Seeding Success: Harnessing IoT for Modern Farming

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ABSTRACT

The Internet of Things is shortened to IoT. IoT refers to any object that can transmit data when it is linked to a network. When Kevin Ashton, the co-founder and executive director of the MIT Auto ID Center, was introducing RFID tags to Procter and Gamble as their brand manager in 1999, he coined the term "internet of things." The idea was to manage the supply chain so that the location and stock at hand of each item coming out of it could be more easily monitored. IoT device is every object that can be controlled through the internet. IoT is used in agriculture by using robots, drones, sensors, and computer imaging along with analytical tools to monitor and gain insights from farms. Physical equipment is positioned on farms to monitor and capture data that is utilized to gain insights. IoT solutions for farming aim to reduce output losses and meet rising demand from traditional farming operations. IoT in agriculture uses robots, drones, remote sensors and computer imaging. In addition to constantly improving machine learning and analytical tools for surveying, mapping, and crop monitoring, these technologies also give farmers access to data for logical farm management strategies that save time and money.

KEY WORDS: IoT, Agriculture, Technology, Smart Farming

INTRODUCTION

The term "Internet of Things" (IOT) was coined in 1999 by a member of the Radio Frequency Identification (RFID) development community. Due to the proliferation of mobile devices, embedded and ubiquitous communication, cloud computing, and data analytics, the IOT has recently gained greater relevance in real-world scenarios.

Internet of things (IOT) is a network of physical objects. The internet is no longer just a network of computers; it has grown to be a network of all kinds of devices, including smart phones, cars, toys, medical equipment, cameras, industrial systems, buildings, people, and animals. These devices communicate and share information according to predetermined protocols, enabling clever reorganizations, positioning, tracing, safe and control, and even personal real-time online monitoring, online upgrades, process control, and administration.

IoT is an environment where objects, animals or people are equipped with unique identifiers capable of data transmission over Internet network without the need for human-human or human-computer interaction. IoT is useful in practically every aspect of contemporary life. Smart homes, smart agriculture, precision agriculture, autonomous vehicles, smart cities, smart industries, and smart health care are a few of the key areas.

A great deal of effort has been put into developing smart farming solutions using IoT technology in the agricultural sector. By analysing the many complexities and difficulties in farming, IoT has brought about a significant revolution in the agricultural environment. The majority of problems have almost entirely been identified by IoT technologies, which also offer cost-effective solutions to boost productivity. We are able to gather data from sensing devices and transmit it to the primary servers thanks to efforts made in wireless sensor networks. Sensor data provides information about various environmental conditions, enabling proper system monitoring. Crop productivity and environmental monitoring are important aspects of crop evaluation, but there are many other factors that also affect crop productivity, such as field management, crop and soil monitoring, the movement of undesired objects, wild animal attacks, theft, and so forth. Additionally, IoT offers a well-organized scheduling system for limited resources, ensuring that the optimal utilization of IoT boosts productivity.

How IoT works

IoT seeks to enhance connectivity by linking multiple devices to the internet simultaneously, enabling man-machine and machine-to-machine interactions. This is similar to how the internet has transformed the way we work and communicate with one another by connecting us through the World Wide Web (internet).

Here, 4 fundamental components of IoT system, which tells us how IoT works:

1. Sensors/Devices

First, minute data from the surrounding environment is collected with the aid of sensors or other devices. The level of complexity of all this data collection can vary, ranging from a basic temperature-monitoring sensor to a complex full video feed. Multiple sensors can be bundled together on a device to perform functions beyond simple sensing. Our phone, for instance, is a multi-sensory device with a GPS, accelerometer, and camera, but it is more than just a sensing tool.

2. Connectivity

Next, that collected data is sent to a cloud infrastructure but it needs a medium for transport. Numerous communication and transport methods, including cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN), low-power wide-area networks, and many more, can be used to link the sensors to the cloud.

3. Data Processing

Following collection and delivery to the cloud, the software processes the data that has been obtained. This can start with something as basic as making sure the temperature reading on appliances like heaters and air conditioners is within a reasonable range. Sometimes it can also be extremely complicated, like when you use computer vision on video to identify objects, like intruders in your home.

4. User Interface

Next, the data that is somehow accessible to the end user. This can be accomplished by sending them emails or texts, or by setting off alarms on their phones. Also, a user may occasionally have access to an interface that allows them to actively monitor their IoT system. For example, if a user installs a camera in their home, they may wish to view all of the feeds and video recordings via a web server.

IoT Real World Applications

Smart Home Applications

IoT applications are actively used in a smart home's operation. In an integrated platform, smart home appliances gather and exchange data, and they can also automate tasks according to the owner's preferences. Therefore, it is evident that they go through a learning process to comprehend their owner's preferences. Smart Thermostats: These devices monitor and regulate home temperatures to ensure the comfort of their owners are among the many IoT use cases associated with smart home appliances. In addition, there is smart lighting, which modifies its own lighting according to user preferences and external lighting.

Smart Cities

Many governments plan to build smart cities – that is – cities which heavily use IoT for several reasons such as parking, public transportation, traffic control, utility billing, etc. Smart Cities can be referred to as large-scale IoT applications which cover a lot of problematic areas in a city. While costly, it can be safe to say the benefits far outweigh the cost. With the combination of sensors, GPS data collection, and cloud platforms, it will be simple to plan construction projects by anticipating their impact on traffic, identify alternate routes when needed, and monitor traffic conditions in a particular area.

Smart Vehicles

IoT applications can also be used to coach drivers based on their driving style and comprehend their behaviour. In addition to tracking fleets in real time via GPS, smart cars also keep an eye on driver behaviour and vehicle health. These cars use advanced sensors and gyroscopes, all of which are connected to cloud platforms and the internet. Connected IoT devices collect important information about cars and drivers, including location tracking, driving habits, vehicle health and alerts, and much more.

Smart Agriculture

Given the rate of population growth and the necessity of agriculture for human survival, maintaining such large-scale agriculture may be difficult without of a major revolution. Farming productivity can be increased and maintained in line with the global population explosion by integrating IoT applications with farming. IoT applications can result in precision farming – that is, use of analytical data to understand soil moisture level, climatic changes, plant requirement, etc, and thus boost yield as well as encourage efficient use of resources.

Health Care

IoT use in the healthcare industry has the potential to completely transform the industry. IoT has the potential to benefit all of these parties. Numerous wearable technologies, such as blood pressure monitors and fitness bands, are already available to patients to aid in their health. These devices also include alert systems designed to alert family members or physicians in the event of an emergency. With the help of an IoT device, doctors can easily access real-time health data and learn about a patient's past.

Smart Industry

In the manufacturing department, IoT combined with Robotics can be used in asset management and inventory management. In the manufacturing sector, implanting robotics with sensors and network connectivity can assist in monitoring system efficiency, identifying machinery errors, identifying root causes of inefficiencies, and more. In the industry, IoT can also aid in addressing unplanned downtime.

IoT in Agriculture

The need for industrialization and intensification in the agricultural sector has increased due to the growing demand for food in terms of both quantity and quality. The Internet of Things, or IoT, is a very promising technology that offers the agriculture industry many creative ways to modernize. Scientific teams and research facilities are continuously trying to use IoT to address various agricultural domains with products and solutions.

IoT deployment in agriculture is considered the ideal solution because this field requires constant monitoring and control. IoT is utilized at various stages of the industrial production chain in the agricultural sector. The main applications of IoT in agriculture are Precision Farming, Livestock, and Greenhouses, which are grouped into different monitoring domains. A proposed IoT management system keeps an eye on a wide range of environmental factors, including wind, soil, atmosphere, and water. Moreover, IoT-based agricultural monitoring solutions have been identified based on the sub-domains to which they belong. The identified sub-domains are soil monitoring, air monitoring, temperature monitoring, water monitoring, disease monitoring, location monitoring, environmental conditions monitoring, pest monitoring, and fertilization monitoring.

Wireless sensor networks (WSNs), which assist farmers in gathering pertinent data through sensing devices, are used to monitor all of these applications using various IoT-based sensors and devices. Certain IoT systems use cloud services to process and analyze remote data, enabling researchers and agriculturists to make more informed decisions. Nowadays, with the advancement of current technology, environment monitoring solutions offer additional facilities in terms of management and decision making.

Smart Farming

Smart Farming is a farming management concept using modern technology to increase the quantity and quality of agricultural products. Today's farmers have access to Internet of Things, GPS, data management, and soil scanning technologies. Establishing a foundation for a farm management decision-making support system is the aim of smart agriculture research. From crop planting and watering to health and harvesting, smart farming believes that it is imperative to address the issues of population growth, climate change, and labor, all of which have received significant technological attention. An irrigation system is automated and a system for monitoring the crop field using sensors (light, humidity, temperature, soil moisture, etc.) is built in IOT-based smart agriculture. In the context of agriculture, IOT (Internet of things) refers to the utilization of sensors, cameras, and other devices to convert every aspect and action of farming into data. ince smart agriculture will significantly reduce the negative environmental externalities of modern agriculture, we need to expand and develop it from where it is now.

Components of a Smart Farm

- **Sensors:** Soil, water, light, humidity, temperature management.
- **Software:** Specialized software solutions that target specific farm types or Applications agnostic IoT platforms.
- **Connectivity:** Cellular, LoRaWAN (Long Range Wide Area Network) etc.
- **Location:** GPS, Satellite, etc.
- **Robotics:** Specific, Autonomous processing facilities**.**
- **Data Analytics:** Standalone analytics solutions, Software and applications for analytic processes

Applications of IoT in Agriculture

Robotics

Agricultural robots are increasing production yields for farmers in various ways. From drones to autonomous tractors to robotic arms, the technology is being deployed in creative and innovative applications. The most common robotic application in agriculture is harvesting and picking because of the precision and speed that robots can provide, increasing yield sizes and decreasing crop waste from left-over crops. Robots 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

Mainly two types of drones- ground-based and aerial-based drones are being used in agriculture for monitoring crops, assessing crop health, applying pesticides, irrigating fields, planting crops, and field analysis. These drones capture multispectral, thermal, and visual imagery during their flight. Drone use has numerous advantages, including enhanced crop yields, time savings, ease of use, integrated GIS mapping, and crop health imaging. Drone technology can revolutionize the agricultural industry by combining it with smart strategy and planning based on real-time data collection.

Remote Sensing

IoT-based remote sensing uses weather stations and other sensors positioned throughout farms to gather data that is then carried forward to analytical tools for examination. Farmers can use analytical dashboards to monitor their crops and take appropriate action based on the insights they gain.

Computer Imaging

Computer imaging uses sensor cameras placed at strategic points around the farm or camera-equipped drones to capture images that are then processed digitally. The fundamental idea behind digital image processing is the application of computer algorithms to an input image. Image processing compares photos taken over time, views images in various spectral intensities, such as infrared, and detects anomalies, which allows for the analysis of limiting factors and improved farm management.

Smart Greenhouse

The IoT can be used to build a smart greenhouse. These smart greenhouses intelligently monitor and control the climate without requiring any sort of manual intervention. A smart greenhouse uses a variety of sensors to measure environmental parameters and determine whether they are suitable for plants. A remote access is created by connecting the system to a cloud with the help of IoT. This eliminates the need for constant manual monitoring. The data processing and control action inside the greenhouse are managed by the cloud server. Important data on temperature, humidity, pressure, and light levels is provided by the IoT sensors that are installed inside the greenhouse. These sensors use a WiFi signal to control everything from opening windows and turning on lights to regulating temperature and cooling down.

Livestock Monitoring

Large farm owners use wireless IoT applications to monitor the location, health, and welfare of their cattle. With the aid of this information, they are better able to recognize sick animals, remove them from the herd, tend to their needs, and stop the disease from spreading to other animals. It is also useful for cutting labor costs as owners can locate their cattle with the help of IoT-based sensors.

IoT in Indian Agriculture

Agriculture is an important sector in any other country, but it is especially so in developing nations like India. Agriculture sector contributes to country's economy more than any other sector. Compared to the current state of agriculture, productivity in that sector was substantially higher both prior to and during independence. The foundation of the nation's economy is agriculture. In our nation, the majority of people work in agriculture. Since India is still a developing nation, agriculture is both the primary industry for economic growth and the only one in which more than 50% of the workforce works directly in the field. In light of India's expanding population, agricultural growth is crucial to meeting demand, and along with it computer technique research is also crucial. A number of variables, including rainfall, temperature in the atmosphere, and topography of the land, have a significant impact on crop yield. The farmers are interested in examining the seasonal changes in order to safeguard the crops from the natural disaster. Data mining techniques can then be used to assist in making a yield prediction based on past field data from the area. Over the last three years, digital transactions have already increased by 88% in India. Up to this point, the digital platform has seen numerous noteworthy advancements since the start of the "Digital India" initiative in 2015. Drones, smartphone apps focused on farming, high-tech sensors that link buyers and sellers to crucial farm-related data, and other new technologies are transforming the Indian agricultural sector. The goal of the Digital Agriculture Mission 2021–2025 is to encourage and accelerate projects that leverage emerging technologies, such as artificial intelligence (AI), blockchain, remote sensing, geographic information system (GIS), robotics, and drone usage.

Benefits of IoT in Agriculture

Data collection

All data can be collected with the help of installed sensors. Such information as the state of the crops, cattle, and weather, among other things. Farmers can quickly check and analyse the data that is centralized so they can make informed decisions.

Reduction of risks

Farmers are able to forecast potential issues and understand the future conditions when they have access to current information. Farmers can also use data to alter business procedures and increase sales.

Automated business operation

The efficiency of many business processes is increasing as they become automated. Farmers can therefore focus on other important processes.

Better quality

Smart agriculture makes it possible to avoid challenges and remove all issues that may arise during farming processes. As a result, customers are receiving better, higher-quality products, and product quality is increasing.

Challenges of IoT in Agriculture

Lack of infrastructure

Due to inadequate communication infrastructure, farmers will not be able to benefit from IoT technology, even if they adopt it. Farms are situated in remote areas with limited internet connectivity. Any farmer should be able to dependably access crop data from anywhere at any time, so any sophisticated monitoring system would be rendered useless by poor connections.

High cost

Equipment needed to implement IoT in agriculture is expensive. Even though sensors are the least expensive part, it would still cost more than $1,000 to equip every farmer's field with them. Because automated machinery includes costs for farm management software and cloud access for data recording, it is more expensive than manually operated machinery. Although it would be difficult for them to make the initial investment to set up IoT technology at their farms, it is important for farmers to invest in these technologies in order to earn higher profits.

Equipment vulnerability

As the agricultural sector is directly influenced by harsh environmental conditions, such as high temperatures, humidity, rain, winds and other phenomena, which can cause serious damage to electromechanical equipment. Since any of these sensors could malfunction, it could be possible to provide inaccurate commands and measurements, which could result in a production disaster.

Security and privacy

Massive amounts of data gathered by IoT systems are challenging to use. It is possible for data to be stolen and used against users. Systems that run over the internet may allow the maker of the device to use or sell user data. Threat actors use Internet of Things (IoT) ransomware to take control of or lock down a device, or several devices, in order to demand money.

CONCLUSION

The Internet of Things has aided in the application of cutting-edge technical solutions to time-tested knowledge in practically every industry. Produce gets processed more quickly and gets to supermarkets in the quickest amount of time thanks to flawless intelligent operations and better business process execution. Further development of data and application infrastructures and their institutional embedment will play a crucial role in the battle among several technology related scenarios. The Internet of Things (IoT) will revolutionize the agricultural industry as technology advances further. An increasing number of intelligent IoT devices are assisting farmers in gathering valuable data. Farmers need to be aware of the potential and power of IoT in agriculture. Given the rapid population growth, farmers are able to effectively meet demand. Although smart technologies will continue to have an impact on Indian agriculture, the vulnerability to hostile cyberattacks is a major worry. When updating or replacing older legacy systems, securing the platform with an embedded firewall, conducting thorough risk analyses to identify potential vulnerabilities and determine the best course of action, and using analytics to extract conclusive insights will all be crucial. However, IoT is revolutionizing the agricultural sector to help farmers overcome the great obstacles. The industry still has to overcome issues such as increasing water scarcity, a shortage of available land, cost management challenges, and meeting the rising demand from global consumers, which is predicted to increase by 70% by 2050. Furthermore, since IoT is a promising technology of the twenty-first century, it continues to open doors for the agricultural sector and farmers by improving the quantity, quality, sustainability, and cost-effectiveness of agricultural production through implementation.

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