**Intelligent Crop Planning and Management using ML**

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CSIS 4495: Applied Research Project

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Agricultural productivity is heavily influenced by environmental conditions such as soil health and weather patterns. Farmers often struggle with selecting the optimal crops to cultivate based on real-time conditions. This project aims to build a machine learning-powered recommendation system that suggests the most suitable crops based on land area, location, soil conditions, and weather data. The system will also predict the time required from sowing to harvesting and the system will recommend suitable crops based on a user's land and location and offer continuous guidance throughout the crop growth cycle. By using real-time weather and soil APIs and predictive analytics, this project aims to enhance decision-making in agriculture, improving yield predictions.

With the availability of real-time weather, soil, and UV index data, the system will enable data-driven decision-making and predictive analytics for improved agricultural outcomes. Current farm management practices often only rely on manual monitoring and historical trends, which can lead to manual errors or not an optimal resource utilization. With the availability of real-time weather, soil, and UV index data, this system will improve agricultural outcomes.

**Problem Statement**

Farmers often struggle to determine the most suitable crops for their land, given fluctuating soil conditions, weather patterns, and climate change. Additionally, they lack real-time insights into when to irrigate and when to expect harvest readiness. The absence of a structured decision-support system results in inefficient resource utilization, reduced crop yields, and financial losses. This research aims to address the following key questions:

1. How can real-time soil and weather data be used to recommend the best crops for a given land area?
2. How can machine learning models predict the duration from sowing to harvest for different crops?
3. How can a weekly advisory system provide farmers with updates on irrigation and crop management actions based on real-time data?

**Limitations Addressed in the Research**

Previous research has demonstrated the use of remote sensing, soil analysis, and weather forecasting in precision agriculture. These studies have explored various machine learning models for crop prediction, including Decision Trees, Random Forests, etc. However, many of these models rely only on historical datasets and do not leverage real-time environmental data for continuous decision-making. Furthermore, existing solutions often require expensive IoT-based soil sensors, making them inaccessible to small-scale farmers. This research aims to bridge this gap by using real-time API-based soil and weather data to provide crop recommendations and without requiring physical sensor installations.

**Hypothesis and Assumptions**

There are two hypotheses for this project:

1. Hypothesis 1: Real-time soil moisture, temperature, and weather data can accurately predict the best crops for a specific location.
2. Hypothesis 2: Machine learning models can accurately estimate sowing-to-harvest time with high accuracy based on environmental conditions.

This research project assumes that the farmers will be able to accurately input their location and the data provided by APIs like soil moisture, temperature, and weather data is real-time and accurate.

**Proposed Research Project**

**Research Design and Objectives**

This research aims to develop an AI-driven crop recommendation and farm management system that helps farmers make data-driven decisions based on real-time weather and soil conditions. In this, machine learning models analyze environmental parameters to generate insights. The study will focus on developing a web-based platform where farmers can input their details and receive dynamic recommendations. The system will use machine learning models to recommend the best crops for a given land area and location. It will also estimate the time from sowing to harvesting. In addition to this, the farmers will get weekly management updates based on live API data. The weekly updates include notification based on irrigation needs, extreme weather alerts, and harvesting time. The primary objective is to enhance agricultural productivity and optimize farm management practices.

**Methodology and Justification**

The research methodology involves data collection, model training, and system deployment. Real-time and historical data from weather and soil APIs will be used to train various predictive models. The justification for this approach is based on past studies that have shown the impact of data-driven decision-making in agriculture, leading to improved yields and resource efficiency. The use of artificial intelligence and real-time data integration addresses existing gaps in traditional farming methods, which often rely on outdated or generalized information.

**Data Collection and Analysis**

The data collection process will rely on APIs providing real-time weather, soil, and UV index data. Data will be cleaned and processed before being used to train machine learning models. The system will analyze patterns in temperature, soil moisture, and weather conditions to generate crop recommendations. The data sources include:

1. ***Weather Data:*** Sourced from OpenWeather API, which provides real-time temperature, humidity, precipitation, and UV index details.
2. ***Soil Data:*** Fetched from AgroAPI which is also from OpenWeather, offering insights into soil moisture, temperature, and other key parameters.
3. ***Historical Data:*** Kaggle-based agricultural datasets will be used to train predictive models.
4. ***User Inputs:*** Land area, location, and crop of choice will be gathered through the web interface and entered by the user.

**Technologies Used**

1. ***Operating System:*** The system will be deployed on AWS EC2 (Ubuntu Linux) for scalability and cloud access.
2. ***Programming Language:*** Python will be the core programming language for data processing and machine learning.
3. ***Frameworks:*** Flask will be used for frontend development.
4. ***Database:*** AWS S3 for storing user data.

**Project Planning & Timeline**

***Gantt Chart***

***A graph of a project

Description automatically generated with medium confidence***

**Detailed Project Timeline**

1. **Week 1&2:** In the first two weeks, the focus is on finalizing the project idea and writing the project proposal. This involves identifying the research objectives, methodologies, and expected outcomes.
2. **Week 3:** Make the proposal ready for submission and experiment with the APIs.
3. **Week 4:** It involves analyzing the APIs (OpenWeather and AgroAPI) and to grasp a full understanding of the data to be used and designing the architecture of the project. Key deliverables include the project structure and backend architecture diagram.
4. **Week 5:** The focus of this phase is on integrating real-time APIs into the backend and displaying data on the user interface. This also includes making a form/input interface for the user to add their location and preferences and to ensure that the front end is functioning.
5. **Week 6-8:** In this phase, machine learning models are trained to recommend the best crops and predict sowing-to-harvest time. Historical datasets from Kaggle and real-time data are utilized for training. The deliverable work is a working set of trained models.
6. **Week 9-10:** Make the dynamic weekly recommendations and alerts based on real-time data. This includes irrigation needs, extreme weather alerts, and crop management suggestions. To enhance usability of the web app, add interactive visualizations on weather and soil data.
7. **Week 11:** Once the app is ready and functioning, deploy it to an AWS. This involves testing the application is live.
8. **Week 12:** Finish the project documentation and work log.

**Project Contract**

I, Harinder Kaur, agree to undertake and complete the research project titled ‘Intelligent Crop Planning and Management Using Machine Learning’ within the timelines and scope defined in the project proposal.