The Smart Management System using Machine Learning and Open Sources Technologies for Irrigation based on IoT

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Abstract: *The scarcity of unpolluted water resources around the globe has generated a requirement of his or her optimum utilization of water. Internet of Things (IoT) solutions, supported the appliance specific sensors, data acquisition and intelligent processing, are bridging the gaps between the cyber and physical worlds. Achieving minimum water- resource utilization within the farming landscape can be done by IoT based smart irrigation management systems using machine learning and open-source technology. This paper presents smart system using an open- source technology to predict the irrigation requirements of a field using the sensors of ground parameter like soil moisture, soil temperature, and environmental conditions along the weather data from the web. The sensing nodes, involved in the ground are soil moisture, soil temperature, air temperature and Ultraviolet (UV) light radiation etc. The intelligence of the proposed system is predicated on a sensible algorithm, which considers sensed data alongside the weather outlook parameters like precipitation, air temperature, humidity, and UV for the near future. The complete system is developed on a pilot scale, where the sensor data is wirelessly collected using the cloud by web-services and a web-based information visualization and decision network. The real-time information provided by decision network which supported the analysis of sensors data and weather data. The system features a provision for control of the water system to understand a totally independent irrigation scheme. The paper describes the system and discusses intimately the knowledge processing results of three weeks' data supported the proposed algorithm. The system is fully functional and therefore the prediction results are very encouraging.*

Key Words: *The Irrigation management system, IoT, Precision agriculture, Prediction algorithm, Machine learning.*

1. INTRODUCTION:

Water scarcity is already affecting a neighborhood of the planet and therefore the situation is getting worse over time. Thanks to the increasing world population and water demands. The current world population is around 7.2 billion and it's expected to be quite 9 billion by 2050 (United Nations, 2013). The agriculture sector, particularly irrigation, consumes a major portion of the freshwater. Due to lack of cost-effective intelligent irrigation systems, developing countries are consuming more water in contrast to the developed countries for achieving an equivalent yield. For example, India has approximately 4% of world's fresh water resources to serve 17% of the world population; however, it takes 2–4 times more water for some of its major Agri-produce as compared to the opposite countries like China, USA. Therefore, there is a need for the development of advanced technologies based on smart strategies and systems for effective utilization of water. An IoT framework with cloud centric storage, processing and analysis of the information received from ubiquitous sensors alongside a choice support interface. An IoT middleware platform that might support intelligent IoT applications. IoT based solutions are proving very helpful in many dimensions of the agricultural landscape and these intelligent solutions could even be fruitful in smart irrigation with optimum utilization of water. Soil moisture, precipitation, and evaporation are the essential parameters for designing a sensible irrigation system.

Fig 1.1 Smart Irrigation

The precipitation and evaporation are two important factors, which influence the soil moisture. In geography and climatology, the wetness of the soil is estimated by the proportion of evaporation and annual precipitation. Daily soil moisture also can be evaluated by the ratio of daily precipitation and evaporation. Precipitation is directly accessible within the routine weather reports though the evaporation is often calculated using other metrological essentials. Soil moisture is an integral quantity in hydrology that represent average conditions in a finite volume of soil. In this a regression technique called Support Vector Machine (SVM) is presented and applied to soil moisture estimation using remote sensing data. SVM depends on statistical learning theory which uses a hypothesis space of linear functions supported Kernel approach. SVM has been won't to predict a quantity forward in time supported training from past data. The strength of SVM helps in minimizing the empirical classification error and maximizing the geometric margin by solving inverse problem. Nonlinear character extraction is based on Kernel Canonical Correlation Analysis (KCCA) is presented during which information of soil and environment are input vectors of model. Nonlinear character is extracted by KCCA, then main character variables are determined which reflects the complex relationship between original input and output data and therefore the array dimension of input file is simplified. Finally, the model based on least squares Support Vector Machine (SVM) were completed. By comparing simulation results, precision and rapidity of the prediction model supported KCCA-SVM are above those of CCA-SVM and LS-SCM model. The experimental results show that the method is very effective.

2. THE PROPOSED SYSTEM:

2.1. System architecture

The architecture of IoT based smart management irrigation system is shown in Figure 2.1.

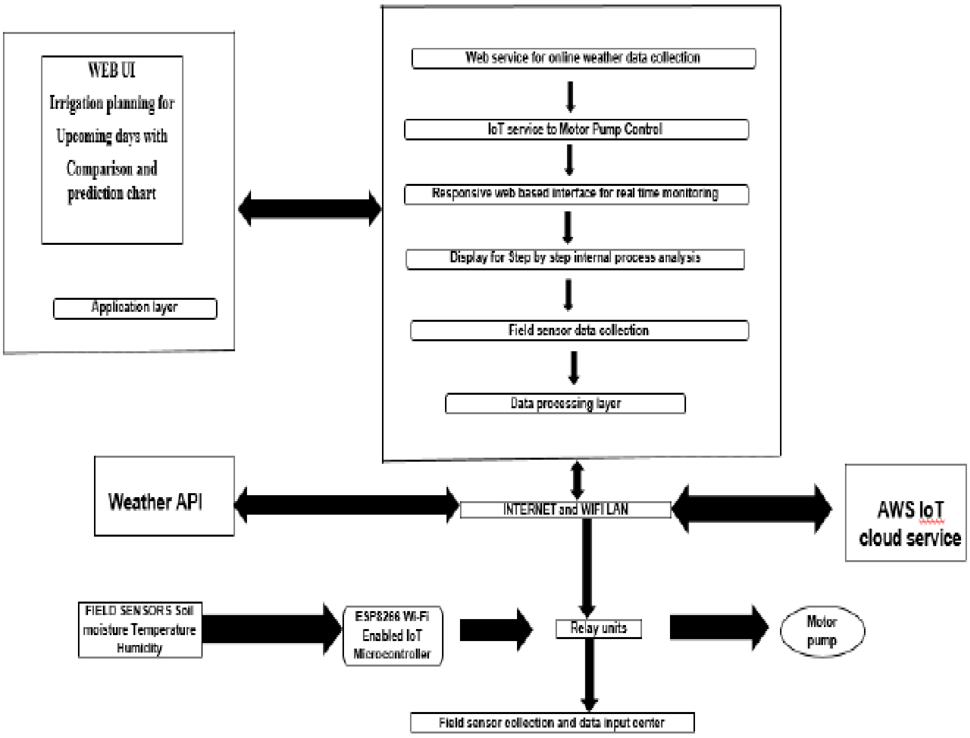

Figure 2.1 Architecture Diagram

It has seven main components, viz., Field data collection device with relay switch; Web service for collecting field sensor data; Web service for collecting weather information available online (Internet); Web service to regulate water motor; Soil moisture prediction algorithm; Responsive web -based interface for real-time monitoring; IoT enabled motor pump. Three different layers of the components, i.e., Data collection and transmission layer, Data processing & intelligence layer and application layer of IoT. Field data collection device Depending on the sector requirements, a standalone sensor node or a wireless sensor network of the sensor nodes could also be deployed. In standalone scenario field data collection device consists of 4 sensors, viz., VH-400 Soil Moisture sensor, Soil temperature sensor, DHT22 temperature and humidity sensor, and Ultraviolet (UV) Light Radiation sensor based on GUVA-S12SD and SGM8521 Op Amp. The output of those sensors is read by an Arduino-Uno. In ESP8266-12F Wi-fi Microcontroller a program is written to hourly fetch the data from sensors and to store the data in database, which is synchronized with the server database using developed web service. For large farming area, a Wireless Sensor Network technology can be implemented in which multiple sensor nodes are often planted within the specified area. Each sensor node will contain the sensors almost like the standalone device. The algorithm explains about information regarding upcoming moisture of the soil. It also provides irrigation suggestions, supported the defined level of soil moisture and predicted precipitation, to save lots of water and energy. The generated information by algorithm and device is stored in Database at the server.

2.1.1 Web service for field sensor Data collection

The Wi-fi Microcontroller sends the field data to the server using this web service. This web service can handle the network fluctuation/outage during synchronizing the information from the filed device to the server with the assistance of flag settings at the database.

2.1.2 Web service for online weather data collection

A web service has been developed to collect the weather forecasting data. This web service also aggregates the weather forecasting data like temperature, humidity, cloudiness, UV Index and precipitation of different web forecasting portal like Open Weather and AccuWeather using API of these considered in the prediction algorithm.

2.1.3 Soil Moisture Prediction algorithm

An algorithm has been developed to predict the soil moisture based on field sensors data and weather forecasting data using support vector regression model algorithm. The algorithm shows the information regarding soil moisture of the upcoming days. It also provides irrigation suggestions, supported the defined level of soil moisture and predicted precipitation, to save lots of water and energy. The generated information by algorithm and device is stored in Database at the server.

2.1.4 Responsive web-based interface for real time monitoring

The interface checks the data of real-time sensors, Soil moisture prediction for upcoming days, and precipitation information. Facility for irrigation scheduling is also provided by it. The user can also schedule the irrigation at a specified threshold value of soil moisture. The system guides to take care of the edge value supported the anticipated pattern of soil moisture and precipitation information. The system can automatically start the irrigation, which stops after achieving the required threshold value of soil moisture.

3. LITERATURE REVIEW:

Juan M. et al has developed a method for better agricultural production. The major objective of this paper is to introduce an automatic sprinkler for irrigation in land to help within the production of crops and also know the precise field condition. The entire system is controlled by Arduino ATmega328 microcontroller, this microcontroller program gives an interrupt signal link to the sprinkler. In addition to that they introduced a webcam to monitor the growth of the plant and insect level in field condition [4].

Dweepayan et al has developed a method. This paper is about a programmed water system with portal. These portals provide the forecasted information in JSON, XML, or HTML format. The developed web service read the forecasted data (JSON format) of the specified location using API and store it in database at the server, which is framework for the terrains which can reduce manual labor and optimizing water usage increasing productivity of crops. Their experimental setup is connected with the cloud framework and data acquisition [5].

B. Sridhar, et al implemented Raspberry Pi based automatic irrigation IOT system is proposed to modernization and improves productivity of the crop. Main aim of the work is for crop development at low quantity water consumption. In order to specialize in water available to the plants at the specified time, for that purpose most of the farmers waste lot time within the fields. An efficient management of water should be developed and therefore the system circuit complexity has to be reduced. The proposed systems supported these values and calculate the water quantity for irrigation. The major advantage of the system is implementation of Precision Agriculture (PA) with cloud computing, that optimize the usage of water fertilizers. while maximizing the yield of the crops and also helped in analyzing the weather conditions of the field [8].

Shweta et al anticipated a method in this paper proposed system is based on IoT that uses real time input data. For remote monitoring and controlling of drips through wireless sensor network, the Smart farm irrigation system uses android phone. Zigbee is employed for communication between sensor nodes and base station. Web-based java graphical interface is used in the accomplishment of the Real time sensed data handling and demonstration on the server. Human intervention is decreased by wireless monitoring of field irrigation system and allows remote monitoring and controlling on android phone.

Cloud Computing is a beautiful solution to the massive amount of knowledge generated by the wireless sensor network. This paper evaluated a cloud- based wireless communication system to watch and control a group of sensors and actuators to assess the plants water need [9].

SuhasAthani, et al developed a method. The objective of this project is to outline a manageable, installation technique to detect and specify the level of soil moisture that is endlessly managed with a view to attain peak plant growth and accompany augment the obtainable irrigation resources. In this project they used the knowledge obtained from the input sensors which is handled using the neural networks algorithm and correction factors for monitoring. Soil monitoring, provides a series of assessments, showing how soil conditions and properties are changed [7].

4. METHOD:

Prediction of soil moisture is significant for effective irrigation management system. The estimation of soil moisture depends upon evapotranspiration. Hargreaves and Samani developed a way supported temperature and extra-terrestrial radiation to estimate ET0. It is expressed in the equation (1)

$$ET_0 = 0.0023R_a\left(\frac{T_{MAX} + T_{MIN} + 17.8}{2}\right)\sqrt{Tmax} - Tmin \longrightarrow (1)$$

Where Tmax and Tmin are maximum temperature and minimum temperature (°C) and Ra means extra-terrestrial radiation (MJm−2 day−1).

Ritchie developed another method for estimation of ET_0 based on temperature and solar radiation. It is expressed in the equation (2)

$$ET0 = \alpha 1\ [3.87 \times 10\text{-}3\ RS\ (0.6TMAX + 0.4TMIN + 29)] \longrightarrow (2)$$

where ET_0 is reference evapotranspiration (mm/day) Tmax and Tmin=maximum and minimum temperature (°C) and Rs is solar radiation (MJm−2 day−1)

$$\left.\begin{array}{ll} 5 < TMAX \leq 35\ OC & \alpha 1 = 1.1 \\ TMAX > 35 & \alpha 1 = 1.1 + 0.05(TMAX - 35) \\ TMAX < 5\ OC & \alpha 1 = 0.01\exp[0.18(TMAX + 20)] \end{array}\right\}$$

Cobaner developed evapotranspiration estimation method supported Neuro-Fuzzy (NF) inference and located that the NF model (based on radiation, air temperature, and relative humidity) exhibits better accuracy than the combination of radiation, air temperature and wind speed.

4.1. SUPPORT VECTOR MACHINES(SVMS)

In the recent few decades there has been very significant developments

$$\text{Minimize } R_{SVMs}(w, \varsigma^{(*)}) = \frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}(\varsigma + \varsigma *) \longrightarrow (3)$$

within the theoretical understanding of Support vector machines (SVMs) as well as algorithmic strategies for implementing them. SVMs introduced by Vapnik et al. within the simple obtainable components decreases the manufacturing and maintenance costs. This makes this system more economical, appropriate and a low maintenance solution for applications, mainly in rural areas and for small scale agriculturist. Early 1990s are machine learning systems that utilize a hypothesis space of linear functions during a high dimensional feature space, trained with optimization algorithms that implements a learning bias derived from statistical learning theory.

Hydrological model application shaves a wide variety of objectives, depending on the problem that needs to be investigated to analyze hydrologic data statistically, the user must know basic definitions and understand the purpose and limitations of SVM analysis. The application of SVM hydrological analyses methods requires measurement of physical phenomena. The modeler has to evaluate the accuracy of the data collected and should have a brief knowledge on how the data are accumulated and processed before they're utilized in modelling activities. Some of the commonly used data in hydrologic studies include rainfall, snow melt, stage, stream flow, temperature, evaporation, and water shed characteristics.

4.1.1 THEORY OF SVM

SVMs are used to estimate the regression function. SVMs estimate the regression using a set of linear functions which are defined during a high dimensional space. SVMs perform the regression estimation by risk minimization where the danger is measured using Vapnik’s e-insensitive loss function. SVMs use a risk function consisting of the empirical error and a regularization term which springs from the structure risk minimization principle.

Given a set of data points G = {(x_i, d_i)}in (x_i is the input vector, d_i is the desired value and ^{n} is the total number of patterns, SVM approximate the function using the following:

$$y = f(x) = w\ \phi(x) + b \longrightarrow (4)$$

Where ϕ(x) is the high dimensional feature space which is non-linearly mapped from the input space X. The coefficients w and b are estimated by minimizing.

$$RSVMS(C) = C\sum_{i=1}^{n}\left(L(di, yi) + \frac{1}{2}||w||\right) \longrightarrow (5)$$

$$L\,\varepsilon(d\,,\,y) = \begin{cases} |d - y| - \varepsilon & |d - y| \geq \varepsilon \\ 0 & \text{otherwise} \end{cases} \longrightarrow (6)$$

In the regularized risk function

C(1/n) Σ ni=1 L ε (di, yi) is empirical error (risk), and matured by function L ε. The second term 0.5||w||2 is regularization term. C is referred to as the regularized constant and is determines the trade-off between the empirical risk and the regularization team Increasing the value of C will result in relative importance of the empirical risk with reference to the regularization term to grow. £ is named the tube size and it's like the approximation accuracy placed on the training data points.

To obtain the estimations of ›r and *b* is transformed to the primal function given by introducing the positive slack variables and d J Finally, by introducing Lagrange multipliers and exploiting the optimality constraints, the decision function given by has the following explicit form zhang (2003)

$$f(x, a_i, a_i) = \sum_{i=1^{\cdot}=1}^{n}(a_i - a_i^{*})K(x, xi) + b \longrightarrow (7)$$

Weather API- In open weather map we tried many of the API for our projects, at the end we come to conclusion to use some relevant API which is helpful to complete our project. They provide lot of available data's, but in free account the limitation is unable getting the current values, it may be 3-5 hours difference. Any way in our project it would helpful for analysis and correlate the real time value with the satellite data's Apart from the given paper we are going to use AGRO API. So, what is agro API -Agro API for natural integration of satellite images to agricultural application and machine learning.

5. ARCHITECTURE

The primary step towards developing a smart irrigation system automatically is deploying that sensor nodes in a network on the field with Wi-Fi communication to the database once the communication is transferred from sensor to the database and it sends an alert signal for the requirement of the resource the sensor nodes are deployed in such a way that they form a star topology with respect to the region of the field. Once the sensor nodes are deployed inside the field the micro-controller which acts as a gateway network for communication between the sensor not this communication is transferred using MQTT protocol which is a publish and subscribe protocol having and cloud MQTT broker. When describing the structure of the node the micro-controller is a best solution which is connected with all the Sensors using a Wi-Fi network. In the field of agriculture, many new technologies have been developed to perform the farming practices and define Precision farming. The major technology which has improved the Precision farming practices is the internet of things connected with data analytic for a healthy crop and higher productivity.

In this project, the major problem by which the crop affected is irrigation requirement. To address this problem a proper algorithm is required to predict the need for water in the field by measuring the soil moisture with help of the sensor data and weather forecast data using a regression model algorithm which is a support vector machine (SVM). The support vector regression model helps in providing information related to the soil moisture for the upcoming days and provides suggestions related to the irrigation based on the predicted soil moisture and the level of precipitation. With this algorithm the amount of water used, high consumption of the energy saved are noted. The information collected from the prediction algorithm can also be stored inside a database at the server for further calculations and requirements. By making predictions on the field with the advanced technologies which include machinery tools can increase the efficiency in the land, labor, time requirement. With this prediction algorithm, the exact quantity of the source can be used which reduces the cost of agro-chemicals in crop production. For post- production activities and proper decision-making prediction algorithm helps to analyze and produce an accurate information to the farmers.

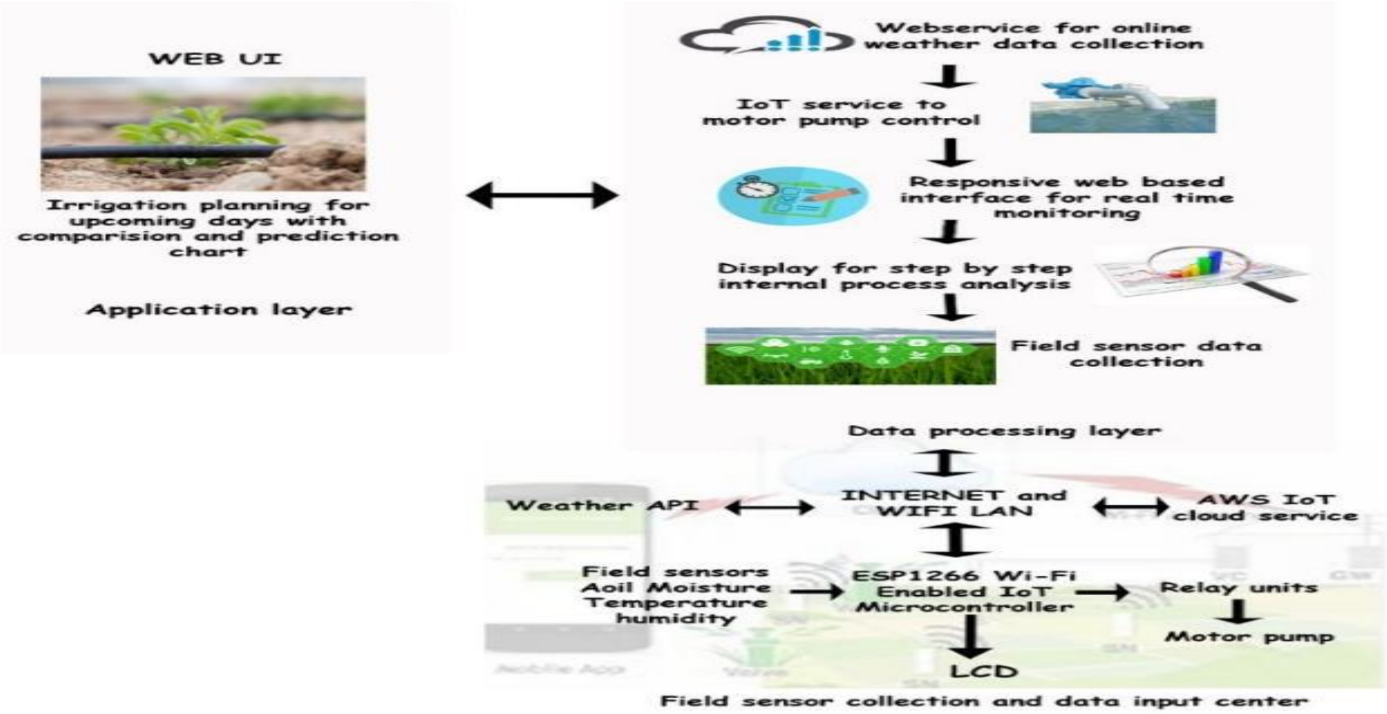

Fig 5.1 Overall Architecture diagram

6. IMPLEMENTATION :

With the introduction of IoT there were many low-power and low-cost nodes which are easily used inside the farm fields to acquire the required climatic data. However, this collected data is sent to the IoT framework with the help of an internet connection. As wireless sensor networks are also included, they are having small units called as motes which are helpful in communicating wireless. These wireless sensor networks acquire the climatic and environmental parameters such as soil moisture, temperature and humidity. With the help of the gateway the data is transmitted. The sensors process, analyze and collect the data with the help of web interface in the IoT cloud. Though it was implemented later wireless sensors were the primary step towards betterment of improving agriculture practices because they also provide real-time calculations which were essential to understand and manage the agriculture field not only managing wireless sensor network also enable the remote sensing areas without physical structure, hence the cost is also reduced. Once the entire data is collected a decision is made automatically whether any resource or inputs are required into the field or not. With the evolution of internet of things (IoT) it was very easy to manage the connected devices and even track the existing and the present field status and also know the conditions for the upcoming data. It helps us to visualize the data from different sensors. There is a high amount of storage and proper security given when the data is collected.

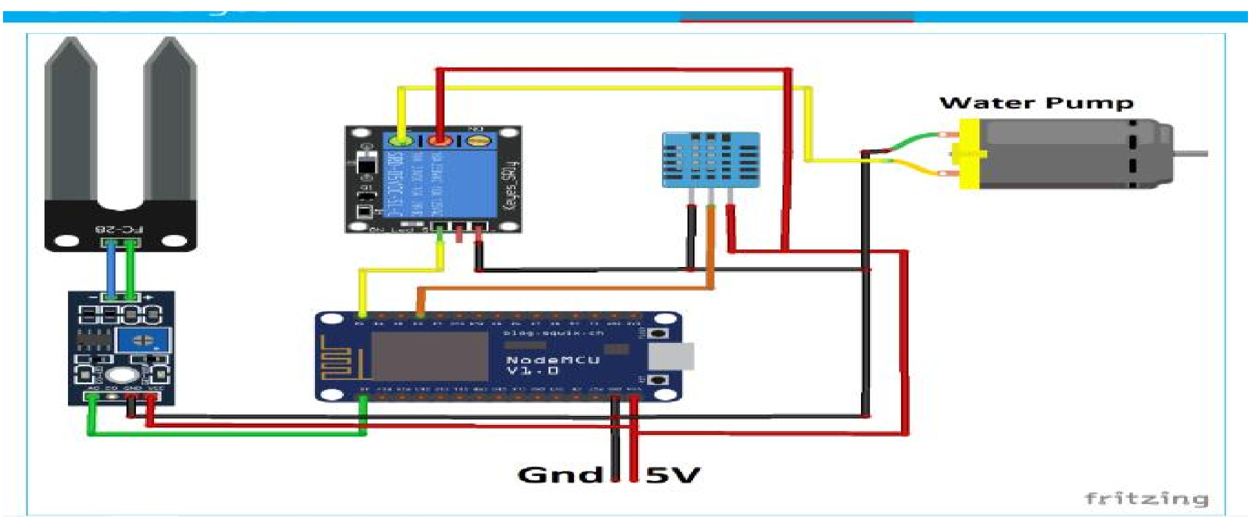

Fig.6a Overall View

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The future of everything is IoT. It is required in every field. This process is able to manage monitor as well as control many things from a certain distance without any effort. With the help of IoT the yield of any crop is maximized. With the use of the smart agriculture, it can also reduce the wastage upon the resources. Apart from the sensors the environmental conditions also equally participate to enhance the growth of the crop and these parameters are easily collected with the help of sensors and the data is sent to the cloud. Compared to the traditional methods there is a very less amount of risk and high amount of yield produced. Due to this there is even an effective decision-making system for the upcoming conditions of the agriculture. The smart agriculture inducing with IoT applications requires a smart sensing, a proper planning analysis and monitoring of the field and the equipment. This data is sent through the IoT cloud using such as AWS, AZURE etc. Once the data is achieved near the cloud the farmer or the user is able to take a precise decision with the graphs and values visualized.

Fig.6b Location

In terms of soil moisture these collected data will let farmers understand how much amount of water is required to irrigate the field, so due to this there is a high reduction and usage of water and the necessity and requirement is also equally fulfilled.

Fig.6c Soil Moisture Retaining Prediction

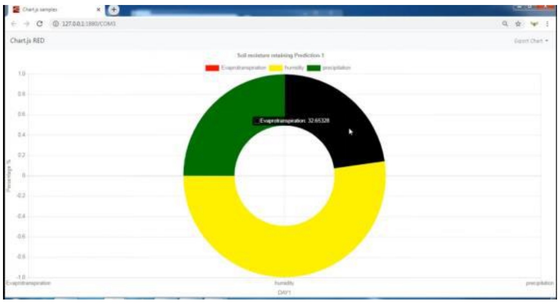

Fig.6d Pie Chart

Fig.4e IoT based Irrigation System results

6.1. ALGORITHM IMPLEMENTATION

6.1.1 Soil Moisture Prediction algorithm

For Growth and economic development in the country, agriculture plays a prominent role. The characteristics of soil are varied with many parameters one such parameter that affect drastically the crop growth is the climatic phenomena. With proper weather conditions, the growing crop can give better yield.

6.1.2. Predictive Analytic Model

The productive analytical model implements many techniques in regard of machine learning with respect to historical information and current calculations to make smart decisions for the upcoming events in the predictive model we can start the previous data to make smart decisions for the future related requirements in this model the data forms different patterns for analyzing the facts for the future predictions Pattern matching and classification of statistical learning includes a predictive analysis model . This process includes analyzing about an event which has occurred in the past and calculate the requirement for a present event with similar conditions. This process can help in making better decisions. The process of prediction model includes collection of data analysis of data and monitoring and presenting the result in the form of a graph.

6.1.3. Irrigation Timings

The field sensors collect real-time data by monitoring and analyzing the data with the corresponding threshold value. In the process of analyzing, if the moisture level is below the current threshold value, the farmers have to take the necessary action to perform the irrigation, if moisture value is higher than the threshold then the irrigation need not be performed. With this process farmer scan have a clear idea on how much level of water is required for the field. Apart from this it also helps in giving an accurate amount of water. For a better yield by collecting the data from the field it is useful for the farmers to efficiently monitor and take the necessary actions for further process.

6.1.4. Integration of weather forecast

To efficiently monitor the crops for production, the weather forecast and the level of Threshold helps in making the irrigation pattern better. If the moisture obtained from the field is close to the existing data and in case if there is rain, the farmer need not perform irrigation or can do it very moderate. As the climatic data is unpredictable irrigation can be based on the weather condition and farmer has to look for the moisture level inside the field and how long the soil can retain the moisture content.

6.1.5 Upcoming Four Days Prediction

This is an empirical and multivariate prediction algorithm. In this historical data is calculated for 1 week and the prediction is obtained for the next four days This cycle repeats which helps in predicting the future events.

7. CONCLUSION :

The soil moisture may be a critical parameter for developing a sensible management irrigation system. The soil moisture is suffering from variety of environmental variables, e.g., air temperature, air humidity, UV, soil temperature, etc. With advancement in technologies, the meteorology accuracy has improved significantly and therefore the weather fore- casted data are often used for prediction of changes within the soil moisture. This paper proposes an IoT based smart irrigation architecture along a side a hybrid machine learning based approach to predict the soil moisture. The proposed algorithm uses sensor's data of recent past and thus the weather forecasted data for prediction of soil moisture of upcoming days. The predicted value of the soil moisture is best in terms of their accuracy and error rate. Further, the prediction approach is integrated into a standalone system prototype. The system prototype is cost effective, because it's predicated on the open standard technologies. The auto mode makes it a sensible system and it are often further customized for application specific scenarios. In future, we are getting to conduct a water saving analysis supported proposed algorithm with multiple nodes along the side minimizing the system cost.

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