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An IoT-Based Smart Farming Using Cloud Fog Environment and Machine Learning

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Abstract: The process of creating natural resources for human survival and economic gain is known as agriculture. Agriculture, on the other hand, promotes economic fairness and helps people all around the world succeed. The COVID-19 outbreak has severely affected the Indian agriculture system. According to survey results, the pandemic has impacted production and sales due to workforce and logistical restrictions. The epidemic caused significant physical, social, economic, and emotional damage to all players in the Indian agriculture sector. The IoT has had a noteworthy effect since its introduction into the agricultural industry. This survey elaborates on cutting-edge smart farming technologies, including the IoT, cloud-fog computing, machine learning, and artificial intelligence, and thoroughly review their applicability in agriculture. This paper advances knowledge in the field by reiterating the issues with smart technology in agriculture emphasizing the worries found in the current smart agriculture framework and proposes a resource allocation algorithm that presents an optimal scheduling solution using the prediction method to inform the system about the incoming task request, considering the task priorities and assigning those requests to optimal resources for improved results in the context of delay, response time, and execution cost, and for processing the data set we supposed to use machine learning model.

Keywords: Smart Farming, Cloud Computing, Fog Computing, Image Processing, Machine Learning.

I. INTRODUCTION

Agriculture has a significant role in the world's food supply system and as a means of subsistence. It is necessary for human survival. However, problems like population growth, industrialization, and climate change all impede the advancement of agriculture. According to the United Nations, the global population will reach 9.7 billion by the year 2050. Due to labor constraints, population aging and declines in rural areas will erode economic power. Many countries have previously used smart agricultural technologies, which use information and communication technology (ICT) to effectively address issues in rural areas including the labor shortage. Smart agriculture recently attempted and implemented total automation, using other modern technologies like big data, the IoT [1], [2], and AI [3] to improve farmers' quality of life.

Precision farming, also called smart farming, is a contemporary approach to agricultural management that uses technology to improve the efficiency, productivity, and sustainability of farming methods. It combines innovative technology like sensors, automation, data analytics, and networking solutions to help farmers make better decisions and enhance the whole agricultural process. Smart farming entails integrating new technology to improve agricultural methods, increase efficiency, and optimize resource utilization. The use of a Cloud Fog environment, which combines cloud computing with fog computing to meet the particular issues of the agricultural sector, is one creative method in smart farming [4], [5].

Computer services delivered via the Internet are referred to as cloud computing. In place of purchasing and maintaining actual servers and infrastructure, users can access and utilize computing resources as a service on a pay-per-use basis. Computing power, storage, databases, network-ing, software, and analytics are examples of these re-sources. Cloud computing enables consumers and organizations to deploy and maintain programs without the need for expensive hardware or technical skills.

Cloud computing serves as the foundation for data storage, processing, and analysis in smart farming [6], [7]. Large amounts of data collected on the farm by sensors, drones, and other smart equipment are transferred to the cloud for centralized processing. Farmers may now get useful insights, make educated decisions, and reap the benefits of data-driven precision agriculture [8], [9].

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The capabilities of fog computing are enhanced by bringing them nearer to the data-generating devices at the edge of the network, which improves cloud computing. The word "fog" refers to the computer infrastructure that exists between the cloud (centralized data centers) and end-user devices (or sensors). To reduce latency and boost efficiency—especially in applications that need real-time processing and decision-making—it aims to move computing power, storage, and networking closer to the data source. In smart farming, fog computing is utilized to install edge devices, including edge servers, actuators, and sensors. This decentralized strategy lowers latency, improves real-time data processing, and enables rapid reaction to changing environmental circumstances [10], [11], [12].

II. BACKGROUND

A sustainable green fog computing framework [11] is a design and operation of fog computing systems that integrate environmentally friendly and energy-efficient concepts in fog computing systems. This strategy seeks to reduce the environmental effect of computer infrastructure.

Here is a list of major components and concepts that may be included in such a framework:

- Choose low-power and energy-efficient hardware for fog nodes and edge devices. This helps to save energy during data processing and communication.
- Use renewable energy to power the fog computing infrastructure.
- Implement dynamic resource allocation techniques to scale computing resources based on demand. This guarantees that resources are used efficiently and turned on only when needed, lowering total energy usage.
- Add sleep modes to fog nodes to save energy while not in use. Nodes can be turned on or off depending on workload demands, which lowers the constant power consumption of inactive devices.
- Use of green data centers methods, such as energy-efficient server hardware, cooling systems, and power management tactics, is recommended if core cloud resources are combined with fog computing.
- Install monitoring tools to keep tabs on energy usage for all fog nodes and devices. Analytics can pinpoint problem areas and maximize the system's overall energy efficiency.
- Analyze collected data using several Machine learning models.

III. LITERATURE REVIEW

In the paper [13] author proposed systems to attain sustainable growth. The architecture put forward by the author offers a comprehensive farming ecology. By identifying factors such as sensor positions, deployment line-of-sight, coverage range, data extraction via aerial systems or relay mechanisms, energy frameworks for airborne vehicles and on-ground sensors, and fog computing paradigm support for backend computing, the toolkit facilitates the simulation of custom farming scenarios for users. The proposed work also provides a reference point for transmission delay, packet delivery ratio, energy consumption, and system resource utilization. In the paper [14] author discussed the idea of continuous connectedness made possible by the development of the information age and the exponential rise in computer devices. Due to the previous computer model's inability to provide millions of users with continuous connectivity, the cloud computing paradigm emerged as the industry standard, offering 24/7 services. Despite its many benefits, the cloud computing paradigm significantly contributes to global warming because of the massive data center’s ever-increasing carbon emissions.

Author Guardo E [15] proposed an approach to Precision Agriculture Using a Fog Computing IoT Framework, proposed an IoT architecture based on Fog that utilizes the two-tier Fog and its resources to reduce waiting times, improve computational load balancing, and reduce the amount of data transmitted to the cloud. All methods of agricultural land management fall under the growing umbrella of precision agriculture, to which the proposed Fog Computing idea is applied. Additionally, the author simulated and illustrated how the two-tier Fog Computing approach may significantly reduce the volume of information uploaded to the cloud. Based on the prior architecture, he also suggests and explains an application proto-type capable of managing and monitoring farms, with a significant influence on both commercial and environ-mental performance.

The [16] research presented a technique for collecting and storing data in a smart agricultural setting, as well as two ways for filtering data in the fog. Temperature and humidity variables from a real dataset were used to test each filtering method. The fog uses the KNN approach to filter the data in all tests. This method classifies the data according to its ranges of values. The author [17] proposed an IoT-based architecture for agricultural disease monitoring systems with fog computing help, allowing sickness in crops to be tracked in real-time with minimal latency. In the paper [18] the author emphasizes data collec-tion reliability as a vital factor in Sustainable Farming, which is facilitated by the IoT.

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In research [19] the author offers a flexible platform capable of meeting soil-free cultivation requirements in full recycling farms with moderately salacious water, based on replaceable inexpensive gadgets, and is backed by a 3-tier software open-source technology at remote levels and the local level where the cyber system communicate with farming device for collecting data so that to conduct instantaneous fashion atomic control operations. The author [20] introduced an alternative service solution built on the Internet of Things (IoT) cloud computing platform, which may enhance the processing speed of the IoT and the integration of existing cloud-to-physical networking mechanisms. In the paper [21] author describes IoT application placement as an optimization issue in this work, to minimize costs while meeting QoS and security requirements. We also investigate the effect of loosening security requirements on placement decisions.
Author [22] Aman studied flower leaf classification using deep learning to classify the categories of flowers. In [23] the author used an ML&DL model to classify the categories of vegetables. The study [24] presents an optimization methodology for delivering dependability and, service continuity to fog-cloud continuum-based smart farms. The suggested model allows Smart Farming stakeholders to calculate the optimal number of fog nodes required to provide farming assistance, taking into consideration differences in fog capabilities, resource requirements, redundancy techniques, and reliability requirements.

IV. METHODOLOGY

In this research, we study several methodologies of smart farming based on cloud fog environment proposed by researchers and analyze the most effective approach. The fundamental fog architecture is supplemented in the suggested framework shown in Figure 2. AI-powered smart gadgets that can detect a variety of factors. Smart end-user devices can remotely coordinate and monitor their users. End-user computing skills are prohibited. They can use the fog layer to do complicated computations. The bulk of responses may be generated automatically for the user; however, some cases require involvement from the analysis data.

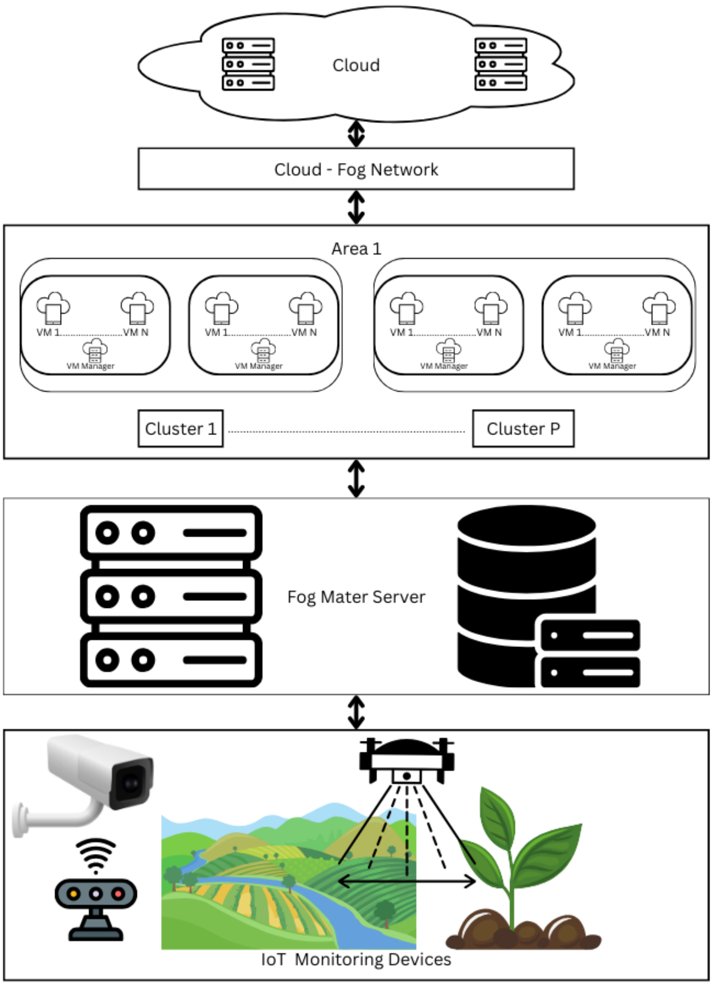

Figure 1 Framework of Smart Farming

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The fog layer can effectively handle such situations and respond to them rapidly by lowering latency, reaction time, and bandwidth constraints [25], [26]. However, despite the cloud's massive computational and storage capacity, latency-sensitive apps would most likely suffer if all requests from various applications were handled directly.

It manages many programs and their data concurrently. Applications that are sensitive to latency will function better if a fog layer is established between the cloud and the user.

Request processing may be able to operate with constrained resources, such as time, money, and bandwidth since it takes place at the fog layer. Processing takes place nearer to the final consumers.

Proposed Resource Allocation Approach

The proposed resource allocation approach pseudocode is presented below. The approach assigns the optimal re-source for computing task requests based on task priority and available resources capable of handling the task request using task log history for optimal response time and reducing delay in various smart farming scenarios.

Pseudocode

```
Input
Tr: Total fog resources in the cluster
A: Set of  available resources
Tt: Set of requests, Tc: Current request
Lr: List of scheduled requests
Hr: Resource-Request log history
Lr= {}, i= 0, j= 0
While (Ri < Ar)
   For every Tc ϵ Tt)
     Calculate significance score (ss) & set priority (pt)
     If(Tc ϵ Hr)
       Predicted_Resource(Ri) ⟵ Tc
       j⟵ j + Required(Tc)
     Else
       If(pt(Tc) > pt(Request(Ti))&&Required(Rc) < Ar – j)
         Resource(Ri) ⟵ Tc
         j⟵ j + Required(Tc)
       Else
         continue
   Hr⟵Predicted_Resource(Tc)
   Process next request
  Lr.update (Request(Ti))
i⟵ i+1
Return Lr
```

Processing the dataset using Machine Learning

- ***Step 1 (Preparation of Dataset)***

Let, I = (x_i , y_i) is a collection of gathered RGB pictures, where I is the dataset of n classes consisting of x_i is i^{th} image and y_i is their corresponding class if belonging $x_i \in I$ can

$$I^r = R_e\left(\{x_i, y_i\}_{i=1}^{n}\right), p \times q, \ \theta_i \quad (1)$$

Where θ_i is a feature of an image to be required after pre-processing the image to a specific size.

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- ***Step 2 (Applying PCA)***

In this stage, the Principal Analysis Component (PCA) is used to extract features from the photos. The data's largest variation determines the primary component, and the subsequent main component is perpendicular to the first main component. In the same way, every major component is computed. Reduce from n-dimensional to k-dimensional can be equated to finding k vector $\mu^1, \mu^2, \ldots\ldots \mu^k$ onto which we will project our data $x_i^1, x_i^2, x_i^3, \ldots\ldots x_i^n$, so as to minimize the projection error without loss of information.

Now, mean normalizing over dataset

$$\mu_j = \frac{1}{n}\sum_{i=1}^{n} x_j^i$$

Every x_j^i will be replaced with $x_j - \mu_j$

Now, to reduce data from $n - dimensional\ to\ k - dimensional,$ with computed covariance matrix

$$\sum = \frac{1}{n}\sum_{i=1}^{n}(x^i)\,(x^i)^T$$

Now, we have chosen the smallest value for k, so the average squared projection error can be minimized.

Avg. square projection error

$$\frac{1}{n}\sum_{i=1}^{n} ||\ x^i - \ \mu^i||^2$$

Total variation in data

$$\frac{1}{n}\sum_{i=1}^{n} ||x^i||^2$$

Now, the chosen k should be as smallest value so that

$$\frac{\frac{1}{n}\sum_{i=1}^{n} ||x^i - \mu^i||^2}{\frac{1}{n}\sum ||x^i||^2} \leq 0.01.$$

- ***Step 3 (Applying ML models)***

Every stage of the study involves revamping the whole dataset before dividing it into train, validation, and test sets.

$$X_{T,}Y_T$$

Let $f(.)$ be a classifier model that can be defined as a

$$\hat{Y}_x = f(x_T, y_T), \{\hat{Y}_x\}_{x=1}^{m} = f(X_T, Y_T)$$

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V. CONCLUSION

The suggested framework may improve the service quality of intelligent smart farming scenarios by establishing communication between the devices. Task scheduling across fog nodes may minimize latency when delivering services to farmers. Fog node clustering can aid in lowering the offloading burden of a process and enhance capabilities.

The work's distinctive feature is the development of two-level resource allocation for improved access to service machines. The proposed resource allocation algorithm presented an optimal scheduling solution using the prediction method to inform the system about the incoming task request, considering the task priorities and assigning those requests to optimal resources for improved results in the context of delay, response time, and execution cost, so that the real time dataset will generate, and machine learning algorithms is utilised to detect and classify them. In the future, the approach will be simulated using the ifogsim toolkit to prove the significance of the proposed approach.

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