IoT based crop monitoring scheme using smart device with machine learning methodology

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Abstract. Internet of Things (IoT) is the most considerable medium for all smart applications, in which it provides a huge support to agricultural industry in fine manner. In literature, there are lots of smart devices are available for monitoring the crops and agricultural field, but all are strucked under certain limitations such as power problem, cost expensiveness and so on. This paper is intended to design a new machine learning enabled Smart Internet of Things medium to support agricultural field in proper way. In this paper, an Intelligent Crop Monitoring Device (ICMD) is introduced to monitor the crops over the agricultural field in 24x7 manner. This kind of monitoring devices enhances the production and quality-service of the agriculture as well as related products. This paper associates an innovative technology to the Smart Device called Machine Learning, but instead of using the classical learning schemes, this approach introduced a new scheme called Modified Learning based Field Analysis Strategy (MLFAS). This approach is inspired from the classical machine learning scheme called Convolutional Neural Network (CNN), in which the proposed Smart Device called ICMD accumulates the real-time agricultural field details and pass it to the monitoring unit for manipulation. The manipulation end maintains the data into the server unit, in which the machine learning model called MLFAS acquires the received field data and process it based on the training samples. The training samples are nothing but data collected from the agriculture field, the collection of received data are maintained into the server end for processing, the proposed MLFAS model manipulates the data and created as a model for further testing. The newly arrived data from the field is considered as a testing data and cross-validate that data into the trained model. The data acquired from the agriculture fields are temperature, humidity and soil moisture level, in which these records are passed to the server unit by using IoT module associated with the ICMD. The data available into the server can easily be monitored by the farmer from anywhere at any time. The learning model predicts the status of the crop in the field by means of analyzing the input acquired from the real-time testing input and report that to the respective farmer for taking an appropriate action. For all this system is useful to the agricultural field and provides good
support to farmers to monitor the crops over the agricultural field from the remote place even. By using this proposed scheme, the farmers can make accurate and efficient crop management decisions with the use of results obtained by using the Smart Device called ICMD.

**Keywords:** Machine Learning, IoT, Crop Monitoring, Intelligent Crop Monitoring Device, ICMD, MLFAS.

1. **Introduction**

In India more than 78% people belongs to agricultural field and related jobs, so that the agriculture plays a vital role in Indian economy. Similarly, many other countries dependent on this same field and in rural environments agriculture is a self-employment job to many youngsters as well as it helps to enhance the interest of earn via domestic animals with respect to the food material preparation to the animals based on the agricultural wastes. Changes in climate might have a severe influence on agricultural production, raising water requirements as well as constraining agricultural output in places that are in need of irrigation. Desalination plants, moisture farmland and subsoil watering are just a few of the strategies used to create healthier harvests that are inefficient with water consumption. To ensure effective water consumption, a computerized system is built. In the method, farmers do not have to physically direct water supply into fields; the technology does so successfully. In literature, there are several researchers introduced lots of systematic agricultural planning [1][2], but all are struck up with certain extends. The traditional crop monitoring system utilize the benefits of water supply through mobile SMS based system as well as the auto power on and power off principles to agricultural land. But all these features are purely manual dependent and the expense for such systems are high in order to implement that in farm lands [3]. These kind of traditional farming systems leads to lots of water and electric resource wastages. The power supply requirements of such devices are huge and it cannot operate on power failure periods. So, that the conventional agricultural monitoring devices need Solar PV panels for acquiring power source from sunlight and operate accordingly on power failure situations. But these all solutions are coming to one single point called cost expensiveness[11][12].

In order to avoid these issues a powerful and robust agricultural monitoring system is required with the presence of new technologies. The logic of Internet of Things (IoT) provides a huge support to variety of smart applications to operate with high efficiency based on support of internet enabled services [4][10]. With respect to the adaptation of such powerful internet enabled devices a smart technology is designed to monitor the agricultural field in an efficient manner without any manual interventions. This paper introduced a new smart device called Intelligent Crop Monitoring Device (ICMD), in which it utilizes the logic of machine learning to perform perfect farming strategy with excellent predictions [13]. A new machine learning strategy is designed over this paper called Modified Learning based Field Analysis Strategy (MLFAS), in which it is derived from the classical machine learning strategy called Convolutional Neural Network. The smart device of ICMD is build with two smart agricultural field monitoring sensors such as Temperature and Humidity measurement sensor and the Soil Moisture Level Identification Sensor. The smart device of ICMD requires only 5v DC power source for the entire operation, in which all these sensors are controlled by the IoT module presented into it. The logic of both the sensors and the presence of Internet of Things in it will be explained in clear manner over the following summary [14][15].

1.1 **Internet of Things (IoT)**

In these modern days everyone belongs to Smart Devices and many of them are building with communication technologies in association with internet enabled services. The classical internet enabled medium provides connectivity in low range as well as the cost expensiveness for such technology is more. Hence the powerful Internet of Things (IoT) is introduced to provide internet services to the smart devices without any interventions. The logic of Internet of Things is enabling the internet source to the associated device and raises a bridge between client end and the server end. In
this agricultural monitoring system, the adaptation of this IoT is helpful in many ways such as manual intervention free agricultural field monitoring, automatic watering system and water flow management.

This kind of IoT enabled technologies reduces the human involvement in complex as well as the complexity of doing such hard things is highly eliminated. So, that many youngsters are interested to do such agriculture business now-a-days with the help of such smart devices. The proposed smart device called Intelligent Crop Monitoring Device (ICMD) utilizes the features of such Internet of Things to transfer the agricultural field data to the remote server within a fraction of second in periodical manner. Once the data is reached into the server end, the scripting function evaluates the data with respect to machine learning formulations. The results of such evaluations are reported properly to the respective farmer without any delay. This is helpful to the farmers to monitor the agricultural field from anywhere in the world without any region oriented limitations. The following figure, Fig-1 portrays the view of proposed Smart Device called ICMD's block diagram in clear manner.

![ICMD Block Diagram](image)

**Figure 1. ICMD Block Diagram**

1.2 ICMD Smart Sensors Association

This proposed Smart Device is build with two powerful agricultural field monitoring sensors such as temperature as well as humidity monitoring sensor and the Soil Moisture Level identification sensor. Both these sensors are associated with the smart device ICMD to make the device to monitor the crop fields in an intelligent manner. For analyzing the temperature and humidity level over the crop fields are accumulated by using DHT11 sensor. The soil moisture level is identified by using the rug type soil moisture level identifier. Both these sensor details are illustrated in clear manner over the following summary.

(i) **DHT11 Sensor**: The DHT11 is a less expensive digital temperature and humidity monitoring sensor with a low-complex circuit design and it measures the atmospheric air through the use of a capacitance temperature measurement and a resistor as well as it outputs a signal on the data pin in digital format. This sensor does not require any analogue pins to operate and it's quite straightforward to use, however data collection demands precision scheduling. Because it updates data every two seconds, input signals could become up to two seconds old whilst using the Adafruit package. This
sensor includes a 4.7 K or else 10 K resistor which is used as a pull up resistor between the digital pins and power supply. The following figure, Fig-2 shows the perception of DHT11 sensor and the respective resistor used to operate the sensor in clear manner.

![DHT11 Sensor with Resistor](image)

**Figure 2. DHT11 Sensor with Resistor**

(ii) Soil Moisture Sensor: This sensor estimate the level of moisture presents into the soil and report that to the respective controller instantly. Capacitive coupling is used to determine the water content over the soil surface and by estimating the dielectric conductivity of the soil, in which it is a method of the water level estimation over the soil space. Simply insert this robust sensing device into the soil to be analyzed and the device reports the volume of water substance level over the soil surface in percentages. This sensor can be used for read both analogue and digital values according to the convenience of the developer. The first two pins of the soil moisture sensor is A0 and D0, in which the A0 pin indicates the analogue pin and D0 pin indicates the digital pin point. Remaining two pins are used for power source such as GND and VCC, in which GND indicates the ground and VCC indicates the 5v DC power supply.

The following figure, Fig-3 shows the perception of Soil Moisture sensor and the associated specifications used to operate the sensor in clear manner.

![Soil Moisture Sensor](image)

**Figure 3. Soil Moisture Sensor**

2. Related Study
Sweksha-Goyal et al., 2019 [5] proposed a paper related to the purpose of using Smart devices and to improve the productions of agricultural fields. In this paper [5], the authors illustrated such as agricultural field has long played a critical role in several countries such as India, and agricultural concerns are becoming increasingly prevalent in recent years. Agriculture that is managed intelligently can serve as a pillar for the country’s economic development. The approach described in this article [5] provides insight into sustainable farming through the use of the IoT devices and due to the potential of Internet of Things assisted sensors to provide valuable information for agribusiness, this notion is becoming more popular among users on a daily basis. This research [5] tries to develop a highly autonomous methodology and the study [5] discusses all of essential issues of agriculture, including surveillance, watering and sustainability. This service's technique is capable of monitoring temperature, relative humidity and motion detection. The pump, shredder and dispenser are supposed to trigger or disabled based on the data collected from all detectors. So does the strategy address the cultivation process and it also addresses the storage facility in which all grown products are housed. The storehouse is equipped with a variety of gadgets that aid in the monitoring of moisture and
associated agricultural details. The warming or cooling unit is usually switch on dependent on the temperature sensors measurement. Similarly, if a motion detector identifies robbery, an alert is activated to warn the farmers.

SagarBhat et al., 2018 [6] proposed a paper related to the exploration of Internet of Things and its associated development. In this paper [6], the authors illustrated such as the term "Internet of Things" describes the process of interconnecting diverse technical gadgets worldwide through the use of the internet. Kevin-Ashton coined the term "Internet of Things" in the year of 1999 and this study [6] describes the fundamentals of Internet of Things and it discusses the many levels that are employed in IoT along with some of the essential terminologies associated with this now. It is essentially an augmentation of the capabilities offered by the Internet and additionally, this research [6] discusses the IoT's infrastructure. For instance, whenever the residential equipment that we need on a regular bases link to the internet, the setup is referred to as a Smart Home in an Internet of Things platform. The Internet of Things is not merely a futuristic concept and it is already being implemented as well as it has ramifications beyond advances in technology.

Anusha et al., 2019 [7] proposed a paper related to the design of smart agricultural environment based on Internet of Things assistance. In this paper [7], the authors illustrated such as throughout the last years, changes in climate and weather have been inconsistent. As a result, numerous Indian farming individuals requires climate-aware approaches dubbed smart agricultural medium in the modern era. Sustainable farming is a sort of computerized and guided communication method that utilizes the IoT devices and it is advancing at a breakneck pace as well as it is being extensively used in all digital situations. Different equipment and the incorporation of Internet of Things via mobile networks have been investigated and discussed in this research [7] using the farming landscape as a case study. Remote-Monitoring-System [7] is offered as a hybrid strategy utilizing internet and its associated connectivity. The primary objective is to collect actual information about the farming production system in order to facilitate commercial operations such as notifications via Short Messaging System and guidance on climate changes, harvests and so forth.

Munaswamy et al., 2019 [8] proposed a paper related to an intelligent agricultural monitoring system powered by Internet of Things methodology. In this paper [8], the authors illustrated such as: in the past, farmers determined the soil nutrients maturity and modified perceptions in order to generate the best produce. They did not even consider the moisture, volume of water, or, more importantly, the environmental strategies that are wreaking havoc on an increasing number of farmers. The Internet of Things is transforming agriculture by helping farmers to overcome field issues through a diverse variety of tactics, such as precision and practical farming. The IoT modernization aides in the collection of data on environmental conditions such as climate, humidity, temperature and soil fertility as well as a crop based examination enables the discovery of wild plants, water levels, bug locations, creature intrusion into the sector, straighten advancement, and agriculture. Internet of Things provides farmers to connect to their home from any location and at any time. Wireless sensors components are used to monitor the homestead's conditions, while microcontrollers are used to control and automate the household shapes. Digital cameras were utilized to view the circumstances completely via images. Internet of Things innovation has the potential to save money and improve the availability of accelerating progress.

Sendra, et al., 2017 [9] proposed a paper related to a development of Internet-of-Things services and its associated farm surveillance system. In this paper [9], the author illustrated such as agricultural production is increasingly utilizing wireless technologies such as WSN, the Internet of Things and drone mapping. The problem of integrating these innovations necessitates the development of a novel and intelligent wireless communication structure for data transmission. Durability and administration are significant issues even though there are a large number of sensors. This article [9] discusses the creation of a moisture stress controller based on an effective surveillance and respective communications. The concept is a robust agricultural technique that allows use of actual statistics such as fixed irrigation rate and field-measured characteristics. The agricultural characteristics, index plants and watering activities, including flowing level, static pressure and wind velocity are monitored
periodically. The information is analyzed by a sophisticated cloud storage service that is built on the Drools-Guvnor platform. A Smartphone can be used to operate the built multimodal infrastructure remotely. Furthermore, the frequency required by the device is determined when it transmits various types of instructions and information.

3. Proposed system methodologies
This paper is intended to design a novel agricultural monitoring system based on machine learning strategy with respect to latest technologies such as Internet of Things and smart sensors. This approach introduced a new machine learning enabled agricultural field monitoring tool called Intelligent Crop Monitoring Device (ICMD), in which it is placed into the agri-fields on random manner as approximately a single ICMD device can cover upto 20 feet distance. The readings accumulated from the smart device are communicated to the centralized remote IoT server by using the IoT module presented into the ICMD. In the server end, a new machine learning strategy is executed called Modified Learning based Field Analysis Strategy (MLFAS), in which it accumulates the data from the crop field and analyze it based on the trained model.

The training model is generated based on the threshold values generated for identifying the emergency needs over agricultural fields. All the received values from the agricultural land are monitored and it will be appended to the training model with proper labeling for further testing process. The testing records acquired from the ICMD over remote server end will be cross-validated with respect to these trained models and the emergency cases will be reported properly to the farmers by using Global System for Mobile Communications (GSM) module connected with the ICMD. In which the alert will be send to the respective farmer with location details as well by using the Global Positioning System (GPS) module. Both these models adaptations are pictorized clearly over the proposed ICMD model block diagram in figure, Fig-1. The temperature and humidity details variation are analyzed properly and in case of any changes over these readings, that will be immediately reported to the farmer. Similarly, the soil moisture sensor takes care of crop watering management, in which it switches on and off the water pump according to the needs of water to the agricultural land without any human intervention. The following system flow diagram illustrates the overall process of the proposed MLFAS model in clear manner.

4. Results and discussions
In this section, the experimental analysis of the proposed approach and its efficiency is portrayed with the help of graphical representation. The proposed machine learning approach summarizes the data received from the smart device called ICMD and extracts the features based on the commas quoted into it. The data coming from the agricultural land is accumulated and specify it based on comma separation, in which it will be helpful while server end processing. The server end learning strategy receives the data and extracts the features with respect to array indexing norms. The proposed approach accumulates the training model for cross-validation and appending the new testing record into it. First the cross-validation process begins by summarize all the trained values and generate the respective threshold for testing process. The real-time data arrived from the agricultural land to the ICMD is called testing data, in which it is passed to the remote server end by means of Internet of Things. The remote server end receives that and manipulate according to the threshold generated based on the trained model average analysis. The resulting values will be moderated according to the labels, in which the resultant value comes up with normal ratio, it will be marked as a label of 0 otherwise the resultant value comes up with abnormal ratio; the label is defined with 1. Based on these strategies the testing value of agricultural field data is evaluated and the record is however maintained into the server for future analysis. The following figure, Fig-5 illustrates the frame success ratio of the proposed approach, in which it shows the overall data frames accumulated from the ICMD and estimate the number of frames which are successfully processed over the server end as well as the number of frames failed to receive over the server end.
The following algorithm illustrates the logical flow of the proposed approach called Modified Learning based Field Analysis Strategy in clear manner.

**Algorithm: Modified Learning based Field Analysis Strategy**

**Input:** Real-Time Agricultural Data {Temperature (T), Humidity (H), Soil Moisture Level (W) and Location (L)}

**Output:** Prediction and Accuracy Ratio of Agricultural Crop

1. Import required system libraries to manipulate the agricultural land details.
2. Collect the agri-field data from the real-time farm land (T, H, W and L).
3. Extract the details with respect to commas and segregate it in separate array indexing for manipulation.
4. Load the dataset, in which it is already trained by using learning strategy and the dataset is dynamically created based on the real-time data accumulated from the agricultural land.
5. Acquire the threshold levels of the dataset for each parameter such as T, H and W.
6. Cross-validate the testing parameters with acquired threshold.
7. If the threshold level indicates as Normal, then store the testing records into the server and append it to the dataset model for further reference.
8. If the threshold level indicates as Abnormal, then store the testing records into the server and alert the respective farmer regarding that with corresponding ICMD location (L).
9. Append the abnormal details into the trained model with proper labeling.
10. Check the level of parameter ‘W’ and if it indicates LOW means trigger the corresponding relay ON to switch the water pump or else switch off the water pump.

![Graphical representation of data ratio analysis and performance estimation]

**Figure 5. Frame Success Ratio**

The following figure, Fig-6 illustrates the data ratio analysis of the proposed approach, in which it shows the normal agricultural field data acquired from the Intelligent Crop Monitoring Device and the quantity of abnormal field data received from the ICMD. This analysis is useful for estimating the dataset training accuracy level, in which the number of data presented into the dataset determines the quality of prediction over outcome. The following figure, Fig-7 portrays graphical representation of proposed approach performance estimation with respect to the alert notification ratio based on time evaluations in seconds. In this case, the metric is evaluated by counting the number of normal data occurrences raised from the smart device called ICMD and it is placed over the desired server location. So, that the respective notification send to the farmer for particular time intervals. This estimation is performed by detecting the abnormal data ratio from the real-time agricultural field information, in which it detects the appropriate number of farmers receive alerts in proper manner. These temporal values are studied and illustrated in depth in the following graphical scenario and the estimations display the average time ratio of the number of abnormal events in occurred in specific period. It will be iterated from 1 to 5, while the y-axis displays the total number of identified abnormal events, the associated alert notification messages delivered to farmers and the total number of failures.
Figure 6. Data Ratio Analysis

The following figure, Fig-7 portrays graphical representation of proposed approach performance estimation with respect to the alert notification ratio based on time evaluations in seconds. In this case, the metric is evaluated by counting the number of normal data occurrences raised from the smart device called ICMD and it is placed over the desired server location. So, that the respective notification send to the farmer for particular time intervals. This estimation is performed by detecting the abnormal data ratio from the real-time agricultural field information, in which it detects the appropriate number of farmers receive alerts in proper manner. These temporal values are studied and illustrated in depth in the following graphical scenario and the estimations display the average time ratio of the number of abnormal events in occurred in specific period. It will be iterated from 1 to 5, while the y-axis displays the total number of identified abnormal events, the associated alert notification messages delivered to farmers and the total number of failures.

Figure 7. Alert notification analysis with respect to identified abnormal data.

5. Conclusion and Future Scope

In this paper, a new machine learning strategy is designed called as Modified Learning based Field Analysis Strategy (MLFAS), in which it operates according to the data retrieved from the smart device called ICMD. Both these innovations are controlled by the smart internet enabled communication
technology called Internet of Things. Conventional farming techniques are inefficient and farmers frequently encounter several issues which can be addressed through conventional ways. As a result, modern technologies in this subject are required to improve such issues. Smart Agriculture Monitoring system with IoT is a far more efficient and effective way than conventional farming. We exhibited in this research an IoT-based framework for agricultural development that seems to be capable of resolving a variety of farmer-related issues. The resulting section shows the proper analysis and the figure, Fig-5 illustrates the frame success ratio of the proposed machine learning model MLFAS in clear manner. And the resulting section figure, Fig-6 illustrates the dataset information ratio in clear manner with proper graphical representation.

In future, the work can be enhanced further by means of adding some deep learning principles to improve the prediction accuracy and eliminate the processing time for evaluating the real-time agricultural field records, in which it improves the overall performance of the smart agricultural production system in fine manner.

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