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Smart Irrigation System for Agriculture using IOT and ML

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Abstract

The IoT(Internet of Things) plays an important role in the terms of technology. It helps to get all the desired things by means of the internet. In the case of farming, choosing the right water level according to the current environmental conditions has always been a hectic task. Monitoring environmental conditions is a very important factor while watering plants. Due to unexpected weather components like temperature and soil moisture, the selected crop may get uneven water supply which may cause poor efficiency at crop yield. To overcome this problem, there must be a system that will suggest to the farmer about the correct choice of crop and watering instructions to the selected crop according to the current environmental factors mentioned above. In this paper, it is proposed to develop a smart irrigation system using IoT and machine learning algorithms. Using machine learning algorithms like KNN(k-nearest neighbor) with IoT, the system will give more accurate predictions for irrigation. The system is connected with the user through an android application, through which the user is able to see the live readings of temperature and soil moisture through cloud, also able to schedule irrigation whenever required. This paper aims to make use of IoT and ML like technologies to prepare a smart irrigation system for agriculture.

Keywords*—IoT(Internet of Things), ML(Machine Learning), KNN(k- nearest neighbor), cloud, Android Application***.**

I. INTRODUCTION

In India, agriculture is a livelihood for a majority of the population and has a major impact on the economy of the country. According to India Brand Equity Foundation, 58% of the people living in rural areas are dependent on agriculture.[9] Large amounts of water is required to irrigate the field from time to time. This water is used from nearby fresh water resources. Most of the irrigation systems in India are operated manually. But there is wastage of water when irrigation is being done manually. There are some automated and semi-automated technologies which have been developed for irrigating fields such as drip irrigation, sprinkler systems etc which have replaced the traditional agricultural mechanism. But these systems too need to be operated manually to turn it on or off. This can lead to excessive water supply in some cases. There is a need for a fully automated system to irrigate the field according to the water requirement of the plant.

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Nowadays, automation rules the world. It is a technique of using computers in monitoring and controlling simple tasks of day to day life. Automation reduces human effort and makes daily activities much simpler and convenient. IoT is one of the powerful aspects of automation. IoT uses various sensors which communicate with each other and provide accuracy in data. IoT provides solutions to various problems and allows things to be sensed or controlled remotely. The important aspect of IoT is that it saves cost and ensures safety.

In agriculture, the water requirement of each crop is different and automated irrigation systems should be aware of this requirement. Use of ML (Machine Learning) can provide this data to the irrigation system. Machine learning is a method of data analysis which enables self learning from data and then applies that learning without the need for human interruption. It is a specific subset of AI (Artificial Intelligence) that trains a machine how to learn. ML uses an iterative approach as when models are exposed to new data, they are able to independently adapt. They learn from previous computations to produce reliable as well as repeatable decisions and results. In machine learning there are various algorithms and can work according to the data being used.

Smart Irrigation System uses soil moisture sensor and temperature sensor which takes real time data of soil moisture of the field and temperature of environment at some intervals of time. This sensor data is then sent to the cloud by using a wifi module. KNN (K Nearest Neighbor) algorithm of machine learning is used in this system. This algorithm divides the previous data into two clusters i.e. dry and moist. By fetching the current sensor data from cloud KNN classifies this new data point into one of the clusters to predict whether the soil is dry or moist. This result is then sent back to the cloud. Using a wifi module, the IoT system fetches the result value from the cloud and the relay turns on or turns off the pump depending on result value. An Android application is provided to the user to keep track of the sensor values which are fetched from the cloud. User can manually turn on or turn off the pump using an android application. This system reduces human efforts to irrigate crops and wastage of water.

The focus of the paper is elaborated with different sections as; section II presents an overview of related works focusing on the requirements. Section III gives information about system architecture, different components of the IoT system also, describes working of KNN algorithm. Section IV describes future scope of the system and conclusion.

II. Related Work

The Internet of things (IoT) describes the network of physical objects “things” that are embedded with sensors, software, and other technologies to attach and exchange data with other devices and systems over the Internet. Things have been evolving on account of the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems [1]. Machine learning (ML) is the study of computer algorithms that improve instinctively through experience. A subset of machine learning is closely associated with computational statistics, which focuses on making predictions using computers. Data mining may be a related field of study that specializes in exploratory data analysis through unsupervised learning. In its application across business problems, machine learning is also referred to as predictive analytics [8]. Earlier India enjoyed abundant water resources. But now population growth and over-exploitation have led to a situation where there is a water demand. The reason behind the shortage of water is using a traditional system of irrigation. To monitor the water requirement of the plants a system is needed. Implementing smart irrigation helps to decrease the loss of water caused by using a traditional system [4]. Various research is administered

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on how soil irrigation is often made more efficient. The researchers have used different ideas depending on the condition of the soil and the quantity of water. The primary investigation is carried out under the following stages, such as Understanding the existing approaches, Understanding the requirements, developing an abstract for the system. The proposed system aims at detecting the moisture content of the soil using sensors that are placed into the soil. These sensors sense the water level of the soil and if the water level is not adequate then the user will be notified through a message that will be sent to the appliance which might be installed on the user's mobile [7]. An Arduino-based remote irrigation system developed for the agricultural plantation, which is placed at the remote location and required water is provided for plantation when the moisture of the soil goes below the required value. But in this, the soil moisture level is not known so to overcome this drawback, the proposed system included an extra feature of soil moisture value and temperature value displayed on the farmer mobile application [6].

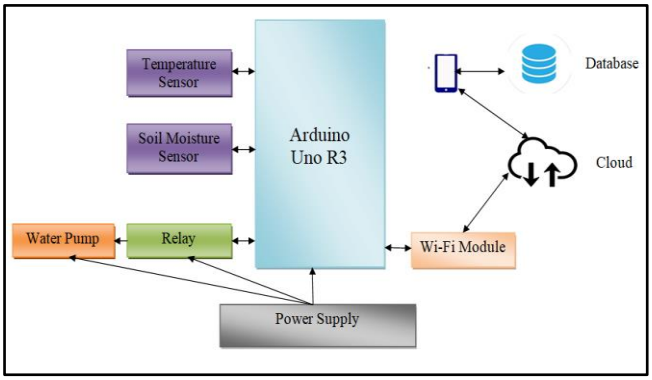

Fig. 1 System Architecture

III. Smart Irrigation System for Agriculture Using IoT and ML

In the architecture of a smart irrigation system for agriculture where sensors are connected to the Arduino board. There are sensors viz., temperature sensor, soil moisture sensor and one Wi-Fi module connected to an arduino board. The system contains a water pump which is connected to the relay which is further connected to the Arduino board. The Arduino board is connected to the power supply. Also, it is connected to the android mobile by android application. Application is connected to a database consisting of the necessary data of environmental conditions. When the system operates, readings of soil moisture and temperature are taken from sensors and uploaded to the cloud using the Wi-Fi module. By applying a machine learning algorithm, it is predicted whether soil is dry or not. According to the need of crop and dryness of soil, the water pump gets on/off automatically, and the report is sent to the user through the android application. Also, users can manually turn on/off the pump.

A. IoT System

The IoT (Internet of Things) is the system of various interrelated and internet-connected objects that are able to collect and transfer data over a wireless network without human interruption.

In this Smart Irrigation system, various sensors like temperature sensor, Soil Moisture sensor and Wi-Fi module ESP8266 is used. Also, 2 channel relay and pump are used for irrigation purposes. A microcontroller like Arduino uno is used which will control all the sensors. The external power supply is given to the arduino board , relay and pump.

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The LM35 is a precession integrated circuit temperature sensor, whose output value varies based on temperature in the surroundings. It can measure the temperature between -55°C to 150°C. The soil moisture sensor module is used to detect the moisture level in the soil. The module has both analog and digital output pins. Both the sensors take +5V power through the arduino board. Below images show the temperature and soil moisture sensors.

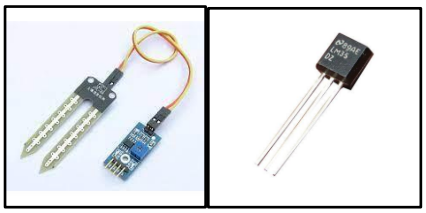

Fig. 2 Soil Moisture and Temperature Sensor

The relay module is an electrical switch that is operated by an electromagnet. It gets on when the controller sends the low signal to the relay. It is a switch which is connected to the pump to initiate the irrigation through a controller. The below image depicts the 2 channel relay module.

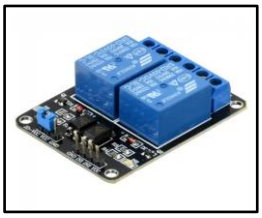

Fig. 3 2-Channel Relay module

ESP8266-01 is a Wi-Fi module which is used to give the internet access to the arduino board. It is used to send the data of sensors to the cloud. It has 8 pins and it works on 3.3V of power. The below image is of esp8266-01 wifi module

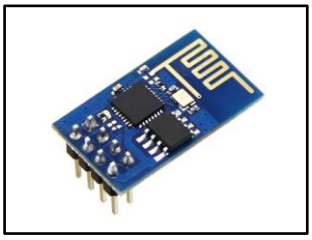

Fig. 4 ESP8266-01 Wi-Fi Module

Arduino Uno r3 is a microcontroller based on ATmega328P. All these sensors and other modules are connected to this microcontroller board. This board has 14 digital input pins and 6 analog input pins. The Arduino board fetches the data through sensors and updates the data to cloud and later it is fetched by knn algorithm to predict the soil moisture(i.e dry or moist). Following is the image of arduino uno.

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Fig. 5 Arduino Uno R3 Board

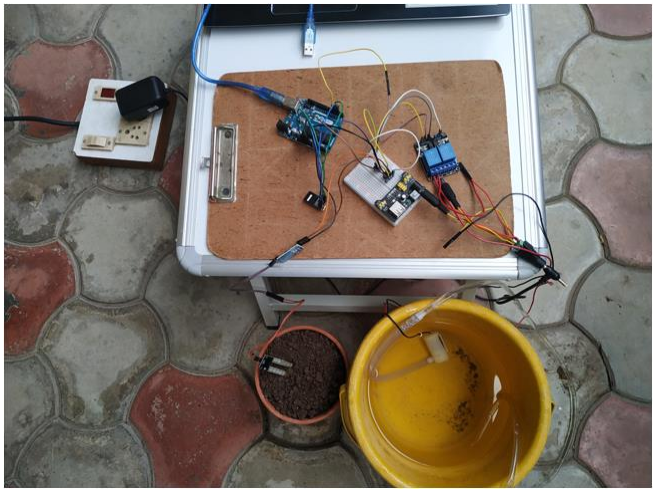

Fig. 6 Actual System Implementation

B. KNN (K- Nearest Neighbor) Algorithm

K-Nearest Neighbour is one among the only Machine Learning algorithms supporting Supervised Learning technique. The K-NN algorithm assumes the similarity between the new case/data and available cases and puts the new case into the category that is most similar to the available categories. K-NN algorithm stores all the available data and then classifies a new data point based on the similarity directed. This means when new data appears then it can be easily classified into a well-suited category by using K- NN algorithm.

The K-NN algorithm is often used for Regression also as for Classification but mostly it's used for Classification problems. K-NN is a non-parametric algorithm, which means it does not make any assumptions on the underlying dataset. It is a lazy learner algorithm because it doesn't learn from the training set immediately instead it stores the dataset and at the time of classification, it performs an action on the dataset. The K-NN algorithm at the training phase just stores the dataset and accordingly when it gets new data, then it classifies that data into a category that is much similar to the new data.

The K-NN working can be explained on the basis of below algorithm:

- **Step-1:** Select the K number for the neighbors
- **Step-2:** For K number of neighbors calculate the Euclidean distance.
- **Step-3:** As per the calculated Euclidean distance take the K nearest neighbors.
- **Step-4:** Count the number of data points in each category, among these k neighbors.

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- **Step-5:** To that category which has the maximum number of the neighbor, assign the new data points.
- **Step-6:** Our model is thus ready.

Below are the points to remember while selecting the value of K in the K-NN algorithm

- There is no particular way to determine the best value for "K", so we need to try some values to find the best out of them. The most preferred value for K is 5.
- A very low value for K such as K=1 or K=2, can be noisy and it can lead to the effects of outliers in the model.
- Large values for K are good, but it may have some difficulties.

Euclidean Distance represents the shortest distance between two points. So, the Euclidean Distance between these two points A and B will be:

$$d = ((p_1 - q_1)^2 + (p_2 - q_2)^2)^{1/2} \quad \text{……...} \quad (1)$$

Manhattan Distance is defined as the sum of absolute differences between points across all the dimensions. So to calculate Manhattan Distance, we will take the sum of absolute distances in both the x and y directions. So, the Manhattan distance in a 2-dimensional space is given as:

$$d = |p_1 - q_1| + |p_2 - q_2| \quad \text{……. (2)}$$

Minkowski Distance is stated as the generalized form of Euclidean and Manhattan distance. The formula for Minkowski Distance is given as:

$$D = \left(\sum_{i=1}^{n} |p_i - q_i|^p \right)^{1/p} \quad \text{.....(3)}$$

Steps to implement the K-NN algorithm:

- Data Preprocessing step
- Fitting the K-NN algorithm to the Training set
- Predicting the test result
- Test accuracy of the result
- Visualizing the test set result.

Advantages of KNN Algorithm:

- It is simple to implement.
- It is robust to noisy training data.
- If the training dataset is large then it can be more efficient.

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Disadvantages of KNN Algorithm:

- There is always a need to determine the value of K which may be complex some time.
- Calculating the distance between the data points for all the training samples can lead to high computation cost.

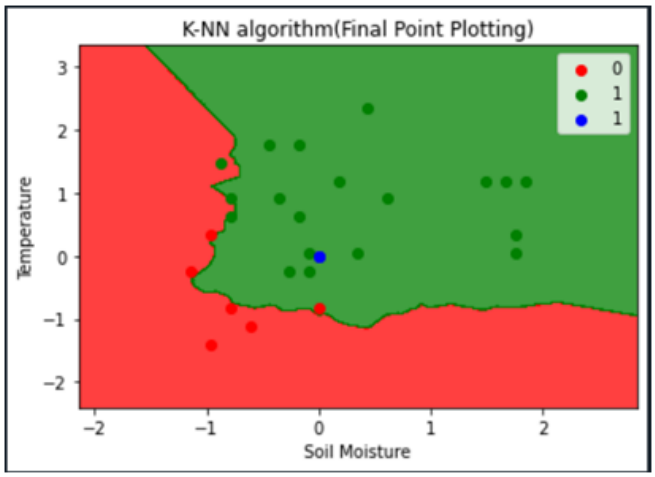

Fig. 7 KNN Algorithm Classification

In the graph above green points are for moist soil(1) and Red Points for dry soil(0). Using the knn algorithm system have fetched the values of soil moisture sensor and temperature sensor for the crop selected by the farmer. Thus accordingly the flag value is set to 1 if soil is moist and to 0 if the soil is dry. Here the blue point represents the flag value which is 1 and is plotted in a green region that means the soil is moist. By considering the flag value, automatically the pump is made on and off. Thus here it can be said that the system is well trained to depict the outcome as per requirements.

IV. Conclusion and Future Scope

The proposed system checks the important environmental factors such as temperature and soil moisture of farm fields to allow farmers with the required amount of water for the selected crop. The system consists of a fixed number of crop types. As the system is based on the KNN algorithm, it predicts the output based on clustering of previous dataset. It predicts the output for current sensor readings and accordingly informs the IoT system. Thus the IoT system acts smartly and provides an efficient amount of water to crop field. This Smart Irrigation System avoids overwatering the crops and reduces water wastage. It provides automatic irrigation to crop fields whenever required hence reduces manual efforts. Users can keep track of the working of the system through an android application. Also, live readings are visible to users on the application.
More crop types can be further added in the existing system. The system can be further considered for a large area of crop field by using an additional number of sensors. Fertilizer sprinklers can be added in the system, through which farmers can manually provide fertilizers to crops whenever required.

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