency
- Accurate positional tracking
- Automated UV-light treatment

CONCLUCION & FINDINGS

The developed framework demonstrated the feasibility of integrating digital twin technologies with robotic and IoT systems for precision UV-C treatment in indoor farms. Experimental results validated accurate tracking, real-time monitoring, and safe autonomous operation, highlighting the system's potential to enhance efficiency, safety, and scalability in controlled agricultural environments.

EXPERIMENT & RESULTS

Position tracking accuracy >= 90%

Webiste latency <= 50 ms

Globally accessed control interface

Able to withstand up to 70kg load