Development of IoT based intelligent irrigation system using particle swarm optimization and XGBoost techniques

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ABSTRACT

A crop needs regular watering throughout its life to grow well. Irrigation improves food growth. Machines irrigate plants. The dry Sahel, which gets a lot of rain during the summer season but is dry in winter, needs irrigation. When it doesn't rain enough, crops need watering. By constantly monitoring soil moisture, humidity, temperature, and pH, precision agriculture reduces water use and increases crop output. Precision gardening uses less water. In many wealthy nations, efficient farming requires the internet of things (IoT). Particle swarm optimization (PSO) and XGBoost are used in this IoT-based intelligent watering system. Humidity and moisture sensors gather soil data at grass roots. Sensors constantly gather this data. These data are useless for smart watering. PSOselects smart watering data. This reduces central cloud info storage. Then, machine learning methods are trained using soil humidity, moisture, crop, and weather data. These programs can calculate a crop's water requirements. IoT devices control irrigation system water flow and results in saving fresh water. XGBoost algorithm is saving water from 23% to 27% for different crops.

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1. INTRODUCTION

Agriculture [1] is a global treasure. Most farming crops worldwide are limited by irrigation water shortages. Researchers created drip irrigation to solve this problem in dry areas. This is because there are no standards or methods for efficiently using water and energy. Farmers must actively inspect their crops, making traditional drip irrigation more expensive. Data mining-supported decision making can also aid with many agricultural tasks. Mining association rules has been used to create standards for controlling processes like when to irrigate gardens and farms.

To grow well, a crop needs water at regular periods throughout its life. Crop growth depends on irrigation. Irrigation is mechanically watering plants. Since precipitation is scarce and unreliable in arid and semiarid areas, this strategy is crucial. Water's importance to plants is complex [2]. Understanding how soil moisture affects plant growth is essential to use climate-appropriate water management strategies. Sand, silt, clay, and diverse soils make up the earth. Each soil type offers unique challenges and opportunities. Sand-based dirt drains well. Flushing nutrients down the drain wastes them. Silty soil holds water longer than sandy soil because its particles are smaller. Sand flows fast. However, this dirt retains water. Agricultural output requires soil quality, including water and nutrient retention. Thus, it's crucial to know your soil's kinds and water needs. Despite adequate rainfall in many agricultural areas [3], crops lack moisture. This is usually due to inadequate water storage or inconvenient rainfall. These forces often interact. We call rainfall less than 100 millimeters inadequate because irrigation needs 100 centimeters. The dry Sahel, which gets lots of rain during the summer season but is dry in winter, needs irrigation. When precipitation is low, water irrigation is necessary to grow good crops [4].

Precision agriculture [5] monitors soil moisture, humidity, temperature, and pH to reduce water use and increase crop output. Precision gardening saves water. Precision agriculture in many rich nations relies solely on the internet of things (IoT). Use of IoT in agriculture is resulting in rising in yield. Wireless sensor networks (WSN) are also becoming the cutting edge of precision farming. Intelligent sensor networks in modern irrigation systems collect field values and optimize watering plans [6]. Machine learning means learning from samples. Algorithms use equations to learn samples and improve over time. ML methods solve nonlinear problems best [7], [8]. Real-world decisions are possible with minimal human assistance. Every industry uses machine learning techniques. Data quality determines reliability. Machine learning methods emphasize dataset representations and goal variables.

The smart irrigation system (SIS) is a state-of-the-art instrument for managing the distribution of water in agricultural systems [9]. The irrigation schedule will be automatically adjusted by the SIS controller based on the current and forecasted weather conditions and the state of the soil. Through the process of defining the soil feature, one can gain both the water-soil relationship as well as the corresponding crop water need. The physical and chemical characteristics of soil are both present.

When compared to other types of soil, clay, silt, and sandy soils require less frequent irrigation. The chemical, physical, and biological properties of the soil all have an influence on the quality of the water that is used for irrigation. This is also true. We can use the salt content of irrigation water as a way to characterize the chemical qualities of the water itself. Autonomous irrigation systems utilize embedded system components such as a microcontroller with associated timers, sensors, and electrical valves in order to regulate the flow of water. This allows the system to be more efficient. A few examples of automated irrigation include controllers for volume and timing, as well as sensors that measure the moisture content of the soil [10], [11].

In addition to having embedded components, the SIS also possesses intelligent controllers in its design. These smart controls react to changes in the weather and other environmental elements to modify the watering timings and quantities accordingly, so minimizing wasteful over- or under-distribution of the liquid. It is essential that you are aware that some of the newest intelligent irrigation controllers make watering schedule decisions based on forecasts of the weather. It is essential for there to be confidence in the data forecasts if such a system is going to be successful.

This article presents IoT based intelligent irrigation system using particle swarm optimization (PSO) and XGBoost techniques. Humidity and moisture sensors are deployed on the grass root level to collect soil related data. This data is voluminous and it is sensed continuously by the sensors. All these data is not useful from the smart irrigation point of view. So, the important data for smart irrigation is selected by PSO. This will also result is reducing the amount of data being stored in centralized cloud. Then the machine learning algorithms are trained by existing data related to soil humidity and moisture details, crop details, weather details. These algorithms become capable of suggesting the amount of water needed for a particular crop in a particular region. Accordingly, IoT devices play a role in turning on and off the water supply for the irrigation. It results in saving water.

2. LITERATURE SURVEY

Precision agriculture is important for yield-boosting farmers. Farmers and other agricultural actors, such as government irrigation agencies, can improve irrigation requirements and crop yield projections by adopting WSN technology. The researchers [12], [13] developed an autonomous precision farming device. Center pivot watering is used. This technology monitors soil temperature and moisture in agricultural areas using buried sensor networks. Thus, sensors are placed, initial power adjustments are made, and energy-efficient network maintenance is done.

In irrigation systems, data transfer requires more power, so energy-saving steps are essential for optimal watering results. Time division multiple access (TDMA) scheduling may benefit WSN-based watering system scheduling, according to [14]. In TDMA, data movement from source to sink or data aggregation can conserve energy. TDMA increases network speed. Goumopoulos *et al.* [15] invented an automated zone irrigation device. It uses ontology-structured wireless sensing or actuators. "Talking plants" allow water-efficient precision agriculture. When a network node fails, this system uses several machine learning methods to fix it and enhance performance. In reaction to the need for irrigation task automation and user friendliness, many end-user programs have been developed. Vellidis *et al.* [16] developed a cotton crop irrigation system. They used data from several cotton-growing areas to determine soil water balance. They created an Android app using these datasets. Their app automatically retrieves weather data from nearby weather stations. The program used local and remote meteorological data to determine how often to water each plant and set up an autonomous watering schedule to increase cotton output. The scheme aimed to boost cotton production.

Abbasi *et al.* [17] examined WSN uses and agricultural demand. Time-dependent farming demands were examined. They also provided a table showing how various sensors can identify agriculturally essential properties. They compared several communication ways with pros and cons. Finally, authors moved to the conclusion that timely delivery of messages is essential to achieve true advantages of IoT technology in agriculture domain. Kodali *et al.* [18] showed that gateway data can be gathered and analyzed to send email or text alerts when metric values meet or exceed predefined values. This enhances field production and decreases agricultural inputs. They focused on sensors that compute statistical features about agricultural areas and provided extensive information on the sensors and their commercial item needs. Precision gardening was always a priority. Sensors detected soil water, moisture, electrical conductivity, pH, weed seeker, temperature, and wind speed in the model.

Ramesh and Vardhan [19] tested data mining techniques on several data sets. They looked for data models to build an agriculture-specific model with high accuracy and generalizability. Artificial neural networks (ANN) and support vector machines use K-means and K-nearest clustering algorithms to predict rainfall. Third-generation farming support system by [20]. This system studied data mining methods and applied them to a soil science database to build a relationship between soil nutrients. This was done to link soil minerals. K-means improved data collection, grouping, and forecast. The study used classification and inventory-based decision induction. Prabhu *et al.* [21] studied precision agriculture and agrarian clustering. The base station received packets at 180 bps, which is 180 outputs. According to the proof, their drip irrigation algorithm could save a lot of water. However, data transport requires more energy as sensor nodes grow. This suggests that precision cultivation needs enough sensor nodes.

3. METHODOLOGY

This section presents IoT based intelligent irrigation system using PSO and XGBoost techniques. This is shown in Figure 1. Humidity and moisture sensors are deployed on the grass root level to collect soil related data. This data is voluminous and it is sensed continuously by the sensors. All these data is not useful from the smart irrigation point of view. So, the important data for smart irrigation is selected by PSO. This will also result is reducing the amount of data being stored in centralized cloud. Then the machine learning algorithms are trained by existing data related to soil humidity and moisture details, crop details, weather details. These algorithms become capable of suggesting the amount of water needed for a particular crop in a particular region. Accordingly, IoT devices play a role in turning on and off the water supply for the irrigation. It results in saving water.

The PSO method is an example of a stochastic strategy that derives its cues from the behaviour of groups of animals, such as flocks of birds or schools of fish. All of the particles in a search space have position and velocity data that can be measured. The speed and acceleration of the particle are nevertheless being manipulated in order to direct it to the area of a prospering particle as well as the spot that was previously fantastic for all other particles [22]. As a result of the fact that the velocities and locations of particles shift throughout the course of time, a set of rules has been formulated in order to characterise this phenomena. This is the location where you may find the regulations in question.

The k-nearest neighbors (KNN) algorithm is a kind of supervised algorithm that is often used in the context of classification. The fact that this approach always produces the same results, even when it is given the exact same set of training data, is the single most important feature of it. It is not impossible to assign a category to each sample, or only one or two of them, depending on the population value that is the most comparable to the value of the sample. The Euclidean distance is determined by the equation that was just supplied. This distance may be used as a measurement to determine how near together two pixel positions are. As a result, the pixels wind up grouped together, which is the outcome that ought to have occurred given the odds. The letter K in KNN denotes the neighbourhood in which any two neighbours may take the route that is the shortest distance between them. The number of residences that are relatively close together is the most important factor to consider. If there are just two, there can never be an even number of courses. There will always be an odd number. The calculation for finding the neighbour with the smallest distance, which takes place at this stage of the method, results in K=1. It is the result with the fewest probable complications in comparison to the others [23].

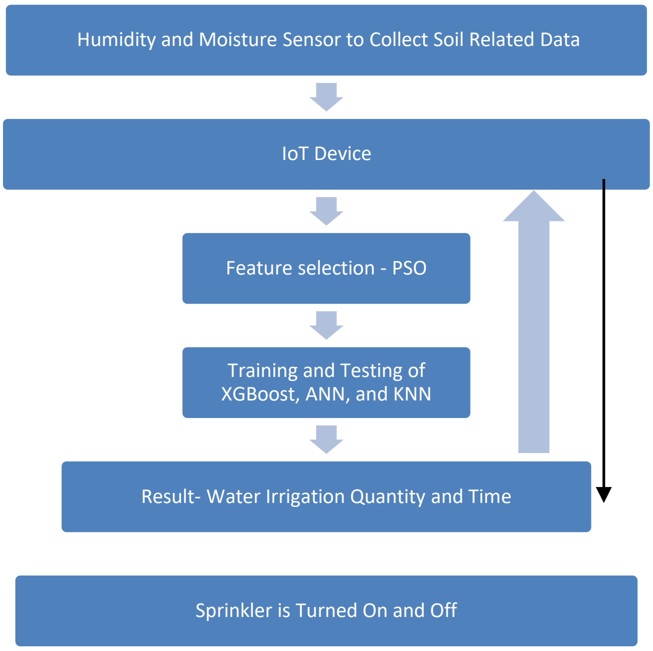

Figure 1. Development of IoT based intelligent irrigation system using PSO and XGBoost techniques

ANN [24] is built on the foundation of perceptrons. In a multi-layer ANN, an extremely large number of neurons are linked in a network. The first sample of data is sent to the input layer, while the last sample is delivered to the output layer. The number of layers located in the core, which are sometimes referred to as "Hidden layers," might range anywhere from one to numerous. Put up some effort. ANN is a kind of ANN in which a signal is supplied into the input layer and then propagates through the network's hidden layers before being output. Before being output, the signal is fed into the input layer of an ANN. No connection may be formed in reverse. The output value is determined by computing the total of the weights that were assigned to each connection. ANNs are dependent on three primary elements: the network architecture, the input and activation functions, and the weights that are allocated to nodes. After beginning with a seemingly arbitrary distribution of the weights, successive adjustments are made in order to achieve a higher level of accuracy.

XGBoost [25] is a sequence model representation. Because of its capacity to handle missing data, scale imbalanced data, derive information from previous mistakes, and fine-tune hyperparameters, our team came to the conclusion that XGBoost would be the most suitable model to deploy. It is feasible to correct the inaccuracies that were produced by earlier models by using a technique known as "boosting" to increasingly bigger ensembles of data. There is evidence to show that XGBoost may aid even the students who are having the greatest difficulty in order for them to do better on difficult classification and regression challenges. It is possible for XGBoost to build new trees that take into account the previous prediction value of the input data in order to maximise the prediction improvements it generates.

4. RESULT ANALYSIS AND DISCUSSION

For experimental data, a data set is prepared by collecting data from [26], [27]. This data set contains details related to soil moisture, humidity, pressure, luminosity, and temperature. These details are related to wheat, capsicum and rice.

Humidity and moisture sensors are deployed on the grass root level to collect soil related data. This data is voluminous and it is sensed continuously by the sensors. All these data is not useful from the smart irrigation point of view. So, the important data for smart irrigation is selected by PSO. This will also result is reducing the amount of data being stored in centralized cloud. Then the machine learning algorithms are trained by existing data related to soil humidity and moisture details, crop details, weather details. These algorithms become capable of suggesting the amount of water needed for a particular crop in a particular region. Accordingly, IoT devices play a role in turning on and off the water supply for the irrigation. It results in saving water. In this study, the performance of a number of different algorithms is analysed and compared based on three criteria: accuracy, sensitivity, and specificity. Performance is shown in Figures 2 and 3.

- Accuracy=(TP+TN)/(TP+TN+FP+FN)
- Sensitivity=TP/(TP+FN)
- Specificity=TN/(TN+FP)

Where TP is true positive, TN is true negative, FP is false positive, and FN is false negative

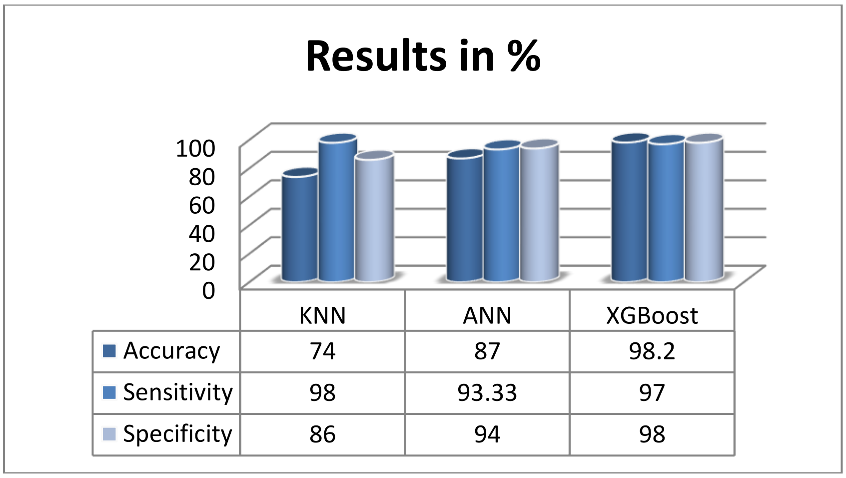

Figure 2. Accuracy, specificity and sensitivity comparison of XGBoost, ANN and KNN algorithm for intelligent irrigation

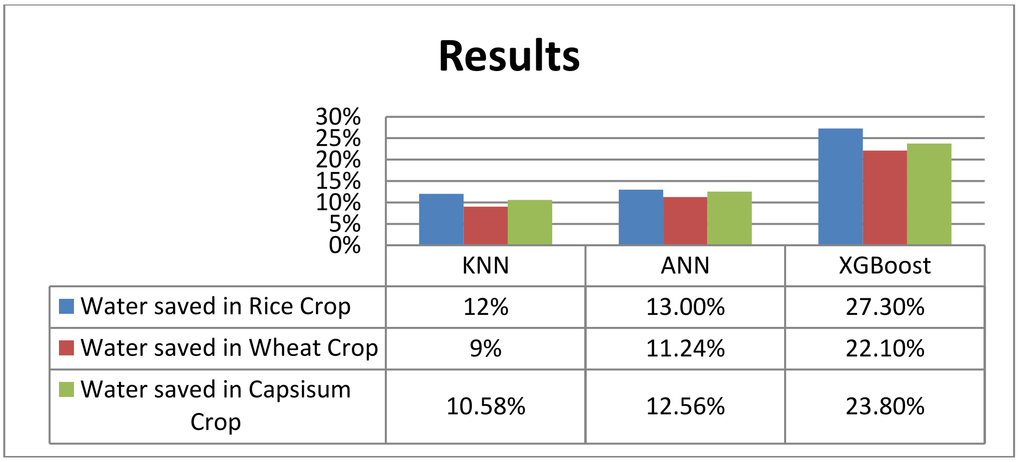

Figure 3. Fresh water saved in rice, wheat and capsicum crop

5. CONCLUSION

A crop requires a constant supply of water at consistent intervals throughout its entire life cycle in order for it to achieve the best possible growth potential. Irrigation is a crucial component of farming since it contributes to the general health and growth of the crops. Irrigation is the practise of providing water to plants via the use of mechanical means. Irrigation is especially crucial in regions that see varying levels of rainfall, such as the arid Sahel, which receives a lot of rain during the monsoon season but is dry during the colder, drier winter months. This makes the monsoon season the most favourable time for irrigation. Irrigation using water is essential for successful crop production in situations when there is an insufficient amount of rain. Precision agriculture is a solution to these difficulties since it decreases the quantity of water that is required for farming while simultaneously boosting crop productivity. This is accomplished by continuously monitoring the moisture level, humidity level, temperature, and pH of the soil. Because of this, precision agriculture is able to make more efficient use of water while it is cultivating. At this moment in time, the IoT is the sole viable option for practising precision farming in many wealthy nations. An intelligent irrigation system that makes use of methods such as PSO and XGBoost is discussed in this article. This system is based on the IoT. Sensors that measure humidity and moisture are utilised to gather information about the soil at the grass-roots level. The sensors are constantly picking up this information, which is a significant amount. All of this data is useless when looking at it from the perspective of intelligent irrigation. Therefore, PSO is the method that is utilised to choose the relevant data for intelligent irrigation. This will also result in a reduction in the amount of data that is kept in a centralised cloud. Then, the pre-existing data on the soil's humidity and wetness, as well as the specifics of the crop and the weather, are used to instruct the machine learning algorithms on how to behave. With the help of these algorithms, it is now feasible to calculate the amount of water that a particular crop in a particular region requires. Therefore, IoT devices assist switch the water supply on and off for the irrigation system. Because of this, it helps to save water.

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