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An Overview of Internet of Things (IoT) Approaches for Automation in Agriculture

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Abstract

The network of devices known as the Internet of Things (IoT) uses the stressed and Wi-Fi Internet to facilitate gadget-to-system (M2M) verbal exchange. IoT in agriculture is a present-day generation that can be used all 12 months round to boost agricultural output. The motive of this study is to offer an outline of IoT programs for agricultural automation within the agricultural zone, as well as to speak about the opportunities and constraints for developing IoT use. Based on historical information, the use of IoT in agriculture was classified, examined, and comparisons were made between the diverse sensors and communique technologies. The limits and future possibilities of IoT in agriculture have been tested in light of the analysis's findings. IoT has been considerably utilized in agriculture for self-sufficient machines, manipulating structures, monitoring systems, and management systems. Furthermore, IoT-based agriculture made use of the several Wi-Fi verbal exchange technologies utilized in agriculture, consisting of Wi-Fi, Bluetooth, ZigBee, and a lengthy-variety extensive region network (LoRaWAN), in addition to cell communication (e.g., 2G, 3G, and 4G). It is predicted that in the future, faster and more complete IoT technology could be used for quite a few agricultural activities with the improvement of different communication technologies, together with 5G. By boosting crop quality and productivity and cutting labour costs, IoT-based total agriculture with a communication system tailor-made to every farming environment may assist with agricultural automation.

Keywords: *IoT, Agricultural Automation, Sensors, Communication Technologies, LoRaWAN and Productivity*

Introduction

When Kevin Ashton first offered the Internet of Things (IoT) in 1999, he expected that it would likely be utilized in some regions, including waste management, agriculture, towns, smart healthcare, homes and buildings, strength, and transportation. An extra 10 billion people are anticipated to sign up for the sector's populace by the year 2050, necessitating accelerated agricultural output. Globally, academics are looking for methods to reinforce agricultural output that allows you to clear up this trouble. By lowering waste, optimizing processes, and developing a safe meal delivery chain, IoT generation has significantly aided in creative, clever farming, permitting agricultural automation, elevating output, and enhancing crop yields.

At a compound annual growth rate (CAGR) of 10.5%, the worldwide IoT industry is projected to reach 1256.1 billion USD by 2025. A new paradigm for agriculture has been introduced by using IoT generation, which is being used for some activities consisting of drones, self-sustaining agricultural systems, irrigation manipulation, inexperienced residence environmental

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manipulation, farm control, and animal tracking. Farmers can effectively control their fields and keep on watch on agricultural situations in real time by integrating wireless sensors and cell networks.

IoT generation has additionally made it viable for farmers to accumulate beneficial information that's then used to create yield maps that permit precision agriculture to supply remarkable, less expensive crops. However, in preference to handling all aspects of agriculture, inclusive of the management of crops and agricultural systems, IoT has been extensively hired as a single solution, such as monitoring and running greenhouses. As a result, it's vital to integrate IoT generation into a lot of agricultural sports.

The purpose of this study is to offer pertinent statistics for developing and implementing IoT structures appropriate for agricultural settings. The specific dreams are to accumulate and classify the exclusive methods that the Internet of Things is currently carrying out in agriculture, to summarise the sensors, networks, and controllers utilized in every piece of software, to analyze the one-of-a-kind wi-fi verbal exchange technologies hired in IoT-primarily based agriculture, and to speak approximately a number of the opportunities and barriers.

Technologies for the Internet of Things

After being governed with the aid of customers at the beginning, machine-to-device (M2M) generation emerged to gather and analyze information through networks and sensors. Through the evolution of IoT technology in M2M, offerings and non-human object verbal exchange are made feasible. Prescriptions and offerings, planning and selection-making, and data processing and accumulating are all examples of IoT capabilities. IoT processes are used in agriculture to accumulate statistics about farms, animals, crops, and agricultural equipment. These statistics are then saved in databases, which might be used to create prescriptions based on professional evaluation and textual content to message to customers. A software layer for agricultural packages, a community layer for information transmission and receiving, and a perception layer for reputation incorporate the Internet of Things structure. Real-time parameter sensing is performed by installing sensor nodes at distinctive places, and the measured records are dispatched to a nearby gateway. Using Wi-Fi sensor networks (WSNs), the nearby gateway receives the statistics and transfers them to the cloud. This device may be used for some agricultural applications and strategies, including unmanned equipment, management, tracking, and control.

Important IoT protocols for agriculture:

- Data collection: In order to acquire statistics on several environmental parameters, such as temperature, humidity, soil moisture, and light tiers, sensors are located in fields.

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These sensors can also be used to comply with the motion of animals, discover pests and ailments, and display crop health.

- Data transmission: A variety of Wi-Fi technologies, along with cell networks, Wi-Fi, and Bluetooth Low Energy (BLE), are used to switch the statistics gathered by using the sensors to an important server or cloud platform.

- Data evaluation: To extract insights and guidelines, the statistics are analysed using artificial intelligence (AI) and device learning strategies. These facts can be used to forecast harvest yields, assess crop strain, and optimise fertilization and irrigation.

- Actionable insights: Farm sports are automated, and nicely informed picks are made using the insights derived from the record analysis. For example, pesticides may be directed towards unique regions of the sector where pests have been discovered, and irrigation structures may be programmed to routinely alter in response to changes in soil moisture degrees.

- Real-time tracking: Farmers can maintain a watch on their plants from anywhere inside the globe using Internet of Things (IoT) devices. This enables them to directly understand and deal with troubles, including a sharp decline in soil moisture content or a pest epidemic.

- Increased production and efficiency: By automating techniques, maximising the use of to-be-had sources, and cutting waste, IoT can assist farmers in growing their productivity and efficiency. Profitability may also enhance as an end result, as well as yields and charges falling.

- Sustainable agriculture: Precision agricultural strategies, which use less water and fertilizer, are just one instance of the way IoT could possibly help farmers implement more sustainable practices. This can also guarantee agriculture's long-term viability and contribute to environmental safety.

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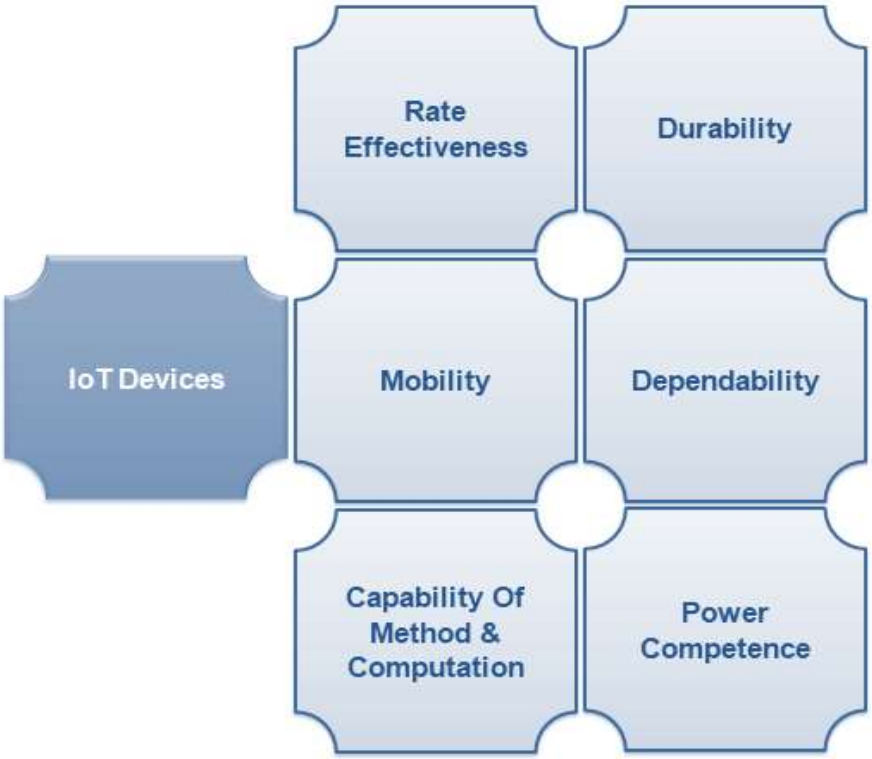
Capabilities of Internet of Things devices

Fig 1: The key attributes of Internet of Things devices



Field-programmable gate arrays, or FPGAs, are programmable interactive modules that are used in embedded systems. In order to monitor and acquire environmental factors that impact production, which include soil nutrients, humidity, temperature, and so forth, sensor gadgets are mainly made to function in open spaces, in nature, in soil, water, and air. Smart farming solutions involve agricultural operations, which are often applied outside on expansive farmlands. As a result, the gadgets helping with these answers should have certain unique traits, just like the potential to endure weather-associated influences, humidity fluctuations, and temperature instability over the course of their provider lives. IoT gadgets are applicable for clever agricultural answers because of a few of their primary characteristics, as shown in Fig 1.

Fig 2: Important IoT processes for agricultural

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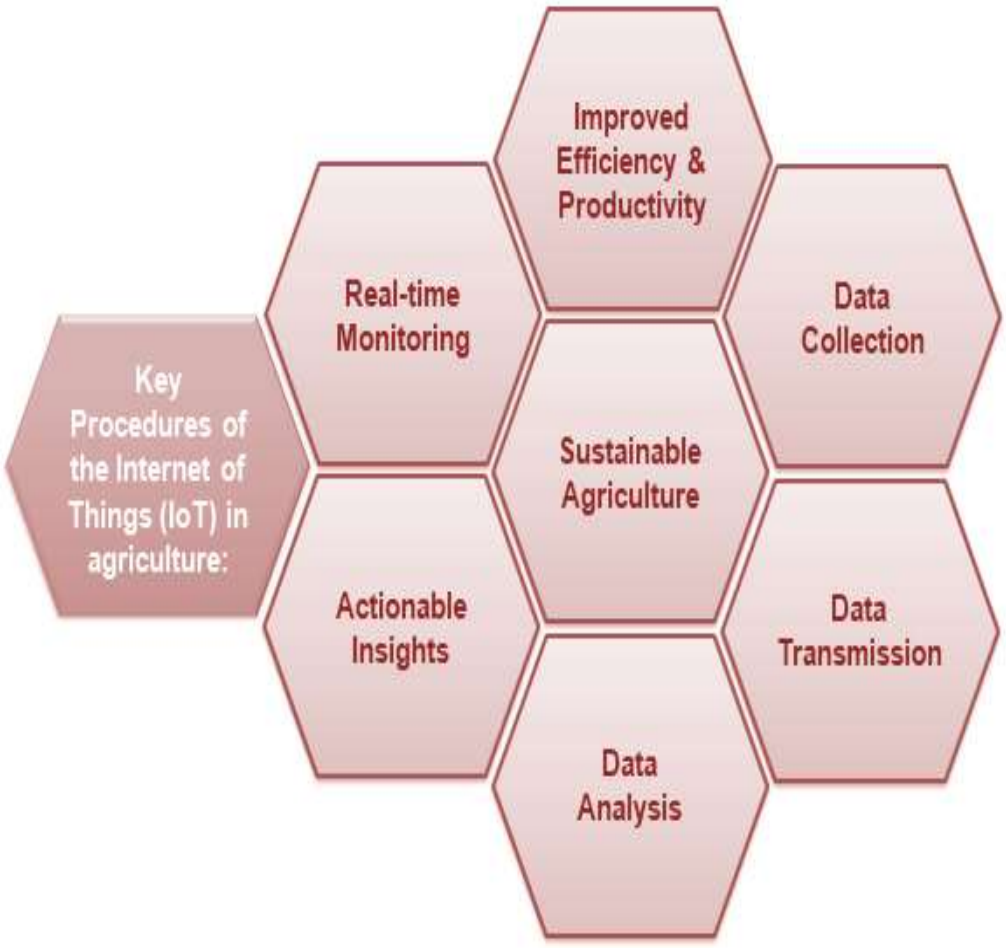

Layers of Perception

The IoT's sensor layer is responsible for figuring out the bodily characteristics of goals consisting of farms, crops, animals, and devices. Actuators, controllers, WSNs, RFID, agricultural equipment, and sensors are all included. Numerous elements, including the surroundings, soil, indoor and outdoor spaces, and water, are taken into account in agriculture. Temperature, wetness, humidity, pressure, pH, ultrasonication, and an accelerometer are the primary sensors hired. The provision of excessive-decision actual-time sensing records is made viable by way of IoT sensing technology, which includes WSNs, NFC, RFID, age processing, and GPS. In IoT-based total agriculture, WSNs encompass spatially dispersed sensor nodes gathering and monitoring undertaking-associated data. The relationship between sensor nodes and the actual environment is proven through the information glide that occurs among sensor nodes, gateway sensor nodes, and the physical world.

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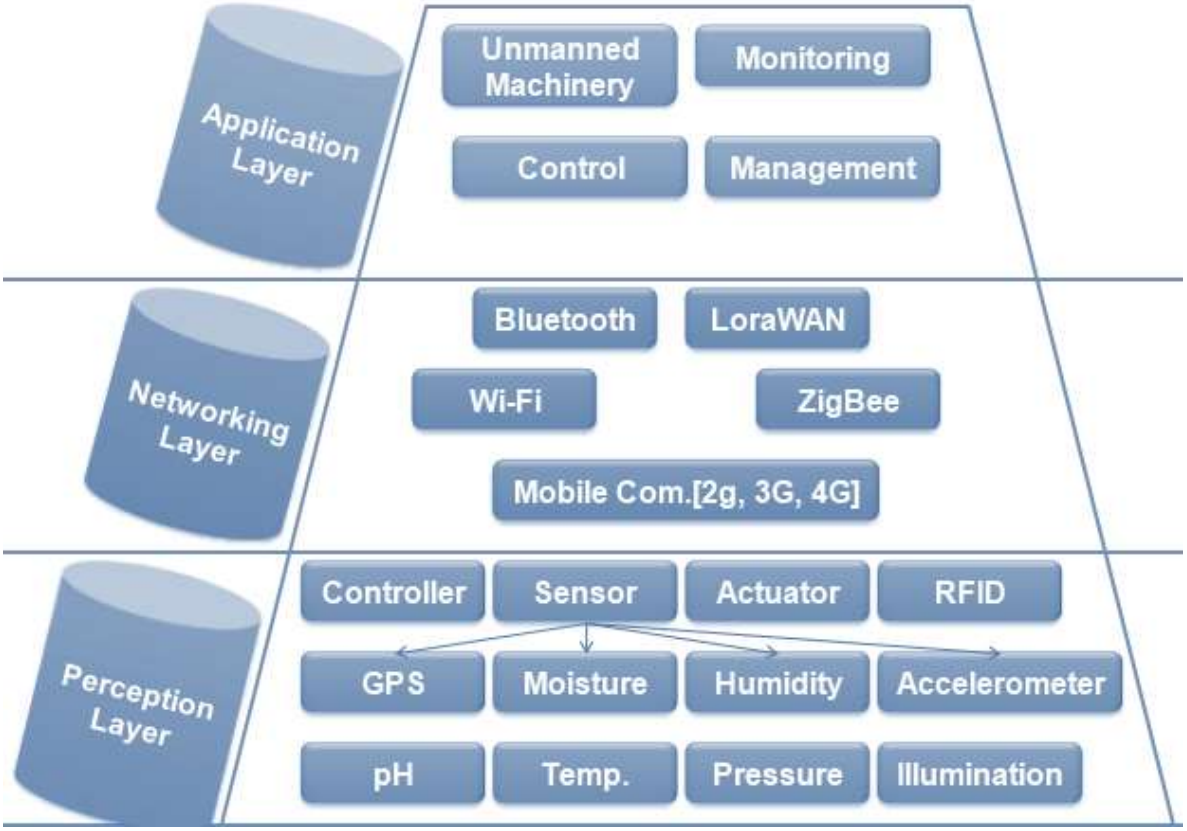
Fig 3: The application layer, network layer, and perception layer comprise the Internet of Things architecture



Additionally, WSNs use virtual alerts to automatically route records to a decision center. To create databases and conduct large-scale fact analysis, the records collected by way of the sensors are most effectively processed by using the embedded device and transferred to the pinnacle layer through the network layer (Shi et al. 2019).

Layers of Networks

Real-time data from the perception layer is processed by means of the community layer before being remotely sent through LANs, the Internet, and telecommunications networks to the utility layer. Data accumulated on the perception layer is dispatched to the application layer through a microprocessor or microcontroller via a whole lot of media, consisting of 3G/4G/5G, Wi-Fi, Bluetooth, IEEE-802.Eleven, NFC, GSM, ZigBee, and GPRS. Related gadgets in the notion layer may be activated by the community layer's transmission of record kinds and manipulation of instructions from the software layer to the notion layer.

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Level of Application

The highest level of layout in the Internet of Things layer, the utility layer, is a clever processing device that applies information processed on the network layer (Foughali et al. 2018). This layer carries quite a few intelligent structures, which include fact management for the rural industry, monitoring and management of farms, animals, vegetation, and devices, early illness detection and diagnosis, self-sustaining equipment operation, and early caution structures for insect infestations. Furthermore, the primary features of the utility layer include statistics processing and evaluation, machine assessment, fashion prediction, choice-making based totally on historical fact sets, and prescription shipping to stop users (Xiaojun et al. 2015). Therefore, by effectively addressing agricultural troubles early on and maximizing manufacturing performance, it's feasible to minimize harm and increase farmers' incomes.

Internet of Things Applications in Agriculture

It is now less difficult to deduce various kinds of facts because of current traits in Wi-Fi sensor networks (Glaroudis et al. 2020). These tendencies have allowed the IoT to resolve a variety of agricultural troubles and facilitate effective and sustainable farming (Antony et al. 2020). IoT programs in agriculture span a huge style of obligations and, as Fig. Four (Aqeel-urRehman et al. 2014; Talavera et al. 2017) illustrates, may be roughly classified into four categories: (a) management systems, (b) tracking structures, (c) manipulating structures, and (d) unmanned equipment.

System of Management

Farmers have not had the resources to control their crops using a price-benefit analysis till lately. It is now simpler to acquire and keep information for agriculture, thanks to advancements in sensor and conversation technologies. As a result, it's essential to manage and employ the numerous forms of information that might be accumulated (Diène et al. 2020). The following is an example of the way control machines are utilized in agriculture to cope with several factors, which include farms, energy, water, and agricultural gadgets.

Farm Equipment

Global agricultural equipment producer AGCO has unveiled a connected farm provider" solution that includes server and cell utility development in conjunction with far-flung monitoring of large-scale agricultural machines. IoT generation is used in conventional agricultural production to offer real-time information on system management, control necessities, and mechanical operations. By remotely tracking discipline situations and agricultural gadget working situations, the machine seeks to grow agricultural manufacturing to be able to ultimately result in elevated output.

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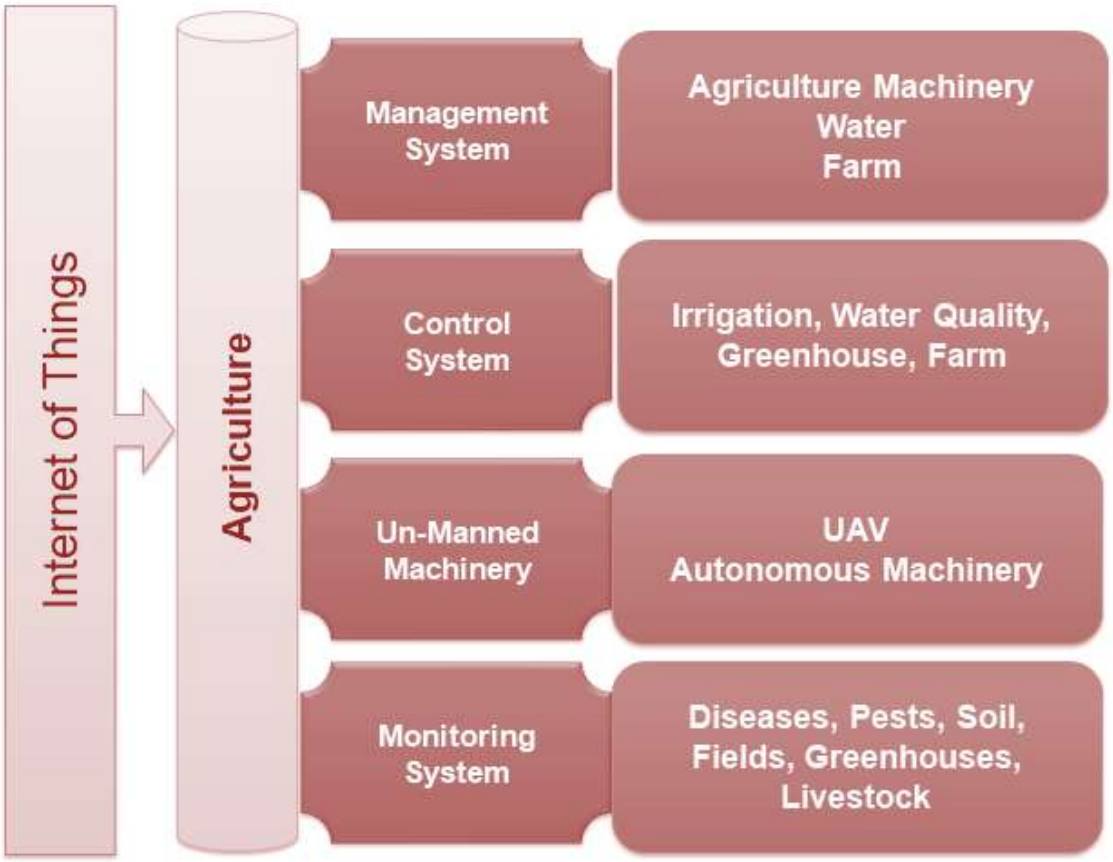
Fig 4: IoT use in agriculture, including unmanned machinery, control, monitoring, and management systems



Farm

By coping with facts from sensors on farms, farm IoT-based total farm management facts structures (FMISs) are being suggested to assist farmers in making knowledgeable picks. These structures provide monetary analysis findings together with machine, seed, fertilizer, and pesticide statistics. Large manufacturing farms are also considering the use of precision agriculture management structures (PAMS), which consist of capabilities such as statistics accumulation, retrieval, evaluation, and far-flung operation.

Water

The multiintelligent management gadget (MICS) was developed for the control of water resources within the agriculture sector because of the short-term growth in water shortages

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(Hadipour et al. 2020). The counseled gadget, which's based totally on the Internet of Things, has been utilized to monitor and alter reservoir water levels and water use so that it will manage all to-be-had water assets. According to reviews, the era might also keep as much as 60% of the water, and it has given the agricultural enterprise a satisfying choice for handling water.

System of Monitoring

Previous monitoring research in agriculture was divided into categories inclusive of soil, animals, greenhouses, illnesses, fields, and pests.

Illness

Using environmental sensor records, an Internet of Things (IoT)-based cognitive monitoring gadget has been created for early plant sickness forecasting. Its motive is to stumble on epidemic breakout circumstances and maintain the highest quality of crop manufacturing. To send out caution alerts, the gadget makes use of prediction algorithms and artificial intelligence. In order to pick out crop ailments in the wild, Zhao et al. (2020) advanced an automatic technique that used a multi-context fusion network (MCFN) and achieved an excellent analysis accuracy of 97.5%. IoT is utilized by each system to achieve real-time crop identification.

Through the use of less expensive sensors and networks, subject monitoring in agriculture can manage crop development situations and increase crop quality and production. It has been advised to apply an intelligent agricultural subject tracking device to measure temperature and humidity inside the soil while also storing facts in the cloud for later examination. It has been shown that this technique when paired with agricultural automation, permits labour value reductions and the powerful utilization of water assets. The tracking module and expertise management (KM) base are crucial elements of this strategy.

Greenhouse

The research emphasizes how important it is to keep an eye fixed on greenhouse environmental elements like humidity and temperature that allow you to maximize crop output. Traditional techniques for tracking Phalaenopsis development and greenhouse conditions are hard work-extensive, time-consuming, low-decision, and non-automatic. An IoT-primarily based system became recommended as an approach to those troubles so that you can tune these variables in addition to the growing situation of Phalaenopsis in an orchid greenhouse. The device permits the real-time evaluation of environmental parameters and leaf improvement in an orchid greenhouse.

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Livestock

Agriculture uses cattle tracking gadgets to accumulate records on animals like chickens and cows. A text messaging machine referred to as Moocall lowers calf death charges by way of more than 95%. Systems for precision cattle farming (PLF) increase growth efficiency, lower the need for human observations, and automate procedures. Farmers may additionally more efficiently handle many animals when they use real-time tracking. A smart chicken management system built on the Internet of Things maximizes the production environment. These methods would possibly improve the efficacy and performance of cattle management in agricultural settings.

Pest

It was recommended (Liao et al. 2012) to force a self-reliant early caution machine to stop the unfolding of pests like the large Oriental fruit fly (Bactrocera dorsalis (Hendel)). The overuse of chemical pesticides with the aid of farmers changed into reduced with the assistance of this technology. It additionally blanketed three critical components: a number control platform (HCP), a remote-sensing statistics gateway (RSIG), and wi-fi monitoring nodes (WMN). It also included wi-fi communication protocols: GSM and ZigBee. In order to protect farms and future food safety, the suggested studies supplied an actual time caution machine to alert system directors and the government while essential occurrences occurred with the use of the GSM platform.

Soil

Crop development is substantially motivated by the soil environment, and agricultural productivity may be extended and farming practices optimized by retaining an eye fixed on it. To monitor soil, an Internet of Things (IoT) smart soil tracking gadget was created, using sensors for temperature, humidity, and pH. Users can also use cell apps to get entry to these facts, which facilitate pesticide spraying and irrigation machine alternatives. Restoring vitamins to the soil using fertilizers may additionally have an effect on crop first-rate and production. On the other hand, overuse of fertilizer may additionally result in farmers spending too much money. IoT-based total fertilizer systems were evolved to solve this hassle. They hire a manipulation system to spray fertilizer, monitor soil nutrients, and calculate the important quantity. These technologies assist farmers in slicing down on wasteful expenditures and making knowledgeable judgments about the yield of their crops.

Management Framework

IoT is used in agriculture to adjust resources along with irrigation, water quality, and the ecosystem of farms and greenhouses (Giri et al. 2016). Control systems were hired, particularly

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in agriculture, to make sure perfect boom situations existed so that farms could produce terrific plants. Table 3 lists the fields, sensors, controllers, and networks where Internet of Things (IoT)-primarily based agricultural manipulation structures have been used.

Agricultural

A manipulative device for agricultural manufacturing that makes use of the Internet of Things era has been created (Marković et al. 2015). The managed device on the farm was utilized to perform the actuators and acquire and track facts using independent sensor devices. According to Warpe and Pippal (2016), the most often lacking vitamins in agricultural soil are nitrogen, phosphorous, and potassium, or N, P, and K, in that order. Light-dependent resistors (LDRs) and light-emitting diodes (LEDs) were used to create Internet of Things (IoT)-primarily based structures through the use of NPK sensors (Lavanya et al. 2018).

Greenhouse

Crop growth and production are significantly impacted by the greenhouse climate. A control system was created by Liao et al. (2017) to hold an Internet of Things greenhouse at the right temperature and humidity. Park et al. (2019) created a Wi-Fi sensor node that uses Bluetooth to effectively engage with a controller inside a greenhouse. Up to 25 meters, there is a 100 percent information charge. To grow the communication range between the sensor node and controller, studies on long-distance Wi-Fi communication strategies like LoRa are important. Further research on remote wireless communication techniques, such as LoR, is needed to increase the communication range between the sensor nodes and the controller. Both studies highlight the importance of suitable greenhouse conditions for successful crop growth.

Irrigation

Precision agriculture efficiently makes use of water assets through the use of IoT-primarily-based irrigation structures. Research has proven that an impartial sprinkler machine can sustain moisture stages by regulating the spray in reaction to present-day data about the moisture content of the soil. This technology uses climate predictions to remotely manipulate the sprinklers, preventing overuse of water and plant loss of life. Chowdhury and Raghukiran came up with this innovative strategy in 2017.

Water Purity

Smart IoT solutions have been created to smooth municipal wastewater and reuse it for agriculture by controlling water quality depending on pH (Khatri et al. 2018). By keeping the water within the allowed limits, the suggested method allowed for the recycling and subsequent use of municipal wastewater for agricultural purposes.

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Unmanned: self-governing equipment

Using present-day sensor structures, self-reliant agricultural equipment has been developed since the 1980s. Global leaders in equipment like Case IH and John Deere are using GPS-primarily-based auto guidance to store labour costs and boost productivity. The benefits of computerized guidance include poor visibility and repeated course tracking. The improvement of absolutely self-reliant tractors has hastened with the creation of IoT and wireless connection technologies. John Deere has created integrated technologies such as AutoTrac Vision, AutoTrac RowSense, and Machine Sync to address obligations remotely, minimizing crop damage, optimizing crop harvesting efficiency, and providing complete coverage for fertilizer applications.

Unmanned Aerial Vehicles

Precision agriculture has revolutionized agriculture by using IoT-primarily-based unmanned aerial vehicles (UAVs) to replace antique methods. UAVs can be used for field-level phenotyping, plant boom tracking, pesticide software, irrigation, fertilization, weed control, and plant disease control. Pest and ailment outbreak evaluation and environmental tracking are packages of low-altitude faraway sensing generation. In addition to tracking plants, illnesses, and water shortages, thermal cameras might also identify risky animals and study the thermal characteristics of crops and plants. However, there are drawbacks, such as issues with strong materials, powerful verbal exchange, and climatic constraints. It is anticipated that resolving those problems will cause IoT-based total UAVs to be extra creative and effective in the future.

Agricultural Uses of Wireless Communication Technologies

With the software of the Internet of Things (IoT) in agriculture, the use of distinct verbal exchange technologies such as Wi-Fi, LoRaWAN, mobile verbal exchange, ZigBee, and Bluetooth has advanced dramatically in recent years. Agriculture may now be automatic at some point in its complete cycle, increasing its performance and comfort. Agricultural IoT makes considerable use of ZigBee and Bluetooth due to their reasonably priced value and energy intake. One popular quick-variety wi-fi communique protocol for the Internet of Things in agriculture is called ZigBee.

When selecting an appropriate verbal exchange generation for a certain type of agriculture, the transmission range of statistics is an important consideration; this is correlated with fees. Farmers need to choose an era primarily based on vital agricultural parameters and one with a suitable information transmission variety. The majority of wireless networks (WSN) used in agriculture have to be low-value, low-energy, and have gradual data speeds. The Internet of Things may be utilized in agriculture by means of evaluating and selecting wireless networks.

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Potential Benefits of IoT for Agriculture

The FAO estimates that 70% more food might be required in 2050 than in 2006, which is a major hassle for the arena's population to satisfy. This dilemma has prompted the improvement of IoT generation. IoT technology can control vineyards, lessen environmental problems, and improve meal safety. Libelium, for instance, decreased phytosanitary remedies and improved growth output in grapes in northwest Spain through the use of 3G. In greenhouses, an automatic watering device cut water intake by ninety%, even as an integrated manipulation technique lowered energy use by ninety%. IoT for agriculture is expected to have considerable worldwide marketplace growth by 2022, while its real worth is projected to attain $15 trillion USD.

Discussion

A lot of studies have been performed recently to apply IoT technology to agriculture. The majority of studies have targeted IoT-based, totally clever management and clever monitoring. Specifically, there has been an enormous emphasis on irrigation and fertilizer management, as well as environmental monitoring of the soil, farm, and greenhouse. Furthermore, a dependable structure for farmers to offer on-the-spot facts through WSN has been furnished via IoT and cloud computing-based structures (Mohanraj et al. 2016). Although IoT is presently being utilized in agriculture, there are nonetheless certain problems that need to be resolved. In the components that follow, we're going to talk about some of the future opportunities for agricultural IoT.

Conclusion:

The Internet of Things (IoT) is used in agriculture, and this study looks at how it is used in exclusive industries. Four categories of IoT-based total agriculture are recognized within the evaluation: unmanned equipment, management structures, monitoring systems, and control structures. In most cases, IoT is used for environmental condition management, irrigation system manipulation, soil, farm animals, and greenhouse monitoring. The use of verbal exchange technology in Internet of Things-based agriculture is tested, which includes Wi-Fi, LoRaWAN, Bluetooth, ZigBee, and mobile conversation. By deciding on sensors and networks in line with parameters such as gearbox variety, strength consumption, and cost, farmers might also get outstanding performance and reasonably-priced fees. IoT gadgets want to be secure in an inclement climate and feature reliable community and statistical safety.

By lowering labour expenses and input requirements, IoT is predicted to enhance the best and most productivity in agriculture while also addressing contemporary issues and boosting agricultural profitability. However, there may be a need for an answer that includes IoT in each issue of agricultural management. Collisions between neighborhood networks and other networks have to be avoided. The improvement and commercialization of self-reliant agricultural

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gadgets require the integration of IoT generation since the contemporary software of IoT in this era is insufficient. To make agricultural technology more commercially feasible, more accurate GPS and Internet of Things-primarily-based management structures are also required.

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