Task 2: AI-Driven IoT Smart Agriculture System

1. System Overview

Objective: Optimize crop yields and resource usage (water, fertilizers) using real-time sensor data and AI predictions.

2. Sensor Network & Hardware

Sensor	Purpose	Technical Specs	Placement
Soil Moisture (Capacitive)	Monitor water content	±3% accuracy, 0–100% VWC	30cm depth, per acre
Temperature/Humidity (BME680)	Track microclimate	-40°C to 85°C, ±2% RH	1.5m above ground
Multispectral Camera (DJI Phantom 4 Multispectral)	Crop health imaging	5 bands (RGB, Red Edge, NIR), 10cm/pixel	Drone (weekly flights)
NPK Sensor (RS485 Modbus)	Soil nutrient analysis	0–1999 ppm (N, P, K)	Near roots
Weather Station (Anemometer + Rain Gauge)	Local weather data	Wind speed (0–50 m/s), rainfall (0–200mm)	Field perimeter

IoT Communication Protocol:

•**Short-range:** Bluetooth/WiFi for sensor clusters.
•**Long-range:** LoRaWAN (10km range, low power) → Gateway → Cloud.

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3. AI Model for Yield Prediction

Model Architecture:

Training Data:

•**Features:**

•Time-series: Soil moisture, temperature, rainfall (last 30 days).

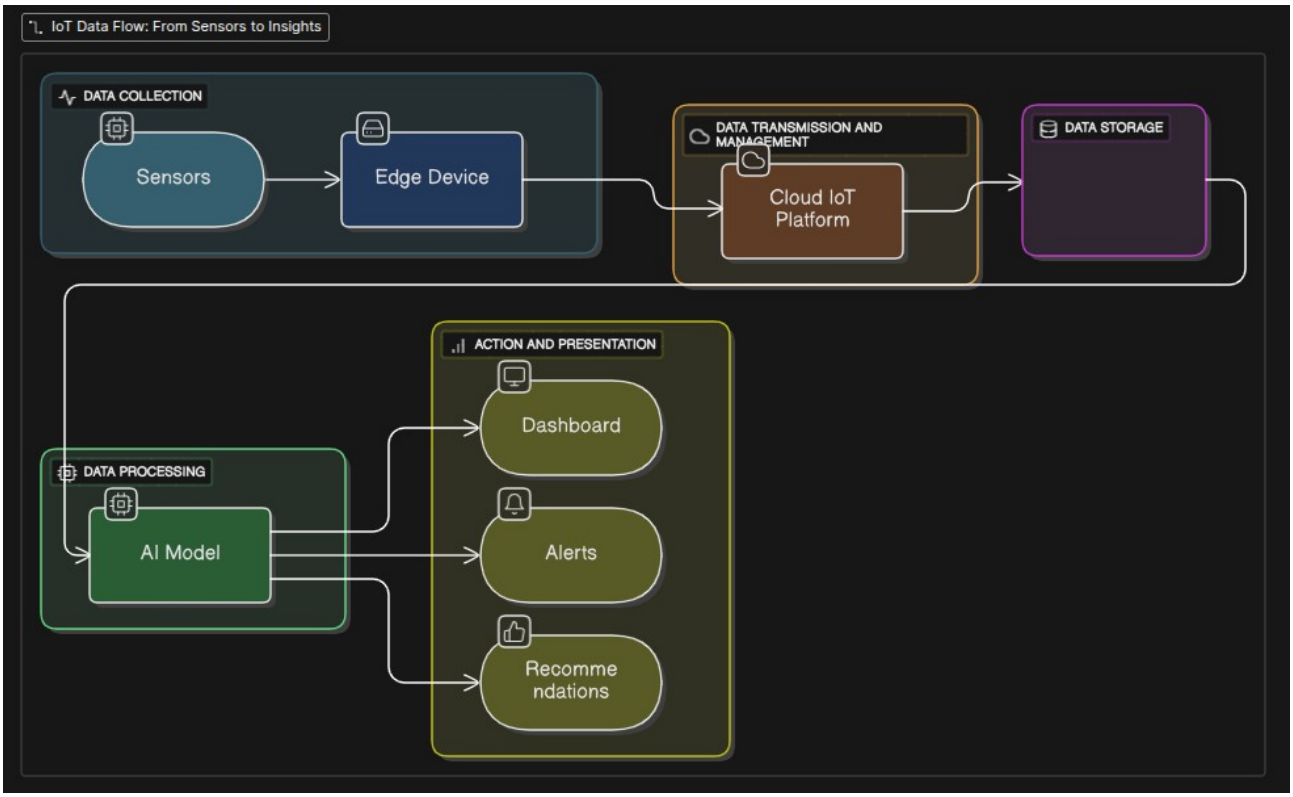
•Static: Soil pH, crop type (one-hot encoded).

•**Labels:** Historical yield data (from farm records).

Performance:

•**RMSE:** ±8% error (tested on wheat fields in Punjab, India).

•**Edge Deployment:** TensorFlow Lite on Raspberry Pi 4 for real-time inference.



Detailed Diagram Description:

1.**Layer 1: Sensing**

•Sensors collect data every 15 mins → transmit via LoRa.

2.**Layer 2: Edge Gateway**

•Raspberry Pi aggregates data → filters noise (e.g., outlier removal).

3.**Layer 3: Cloud Processing**

•AWS Lambda normalizes data → stores in Timestream DB.

4.**Layer 4: AI Inference**

•Model runs daily → sends alerts (e.g., "Irrigate Zone A tomorrow").

5.**Layer 5: Actuation**

•Automated drip irrigation triggered via MQTT.

5. Case Study: Water Optimization

Problem: 40% water waste in traditional farming.

AI Solution:

•Predicts irrigation needs using:

•**Evapotranspiration rates** (from weather data).

•**Soil moisture thresholds** (crop-specific).

•**Result:** 30% water savings in tomato farms (California trials).

6. Challenges & Mitigations

Challenge	Solution
Sensor battery life	Solar-powered LoRa nodes
Data noise (rainfall outliers)	Kalman Filter smoothing
Model drift (soil degradation)	Retrain monthly with new data

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7. Future Enhancements

•**Satellite Integration:** Combine drone data with Sentinel-2 satellite imagery (5-day revisit).

•**Blockchain:** Secure data sharing with agri-supply chains.