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A Review: Smart Farming Using IOT in the Area of Crop Monitoring

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ABSTRACT

Farming can be made more productive and accurate with the help of technologies like IOT. IOT can be used in different domains of farming or agriculture. The area of implementation of IOT is wide and it can be implemented in every field. But still it is lacking in the field of agriculture where the technology has not been accepted due to economic conditions of the farmer. This paper is about brief survey on development of IOT in different areas of Agriculture field especially in crop monitoring. In this paper surveyed various research papers on crop monitoring in the field of agriculture. Typical agriculture methods used by farmers and their difficulties they face. This survey provides an overview of some of the key IOT challenges and its stack layers also provide a summary of related research works on crop monitoring.

Keywords: IOT, Agriculture, Smart farming, Crop Monitoring, IOT Challenges, IOT Layers, IOT Application.

1. Introduction

In an Agricultural field using technologies is much needed to reduce a human labor and at the same time to reduce the wastage of water in farmland. Lot of different systems has been developed by using IOT and Wireless Sensor networks to monitor and predict the soil conditions for irrigating the field. The kind of crops predictions is the toughest task for agriculture domain. The agriculture crop depends on various factors. Agriculture crops growth depends on different parameters, namely weather, soil characteristics, soil moisture and surface temperature. Internet of things, cloud computing and machine learning are recent technologies from last few years. Large areas of farming and agricultural activities are based on the predictions, which fail at time. Farmers may need to bear huge losses and if not at times they end up committing suicide. Because of changing soil structure due to different weather conditions, farmers are not well aware of which crop would be optimally suited for growing in that soil. IOT system can be used to solve such farmers' problem. Agriculture is not a very exciting career for future generation to choose. There are many reasons, some of them are severe and to be corrected as soon as possible. Major reasons for Agriculture's non growths are – other exciting fields which are more glamorous and rewarding, failure of seasonal rains across the country along with ground water scarcity, converting farm lands into residential or other infra development purpose, still many in agriculture not aware of using the latest and cost effective methods in farming. India is a land of various soils and different change of weather conditions. Indian farmers face problems such as damage to the already grown crops in their fields because of sudden rain, various diseases and without precise weather forecast.

Concerned the above perspectives the following research questions to be addressed:

1. How can IOT play a vital role in Smart Farming?
2. What Tools and technologies are used and how are they implemented in farmland?
3. What are the expected outcomes that are produced by Crop Management?
4. What are the challenges need to be addressed in implementation of IOT in Smart farming?

Answering these questions and structuring the review process a proper survey and analysis has been done, which is expected to be useful for researchers to perform further study of Crop Monitoring using IOT and other Technologies.

2. Review Methodology

The survey was conducted in a Systematic manner. The selected papers for this review are subject to the criteria like Crop monitoring, IOT application areas and crop disease detection or classification. The papers are collected from the SCOPUS databases like IEEE, Elsevier etc. with keywords of "IOT in Smart farming" and "Crop Monitoring" to address those research questions identified.

Initially sixty journals and conferences have been downloaded, after that the recent publications from 2015 to

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2020 have been selected for a review process. It was 38, which shows current IOT technologies and tools applied to agriculture field and crops. After that publications that are already cited and less than 5 pages has been removed and excluded the papers which are not clearly related to crop management. Finally 33 papers are reviewed. These selected papers are sufficient to provide Smart farming trend using IOT for a researcher in this field. All the selected papers are thoroughly studied and analyzed one by one and summarized in a table-1.

TABLE: 1 ANALYSIS OF RECENT RESEARCH PAPERS IN THE AREA OF CROP MANAGEMENT USING IOT

Title	**Problems Discussed**	**Tools/Technology used**	**Results**	**Research Gaps Identified**
Smart Irrigation with Field Protection and Crop Health Monitoring system using Autonomous Rover [29]	Health management of crops discussed. Automated irrigation. Identifying the type of disease affecting or nutrition deficiencies in the crop. Protection of farmland from animals trespassing and fire.	Raspberry Pi, Sensors, Rover, Image processing, MATLAB, LBP, SVM Classification Algorithm.	Detection of nutrition deficiencies and diseases at earlier stage. Reduce manual labor and errors. Increasing the productivity of the crops. Water waste management. Classification of Leaf image.	Rover used to inspecting the farmland. Where as Aerial vehicle could have been used for better inspection. Accuracy of results are not addressed. Lack of advanced Deep Learning algorithms for better classification. Need of cloud storage not addressed.
Design of Novel Wireless Sensor Network Enabled IOT based Smart Health Monitoring System for Thicket of Trees[8]	IOT based smart coconut tree health monitoring. Low power consumption and solar power to avoid power break. High Quality security. Data analysis based on Cloud Computing. Remotely monitor the health condition of a tree flock spread over acres of land.	Raspberry Pi 3 Embedded Board, Universal Software Radio Peripheral (USRP), GNU Radio, Deep Learning Techniques, Sensors.	Field Study of Coconut groves of large area. Data Analytics and Real-time surveillance. Performances of Sensors are analyzed at different environmental conditions. Evaluated security and Speed. Evaluated Different performance metrics using deep learning.	Role of communication technologies are not addressed. How to handle large acres of coconut land not addressed well. Role of sensors and their types not discussed. Lack of comparison study with other existing framework.
Plant Disease Prediction using Deep Learning and IOT[3]	Identify the stress to the plants by an environmental imbalance, soil fertility, and crop diseases. Leaves are considered for crop disease where as existing system works on only leaf. Drone with camera used to monitor crops	Raspberry pi Drones with camera CNN, Web API,	Predict leaves disease. High Accuracy Comparison of SVM and CNN based on the size of datasets and accuracy.	Crop datasets are limited with three crops.(maize, papaya, Bottle Gourd) How to handle sensor data's and drone images are not discussed. Communication technologies were not discussed. Types of sensors and drones used are not discussed.

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IOT Solution for Plant Monitoring in Smart Agriculture [18]	Decision Support System for Precision Agriculture. Power efficient Solar panel Supplied IOT system for productive agricultural process. IOT ADCON-based system. Focused study on grape. Use of Solar Energy	ADCON, Cloud and Cloud Computing(SaaS,PaaS, IaaS), sensors(temperature, leaf wetness, relative humidity of air and soil and temperature of soil)	The result was better grape quality. Improved management with lower costs. Power Efficient. Results on Variation of parameters during days.	Study limited to one crop (grape) DoS attack not tested. Role of solar panel was not discussed. Challenges of IOT deployment mode were not discussed. How to handle cloud storage not addressed.
Disease Detection in Tomato plants and Remote Monitoring of agricultural parameters[2]	Remote monitoring of tomato plants. Disease Detection using CNN. Considered Different Types of soil and moisture content. Disease classification	Convolutional Neural Network (CNN), Internet of Things (IOT), Deep Learning (DL), DroidCamX, DHT11 temperature and humidity sensor, FC-28 the soil moisture sensor. NodeMCU, Blynk cloud, Keras,wifi	Tested on live image. Classified correctly 42/50 images.(diseased or healthy) Achieved accuracy of 84%. Training accuracy 95% validation accuracy around 92%.	The purpose of blynk cloud and Keras was not clear. Fog computing could have introduced for latency. Type of Classification algorithm was not discussed. Limited to disease detection on one plant.
Early Rice Disease Detection and Position Mapping System using Drone and IOT Architecture [25]	Data acquisition and data analysis are done by using image processing technique. Rice disease detection and classification in the early stage. Define the position in real time.	Sensor devices, camera, drone and GPS .Wi-fi, HTTP,Image Processing, Supervised Machine Learning Algorithm(SVM).	Detects the Occurrence of disease and region on leaf. Position Mapping.	Type of disease was not classified. Performance metrics are not discussed. Latency and Accuracy could have been considered for early detection
Aerial Visual Perception in Smart Farming: Field Study of Wheat Yellow Rust Monitoring [19]	Field study on wheat field to detect rust disease in wheat. Integrated deep learning algorithms along with multispectral aerial images of Unmanned Aerial Vehicle (UAV). Open access dataset.	UAV, Deep Learning U-Net, Multispectral Imaging.	Performance has improved over purely spectral based classifier. Different network Input band combinations were tested. U-Net with various input bands are tested and compared. Improvement on segmentation performance over RGB image.	Limited to one season on wheat. Scope of IOT was not explained. Handling image from drone was not discussed. Field study was limited to one disease.(yellow rust) Lack of comparison with existing frameworks.

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Precision Crop Monitoring with Affordable IOT: Experiences with Okra[28]	Practical field study on Okra during the Kharif (July-October). Monitored cultivation cycle. (4months). Early disease detection. Reliable and affordable IOT framework.	AgriSense Gateway/Mobile ZigBee and WiFi, IRIS,JSON, HTTP, Leaf wetness sensor, Soil Moisture Sensor, Temperature and humidity Sensor, Luminosity Sensor	Pests and nutrient deficiencies were captured. Timely Irrigation Decisions. 10% improvements in yields. Reduced wastage of water.	Research object is limited to one crop (Okra). Lack of storage management. Type of soil used for Okra is not mentioned.
IOT based smart crop monitoring in farm land[10]	Introducing IOT with different sensors in the farmland. Collecting information related to field with help of sensors. Adopting GSM Technology	Arduino microcontroller AT mega328, Soil moisture sensor YL-69, Temperature and Humidity sensor DHT11, GSM Module, WiFi Module, MAX 232.	Experimental results are shown with necessary circuit connection. Different outputs are checked with dry soil sample and wet soil sample.	Sensors are used to monitor only the crops with limited area. Lack of automated irrigation. The importance of security is not addressed. There is no clear evidence of storing mass data.

3. Related Work

In this section a survey of some recent published research papers on smart farming with deployment of Internet of Things (IOT) in the field of agriculture is presented especially a highlighted study on various crop management systems. This section presented an updated review of Smart farming using IOT and Crop Management.

S. B. Choudhury et al, [28], the author observed the practical study on Okra during the Kharif and monitored the cultivation cycle for 4months. With affordable IOT pests and nutrient deficiencies were captured and also automated irrigation decisions. The author showed 10% of improvements in yield by deploying IOT in precision agriculture.

A. K. Gupta,[3], Plant diseases were predicted using drones with camera.The author also shown the high accuracy on CNN by comparing SVM. The author worked on the leaves where existing system works only on leaf.

I. Marcu, G. Suciu,[18], In this paper author used a cloud computing for implementing decision support system for precision agriculture. The field study on grape used IOT ADCON based system with Solar Energy for better power Efficiency with lower costs.

A. H. Deepak, A. Gupta, [2],classified Diseases on Tomato plants. The Disease was detected using CNN by considering different types of soil and moisture content. Tested on live image and achieved accuracy of 84%. NodeMCU, Blynk cloud and wifi's are used to implement the system.

N. Kitpo and M. Inoue, [25] The Early rice disease detection using image processing is implemented. This system detects the occurrence of disease and region on leaf by using position mapping. Supervised machine learning algorithm (SVM) has been used.

J. Su et al., [19], in this paper author used UAV, Deep Learning U-Net technologies on wheat field to detect rust disease in wheat. The author showed the improved performance over other spectral based classifier. Different input band combinations were tested.

S. Gobhinath, [29], Used Autonomous Rover for smart irrigation and crop health monitoring. The system detected nutrition deficiencies and diseases at earlier stage.

Shekhar, [30], this paper has proposed an IOT based model for automatic irrigation system. KNN (K- Nearest Neighbor) classification machine learning algorithm has been proposed for analyzing the sensor data for prediction towards water irrigation.

B. Sridhar, [8], in this paper, Data analysis was based on cloud computing and different deep learning techniques are used. The author observed a field study on coconut groves of large areas.

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Patil K [27], in this paper the author used Remote Monitoring System (RMS). Crop Disease identification also done by image analysis and SMS based alerts.

BACCO, [9], Author used an unmanned aerial vehicles (UAVs) this vehicles exchange data with various ground sensors for monitoring and controlling crop cultivations. IEEE 802.15.4- based system used for communication between an aerial vehicle and fixed ground sensors.

4. Applications of IOT in Smart Farming

With the adoption of IOT in various areas like Industry, Homes, Vehicles and even Cities, There are huge potential is seen to make everything Intelligent and Smart. Also the Agricultural field is also embracingIOT technology, and this in turn has led to the development of Smart farming using Internet of Things (IOT) or Precision farming.

The Fig-1 shows the different application areas where IOT is used to make Smart Agriculture.

Crop Management using IOT

Crop Management System enables detection of disease in the leaf, weed, and level of water, pest detection, and animal intrusion in to the field of crop growth in an agriculture field. The farmers can understand the crop requirements and forecast their growth accurately. The parameters that are needs to be monitored in the farmlands are soil characteristics, weather conditions, moisture, temperature, etc. Crop monitoring means identifying and monitoring health of crop. IOT sensors and RFID chips can identify the diseases present in plants and crops.

Smart Irrigation System

Smart Irrigation or automated irrigation understands the water needs of a plant or a field. It efficiently calculates required water to each plant in the field in a smart manner. The role of Smart irrigation is to provide an automated irrigation system for saving time, water and power of the farmer. The conventional techniques of irrigation require manual intervention. This automated irrigation technology can reduce human interference. Using various sensors such as temperature, humidity, soil moisture sensors used to senses the various parameters of the soil and based on sensor values decisions are made whether to irrigate or not.

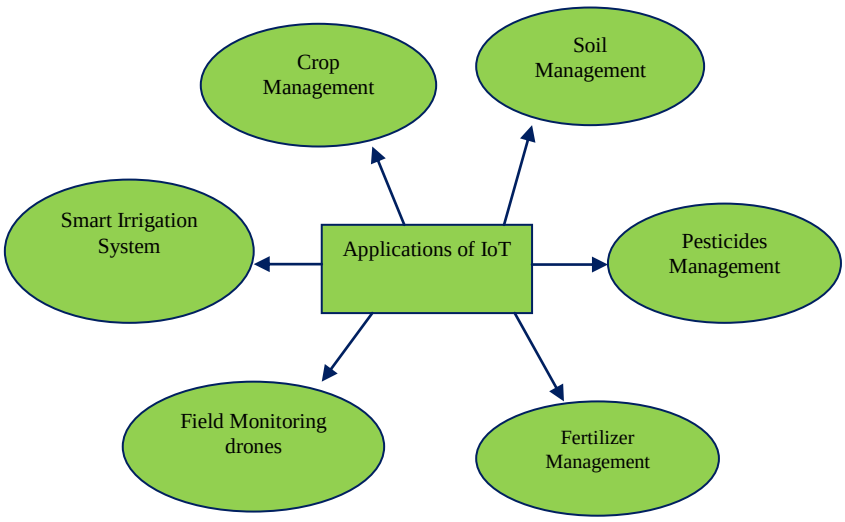

Fig.1 Applications of IOT in Smart Farming

Soil Management

Soil monitoring using IOT shows how soil conditions and properties change over time. Every farmer needs to understand the different types of soil and soil mineral requirements for creating suitable crop growth conditions. The pH value, temperature and moisture content of the soil are the basic parameters that help to characterize the soil and therefore to make the right decisions regarding the use of fertilizers and the choice of crops has shown.

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Filed Monitoring using drones

Agricultural drones also known as UAVs (unmanned aerial vehicles), used in smart farming, are used to collect agricultural data. In addition to monitoring capabilities drone may also perform other tasks that previously involved human labor, such as crop planting, pest control and infection control, spraying of cultivation, crop tracking etc.

Cattle Monitoring and Management

Just like other application areas, there are IOT agriculture sensors that can be attached to the animals on a farm to monitor their health and performance. Livestock tracking and monitoring helps to gather data about the health of cattle, well-being and physical location of stocks. Sensors used in cattle monitoring can identify sick and wounded animals so that farmers can separate them from the herd to avoid contamination. Using drones for cattle tracking also helps farmers reduce labor expenses.

Pesticides and fertilizer Management

Monitoring pesticide levels on crops can help farmer's better yield on the results. When it rains a farmer may need to give pesticides more often, but the impact that a storm has on different areas of a field can lead to over- and under-application of pesticides in different locations. The chemical levels can be monitored using sensors in the soil or above ground near plants. In a pesticides and fertilizer management we can understand pests and their activity, location and patterns.

5. IOT Technology Stack Layers

The IOT Layers are classified as five Technology stack layers. This section presents a brief study on all five technological stack layers of IOT.

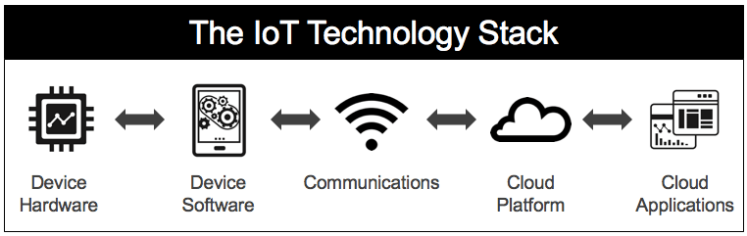

Fig .2 Different Levels of IOT (5-Layers)

Device Hardware(Layer-1)

In this layer of the IOT stack, The main aim is to understand hardware parameters like cost, size, ease of deployment, reliability, lifetime, etc. Table 2 shows the some important hardware platform used in the smart agriculture researches and projects

Table: 2 IOT Hardware used in Smart Farming and their Features

S.NO	Type of Hardware	Features
1	Arduino Mega	Arduino offers products for entry level projects and complex projects. These boards and modules are the best to start learning and coding.Supportsarduino Language.
2	Arduino Uno	
3	Arduino Yun	
4	Beaglebone	BeagleBone family of blue, black, and AI boards is available. Black is a low-cost development platform for developers and researchers. It is very useful in developing IOT applications with low cost.Supports c, c++,java, python etc.
5	Raspberry Pi	• There are various families of Raspberry Pi starts from level 1, 2,3 and zero. • It is used as Single-board system with wireless LAN and Bluetooth connectivity.

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		• The Raspberry Pi 3 is the recent model of the third-generation Raspberry Pi. It has Built in Wi-Fi as well. • Powerful tool for IOT and embedded projects.
6	Node MCU	It is an open-source IOT platform. It generally refers to firmware rather than the development kits. It is a low-cost open-source kit/module developed for the ESP8266 Wi-Fi chip. It can be developed in the Arduino IDE environment
7	Banana Pi	It is a low-cost credit-card-sized single-board system. The hardware design is hugely influenced by Raspberry Pi. It is also compatible with Raspberry Pi family of boards. It can be developed on Android or Linux system.

Device software (Layer-2)

Device software is the second layer of the IOT. Software is the component that makes the device hardware into a smart device. Device software allows the communication with the Cloud and other local devices. Some of IOT software used in smart farming are Raspbian OS, Contiki, Cooja, iFogSim, FramBeats etc.

Communications or Connectivity (Layer 3)

Communications refer to an exchange of information. It is a level 3 of IOT layers. It is also referred as Connectivity. Communication is nothing but networks and the protocols used in a system. Choosing the suitable communication mechanisms are a critical part of IOT systems. This does not only decide how you get data from and into the cloud (e.g. using Wi-Fi, WAN, LAN, 4 G , 5 G, LoRA, etc.) but also how you interact with third party apps.Some of the WSN used in Smart Farming are 6LoWPAN, Wifi, WiLD, IEEE 802.15.4(LR-WPAN) etc.

Cloud Platform (Layer-4)

The cloud platform plays an important role of IOT solution.
The cloud infrastructure forms the foundation of IOTin all application areas. There are many well knowncomputing companies offers cloud services. Examples are Microsoft, Google, Amazon, and others startedIOT as a service. The IOT cloud platform has the advantages of scalability, virtualization, low cost, and covers large scale.

Cloud Applications (Layer 5)

The fifth layer of the IOT is Cloud Application. These applications are web-based and designed for the user needs.

6. Implementation Challenges of IOT in Smart Farming

In this section the challenges of deploying IOT in the farm land is classified based on the technological challenging in the farmland. When incorporating recent technology such as IOT, Big data and Cloud computing in farming regions where only simple internet connectivity is a challenge.There are certain challenges the farmer need to be aware of it if they have decided to invest on smart farming. This section described the five main challenges that the agriculture sector faces in implementing IOT technology as follows.

Interoperability standard issues

In an agricultural environment deploying IOT technologies where information exchange should take place between all the interconnected IOT devices.Those devices are communicating via a common protocol, with required connectivity and standards. For this reason the most challenging fact is Interoperability. It is difficult to integrate heterogeneous data coming from different sensors (like moisture sensor, soil sensors, temperature sensor etc.) We need to spend a great deal of time and money to create standardized common protocols to all IOT devices.

Storage Issues for massive agricultural data

Large volume of data generated from different IOT devices (like sensors, camera, weather stations etc.) connected in a farmland. For storing such huge volume of data, a large repository is needed. Storing data in the

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database is not sufficient to handle such a huge volume of data. Technologies like cloud computing and fog computing would do the better performance for storage and latency concern.

Connectivity Issues

Providing connectivity with the data exchange between aIOT device and database or cloud is a major issue since making wireless connectivity is too difficult.The basic problem is Poor Internet Connectivity in Farms. Most farms are situated in remote areas where access to the internet may not be good enough for quick transmission speed. Furthermore, communication lines may be disturbed by crops, bad weather, and other physical barriers. The 5G technologies which use space-based Internet might be the solution for this in future.

Hardware and software implementation challenges and their maintenance

For developing an Agri based solution we have to select the right hardware and software tools and techniques. The quality of sensors ,better storage techniques to store data and powerful data analytical tools. Because the results will be based on the accuracy of the data and its reliability. Since the sensors placed for monitoring the field might get affected by the animals, high wind, rain etc., Hardware maintenance is a challenging task in the field of agriculture. Thus, we require to make ensure hardware is durable and maintainable. Otherwise we need to replace sensors more frequently that leads to extra expenses.

Security Issues When implementingIOT on farmers are in need of having knowledge of security concept and it set up security policies. Smart farming and IOT technology imply working with huge volume of data's from different sensors which increases the number of potential security loopholes that perpetrators can use for data theft and hacking attacks. Data security in agriculture is an unaware and challenging task. Many farms use drones that transmit data to farm devices. These devices connected to the Internet but have little to no security protections like ser passwords or remote access authentications.

7. Conclusion And Future Work

This paper presented an updated review of IOT applications for Crop Management in smart farming. There are plenty of initial studies extracted from electronic databases to answer research questions. This paper surveyed a role of IOT in smart farming in the area of crop monitoring along with its implementation challenges, different application areas of IOT, and its technological stack layers are explained briefly. An analytic study of various research articles in the field of crop monitoring is presented and also highlighted their most focused sections and gaps or areas not addressed. A systematic review of different articles focusing especially on crop monitoring, disease detection, and farm management is offered. From the studies, certain issues are put forward that demand research and experimentation in the future, a communication technologies and the hardware platforms of IOT are also discussed. The issues, challenges, and future research directions are also highlighted. As a whole, the in-depth description of various aspects of IOT for agriculture has been discussed and how these studies should be catered in a way to create efficient and smart agricultural scenarios. It was identified that universal variables such as temperature, humidity, pH value of the air, soil moisture and solar radiation have commonly taken as a measure in agricultural applications based on the Literature reviewed. It was also observed that cloud storage and fog computing have not been widely adopted in agriculture projects, resulting that there are various scope for research and development in these areas.However, there are still some key issues in Crop Monitoring for further study.

- The research object focused is relatively simple and limited to few crops.
- The Accuracy of disease prediction on crop is not high enough.
- Need improvement on the classification algorithms and their mechanisms.
- Training a farmer to adopt into smart farming where they lack in basic education is not addressed in the paper reviewed.

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