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Review of IoT Framework Design and Development for Agriculture Applications using Quantum Technology

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A new era of agricultural productivity has begun thanks to the Internet of Things (IoT) in agriculture. It does more than just raise crop yields; it has the potential to improve crop quality, cut labor costs, boost farmers' incomes, and bring about a genuine agricultural rejuvenation and understanding. For the benefit of farmers, this study discusses traditional methods while also introducing new techniques developed via research to improve and expand crops. We have launched a trustworthy, scalable, adaptable, and inexpensive Internet of Things (IoT) platform designed specifically for smallholder farmers to fill this need. Their ability to see, track, and manage data collected in real-time from their crops, cattle, and other agricultural assets is enhanced by this goal. In order to construct an IoT-based smart farm, these features made use of a wide range of technologies and methods. The next step is to compare all of the works and choose the one that will help smart farming the most.

Keywords: Smart Irrigation System, IoT (Internet of Things), Smart Agriculture.

1. Introduction

"Internet of Things" (IoT) is a portmanteau of the technical words "Internet" and "Things," and it accounts for the vast majority of use. One implication of the "things" idea in the Internet of Things is that various IoT devices will have unique identifiers and the capacity to carry out remote recognition, activation, and online observation of certain data types. In addition to facilitating direct data exchange with other relevant devices and applications, IoT devices may also gather data from other devices, process it, and transmit it to other servers [11]. One component of the future Internet that will be crucial is the Internet of Things (IoT), which consists of web-connected objects and global data. The goal of the Internet of Things is to optimize processes without involving humans in any way. The Internet of Things (IoT) uses sensors to gather data, controllers to interpret that data, and actuators to finish the automation process [12]. The Internet of Things (IoT) stands out as a network of preexisting connections that enable data exchange across billions of computers globally. This leads us to the following definition of the Internet of Things: Standardized and connectable operable communication forms the basis of a self-configuring global arrangement system. It is at the intersection of data gathering and usage that the Internet of Things truly shines. Without a mechanism to assess the data in real-time, all the data collected by sensors worldwide would be meaningless. Automating all aspects of farming and agricultural procedures to make the process well-planned is the single emphasis of the Internet of Things (IoT) in agriculture. Precision agriculture (PA) is one approach to farming that aims to improve crop yields by minimizing the use of pesticides, manures, and water systems. This is in contrast to traditional conservation farming methods, which rely on human intervention and have a number of drawbacks, such as higher labor costs, higher electricity usage, and so on [13,14]. Expand trim development while making the most of available resources and reducing natural impacts by incorporating data like as temperature, stickiness, manure, and soil moisture into a decision-support framework [16].Figure 1 presents an image of the extensive and varied Internet of Things (IoT) for smart agriculture applications.

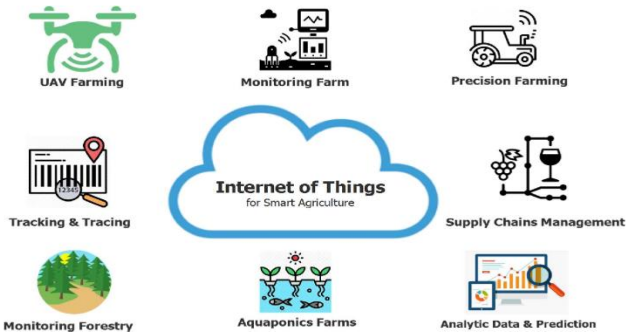


Figure 1. A picture of IoT applications for smart agriculture.

2. Literature Review

The work of Ankush Manocha and others[1] Using 69% of the world's freshwater, the agriculture industry must double productivity and decrease water usage from 2012–2050. IoT, DT, and AI are helping achieve the goal swiftly. The DT may be used for farming initially. This study presents a use case-specific digital twin-driven smart irrigation architecture. Connecting irrigation system sensors and actuators to digital counterparts creates a digital twin.

K. Bhakthavatsala et al. With IoT data from vast agricultural regions, we can utilize our machine learning system to anticipate crops. The ideas are based on nutrient, phosphorus, potassium, temperature, humidity, and precipitation. These factors determine the proposed crop. The input set has 2200 instances with 8 attributes. Over twenty-two crops are recommended for each eight-characteristicpermutation.

In 2022, N Ferehan et al. [3] build an IoT-based wireless mobile robot for outdoor tasks. This project yields more accurate and efficient data and less staff. This evaluation helps agriculture, arrival, and water division. In areas without IoT and remote sensor networks, strong agricultural frameworks exist.

Due to increased populations, dwindling agriculture, and more unpredictable weather, Quy, Vu Khanh et al. [4] say governments worldwide are anxious about food security. Smart agriculture can leverage the Internet of Things (IoT), and this article reviews Io options.

Haseeb K et al. [5] say wireless sensor networks (WSNs) have been methodically created to increase network performance. Using environmental sensors is driven by their manageability and configuration convenience. Additionally, sensor nodes autonomously build the network topology.

The Coelho et al. research [6] Sensor signals must be monitored during irrigation optimization to optimize soil factor management. Some research suggest that LoRa data transfer might allow us to monitor long distances with less energy.

According to Shi, Xiaojie et al. [7], MIT's Auto-ID Labs introduced a network RFID system in 1999, which led to the Internet of Things. New technologies are emerging from the IoT's massive changes. A vast web of high-quality, interoperable communication protocols links actual and virtual "things"in the Internet of Things (IoT). Muangprathub et al. [8] Since IoTs have become more common, we may utilize our knowledge and skills to change our environment. The environmental and agro-industrial sectors employ IoTs to avoid illness and domination. This article discusses optimizing farming with computers and the Internet of Things (IoT). A Wireless Sensor Network (WSN) in agricultural areas has increased farmer production.

“Subhanth et al.” [9] stated IoT-powered smart agriculture delivers irrigation data, smart control, and intelligent decision-making based on real-time field data. These activities may be remotely controlled from any smart device using sensors, Wi-Fi, actuators, and other devices.

M. Dholu et al.” Global agricultural shortages will be caused by overpopulation and urbanization. Due to overpopulation and increased demand for agricultural commodities, much farmland is being converted into non-agricultural fields (NA) to make room for infrastructural development near cities. Fundamentally, farming is falling, which might lower agricultural output, and rural regions are vanishing rapidly.

Table 1 Comparison table

Author	Methodology	Features	Challenges
K. Bakthavatchalamet al [2]	ML Algorithms	N, P, K, pH, Temperature, Humidity	The ML model suggested in this study encountered challenges in effectively
N Ferehan et al [3]	Predictive Kalman filter	Accuracy Increased	computation for decision-making capable system for former
Quy, Vu Khanhet al [4]	Sensor Technology	improved the durability of IoT devices	Need to farmers enhance their skills to apply the IoT solutions.

Haseeb K et al [5]	Energy efficient WSN technolog y	energy consumption with improved data delivery performance in farming land.	Incorporating additional data Need to reduce the overall cost.
A. D. Coelhoet al [6]	Sensor Technolog y	Monitor the soil, humidity, and temperature.	Required Low Maintenance cost
Shi, Xiaojie et al [7]	WSN	the hardware devices must be fully upgraded	Cost effectives.
Muangprat hub, J et al [8]	Wireless based sensor network	Web and mobile based application support system	Not appropriate for mixed farming

3. ISSUES AND CHALLENGES OF SMART AGRICULTURE

Some smart agricultural challenges must be addressed immediately. Smart agriculture faces signal interface, security network, hardware, and organizational obstacles. Smart agriculture and app adoption face additional obstacles [9]. The following sections describe current technique issues and improvements.

Smart farming focuses on improvement of indispensable wireless devices and the battery life of the devices is extended. Smart farming uses high-energy harvesting and low-power usage. Solar cells and low-power sensors based on situation protocols are examples of these solutions. LoRa and ZigBee were found to be the best wireless protocols for agriculture. The reason is their low power consumption and high communication range.

Hardware

IoT hardware design is critical, including IP67 specifications for open-environment devices. Heavy rains, high temperatures, and maximum humidity must be avoided for such hardware devices. Climate may damage gear, especially electronics.

Networking

Due to physical device barriers, typical agricultural operations have significant wiring and transmission costs and poor transceivers. Smart agriculture uses wireless connectivity extensively to address this. Data transformation in agricultural contexts now uses more resilient and dependable network solutions.

In agriculture, supporting the environment and monitoring IoT infrastructure in real-time are crucial. Others are simpler than this infrastructure. An SOA strategy is excellent for a software platform. Farmers need open-sourcing technologies for sustainable infrastructure.

Communication

Signal network communication is vital in agriculture. Most rural regions are undeveloped, while emerging places may lack networking resources. Smart agriculture requires excellent network performance and bandwidth. If not, smart agriculture may not emerge. Communication might be hindered by dense and tall trees in farmlands.

Scalability, reliability

Most IoT devices are deployed in open fields with harsh climatic conditions. These weather conditions disrupt IoT communication. Such failures may hinder data transfer to the server or cloud. To improve IoT device and application performance, more gateways are needed. To support the complicated application, IoT agriculture's network and database must be trustworthy.

Knowing and Farmers in rural regions are typically uneducated and unaware of IoT applications. This may hinder rural IoT growth. Thus, farmers must learn how IoT technologies improve farming methods and boost productivity and profitability.

Safeguard data

Intelligent gadgets are used in IoT applications. The design of these gadgets is not centered on security and privacy. Lack of security causes data authentication, integrity, and access control difficulties. Thus, these IoT devices must be validated for data security and encrypted before transferring data. The network layers of IoT must offer and guarantee data security.

Smart Sensors

Smart Sensors are intelligent sensors. Microprocessors process sensor signals and deliver useful information to external users.A smart sensor detects physical input and utilizes built-in computational resources to execute predetermined operations and analyze data before sending it on.

Agricultural 4.0 is a crucial aspect of modern agriculture, allowing farmers to optimize crop yields and help reduce resource usage. This proposed framework proposes a system that will integrate weather, temperature, soil humidity, and humidity sensors to improve farm management and sustainability. The proposed system and dashboard services for smart farming using quantum computing is shown in following figure 2 The weather sensors will provide real-time data, allowing the farmers to make informed decisions about planting, harvesting, irrigation, pest and disease management, and climate control. The temperature sensors will aid in the optimization of planting times, monitor pest and disease conditions, and provide fertilization recommendations. The humidity sensors optimize ventilation and predict disease outbreaks. This data-driven approach will strategically enhance crop yield and quality, promoting sustainability and productivity in the agriculture industry.

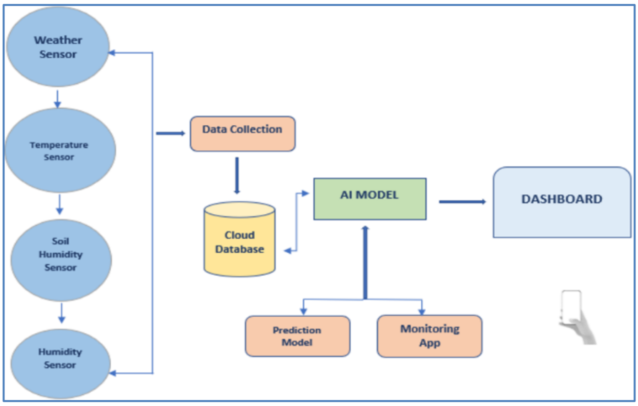
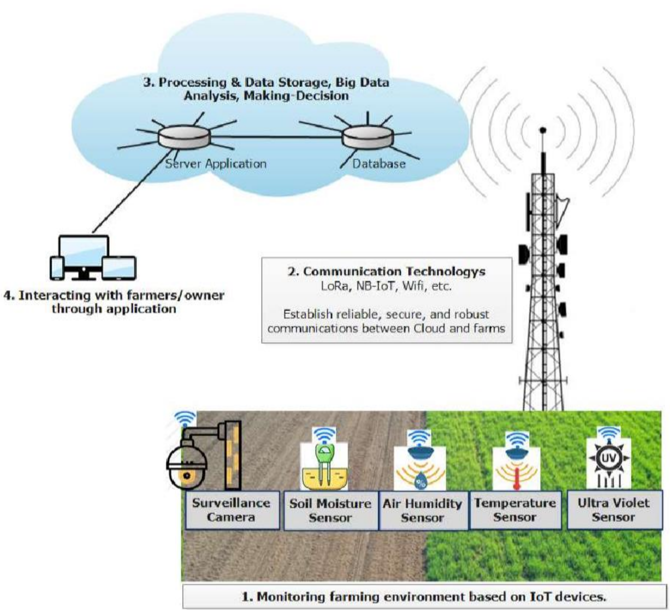


Figure 2:The proposed system and dashboard services for smart farming framework

4. Methodology

Based on the identified opportunities and challenges, the proposed IoT-based framework for smart agriculture consists of the following key componentsQuantum sensors have been in the limelight for years due to their promise to revolutionize measurement and sensing. Quantum sensors are more sensitive than conventional sensors due to quantum characteristics of matter and light. Quantum sensors can bypass the Heisenberg uncertainty principle by using quantum entanglement and coherence. These qualities allow quantum sensors to detect even minute changes in magnetic fields, electric fields, temperature, pressure, and acceleration. Quantum sensors are suitable for medical diagnosis, environmental monitoring, navigation, and defense



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1. Quantum sensors detect environmental changes using quantum mechanics. This entails monitoring how the environment affects quantum stuff.

2. Quantum sensors are sensitive enough to detect environmental changes too tiny for ordinary sensors. Quantum sensors can detect Earth's magnetic field variations for navigation and geophysics.

3. Quantum sensors are employed in medical imaging, environmental monitoring, and defense.

4. Quantum computing is a promising use of quantum sensors. Quantum sensors measure a quantum computer's state, which is needed for calculations.

Here are several quantum sensor benefits over conventional sensors:

1. High sensitivity: Quantum sensors can precisely and accurately detect even the tiniest physical quantity changes. A million times more sensitive than conventional magnetometers, quantum magnetometers can measure magnetic fields at a few picoTesla. This makes quantum sensors useful for sensing biomagnetic fields like heart and brain magnetic fields.

2. Non-invasive: Quantum sensors measure without touching the item. They can detect magnetic and electric fields created by the body without harming or discomforting the patient, making them suitable for medical diagnostics and imaging. Quantum sensors can measure magnetic characteristics to detect early-stage cancer cells.

3. Compact and portable: Quantum sensors may be made tiny and lightweight for field application. This helps environmental monitoring, which requires distant sensors to detect air and water quality, climate change, and natural calamities. Quantum gravity sensors can measure Earth's gravitational field to find subsurface water.

4. Power efficiency: Quantum sensors use less power than conventional sensors, saving energy and money. For long-term sensor use in severe settings and extreme temperatures, such as space travel, this is crucial. Quantum temperature sensors can accurately and reliably detect spacecraft and satellite temperatures.

Compared to classical sensors, quantum sensors are sensitive, non-invasive, tiny, and low-power. The benefits of quantum sensors make them potential for use in research, health, industry, and military.

The smart farming system that has been proposed represents a comprehensive strategy aimed at modernizing the agricultural sector, improving efficiency and output, and fostering sustainability in response to worldwide issues. Through the utilization of cutting-edge technology, sophisticated data analytics, and autonomous machinery, farmers have the ability to enhance the efficiency of resource allocation, mitigate detrimental effects on the environment, and effectively respond to the challenges posed by shifting climate conditions. The increasing integration of technology and data in agriculture is anticipated to have a significant impact on food security and environmental conservation, with smart farming positioned as a crucial component in this transition.

IoT Devices:

The basic architecture of an IoT device contains sensors to gather information from the environment, actuators based on wired or wireless relations, and an embedded system that has a processor, memory, communication modules, input–output interfaces, and battery power [17]. The common architecture of a typical IoT device for smart agriculture is shown in Figure 4.

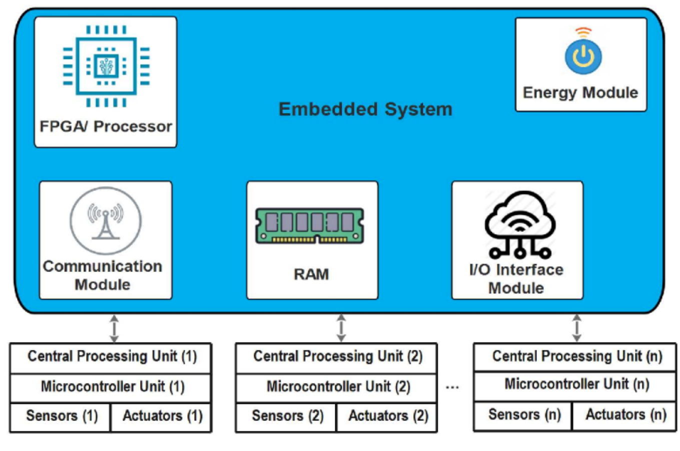

Figure 4. The common architecture of an IoT device.

Technologies Used in Smart Farming

Global Positioning System (GPS)

Latitude, longitude, and height data is reliably recorded by GPS devices [18]. In order for GPS receivers to calculate their location in real-time and provide continuous locations while moving, signals are transmitted by Global Positioning System satellites. Farmers may learn where yield-reducing factors like pests, soil types, weeds, and other obstacles are located with the use of accurate location data. In order to administer the required inputs (seed, fertilizer, herbicide, pesticide, and water) to a specific field, the system makes it easier to recognize different field locations [19].

MonitoringDevices

Soil, nutrient, plant, air, temperature, vapor, and physicochemical parameters may all be approximated with the use of methods like photoelectricity, electromagnetics, conductivity, and ultrasound. The use of remote sensing technology has several applications in agriculture, including the classification of weeds and pests, the identification of soil and plant stress points, and the monitoring of drought [20].

5. Conclusion

Agriculture has been revolutionized into Agriculture 4.0 by the use of data-centric decision-making and technological advancements. Automation, the Internet of Things (IoT), artificial intelligence (AI), machine learning (ML), robotics, and sustainability in agriculture have all seen significant improvements in recent years. Agricultural productivity, resource distribution, and animal welfare are all enhanced by these technologies, as demonstrated in case studies. Successful implementation of Agricultural 4.0 depends on resolving data security, infrastructure, and ethical concerns. Quantum computing has the potential to enhance smart farming. Potentially game-changing for our metric system are quantum sensors. They have a heightened sensitivity to environmental changes that are too subtle for most sensors to pick up on. As research into quantum sensors continues, their potential uses will expand.In order to reap the full benefits of Agricultural 4.0, the paper emphasizes its ethical application. In order to ensure the long-term viability and economic success of agricultural communities across the world, it places an emphasis on training, capacity building, funding, collaborative networks, and a strategy that is centered around farmers.

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