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# Use of IOT in Agriculture Sector, Opportunities and Challenges

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**Abstract**

The internet of things (IoT) technologies getting popular nowadays in agriculture and allied sectors. In the future, this technology helps to farmer to increase productivity through the sustainable cultivation of food, like that to take care of land and also reduce the use of water and the optimization of inputs and technologies. IoT based solutions are being developed to automatically maintain and monitor agricultural farms with minimal human involvement. In this paper, the connection of IoT based agriculture systems like remote monitoring system, decision support tools, automated irrigation system, frost protection system and fertilization system with relevant technologies including cloud computing, big data storage and analytics are presented considering the above facts, to take the needs to farmers and also researchers with a ability to see all the relevant data clearly of IoT applications in agriculture. The review of this paper is to offer an overview of the IoT application in agriculture through the points such IoT- based software applications for smart agriculture available in the market, IoT based devices used in agriculture as well as benefits of this kind of technologies to providing agricultural product.

***Keywords*** *IOT, agriculture, smart farming, crop residue, challenges, agricultural automation, wireless sensor network*

## 1. Introduction

The term Internet of Things (IoT) was coined in 1999 by Kevin Ashton, co-founder and executive Director of the Massachusetts Institute of Technology (MIT) Auto-ID Laboratory, while he was giving a presentation at Procter and Gamble (P&G) as their Brand Manager. The presentation that Ashton made for P&G was meant to introduce radio-frequency identification (RFID) tags to manage the supply chain so that the location and stock at hand of each item coming out of it can be more easily monitored.

Riding the RFID wave, LG Electronics then put out a refrigerator known as the Internet Digital DIOS back in the year 2000 which was connected to the Internet. It kept track of the kind of food items that were stored in it as well as their respective quantities by scanning their RFID tags. Though the Internet Digital DIOS refrigerator didn't sell well because most people thought it was too expensive for their needs, it would eventually pave the way for more house appliances to be managed via internet.

According to Cisco Internet Business Solutions Group (IBSG), though the term was coined in 1999, the IoT was born in between 2008 and 2009 at simply the point in time when more "things or objects" were connected to the Internet than people. Citing the growth of smartphones, tablet PCs, and other smart gadgets, the number of devices connected to the Internet was brought to 12.5 billion in 2010 while the world's human population increased to 6.8 billion, making the number of connected devices per person more than 1 (1.84 to be exact) for the first time in history.

The IOT is an emerging field nowadays and that can be used anywhere. We can use it in an agriculture also for reducing uses of fertilizers in agriculture that make many hazards effect on human life and many more thinks like soil, birds, and it causes air pollution so by using IOT. We reduces uses of fertilizers. In the current scenario, the sometime farmer doesn't know the current status of the soil moisture and other think about their land and crop. The purpose of this research study is to explore the usage of IOT devices and application areas that are being used in agriculture, we can produce organic crops.

## 2. Methodology

The methodology behind this study is to identify trends and review the open challenges, application areas and architectures for IOT in agro industry. This survey is based on a

systematic literature review, where related research is grouped into four domains such as monitoring, control, prediction, and logistics.

## 3. Results & Discussion

This research study presents a detailed work of the eminent researchers and designs of computer architecture that can be applied in agriculture for smart farming and organic farming, at current time IOT is used for increasing productivity. But we have to increase quality of food and crops also for increasing good quality of food. This study makes some efforts to discuss past research and open challenges in IOT based agriculture.

### 3.1 Smart Agriculture Using IoT: Understanding the Need of Implementation

IOT smart agriculture products are designed to help monitor crop fields using sensors and by automating the irrigation systems. As a result, farmers and associated brands can easily monitor the field conditions from anywhere without any hassle. Take a look at the different uses of IOT in agriculture by means of various IOT solutions:

**Robotics**

Since the industrial revolution in the 1800s, automation got more advanced to efficiently handle sophisticated tasks and increase production. With increasing demands and shortage of labor across the globe, agriculture robots or commonly known as Agribots are starting to gain attention among farmers. Crop production decreased by an estimated 213 crores approx ($3.1 billion) a year due to labor shortages in the USA alone. Recent advancements in sensors and AI technology that lets machines to train on their surroundings has made agribots more notable. We are still in the early stages of an agri-robotics revolution, harnessing the full potential of Internet of Things in agriculture, with most of the products still in early trial phases and R&D mode.

**Table 1** Literature review on IoT applications

| **Sensor** | **Application** |
|---|---|
| Soil sensors Volumetric water content sensors Tension meters Soil profiling | Measures soil water volumetric content, soil water potential, soil moisture respectively |
| Grain Pro Eco Wise | Standard Wireless system designed to remotely monitor the temperature and humidity |

| | |
|---|---|
| Wind Speed (PK 100-02) and direction (110 âĂŞ 2) sensors | Measures the speed and direction of the wind |
| Pyrometer (PK 200 - 03) and solar radiation (200 - 04) sensors | Measures the intensity of the solar radiation |
| Water sensors:<br>OTT Orpheus Mini Water Level Logger OTT ecology 500 Water level logger OTT CTD sensors | Used to measure the water pressure, water level, water pressure and water conductivity |

**Weeding Robots**

These smart agribots use digital image processing to look through the images of weeds in their database to detect similarity with crops and weed out or spray them directly by their robotic arms. With increasing number of plants becoming resistant to pesticides they are a boon to the environment and also to farmers who used to spread the pesticides throughout the farm. An estimated 13,000 kilograms (3 billion pounds) of herbicides are applied at a cost of 1,725 crores ($25B) each year, thus reducing their overall cost.

**Machine Navigation**

As remote-controlled toy cars are enabled with a controller, tractors and heavy plowing equipment can be run automatically from the comfort of home through GPS. These integrated automatic machines are highly accurate and self-adjust when they detect difference in terrains, simplifying the labor-intensive tasks. Their movements as well as work progress can be easily checked on smartphones. With advancements in IoT-based smart agriculture and machine learning, these tech-driven motors are becoming smarter and independent with features such as automatic obstacle detection.

**Harvesting Robotics**

Utilizing agribots to pick crops is solving the problem of labor shortages. Working the delicate process of picking fruits and vegetables these innovative machines can operate 24/7. A combination of image processing and robotic arms is used by these machines to determine the fruits to pick hence controlling the quality. Due to high operational costs, crops that have an early focus on agribot harvesting are orchard fruits like apples. Greenhouse harvesting also finds applications with these bots for high value crops like tomatoes and strawberries. These bots can work in greenhouses to aptly determine the stage of crop and harvest them at the right time.

**Material Handling**

Robots can perform dreaded manual labor tasks working alongside the labors. They can lift heavy materials and perform tasks like plant spacing with high accuracy, therefore optimizing the space and plant quality and reducing production costs.

**Drones**

Agriculture is one of the major sectors to incorporate drones. Drones equipped with sensors and cameras are used for imaging, mapping and surveying the farms. There are ground-based drones and aerial drones. Ground drones are bots that survey the fields on wheels. Aerial drones, formally known as unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UAS), are flying robots. Drones can be controlled remotely or they can fly automatically through software-controlled flight plans in their embedded systems, working in coordination with sensors and GPS. From the drone data, insights can be drawn regarding crop health, irrigation, spraying, planting, soil and field, plant counting, yield prediction and much more. Drones can either be scheduled for farm surveys (drone as a service) or can be bought and stored near farms where they can be recharged and maintained. After the surveys, the drones need to be taken to nearby labs to analyze the data that has been collected, thereby helping leverage IoT-based smart agriculture better.

**Remote Sensing**

IoT-based remote sensing utilizes sensors placed along the farms like weather stations for gathering data, which is transmitted to analytical tools for analysis. Sensors are devices sensitive to anomalies. Farmers can monitor the crops from analytical dashboard and take action based on insights.

- **Crop Monitoring**

Sensors placed along the farms monitor the crops for changes in light, humidity, temperature, shape, and size. Any anomaly is detected by the sensors is analyzed and farmer is notified. Thus, remote sensing can help prevent the spread of diseases and keep an eye on the growth of crops.

- **Weather conditions**

The data collected by sensors in terms of humidity, temperature, moisture precipitation, and dew detection help in determining the weather pattern in farms so that cultivation is done for suitable crops.

- **Soil quality**

Soil health analysis helps in determining the nutrient value and drier areas of farms, soil drainage capacity, or acidity, which allows to adjust the amount of water needed for irrigation and the most beneficial type of cultivation. Main application of IOT in agriculture are precision forming, Livestock and green houses, which are grouped in different monitoring domains all these applications are monitored with the help of different IOT based sensor networks (WSNS) that helps the farmers collect relevant data through sensing devices some

IOT based setups analyze and process the remote data by applying cloud services, which help the researches and agriculturist make better decision. Researchers have proposed different IOT based technologies in the agriculture field that are increasing the production with less workforce efforts in the last few decades a large number of studies have been presented in the IOT based agriculture domain. Therefore, it is important to collect summarize, analyze and classify the state-of-the-art research in this area. the purpose of this research is to present a comprehensive systematic literature review in the field of IOT agriculture

**Table 2** Literature review on IoT applications

| SN | Author Name & Year | Contribution |
|---|---|---|
| 1 | Goldstein, A., Fink, L. (2018). | Crop yield prediction from the collected data form soil and environmental variables which applied on eight plots. However, machine learning (ML) algorithms applied different for the classification and regression of the efficient crop yield. |
| 2 | Ana Laura Diedrichs (2018) | Presented a model of ML algorithms which predicts the agricultural frost prediction system on the basis of different condition of the crop yield. They monitored thermodynamics conditions from the environment to predict suing training set of the data obtained from sensors |
| 3 | Anat Goldstein, Lior Fink, Amit Meitin (2017) | The study is about predicting irrigation recommendations. Different regression and classification algorithms were applied on this dataset to develop models that were able to predict the weekly irrigation plan as recommended by the agronomist. |
| 4 | Keith H. Coble (2018) | An efficient analytical technique related to the agricultural and applied economics contribution. Big data concepts are discussed in detailed which is part of the research and development of the agricultural data analytics. |
| 5 | Tiantian Yang et.al (2016) | A robust reservoir outflow simulation model is presented, which incorporates one of the well-developed data-mining models (Classification and Regression Tree) to predict the complicated human-controlled reservoir outflow and extract the reservoir operation patterns. |
| 6 | Sami Khanal et. al (2017) | A review focuses on the application areas of thermal RS in agriculture discussed here include irrigation scheduling, drought monitoring, crop disease, detection, and mapping of soil properties, residues and tillage, field tiles, and crop maturity and yield. Some of the issues related to its application include spatial and temporal resolution, atmospheric conditions, and crop growth stages. |

| | | |
|---|---|---|
| 7 | Rehman, T. U. (2019) | The study is to review the statistical machine learning techniques including supervised and unsupervised learning for the agricultural environment. The study is to apply machine vision approach in agricultural data and suggest some future implementation of the machine vision approaches. |
| 8 | Park, S (2016) | The study is to research six drought factors were selected based on the relative importance by their category to develop drought indicators that represent meteorological and agricultural drought by using the relative importance as weights. While TRMM showed higher relative importance for meteorological drought, LST and NDVI showed higher relative importance for agricultural drought in the arid and humid regions, respectively. |
| 9 | Vineela, M. T (2018) | Automated irrigation control with the same approach is also discussed in (Vineela et al. 2018). The study also focused on the implementation of the IoT and WSN technology for the monitoring of the water stress in the pipe, water need in the agricultural field with the water arrival of the each and every part of the crops. |

## 4. Conclusion

The study presented in this paper provided an overview of IOT and emerging technologies which covers the agricultural monitoring with several IOT devices. The new applications were discussed which are latest focus of the study in the research community. Furthermore, it can be more comprehensive if other areas of the livestock are merged for the further implementation of the study. The new applications can also be developed if required. IOT provides the ease of heterogeneity, but still has certain issues which can be difficult for the real time monitoring, e.g., security and connectivity.

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