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Automation of Agricultural Fertigation using IoT and Machine Learning with Intrusion Alert

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***Abstract*—Agriculture sector supports the country's economy to a great extent and to maintain that, it is required to produce great yield which requires proper irrigation water and fertilizer management. With the concept of IoT, Cloud and Machine Learning there is a scope of economical monitoring system in real time with field status notification. Thus, the proposed model provides the automated fertigation and observing system using IoT to monitor the soil's moisture level, temperature and humidity of atmosphere, machine learning to predict the right amount of water along with intrusion detection and control of pesticide sprayer using webpage. The raw sensor data are transferred to cloud platform and depending on prediction value relay turn ON/OFF the motors accordingly. The results obtained from the proposed project are promising and justifies the work.**

***Index Terms*—Keywords.**

I. INTRODUCTION

In this technology driven era, need of automation in agriculture is essential for a farmer to enhance the annual yield and make their life simple. The main needs relate to keep an eye on agricultural field criteria's continuously, re-solve the problem of lack of farmer to monitor and control field from a distance, spontaneous rapid analysis and implementation of functions to automate fertigation tasks with secured, authentication connection and to avoid entries of animals or unknown/suspicious persons into field during both day and night times. Also, now-a-days water inadequacy is an alarming issue all over the world so water management is also taken into account while designing the smart fertigation system.

Incorporation of modern and developing technologies in agricultural area is necessary to overcome the above-mentioned drawbacks with an eco-friendly solution and improve the standard of the farmer's life. So, a model is proposed with upcoming technologies like machine learning, IoT, multiple sensor node interfaced communication and cloud computing contributing for a smart monitoring and control of farm. Role of sensors play a vital role as the final action is the result of the output from the sensors. Over or less irrigation and over or malnutrition, could affect the annual production and so fertigation automated system is necessary. Efficient fertigation system makes sure that sustainable mixing and use of water and fertilizers is done adding to replenish groundwater. This project presents an economical approach of automating fertigation systems along with cloud control of fertilizer/pesticide sprayer and also intrusion detection is notified.

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II. LITERATURE REVIEW

Joaquín Gutierrez, Juan Francisco along with a team created automatic WSN based irrigation model with moisture and temperature sensor with web management in the year 2014, but WSN are less efficient for big fields [1]. Gupta AJ and team in 2014, demonstrated the fertigation and irrigation using drip practices for commercial cultivation in Kashmir climatic and soil conditions of hybrid variety of cucumber and various fertilizer methods efficiencies were discussed [2]. C. Ersin, R. Gurbuz and team presented an automatic irrigation system using micro-controller which was economical and quite efficient in comparison with precision irrigation practices and other conventional methods but not efficient for big fields [3].

TABLE I. EFFICIENCS OF FERTILIZER METHODS

NUTIRENTS	USE EFFICIENCY OF FERTILISER (%)	
	DIRECT SOIL APPLICATION	FERTIGAITON METHOD
POTASSIUM	52	80
NITROGEN	32-53	95
PHOSPHOROUS	25	47

In the year 2016, Prof. Dr. R. S. Kawitkar along with Nikesh Gondchawarl and team designed an irrigation setup using only sensor for measuring moisture with Raspberry Pi microcontroller which helped with machine learning techniques [4]. In the year 2017, Bapat V., Kale P. and group developed a device to protect crops from attack of animals using distance sensor (PIR), Arduino and for notification purpose a GUI was provided [5]. The model presented by A. Agrawal, R. Gupta, M. Pandey and team in 2018, gave a simple automated irrigation system using microcontroller and moisture sensing technologies where supply power was through solar panels but this setup but is not feasible in very big fields [6]. In 2019, V. K. Sarker, T. N. Gia and team proposed the use of end user device for on-device computations and explains its merits in improving bandwidth need for the sensor network communications [7]. In the year 2019, B. Bellini, J. P. Becona, A. S. Pereira and group designed system monitors field on daily basis and controls the distribution of water and gives the accountablility to water amount used in the farm in real-time [8]. S Iyer in year 2020, gave the conceptional controlling and monitoring of field status using mobile app and cloud platform using a greater number of nodes where there is chance of malfunction of entire system if small defect happens in small components [9]. In 2020, K. Priandana and R. A. Wahyu's model focuses Chili plant specific automatic irrigation system using the soil moisture sensor in Indonesia which employed soleniod valve and relay since this model is specific to one plant can't be applicable to variety of crops [10]. In the year 2021, M. Safdar Munir, Imran Sarwar Bajwa and team proposed an approach of automatic irrigation using IoT with network of sensors to trace and analyse the field data at edge server and predict necessary actions for the crop and application is employed to display results [11].

III. TECHNOLOGIES INVOLVED

A. Fertigation

One of method of application of the fertilizer to agricultural field is fertigation, where fertilizer is mixed along with the water to be used for the irrigation having drip kind of practices. The main advantage of this method is that the fertilizer solution is evenly distributed throughout the field. Both the water soluble and liquid form fertilizers are employed. Using this technology, the use efficiency of fertilizer is improved from 80 to 90 percent and nutrients are more [12]. Table 1 shows the comparison between the fertigation and direct soil applications use efficiencies.

B. IoT

Internet of Things (IoT) essentially contributes to transformation of current industry 3.0 to Industry 4.0 by automation and digitalization of organization and society. It facilitates the internet to connect to the physical things and these items communicate by exchanging information and data are transmitted to other systems as well. The data they share include the information about objects in that environment and in which they are attached to. Here in this model IoT is employed for transmitting the field sensors data to the cloud and for the control of the pesticide sprayer [13] which is shown in the Figure 1.

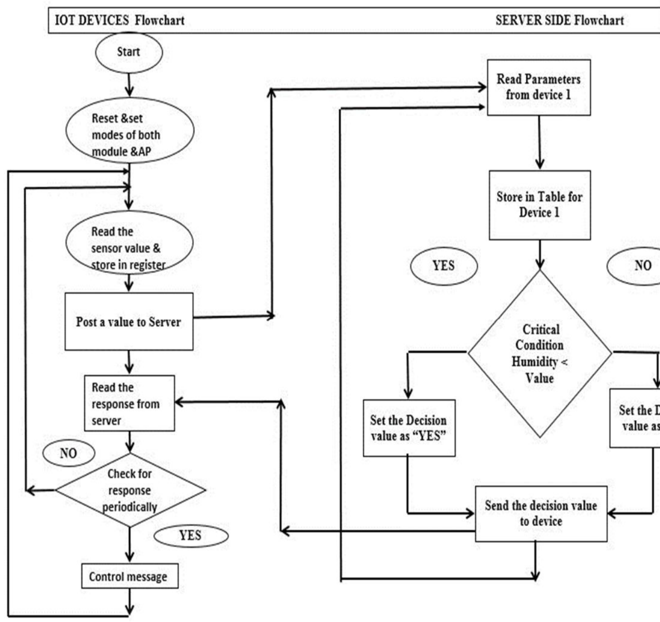

Figure 1. Flowchart of IOT Process

C. Machine Learning

Machine learning, a part of artificial intelligence is the science of making computers to perform action without being programmed explicitly and adjust actions accordingly. It concentrates on the computer development through which it can access data and use that to learn by themselves. The proposed model uses Support Vector Machine (SVM) algorithm under supervised type.

Support Vector Machine is employed for the both regression as well as classification type of problem in machine learning. The aim of this algorithm is to create a best decision boundary which can segregate n-dimensional space into various classes so that the new data point can be put into correct category automatically in future [14].

IV. VARIOUS SENSORS USED

The various types of sensor employed for the smart fertigation model are listed as follows:

a) Soil moisture Sensor,
b) Temperature Sensor,
c) Ultrasonic Sensor and
d) Humidity Sensor.

A. Soil moisture sensor

The soil moisture sensor is used for measuring the volumetric content of water with the help of probes. These fork-shaped probe along with exposed conductors, behaves similar to variable resistor (as like a potentiometer) whose resistance value changes proportionally to the water content present in the soil. An output voltage is produced by the sensor based on the resistance by which we can measure the current moisture level [15].

B. Temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, which produces output voltage linearly proportional to the temperature. This LM35 device is rated to well operate over a −55°C to 150°C temperature range. It provides output voltage in Centigrade (Celsius). The output changes in this type of sensor describes the linearity (+ 10-mV/°C Scale Factor).

C. Ultrasonic sensor

HC-SR04 Ultrasonic distance sensor is an electronic device which emits the ultrasonic sound waves to measure the target distance object and converts the received reflected sound waves into corresponding electrical signals. The sensor provides great non-contact detection of range between 2cm to 400 cm with an excellent accuracy of

3.5mm. Here this sensor is used for the intrusion detection in the field mostly during night times. The Equation (1) gives the formula by which the microcontroller intercepts the distance from the time signal [16].

$$Distance\ (cm) = \frac{echo\ pulse\ width\ (uS)}{58} \quad (1)$$

Since the distance calculated by Eq. (1) is the total distance travelled by the ultrasonic waves from transduces to the object and back to the transducer (two-way trip). So, dividing this total distance by 2 we can determine the actual distance of the object from the ultrasonic transducer [16] with is given by the Equation (2). The ultrasonic waves normally travel at the speed of sound (343 m/s) at 20°C.

$$distance = \frac{time\ taken\ x\ speed\ of\ sound}{2} \quad (2)$$

D. Humidity senor

DHT11 is the digital humidity and temperature sensor which is calibrated to digital signal output of the temperature and humidity values. It helps in calculating relative humidity of the surrounding by measuring the electrical resistances between two electrodes. The conductivity between the electrodes is increased and output is produced, when ions are released by substrate during the absorption of water vapor from air. The relative humidity is directly proportional to the change in resistance between these electrodes.

V. METHODOLOGY

The main purpose of this model is to intimate the end-user (farmer) whenever a critical action needs to be taken by the system in automatic manner. The “digitalRead()” built-in function in arduino is very useful in live tracking of sensor employed.

A. Components employed

- Arduino Uno microcontroller
- Nodemcu module - ESP8266
- GSM Module - GSM900A
- 2 Channel relay
- Soil moisture sensor
- Temperature senor - LM35
- Humidity sensor - DHT11
- Ultrasonic sensor - HC-SR04
- LCD Display - 16X2 matrix
- Pesticide sprayer
- Thingspeak Cloud - opensource
- Personal computer

B. Block Diagram

The Figure 2 show the block diagram about the connection of components to the Arduino Uno and Figure 3 describes about the machine learning part of the model and related control components.

Input I/0 is from the Temperature sensor. Input I/1 indicates the level of humidity in the surroundings. Input I/2 is from soil moisture level sensor.

Input I/3 is from ultrasonic sensor for intrusion detection. The output O/0 is given to the nodemcu for transferring data to the cloud. The output O/1 is given to the GSM module for sending notification to the owner. The output O/2 is given to LCD display for displaying current status of motor.

Based on the machine learning produced prediction value fertigation mixture is applied to field and by means of cloud the pesticide/fertilizer sprayer is controlled.

C. Working of the proposed system

Since soil conditions of filed depends on parameters like temperature and humidity, soil moisture content, etc. they are measured using various types of sensors.

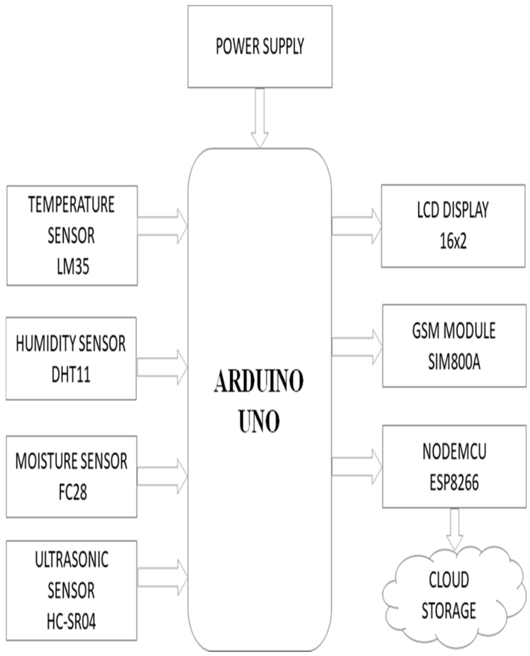

Figure 2 Block Diagram of Controller Connection

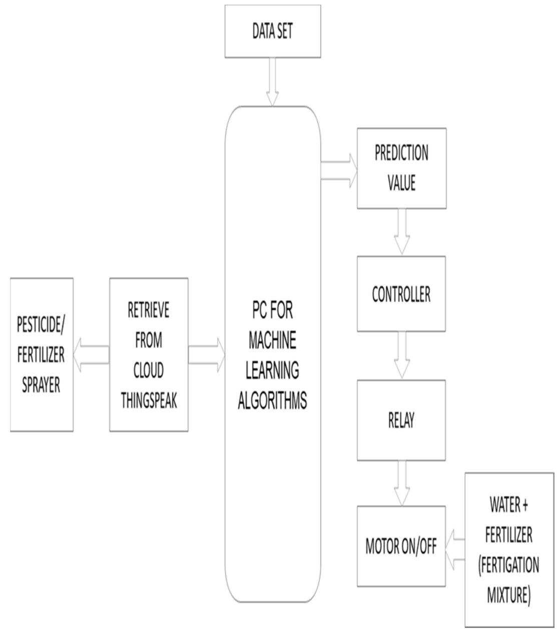

Figure 3 Block Diagram of Machine Learning model

Using a controller, the sensor data are transmitted to the cloud Thingspeak platform by means of nodemcu module with help of Wi-Fi connection and establishes a communication link between the sensor arrays and the server. The Table 2 describes about the parameters controlled by the IoT and machine learning technologies.

The farmer can access the server/cloud about the field condition anytime, anywhere thereby reducing the manpower and time. With the help of machine learning SVM algorithm a prediction value is generated by comparison with the reference data set.

TABLE II. PARAMETER MONITERING CLASSIFICATION

Internet of things (IoT) parameters	Machine learning parameters
Soil Moisture sensing	Support vector machine algorithm
Distance measurement	Prediction value generation
Temperature measurement	Motor control
Humidity level measurement	Pesticide/sprayer control
Upload data to cloud	Running data set

Depending on this prediction value the motor is turned on by means of relay and the mixture of fertilizer and water (fertigation mixture) is sent to the field. Also, through the cloud we control the sprayer to provide frequent pesticide or extra nutrients to the crops for better yield. The intrusion can be detected by the ultrasonic sensors and a notification is sent to the user by means of GSM module so safety is ensured for the farm. The Figure 4 shows the prototype of the proposed system in a simple manner.

VI. RESULTS AND OUTPUT

For the practical purpose the input supply is given through two 12V battery which is able to monitor a wide area field effectively. The following results were obtained by testing with the real field:

- At first the field was selected such that it’s a dry soil and so the sensor detected it and motor was turned on automatically.
- Notification is sent to user if the motor is not turned off automatically show in or if system functions abnormally.
- The motor is turned off by the relay after sufficient fertigation the system is again reset to normal condition.

- The system is tested with different environmental conditions with high temperature and less humidity situations in which the results were appreciable.
- If any intrusion detection is found a notification message is sent though gsm module show in Figure 5 where motion detected and timing information are displayed.
- Graphical representation of the sensor value displayed in Figure 6 is provided to the user by means of Thingspeak platform which helps in analysing the climatic condition.
- The pesticide/fertilizer sprayer is controlled by means of cloud webpage.

VII. Further Enchancements

Next step that can be taken to improve the system is to use the Raspberry pi in which machine learning algorithm can be applied by which use of separate computer is eliminated.

Adding other sensors like pH level, rain sensors improve the efficiency of the model and accurate results can be produced by using other types of machine learning algorithms.

The renewable energy like solar/wind sources can be added as the input supply for the whole setup which will reduce the power consumption and will be useful for the future generation upgrading.

Mobile application [17] can be created for the end users to bring all the control options under single GUI which helps for easy understanding and usage of the model.

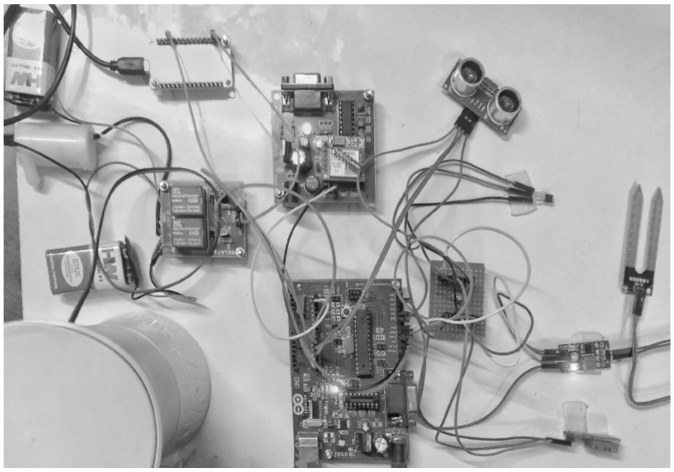

Fig 4 Working Model Setup

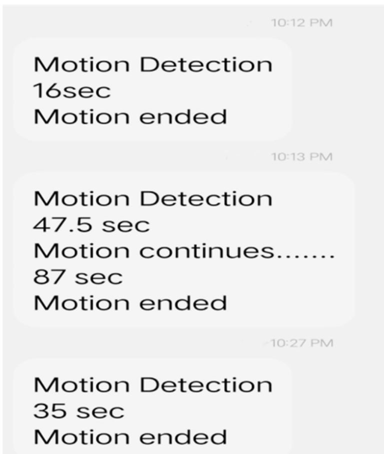

Fig 5 Intrusion Detection Notification

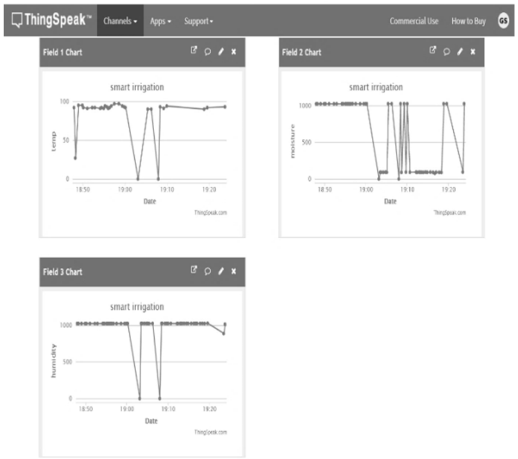

Fig 6 Thingspeak Graphical View of Field Condition

VIII. Conclusion

In the modern world with the development in various streams, automation in agricultural will be a great support for the farmers and will also support the growth of the nation. Modern approaches like machine learning and IoT helps to reduce the man labour and also ensure the yield rate is improving.

The automatic on/off of the fertigation motor reduces the cost for labour and machine learning prediction value helps in providing the required supply of fertigation mixture to crops and avoids over/less application of mixture.

The addition of intrusion detection notification feature helps the farmer to check if unknown person/animal entrance into the field when they are out of station or at night time.

The webpage control of sprayer helps in maintaining pest free and disease risk reduced crops thereby enhancing the annual yield of farm and major damages are considerably reduced.

It is observed that the overall input cost for the proposed model is economical which makes it affordable for the farmers.

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