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An IoT based Application for Real Time Monitoring of the Crops for Agriculture Lands

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***Abstract:** The Internet of Things (IoT) provides the opportunity of individuals and devices to educate and collaborate with lots of things namely sensors, actuators, appliances and other wirelessly connected things and we proposed an idea to implement IoT in Agriculture. Environmental attributes are measured using sensors. Regarding our survey, we came to know that website is used as an interface, linked to the sensed data. Uses local Database and services which makes app huge. Lags Disease detection and other predictions are not done. Our project generates data in real time and predict the problems, gives early cautioning and prevent interlude, develop new opportunities and plan better Agri-lands for the future by using simulations. Predicts crop diseases and gives preventive measures. Forecasts the climatic conditions like humidity, rainfall and manage the irrigation, checks soil fertility, monitors water quality for optimal plant growth, controls water usage and irrigation management.*

***Keywords:** Internet of Things, Smart Agriculture, Irrigation Automation, Rain based irrigation, Fertilizer Management.*

I. INTRODUCTION

The Internet of Things is a digital infrastructure of products embedded with software, sensors, electronics allowing the devices to exchange data among themselves without involving contact between person and other individuals, or between human and machine via Internet. It is a more common way to integrate computer-based systems with the physical systems around us. It is also referred to as Machine-To-Machine or Internet of Everything. They help in monitoring a sector or field anywhere and anytime through an internet connection. IoT platforms can help organizations through improved process efficiency, asset utilization and productivity.

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IoT products also help to reduce the day to day human workload. An added advantage in case of embedded computing devices is that they are exposed to internet influence. IoT connects all potential entities which must engage on the internet to maintain a secure and relaxed earthling life.

On account of automation in IoT, the right decision is made after receiving the precise data from the smart devices and can be deployed for further processes.

Money and time consumption are efficient as it is an automated process and can replace manual works in charge of monitoring and maintaining crops or resources [1].

Before decades, communication between people was with telephones or via Short Message Service. After the evolution of World Wide Web, interaction and transmission of data was easier and faster with the help of e-mail. These days, emergence of IoT has a much faster and efficient transmission of data among smart devices and the physical system without the intervention of humans using wireless network technologies. Nowadays, IoT is applied in major sectors such as agriculture, medical and healthcare system, environmental monitoring, transport system, large scale developments, industrial applications, building and home automation, energy management and infrastructure management.

In Agriculture, IoT plays a vital role to increase the yield of a farmland by reducing the harmful effects that cause the farmers' productivity. Agri-lands environment can be monitored by detecting humidity, temperature of atmosphere and also water quality of the soil using sensors such as DHT22 [Atmospheric Temperature and Humidity], DS18B20[Soil Temperature], Soil Moisture and pH sensor [2].

In this paper, we have discussed about the basic working principle of our project proposed our idea behind this project work, how we came upon this idea after a survey, its list of modules and future enhancements that can be further implemented later, which highly helps all the farmers in means of time and currency management.

II. RELATED WORKS

A. Advanced Agriculture

Alaa Adel Araby et al [3] developed an IoT based Agriculture Monitoring System with predictive analysis which may reduce the loss of the farmers and decreases the harmful effects of the crops. Moisture soil moisture is measured using soil moisture sensor. It is based on Ohm's law and resistance between the poles are calculated. If the moisture level is less than the expected threshold level, then irrigation system is activated. It also continuously monitors the irrigation system. If it not works properly then inform the farmer and the service team. For irrigation, water reserve is measured and restores water.

If the water level is comfortable then crops are irrigated. Finally crop irrigation is automated. The process runs into multiple stages. The initial stage checks for efficiency of deficiency of any given fertilizer, then in following stage checks which fertilizer is causing the issue. Workflow is performed using two sensors. pH value is monitored by the first set of sensors.

Deficiency or excessiveness of fertilizer is sensed by the second set of sensors. Several processes are done in order to perform various tasks that are associated with the feature which leads to the complete automation of the feature by reducing human intervention.

Vaishali Puranik et al implemented Automation in agriculture which reduces the farmers workload but not at the fullest. Environmental attributes are measured using temperature sensor, humidity sensor and soil moisture sensor. For communication between sensor and cloud gateway, Wi-Fi module and MQTT protocol is used. Website is used as an interface. It is linked to the sensed data and the machine learning results which is displayed. Uses local Database and services which makes app huge. Moving to cloud and processing the data in server makes it less in size and improves performance of the processing. Temperature sensor, humidity sensor and soil moisture sensor are used to measure environmental and yield conditions. Other predictions are not done. Lags Disease detection and stage of disease. Fertilizer quantity in soil is not monitored and time period for refilling. Irrigation is not automated. It requires manual work to be done. Uses a website where users need to login each time to know about his/her farm [4].

Manishkumar Dholu et al projected the conceptual principle of function which is articulated in which it comprises of different elements, including humidity & temperature sensor, soil moisture sensor, microcontroller unit (MCU) alongside WiFi board, wifi router, the cloud of devices and finally the mobile application. Measurement in soil moisture is accomplished by utilizing YL-69 electrode. There are dual in-electrode terminals which indicates the resistance respectively. The resistance between these two points varies with shift of soil moisture. So, this change in humidity is a measure of the amount of water in the world. This chip output is fed to MCU machine. Digital output pin that can generate the actuator signal. Use capacitive sensing equipment and measuring temperature with thermistor inserted inside a tiny cabinet, detects humidity. It provides digital pulse output so it's linked to MCU's digital data. The data on soil moisture is converted into the percent value so that it can be properly understood. The MCU development is achieved using Arduino IDE tools. Then, it is a forum for programming such a concept surface. Three analog information was sent to the area where we have the information presented graphically [5].

B. Existing System

The existing system uses local database and services to store and process the value. Making use of this local system is difficult to maintain which when affected by some failure whole system is destroyed. As it uses a local service, hardware must be equipped enough to make all processing which intern increases the product cost. Deploying powerful hardware at all places needs a huge investment from the farmer. Moving to cloud and processing the data in server makes it less in size and improves performance of the processing.

Air temperature sensor, humidity sensor and soil moisture sensor are used to measure environmental and yield conditions. Other parameters are not monitored and predictions are not done. Lags Disease detection and stage of disease. Fertilizer quantity in soil is not monitored and time period for refilling. Water level is not measured so irrigation has to be done manually and cannot be automated. Physical interaction is needed to perform the action.

This survey helps to improve our knowledge related to this paper work and we easily sort out the existing system drawbacks which aids to us to develop a much more advanced IoT based crop monitoring system with an interactive user interface for the end users.

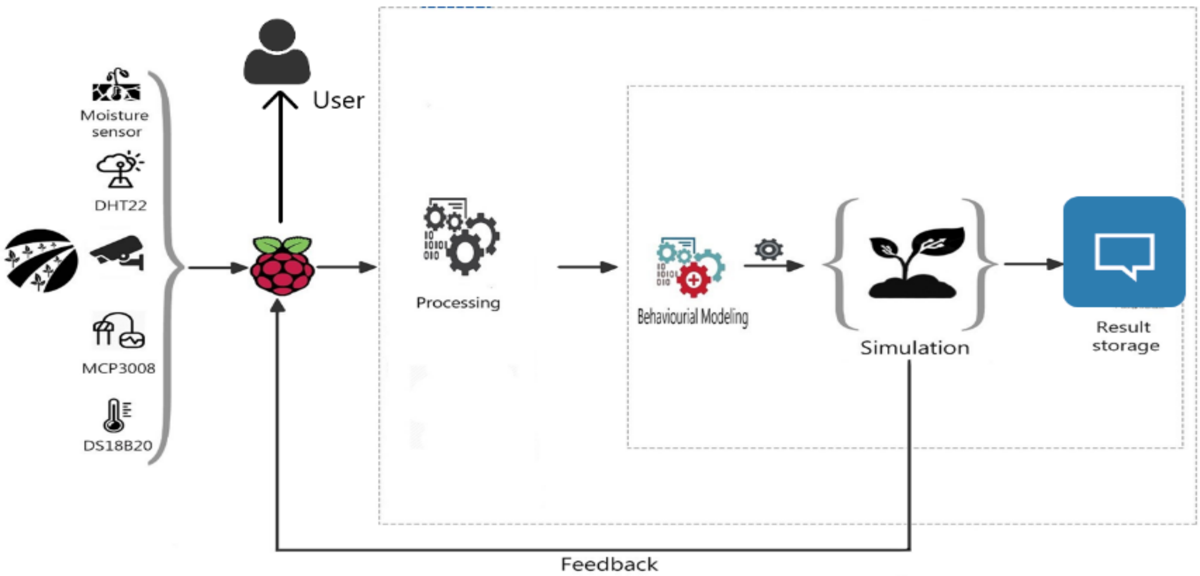

Fig. 3. Architecture of Proposed System

III. PROPOSED SYSTEM

Our work has overcome most of the drawbacks in the existing system such as generating data in real time and predict the problems in advance or give early cautioning and prevent interlude, develop new opportunities and even plan better Agri-lands for the future by using simulations. It predicts water problem in farmstead and also predicts crop diseases and gives preventive measures. Additionally, it forecasts the climatic conditions like humidity, rainfall and manage the irrigation. Its serves as a farm assist which checks soil fertility. It not only monitors the water quality for optimal plant growth but also controlling water usage and irrigation management and thus resulting in an optimized yield production and reducing the loss for farmers.

The farmland is monitored 24x7 using sensors such as DHT22 [Atmospheric Temperature and Humidity Sensor], Moisture Sensor, DS18B20 [Soil Temperature and Humidity Sensor] and pH sensor. These external hardware devices are connected to the GPIO pins of Raspberry Pi 3B+, which is a credit-card sized computer. The devices data are fetched using a python program with the required libraries and are sent to ThingSpeak server at regular intervals of time using PIGPIO library. ThingSpeak is an IoT application and API with public and private keys to save and retrieve data using HTTP protocol. From that cloud server, the uploaded sensor data are further processed under various mathematical models and simulation. The processed values are stored in the knowledge base and are retrieved for user's view in an interactive manner with the help of Android application. The Android app is also integrated with ThingSpeak to predict and receive real time data related to the farmer's agricultural land which highly reduces the cultivator's manual work.

A.List Of Modules

- Irrigation Automation
- Rain Based Irrigation
- Fertilizer Management
- Simulation Based Yield Prediction
- Disease Detection

3.1. Irrigation Automation

As water is most essential for an agricultural productivity, water management is important. Automated Irrigation distributes water automatically when required based on the parameters such as soil moisture, humidity, temperature and weather conditions. This smart system is based on IOT using Raspberry pi which has a control in soil moisture, temperature and humidity acting as a sensor. This sensing leads to distribute water only for a required amount as the soil moisture must not exceed its limit affecting the plants or crops. With the help of an Automated Irrigation system, energy and time consumption of a famer could be reduced and can be irrigated in an efficient way. The farmer could sense the status of any lifespan of plants or crops at any time by implementing Automated Irrigation system. A user interface is provided to the farmer to sprinkle the plants at any time on his wish.

Using sensors, it is easy to identify that if there is a block in the tube and the farmer could rectify the problem occurred manually. The Automated Irrigation is cost efficient and could be implemented in any farm field. The soil moisture, humidity and temperature (DHT22), soil temperature (DS18B20) sensors are used to measure the moisture content, atmospheric water vapor content and temperature respectively. PIGPIO python Library [6] is used in Raspberry Pi in order to obtain the readings of various sensors. The moisture sensor produces output as analog signal and hence it must be converted to digital signal that could be acceptable by Raspberry Pi which interfaces with driver circuit connecting the water motor. The analog signals are converted to digital signals using Analog to Digital Converter (MPC3008) [7]. In accordance with the digital signals obtained, the water is distributed to plants or crops at regular intervals of time or when plants/crops are in need of water.

3.2. Rain Based Irrigation

Efficient water usage is the most spoken topic worldwide. So even in agricultural lands, water management is an important. Based on the factors like humidity, temperature, climate, etc. We can determine the rainfall in advance. Predicting the rain fall lets us to manage the irrigation. For instance, if it is going to rain tomorrow, we can predict it today and the water used for irrigation can be minimized for today or tomorrow. We use OpenWeatherMap API [8] to predict the rain fall. The atmospheric humidity and temperature are sensed using DHT22 and the values are sent to the cloud where the predictions are done by the models with the help of these data. The feedback is sent to the physical system based on the predictions made. So, we can either accomplish this module either train a model using Support Vector Machine or using OpenWeatherMap API. The API prediction is more accurate than our SVM model, hence API is integrated to the physical system to distribute water at a required amount to the cropland.

3.3. Fertilizer Management

Overuse of fertilizers can even drive to crop's death. To overcome this, we help farmers in better fertilizer management via digital twin. Essential elements can occur in either of the physical form: solid, liquid or gas. we tend to deal primarily with solid and liquid forms of the elements in soil but the non-mineral elements as well as NO2 and S can also occur in gaseous forms. under certain soil conditions the chemical form of an element strongly influence how a nutrient reacts with other elements or compound found in the soil. Soil nitrogen is the most difficult nutrient to characterize, it occurs in organic and inorganic forms in soil and as a gas. As cations and anions plant roots absorb only the inorganic forms. Common forms of nitrogen contained in fertilizers and fresh manures includes NH3 and CH4N2O &(NH4) (NO3). We use a pH sensor attached with a BNC Module [9] for this part of the work in order to detect the pH value of the water to be distributed along with the fertilizer. The crops at which they won't be affected should have a pH value between 6 to 7, that is a neutral reading. Conveyance of notification after the occurrence that any fertilizer or water quality is abnormal is the fundamental part of this module. The drawback is that it cannot distinguish the acid or base content in the water to be distributed, as it can only detect the pH value. But also, it prevents from damaging of crops in advance by notifying the farmer.

3.4. Simulation Based Yield Prediction

Running simulations periodically and predicting the yield can help farmers to increase the yield.
Simulations are being run in the cloud (**EC2** [10]) and feedback are provided to the physical system's edge software to make changes to physical system immediately. This helps to improves the crop yield. We gathered datasets of various croplands available in Tamilnadu, India from Kaggle [11]. These datasets are pre-processed in accordance with their respective crops, area, production and its lifespan. We train this mathematical model using Polynomial Regression [12] and got an accuracy of about 85.51% with a system of intel i7 7^{th} Gen, 8GB RAM and GPU GTX 1050 (4GB) specifications. The Yield predictions vary accordingly to the real time data acquired for a year. The farmer can use the simulation to know the predicted outcome for every crop cultivated and investments on buying the resources can highly be reduced.

3.5. Disease Detection

Machine Learning and Computer vision had a tremendous growth in past few years. We came to think about the following questions such as Why can't we apply these ideas to improve agricultural yield? The detection of diseases can aid farm people to produce good crop yield and What if a picture of a plant can say the disease it is affected by? Predicting the disease and providing solution to it, ease the work of famers and crops can be protected before any major setback. The farmer feeds the image of the affected plant to our twin and the twin predicts the disease it may be affected by. This is done by feeding the image into the Convolutional Neural Network model [13] we have trained and provide necessary steps to be taken to protect the crops which resulted with an accuracy of 96 %. Datasets include around 50000 images of various plants and their leaves for training and one-fourth of them is used for testing. This reduces the time and man work of the farmers. An affected crop is captured by the rear camera of the smartphone, this image is used to identify the crop that is affected and the farmer is notified with a remedy for that plant disease, thus prevented from spreading and affecting the farmland. This part of our work helps farmer in prevention of disease from crops and outcome of the agriculture.

IV. EXPERIMENTAL RESULTS

The result of our project is clear and seamless and it can work perfect in a good condition because we use mainly cloud for data store and it is accessible from anywhere and any location. At first the data is sent from Raspberry pi to ThingSpeak and from there the data and clear and it is easily identifiable.

Following are the snapshots of sensor data in respective to that particular date and time which are represented in a graph in Thingspeak Server (Cloud).

Fig. 4. Soil Moisture Graph Representation

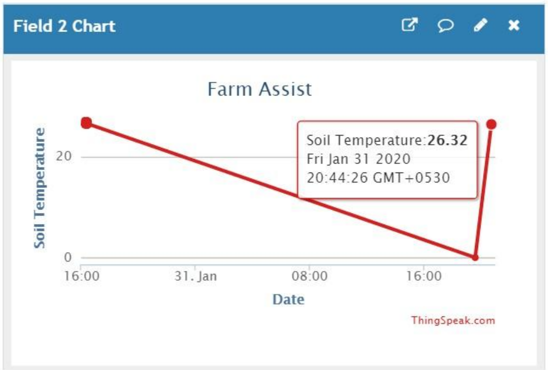

Fig. 5. Soil Temperature Graph Representation

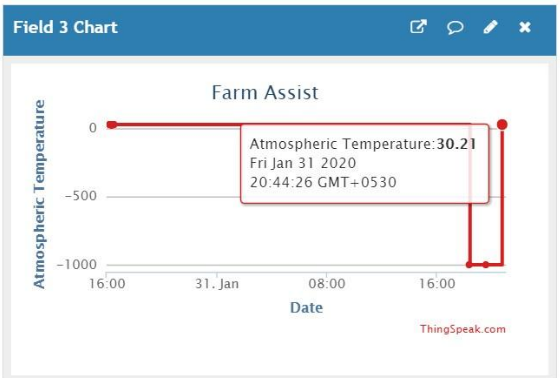

Fig. 6. Atmospheric Temperature Graph Representation

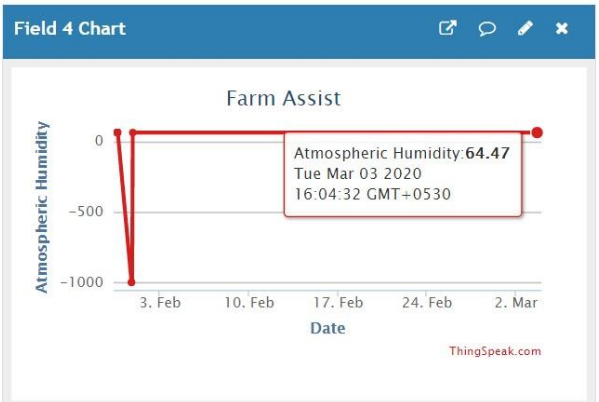

Fig. 7. Atmospheric Humidity Graph Representation

These uploaded data can be integrated to the android application that reads all the data and presents it in a UI that tells about all the farmland parameters and it will be easy for the farmer to view it in mobile anywhere remotely.

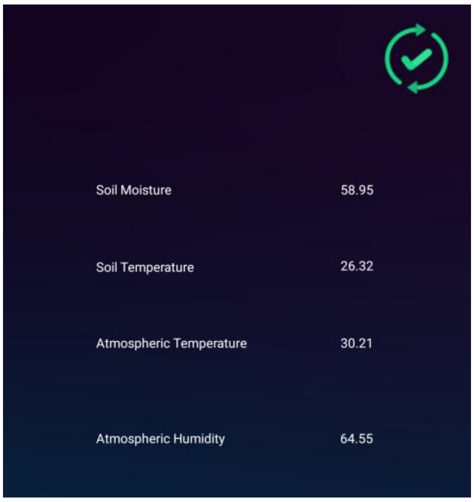

Fig. 8. An activity that represents Farmland parameters

Regarding the Simulation model, we have got an accuracy of about 85.5 % with developing a mathematical model of past datasets obtained in Tamilnadu regions where it includes production, area, humidity, temperature and specific time period of those crops. This may result in helping farmers to predict the yield production in future.

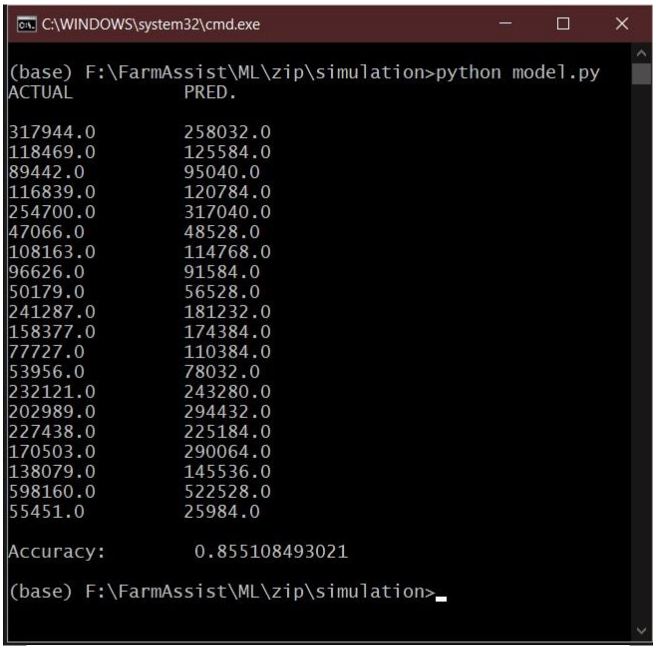

Fig. 9. Results obtained for Simulation based Yield Prediction

Regarding Disease Detection Mathematical Model, we obtained an accuracy of about 96.3 % during validation with various affected leaves (test data). This may help the farmers to identify the disease and its stage the plant is affected in advance and thus provides alternate measures to be taken.

Fig. 10. Results obtained for Disease Detection

V. CONCLUSION

Our work helps the farmers in accurately predicting the current state and future of physical assets by analyzing their digital duplicate. Farmers can gain better insights on their crop performance, improve crop yield and make better strategic decisions based on these insights. It is not completely possible to manage the Yield, Irrigation, Rain Water, Fertilizer, Quality of plant, Water Quality, and other miscellaneous factors that are been a pain to a farmer these days. Here we introduce our paper to manage all those farmer works in a single conversation and an application.

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