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Machine Learning-based Peer-to-Peer Platform for Precision Agriculture in Crop Growth and Disease Monitoring

Imtiaz Ahmed[1,*], Gousia Habib[1], Parmod Kumar Yadav[2]

Abstract

Farmer suicides are a significant problem in India due to various circumstances. One of the main problems is the financial side of managing and growing crops while still trying to make a profit. This study proposes a decentralized platform for buying and selling agricultural produce by connecting farmers with individuals interested in investing in their fields and continuous monitoring of quality and crop health using IoT, Blockchain, and Machine Learning for disease prediction in agricultural produce. Blockchain has swiftly become a key technology in various precision agriculture applications. The requirement for smart peer-to-peer systems capable of verifying, securing, monitoring, and analysing agricultural data has prompted researchers to consider developing blockchain-based IoT systems in precision agriculture. The significance of blockchain in replacing traditional means of storing, sorting, and sharing agricultural data with a more trustworthy, immutable, transparent, and decentralized system is critical. In precision farming, the Internet of Things and blockchain will transform us from having merely smart farms to having the internet of smart farms, giving us more control over supply-chain networks. As a result of this combination, precision agriculture will be managed with more autonomy and intelligence in a more efficient and optimum manner. This research provides a thorough examination of the value of combining blockchain and IoT in developing smart precision agriculture applications. Novel blockchain models were also offered in the study, which can be employed as essential solutions to major difficulties in IoT-based precision agriculture systems. Furthermore, the study examined and thoroughly highlighted the major roles and strengths of typical blockchain platforms used to control several precision agriculture sub-sectors, such as crops, livestock grazing, and the food supply chain. Finally, the study examined some of the security and privacy concerns and blockchain-related issues that have hampered the development of blockchain-based precision agriculture systems. A farmer's difficulty may be the same as another farmer's problem in another place. It has always been difficult to provide information to farmers and connect them. Cloud computing and economic development are viable options for addressing these issues.

Keywords: Machine learning, blockchain, precision agriculture, food supply, blockchain technology, IoT

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INTRODUCTION

Agriculture is extremely important in India, which ranks second globally in terms of farm output. Agriculture employs more than half of India's workforce and contributes nearly 20% of the country's GDP. Various problems like mediators, infections, incorrect storage, and loans significantly affect this industry, resulting in significant losses and suicides in India [1]. As a result, our Peer-to-Peer platform allows consumers to invest directly in farmers at the start of the month and monitor crop health using various sensors and Machine Learning to predict disease in the crop, allowing crops to be sold to customers at a fixed price and ensuring good quality through continuous monitoring [2].

Farmers no longer need to take out bank loans because the money comes straight from the consumers, and the health of the crops is regularly monitored. The necessity of adopting developing technology in precision agriculture is increasingly recognized in the literature. Precision agriculture is a new technique that combines information technology (IT), satellite technology, geographic information systems (GIS), and remote sensing to improve all aspects of the agriculture sector's functions and services. Precision agriculture is now reliant on mobile apps. Sensors are the smart drones. Cloud computing is a term that refers to Artificial intelligence (AI), the internet of things (IoT), and block chain are all keywords these days [3]. It is now possible to process and retrieve real-time data about soil, crop, and weather conditions and other important services such as crop and fruit supply chain, food safety, and animal grazing. According to many statistical reports, precision agriculture, based on the utilization of advanced technology in all agriculture subsectors, will add additional improvement to the world economy [4]. According to a market research and consultancy organization, the global precision agriculture industry will increase at a 14.7% annual rate to reach $ 10–60 billion by 2025. Furthermore, the worldwide precision farming market is expected to increase at a compound annual growth rate (CAGR) of 13.7% from USD 7.5 billion in 2020 to 12.7 billion in 2025.

5G, Edge computing, energy management, supply chain, and the stock market are just a few areas where blockchain and deep learning have been useful. Blockchain is becoming more often utilised in the management of agricultural finances and food supply chain. Farmers enter into smart contracts with one another, as well as those who purchase agricultural products [5].

Every transaction they are listed and block chained, ensuring a secure and suborn-free environment. Way of dealing with money is especially beneficial for farmers facing challenges. Blockchain is a distributed ledger, which is why there are economic problems. They played an important role in adding security to the network. Moreover, the blockchain also aids in the management of the food supply chain, making everything more efficient [6]. The transparency of the services enables people to purchase safe agricultural products.

This research provides a blockchain-based system for crowdsourcing data collected by farmers to assist them in crop management and provide incentives. Our investigation work includes an incentivization approach and a revenue model ensuring data security and privacy by exploiting the intrinsic properties of the blockchain [7]. However, network transactions may get more complex. Due to the enormous number of transactions, it is time-consuming and nonsensical. The blockchain is irreversible nature. We employ deep neural networks for anomaly detection and exact prediction projections for the crops to allow coherence [8].

The latest growing computer technologies include blockchain technology: cloud computing, the internet of things (IoT), and machine learning (ML), and deep learning (DL). It has previously been utilised to address complex problems by researchers in various fields such as healthcare, cybercrime, biochemistry, robotics, metrology, banking, medicine, and food [9]. Many machine-learning and IoT applications in various domains are presented. Machine learning is becoming more powerful and accurate thanks to deep learning algorithms. Using automated machine learning (AutoML), one can reduce the requirement for machine learning expertise while also automating the ML process with greater accuracy. Agriculture-related tasks are divided into major sub-categories [10]. These four sub-domains of agricultural chores are depicted in Figure 1.

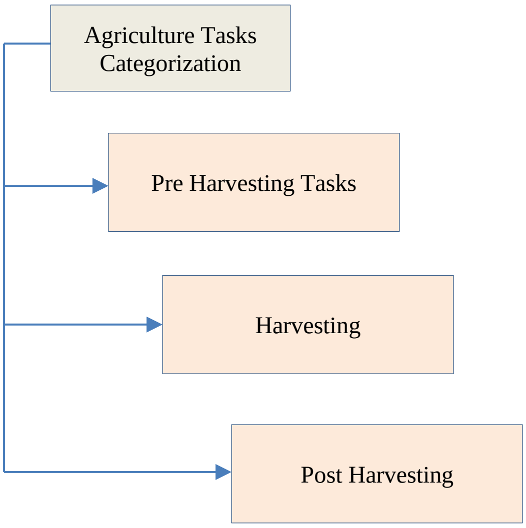

Figure 1. Shows the general classification of agricultural tasks.

Farmers concentrate on crop selection, land preparation, seed sowing, irrigation, and crop management, including pesticide application and pruning, during pre-harvesting operations. Farmers do tasks such as yield mapping and counting the number of fruits during yield estimation to forecast production and make the appropriate arrangements for harvesting or post-harvesting [11]. Farmers are focused on crop maturity or fruit market quality while harvesting. Farmers focus on post-harvest storage and processing technologies in post-harvesting.

In the Farming nutrition stream restraint, the contributing unit has a role, which makes suggestions, and communicates with the smart contract. There are five contributing units, which are summarized in the Taxonomy diagram [12].

The following is a description of each block in Figure 2:

i. In the farming stream, restraint is the elementary object complex. They grow crops on the ground and deliver them to the next object processor.
ii. *Processor:* In farming stream re-strain, a processor is an additional unit. They clean the agriculturalist's cultured creation by removing any foreign materials. Finally, the product is delivered to the vendor [13].
iii. *Distributor:* A supplier is typically a storeroom that purchases final crops from the mainframe. It is a unit that plays an important role in food supply to the general public.
iv. *Retailer:* A retailer buys finished items from a distributor in small quantities, usually in lots with visible identifiers, and sells them to clients. For example, the shop may purchase in bulk and sell to the customer in a smaller quantity.
v. *Customer:* The customer is the end-user who purchases and consumes the produce from the retailer [14].

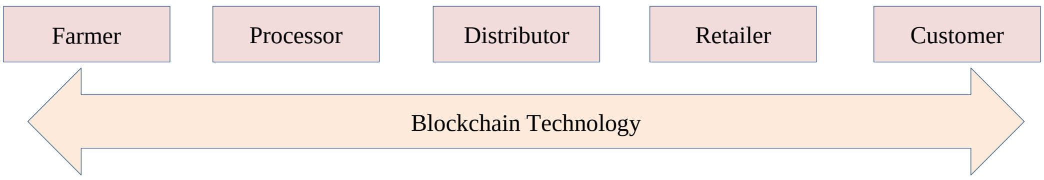

Figure 2. Classification Diagram.

BACKGROUND AND RELATED WORK

Machine Learning (ML) and blockchain are used to create crowdsourcing apps and frameworks which have exploded in popularity.

Khan et al. [15] suggested a resource-efficient, blockchain-based solution for private and secure IoT [15]. Gargi et al. [16] proposed a new privacy-preserving anonymous IoT approach. Ali et al. [17] proposed a Wireless Visual Sensor Network (WVSN)-based system that uses machine learning and image processing to detect any deficit, pest, or disease on plant leaves. They place camera sensors all over the greenhouse. Each sensor node takes an image from the greenhouse and detects fungus using machine learning and image processing [16]. Much research has aided the work of farmers and farmer communities in agriculture. Numerous researchers have employed deep learning and machine learning techniques, including ResNets, Faster-RCNN, and CNN, among others. Although there have been several attempts to anticipate plant and crop diseases, most of them rely on mathematical models based on data acquired in laboratories. Such systems have yet to recognise many diseases and problems affecting plants and crops, but many people have found solutions [17]. Table 1 examines the contributions, strengths, and flaws of recent relevant researches in crop protection.

Table 1. Comparison with related work.

Reference	Contribution	Strengths	Weakness
Dongyan Zhang et al. [18]	Wheat grain detection using image processing and machine learning techniques	In a variety of ways, it outperformed the preceding model.	The product was put to the test in a lab setting.
Jie Xue et al. [19]	CNN will determine whether Zingiber find the most suitable is healthy or rusted plants disease	Neural Networks for Plant Disease Detection Have Been Introduced	Only one crop species is targeted.
Xu J, Wei H, et al. [20]	For accurate crop disease detection, MDFC-ResNet and IoT were used.	The use of IoT to automate detection and provide messages to farmers	There are no farmer-to-farmer communications or incentives.
Our strategy is as pursues:	Implement a blockchain-based crowdsourcing network to diagnose agricultural diseases and establish peer-to-peer communication amongst farmers including incentives and a platform for sharing solutions.	Detects crop diseases in a safe and cost-effective manner. Our website also allows them to earn bonuses by assisting fellow farms in spreading our illnesses [21].	Due to the fundamental behaviour of blockchain, transactions on the network may take some time to complete and may not support frequent large transactions.

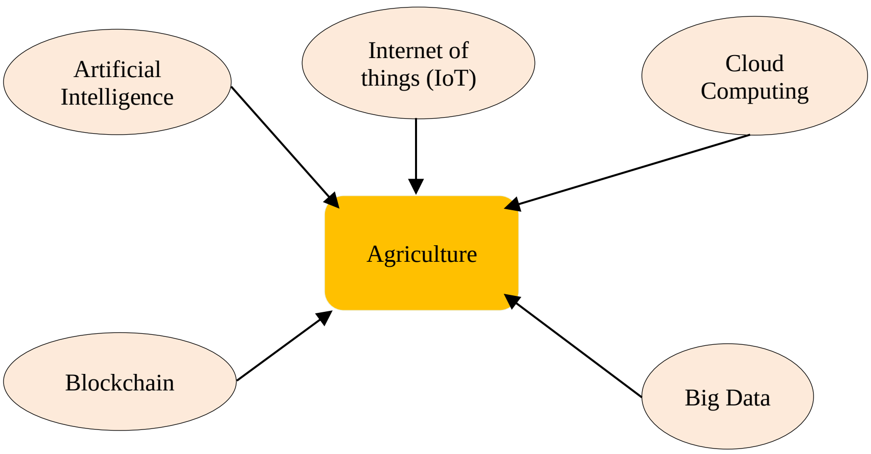

Figure 3. Innovation in horticulture.

As a result, some food preparation firms adhere to outdated or traditional techniques that must be updated to keep up with technological advancements as shown in Figure 3 [22].

BLOCKCHAIN BASED ON THE INTERNET OF THINGS

It is a system component that comprises logic and is also incorporated in a blockchain smart contract as a gateway to the blockchain. A module can have many different types and complexities depending on the capabilities of the blockchain programme and client interface, according to the blockchain chosen [23]. The data is stored on a network, and a blockchain can be described as a decentralised database. A user can use blockchain technology to conduct peer-to-peer transactions (Singh & Kim, 2018) [21]. The blockchain structure based on IoT technology is depicted in Figure 4.

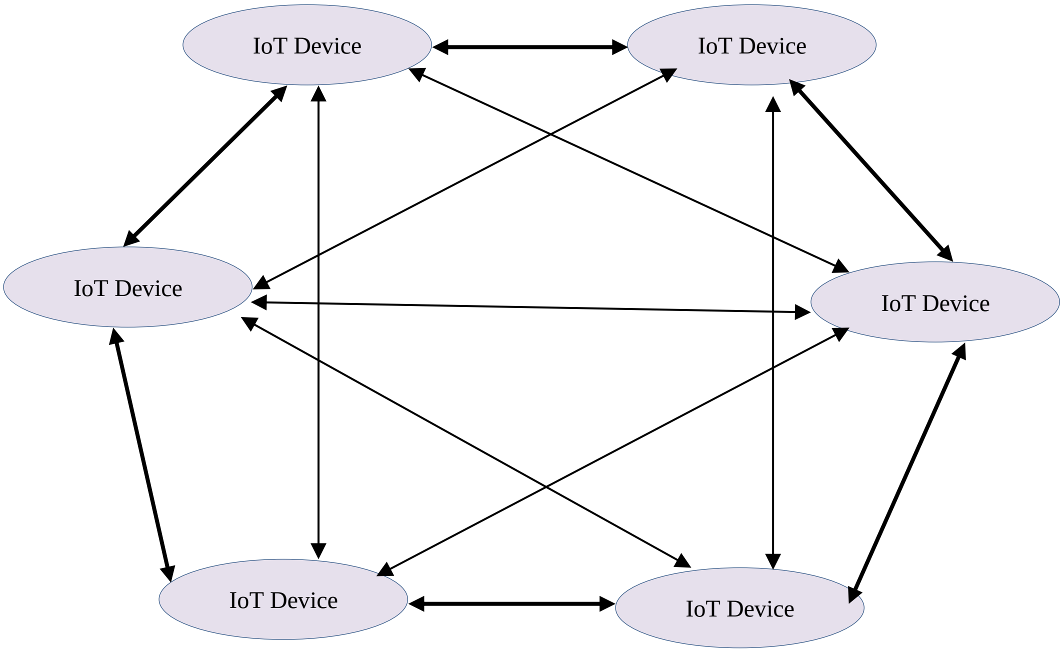

Figure 4. Blockchain Network for IoT.

Blockchain is a collection of cryptographically related blocks and time derived from transactions. To prevent malicious assaults, a node identifies each block in a system. The blockchain technology used is beneficial to IoT because it allows for service sharing and data tracking. For improved security, data sources may be identified and do not alter over time. With blockchain technology, IoT security is improving [24].

Agriculture Blockchain Applications and Privileges

These characteristics are advantageous in agricultural applications. The following are some of the most important blockchain applications:

- Agribusiness Insurance;
- Traceability in Smart Farming;
- Registration of Land;
- Supply Chain for Food;
- Farms' Security and Safety; and
- Agricultural Products E-Commerce.

Food Supply Chain Management

Food supply chain management is a method of explaining how food from a farm ends up on our plates. All aspects of manufacturing, refinement, delivery, selling, consumption, and disposal are included in supply chain management. Figure 5 depicts the supply chain process in its entirety [25]. The food supply chain in developing nations must overcome a number of obstacles, such as the need for stakeholder confidence, which is frequently correlated with the credibility and traceability demanded by end users, and the difficulty of managing risks, delays, or disruptions, which are frequently brought on by inadequate or missing information. One of the most effective methods to address these issues is to use blockchain technology [26].

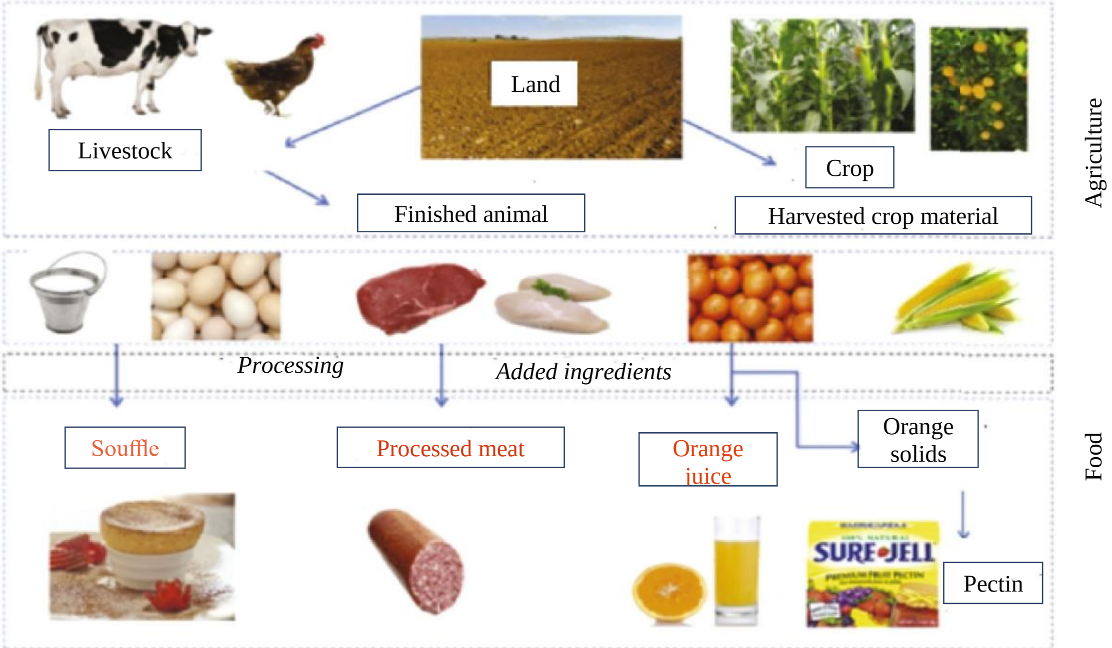

Figure 5. Depicts the agricultural food supply chain [12].

Blockchain Technology

Blockchain is a distributed database that enables data to be stored and exchanged across a decentralised computing network in a secure and private manner. In addition, if the data is dispersed, transactions can only be made by the owner who possesses the private key [27]. Other devices or computers on the network serve as validators. It uses a public ledger to safely record transactions, without the need for a third party to be trusted, between nodes. In a centralised cloud method, an asset or item is either held under the custody of the owner, a reliable third party, or a centralised authority like a bank. In a centralized computing system, multiple clients are served by a single server, which has more resources than the clients [28]. Blockchain keeps track of transactions in block units, with each block containing the hash of the previous block, the hash of the current block, the date, additional details, and the block's transactions. A sender node distributes a transaction to the other nodes in the network after it is finished. The receiving nodes have proof of work and verify the transaction. The node that completes the proof of work will link the block to the chain and publish the result to all other nodes. The transaction must be signed by the sender and contain the recipient's public key. As a result, any other node will check the transaction's authenticity. Each block has a hash of the preceding block, proving their connection. Figure 6 depicts the fundamental characteristics of blockchain [29].

MATERIALS AND METHOD

This section presents the smart model architecture and smart model protocol design.

Smart Model Architecture

A prospective smart model for agricultural environmental monitoring and the food supply chain, as depicted in Figure 6, is made up of three layers: physical data, logical data, and a web interface layer [30]. This tiered approach enables for a framework that is scalable, adaptable, and efficient to deploy. The farm environment and crop growth are monitored using a range of IoT nodes at the physical data layer. IoT nodes take data from the cluster farm and deliver it via IoT gateway and wireless router to the base station, which then sends it to the database [31].

A GPRS router is incorporated onto a single central board device that functions as a remote Radio Frequency Gateway (RFG) for wireless telemetry [18].

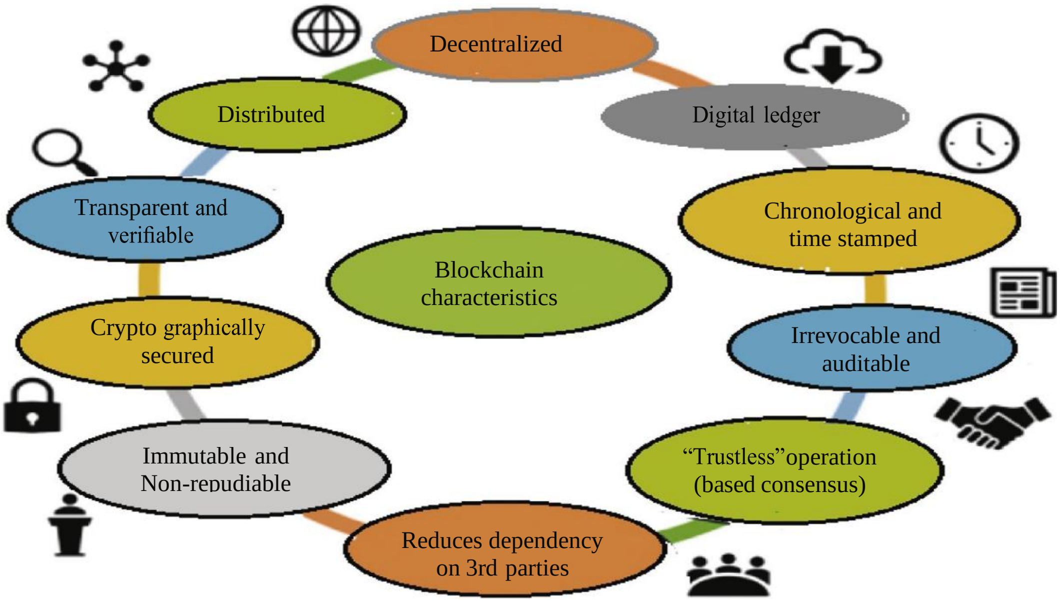

Figure 6. Blockchain technology's key characteristics.

To achieve effective control management and synchronisation of two relatively unrelated data sources, the RFG gateway serves as a coordinator between two different data streams and supports remote access, enabling full remote control of all devices in the cluster farm [23]. It also collects data through IoT nodes for soil parameters and IoT crop monitoring information. The data acquired from the cluster farm is stored in the logical data layer of a SQL database server. The complexity of numerous physical layer devices is handled by the SQL server as a more intermediary layer, which also enables database server data validation. The SQL database stores raw data, which is then exported to a local file system [19].

Agriculture Protocol for the Smart Model based on IoT

IoT nodes are suitable for cluster farms since they use less energy than WSN and can be much lower with a good clustering protocol [11]. As a result, based on the LEACH protocol, this study developed a novel clustering protocol for IoT-based agriculture, as illustrated in Figure 7, to reduce energy consumption and increase network life, as shown in Figure 8 [20].

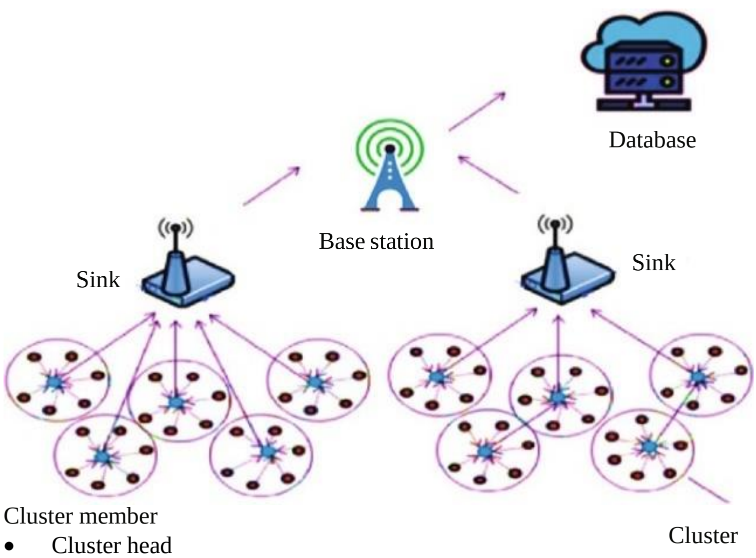

Figure 7. IoT based agriculture clustering protocol.

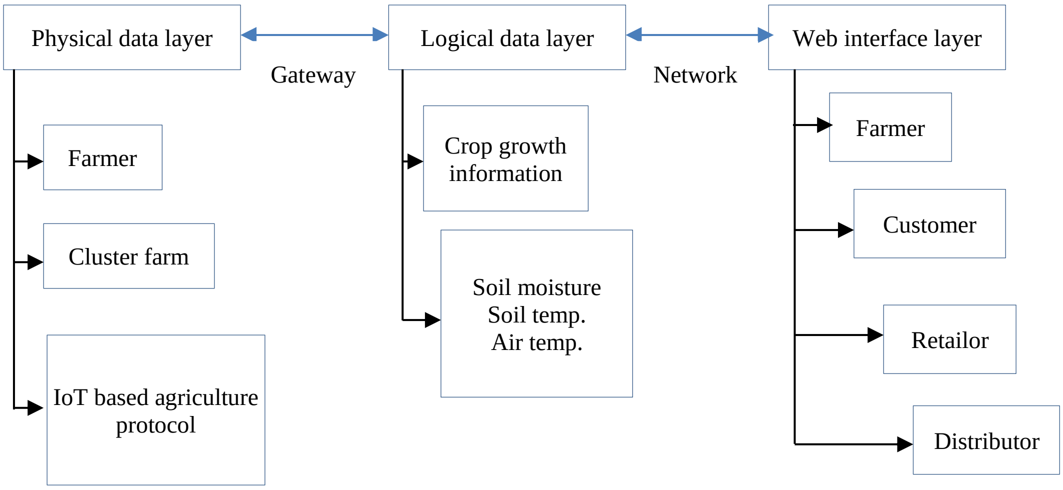

Figure 8. Blockchain an IoT smart model.

Technique Approaches

We use a blockchain network for speedier data transfer from the seed node to the destination node while maintaining sufficient security. The sparse autoencoder is used to forecast disease using data obtained from IoT devices as input. Figure 9 depicts the data collecting and processing procedure for identifying the ailment utilising an effective blockchain and deep learning mechanism [21]. It begins with data collecting, and then the obtained data is safely sent over blockchains. The data is pre-processed, features extracted, and then classed to determine the disease kind on the cloud servers.

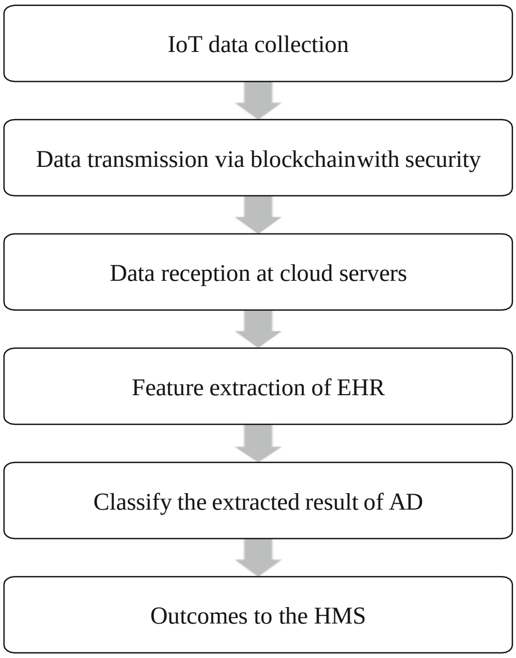

Figure 9. Architecture diagram.

PROPOSED NETWORK MODEL

Consider a group of farmers A=A1, A2, A3…, An, where n represents the number of farmers in our network at any particular time [32]. Any farmer Ai€A can either request that their problem be discovered using Various tokens, the machine learning node can contribute to the network presenting their answer to a certain Issue. Any farmer in the area can use any alternative solution recommended by any other exchange for tokens [33]. Convolutional Neural Networks (CNN) are used in our framework to sort the photos into the various categories stated in Table 2.

Table 2. Classes on plants disease model trained.

Class	Tomato healthy
	Tomato mosaic virus
	Tomato yellow leaf curl virus
	Tomato target spot
	Tomato Septoria leaf spot
	Tomato leaf mold
	Tomato late blight
	Tomato early blight
	Tomato bacterial spot
	Potato healthy
	Potato late blight
	Potato early blight
	Bell pepper healthy
	Bell pepper bacterial spot

Preparing Data for Model Training

All of the pictures required to be identical in order to achieve the best results. The photographs were of various resolutions and grades. To create an identical-looking dataset, the photographs had to be re-scaled and colour toned. The images were all scaled to 256×256 pixels [34]. As a result, our technique works effectively even when using diverse image sizes, because each input image is scaled to 256×256 pixels and then passed on to the deep neural network model for classification. As a result, our proposed approach is resistant to changes in input image size. Using rotation, scaling, shifting, and zooming, image augmentation is then utilized to generate additional data [35].

NUMERICAL ANALYSIS AND RESULTS

Numerical analysis is concerned with all aspects of the numerical solution of a problem, from the theoretical design and understanding of numerical methods to their practical implementation as reliable and effective computer programmes. Although most numerical analysts specialize in particular subfields, they share some common issues, viewpoints, and mathematical analytic approaches.

Parameters for Image Recognition

The Convolutional Neural Network was developed using the Keras framework. The model had 29 layers has many parameters, of which few could be trained. Rotation, height, and breadth shifts, as well as zoom and horizontal flips, were used to enhance all the photos for better recognition. The SoftMax activation function was used to define the output. Four dropout layers with values of 0.35 after layer 4, 0.26 after layer 14, 0.26 after layer 22, and 0.6 after layer 27 were utilised to improve the accuracy and avoid overfitting of the Deep Neural Network. The best batch size for training the network was 33, the epochs were 55, and the steps per epochs were 75.

The Framework's Quality was Evaluated

Our strategy directly targets issues such as time, incentives, and crop-protection measures, which encourages all farmers to become more active on the network and contribute more. In the search for new incentives and better solutions, the network would be strengthened, which would improve the network's accuracy and legitimacy. Figure 10 displays some prediction findings produced within our framework for leaf disease diagnosis, which would aid farmers in guaranteeing the adoption of appropriate crop protection measures based on the problem at hand.

Existing architectures lack incentives and do not connect farmers to one another. The same farmer boosts contributions after adding the missing incentive model, and now uses the predictions to deliver better solutions.

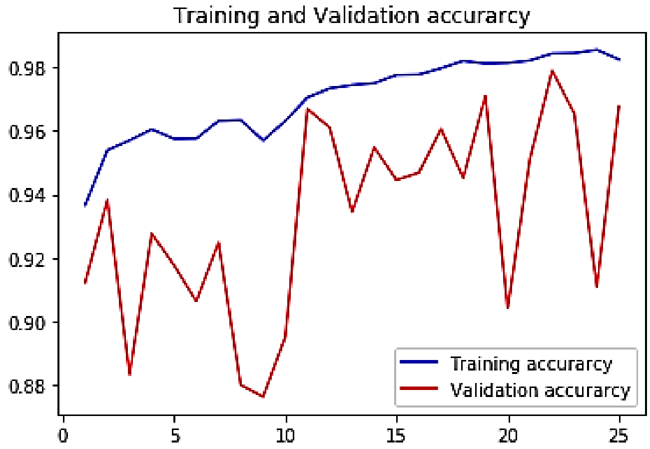

Figure 10. Training and validation accuracy.

The several optimization methodologies utilised in the model training are evaluated in Figures 11–14. RMSProp and Adam optimizer were the two main optimizers that were compared. Though the RMSProp had a faster convergence with lower losses and higher training accuracy than the Adam optimizer, the validation accuracy was not as good.

When compared to the Adam optimizer, the validation loss was also larger, making the Adam optimizer the clear winner. The red line in the graphic depicts the average cost of identifications and research for the treatment of plant diseases.

This cost is constant since it is an expense incurred by the farmer in discovering various characteristics or diseases in their crops. Many farmers are burdened by this cost, but our model can assist them in coping with it. If the farmer contributes to our model on a regular basis by supplying solutions to various ailments, the proposed framework's incentives will eventually outweigh the average cost.

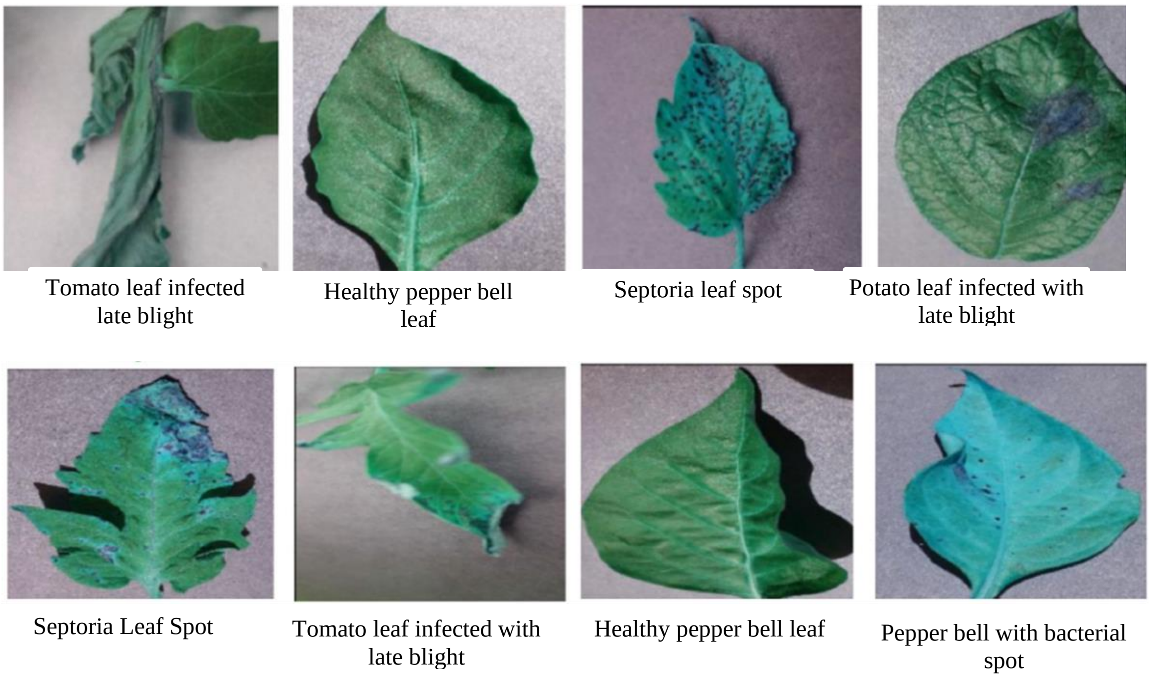

Figure 11. Result images for disease identification.

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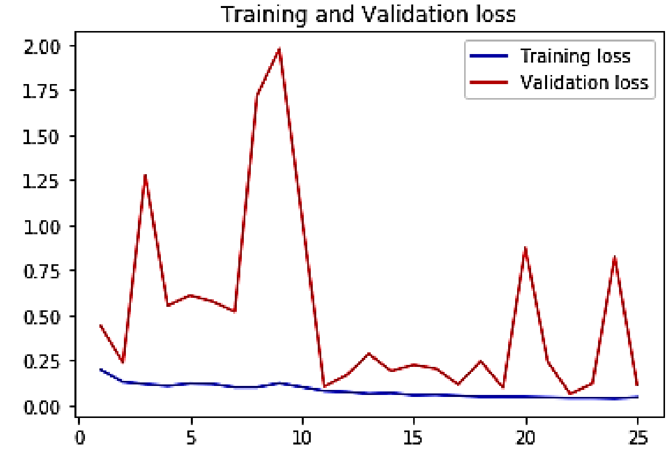

Figure 12. Training and validation loss.

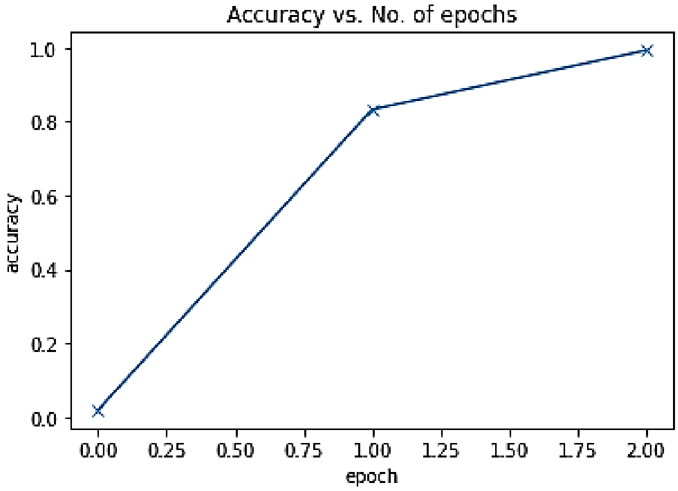

Figure 13. Validation accuracy.

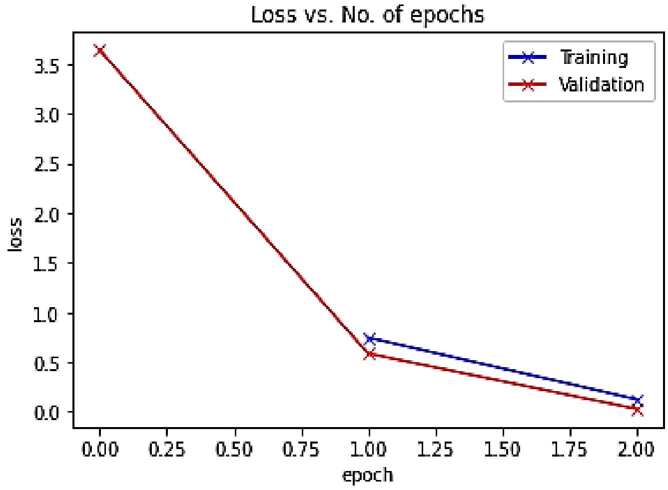

Figure 14. Validation loss.

Our current paradigm may accommodate several users, however transaction times may be longer; nevertheless, when combined with a parallel blockchain, this model can be horizontally scalable. The current machine-learning model has been trained on three types of plants, each with its own set of illnesses. The dataset expands as the number of unfulfilled requests grows, and the model may be retrained quickly. We hope to expand our work in the future to provide farmers with proper crop management and crop rotation recommendations based on semantic segmentation of rural UAV images. The findings will also assist farmers in determining the best production zones and patterns to use in order to avoid resource waste during cultivation and harvesting.

CONCLUSION

Using a blockchain network and deep neural networks, we proposed a framework for safeguarding and boosting crop yield in this study. Users who join the network have the option to earn incentives and bitcoin by providing solutions and assisting other farmers. They can then use the machine learning nodes to earn these incentives as well as get a report on the troubles they are having on their farm. We used the Convolutional Neural Network technique to forecast diseases and recognize them. Because of the incentivization, the results show that our methodology should be able to reach a larger number of participants. Crop tracking is a useful tool for keeping track of crop progress and recording data. Another distinguishing feature of Blockchain is a smart model that provides real-time updates to all supply chain participants on the safety of food items chain, which considerably reduces the vulnerability of centralised systems, more extensively disseminates information networks and makes them safe, more available, accessible, and interactive. The clever model will greatly increase the system's dependability and efficiency in the food supply chain, enhancing food safety and regaining the trust of consumers in the food industry.

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