Capstone Project Concept Note and Implementation Plan

Project Title: Smart Irrigation

Team Members

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Concept Note

1. Project Overview

This project aims to develop a machine learning-based smart irrigation system that predicts the optimal frequency of watering for crops. The system will analyze environmental data (such as soil moisture, weather conditions, and crop type) to ensure that crops receive the right amount of water, thereby conserving water resources and improving crop yield. This project aligns with **SDG 6: Clean Water and Sanitation** by promoting efficient water use in agriculture..

2. Objectives

- Develop a predictive model to determine the optimal watering schedule for various crops.
- Integrate IoT sensors to collect real-time data on soil moisture and weather conditions.
- Implement a smart irrigation system that autonomously adjusts watering schedules based on model predictions.
- Reduce water consumption in agriculture while maintaining or improving crop yields.

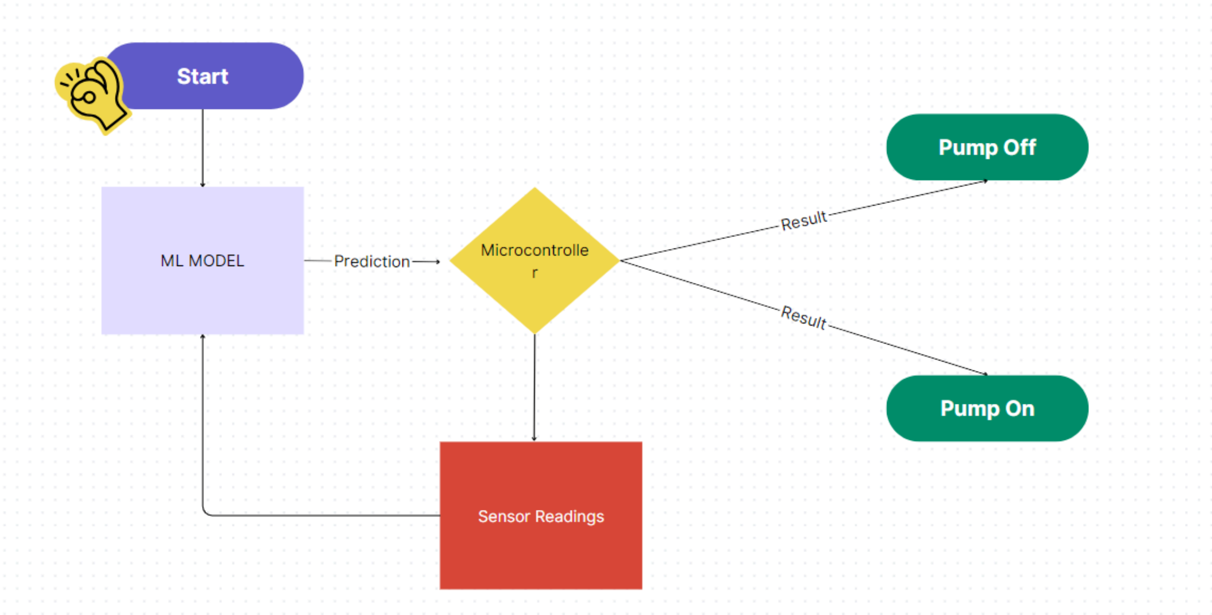
3. Background

The overwatering or underwatering caused by current irrigation techniques can waste water and be detrimental to crop health. Timer-based systems are one type of existing technology that cannot adjust to changing environmental conditions. Using real-time data, a machine learning approach can dynamically modify irrigation schedules, offering a more sustainable and effective solution.

4. Methodology

The project will utilize supervised learning algorithm (classification) to predict the optimal watering schedule. The model will be trained on historical data, including soil moisture levels, nitrogen,phosphorous, potassium content in the soil, temperature, humidity,soil PH level,crop type, soil type, sunlight exposure and crop-specific watering needs etc. Real-time data from IoT sensors will be fed into the model to continuously update the predictions.

5. Architecture Design Diagram



1. Microcontroller (IoT device): The source of sensor data (e.g., temperature, humidity, light, etc.).
2. Data Transfer Layer: Using wifi module(with ESP8266/ESP32) to communicate with the ML model
3. Server: Host of the ML model
4. Pre-trained ML model: Processes the incoming data and provides a prediction
5. Prediction: The prediction by the ML model is then sent to the microcontroller which then processes this input and determines whether to turn on / off the pump.

6. Data Sources

The data used in smart irrigation systems typically include soil moisture levels, weather data (e.g., temperature, humidity, rainfall), and crop-specific information.The Smart Farming 2024 (SF24) dataset is a comprehensive collection of agricultural data gathered from various farms across California, designed to enhance crop health monitoring and environmental stress assessment.

7. Literature Review

Recent studies have focused on developing intelligent irrigation systems using IoT and machine learning to optimize water usage in agriculture. Khalil Ibrahim Mohammad Abuzanouneh et al. introduced a novel IoT-ML-based Smart Irrigation System (IoTML-SIS), which involves data collection through sensors, classification using LS-SVM to determine water needs, and optimization of the model's parameters via AAA for improved accuracy. The system outperforms other approaches based on various evaluation metrics. Similarly, Ahmet A. Esmail et al. proposed a smart irrigation system that leverages machine learning, data analysis, and IoT to optimize irrigation scheduling. Their system uses a dataset from Kaggle, "Crop Irrigation Scheduling," with six key attributes: temperature, humidity, irrigation, crop type, crop days, and soil moisture, providing critical data for precise irrigation control.

Implementation Plan

1. Technology Stack:

- **Programming Languages:** Python, R
- **Libraries:** TensorFlow, scikit-learn, Pandas, NumPy
- **Frameworks:** Flask for web-based control systems, TensorFlow for ML model deployment
- **Hardware:** IoT sensors (soil moisture sensors, weather stations), microcontrollers (Arduino or Raspberry Pi)
- **Other Tools:** AWS or Google Cloud for cloud computing and storage, Docker for containerization

2. Timeline:

- **Data Collection and Preprocessing:** Week 1
- **Model Development:** Week 2
- **Training and Evaluation:** Weeks 2-3
- **Deployment:** Weeks 3-4

3. Milestones:

- Completion of data collection and preprocessing
- Successful development and validation of the predictive model
- Integration of the predictive model with the irrigation control system

- Full deployment of the smart irrigation system in a test field

4. Challenges and Mitigations:

- **Data Quality:** Ensure that the IoT sensors are calibrated correctly and that data preprocessing includes rigorous cleaning and validation.
- **Model Performance:** Use cross-validation and hyperparameter tuning to optimize model accuracy and reliability.
- **Technical Constraints:** Choose cost-effective and scalable IoT hardware to ensure that the system can be deployed widely.

5. Ethical Considerations

The project will address data privacy concerns by anonymizing data collected from the field. Additionally, the system will be designed to minimize any potential negative impact on the local ecosystem by ensuring that the model's predictions do not lead to over-irrigation.

6. References

(PDF) Smart irrigation system using IoT and machine learning methods (researchgate.net)

TSP_CMC_22648.pdf (techscience.cn)