

Big data based on IoT in the agriculture industry: developments, opportunities, and challenges ahead

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ARTICLE INFO

Received: 10 March 2022

Reviewed: 06 May 2022

Revised: 10 May 2022

Accepted: 18 May 2022

Keywords:

Big Data, Agricultural Industry, Internet of Things, Smart Agriculture.

ABSTRACT

With the creation of mobile phones and new technologies, new opportunities have been created in industries; This is while among these technologies are big data and the Internet of Things, which can help increase the potential of the agricultural industry. Meanwhile, technological advances have also changed the way data is collected, shared, and used. Governments and non-governmental actors are increasingly using digital technologies, and new sources and approaches to data have increased the determination of governments and professionals to further integrate data science with agriculture. Our goal is to evaluate the acceptance conditions of big data technologies in agricultural applications, based on the research conducted in this direction based on the growing technologies in this field. In this regard, the literature of the subject has been reviewed and the most important features, opportunities and challenges facing the agricultural industry in the face of the huge amount of data have been reviewed and evaluated. The results show that among the main characteristics of big data (volume, speed, variety, accuracy) in the field of agriculture, the most emphasis is on speed and variety. The main concern of the stakeholders is the cost, user-friendliness and embedding of the solution in their current working procedure.

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<https://doi.org/10.52547/jda.1.1.25>

1. Introduction

The field of food industry is one of the most important fields that is used in all human societies. From the past to the present day, many activities have been carried out to preserve food as best as possible, but many people have died due to unhealthy food and lack of food resources, and this process continued until scientists scientifically They managed to slow down this growth and stopped it in some parts of the world. One of the sciences that is increasing and growing more and more today and has many applications is the Internet of Things. The Internet of Things is one of the new and developing technologies in various industries, including the food industry (Nozari et al., 2019).

In today's era, due to global warming, lack of water resources and drought in most parts of the world, this has created a concern for food scientists and experts to find solutions for maintaining food safety, reducing food waste and maintaining the quality of nutrients and how to pack Suggest product classification. The Internet of Things is a vision of connecting anything, anytime, anywhere, which may have an impact on our daily lives, like the impact of the Internet two decades ago (Nozari et al., 2021). Internet of things is often associated with terms such as cyber system. Technologies related to information technology and the use of radio frequency identification system in wireless sensor networks, human-machine interaction, middleware, web service, information systems, etc(Gahremani-Nahr et al., 2021).

During the last 2 years, the epidemic of the Covid-19 disease has dramatically affected the livelihood and food security of people in all parts of the world, especially poor countries. Today, many countries in the world are developing policies aimed at reducing hunger, improving food security and ensuring sustainable food supply. The issue of using data science and big data analysis in order to provide food security is an issue that has been neglected by many actors in this field, such as governments, international organizations and civil society. Advances in technology have also changed the way data is collected, shared, and used. Governments and non-governmental actors are increasingly using digital technologies, and new sources and approaches to data have increased the determination of governments and professionals to further integrate data science with agriculture (Nozari et al., 2022).

The efficiency of big data in the field of agriculture is a combination of applied technologies and data analysis. This includes collecting, categorizing and processing new and updated data to help farmers make better and more informed decisions. These days, the intelligentization of agricultural infrastructure and the possibility of receiving various data from the existing processes have caused the increasing use of these data. On the other hand, big data is also useful in cases such as extracting information about weather, market and other farm standards (Tavakkoli-Moghaddam et al., 2021).

The promise of precision agriculture is to collect and evaluate a wealth of real-time data on factors such as air, water and nitrogen levels, air quality and disease, not just specific to each farm or hectare. Rather, it is specific to every square centimeter of agricultural land. In smart agriculture based on big data from the Internet of Things (IoT), we have a system to monitor and monitor agricultural land. This system provides us with integrated information using sensors (light, air humidity, air humidity, temperature, etc.) and also automates the irrigation of the land. Farmers can monitor the condition of the land wherever they are in the world. Agricultural systems based on the Internet of Things, in addition to being used in traditional and large-scale farming methods, can be used in small home farms and organic and modern farming methods (Najafi et al., 2022).

In this research, our goal is to investigate the use of big data from Internet of Things-based technologies in agricultural industries. In the following, after introducing the basic features of big data, we will

examine the dimensions, opportunities and challenges that big data brings with it in agricultural industries.

2. Literature Review

These days, many people have realized the widespread use of big data and data science in the development of technology-related industries. Now the question that is raised in the field of agriculture and providing food security is, how does big data analysis cause transformation in agriculture? IoT applications in agriculture with the ability to generate a lot of data include agricultural vehicle tracking, livestock monitoring, warehousing monitoring, and other things such as the following:

- Cattle sensors that can notify the shepherd when animals leave the herd to return them to the herd.
- Soil sensors that can alert farmers to erratic conditions, such as excessive soil acidity, allow farmers to produce better quality crops.
- Unmanned tractors that can be remotely controlled, which will save significant labor costs.
- Sensors to detect moisture, temperature and mineral composition of the soil in order to better monitor agriculture

Big data applications in agriculture are a combination of technology and analytics. This requires timely collection, compilation and processing of new data to help scientists and farmers make better and more informed decisions. Agricultural processes are becoming increasingly data-driven thanks to intelligent machines and sensors generating large amounts of farm data. Traditional and old tools are replaced by devices equipped with smart sensors that can collect data from their environment to control their behavior and performance; such as thermostats for temperature regulation or algorithms for implementing crop protection strategies (Ghahremani-Nahr et al., 2022).

Sustainability, global food security, safety and efficiency improvement are some of the important issues addressed by big data applications in agriculture. Undoubtedly, these global issues have expanded the scope of big data beyond agriculture and now encompass the entire food supply chain. With the development of the Internet, everything from different components of agriculture and the supply chain are connected wirelessly, generating data that can be accessed instantly. Primary sources of data include operations, transactions, and images and videos captured by sensors and robots. However, extracting the full potential of this data set lies in efficient analysis. The development of applications related to risk management, deployment of sensors, predictive modeling and benchmarking has become possible thanks to big data (Nozari et al., 2021). In Figure 1, the applications of big data in agriculture are shown schematically.

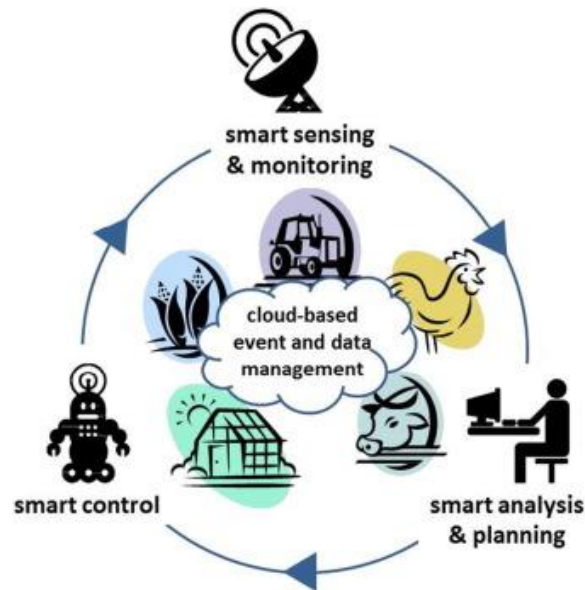


Fig. 1. The role of big data in agriculture (Sharma, 2020)

On the other hand, in smart agriculture based on the Internet of Things, a system is used to monitor agricultural land. This system collects integrated information using a variety of sensors (light, humidity, temperature, etc.) and automatically adjusts the irrigation of the land after analyzing the data. With the help of these systems, farmers can check the condition of the land from any corner of the world.

The Internet of Things in agriculture makes the processes of planting, harvesting and harvesting automated, and predicting many situations becomes possible. Prediction of soil dryness, control of fertilizer solutions, adequate irrigation and forecast related to weather, etc. are among the factors that help farmers improve efficiency and increase efficiency in many of their activities. The agriculture sector has been influenced by wireless sensor technology (WSN) and is expected to benefit equally from IoT. IoT plays a fundamental role in managing and analyzing information obtained from sensors. The predictions of the Internet of Things in agriculture are made based on the same information obtained from the sensors; therefore, the error rate is as low as possible. In fact, it can be said that these predictions depend on scientific data (Osinga et al., 2022).

Smart agriculture is mostly used to demonstrate the application of IoT solutions in agriculture. The adoption of IoT solutions for agriculture is continuously growing. As technology and technology continue to grow and develop, there will be plenty of opportunities to create jobs in the field of IoT in agriculture. Building IoT products for agriculture in the coming years can bring significant changes in this field. Technologies and IoT have the potential to change and evolve in different sectors of agriculture (Melgar-García et al., 2022).

As a result, all these factors can ultimately lead to more income. As the IoT network expands, IoT products become more complete and accurate. IoT grows like a child and learns new things. Internet of things in agriculture has the potential to develop and create new jobs and new agricultural devices

3. Applications of big data analysis in agriculture

Smart agriculture is a development that emphasizes the use of information and communication technology in the cyber-physical farm management cycle. New technologies such as the Internet of Things and cloud computing are expected to boost this progress and bring more robots and artificial intelligence to agriculture. This issue lies in the capture of the emerging phenomenon called Big Data, a huge volume of data with a wide range that can be used and analyzed for decision-making purposes. The purpose of this article is to gain insight into recent developments in the field of big data applications in smart agriculture and to identify related social and economic challenges that need to be addressed (Wolfert et al., 2017).

These days, big data has found many uses. Experts in the field of data science, in order to deal with the existing challenges around food security, have started to make the most of the capacities of big data in line with the development of intelligent agriculture. Some of the advantages of using big data in agricultural industries are as follows:

- **Improving Productivity:** Data collected through equipment such as GPS-equipped tractors, intelligent soil sensors and other tools help to improve the management of seeds, toxins, fertilizers and ultimately increase productivity in order to feed the global population and ensure food security.
- **Efficiency analysis:** Data and their analysis can be used to predict the productivity of agricultural land and the amount of crop production in the future. These forecasts become more accurate with the passage of time and the development of data-driven technologies.
- **Risk management:** Data-driven agriculture reduces crop defects caused by changing weather patterns, pests, pollutants in the soil and air.
- **Thrift:** Agriculture based on big data analysis significantly saves resources such as water, fertilizers and pesticides.

Experts and stakeholders in this field, during in-depth investigations in this field, have encountered 5 basic challenges in the field of using big data in providing food security.

- **Lack of prioritization and lack of sufficient attention from policy makers:** Experts in the field of data science believe that most governments have not understood the value of data in agriculture and providing food security, and this has caused many countries in the world not to prioritize the use of data in the field of agriculture.
- **Lack of sustainable investment in the field of statistics and data science:** The lack of investment in data and statistics of agricultural and food systems is one of the most important challenges in this field. Many low- and middle-income countries do not have enough financial resources to extract and analyze data in order to improve and modernize their agricultural industry.
- **Weak coordination and cooperation between actors in this field and economic obstacle:** Almost all actors and stakeholders in this field believe that the inconsistency and weakness in the development of existing cooperation in this field has slowed down the development process of using big data in the food and agriculture industries.
- **Lack of statistical capacity and digital skills to use new technologies:** The lack of investment and lack of attention to the need to develop this field will eventually reduce the statistical capacity and digital skills needed in this field of study.
- **Limited access to new data sources:** Inaccessibility of information sources is another serious problem in this field. Most of the developing and less developed countries, due to weak infrastructure and lack of financial resources, cannot collect the accurate information they need.

4. IoT in agriculture

In the next few years, we will see the increasing use of these technologies and other technologies in the field of smart agriculture. In fact, the deployment of IoT devices in the world of agriculture can lead to an annual growth of 20% in agricultural products. The entire agricultural life cycle includes soil preparation, planting seeds, adding fertilizer, watering, protecting the crop from weeds, harvesting and storing the crops. At each stage, producers or farmers must rely on experiences, calculations and probabilities based on the right time and other factors. This is while artificial intelligence and ML can miraculously help them and, in this way, farmers can benefit from accurate data analysis and proven predictions of these technologies. All-important agricultural data collected by IoT devices and ML algorithms are processed and channelized by data science. Farmers cannot use raw data and hence data knowledge changes the life critical decisions of farmers. In Figure 2, agriculture based on the Internet of Things is shown (Ramachandran et al., 2022).

With the preparation of products and productions, farmers face the problems of business, sales, marketing and proving the authenticity of their products. Blockchain developers help farmers ensure the safety of their produce, prevent any theft and fraud, manage the supply chain more effectively, and ultimately balance the food ecosystem. Therefore, it is possible to achieve the international promise of meeting the ever-increasing demand of the population by rapidly producing agricultural products on a large scale with less human intervention (Quy et al., 2022).

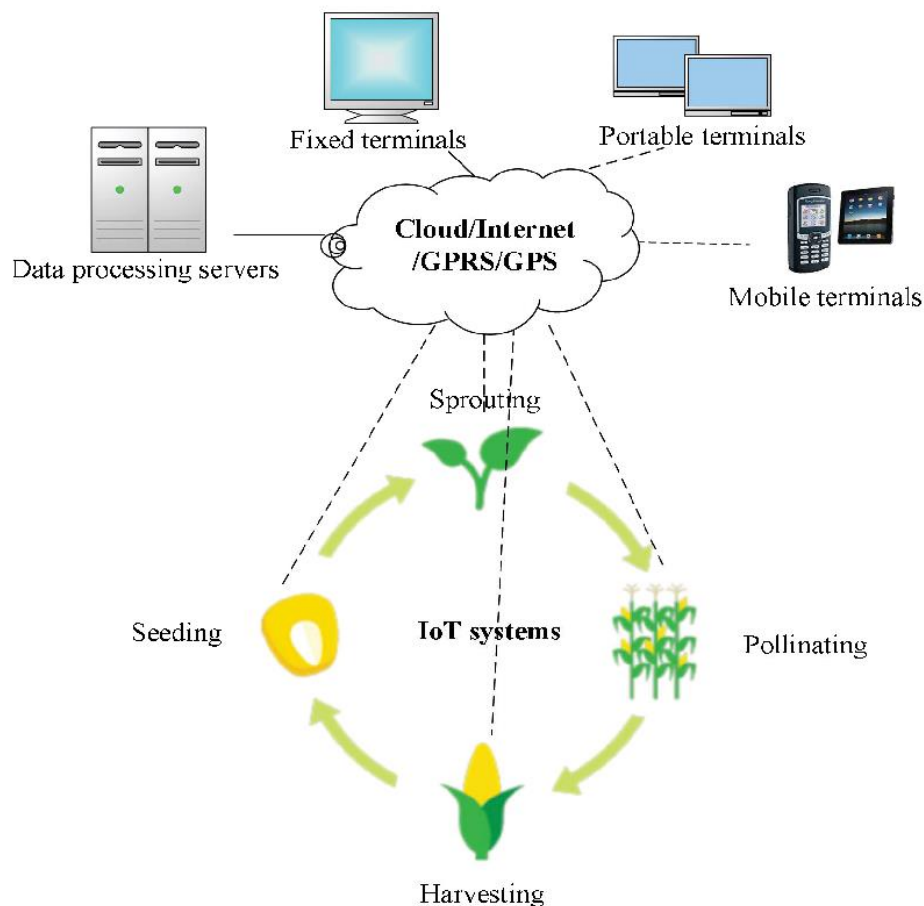


Fig. 2. Agriculture based on the Internet of Things (Ruan et al., 2091)

Below are some examples of IoT applications in agriculture (Farooq et al., 2022):

- **Soil monitoring system:** Hardware and software systems that measure soil moisture, temperature, and electrical conductivity. This system alerts farmers how much irrigation they need.
- **Wireless sensor monitoring:** It helps farmers to protect and maintain their crops. Silo and grain elevators can be dangerous by creating fire and dust. The use of these sensors to deal with risks is of special value.
- **Smart equipment:** Farmers can set up equipment on Autopilot and use this device to improve crop flow, minimize losses, and automate the equipment process.
- **Information management platform:** An autonomous UAV that collects high-quality data through an array of sensors used to map and image agricultural land. Before sending the drone into the air, farmers decide what part of the field to survey and adjust its accuracy or height.

5. Conclusion

Big data analysis has brought new business models such as data valorization and business transformation. In fact, organizations use big data according to their maturity level. As organizations grow and mature, they not only rely on real-time analytics of big data to optimize strategies and processes, but also go beyond and monetize the value of big data. The ever-increasing population growth on the one hand and the reduction of arable land on the other hand, have faced mankind with a formidable challenge of how to provide food for more people with less land. Issues such as the reduction of water and energy resources, climate change and the emission of greenhouse gases have made this crisis more serious, especially in recent years. The Internet of Things is an emerging technology that will have a deep and meaningful effect on the livelihood of billions of people and the future of the world in various fields, especially agriculture, and the answer to this critical issue. The emergence of intelligent Internet of Things solutions for data-based decision-making and the connection between data and the environment in agriculture has caused a fundamental change in all aspects of traditional methods and laid the foundation for the development of a new model of agriculture called intelligent agriculture. The data based on the Internet of Things technology are very voluminous and large, which cannot be processed and managed with management tools and traditional databases. Big data technology has been developed in order to store, process and analyze big data such as data based on the Internet of Things in various fields, especially agriculture. Therefore, smart agriculture and achieving sustainable agricultural development requires the integration of Internet of Things and big data technologies.

In this article, the concepts of two technologies, Internet of Things and Big Data, were investigated from the perspective of application in agriculture and their role in the development of smart agriculture. Surveys showed that the application of two technologies, Internet of Things and Big Data, which are related to each other, is increasing. The development of big data analysis methods based on artificial intelligence has also increased the integration of these technologies and their application, especially in agriculture, in recent years. Therefore, it can be expected that optimal agriculture will not be possible in the not-too-distant future without the existence of these technologies and the use of intelligent Internet of Things solutions. Based on this, planning to create the necessary infrastructure for the development of these technologies or their localization according to the needs of the world is necessary and has priority.

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