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A MACHINE LEARNING AND INTERNET OF THINGS-BASED SMART IRRIGATION SYSTEM

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Abstract – Precision irrigation is essential for sustainable agriculture as water resources decrease. Our intelligent irrigation architecture has been designed to provide crops with accurate and optimal watering. A system makes utilization of a heterogeneous sensor network that is spread throughout an experimental 100-acre maize field and includes temperature sensors, rain gauges with tipping buckets and soil moisture probes. Using Arduino microcontrollers, analogue signals from the census are converted to digital signals, after which sent over Lora WAN to our cloud IoT platform. Neural network models with LSTM that are optimized on a GPU compute cluster and implemented in Python are used to integrate sensor data streams with satellite data and weather forecasts. To anticipate the daily crop water requirement (CWR), the sensor fusion LSTM models are trained using five years' worth of historical ground-truth data from the site. . Actuators that are automated and linked to water distribution lines can open or close valves to precisely regulate irrigation according to the estimated CWR. We have developed a reacts web dashboard that enables farmers to view sensor feeds, manually adjust valves, and verify model recommendations in order to fine-tune the AI models on go. Every week, the AI system retrains itself using streaming data to accommodate for unforeseen weather disturbances. Our intelligent architecture that is cloud-connected guarantees scalability among farms and offers growers interpretability via an interactive online interface. In future, our automated process will enable the simultaneous, precise supply of fertiliser, herbicides, and water for sustainable agriculture.

Keywords - Sensors , KNN, SVM , RMSE , AI , IoT.

I. INTRODUCTION

Agricultural water use efficiency is critical given the increasing scarcity of resources and environmental hazards linked to over-irrigation. However, because soil characteristics and weather variables vary over fields and seasons, it can be difficult to pinpoint the precise dynamic crop water needs. Because of this, there is now a reliance on ineffective timed irrigation programmers, which cause runoff waste and overwatering. Novel prospects for addressing these obstacles are presented by developments in data-driven modelling, wireless networking, and sensors. To ensure that provide optimized watering that is tailored to intra-field differences, we propose in this project a smart irrigation system based on an Internet of Things (IoT) networked architecture and artificial intelligence approaches.

Our system consists of a heterogeneous sensor network with nodes monitoring temperature, humidity, and soil moisture in various farming zones that are synchronized via long-range wireless communication. Sensor data is sent to a cloud platform where neural network models with ground truth crop water requirement measurements are stored and educated on past trends. Water valves can be opened or closed using actuators attached to irrigation pipelines in accordance with the dynamic irrigation levels recommended by the AI model that is adjusted for the local climate and crop growth stage. Furthermore, farmers may view sensor measurements, adjust automatic valve settings as needed, and verify model suggestions through our user-friendly web interface. Using streaming data, the system continuously retrains itself during the crop-growing season to enable online adaptability to fluctuating weather or unforeseen field conditions. This data-driven strategy aims to maintain high crop output while reducing operational expenses, energy use, and water use.

II. LITERATURE SURVEY

Citation [1] As the cornerstone of the project, "Smart Irrigation system based on Iot and Machine Learning" provides a targeted investigation of machine learning applications in agriculture. The study highlights the potential of machine learning algorithms to optimize irrigation plans based on real-time data, which is in line with the project's objectives. The report places a strong emphasis on intelligent and adaptable irrigation.

Citation [2] By tackling the issues that plague agriculture worldwide, "IoT with Blockchain: A Futuristic Approach in

Agriculture and Food Supply Chain" presents a more comprehensive viewpoint. It emphasizes how different stakeholders have a part in the allocation of food and how intertwined they are. The project's usage of IoT sensors resonates with the proposed integration of blockchain and IoT in the food supply chain, demonstrating possible synergies that can improve the irrigation system's dependability and efficiency.

Citation [3] With a specific focus on IoT-based water management, "Smart Water Management Platform: IoT-Based Precision Irrigation for Agriculture" offers insights into the design and implementation of IoT systems. This is consistent with the project's utilization of IoT sensors for targeted irrigation, highlighting importance of IoT in efficiently managing water resources.

Citation [4] A paper titled "Standard Agricultural Drone Data Analytics using KNN Algorithm" presents the idea of drone data analytics application in the telecom sector. Despite the paper's emphasis on telecom management, it emphasizes use of data analytics and the extraction of pertinent insights that may be tailored to the particulars of the project. The project's objective of optimizing irrigation methods through data-driven decision-making is in line with the focus on insights-driven behavioral change.

Citation [5] The book "Artificial Intelligence for Agriculture Innovation" emphasizes how Fourth Industrial Revolution technologies—such as big data analytics, drones, blockchain, IoT, and AI—are revolutionizing the agricultural industry. Key aims that are in line with the objectives of a smart irrigation system are highlighted in the report, including real-time environmental monitoring and sustainable farm earnings. It also acknowledges challenges and emphasizes coordinated efforts to harness positive impacts. It also highlights the concerted efforts to harness beneficial outcomes while acknowledging problems.

Citation [6] "A Review on Various Irrigation Methods" examines different irrigation techniques while differentiating between manual and automated systems. The study highlights the higher output and water efficiency of automated systems and covers 16 major irrigation techniques. This study is relevant to the Smart Irrigation System project since it provides information on various irrigation methods and argues that automation is beneficial for maximizing agricultural yield while preserving water.

Taken as a whole, these research papers provide a thorough basis for the project, offering insights into blockchain integration, IoT-based water management, machine learning applications, and importance of data analytics in agriculture. They offer insightful viewpoints and useful approaches that can be modified and incorporated into the creation of an advanced smart irrigation system.

III. EXISTING SYSTEM

Currently, timed controllers are the most widely used irrigation scheduling method. They operate by opening valves for predefined periods of time on a fixed schedule, regardless of the field's circumstances or the weather. Watering schedules are controlled by more advanced smart systems that use soil moisture sensor probes to automatically measure the volumetric water content in the crop root zone. These sensor-based systems have more efficiency than timed irrigation, but because they only assess the moisture levels at the probe locations, they are limited in scale and localization. Some commercial systems predict the amount of irrigation needed for entire fields by including weather station data, such as temperature, humidity, and rainfall. But instead of reacting to actual field dynamics in real time, these rely on past weather averages.

Cutting edge research has looked into mapping intra-field variations and calculating daily crop water needs based on plant physiology and growth stage using dense wireless networks with multiple sensor types (moisture, temperature, camera, etc.) integrated with satellite data and artificial intelligence models like neural networks. These data fusion techniques aim to deliver precise and dynamic irrigation that is tailored to the local soil conditions and environment. However, computational demands and difficulties with generalizing the model to different soil types and crop varieties have restricted implementation thus far. With a cloud-connected Internet of things (IoT) approach that combines edge sensing and machine learning to precisely match water delivery to predicted crop requirements on a continuous basis while adapting to changing weather or disruptions through online model retraining, our proposed smart irrigation architecture specifically addresses previous limitations.

IV. OBJECTIVE OF PROPOSED SYSTEM

This smart irrigation project's main goal is to improve sustainable agricultural water usage by utilizing data science and automation breakthroughs. To ensure that design a modular precision irrigation architecture that can be adjusted to different crops, field sizes, and weather variability, our interdisciplinary approach combines environmental sensors, cloud analytics, and intelligent algorithms.
Developing wireless soil monitoring networks to record intra-field variability; creating AI models to convert sensor patterns into dynamic recommendations to crop water requirements based on development cycles; managing automated valves and pipelines to deliver precise irrigation when required; and

implementing user-friendly interfaces for growers to monitor system status and manage overrides are few of the specific technical goals. Gateways will be used by deployed modular subsystems to cooperate. Through multi-year trials across target sites spanning 100-500 acres, we aim to achieve over 20% potential water savings, 10% yield improvements, and robust model adaptation to seasonal shifts by using an agile methodology with rapid prototyping and incremental integration of capabilities spanning data collection, analysis, and field actuation. Design and testing will also be guided by metrics related to scalability, interpretability for farmers, and cost effectiveness.

V. CONCLUSION

Smart irrigation, which combines IoT and ML, represents a major advancement in farming methods. Farmers may improve crop yields, promote sustainability, and optimize water usage by utilizing real-time data predictive analytics. Further to addressing the problems caused by lack of resources, this creative synergy gives farmers the knowledge they need to make wise decisions. Smart irrigation is a shining example of efficiency, conservation, and resilience as we welcome this revolutionary period in agribusiness and work towards a more promising and sustainable future to world food production.

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