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Secured Framework for Smart Farming in Hydroponics with Intelligent and Precise Management based on IoT with Blockchain Technology

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Abstract— Hydroponics is a type of soil-free farming that uses less water and other resources than conventional soil-based farming methods. However, due to the simultaneous supervision of multiple factors, nutrition advice, and plant diagnosis system, monitoring hydroponics farming is a difficult task. Hydroponic techniques utilizing the IoT show to deliver the finest outcomes, despite the usage of various artificial culture methods. Though, the usage of smart communication technologies and IoT exposes environments for smart farming to a wide range of cybersecurity risks and weaknesses. However, the adoption of intelligence-based controlling algorithms in the agricultural industry is a good use of current technical advancements to address these issues. This paper presented a secured framework for smart farming in hydroponics system. The proposed architecture is characterized into four-layer IoT based framework, sensor, communication, fog and cloud layer. Data analytics is performed using supervised machine learning techniques with intelligent and precise management and is applied at the fog layer for efficient computation over the cloud layer. The data security over channel is protected by using Blockchain Technology. The experimental results are evaluated and analyzed for several statistical parameters in order to improve the system efficacy.

Keywords- Blockchain, Fog Computing, Hydronic System, Internet of Thing, Machine Learning, Smart Farming.

I. INTRODUCTION

Smart farming, often known as "smart agriculture," is the use of the Internet of Things (IoT) to the cultivation of crops with the potential to save labor and resource use, increase fine-grained control over irrigation and fertilizing, and improve information gathering regarding planting environments. A branch of hydroculture called hydroponics uses mineral fertilizer solutions dissolved in water to grow plants, usually crops, without the use of soil. Terrestrial plants can be cultivated either with their roots supported by inert substrates like perlite, gravel, or other substrates or with just their roots exposed to the nourishing liquid. In spite of inert media, roots can change the pH of the rhizosphere and root exudates can impact the rhizosphere's life. It is a method of agriculture in which plants are cultivated in a nutrient solution without the use of soil. To give roots support, sterile mediums like as vermiculite, rockwool, gravel, sand, clay pellets, and per lite are used instead of soil. Considering the type of hydroponic system used, nutrients are given through roots in different ways, and oxygen is pumped through, the pH level is maintained, and enough light is provided to carry out photosynthesis [1] [2]. Artificial lighting is used in areas when natural light is not available. It is a cutting-edge farming technique that is now widely used in the food industry. The hydroponic approach is used to diagnose nutrient deficiency symptoms in plants and to identify critical nutrients for plant growth and development. The fertilizer solution in a hydroponic system is responsible for supplying and distributing the most important macro and micronutrients to the plants for their proper growth.

The IoT is now crucial to the success of every market. Farmers can track the current state of the plants with the help of good farming. Farmers can collect data and evaluate statistics and analysis based on the information by connecting with IoT. In a hydroponics system, an Internet of Things

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device may control pH, temperature, relative humidity, water inflow and outflow, and the amount of fertilizer solution [2]. Artificial Intelligence (AI) is a branch of computer science that is used to create algorithms that have the ability to self-learn. Machine Learning (ML) is a term that is used interchangeably with AI and it is subset of AI. The human mind learns from prior facts and performs tasks accordingly. Similarly, a large amount of previously available data is used to train the algorithm. These algorithms can generate information and develop a model of the system based on the data. Additionally, the entire framework can be prepared to predict future traits. Traditional Algorithms cannot be used to predict the correct information in smart agricultural fields. There are mainly two types of machine learning algorithms: supervised and unsupervised. And in supervised learning, there are two types: classification and regression-based learning which is decided as the output nature of dataset [3].

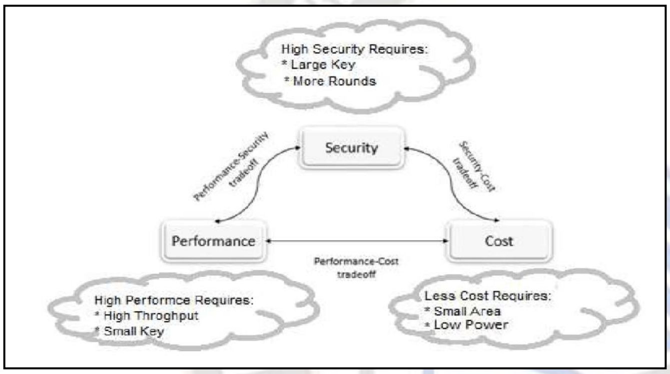

Figure 1: Performance, security and cost tradeoff for cryptosystem

Due to expenses, many IoT solutions remain pricey. Closed-source code also promotes a lack of trust. Transparency is crucial to boosting security and trust, hence open-source strategies should be considered while creating the upcoming generation of IoT solutions. Figure 1 illustrates the trade-offs between performance, security, and cost for a cryptosystem. The current cryptosystem method is mostly focused on hash-based algorithms, encryption/decryption techniques, and Blockchain technology. The main benefit of blockchain is that it enables direct communication with another person or entity without the need for intermediaries. Despite the fact that many different technologies, as shown in figure 2, utilize blockchain technology. The blockchain becomes less effective scalability, throughput, and energy consumption due to the mining process, which is undesirable in an IoT network. Even a modest portion of a regular blockchain would be too much for the majority of IoT nodes to handle. Furthermore, keep in mind that many nodes are required to store substantial volumes of data that are not relevant to them, which might be seen as a waste of computational resources. By deploying lightweight nodes, which can complete blockchain transactions, this problem could be avoided [5][8].

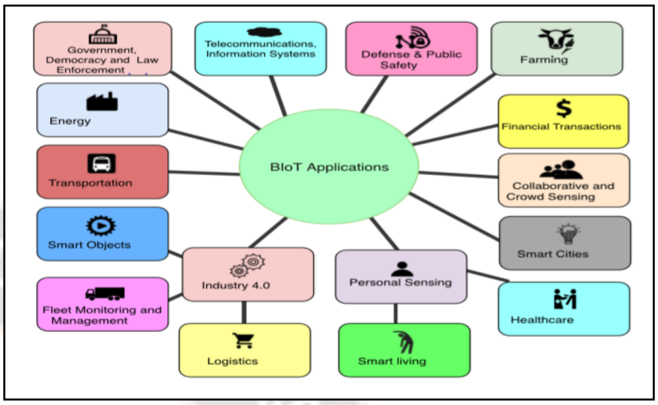

Figure 2: Related applications of Blockchain technology

Our main goal is to create a simple, autonomous, adaptable, secured and cost-effective technology that can be applied to both small-scale and industrial farming. The main contribution of this work is as follows.

- Use of blockchain technology for secured smart hydroponic system
- Design intelligent and precise management system for smart hydroponic system using supervised based machine learning approach.
- Develop supervised classification-based approach for intelligent management system and supervised regression approach for precise management system
- Improvise the proposed classification and regression machine learning model with the help of grid search hyper-tuning optimization.

This paper is structured as follows. Section 2 describes about related work of hydroponic system. Section 3 defines the methodology with experimental setups. In section 4, experimental result is discussed and finally conclusion is shown in last section.

II. RELATED WORK

The use of latest technologies for the use of smart farming is presented by various researchers are given as follows.

An intelligent hydroponic with the Internet of Things developed with a GUI that enables the user to monitor and control sensed data by building a UI node for NodeRed and combining it with realistic sensor data [4]. The system's characteristics, including the light wavelength, ideal temperature, electrical conductivity (EC), pH, and the quantity of water that system needs monitored on Thingspeak Platform, were researched and computed [5]. A smart hydroponic based IoT that employs Deep Neural Networks to control the water flow and sprinkler for the hydroponic environment depending on a number of input factors collected from sensors such as temperature, pH, water flow and humidity [6]. An automated hydroponics system for managing and monitoring plant growth has been created [8]. A hydroponic system with drip irrigation automation, nourishment plants systems, and hydroponic administration and monitoring system has been designed [9]. Overall, crop quality management through nutrient solutions is a practical method that is already in use and offers completely new possibilities for overcoming current limitations [10]. A completely automatize greenhouse with vertical farming and hydroponics, as well as superior security and monitoring systems, might become a more advanced and diverse version of present models [11]. With cloud-based IoT, the automate pyramid for an aquaponics system has been improved with predictive analytics [12]. A micro-climate horticulture system uses an electronic sensors board to track water, soil, and air quality at the location [13]. It was found that a prototype smart sprayer equipped with artificial intelligence (AI)-based machine vision software using deep learning to recognise specific target weeds and hardware with 12 separate rapid reaction nozzles for spraying performed better than its manual counterpart [14].

An IoT-enabled hydroponic installation's architecture and ongoing implementation effort. Using machine learning techniques, we want to be among the first to generate recommendations to help expert agronomists with their workload [15]. Among the IoT data gathered weekly for further investigation [16] were metrics related to the environment, the rate of population increase, and agricultural output. A smart system that uses Deep Neural Networks to provide the based on the numerous input characteristics, choose the best control action for the hydroponic environment [17]. By applying machine learning and image processing technologies to the goal of discriminating between fresh and withered vegetables, a comparison of different machine learning classifiers for the identification of fresh/withered vegetable was made [18]. A smart NFT hydroponics farm was designed and implemented using Bayesian Network inference, which atomized the crop growing process using exact inference using actuators and sensors deployed to control and monitor physical events such as pH, light intensity, water temperature, electrical conductivity, and relative humidity [19]. The study's overarching objective was to create a system that could help farmers and hydroponic farm owners with tasks like system upkeep and new system construction by making use of a commercially available, cost-effective hardware module [20]. An intelligent measurement and control system for PGC has been proposed [21], including a double-level control technique, an Android device and software, WiFi connectivity, an Internet of Things server, and a neural network model. The IPCH-Box, or Intelligent Plant Care Hydroponic Box, employs techniques of environment-driven control through the use of an Internet of Things management application called IoTtalk. Adding, removing, or swapping out actuators and sensors, as well as programming their interactions, is a breeze with IoTtalk's scalable and customizable software [22]. An automated microcontroller system for aquaculture in deep water has been created. It is essential to maintain a stable pH in the reservoir to ensure adequate nutrient uptake by the plant [23].

A flexible deep learning-based system is suggested and put to the test in a variety of potential circumstances [24]. The tracking and traceability of soybeans throughout the agricultural supply chain is effectively accomplished via a method that makes use of the Ethereum blockchain and smart contracts [25]. The Blockchain Machine Learning-based Food Traceability System (BMLFTS) [26] is a revolutionary extension of blockchain technology, machine learning technology (ML), and a fuzzy logic traceability system based on the shelf-life management system for manipulating perishable food. Methodology for routinely checking the quality of a shield tunnel's prefabricated lining rings [27]. In [28], the authors detail a decentralized authentication and access control method for mobile IoT devices that may be used in different contexts. [29] offers a fresh evaluation of the literature on blockchain in IoT. A blockchain-based solution has been offered [30] that eliminates the need for middlemen, information transfers, and a safe centralized architecture, improves performance, and complies with strict security and integrity requirements. An intelligent video architecture [31] that incorporates Blockchain technology and machine learning facilitates the exchange of important video data as permitted events on a public blockchain of the Hyperledger network.

The smart robot needs to identify weeds and eradicate them, determine how much pesticide is needed, plant seeds, measure soil moisture, transmit data wirelessly, and pinpoint the precise location of crops [32]. Protecting BT-based smart applications from cyberattacks [33] is a growing area of study and application for machine learning. In [34], we see a blockchain- and smart-contract-based Internet of Things (IoT) architecture for the Smart Home that solves all the major problems. It has been suggested that the requirements of the Internet of Things can be met by a layered Lightweight Scalable Blockchain (LSB) [35]. In this article [36], we examine how blockchain technology may affect farming and the distribution of food. In order to support a variety of lightweight client instantiations, the SmartLight method [37] permits the incorporation of filters/libraries into smart contracts.

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III. MATERIALS AND METHODS

1 PROPOSED SECURED FRAMEWORK FOR SMART FARMING IN HYDROPONICS

The proposed secured framework for smart farming in hydroponics system is as shown in fig 3, discussed below.

1.1 Hydroponic Farm Site

We assumed in our suggested experiment that the hydroponic site consisted of a fully atomized nutrient film technology based hydroponic model with sensors and actuators. In a hydroponic system, various sensors for monitoring pH, electrical conductivity, light intensity, water temperature, air temperature, air humidity, and water level, as well as actuators for controlling light sources, humidifiers, water pump, and nutritional solution pump, are placed.

1.2 Device Layer

In device layer, sensors and actuators are interfaced with a microcontroller to collect data from sensors, process it, and then control actuators based on the control signal provided by the analytics system in the fog layer.

1.3 Communication Layer

In communication layer, data is communicated between device layer to fog layer and vice versa by using various communication medium wifi, bluetooth, satellite and GSM.

1.4 Fog Layer

In fog layer, data analytics system is deployed, which is developed using machine learning algorithms. Intelligence system is created based on expertize knowledge, which is collected from device layer under the observation of experts from experimental setups.

1.5 Cloud Storage

Real time data from prototype developed hydroponic system can be monitored and stored on cloud storage. An UI based application visualizes the real time data and respective controlling action status.

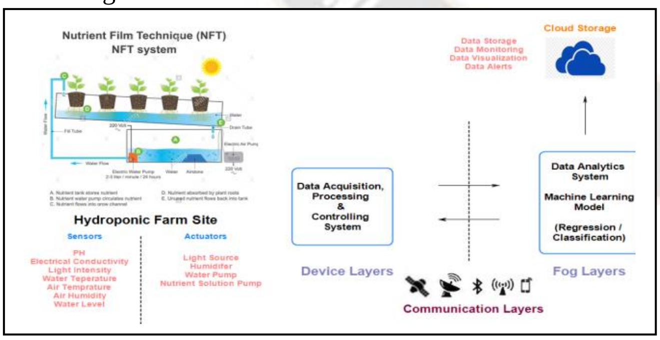

Figure 3: Proposed smart hydroponics framework

2 DATA ANALYTICS SYSTEM

Figure 4 depicts the proposed approach established at fog layer for use in a data analytics system, with machine learning algorithms commonly employed for classification and regression modelling as detailed in further depth below.

2.1 Create and Access Dataset

To train a model using data collected in an experimental setup, machine learning requires splitting the data into train and test sets, each with its own copy of the output data label. The train-to-test split ratio was utilized to divide the data into a 70% training/30% evaluation split. Below the two types of datasets or situations used, that utilized in our research to put this idea into practice.

2.2 Dataset Type - 1

The dataset used in this investigation [16] was compiled from an earlier study that investigated lettuce cultivation in Nonthaburi Province. From February 2017 through August 2018, 326 samples were taken, representing 8 distinct planting seasons. Key elements of our data collection include environmental parameters present during farming, weekly records of growth factors, and measured growth factors. They have collected readings on a per-day and per-hour basis.

2.3 Dataset Type - 2

A hydroponics plant for many crops was set up in PKV, Amravati, and real-time data from there was included into the system (lettuce, broccoli). They employ instruments to classify the results as poor, average, good, or great, depending on the plant's condition. Over the course of two years, they measured a single parameter every day to compile the dataset.

2.4 Feature Engineering

The dataset is in *.csv format, and the 'python' computer language may be used to extract the raw data. Data collection and the use of machine learning techniques like classification and regression are aided by this procedure. Feature Extraction is a process that identifies undiscovered features from a dataset by selecting and combining features to create a smaller feature subset, all the while maintaining a precise and complete relationship between the dataset and its features. For machine learning methods like clustering, classification, etc., Feature Selection is the process of selecting features from a dataset. Many techniques, like univariate analysis, correlation analysis, etc., can help you get there. Univariate feature selection, which just uses one statistic to determine which characteristics are optimal, is what used here.

2.5 Develop Predictive Model

When the features have been extracted from the datasets, the train and test features are acquired. Stochastic Gradient Descent (SGD), Support Vector Machine (SVM), and Multi-layer Perceptron Neural Network (MLPNN) are then used to train the model as supervised classification and regression machine learning methods (MLP). Therefore, effective parameters must be tweaked or established during training with hyper-parameter tuning to achieve the best classification result of the test dataset.

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2.6 Deploy Model

As part of the deployment process, data is put through its paces against the trained model and the system's performance parameters are analyzed. Labels created from predicted output are utilized to feed data into a hydroponic model at the device layer, which is controlled by the cloud layer.

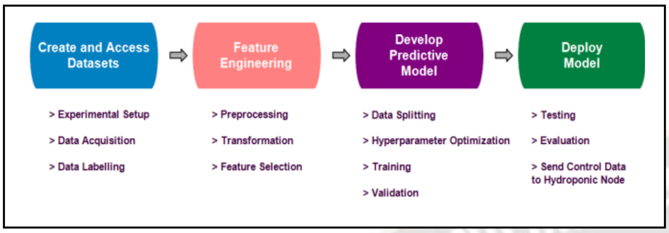

Figure 4: Data Analytics System Deployment Lifecycle

3 PROPOSED ALGORTIHMS

INPUT:

"Features Set"

Hydroponics attributes, Dataset 1 –

Input - (Bath, table, DATE, light duration, Over 540 Lux, Over 1080 Lux, Over 2160 Lux, Over 3240 Lux, Over 4320 Lux, Over 5400 Lux, Over 8100 Lux, Over 10800 Lux, Over 16200 Lux, Maximum light intensity (lux), Minimum light intensity (lux), Average light intensity (lux), Maximum humidity (percent), Minimum humidity (percent), Average humidity (percent), Maximum temperature (Celsius), Minimum temperature (Celsius), Average temperature (Celsius), Maximum temperature water (Celsius), Minimum temperature water (Celsius), Average temperature water (Celsius))

Output - (Number of leaf, Avg Leaf area, Stem diameter, Plant height, Avg Plant width)

Hydroponics attributes, Dataset 2 –

Input - (ph, ec, light intensity, water level, air temperature and humidity)

Output – (poor, average, good, excellent)

OUTPUT:

Predicted Output with labels (classification) and values (regression).

PROCEDURE:

Step1: Features are gathered, cleaned, and labelled using datasets' original values.

Step2: Make use of feature engineering on all of the feature data

Determine the missing data, fill in the means, etc.

Find the value of the normalised feature set.

The feature data must be scaled to a certain range.

Step3: For classification and regression, decide between SGD, SVM, and MLP, three machine learning models.

Step4: Select a hyper-parameter value range for ML algorithms.

Step5: Applying the Grid Search CV Optimization technique, we may fine-tune the hyperparameter values.

Step6: The best estimator for the chosen classifier may be found by calculating the best possible score.

Step7: To ensure the validation of your model, try using the K-Fold Validation Learning Approach.

Step8: Tune the hyper-parameters of your choice for the machine learning training process.

Step9: Collect feature and label information for a training set from scratch.

Step10: For each ML algorithm, train the model.

Step11: To ensure the model's accuracy, use a K-fold cross validation technique.

Step12: If validation is successful, the trained model is saved or deployed; otherwise, steps 2 and 8 are repeated.

Step13: Build the test dataset's features from scratch.

Step14: ML methods should be loaded with the learned model.

Step15: Predict the results whether its class1, class2 or class 'n'. (classification, Regression)

Step16: Evaluate RMSE (Regression) and Plot Confusion matrix between actual and predicted label data (Classification) to check system accuracy.

Step 17: Calculate the ROC and the TP, FP, TN, and FN parameters of the confusion matrix and evaluate the efficacy of the "C" classification model

4 DATA SECURITY SYSTEM USING LIGHTWEIGHT BLOCKCHAIN

The proposed lightweight blockchain mechanism for smart farming system is as shown in figure 5. The diagram shows the data flow from device layer to fog layer communication with blockchain mechanism.

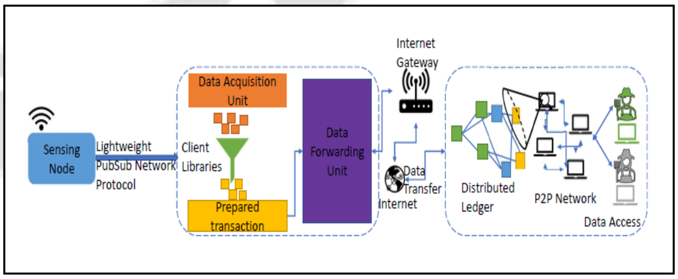

Figure 5: Lightweight Blockchain Mechanism

Lightweight hashing algorithms that are used to block mine each node's detected data. When building the hash list, it's important to choose a hash algorithm that can provide security cryptographically and can be implemented in a minimal space. Additionally, a few compact hash algorithms are chosen based on two criteria. The output size of the

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lightweight hash function is 256 bits, first. The output size's security strength is insufficient if it is less than 256 bits. The SHA-1 practice attack, which produces data with a 160-bit output size. Second, it should be compactly constructed to serve the specific functions of the resource-constrained devices, such as IoT devices, on which the suggested architecture is focused. IoT devices can only execute one specialized task, therefore they lack the memory or processing capability to compute area or install a hardware module.

4.1 Algorithm: Data Uploading Steps
Input: Temperature, Humidity, Water level and other sensor data from sensing node
Output: Hash of a transaction from a private distributed ledger
Step1: For each sensing node S, a topic is produced.
Step 2: Every edge node. E is capable of subscribing to topics from various sensing nodes.
Step 3: E.subscribe(τS)
Step 4: For each interval of time ti do
Make a message μ with Humidity(hum), Temperature (temp), Water(wat) and Other sensing data (OtherD)
S.Publish (τ,μ(Hum, temp, Wat, OtherD))
end for
Step 6: while for each Message ∈ topic τ do
E ← Receive (τ , μ)
Run the selection algorithm in E.
A Proof-of-Work (PoW) is computed by an edge node and Nonce.
Prepare the payload ρ from Client (μ(hum, temp, SensedData),η)
Prepare the Transaction Γ from Client (ρ,η)
if connection of client is established? then
result - Connect and send the Transaction (Γ)
else
Connect the client with Provider URL and Port
result – Connect and send the Transaction (Γ)
end if
return Hash value of Lightweight Function
end while
4.2 Algorithm: Data Accessing Steps
Input: Client and Root Node, Port Number
Output: Collected information from a tangle
Step1: Using the streams framework, a channel τ is produced.
Step 2: Publisher Y access to the intended recipient's public key information, Kpub, and encrypt data before transmitting it to the ledger.
Step 3: In order to receive messages from Publisher Y in real-time, Recipient subscribes to the desired channel.
Step 4: Subscribe the channel with topic (τ)
Step 5: while each message ∈ stream τ do
Message ψ sent to the recipient ρ is encrypted. Recipient receives encrypted message
Receive the topic (τ) to recipient ρ.
Receiving party's private key Kprv is used to decipher encrypted data ψ.
Decrypted the encrypted data ψ with private key Kprv to get the message μ.
Results could show decrypted messages.
if connection of node is not established? then
Connect the Client having Client Node, Port and URL
end if
end while;

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The classification was performed on a Windows 10 (64-bit) laptop with a 2.30GHz Intel (R) core (TM) processor, 8GB of RAM, with no other applications open. As for software, the Pycharm IDE, Anaconda Distribution, with the Scikit Learn Machine Learning Toolkit used. The RMSE, Confusion Matrix, Accuracy, Precision, Recall, and F-score are examined as performance measures.

Table 1 and 2 describes the hyper-parameter required to tune the regression and classification modelling. The last column indicates that final hyper-parameters which are used to train the regression and classification based machine learning model.

Table 1: Hyper-parameter Tuning for Regression Modelling

Prediction Algorithm (Regression)	Model Parameters	Range Searched	Range Selected
SGD Regressor	max_iter	100,500, 1000	1000
	random_state	1,01,00,500	100
SVM Regressor	max_iter	10, 30, 50	10
	kernel	rbf, poly, sigmoid	poly
MLP Regressor	max_iter	100,200, 300	200
	Hidden_layer_size	10, 50, 100	100

Table 2: Hyperparameter Tuning for Classification Modelling

Prediction Algorithm (Classification)	Model Parameters	Range Searched	Range Selected
SGD Classifier	max_iter	100, 500, 1000	500
	random_state	1,01,00,500	100
SVM Classifier	max_iter	10, 30, 50	30
	kernel	rbf, poly, sigmoid	rbf
MLP Classifier	max_iter	100, 200, 300	300
	Hidden_layer_size	10, 50, 100	100

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The evaluation time required to train and tests the both classification and regression model is defined in table 3. It is observed that MLP algorithm required maximum time to train or to test the model due to maximum number of hyper-parameters available as shown in figure 6.

Table 3: Evaluation Time for train and test phase

Phases	Evaluation Time (sec)					
	Regression			Classification		
	SGDR	SVMR	MLPR	SGDC	SVMC	MLPC
Training	300.15	315.78	446.27	298.61	308.42	419.64
Testing	65.44	72.95	75.21	68.75	71.93	72.83

Fig 6: performance evaluation time for different classifier model

The RMSE metrics are used to characterize the effectiveness of a regression model as shown in table 4. From figure 7, it is cleared that SVM has least RMSE value as compared to other regressor algorithms. Also, classification model efficiency is evaluated using confusion matrix parameters, figure 8 shown the confusion matrix for respective classifier model. Table 5 described the performance metrics calculated based on confusion matrix. It is observed that all metrics has efficient value in case of MLP algorithm as shown in figure 9.

Table 4: Root Mean Square Error Value for Regression

Regressor	**Avg RMSE**
SGD	0.15
SVM	0.12
MLP	0.13

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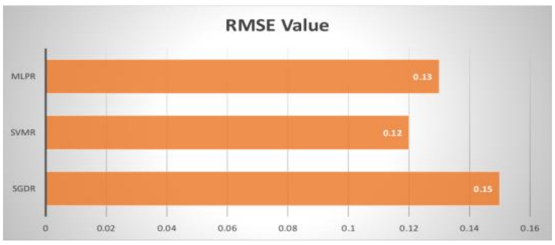

Fig 7: Root mean square value (RMSE) for different regression model

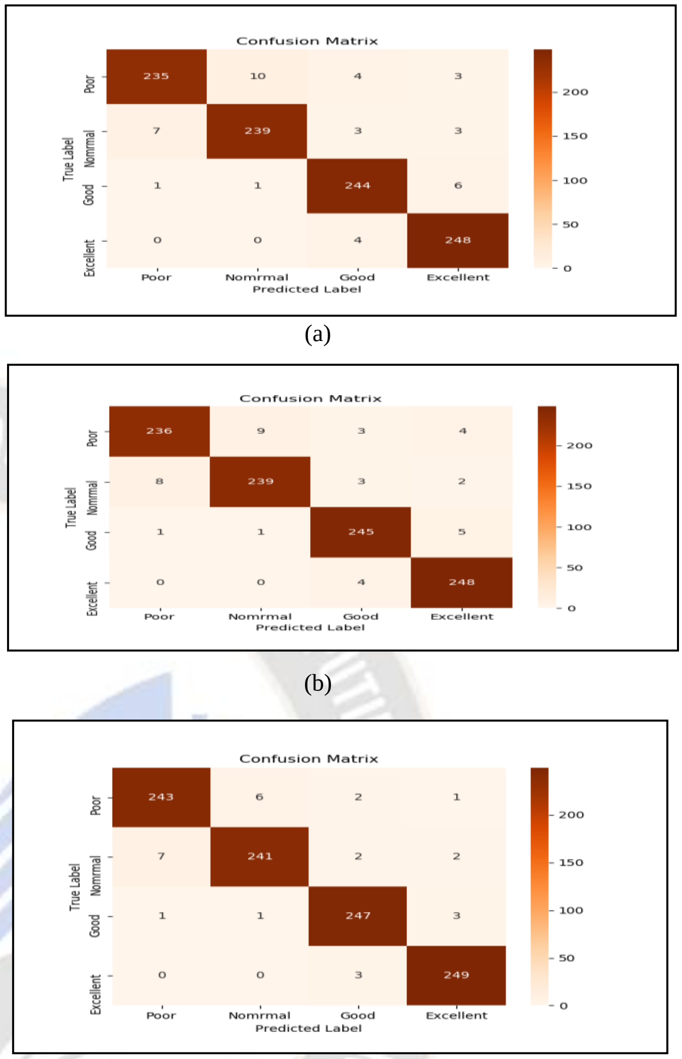

Fig 8: Confusion Matrix Plot for different classifiers, a) SGDC, b) SVMC, c) MLPC

Table 5: Performance evaluation parameters of different classifier system

Classifier	Accuracy (%)	Precision (%)	Recall (%)	F-score (%)
SGDC	95.8344	95.8446	95.8333	95.824
SVMC	96.0326	96.0364	96.0317	96.0226
MLPC	97.2222	97.2203	97.2183	97.2223

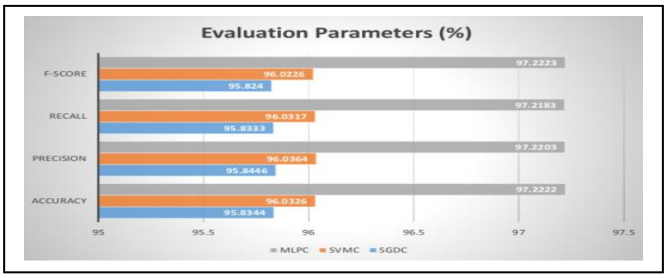

Fig 9: System evaluation parameters plot

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The lightweight blockchain mechanism is simulated and analyzed in python environment by creating hash block for respective sensed data from device layer. The performance of lightweight hash is analyzed for latency, throughput as shown in figure 10-11. It is observed that proposed system has better output than existing system.

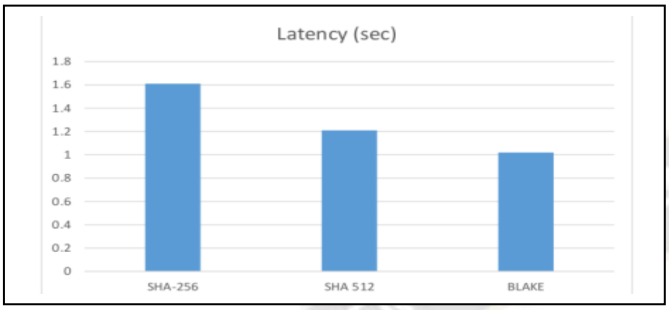

Fig 10: System evaluation parameters plot

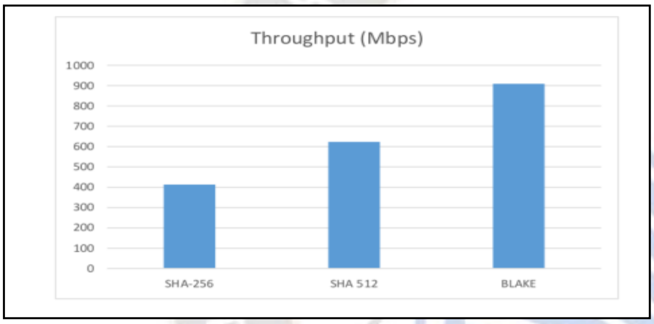

Fig 11: System evaluation parameters plot

The proposed system is compared with existing work in terms of techniques used, with their shortfalls and accuracy values as described in table 6 and table 7. The experimental results in proposed approach are efficient as compared to existing scenarios.

Table 6: Comparative studies among various existing approaches

Ref	Methodology	Techniques Used	Shortfalls/Advantages	**Accuracy**
SK 40C [11]	Automation of pH control	-	Focus on automating pH regulation.	90%
Raspberry Pi [36]	An intelligent system with ecological benefits	Bayesian Network & Machine Learning	Less information to analyse	66%
[37]	Extraordinarily precise in making forecasts	ANN and fuzzy logic	Expensive system	97%
Arduino Yun [41]	Good scalability and configurability	IoT Talk	Adaptable to large-scale systems	38%
Arduino Uno & Raspberry Pi 2[42]	Has improved efficiency with CEA	Web Based Analysis	No intelligence is added to the data collecting process.	90%
Arduino Mega, Raspberry Pi[50]	Real time Data Acquisition	Deep Neural Network	Analysis conducted using data from low-volume productions	88%
Proposed Approach	Used Real Time Dataset for different conditions	Fog Based Machine Learning Analysis (Regression/Classification)	1.Considered all possible parameters used in hydroponics, 2.Intelligence system with two kind of output nature 3. Smart and precise management using classification and regression 4.Enhance security framework 5.Consider more hyper-parameters to tune algorithm	Acc - 95-98% RMSE – 0.1-0.15

Table 7: Comparative analysis based on technologies used

Items	**Traditional centralized system [24]**	**Soybean traceability system [25]**	**BMLFTS-based system [26]**	**Maintenance system [27]**	**Proposed Scheme**
IoT	No	No	No	Yes	Yes
Data Protection Mechanism	No	No	No	Yes	Yes

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Decentralization	None	Low	Low	Low	High
Fog Intelligence	No	No	No	No	Yes
Computation Complexity	High	High	Low	Medium	Low
Authenticity of Source Data	No	No	No	No	Yes
Credibility	No	No	Yes	No	Yes

V. CONCLUSION

In this paper, a secure, fully automated smart hydroponics system is presented that can use Internet of Things and Blockchain ideas and technology to the an existing approach. A user may keep tabs on and adjust realistic data flowing between their device and the fog layer, and vice versa, with the use of a framework that uses real-time sensor data. Information is also stored in the cloud and may be accessed from anywhere. Hydroponic food production systems can benefit from the Internet of Things idea by centralizing their growing and monitoring processes in a safe cloud environment. The internet of things provides a framework for cloud-based system monitoring, which helps reduce maintenance costs—one of the most pressing problems in automation today. Finally, the smart hydroponic system's performance is evaluated for prudent and precise management through regression and classification supervised machine learning algorithms. However, further work might be done to improve the system by using data analytics or machine learning to construct algorithms that foresee outcomes, by adding more sensors to obtain more precise data, and by supporting the Artificial Intelligence system in making the prediction.

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