Smart Agrotech: A Machine Learning based Irrigation Management System using IoT

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Abstract

The basis of sustainable agriculture is efficient water management, especially in regions which are affected by water scarcity or erratic rainfall. In recent times, new technologies such as the Internet of Things (IoT), machine learning (ML), and edge computing, have emerged which have shown the greatest potential to change traditional irrigation practices into intelligent data-driven. This research work proposes a comprehensive Smart Agrotech system that will use a hybrid architecture of cloud and edge computing, a next- generation sensor network, and real time algorithms for optimization of irrigation scheduling and consumption of water. Various environmental sensors are used for continuously obtaining data related to soil moisture, temperature, humidity, and local weather conditions. These streams are processed at the edge for immediate decision-making, while some of them are sent to the cloud for long-term trend analysis and model updates. Convolutional Neural Networks and Logistic Regression to recognize patterns in sensor data using binary irrigation decisions (irrigate or not irrigate) provide the system an intelligent adaptive response to altering environmental factors. This pair of models together gives quite high accuracy on judging the timing and amount of irrigation. Further, this research focuses much on developing synergies between cloud computing for large-scale data analytics and edge computing to enhance latency and real time responsiveness. A simple framework that can be scaled and modularized is presented as a proof of concept for the above features in the adaptation of the Smart Agrotech system to types of crops, geographic settings, and sizes of fields. Performance evaluation of both simulated and field agricultural experiments have shown significant improvements in water-use efficiency and crop yield as well as system responsiveness compared to traditional irrigation systems. The experimental work has perfunctory significance in the huge fast-growing field of precision agriculture, as it provides a reliable, scalable, and intelligent solution for optimizing water resources. The system might be dedicated to immediate irrigation purposes but would work closely with sustainability and resilience of farming operations into the longer term through continual learning and adaptation. "Performance evaluation of the Smart Agrotech system is reported on precision, recall, accuracy, and F1-score metrics." The analysis reveals that LR attained 91.3%, and CNN-based deep learning models delivered the highest accuracy at 98.4%. Among all, CNN outperforms with its superior prediction capability, ensuring precise irrigation scheduling based on real- time soil moisture, weather, and crop data. The integration of IoT sensors and machine learning empowers farmers to make timely, data-driven irrigation decisions, significantly improving water conservation and crop productivity across different agricultural environments.

Keywords

Irrigation Optimization, Water Management, Edge Computing, Cloud Computing, IoT Sensors, Machine Learning, Convolutional Neural Networks (CNN), Logistic Regression, Real-time Decision Making, Soil Moisture Monitoring, Sustainable Agriculture.