Project Title：AI-Based Fertilizer Composition Recommendation for Soil Types

Name: Aditya Dadhich Roll No:220107100

---

1. Introduction

- Agriculture is a major consumer of chemical fertilizers, where overuse or underuse of nitrogen (N), phosphorus (P), and potassium (K) can lead to poor yield and soil degradation.
- Traditional fertilizer recommendations are often generic and not optimized for specific soil types or crop requirements.
- AI and ML techniques can optimize fertilizer usage by recommending ideal NPK ratios based on real-time soil data and crop types.

---

2. Objectives

- Develop a machine learning model that recommends optimal NPK values for given soil compositions.
- Compare various ML models like Random Forest, XGBoost, and Neural Networks for recommendation performance.
- Build a user-friendly dashboard for real-time fertilizer recommendation based on soil inputs.

---

3. Problem Statement

“To design a machine learning-based recommendation system that predicts optimal NPK fertilizer compositions for various soil types to improve crop yield and minimize environmental harm.”

---

4. Significance of the Study

- Encourages sustainable agriculture with minimal chemical runoff.
- Helps farmers apply precise fertilizer quantities, reducing cost and boosting productivity.
- Improves soil health monitoring and long-term land use planning.

---

5. Data Description and Preprocessing

- **Source:** Kaggle’s Crop Recommendation Dataset (https://www.kaggle.com/datasets/atharvaingle/crop-recommendation-dataset?resource=download)
- **Features:** N, P, K, temperature, humidity, pH, rainfall
- **Target (can be transformed):** Crop type → Translate to required NPK values based on literature
- **Steps:**
    - Normalize input features
    - One-hot encode crop types (if used)

    - Group crops based on similar NPK needs
    - Handle missing values and outliers

---

7. Model Selection & Rationale

- **Random Forest & XGBoost:** Handle tabular data well and capture nonlinearities.
- **Neural Networks (MLP):** For deeper patterns if the dataset is large enough.
- **K-Means Clustering:** To group crops/soil types into similar nutrient need clusters (optional enhancement).

---

8. Model Training & Validation

- Train/test split (80/20)
- K-Fold cross-validation
- Hyperparameter tuning using Random Search/Grid Search
- Evaluation using MAE/RMSE for NPK prediction

---

9. Evaluation Metrics

- **MAE** (Mean Absolute Error)

- **RMSE** (Root Mean Squared Error)
- **R^2 Score** for regression performance

---

10. Deployment Strategy

- Flask/FastAPI-based backend
- Web dashboard using React or Streamlit
- Allow user input of soil features → Output NPK values with dosage
- Dashboard for engineers with performance visualization (UI/UX).

---

11. Tools and Libraries Used

- **Pandas, NumPy, Scikit-learn**: Data processing and modeling
- **NumPy, Pandas**: For data manipulation.
- **TensorFlow/PyTorch (optional)**: For neural network implementation.
- **Streamlit/Flask**: For deployment.
- **Matplotlib/Seaborn**: Visualizations.

---

12. Scalability and Optimization

- Save trained model with joblib/pickle
- Enable batch predictions via API
- Future integration: IoT sensor input from farms

---

13. Use Case in Chemical Engineering

- Data-driven formulation of chemical fertilizers
- Chemical optimization of NPK products for crop-soil combos
- Real-time quality control of soil enrichment processes

---

14. Expected Impact

- Reduces fertilizer waste and pollution
- Promotes eco-friendly farming
- Boosts crop yield and lowers input cost

---

15. Conclusion

- AI offers a revolutionary way to personalize fertilizer recommendations.
- With accessible datasets and open-source ML tools, chemical engineers can bridge AI with sustainable agriculture.
- Future work includes live sensor integration and expanding to micronutrient recommendations.