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Internet of Things (IoT) Enabled Cloud Computing Drone for Smart Agriculture: Superior Growth and Life

Parkavi G[1]*, Daphine Desona Clemency C A[2], Rehash Rushmi Pavitra A[3], P. Uma Maheswari[4], I. Daniel Lawrence[5]

[1]Assistant Professor, Department of Computer Science, Mannar Thirumalai Naicker College, Madurai, India.

[2]Assistant Professor, Department of Computer Science and Engineering, Sathyabama Institute of Science and Technology, Chennai, India.

[3]Associate Professor, Department of Artificial Intelligence and Data Science, Sri Sairam Engineering College, Chennai, India.

[4]Assistant Professor, Department of Computer Science and Engineering, Anna University Regional Campus, Madurai, India.

[5]Associate Professor, Department of Mechanical Engineering, Agni College of Technology, Chennai, India

***Corresponding author:** Parkavi G, Assistant Professor, Department of Computer Science, Mannar Thirumalai Naicker College, Madurai, India.

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ABSTRACT

In recent days, smart farming will reach every corner of the globe to expand the quality and quantity of production. Subsequently, the standard deployment of unmanned aerial vehicles (UAV) for smart farming is enormous and move towards fourth industrial revolution. In addition, drones outfitted with proper cameras, sensors and integrating elements that aid to attain transparent, efficient and precision agriculture. The agriculture sector is using the Internet of Things (IoT) and cloud computing more frequently, which has boosted crop output through cost control, performance monitoring, and maintenance. Because of the efficient use of resources and increased crop yield, this has immensely helped farmers. In order to further sustainable smart agriculture, the proposed research aims to create a smart drone for crop management that makes use of real-time data along with IoT and cloud computing technologies. Integrating these drone solutions with other cloud and IoT technologies can improve their potential for future development. The importance of IoT in agriculture and the real-world uses that can be made are also emphasized in this piece.

Keywords: *Cloud computing, Internet of Things (IoT), Smart Agriculture, Unmanned Aerial Vehicle, Drone Data*

INTRODUCTION

Over the globe, the agriculture sector is confronted with formidable obstacles. According to the Food and Agriculture Organization of the United Nations, in order to fulfil the rising demand brought on by economic development and population expansion, food production must rise by 70% over the next 40 years. Feeding a growing population—which is anticipated to increase from seven billion people today to nine billion by 2050—is the primary challenge facing the world's agriculture industry. The population of India is expected to increase from 1.34 billion to 1.51 billion and 1.66 billion by the year 2050. This study suggests using a smart drone for remote agricultural field inspection and crop screening combined with IoT and cloud computing technologies to solve this problem. Drone data offers rapid, dependable, and affordable services to farmers, including information on plant health, counting, height measurement, field mapping, water drainage, and forecasting, among other things. IoT technologies are becoming more and more common, and they may be implemented into agricultural drones to accelerate the development of the agriculture business. Farmers may utilize drones to collect precise, real-time data since they are more user-friendly, effective, and can be controlled. More effective crop management may be achieved by localization, mapping, and analysis of the high-resolution photographs the drone obtained.

Smart farming and precision agriculture have aroused even greater attention in recent years. Modern information and communication technology opens up new possibilities for active surveillance of agriculture, livestock, and water infrastructure, with the ultimate objective of lowering the number of living creatures [Khan et al, 2021]. Information from edge devices is processed and stored using edge and fog computing, which are additions to the cloud computing architecture. Using fog computing technologies, smart cities may achieve sustainability [Datta et al, 2018]. The use of Wireless Sensor Networks (WSN) may significantly extend the life of a smart city network. It is crucial to regularly monitor and archive the information these sensors are gathering. This information is often acquired, preserved, and examined in a cloud setting. Effective processing is required because sensors gather so much data. Big data analytics is highly adapted for processing data in real-time and can handle the requirements of sensor data. By creating effective data sharing protocols, the amount of electricity needed to process such massive volumes of data may be reduced. [Lee et al, 2017., Bestak et al, 2019., Duraipandian et al, 2019]. The use of drones is to improve crop quality in agricultural fields. By identifying the gaps in advance, this might assist the farmers in increasing productivity. The crops might be controlled by using particular drone-mounted cameras to spot water shortages and dangerous pests.

Normally, Food will always be in high demand on a global scale. With the growth in human population, there is a scarcity of food worldwide since technology is not integrated and used effectively. Simply said, agriculture is the study of improving and cultivating the land, increasing yields and raising animals, and then selling the ensuing products [Devi et al, 2019]. Bauer has presented a system that primarily consists of a wireless sensor network-based monitoring system for precision crop development and focuses on leaf area index continually. The monitoring system communicates with the main server over the Public Land Mobile Network and an Internet of Things (IoT) architecture based on Message Queuing Telemetry Transport. The system is somewhat less rich due to the absence of any environmental sensors [Bauer et al, 2018]. Agriculture would be monitored and managed using robust end-nodes and computationally taxing sensors like image sensors. The photos that are taken are processed either on-board or at the network's edge, or they are just used to monitor the cropping. The system will assist in producing greater agricultural yields if soil sensors are employed in addition to these sensors [Katsoulas et al, 2016]. Integrating advanced computers and sensors into physical items is central to the Internet of Things (IoT) idea. This makes it possible to amass helpful data that can be examined, organized, and used to get better results. IoT increases the adaptability of the Internet by integrating everything into a system of interaction via embedded technology, creating a widely dispersed network of objects that can communicate with one another and with humans [Abraham et al, 2018]. The application of aerial drones includes soil testing, irrigation inspection, crop health analysis, and animal monitoring. Real-time data may be gathered and analyzed using drones. Large agricultural regions are imaged, mapped, and surveyed at regular periods to improve oversight. Aerial drones take thermal, multispectral, and visual pictures during the whole flight [Xia et al, 2012]. Drones used in agriculture are a really good example of IoT services in this sector. At the present, one of the main sectors where drones may be used is the agricultural industry. Drones are used in agriculture; both aerially and on the ground, for a variety of tasks include plant health evaluation, irrigation management, planting, and field and ground condition monitoring [Malavade et al, 2016]. Drones may be used in agriculture in a variety of ways, from a single, strong solitary drone to a swarm of weaker, more numerous drones. Field surveys, crop monitoring, and other agricultural uses are all possible with these drones. Nevertheless, it has been shown that using many smaller UAVs rather than a single big one is more effective in terms of scalability, durability, speed, cost, and bandwidth needs [Gupta et al. 2015]. To cooperate with a UAV, a low-cost XBEE-based WSN is created. Since that XBEE nodes' communication range is constrained, the UAV is seen as a mobile intermediate node and is utilized to access the data kept in ground nodes [Polo et al, 2015]. However, the convergence of UAV technology research and applications are still lacking.

Internet of Things (IoT) and Cloud Computing

The "Internet of Things" (IoT) is a system that uses numerous sensors to link the whole world to the Internet. Using the already-built network infrastructure, this makes it possible to remotely sense or operate items, opening up possibilities for the direct integration of the real world with computer-based systems. This lessens the need for human interaction while increasing efficiency, accuracy, and financial benefit [Mattern et al, 2010]. IoT now refers to a wide variety of objects that may all be read, identified, addressed, found, and/or controlled online, including furniture, clothes, automobiles, roadways, and smart materials. It combines ubiquitous communications, ambient intelligence, and pervasive technologies. Today's term in the information technology industry, "cloud computing," refers to a computer paradigm that gives huge groups of privately, publically, or hybrid networked devices on-demand access to either application data or storage space. It represents a novel approach to adding, using, and exchanging internet-based IT services that include supplying flexible, extendable, and virtualized resources [Pingli et al, 2011]. The essential principle behind the innovative concept of cloud computing is the reusability of IT skills, a key aspect for cost efficiency.

Smart drones with IoT and cloud computing technologies may work together to remotely monitor and inspect agricultural fields and crops. Drone data may provide crucial agricultural insights such as field water management, plant height measurement, plant count, field forecasts, and plant health indicators. This enables quick, dependable, and affordable services for farmers.

METHODOLOGY

The purpose of this research is to use cloud computing and IoT-powered smart drones to provide farmers with intelligent agricultural management. Smart drones are unmanned aerial vehicles (UAVs) with sensors that transfer data to a network infrastructure, where they may connect to the Internet and interact with other devices, enabling them to make choices.

Architecture of Smart system

A multi-rotor aerial vehicle with sensors that can go at high speeds, have a long flight time, and cover a lot of ground would be a smart drone. It will be equipped with embedded software for GPS (Global Positioning System)-based flight planning and control. The aerial sensor equipped drone and Ground based sensors are connected through IoT and cloud. The Architecture of Smart system for modern agriculture is represented in Figure 1.

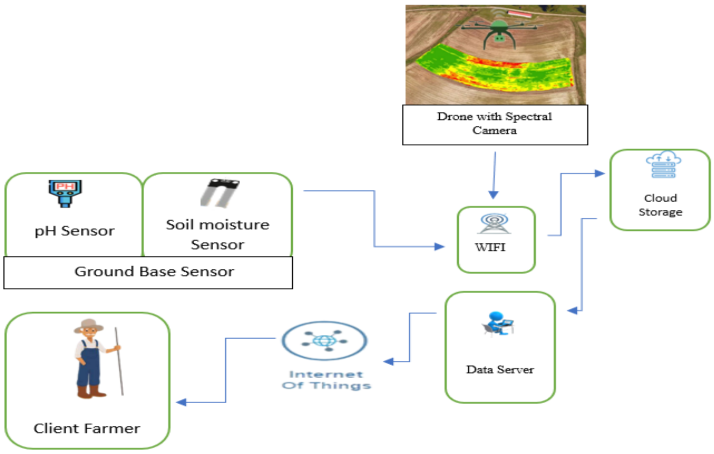

FIGURE 1: The Architecture of Smart system for modern agriculture

pH sensor

The pH and dielectric soil sensors collaborate to assess the soil's pH and moisture content. A website and a mobile application both show this data, which is saved in the cloud. The quantity and quality of the soil have a crucial role in crop health. Hence, pH monitoring is a crucial component. Typically, a pH of 5.5 to 7 is ideal for plants. Certain plants may need more acidic or alkaline soil, depending on their needs. Ph control maximizes the effectiveness of fertilizers by regulating the soil's nutrients' bioavailability. Toxin content, soil composition, and microbial activity are just a few of the numerous variables that are impacted by soil pH. The pH sensor employs a voltage test that needs an electrical current in order to determine the pH level and hydrogen content.

Dielectric soil moisture sensor

The quantity of water present in the soil is measured or estimated using soil moisture sensors. Both permanent and movable sensors, such as portable probes, are possible for these systems. Although permanent sensors are normally placed at predetermined depths and places in the field, portable probes may monitor soil moisture at a variety of sites. Dielectric soil moisture sensors monitor the dielectric constant of the soil, which is greatly influenced by the amount of moisture in the soil. The constant for a dry soil is between one and five, where one is for air and eighty is for water.

The Hyperspectral sensor

The Hyperspectral sensor is used to safeguard crops from environmental threats like pests, diseases, etc. Moreover, the photos taken reveal the crops' present state. An RGB-D sensor is a special kind of depth sensor that works in conjunction with an RGB camera. Infrared sensor depth information is used with a calibrated Hyperspectral camera to create an picture that has a depth value assigned to each pixel. For instance, if a piece of the field's crops develop yellow coloration as a result of a disease and are reflected in the Hyperspectral camera images, the farmer may cure that area before the whole field becomes afflicted. This in turn aids in maintaining efficient and effective crop management.

ARMv7 Controller

ARMv7 is a 32-bit CPU architecture. It is also a load/store architecture, which means that data-processing instructions only work with values in general purpose registers. Only load and store instructions have access to memory. Wi-Fi and Bluetooth capabilities are available in ARMv7. Via this module, the acquired parameters' transformed digital counterparts may be uploaded to any cloud storage system through the internet. A secure wireless connection is used to link the sensors to the ARMv7. In addition to these advantages, this model was selected because it can move seamlessly between mobile apps and large websites without lagging. Web surfing also enables us to browse websites that were specifically designed for this system. The pH Sensor, Dielectric soil moisture sensor, ARMv7 Controller, Hyperspectral sensor equipped drone and Agricultural Field are displayed in Figure 2.

FIGURE 2: The pH Sensor, Dielectric soil moisture sensor, ARMv7 Controller, Hyperspectral sensor equipped drone and Agricultural Field

Micro Drone

A farmer may observe his land from the air using an agricultural drone. The benefit of a bird's eye perspective is that it highlights a wide range of issues, including soil differences, irrigation challenges, insect management, etc. An unmanned aerial vehicle (UAV) used in agriculture allows farmers to monitor crop growth, enhance soil productivity, and increase agricultural yields. The sensors and cameras on these unmanned aerial vehicles allow farmers to observe their crops more clearly (UAVs). By distinguishing between healthy and ill crops, high-resolution photos captured, localized, mapped, and analyzed provide farmers with a thorough perspective.

RESULTS AND DISCUSSION

Implementing field monitoring in paddy fields requires three key elements: the cloud, a web or mobile application, and monitoring nodes. To monitor the soil in the field, a number of sensors or monitoring nodes are set up, including pH sensors and dielectric soil moisture sensors. For monitoring reasons, the pH sensor is coupled to an analog-to-digital converter (ADC), which is then connected to an ARMv7. The glass electrode draws hydrogen ions, and when this is done in comparison to the reference electrode, a little voltage is produced. Sending a signal to the indicator causes the voltage difference between the two electrodes to be converted into a pH measurement. In order to keep a running track of the soil moisture content, dielectric soil moisture sensors are utilized and coupled to data loggers. A substance known as the dielectric, which is impermeable to the flow of an electric current, separates two electrodes. The less often that happens when the soil moisture content is higher. After that, the volumetric soil moisture content is estimated using this frequency.

The soil's pH and moisture content are continuously measured by the array of sensors, and the website is updated with the results. A surveillance system that uses a drone or UAV with an RGB-D sensor to examine the health of the crops so that in the event of insect infestations. A battery is a feature of the UAV, and it gives it the power it needs to go through the needed spaces and fly. Using the on-board, locally stored map of the field, the UAV's movement is modeled. Using the threshold values established for each sensor, the received data is checked. The varied data produced are kept in the cloud and will be utilized for further research to improve farming practices. To help farmers stay informed, these statistics are updated on the internet. The farmer's phone has a phone app loaded that keeps track of all these data.

In terms of precision farming, this technology performs better than the ones that are already in place. UAVs play a very important function in monitoring the crops and determining their health, which results in labour savings of around 70–80%. Farmers may make better choices about harvesting in the future by using predictive analysis of the data collected by the sensors. Since the system's sensors are widely accessible, it can be constructed anywhere in the globe. Many different forms of soil modeling used in agriculture may benefit from the precise measurements provided by the selected sensors.

Data Sensing

The drones are equipped with synchronized sensors for data collecting, including spectral cameras and flying and navigation sensors. The drone's status and flight parameters control the flight and navigation sensors, such as the gyroscope, sensors, GPS, and obstacle and terrain sensors. The sensors also assist with navigation and keep an eye on the drone's immediate and extended environment to help it spot and avoid unexpected obstacles.

The smart Drone is used to Identifying pests, weeds, and infections aids in maximizing the use of pesticides and crop sprays and also Provide plant counts in order to estimate agricultural production. Images of agricultural vegetation, pest and disease detection are captured using spectral cameras. Nutrient shortages and soil moisture are found using ground-based sensors like pH and dielectric soil moisture sensors.

Data Communication

Information flow depends on communication, which must be strong to environmental uncertainties and fast to adapt to changes in network architecture. A drone antenna with a 4G modem that is integrated with IoT wireless technologies like Wi-Fi and Zig Bee that are tested for aerial networks is used to communicate wirelessly so that a person may operate a drone from a distance and receive data that the drone has collected. The information gathered may be transferred in real time to the cloud and seen online since the suggested drone is equipped with WiFi. The data analysis and evaluation process use the data that has been gathered from the monitoring nodes and saved in the cloud-based application. With this information, farmers are then given the best techniques and plans of action for certain circumstances.

Data Process

Aerial pictures are taken when the intelligent drone takes off and flies over the designated route. Data is collected using sensors buried in the ground, such pH and soil moisture meter. Data from ground-based sensors and drones is gathered and transmitted to the cloud system. We modify the appropriate algorithm to identify any suspicion based on the observed data. Data is pulled from the cloud system in accordance with the need and the issue at hand, and then it is analyzed and reviewed by the researchers who are interested in finding a solution to assist farmers practice on fields.

The suggested Smart Drone uses sensors and cameras to collect crucial agricultural field characteristics using IoT and cloud computing technologies. It helps develop a sustainable smart farming practice by anticipating calamities, forecasting field conditions, and suggesting optimal practices to be used on the farm by giving photographs and live streaming.

CONCLUSION

Since its introduction in 1980, unmanned aerial vehicles (UAVs) have been used for a variety of purposes, which are now quickly developing. The use of drones in agriculture is a practical way to meet the demand for increased food production and population due to their increased accuracy, efficiency, and capacity to overcome challenges that traditional machinery cannot. Accurate measurements, real-time data collection, and effective crop management will greatly advance this segment. The objective of this research is, The pH of the soil and the amount of moisture in the soil that the crops need are observed.

Using a Hyperspectral camera, the Drones will assist with crop monitoring by taking Aerial pictures.

To enhance the functioning of Smart Drones, a number of functions might be incorporated. Other improvements include expanding the drone's functionality by adding a pluggable scheduler and an intelligent analyzer that requires less human interaction when a strange crop discovery is made.

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