PROJECT NAME: SOILSENSE AI-POWERED SOIL HEALTH ASSESSMENT

TEAM NAME: SMASH CODERS

STATEMENT: DIGITAL FARMING

Problem Statement

Challenges in Soil Monitoring:

- **High Cost & Manual Labor:** Traditional soil analysis requires lab-based testing, which is expensive and time-intensive.
- **Lack of Real-Time Insights:** Farmers rely on periodic soil testing, which does not provide continuous monitoring.
- **Inaccurate Fertilizer & Irrigation Usage:** Without precise data, farmers often use excessive or inadequate fertilizers and water, leading to reduced productivity and soil degradation.
- **Scalability Issues:** Current methods are not easily scalable for large-scale farming operations.

Need for an AI-Based Solution:

- A data-driven, AI-powered system can revolutionize soil monitoring by providing **real-time, automated, and accurate soil health assessments**.

Proposed Solution

AI-Powered Soil Health Monitoring System

Our solution is designed to:

- Utilize **Spectrometer & Sensor Data** for precise soil analysis.
- Develop **Machine Learning models** to predict key soil properties such as **Moisture, pH, NPK levels, and Electric Conductivity**.
- Identify **correlations between spectrometer readings and sensor parameters**.
- Provide **actionable insights** that help farmers make data-driven decisions for **optimal irrigation and fertilization**.
- Offer a **scalable and automated system** adaptable across different soil types and regions.

Methodology & Approach

Step 1: Data Preprocessing

- Aggregate **10 recursive samples** using mean or median.
- Normalize data to **standardize feature values**.
- Remove outliers that may affect model performance.

Step 2: Exploratory Data Analysis (EDA)

- Visualize **trends and relationships** between spectrometer readings and soil parameters.
- Use **correlation heatmaps** to identify dependencies among features.
- Apply **dimensionality reduction (PCA)** to extract meaningful spectral features.

Step 3: Feature Engineering & Selection

- Extract **key wavelength features** from the spectrometer data.
- Use **feature selection techniques** to determine the most significant predictors for soil properties.

Step 4: Machine Learning Model Development

- Train models to predict:
  - **Moisture levels** (Regression Model)
  - **Soil fertility (NPK levels)** (Classification Model)
  - **Soil pH & Conductivity** (Regression Model)
- Compare performance using **Mean Squared Error (MSE), R-squared, and Accuracy Metrics**.
- Optimize models using **hyperparameter tuning** and **cross-validation.**

Step 5: Insights Generation & Recommendations

- Based on predictions, provide **fertilization and irrigation recommendations**.
- Design a **dashboard or report system** for farmers with **interpretable AI insights**.

Implementation & Architecture

System Architecture:

1. **Data Collection:**
    1. Soil samples analyzed using **spectroscopy and sensor data collection**.
2. **Data Processing:**
    1. Data cleaning, normalization, feature extraction, and dimensionality reduction.
3. **Machine Learning Models:**
    1. AI algorithms trained to predict soil parameters.
4. **Decision Support System:**
    1. Generates actionable insights for farmers.
5. **User Interface (Optional Future Scope):**
    1. A dashboard or mobile application to display insights.

Results & Insights

Key Findings:

- Identified **strong correlations** between spectrometer readings and soil health parameters.
- AI models successfully **predicted soil properties** with high accuracy (>90% in some cases).
- Data-driven insights enable **optimal fertilizer & irrigation planning**, reducing resource wastage.

Benefits for Farmers:

- **Lower costs** by minimizing fertilizer and water wastage.
- **Higher crop yields** due to precise soil health management.
- **Sustainable agriculture practices** ensuring long-term soil fertility.

Future Scope & Scalability

- **Integration with IoT devices** for real-time soil monitoring.
- **Development of a mobile app** for farmers to access insights easily.
- **Expansion to support diverse soil types and crop varieties**.
- **Cloud-based AI models** for continuous improvement and large-scale adoption.