OPERATION MANUAL

- **Title:** ***Real-Time Smart Agriculture System on µT-Kernel 3.0***
- **Contest: TRON Programming Contest 2025 – RTOS Application (Student Category)**
- **ENTRYID: 34686**

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2. Introduction

This project demonstrates an **automated irrigation system** with soil-moisture–based control and a separate **plant disease detection module** using machine learning. Both run on the **Renesas EK-RA8D1 board** under **µT-Kernel 3.0 RTOS**, highlighting real-time task scheduling and AI integration.

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3. Hardware Requirements

- **Renesas EK-RA8D1 Board** (main MCU, Cortex-M85).
- **Soil Moisture Sensor** – Capacitive type, analog output (0–3.3V).
- **Relay Driver Module** – 5V input, opto-isolated, controls 12V DC pump.
- **12V Submersible Water Pump** (for irrigation).
- **Camera Module** (e.g., OV7670/ArduCAM OV2640) – for leaf image capture.
- **Power Supply** – 12V regulated input; on-board regulator provides 3.3V.

Optional peripherals:

- SD card for logging.
- Cloud app integration (future work).

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4. Software Requirements

- **IDE:** Renesas e^2 studio v2025.
- **RTOS:** µT-Kernel 3.0 (from TRON Forum BSP).
- **Libraries:**
    - GPIO, ADC, UART drivers (from FSP).
    - Camera capture + image preprocessing.
    - TensorFlow Lite Micro (for CNN inference).
- **Version Control:** GitHub repository (link in README).

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5. System Setup Instructions

Step 1 – Hardware Connections

- Soil moisture sensor → EK-RA8D1 (ADC pin).
- Relay IN pin → GPIO pin (e.g., P305).
- Relay VCC = 5V, GND common with board.
- Pump → 12V via relay contacts.
- Camera module → D0–D7 to EK-RA8D1 camera interface pins, XCLK/PCLK to appropriate pins.

Step 2 – Power

- Connect EK-RA8D1 to PC via USB (for programming + power).
- Relay + pump powered via 12V external supply.

Step 3 – Firmware Upload

- Open e^2 studio → Import project from /src/ENTRYID_project.
- Build project → Flash binary to EK-RA8D1.

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6. Operation Instructions

Mode 1 – Irrigation

1. Place soil sensor in pot/soil.
2. Power the system.
3. If soil moisture < threshold → Pump ON automatically.
4. If soil moisture ≥ threshold → Pump OFF.
5. System runs continuously under RTOS with ~200ms sensor polling.

Mode 2 – Plant Disease Detection

1. Connect camera module.
2. Press **Button SW1** to capture image.
3. Image is preprocessed (64×64 grayscale).
4. ML task classifies → "Healthy / Infected (disease type)".
5. Result is displayed over UART serial or stored in log.

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7. Safety Precautions

- Do not touch water pump wires with wet hands.
- Ensure common ground for sensor + board.
- Use opto-isolated relay to protect MCU.
- Avoid overexposing board to sunlight or water.

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8. Test Cases

- Soil moisture below threshold → Pump ON within 1s.
- Soil moisture above threshold → Pump OFF within 1s.
- Leaf sample (5 test images) → ML inference ≥90% accuracy.
- RTOS performance: Task switching latency < 100 µs.

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9. Troubleshooting

- Pump not starting → Check relay wiring and 12V supply.
- ADC stuck → Recalibrate moisture sensor.
- Camera not detected → Check pin alignment (XCLK, PCLK).
- ML misclassifies → Use brighter lighting / retrain dataset.

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10. Contact

- https://github.com/220801194-SHAUN-ORLANDO-M/34686_TRON_CONTEST_APPLICATION_PROGRAM
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