KTO KARATAY UNIVERSITY

FACULTY OF ENGINEERING

MECHATRONICS ENGINEERING

INTELLIGENT MECHATRONIC SYSTEMS (MEM-820)

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Working Area	: Weather-Based Smart Irrigation System

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1. INTRODUCTION

Intelligent mechatronic systems integrate sensing, computation, actuation, and decision-making to perform context-aware tasks autonomously. In this project, an intelligent irrigation system is designed that uses environmental sensing and online weather prediction to make optimized irrigation decisions. The system exemplifies a shift from traditional automation to smart adaptive systems, where real-time data and decision algorithms reduce unnecessary actions and increase system efficiency.

1.1 Objective

The objective of this project is to design and implement an intelligent, adaptive irrigation system that:

- Automatically decides whether to irrigate based on both soil moisture and forecasted weather data.
- Incorporates contextual awareness to avoid redundant watering actions.
- Lays the groundwork for more complex AI-based decision models in agricultural automation.
- Embeds basic AI logic (rule-based decision-making) and paves the way for future enhancements using machine learning.

1.2 Research or Implementation Methods Used

- Internet Resources – Sensor interfacing, API integration, and smart irrigation principles.
- Academic Literature – Studies on artificial intelligence in agriculture and intelligent environmental systems.
- Algorithm Design – Rule-based AI model for autonomous decision-making.
- Prototyping – Hardware setup using Raspberry Pi, sensors, and relays.

2. PROJECT

2.1 Adaptive Assembly System

The irrigation system is built around an intelligent decision-making module. This module combines:

- Real-time sensor data (soil moisture)
- External cloud data (OpenWeatherMap API)
- Embedded logic to execute an optimal watering plan.

The system qualifies as an intelligent system by meeting core principles:

- Reactivity: Responds to sensor input and weather.
- Autonomy: Operates without human intervention.
- Context-awareness: Adjusts behavior based on internal/external state.

2.2 Fields of Use

※ **Smart Agriculture (AI-supported decision-making):**
Data-driven decision-making is becoming essential in agricultural applications. This system combines soil moisture readings with weather forecasts to prevent unnecessary irrigation, optimizing water usage. With further integration of advanced AI algorithms, it can support precision farming to increase crop yield and resource efficiency.

※ **Smart Cities (urban farming):**
In smart city initiatives, managing green areas and urban farming projects sustainably is critical. This system can be deployed in small-scale urban farms to maximize water and energy efficiency, providing environmentally conscious solutions suitable for densely populated environments.

※ **Greenhouse Automation:**
Greenhouses require precise control over humidity and irrigation. The proposed system enables real-time monitoring and automated watering, reducing manual intervention and maintaining ideal growth conditions for plants throughout the day.

※ **Educational AI & Mechatronics Platforms:**
This project serves as a practical example for students to understand the integration of artificial intelligence and mechatronics. It involves sensor data acquisition, API-based decision-making, and control actuation□all of which are essential components in multidisciplinary engineering education.

2.3 Model Circuit Schematic

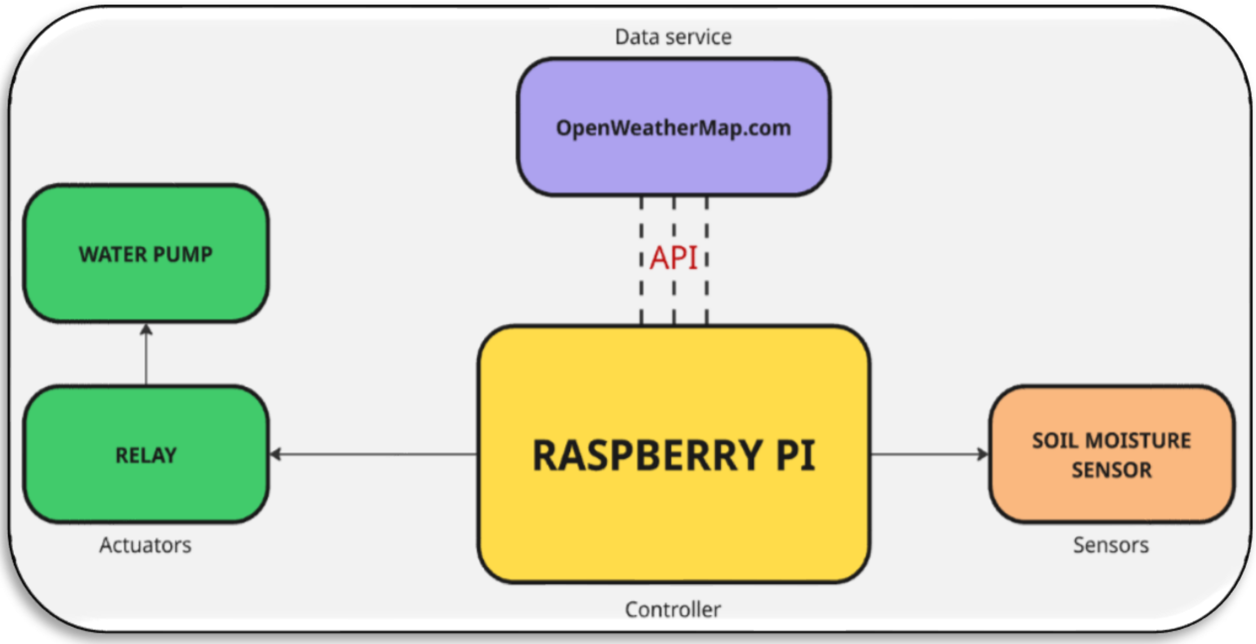

Figure2. System Schematic

2.4. Operation Algorithm

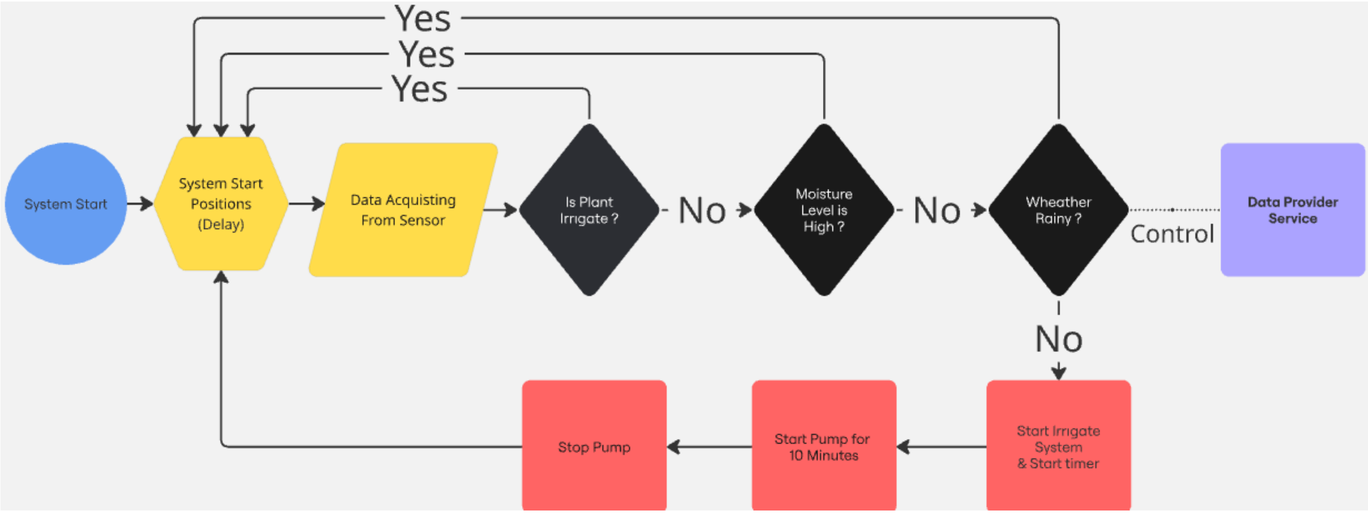

Figure 3. System Operation Algorithm

2.5. ARTIFICIAL INTELLIGENCE AND INTELLIGENT SYSTEM FEATURES

While this project does not implement a machine learning algorithm, it incorporates a basic rule-based intelligent control system using sensor data and real-time weather information. The decision-making is performed through conditional logic (if-else), which evaluates soil moisture status and weather conditions retrieved from the OpenWeatherMap API.

The system performs the following intelligent operations:

- Environmental awareness: The system checks if the soil is dry and if there is no rain expected before activating the pump, avoiding unnecessary watering.
- Sensor-actuator feedback loop: Soil condition is monitored using a digital moisture sensor, and the water pump is actuated accordingly via GPIO-controlled relay.
- External data integration: Weather conditions such as rainfall, temperature, and humidity are continuously fetched from an online API, enhancing decision precision.

These elements demonstrate an intelligent behavior pattern, where the system adapts its actions based on dynamic internal (sensor) and external (weather) inputs—without requiring user intervention. Though simple in structure, this forms the basis of a context-aware, autonomous mechatronic system as targeted by the course objectives.

2.6. System Codes

The system is implemented in Python and runs on a Raspberry Pi platform. It utilizes the RPi.GPIO library for hardware control and the requests library to access real-time weather data via the OpenWeatherMap API. The code continuously monitors soil moisture and environmental conditions to make autonomous irrigation decisions based on predefined logic.

```
import time
import requests
import RPi.GPIO as GPIO

# GPIO pin setup
SOIL_MOISTURE_PIN = 18
RELAY_PIN = 17
GPIO.setmode(GPIO.BCM)
GPIO.setup(SOIL_MOISTURE_PIN, GPIO.IN)
GPIO.setup(RELAY_PIN, GPIO.OUT)
GPIO.output(RELAY_PIN, GPIO.HIGH)

# OpenWeatherMap setup
API_KEY = 'de7ecd2a916df77f88a4e3b5c8ab5eec'
CITY = 'KONYA'
WEATHER_API_URL =
f"http://api.openweathermap.org/data/2.5/weather?q={CITY}&appid={API_KEY}&units=metric"

def get_weather_data():
    try:
        response = requests.get(WEATHER_API_URL)
        data = response.json()
        rain = (data['weather'][0]['main'] == 'Rain')
        temp = data['main']['temp']
        humidity = data['main']['humidity']
        return rain, temp, humidity
    except Exception as e:
        print(f"Weather data error: {e}")
        return False, None, None

try:
    while True:
        soil_moisture = GPIO.input(SOIL_MOISTURE_PIN)
        print(f"Soil Moisture Level: {'Wet' if soil_moisture == GPIO.HIGH else 'Dry'}")

        rain, temp, humidity = get_weather_data()
        print(f"Rain: {rain}, Temp: {temp}C, Humidity: {humidity}%")

        if soil_moisture == GPIO.LOW and not rain:
            GPIO.output(RELAY_PIN, GPIO.LOW)
            print("Pump ON")
        else:
            GPIO.output(RELAY_PIN, GPIO.HIGH)
            print("Pump OFF")

        time.sleep(600)

except KeyboardInterrupt:
    print("Program interrupted")
    GPIO.cleanup()
```

3 REFERENCES

Raspberry Pi GPIO Documentation:

- Raspberry Pi Official Documentation: https://www.raspberrypi.com/documentation/:contentReference[oaicite:5]{index=5}
- RPi.GPIO Python Package (PyPI): https://pypi.org/project/RPi.GPIO/:contentReference[oaicite:10]{index=10}
- RPi.GPIO Examples and Wiki: http://sourceforge.net/p/raspberry-gpio-python/wiki/Examples/Raspberry Pi Stack Exchange+1forums.raspberrypi.com+1

OpenWeatherMap API Documentation:

- OpenWeatherMap API Overview: https://openweathermap.org/api
- One Call API 3.0 Documentation: https://openweathermap.org/api/one-call-3Howto Raspberry Pi+3openweathermap.org+3openweathermap.org+3
- Getting Started with OpenWeather API: https://docs.openweather.co.uk/appidFinancial Times+4docs.openweather.co.uk+4Raspberry Pi Stack Exchange+4

Articles on Smart Agriculture and AI-based Irrigation Systems:

- A novel autonomous irrigation system for smart agriculture using AI and 6G-enabled IoT: https://www.sciencedirect.com/science/article/pii/S0141933123001497ScienceDirect+1ScienceDirect+1
- Integrating Artificial Intelligence into an Automated Irrigation System: https://www.mdpi.com/1424-8220/25/4/1199MDPI
- Smart Irrigation Systems in Agriculture: A Systematic Review: https://www.researchgate.net/publication/367392753_Smart_Irrigation_Systems_in_Agriculture_A_Systematic_Review:contentReference[oaicite:57]{index=57}
- Smart Irrigation: How High-Tech Watering Systems are Changing Agriculture: https://forwardfooding.com/blog/foodtech-trends-and-insights/water-tech-smart-irrigation-technologies-for-sustainable-agriculture/:contentReference[oaicite:62]{index=62}