Smart Irrigation System

Sommario

System Description

Smart Irrigation System is a solution designed to optimize water usage in agricultural applications. By using a combination of sensors, data analytics and automated control systems, this smart system will ensure that plants receive the right amount of water at the right time.

The Smart Irrigation System continuously monitors environmental conditions through its network of sensors. When the soil moisture level drops below a certain threshold, the system triggers the irrigation devices to water the plants. Conversely, if the weather forecast predicts rain, the system can cancel watering to conserve water.

Functional requirements

Real time monitoring

The system should continuously monitor environmental conditions through sensors, including soil moisture sensors, temperature sensors, humidity sensors and light sensors.

Automated watering

When the soil moisture level falls below a certain threshold, the rule-based decision function triggers irrigation devices to water the plants.

Weather integration

The system integrates with weather forecasts to adjust watering plans. If rain is predicted, the system may cancel watering based on rule-defined conditions.

User interface

The user interface should provide real time status updates of the system, allow users to adjust system settings, offer water usage consumption and influencing the rule-based decision-making process.

Data storage

The system must store sensor data for further analysis and the system configuration settings. e.g., moisture level threshold.

Non-functional requirements

Reliability

The system must operate under varying environmental conditions.

Scalability

The system should be able to accommodate additional sensors or irrigation devices if necessary.

Performance

The system should be able to respond promptly to changes in environmental conditions.

Compatibility

The system should be compatible with a variety of sensors and irrigation devices.

System components

The smart irrigation system is composed of several key components such as:

Sensors

These are crucial for **monitoring** and gathering real-time data about environmental conditions. The main sensors are:

- Soil moisture sensor
- Temperature sensor
- Humidity sensor
- Light sensor

Irrigation devices

The irrigation devices are the physical components that deliver water to the plants. The Central Control System with these devices, instructing them when to start or stop watering.

Examples of irrigation devices:

- Sprinklers
- Drip irrigation lines

Central Control System

The Central Control System is responsible of **analyzing** the data gathered by the sensors, it also considers the weather forecast and historical data to determine the need for watering.

Based on the analysis, the system creates a **plan** adhering to rule-based decisions**.** If the soil needs watering and no rain is forecasted, the plan will include turning on the irrigation system. If rain is predicted, the plan might cancel watering. The goal is to devise a plan that ensures the plants receive the right amount of water at the right time optimizing water usage.

The system then **executes** the plan based on rule-defined conditions. If the plan involves turning on the irrigation system, it sends a command to the irrigation devices to start watering. If the plan involves canceling watering, the system cancels the irrigation.

Adaptation goals

Goal	**Description**	**Evaluation metric**
Trigger irrigation devices	Trigger irrigation devices when the soil moisture level drops below a certain threshold and rain is not predicted in the next X hours (adjustable by the user).	$(Sml \ \leq Smt) \land \neg Rp$
Stop irrigation	Stop irrigation when the soil moisture level has reached the soil moisture threshold or rain is predicted rain in the next X hours (adjustable by the user) to avoid overwatering.	$(Sml \ > \ Smt) \lor \ Rp$

- *Sml*: Soil moisture level
- *Smt*: Soil moisture threshold
- *Rp*: Rain prediction

Decision function

The Smart Irrigation System employs a rule-based decision-making approach to determine optimal watering plans. The decision logic is governed by a set of predefined rules that consider environmental conditions, weather forecasts, historical data, and user-defined settings.

User Interface

The user interface will allow users to monitor the system's status, adjust settings, and view water usage reports.

Data storage

The data collected by the sensors and the system configuration settings will be stored on a database.

Technologies

The system will be developed following the MAPE-K loop with the following technologies:

- MQTT: as communication protocol.
- Mosquitto: to collect real-time data from sensors and communication between the central control system and the irrigation devices.
- Paho MQTT
- InfluxDB: for storing storical sensor data.
- Grafana: for visualizing system performance and historical data.
- OpenWeatherMap API: for getting real-time weather forecasts.
- Docker: for containerizing the application components to unsure portability and easy deployment across different environments.
- Git: for version control.
- Python: for the implementation of the analyzer, planner, and executer.
- Express.js: for the implementation of the backend.
- MongoDB: system configuration settings. e.g., moisture level threshold.
- NodeRED: for the implementation of the dashboard.