Advanced IoT Solutions for Plant Growth Monitoring: A Comparative Analysis of Machine Learning Approaches

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Introduction

- Advancement of IoT technology encourages **IoT-based Agriculture**.
- Today's Agriculture industry is **data-centered, Advanced and smarter** than ever.
- Smart Agriculture moved the industry from **statistical to a quantitative** approach.

Objective

- Monitor plant growth using **Machine Learning (ML) and predict plant growth** patterns.
  - Integrate and analyze ML models for data collected from IoT devices and predict plant health and growth.
  - Access the performance of several IoT communication protocol LoRa in terms of data transmission, dependability and energy efficiency.

Methodology

Data Collection :Sensor Deployment: Various sensors such as temperature, humidity, light intensity, soil moisture, and pH sensors are deployed across the plant growth environment.
Data Logging: Sensor data including real-time measurements and timestamps are logged regularly to capture the plant growth conditions accurately.

Results and Discussion

ML classifiers	Accuracy achieved
Support Vector Machine (SVM)	99.96%
Naïve Bayes	99.91%
Decision Trees	99.91%
K-Nearest Neighbors	98.99%

Table 1: Accuracy against ML classifiers

Table 1 summarizes the accuracy achieved against ML classifiers experimented in out study. We have observed that **Support Vector Machine (SVM) performed best** from other classifiers such as Naïve Bayes, Decision trees and K-Nearest Neighbors.

2. Data Preprocessing :Data Cleaning: Removing outliers, handling missing values, and ensuring data consistency. Normalization: Scaling the sensor data to a common range to improve model performance.. **3. Feature Engineering**
Feature Selection: Identifying relevant features that impact plant growth and discarding irrelevant ones.
Feature Transformation: Creating new features based on domain knowledge to enhance model interpretability.
4. Model Development :Baseline Models: Implementing traditional machine learning models like Random Forest, Support Vector Machines, and K-Nearest Neighbors for comparison.

- 5. Model Training and Evaluation
- **Training: Splitting the data into training and validation sets for model training.**
- **Hyperparameter Tuning: Optimizing model hyperparameters using techniques like grid search or random search.**
- **Evaluation Metrics: Using metrics like Mean Squared Error, Accuracy, Precision, Recall, and F1 Score to evaluate model performance.**

6. Comparative Analysis

- **Performance Metrics Comparison**: Comparing the performance of different models based on evaluation metrics. **Scalability Analysis**: Evaluating the scalability of models concerning the size of the dataset and computational resources required.

7. Deployment

Real-time Monitoring System: Implementing a real-time monitoring system for plant growth based on the selected model.

Integration with IoT Platforms: Integrating the model with IoT platforms for seamless data transmission and analysis.

User Interface Development: Creating a user-friendly interface for users to visualize plant growth metrics and receive alerts.

8. Maintenance and Updates

Model Maintenance: Regularly updating the model with new data to ensure its relevance.

Software Updates: Updating the monitoring system and IoT devices to incorporate new features and enhance system performance.

9. Ethical Considerations

Data Privacy: Ensuring the privacy and security of collected data.

Transparency: Providing transparency in model decisions and recommendations.

Bias Mitigation: Addressing biases that might arise in the data or models used.

Objectives : **Evaluate Model Performance**: Assess the effectiveness of various machine learning approaches in accurately monitoring and predicting plant growth conditions based on sensor data. **Identify Optimal Model**: Determine the most suitable machine learning model for real-time plant growth monitoring that balances accuracy, scalability, and computational efficiency.

Enable Real-time Monitoring: Develop a robust system capable of continuous real-time monitoring of plant growth parameters using IoT sensors and machine learning algorithms. **Decision-making**: Provide actionable insights to farmers, researchers, and stakeholders to optimize plant growth strategies, resource allocation, and overall productivity. **Ensure System Reliability:** Establish a reliable and robust monitoring system that can operate seamlessly in diverse environmental conditions and handle fluctuations in sensor data.