**Real Time Soil Monitoring System**Project Overview  
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1. **Objective**

The primary goal of this project is to design and implement a real-time soil monitoring system. This system will use sensors and machine learning models to provide farmers with actionable insights, improving irrigation and fertilization practices, and ultimately enhancing crop yield, resource optimization, and sustainability.

1. **Components**

* **Edge Device:** Microcontrollers (e.g., Raspberry Pi, Arduino)

Host Sensors and perform basic preprocessing task, Real – time data collection from site.

* **Sensors**
* *Soil Moisture Sensor:* Measures the volumetric water content in the soil to help monitor irrigation requirements.
* *pH Sensor:* Tracks the acidity or alkalinity levels of the soil, which are critical for nutrient absorption and crop health.
* *Nutrient Sensor:* Detects essential nutrient levels like nitrogen (N), phosphorus (P), and potassium (K), essential for determining soil fertility.
* **Machine Learning Models**
* The model will use the collected sensor data to make predictions about soil health, irrigation timing, and nutrient levels.
* It will be trained on historical soil data and deployed on the edge device for local predictions.

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| Task | Models |
| Predicting Soil Moisture | Linear Regression, Random Forest Regressor |
| Classifying Soil Health | Logistic Regression, SVM, Gradient Boosting |
| Clustering Soil Conditions | K-Means, DBSCAN |
| Anomaly Detection | Isolation Forest, Autoencoders |
| Time-Series Prediction | |  | | --- | |  |  |  | | --- | | LSTM, ARIMA, Prophet | |

* **Communication Module:** Data transmission from the edge device to a central server or cloud will be achieved via Wi-Fi or long-range communication protocols like LoRa.
* **Dashboard:** A web or mobile application will provide farmers with an intuitive interface to visualize real-time data, track historical trends, and receive actionable recommendations.

1. **Core Features**

* **Real-time Monitoring:** Continuous data collection and monitoring from sensors deployed in the field.
* **Local Processing:** Data preprocessing and immediate analysis on the edge device to reduce latency.
* **Machine Learning Insights:** Recommendations for irrigation and fertilization are generated based on predictive models.
* **Alerts:** Immediate notifications for critical conditions like drought or nutrient deficiency.
* **Data Storage and Analysis:** Optional integration with cloud services for storing historical data and performing advanced analytics.

1. **Work Process**

* **Step 1: Data Collection**

Sensors collect real-time data on moisture, pH, and nutrient levels.

The edge device aggregates and transmits these readings for further analysis.

* **Step 2: Data Preprocessing**

Noise and outlier removal from raw sensor data.

Normalization ensures consistent interpretation across varying sensor inputs.

* **Step 3: Model Deployment**

The machine learning model is trained on offline datasets containing historical soil data.

This model is then deployed on the edge device for real-time predictions.

* **Step 4: Real-Time Feedback**

Edge devices analyse sensor data and provide immediate recommendations.

Farmers receive alerts and insights through a mobile app or visual indicators.

* **Step 5: Cloud Integration (Optional)**

Data is transmitted to a central cloud server for storage and advanced analytics.

Historical trends and in-depth insights are visualized on the dashboard.

* **Step 6: Farmer Actions**

Farmers adjust irrigation and fertilization schedules based on the provided recommendations.

1. **Estimate Hardware Cost**

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| Components | Cost / Unit | Notes |
| Arduino | 1500 – 2000 | Arduino is cost-effective for prototyping. |
| Rasbery Pi | 4049 – 8299 | Basic versions are sufficient for testing. |
| Soil Moisture Sensor | 300 – 600 | Basic versions are sufficient for testing. |
| pH Sensor | 1000 – 1800 | Affordable sensors are available online. |
| Nutrient Sensor\* | 1500 – 3000 | Can be simplified if nutrient analysis isn't core. |
| Power Supply (Batter/Adapter) | 500 – 1000 | Rechargeable batteries or adapters. |
| Communication Module  (ESP8266 Wi-Fi) | 400 – 1000 | Low-cost modules are suitable for academic use. |
| Cables, Breadboards etc. | 1000 – 1500 | Basic Supply |

Research Paper Cites  
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