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SMART AGRICULTURE USING INTERNET OF THINGS

Ms.K.S. Shanthini[1](Assistant Professor), Ms. R. Suganya[2] (Assistant Professor),
Ms. R. Seyamala[3] (MCA) , Ms.V.Nithya [4](MCA)
Department of MCA,
KIT – KalaignarKarunanidhi Institute of Technology,Coimbatore-641402.
Shanthini.kitcbe@gmail.com ,suganya.kitcbe@gmail.com, kit.24.22mmc051@gmail.com, kit.24.22mmc034@gmail.com

ABSTRACT: The advent of the Internet of Things (IoT) has brought about transformative changes to agriculture-related products. It has not only improved agricultural management but also resulted in a significant improvement in agricultural output quality, reduction in labor costs, increased producer income, and facilitated agricultural modernization and intelligence. The research paper offers a comprehensive overview of agricultural IoT research, covering its current state, system architecture, and five core technologies. Additionally, the paper examines the operation of agricultural IoT in five representative regionsto highlight its practical application. The paper also discusses the challenges agricultural IoT faces, includingdata security, interoperability, and the adoption of standardized protocols, and presents a vision for its future growth potential, including increased adoption, greater integration with other technologies, and emerging applications and use cases.

KEYWORDS: Robotic in Agriculture, Drones in Agriculture Remote, Remote Sensing In Agriculture,Computer Imagine In Agriculture

1. INTRODUCTION:

The Agrarian Internet of Things (IoT) is a system that connects physical entities such as animals, crops, equipment, and other virtual objects in the agricultural environment to the internet through agricultural data sensing devices using specific protocols for data exchange and communication [3]. Itaims to enable the precise identification, positioning, tracking, monitoring, and management of agricultural objects and processes.The human-machine interface of agricultural IoT can help people monitor and control diverse agricultural entities, processes, and systems in a more sophisticated and efficient manner. It can also enhance our understanding of the essential aspects of the lives of agricultural animals and crops, facilitate the management of complex agricultural systems, and help in addressingagricultural challenges [2]. Currently, agricultural IoTresearch is extensive and intense globally, with most operations in the experimental stage. This research paper provides a comprehensive summaryof agricultural IoT research, covering its current status, system architecture, and the five critical technologies of agricultural IoT. It also presents the application of agricultural IoT in five representative regions. Finally, the challenges of agricultural IoT are analyzed, and the future development potential of agricultural IoT isdiscussed [5].

2. ROBOTIC IN AGRICULTURE:

Automation has advanced significantly since the Industrial Revolution of the 1800s, enabling the handling of complex tasks and increasing production efficiency [1]. Agriculture robots, also known as "agrons", are attracting the attention of farmers worldwide due to a global labor shortage and increasing demand. In the United States alone,crop production decreased by an estimated $3.1 billion per year due to a shortage of labor. Thanks to recent developments in sensor and AI technology that allow machines to learn from theirsurroundings, agrons have become more popular. Although the

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majority of these products are still inthe early stages of testing and research and development, we are in the early stages of an ag- robotics revolution that will fully utilize the Internet of Things in agriculture [6]. Automation has advanced significantly since the Industrial Revolution of the 1800s, enabling the handling of complex tasks and increasing production efficiency.

2.1. WEEDING ROBOTS:

Intelligent agricultural robots use digital imageprocessing to scan images of weeds stored in theirdatabase to identify similarities with crops, and then use their robotic arms to pull them out or spraythem directly [9]. This approach is beneficial for boththe environment and farmers, as it addresses the issue of growing pesticide resistance among plants. Previously, farmers applied pesticides generously throughout their farms, resulting in a cost of approximately 1,725 crores ($25B) per year, or around 13,000 kilograms (3 billion pounds). However, with the use of these robots, this cost canbe significantly reduced [10].

2.2. MACHINE NAVIGATION:

Large farming equipment like tractors and plowingmachines can now be operated autonomously through GPS, similar to remote-control toy cars. The high precision of these automated machines and their ability to adjust to changes in the terrain make difficult tasks easier [11]. With the use of smartphones, tracking their location and productivity has become effortless. Thanks to advancements in Agriculture IOT and machine learning, these technology-driven vehicles are enabling advanced farming with features like automatic obstacle detection [12].

2.3. HARVESTING ROBOTICS:

To tackle the labor shortage issue, farmers are nowturning to agrions for crop selection. These advanced machines can operate 24/7 and handlethe delicate task of picking fruits and vegetables. Using automated arms and image processing, the agrions select the produce and control the quality. Due to the high operational costs, orchard fruits such as apples are among the crops that are prioritized for agrion harvesting [10]. Moreover, these robots can be used for high-value crop harvesting in greenhouses, such as strawberries and tomatoes.They can accurately assess the growth stage of crops in nurseries and harvest them when necessary [5].

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2.4. MATERIAL HANDLING:

The feared manual work errands can be carried outby robots working nearby people. They can lift overwhelming objects and space plants absolutely,which makes strides the quality of the space and plant and brings down generation costs. Secure thebroader issue overhauled of enormous realities in innovative improvement that nearly each individual can be a up to date [2].

3. DRONES IN AGRICULTEURE:

Drones are widely used to enhance and optimize various farming activities such as crop monitoring, spraying, soil analysis, and mapping. Agriculture is one of the key industries that utilize drones. Drones equipped with sensors and cameras are used for farm imaging, mapping, and surveying. Both ground-based and aerial drones are available for this purpose [12]. Ground drones are portable robots that survey areas while aerial drones, also known as unmanned aerial vehicles or unmanned aircraft systems, are flying robots [8]. Drones have the capability to operate either under remote control or autonomously through software-controlled flight plans, which are seamlessly integrated with sensors and GPS within their embedded systems. Insights about crop health, irrigation and spraying, planting, soil and field, and plant health can be inferred from drone data [14]. Agriculture is one of the key industries that utilize drones. Drones equipped with sensors and cameras are used for farm imaging, mapping, and surveying. Ground drones are portable robots that survey areas while aerial drones, also known as unmanned aerial vehicles or unmanned aircraft systems, are flying robots [8].

4. REMOTE SENSING IN AGRICULTURE:

Remote sensing using IoT technology involves thedeployment of sensors next to farms, such as weather stations, to collect data that is transmittedto analytical tools for analysis [15]. This approach is transforming how data is collected from different areas of a farm. Sensors are capable of detecting anomalies and transmitting this information to an analytical dashboard.

4.1. CROP MONITORING:

Throughout the farms, sensors are strategically positioned to identify variations in light, humidity, temperature, as well as changes in the shape and size of the crops. These sensors detect any anomalyand notify the farmer. Therefore, remote sensing can monitor crop growth and help prevent thespread of disease.

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4.2. WEATHER CONDITIONS:

Sensors installed in farms collect data on humidity,temperature, precipitation, and dew detection, which is used to determine the weather conditionsand identify the crops suitable for cultivation [2].

4.3. SOIL QUALITY:

Soil health analysis is crucial for determining the amount of water need for irrigation and choosing the most suitable crop type for maximum profitability. It helps identify the nutrient value and dry areas of farms, soil drainage capacity, and acidity. Knowing when and how to increase organic matter can improve soil structure, make regenerative farming more effective, and ultimately pave the way for climate-smart agriculture.

4.4. CLIMATE CONDITION:

Agriculture heavily relies on favorable weatherconditions. Without accurate knowledge of the climate, crop production could suffer in terms of quality and quantity. However, IoT solutions offerreal-time weather updates to farmers. Sensors are strategically placed both inside and outside the agricultural fields to collect data from the environment. This information helps farmers in selecting crops that can thrive in specific climatic conditions. The entire IoT ecosystem is composedof sensors that accurately detect various weather parameters such as humidity, precipitation, temperature, and more. With a variety of sensors available, they can be configured to meet the specific needs of smart farming. These sensorscontinuously monitor plant conditions and weatherchanges. In the event of disruptive weather conditions, alerts are sent, eliminating the need forphysical presence during such times. This increasesproductivity and helps farmers to reap more agricultural benefits [16].

4.5. SMART GREENHOUSE:

Internet of Things (IoT) technology has been used to make our greenhouses smart by allowing automated adjustment of climate conditions based on specificparameters. This implementation of IoT in nurseries has eliminated the need for manual intervention, making the entire process cost-effective while increasing efficiency. For instance,the use of solar-powered IoT sensors enables modern and affordable greenhouses. These sensorscollect and transmit real-time data, enabling the monitoring of the nursery condition in real-time. The sensors also provide alerts via email or SMS on water usage and nursery conditions. Smart and automated irrigation is facilitated by these sensors,which provide information on pressure, humidity, temperature, and light conditions [10].

4.6. DATA ANALYTICS:

The conventional database system is inadequate to handle the vast amount of data collected from IoT sensors. Cloud-based data storage and end-to-end IoT platforms are essential for smart agriculture systems to function effectively. These systems enable high-performance activities to be carried out. Sensors are the primary means of collecting data on a large scale in the IoT world [14]. The collected data is analyzed and transformed into meaningful information using analytical tools. This data analytics helps in the examination of weather, animal conditions, and crop conditions [11]. The data collected is leveraged with technological advancements, leading to better decision-making. With the help of IoT devices, farmers can monitor the real-time status of crops by capturing data from sensors. Using predictive analytics, they can make informed decisions related to harvesting. The analysis helps farmers to understand the upcoming weather and crop yield. By implementing IoT in the Agriculture Industry, farmers have been able to preserve crop quality and soil fertility, leading to improved stock volume and quality [15].

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4.7. PRECISION FARMING:

Precision Agriculture, also known as Precision Farming, is a popular application of IoT in the agriculture industry. It makes farming practices more precise and controlled by using smart farming applications like livestock monitoring, vehicle tracking, field observation, and inventory monitoring. The main goal of precision agriculture is to use the data generated by sensors to take appropriate actions [3]. Precision Farming enables farmers to collect data with the help of sensors and analyze it to make intelligent and quick decisions. An array of precision farming techniques, such as irrigation management, livestock monitoring, vehicle tracking, and others, significantly contribute to enhancing efficiency and effectiveness in agricultural practices. With the help of Precision Farming, farmers can analyze soil conditions and other related parameters to maximize operational efficiency. Additionally, farmers can also monitor the real-time working conditions of associated devices to identify water and nutrient levels [1]

5. COMPUTER IMAGINE INAGRICLUTURE:

Strategically placed sensor cameras or drones equipped with cameras are utilized in computer imaging to capture images that are then digitally processed. The main idea behind digital image processing is to use computer algorithms to manipulate an input image. Image processing analyzes limiting factors and assists in better farm management by viewing images in various spectral powers, such as infrared, comparing images obtained over time, and identifying irregularities [12].

6. SMART AGRICULTURE USING WIRELESS SENSOR TECHNOLOGIES:

6.1. TEMPERATURE SENSOR:

Maintaining the optimal temperature is crucial for crop growth in both indoor and outdoor smartfarms. For example, wheat is sensitive to temperature changes. Even if it's just for a short period, high temperatures can affect shoot growth and, consequently, root growth. Moreover, high soil temperature is even more critical since it can cause severe root damage, resulting in a significantreduction in shoot growth [5].

6.2. HUMIDITY SENSORS:

Monitoring humidity is essential for crop growth toevaluate water loss due to evaporation, which is critical for the photosynthesis process. Other issuesassociated with humid conditions include the growth of mold and bacteria, which can cause plants to die and crops to fail, as well as conditionssuch as root or crown rot. Pests like fungus gnats, whose larvae feed on plant roots and thrive in moistsoil, also thrive in humid conditions [3].

6.3. SOIL SENSOR:

Various types of soil moisture sensors are utilized in SAS to analyze parameters such as pH andconductivity. Soil conductivity maps help to predict crop yield as they indirectly reflect soil organic matter and soil texture. These two parameters are indicators of available water content and the presence of potential weeds. Therefore, soil electrical conductivity measurement is also used for the measurement of quantities of soil-applied herbicides. Similarly, soil pH is crucial to have healthy crops as strongly acidic soils with a pH in the range of 4.0-5.0 can have high concentrations of soluble aluminum, iron, and manganese, which can be toxic to the growth of some plants. A pH range of around 6 to 7 identifies the ideal level of plant nutrients [14].

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6.4. FLUID LEVEL SENSOR:

Level sensors are commonly used in SAS to detectthe concentration of substances, such as fluids, powders, and granular materials. These sensors areparticularly important when hydroponics is used for smart irrigation, as they allow for the monitoring of nutrient solution levels [3].

7. CONCLUSION:

Any device that can be connected to the internet isconsidered an IOT device, including wearable IOTproducts like smartwatches and smart homeproducts like Google Home, making IOT devices widely available in consumer markets. By 2020, itwas projected that over 30 billion devices would be connected to the Internet of Things. To meet increasing demand and reduce production losses, IoT applications in agriculture focus on traditionalfarming operations. Robots, drones, remote sensors, computer imaging, and constantlyevolving machine learning and analytical tools areused in IoT in agriculture to monitor crops, study and map fields, and provide farmers with information they can use to make time- and cost- saving farm management decisions.

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