Internet of things and data analysis in agriculture

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Abstract. The growing world population has come up with many unprecedented crises. Among those issues, ensuring food security has been considered as one of the major ones. Leading countries have taken many initiatives over the years. But the shrinking farmland and natural resources across the globe have made the problem even harder. As the farmers cannot get enough land to cultivate, they are forced to increase the crop yield from the available farmland. The researchers are looking forward to coming up with sustainable solutions for this problem. They have implemented many technologies in agriculture to increase production with the available land resource. Among these solutions, the implementation of the Internet of Things (IoT) and data analysis has shown tremendous potential to solve this issue. This paper reviews the current application of IoT devices and data analysis applications in the agriculture industry. The paper also discusses the IoT device architecture and different data analysis tools. In addition to that, to analyse the recent trends of agriculture, the paper reviews recent research in this domain. In addition to the review of the ongoing research, the paper also discusses the possible future trends in agriculture.

1. Introduction

With the increasing global population and climate changes, the challenges of food production and consumption are increasing day by day. IoT and data analysis based agriculture is the main strategy and concept for producing a vast amount of food and minimizing environmental impacts [1]. These technologies are advancing and may become an obvious part of the future of agriculture. Digital farming is developing its advancement on the bases of GPS signals, spatial data with enhancement, intelligent services for applying and managing ICT, transverse integration of food in regards to safety and traceability. IoT is the need of time as it ensures data flow, analysis, automatic data processing, accessing and all this leads to more time and cost-effective production and management in agriculture [2]. At the same time, it also alarms us about environmental hazards like floods, intense storms, weeds, pests or insects attack, etc. so we can easily monitor conditions and cope with these situations [3]. It also eases us in the matter of surveying and keeps records about agriculture which is helpful and it is gaining importance all over the world. This concept was introduced by Kevin Ashton in 1999 to link RFID for supply chains to the internet but at that time it has not any official definition. It implies the connection of things without having any human involvement. There are advantages of applying IoT in the agriculture field because we can monitor and control many things with the increasing use of heterogeneous automated components [4].
Summarizing the aim of this research report:

- Provide an overview of the current need for IoT in the agricultural field.
- Sketching of different applications and capabilities of technology of IoT.
- Identifying main challenges encountered by IoT in arable farming
- The suggestion of solutions and posing future directions of IoT in agriculture.

2. **Impact of IoT in agriculture**

IoT has seen its application in almost every area including transportation, manufacturing, energy, retail, healthcare, and agriculture. It offers the user-friendly operation of different devices and ensures better connectivity between the device and the user [5]. In this section, the elements of an IoT system have been described and its application and impact in the agriculture domain have been investigated.

2.1. **IoT system elements**

The elements of most of the IoT systems are pretty similar to one another [6]. However, depending on its application, the hardware and software parts of the systems change. The following are the most common elements within any IoT based system:

- **Sensors:** A huge part of any IoT based system is its sensors. These sensors collect different types of data and send them to the incorporated device. Using this information, the device can take its decision.
- **Connectivity:** The sensors and devices remain connected to the cloud using various methods including Wi-Fi, cellular, Bluetooth, etc. Connectivity is absolutely vital for any IoT device and the device cannot work properly without the connection.
- **Data Processing:** When different sensors send their data to the cloud, the software part take the control and perform different types of data processing.
- **User Interface:** The user receives the data from the cloud server after its being processed by the software. The user can receive this data by many means depending on the types of systems.

2.2. **Application and impact of IoT in agriculture**

IoT is currently used in almost every aspect of agriculture. Although, the most use of IoT technologies can be seen in precision agriculture. IoT is offering more reliable maintenance and security in farming. These types of agricultural farms are getting popularity in smart cities. Another popular application of IoT can be found in the automatic irrigation system that obtains values of different parameters such as humidity, soil moisture, temperature. Different decision-making systems are also being used to analyze agriculture data [7].

3. **Data analysis techniques and their impact in agriculture**

3.1. **Big Data analysis**

Different data analysis techniques are currently used in agriculture to improve the yield of production, reduce cost, and improve disaster management. Among these analyses, big data and machine learning are the most common ones. Using big data, farmers can get a more accurate prediction on the future rainfall pattern, required fertilizers, and much other information [8]. They can use this information to make better decisions about their farm, which results in better farm yield and more profit. They can also make better decisions about the proper time to harvest [9].

3.2. **Machine learning**

Implementation of machine learning is taking farming to the next level with the use of different artificial intelligent systems. Currently, machine learning is used to solve specific problems, with the possibility to take automated decisions in the future. Machine learning-driven farms perform different real-time
data analysis to obtain significant data. These data can be used to make important decisions by the farm owners. Machine learning is also used for automated soil preparation, harvesting, and water management. Most of the popular machine learning models such as Artificial Neural Networks and Deep Neural Networks are being used in agriculture to accelerate the decision-making process [10].

4. Future trend of IoT and data analysis in agriculture

In the future, the application of IoT devices will increase by a large margin. Those devices are most likely to include different advanced sensors, RFID, and FPGA. Transportation in the agriculture industry may take a huge leap with the emergence of new automated vehicles. Different robots and drones will be used for fertilizer distribution, and crop collection. The developed IoT platform for crops will shift towards a universal platform that will ensure easier monitoring of crops and will connect the consumer to the farmers in an easier manner. Security is currently a huge caveat to use many IoT devices. In the future, implementation of end-to-end security in IoT devices may provide better security, and blockchain based servers can also reduce the possibility of cyber-attack [11]. Data analysis techniques are also likely to be used more in agriculture to provide more accurate analyses. In addition to that, weather prediction data are likely to be more accurate. Overall, with the use of IoT and data analysis, the agriculture industry will continue to grow even more.

5. Challenges and solutions

Investment for establishing IoT based systems is high which is not affordable for small farms while easy for large farms. Uncertainties regarding costs of requirements gave little margin for farmers to utilize IoT based systems. Trust in this system also plays a crucial role in this as we have the fact that in Europe 70% of all needed machinery equipped with at least one technology but 25% of farmers in real use precision in their farms [12]. Technology makers should increase the perceived value by signifying a financial return to reduce the stress of farmers. These technologies need to minimize the workload, need to develop interoperable and flexible solutions that can easily be applied. Governments can also make policies and regulations for implementing IoT based systems in agriculture.

- **Data heterogeneity**
  The varied data sources and sensors makers imply the use of different unit systems in different formats. This heterogeneity can affect the performance of protocols also the challenge becomes more crucial in systems like sharing information with other systems etc. Usage of standardizing format is the only solution for these challenges.

- **Flexibility**
  Many systems described the articles centralized, closed and difficult to interpret in other platforms. They also complain that these are difficult to implement in various situations. The use of standardized dynamic protocols, fast and reliable API’s, SOA and middleware platforms are tools that enable flexibility.

- **Robustness**
  Robust wireless connectivity is a major factor that limits in many systems. While making the design of IoT these issues need to be considered.

- **Complexity**
  The agricultural system is quite complex in both natural and technological ways. Depending on the implementation of setup and background check-up this complexity can be reduced.

- **Lacking products**
Many products that integrated agronomy and ICT engineering are lacking which makes hurdle for adoption. This can be noticed by manufacturers to cope with this challenge.

6. Conclusion
In this paper, the different IoT technologies that have changed the landscape of the agriculture industry has been discussed. Different areas where IoT has been implemented were investigated with the help of a thorough literature review. Different recent technologies that can improve the crop yield has been analyzed to find the current trend of IoT technology in agriculture. With the help of these new techs, farmers can now easily learn about the farm’s status in real-time, and with the help of wireless sensing technology, they can also control their farm remotely. In addition to that, different data analysis tools have been also reviewed in this paper. These tools are mostly used to analyze raw data obtained from the field and can be processed to generate various results that can be used to make important decisions. The paper also discusses the possible trends of IoT applications and data analysis. The implementation of IoT and data analysis are most likely to increase more in the future. The following conclusions can be drawn from this research:

- IoT will overtake most of the classic agriculture equipment.
- Data analysis will be more precise in future, which will result in better crop yield.
- Most of the agriculture sensors will be connected to the internet in near future and can be controlled remotely.
- Human effort in agriculture will reduce and more production will be possible from the same amount of farmland.

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