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# A Review on Use of IOT in Precision Agriculture using ML Algorithm

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**ABSTRACT:** Agriculture plays a very important role in the economic growth of any country. As population increase, limited resources and frequent changes in climatic conditions it becomes a challenging task to fulfil the food requirement of the present population. Precision agriculture also known as smart farming have arose as an advanced tool to address current challenges in agricultural sustainability. Internet of things (IoT) and machine learning (ML) based solution are reforming many fields of humankind like transportation, business, environment, and agriculture. The fresh water resources, which are already stressed, are being used wastefully in many countries. The Internet of Things and machine Learning techniques can be used to enhance the water usage in irrigation. This paper presents the Use of IOT and ML techniques to enhance the irrigation water usage by predicting the future soil moisture of a field in an IoT driven smart irrigation framework. The field data collected from the positioned sensors and the weather forecast data from the Internet are used for predicting the future soil moisture.

**KEYWORDS:** Internet of Things, Machine Learning, smart irrigation, Soil moisture prediction

## I. INTRODUCTION

Fresh-water scarcity is one of the biggest problems faced by many nations in the world and the problem is getting adverse with time due to increase in population and inefficient usage of fresh water. Agriculture sector preoccupy a large amount of water in irrigation practices. In India, a water stressed nation, around 80% of fresh water resources are used in agriculture sector. The traditional irrigation techniques do not utilize water optimally, which raises a need for precision agriculture with smart irrigation. Internet of Things (IoT) and machine learning (ML) based solutions have a great potential to improve the agricultural landscape. The solutions can be used in various dimensions, e.g., smart irrigation; monitoring and control and agri-resource management; agri-business management. The smart irrigation techniques have gained much attention in recent past. Many irrigation systems are proposed based on wireless sensors networks (WSN), IoT and Artificial Intelligence (AI)/ML. Precision agriculture is one of the solutions to ensure food security for the entire world. Precision agriculture also abbreviated as digital agriculture is a technology-enabled data-driven sustainable farm management system. It is basically the adoption of modern information technologies, software tools, and smart embedded devices for decision support in agriculture. Digital technologies such as IoT, AI, data analytics, cloud computing, and block-chain technology play a key role in precision agriculture. In precision farming, IoT based smart sensors are deployed in the agriculture land for collecting data related to soil nutrients, fertilizers, and water requirements as well as for analysing the crop growth. ML algorithms are also used for weather and rainfall prediction based on the data obtained from sensors, climatic records, and satellite images. Fig. 1 Shows use of IOT in agriculture field.

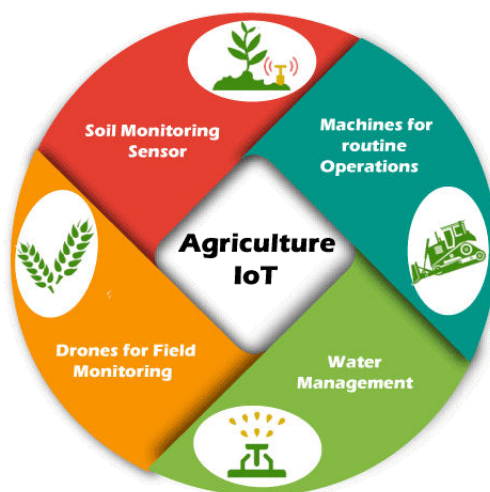


Fig.1: Use of IOT in Agriculture Field

## II. RELATED WORK

Goap et al. proposed Crop irrigation management system based on Machine Learning (ML) techniques. It is an automated irrigation management system to predict future soil moisture of upcoming days. The system uses the field data collected via sensors placed in a field and the weather data from weather forecasting sites. The prediction of future soil moisture could be very helpful in effective provisioning and usage of water in irrigation. An effective implementation of machine learning techniques for soil moisture prediction is a challenging and open research direction. This paper considers ML based techniques for prediction of soil moisture of upcoming days based on the sensors data received from the field and the weather forecast information. The sensors node deployed in the field collects data for current soil moisture, soil temperature, environmental temperature and humidity, which is used for future soil moisture prediction. Various machine learning techniques, viz., Gradient Boosted Regression Tree (GBRT), Random Forest Regression (RFR), Multiple Linear Regression (MLR) and Elastic Net Regression (ENR), are used for the prediction and the prediction results are very encouraging [1].

L.S. Pereira et al. proposed a soil water balance (SWB) model approaches to determine crop irrigation requirements and scheduling irrigation adopting the FAO56 method. In this study the Kc-ET<sub>o</sub> approach is discussed with consideration of baseline concepts namely standard vs. actual Kc concepts. also single and dual Kc approaches are compared. An overview on models development is done in this study. Features of dual Kc modeling approaches are analyzed through a few applications of the SWB model SIM DualKc, mainly for derivation of basal and single Kc, extending the basal Kc approach to relay intercrop cultivation, assessing alternative planting dates, determining beneficial and nonbeneficial uses of water by an irrigated crop, and assessing the groundwater contribution to crop ET in the presence of a shallow water table. Study also discusses the challenges placed to SWB modeling for real time irrigation scheduling and use of cloud computing and internet of things well as an improved wireless association of modeling with plant and soil sensors [3].

Juan M. et. Al. presents the design and implementation of a precision agriculture system using sensor networks for white cabbage. The main aim of this study is to transfer knowledge and mitigate the effects of the soil and climate change on white cabbage crop [4].

Roque Torres et al. proposed a study of several learning techniques in order to determine the goodness and error relative to expert decision. Nine orchards were tested during 2018 using random forest regression (RFR), linear regression (LR), and support vector regression (SVR) methods as engines of the irrigation decision support system (IDSS) proposed. The results obtained by the learning methods in three of these orchards have been compared with the decisions made by the agronomist over an entire year. The prediction model errors determined the best fitting regression model [5].

Fresh water is the lifeline of humankind; it is not only precious but also limited on this earth. A major chunk of fresh water is used in agriculture sector. It has seen that many countries do not use water resources optimally in



irrigation. It not only causes wastage of water, it can also cause lower yield of agri-produce. To optimize the water usage in irrigation an IoT and ML based approach is presented in this paper. As the soil moisture plays the critical role in measuring optimum water usage in irrigation, the ML techniques are used for prediction of soil moisture of upcoming days based on the sensors' data collected from the field and the weather forecast information. The impact of AI and IoT in smart farm management is discussed with a brief introduction to ML algorithms which are most commonly used in precision agriculture.

In the modern era, irrigation for crops has been improvised using the concept of drip irrigation, where the system consists of thin plastic tubes placed in or above the soil along the vertical rows of the plants for nurturing the water supply to the crops. Employing the proper operational management of drip irrigation, minimizes the utilization of water supply for crop production, and provides a better yield of crops. Socioeconomic and environmental demands have widely appreciated in use of drip irrigation on farmlands for agriculture, especially for the high cost valued crops i.e., vegetables and fruits. Furthermore, drip irrigation is based on the low-pressure watering system in comparison to sprinkler systems; this makes the system more efficient in terms of energy consumption. Various advantages have been observed using drip irrigation in agriculture over other irrigation systems which include sub-irrigation systems or sprinkler irrigation systems. These advantages are entitled to minimal usage of water supply, usage of soluble fertilizers through a drip irrigation system, automated system, minimization of soil erosion, uninterrupted activities, minimized weed problems, facilitation of double-cropping. Precision irrigation is another innovative approach in intelligent farming where it uses the water intelligently that further helps the farmers to achieve better yield in crops with minimal water usage. It can also be featured as providing the right amount of water, at the right time and the right place in the field. It focuses its implementation based on variable rate irrigation (VRI) methods employing drips or sprinklers. Advancements in the field of on-farm sensor technologies, weather forecasting, IoT based sensor detection system of vegetation and precision-based smart irrigation produces a huge size of data that ultimately benefits the farmers in optimizing the usage of water resources, improve the yield of crops and maximizes the profit of farmers.

Chang et al. developed a smart irrigation model based on ML with the LoRa P2P network to learn the irrigation experiences from the expert farmers working on greenhouse organic crops. Singh et al. have discussed an ML and IoT based model for soil moisture prediction during irrigation. Torres-Sanchez et al. proposed a decision support system for irrigation management of citric crops in southeast Spain. In the proposed model smart sensors are deployed in the field to monitor water supplied previous week, weather data, soil water status, and based on this data three regression models SVM, RF, and Linear regression was trained to build the irrigation decision support system. RF best predicts with comparatively less prediction error.

Goumopoulos et al. proposed a real-time adaptable intelligent and autonomous closed-loop irrigation management system. The authors built an experimental set-up in a greenhouse and deployed wireless sensors for monitoring the plant growth and environmental conditions along with plant growth control actuators. Estimation of evapotranspiration (ET<sub>c</sub>) plays a vital role in water resource management system. Chen et al. estimate crop actual ET<sub>c</sub> from temporal convolution network (TCN) from the dataset of lysimeters for maize under drip irrigation with film mulch. Simulation results show that the proposed model best predicts ET<sub>c</sub> with an improved correlation coefficient and decreases MSE and MAE.

Roque Torres et al. presents the development of an irrigation decision support system (IDSS) for irrigation management optimization in citrus trees. The system uses the following information obtained. automatically by in-the-field sensors: (1) weather data, (2) the amount of applied water data from the previous week, and (3) soil water status and water quality data. We also considered aspects such as meteorological predictions, the type of crop, and the phenological stage on which the model performs the irrigation calculation. The system was trained using reports made by agronomists for determining the irrigation frequency and doses on a weekly basis. Three regression learning algorithms were compared for performance purposes: linear regression (LR), SVR, and RFR. The models were evaluated using leave-one-out cross-validation (LOOCV) and random 90-10 shuffle cross-validation techniques. The irrigation amount estimated for an entire year by the IDSS was compared with the irrigation water applied by the agronomists, allowing us to compare the performance of different learning algorithms [5].

Anat Goldstein et al. proposed research which aims at using the collected data not only for monitoring and controlling the crop, but also for predicting irrigation recommendations. A dataset was constructed by integrating data gathered over almost two years from 22 soil-sensors spread in four major from a meteorological station, and from actual irrigation records. Different regression and classification algorithms were applied on this dataset to develop models that were able to predict the weekly irrigation plan as recommended by the agronomist. The models were



developed using eight different subsets of variables to identify which variables consistently contributed to prediction accuracy. Also, the study discussed about the potential of applying machine learning on the company data for yield and disease prediction [6].

S.A. O'Shaughnessy et.al. The TTT algorithm was used to schedule irrigations for alternating blocks under a 3-span center pivot in an automated center pivot irrigation system. Yields from the automatically irrigated treatments were compared to those from treatments in which irrigations were sched [7].

J. Daniel Francis Selvaraj et.al. proposes an automatic wireless water management system (AWWMS) using Internet of Things for vineyard growth. The proposed system mainly focuses on optimal water usage and reduction in manual labour on vineyard field so that wastage of time, cost and power on grape production can be saved. The system involves the coordination of wireless sensors deployed in the soil for collecting required real-time information such as air humidity, soil moisture and environmental temperature which is then passed to the cloud server through IoT gateway for making decisions about irrigation. The proposed AWWMS system was implemented and tested on a small-scale environment [9].

Amarendra Goap et.al. presents an open-source technology based smart system to predict the irrigation requirements of a field using the sensing of parameter like soil temperature, soil moisture and environmental conditions along with the weather forecast data from the Internet. The sensing nodes, involved in the ground and environmental sensing, consider soil temperature, soil moisture air temperature, Ultraviolet (UV) light radiation, and relative humidity of the crop field. The smartness of the proposed system is based on a smart algorithm, which considers sensed data along with the weather forecast parameters like precipitation, air temperature, humidity, and UV for the near future [10].

Deepak Sharma et.al. presents a technical analysis of IOT based application scenarios for agriculture sector. The article presents a brief introduction to IOT framework for agricultural applications. The article also discusses various agriculture specific application circumstances, e.g., decision support system, farming resource optimization, environment monitoring and control systems [11].

Haikal Hafiz Kadar et.al. proposed article principally reviews the engagement of a smart water management system prototype, the AGRIZL system, proposed as part of the IoT solution. The system architecture and a detailed description of the physical scenario on how AGRIZL system works for data management as part of IoT platforms. AGRIZL system allows being interoperable and manageable in the specific context of water resource management processes. The main purpose of proposed prototype is to design an implementation detail of smart water level and leakage monitoring system by engaging the real-time data to facilitate the analyst focuses more on analysis and actions in short period with low cost [12].

V. V. Palazzi et.al. This work presents an RFID-based autonomous leaf-compatible temperature sensing system for precision agriculture. The wireless transponders are based on the EM4325 chip by EM Microelectronic, which features an integrated temperature sensor. A field test demonstrates that the sensors can be successfully deployed to monitor leaf temperature and, through the analysis of the leaf-to-air temperature differential, they can be used to check the water stress status of crops [13].

Gábor Gyarmati et.al. The major aim of this study is to give an overview of the present and possible future directions of the precision farming in a global content [14].

Carlos Kamienski et.al. proposed the SWAMP platform, architecture, and system deployments that highlight the replicability of the platform. It also includes a performance analysis of FIWARE components used in the Platform. Results obtained in this study show that it is able to provide adequate performance for the SWAMP pilots, it requires specially designed configurations and the re-engineering of some components, it will provide higher scalability using less computational resources [15]. Joaquín Gutiérrez et.al. designed An automated irrigation sensor implemented to use in agricultural crops. The designed sensor uses a smartphone to capture and process digital images of the soil adjacent to the root zone of the crop, it also estimates optically the water contents. The sensor is kept in a chamber under controlled brightness and buried at the root level of the plants. An Android App was developed in the smartphone to operate directly the computing and connectivity components, such as the digital camera and the Wi-Fi network. The mobile App initiates the smartphone, activating the device with user-defined parameters, after that the built-in camera takes a picture of the soil through an anti-reflective glass window. Then soil picture is processed from RGB to gray scale to estimate the ratio between wet and dry area of the image [16].

Zhijun Chen et.al. Proposed a study in which a Temporal Convolution Network (TCN) with two engineering methods and Maximal Information Coefficient (MIC) and Principal Component Analysis (PCA) was developed to predict ETc using a two-year dataset from lysimeters for maize crop under drip irrigation with film mulch. The TCN models comprised of Long Short-Term Memory Networks (LSTM) and Deep Neural Networks (DNN). The study continues to test the results of the TCN models, the results were compared in predicting Kc values with FAO-56 Kc values in the literature. The results suggested that soil temperature, mean temperature, maximal temperature, relative humidity, plant height solar radiation and leaf-area index are the seven most important features affecting maize evapotranspiration [17].

### III. ML TECHNIQUE FOR IRRIGATION IN AGRICULTURE

**Gradient Boosting Regression Trees:** Gradient boosting is a flexible nonparametric statistical technique used for classification and regression problems. It generates a prediction model in the form of an ensemble of models with weak prediction, typically decision trees. The model is built in a stage-wise manner and generalizes them by allowing optimization of an arbitrary differentiable loss function. Gradient Boosting (GB) helps to formulate an additive model in a forward state-wise manner. A regression tree is fit on the negative gradient of the given loss function at every iteration. Each new model tries to compensate the error made by the previous tree.

**Multiple Linear Regression:** Multiple regression also known as Multiple linear regression is a statistical technique which is used to model the linear relationship between independent variables and dependent variables. This technique is an extension of ordinary least square regression (OLS). The model formulates a relationship in the form of a straight line (linear) that approximates all the individual data points in the best way. For  $p$  predictor variables  $x_1, x_2, \dots, x_p$  and the response  $Y$ , it can be represented as:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p + \epsilon$$

Where  $\beta$  values represents regression coefficient ( $\beta_0 = Y$ -intercept/constant-term,  $\beta_p =$  slope coefficients for each explanatory variable) and  $\epsilon$  is the error term (also known as the residuals)

**Elastic Net Regression:** Elastic Net is a regularized regression method that linearly combines the penalties of ridge and lasso regression. it tries to minimize the loss function. In other words, it is a convex combination of ridge and lasso regression.

**Random Forest Regression:** Random forest Regression is an ensemble learning technique for regression and classification problems. Random forest technique corrects the decision tree technique's habit of over fitting to their training set [12]. The random forest model works in a way of additive model which makes predictions by combining of decisions from base-models' sequence. It can be written as:

$$g(x) = f_0(x) + f_1(x) + f_2(x) + \dots$$

where the simple base models are represented by  $f_i$  and the final model is represented by  $g$ . The base classifiers represent simple decision trees. This technique uses multiple models to obtain improved predictive performance which is also known as model ensembling. All the base models are constructed independently in a random forests technique using a different subsample of the data.

### IV. PRECISION AGRICULTURE

Precision agriculture refers to a system with minimizing direct involvement of the caretaker/farmer except when there is an urgent need or an emergency i.e. when there is a failure in the system. IoT helps in maintaining the defined standards of parameters needed for day to day work in agriculture. The parameters can be measured using the required sensors and can be uploaded to an IoT cloud for remote monitoring so that the direct involvement of farmers is minimized. The IoT cloud can be used for control purposes also, say for example in detecting and avoiding animal intrusion in the agriculture field. Sensors are an integral part of IoT for precision agriculture without which the monitoring and controlling becomes next to impossible task. Table 1 shows sensors used in precision agriculture.

Sensor	Measuring Parameter
Accelerometer (ADXL345)	Static and Dynamic acceleration
Air Humidity (HTU21D)	Relative Humidity & Temperature
Air Temperature (SHT11)	Relative Humidity & Temperature
Camera (PixyCam, Raspberry Pi)	Image
Capacitive Touch (MPR121)	Capacitance
Light (GL5528)	Light intensity
Proximity (HC-SR501)	Light intensity
RGB Colour (TCS34725)	Photodiode current
Soil Moisture (SEN0114)	Resistance
Sound (SEN-12642)	voltage
Distance (HC-SR04)	Time
Pulse Oximeter	Current
Temperature (MAX30205)	Temperature
Piezoelectric (PZT)	Voltage difference

Table 1: Sensor Parameters used in Precision Agriculture

## V. CONCLUSION

Fresh water is the lifeline of humankind; it is not only precious but also limited on this earth. A major chunk of fresh water is used in agriculture sector. It has seen that many countries do not use water resources optimally in irrigation. IoT enabled smart sensors, actuators, satellite images, robots, drones are some of the key technological revolutions that boosted the agriculture industry. These components play a vital role in collecting real-time data and accordingly making decisions without human support. Artificial intelligence which is the automation of intelligent behaviour is continuously benefiting our planet and helping humans in various aspects of life. This paper reviewed ML applications for precision agriculture. The impact of AI and IoT in smart farm management is discussed with a brief introduction to ML algorithms which are most commonly used in precision agriculture.

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