Role of IoT in Enhancing Smart Agriculture System

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Abstract

Internet of things (IoT) has shown a different research direction in the domain of farming and agriculture. Smart agriculture has reduced the farmer's effort and improved their capability in managing their crops, soil, water, field monitoring, pesticide control, etc. IoT-based solutions have increased the farmer's attention toward humidity, temperature, pH value and environment conditions that are the most important concern in agriculture. The unique features of Internet of things like faster access to application and data, reduced human efforts, efficient communication and the global connectivity through different devices have made it a fast-growing technology in providing agriculture solutions. This paper explored various IoT smart agriculture systems and the challenges faced in deploying these systems.

Keywords

Internet of things • Smart agriculture • Monitoring • Humidity sensor • Temperature sensor • Crop monitoring

1 Introduction

The Internet of things (IoT) is viewed as sanguine technology that is a combination of the objects and the data spread over the World Wide Web. These objects use the data and make intelligent and smart collaborations among them, which are available anywhere and anytime. The main focus of IoT is to reduce the human intervention by implementing the automation. Different devices and technologies such as actuators and sensors, for sensing and collecting the data, controllers for processing the data, Internet and cloud computing used as infrastructures for communication, completes the process of automation (Dlodlo and Kalezhi, 2015; Madushanki et al., 2019). The basic model of IoT is shown in Fig. 1 which encompasses a variety of devices or things, which are smart in nature such that they can connect in the network; these smart things are capable enough to accumulate the information about themselves, other devices and environments and transfer the same information to various other devices and connected systems through Internet (Lakhwani et al., 2019).

The applications of IoT include smart transport system, smart agriculture, environment monitoring, promotions, marketing, healthcare system and infrastructure monitoring (Venkatesan and Tamilvanan, 2017). In agriculture, the goal of IoT is to automate different aspects of farming and agri-business and to make the agricultural methods more effective and efficient. Still, there are many areas in which there is a high human intervention which is needed; one of them is cattle heat detection system, which is not fully automated (Arvind et al., 2017; Zhao et al., 2017; Sagar et al., 2017; Saraf and Gawali, 2017; Rama Chidambaram and Upadhyaya, 2017). Many researchers have focused on different areas of agriculture and farming to make more productive, efficient by controlling various parameters and make them automated such as smart irrigation system, smart insects detection system and smart fire detection system etc. with the help of IoT (Vaishali et al., 2017; Rajkumar et al., 2017; Rau

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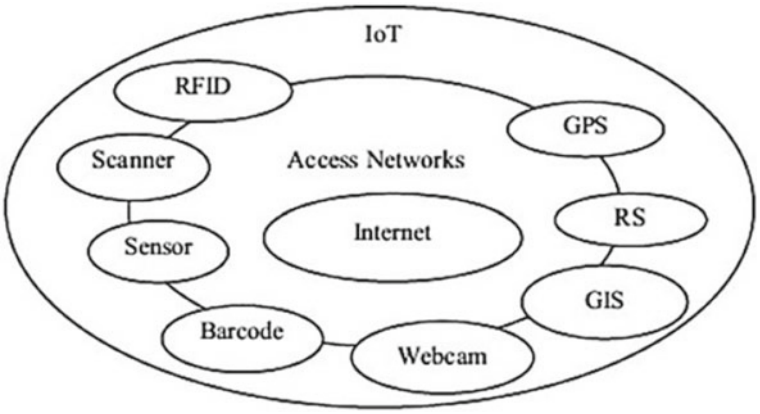

Fig. 1 Basic model of IoT

et al., 2017; Salvi et al., 2017). The primary focus of this exposition is to explore and analyze the use and the challenges of Internet of things as technology in agriculture system. More specifically, the paper is organized in four more sections: Sect. 2 explains the traditional agriculture methods and system in India. Section 3 describes the role of Internet of things (IoT) in agriculture. Then, Sect. 4 discusses various challenges of deployment of IoT in agriculture. Section 5 gives the concluding remarks of this paper.

2 Traditional System of Agriculture

The traditional Indian agriculture system is one of the ancient methods in agriculture. The traditional method reflects the complete manual method for analyzing different parameters of agriculture. In this system, the farmers use manually find and confirm all the parameters. They analyze and calculate the readings based on those found parameters (Vyavahare et al., 2020). Although agriculture is one of the important work professions of Indian financial system, the farmer generally used traditional methods for crop selection, harvesting, irrigation, etc. The farmers are totally dependent upon their experience about the agriculture. The crop obtained generally relies upon climate situations such as rainfall patterns, which generally influence the irrigation. So, the traditional techniques of farming or agriculture are not pleasing the farmers as they are not so cost effective, and moreover, the output is comparatively low. So, this is the necessity of farmers and agriculturalists to have some solutions, based on the previous data, weather forecasting and other parameters to maximize the crop.

3 Role of IoT in Agriculture

Agriculture has always been a crucial role in any country's economy. It became a strong backbone of the Indian economy. For any developing country like India, the role of technology is growing at vast for food, nutrition, farming and agriculture. This section discusses the new technologies, methods and systems that are getting popularity with IoT in the present scenario. The irrigation and crop field monitoring system, organic farming system, modified crop system, food production system, soil temperature and moisture monitoring system are few examples (Alam, 2014).

Such systems help in improving the food quality, better crop production, crop disease prediction and management, etc. Among all the existing solutions available, Internet of things (IoT) is providing lot of unique solutions which has transformed agriculture along with many other industries. IoT has given rise to smart agriculture. Smart agriculture using IoT is proving to be best for managing agriculture + business-like farm management, precision /smart farming, back-end analytics—AI, smart dairy, etc. (Mundada, 2016).

The methodical approach of agriculture + business using IoT has gradually changed the viewpoint of farmers and users. The concept of IoT in agriculture has grown to fulfill the need of users or farmers and to take advantage it provides from managing labor productivity using smart harvesting, monitoring of lands using drones, predicting crop health and disease using crop monitoring system and predicting weather using weather data system, understanding and decision making of soil sciences like temperature,

nutrients, pH value and humidity using soil management system. The adaptability to the smart agriculture or IoT-based solutions for agriculture has increased the anticipation of farmers and users toward (Mundada, 2016; Naveen Balaji et al., 2018a).

IoT for agriculture has evolved over time as shown in Fig. 2 in order to fulfill the need of farmers. In agriculture, tractors as product, tool or machine have played a crucial role and became friends forever for farmers. The first evolution confirms the connectivity of these tools with technology like connecting tractors with GPS to optimize routes which will reduce fuel consumption to make the next level of smart product. Then, the deployment of sensors and its connectivity with smart product defines another level. The sensors have different roles in performing the tasks related to agriculture. The deployment of sensors initiates precision agriculture. The next level transforms the smart, connected product to product system like farm equipment system, crop management system, water management system, irrigation system, etc. The next level of evolution shows the connectivity from a digitized product to a platform where all the mentioned systems are connected (Naveen Balaji et al., 2018a) (García et al., 2020). This scenario offers the integrated systems of systems solution (Khanna and Kaur, 2019).

Internet of things as technology has a huge potential for developing the applications in the agriculture field. Table 1 describes the role of Internet of things (IoT) technology in agriculture. Here, IoT-based solution systems developed for the respective application and its outcomes are discussed.

From Table 1, the survey showed around 12 IoT-based agriculture and farming subareas. According to the results obtained, the topmost area was water management (25%) shown in Fig. 3.

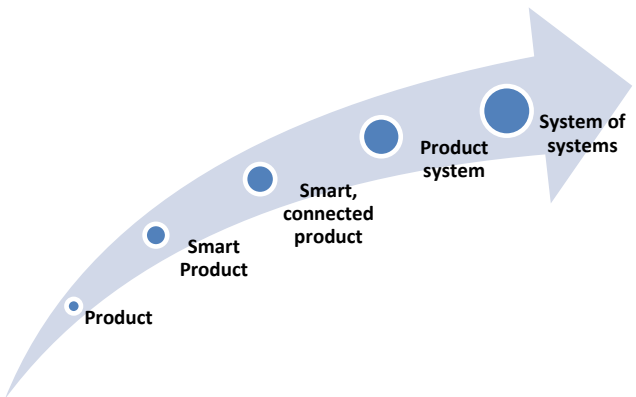

Fig. 2 Evolution of IoT for agriculture

In addition, Fig. 4 shows different parameters for which sensors are being used to collect the data. It is concluded that the temperature sensor is the most commonly used sensor in agriculture.

4 Challenges of IoT Deployment in Smart Agriculture

This section discusses the challenges in deploying different IoT-based solution applications for smart agriculture. Smart agriculture is the way of providing and reaching to end farmer through IoT-based solution application. Although IoT has offered plenty of potential solutions (discussed in Sect. 3) to farmers and users, still there are many challenges in deploying these applications. In India, the major challenge faced by farmers and users is the Internet availability, Internet connectivity and lack of infrastructure. These challenges sometimes become obstacle for the adoption of IoT-based solutions for smart agriculture. But, in general, the challenges are the mainly concerned with the kind of application and its implementation issues. With the use of huge number of sensors, the large volume of data is produced. Data management becomes the major concern for such applications. The integration of such applications with other devices is further very challenging. In addition to this, as shown in Fig. 5, poor infrastructure for Information and Communication Technology, fear of new technology, untrained workforce, understanding of policies, coverage and connectivity, high investment, lack of knowledge and lack of awareness of Information and Communication Technology infrastructure are the major challenges that are faced while deploying the IoT-based solutions (Nayyar and Er. Vikram Puri, 2016; Ali et al., 2017; Dr et al., 2018; Naveen Balaji et. al., 2018; Swarna Krishnan et al., 2020).

5 Conclusion

In agriculture, farmers use their experience to check the maturity level of soil, take harvesting decision, identifying the crop disease, manage the water quantity, protect fields from animals, etc. With the evolution of Internet of things, plenty of solutions have been provided that have minimized the farmer or user effort. IoT-based solutions for agriculture have given rise to smart agriculture. This paper discusses the traditional system of agriculture and role of IoT in agriculture. Various IoT-based solution applications have been discussed that has not only reduced the effort of the farmers

Table 1 Role of IoT in agriculture

Focus area	Sustainable solution for	Task supported for IoT enabled farming	Outcome
Smart Farming (Jayaraman et al., 1884)	1. Scalable sensor data acquisition 2. Analysis and visualization platform	1. Support virtually any IoT devices 2. Rapid ingestion and visualization of IoT data using zero-programming effort 3. Virtual laboratory environment for visualization and sharing of study data 4. Scalability of the SmartFarmNet platform	Performance of SmartFarmNet with the real-time analysis is twofold better than without real-time analytics
GPS based remote controlled robot (Gondchawar and Kawitkar, 2016)	1. Solution to field activities, irrigation problems and storage problems using remote-controlled robot 2. Smart irrigation system and a smart warehouse management system	1. Weeding, spraying, moisture sensing, bird and animal scaring, keeping vigilance 2. Smart irrigation with smart control and intelligent decision making, smart warehouse management	1. Automatically, start cooling fan in auto mode 2. Automatically, start water pump
IoT Agriculture Stick Monitoring (Nayyar and Vikram Puri, 2016)	1. Live data (temperature, soil moisture) 2. Increase overall yield and quality of products	Data of soil moisture, environment temperature at very low cost	1. Increasing agriculture yield and take efficient care of food production 2. Accurate live feed of environmental temperature 3. Soil moisture with more than 99% accurate results
Agriculture Productivity Enhancement System (Satish et al., 2017)	1. Predict various diseases affecting the crop growth and to inform the farmer 2. Ratio of pesticides to be used to reduce the risk caused by excessive usage of pesticides both on human health and environment	1. Improve plant productivity 2. Identify the diseases depending on environment 3. Achieve efficient utilization of the pesticides using supervised machine learning algorithm	Informs the farmer, the proportion of pesticides to be used to enhance the agricultural growth and productivity and reduce the damage done by pests on a large scale
Precision agricultural system (Ali et al., 2017)	1. Optimize crop yields 2. Reduce the waste of resources 3. Minimizing the environmental impact of farming	Achieve Green Internet of Things technologies in agriculture which can be deployed, which will help to conserve the energy and utilize the agriculture resources effectively	1. Precision agriculture applications based on IoT 2. Overcome the existing challenges and the future road maps
Crop Monitoring System (Naveen Balaji et al., 2018b)	1. Secures the crops by the deployment of sensor 2. Prevents intrusion of animals using image processing technique	To monitor the crop water requirements, temperature and humidity of the cultivating land	Increases the crop yield which will not be harmful to the cultivation as well as to the animals
Automated irrigation system (Ramachandran and Ramalakshmi, 2018)	Optimization model for reducing the water usage	Optimization model to compute the optimal irrigation rate which are automated using a solenoid valve controlled using an ARM controller	1. Reduction in water utilization 2. Increase in data availability, and visualization
Automatic Monitoring and Irrigation System (Dr et al., 2018)	Automated irrigation and crop field monitoring system is used to optimize the use of water resource for agriculture	Monitor the soil moisture, temperature, humidity, color and water level	Improving the agricultural fields yield by providing a monitoring system with effective and efficient usage of water resource
Crop monitoring system (International Journal of Scientific Research in Computer Science, Engineering and Information Technology 2018)	Proposed a method for efficient crop monitoring for agricultural field by deploying sensors in the field to sense the water requirement of the soil and provides irrigation automatically	Monitor the soil characteristics, weather conditions, moisture and temperature	Improve the crop productivity efficiently by monitoring soil characteristics

(continued)

Table 1 (continued)

Focus area	Sustainable solution for	Task supported for IoT enabled farming	Outcome
Remote monitoring system (Smart Agro Mobile Application) (Naveen Balaji et al., 2018)	Proposed a system that collect data from multiple nodes, and using this sensor data, the farmers is able to control the operations on the agricultural field wirelessly and remotely anytime	Allow the farmers to have complete wireless connectivity for their agriculture farm	Improve economy steadily
Remote Monitoring System (Agraj et al., 2018)	To gather continuous information of farming generation condition that gives simple access to horticultural offices, for example, alarms through Short Messaging Service (SMS) and advices on climate design, crops and so on	To monitor temperature, soil moisture and humidity	Decrease the dirt disintegration and wastage of water
WSNs application to watering crops (Anusha et al., 2019)	To design and develop a control system using node sensors in the crop field with data management via smart phone and a Web application	Control the crop watering, monitor soil moisture, humidity and temperature and collect other data of crop and agriculture field	To improve crop yields, improve quality and reduce costs
Centralize monitoring and control system (Muangprathub, 2019)	The proposed system saves water and vitality by utilizing dribble water system technique and to screen the plants by keeping up the ideal temperature	To collect data automatically about fertilization, soil, irrigation and environment	To assess and compute crop forecast, performance and recommendations
Suitable Crop Prediction System (Dhawale and Dr. 2019)	1. Low-cost IoT-enabled smart agricultural system 2. Predict which crop is best for that land based on the data collected from local conditions of that land varying from humidity to soil moisture content	Analysis and prediction of type of crops best to grow in the particular agricultural field	Cost effective
Real time monitoring system (Sidhanth Kamath et al. 2278)	1. Develop real-time monitoring system for soil properties 2. Crop disease identification using image analysis and SMS-based alerts	1. Detecting the field conditions like soil moisture content, temperature condition, intruder detection 2. Leaf disease at the earlier stage as soon as it occurs on the leaf	Improve the yield of the efficient crops
GPS based robot (Vijayalakshmi, 2019)	1. Perform tasks like weeding, spraying, moisture sensing, bird scaring, keeping vigilance 2. Provide smart irrigation with smart control to give best decision making based on accurate real-time data	GPS-based controlling robot which can work both manually and automatically for doing weeding, seeding and harvesting	To improve crop quality

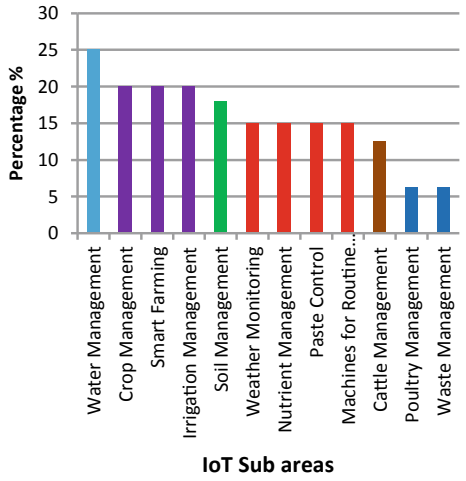

Fig. 3 Agriculture and farming subareas

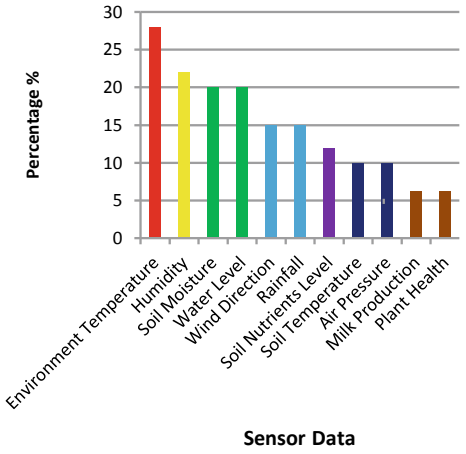

Fig. 4 Utilization of sensors for collecting the data

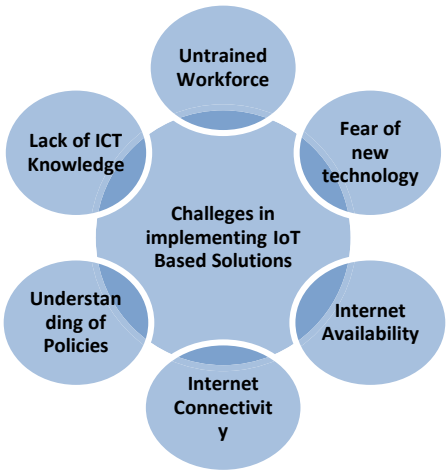

Fig. 5 Challenges in implementing IoT-based solutions

but also helped in making better decisions. Smart agriculture has given a successful platform to farmers to take corrective measures for their field or soil, crop, water, storage, pesticide, etc. The paper also discussed the major challenges that can arise while deploying IoT-based solutions in agriculture. This can help the farmers in providing more awareness about the existing IoT-based solutions and their deployment challenges.

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