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Deep Learning based Robust Food Supply Chain Enabled Effective Management with Blockchain

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Abstract: The supply chain for agriculture is heavily involved in daily life. While farmers are focusing on maximizing their profits, product safety is given greater consideration. Furthermore, the production of agricultural products is dynamic, making it difficult and time-consuming to track their production and distribution. With regard to these circumstances, we suggest a safe framework built on blockchain technology for tracking and controlling the supply of pulses combined with factory storage capacity. Analysis is done on production, shipping, penalty, and storage costs. The AlexNet architecture is suggested in order to increase profitability and manage production to improve storage. This helps to supply the products and categorizes the retailers' needs properly. A simulation is run, and the robustness of the suggested work is evaluated by contrasting it with various methods such as supply chain management (SCM), fully CNN, and Deep reinforcement learning with supply chain management (DR-SCM). The methods such as SCM, FCN, DR-SCM and proposed work provided the accuracy levels of 80%, 85%, 88% and 96.1% due to 10000th episodes. The results demonstrate that the suggested effort boosts production and profitability.

Keywords: Agri-products, Supply chain, Blockchain, Secured, AlexNet.

1. Introduction

Food on every individual's chart is made possible by the food supply chain [1], it involves a series of phases starting with the producer and ending at the meal with the client, there are other parties involved in this cord, such as merchants, suppliers, and producers. Each party included in the supply network of agricultural, that involves cultivators, seed creators, vendors, suppliers, financiers, carriers, and risk managers participate in the formation of nutritional groups. The manufacturing, accumulation, interpreting, dissemination, and ingestion of nutritional products [2] as well as the elimination of waste are all included in the primary framework, as is an additional set of amenities that facilitate this movement, these events take place in both an inherent and social setting. The commodity or final good to a client is delivered by requiring each stage present in the supply chain.

When the customer can get the goods, the completed goods towards store location or warehouse shipped in which moving them to the industrial facility and the initial supplies located the process. Food Chain Management (FCM) [3] considers the alimentary fabrication network as a whole, starting with the initial cultivation and continuing through processing and delivery to end users. By minimizing the requirement for storing and antimicrobial use, operating regionally instead of shipping goods across town improves the product's general condition and gives consumers the availability of an unlimited supply of products. Minimal distribution chains in the agricultural business also save cultivators' and manufacturers with removal costs and waste.

The ideal ratio of stock, shipping, and production expenses are determined based on the supply chain that controlled and organized via various methods. The method by which a business organizes and controls its supply chain to determine the ideal ratio of stock, shipping, and production expenses is known as supply chain planning [4]. The providers of parts, basic supplies, and assistance that a business requires to create and transfer its goods to downstream or final buyers are included in the concept of a supply chain framework. An official method for regulating the connections between a company and its vendors is called supply chain management. The main objective of the supply chain administration creating this plan typically is to maximize productivity at all levels of the manufacturing procedure. The movement of products and components is managed by a supply chain straight connected is enclosed with this procedure, including entities, assets, statistics, and each worker. Distribution chain developments assist altogether categories of industries by enhancing productivity and plummeting expenditures. The negative effects of a supply chain reverberation include inadequate client service, failure to comply, extended manufacturing cycles, growing logistical expenses, tardiness in delivery, and inefficient control of inventory.

Deep Learning combined with Blockchain has the potential to revolutionize food supply chain management by providing enhanced traceability, quality control, predictive analytics, real-time monitoring, fraud detection, compliance automation, supply chain collaboration, and consumer empowerment. By leveraging these technologies synergistically, stakeholders can create a more resilient, efficient, and transparent food supply chain ecosystem.

The balance section of this paper is organized as: The survey of the existing research is analyzed in section 2. The system model of secured supply chain prototypical is encompassed in section 3. The problem formulation is made in section 4. The proposed method for the enhancement of profit of farmers is enclosed in section 5. The simulation is demonstrated in section 6 and section 7 end up the article.

2. Literature survey

Bhutta et al. [5] have demonstrated the supply chain management (SCM) process to enhance cooperation between distribution system partners. These devices collect data related to the health distribution system, such as identifying objects or people with tags and identifying changes in the immediate surroundings. Enterprises run the possibility of undermining or potentially undermining the positive because it is an erroneously changeable situation. Its goal is to create a dependable Internet of Things-based surveillance and interaction network. As such, it is antiquated, cumbersome, and ineffectual.

Zawish et al. [6] have presented a fully CNN (FCN) model that is applied to estimate productivity using UAV-captured photos. It justifies the prospect of continuous reduction to give numerous job-related simulations with different complications and precision instead of an individual-constrained FCN framework for implementation on UAVs. In a 6G-enabled adaptive UAV system, the suggested design decision technique will help UAVs modify the representation according to temporal bandwidth needs, therefore mitigating the consequence of mission rejection. It is still unsatisfactory in convoluted environments.

Hassija et al. [7] have implemented a blockchain-based framework to support the agricultural network by fostering an ecosystem of cultivators and sharing the information producer’s supply. The findings indicate that thanks to incentives, the approach ought to be able to attract a broader range of players. In a distributed topology, every sub chain can continuously change the number of events based on its available bandwidth. The frequency of transactions is the fundamental speed of computation thanks to configurable fragmenting. It is beneficial to include a parallel database framework to offset the shortcomings of the suggested architecture. Nevertheless, client idleness may render such designs ineffective.

Deep reinforcement learning with supply chain management (DR-SCM) was suggested by Chen et al. [8] to maximize profits by making wise choices about the cultivation and warehousing of agricultural goods. The usefulness of the recommended blockchain relies upon structure and the technique of DR-SCM for agri-food supply chains (ASC) enhancement is confirmed by the complete simulation investigation. Furthermore, the DR-SCM realises outstanding knowledge concert in various ASC administration circumstances while outperforming qualitative learning and typical unconventional approaches in terms of compensation. To evaluate feasibility in real-world contexts, nevertheless, is insufficient.

Dayana et al. [9] highlighted circular blockchain oriented bitcoin and traceability calculation in agricultural nutrition crop systems to achieve authenticity and integrity. The distribution network is transparent and identifiable since every activity is handled in a decentralized global database that is

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connected to a randomized storage system. Customers and other participants can see through all of the manufacturing chain's connected processes. With the use of QR codes, food monitoring is effectively handled, fostering a connection of credibility between farmers and consumers. The suggested solution offers sharing, quick settlement, a distributed database, agreement, and reliability. Fixing service-related issues thus gets more difficult.

3. 3. System model

In our work we proposed an agricultural product supply chain and to safeguard the products we adopted the blockchain. The blockchain based proposed system model is depicted in Figure 1. The consensus issues of the Bitcoin network are solved with the association of blockchain, since the blockchains are made of several blocks along the chain. The data are stored in a block and attached to previous blocks and thus form chain. The addition of block is performed with the verification of PoW task of all the participants. Hence it ensures the security of the supply chain. In Figure 1, the digital data are gathered using the technologies such as QR codes, bar codes, RFID, near field communication (NFC), mobiles, and sensors. These data are added to the chain as blocks after the validation and is preserved for the future usage as a permanent document. The elements presented in the proposed system model are,

- **Providers:** The seeds, fertilizers, and pesticides are bought from the providers for the farmers.
- **Farmers:** The trace the information such as cultivation process, transaction details from the providers to the processors, weather, farming practices, etc.
- **Processors:** To trace the information such as processing, factories, transactions by the distributors, and the farmers etc, this module is used.
- **Distributors:** To trace the details such as storage, transportation, communication and transaction among the retailers and processors are made with this module.
- **Retailers:** To trace the quality, price, quantity along with the expiration dates this module is used. Moreover, the transaction details of consumers and distributors are collected from this module.

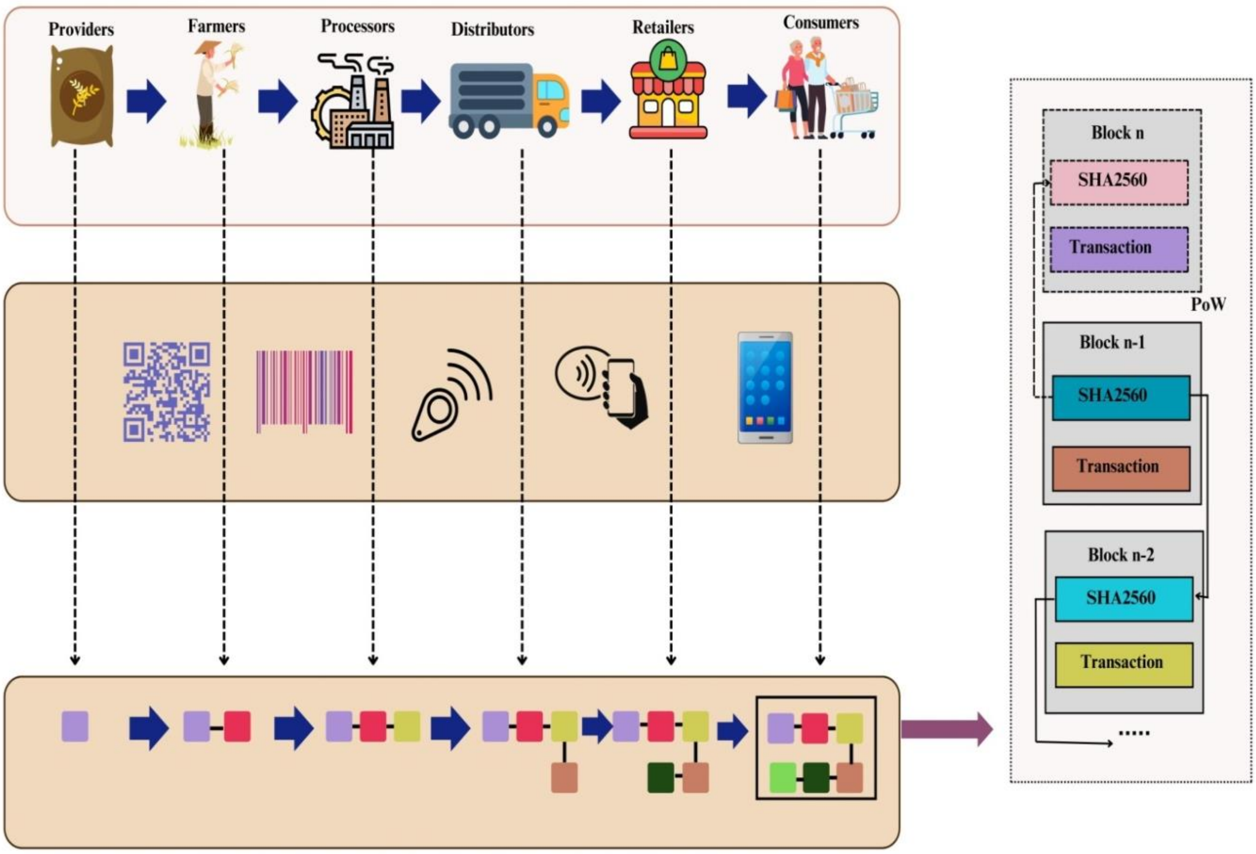

Figure. 1 System model of the proposed secured supply chain

Consumers: To trace the information of agricultural products from the providers by the consumer this module is used. Mostly mobiles phones are used to trace the information.

The puzzle used for the mining of the blocks are expressed as below,

$$Findms.t.SHA256\big(SHA256(f.m)\big) < target \quad (1)$$

The contents presented in the block is f with the random number m and the string concatenate operator is $'.'$, the hash function $SHA256()$is used to evaluate the 256 binary number. The small value of this denotes that the arduous in the mining to solve the puzzle successfully.

4. Problem formulation

To improvise the productivity and income of farmers we employed the problems faced during the supply chain in this section. For the formulation we have deemed the processor with pulse factory and various retailers. The pulses are shipped to retailers via the distributors from the factory with the association of truck. The amount of production of pulses and sorted at the processor followed by the shipping to the retailers are determined. The demands for the pulses are vary with the retailer and if that is not attained, punishment will be given. In reality, the limitations of the production, processor storage and retailers' storage shortage also considered [11]. Meanwhile, sometimes, the demand might exceed the processors' production capacity and make them to meet the need. This can be tackled with the efficiently rebuilding the stock by the processor and retailers based on the demands.

Consider one processor p_0 with multiple retailers such as $R = \{p_{1,}p_2, \ldots, p_m\}$. For simplification, we have combined the problem as$P = \{p_0, p_1, \ldots., p_m\}$. The total turnover of selling the pulses by the retailer is expressed as,

$$T_u = v. \textstyle\sum_{j=1}^{m} D_i \quad (2)$$

The price of pulses per kg is determined as v with the demand of pulses by the retailers are taken as $D_j = \sum_{n=1}^{N} D_{j,n}$ within the time period of N. in this work we considered the time period as 12 months. The demand for the pulses for the time period is expressed as,

$$D_{j,n} = \left\lfloor \frac{D_{Max}}{2} + \frac{D_{Max}}{2}.sin\left(\frac{(2j+n).\Pi}{6}\right) + ST_{j,n} \right\rfloor \quad (3)$$

The maximum demand by the retailer is D_{Max} with the stochastic factor of $ST_{j,n}$ with the arbitrarily allocated value of 0 and 1 with varying intervals. This is used to trigger the increasing demand of the pulses. The production cost of the pulses is given as,

$$C_P = c_{pr}.b_0 \quad (4)$$

The production cost of pulses per kg is $c_{pr}$and the capacity of the production of pulses of the processor is b_0. The next step is to evaluate the transportation cost of the pulses as,

$$C_{Tr} = \textstyle\sum_{j=1}^{m} \left(c_{\rho,j}.\left\lceil \frac{b_j}{\rho_{cap,j}} \right\rceil\right) \quad (5)$$

The shipping charge of truck from the processor to the retailer is $c_{\rho,j}$with the capacity of $\rho_{cap,j}$. The volume of transportation of the retailer is b_j. The cost of storing the pulses is given as,

$$C_{St} = \textstyle\sum_{j=0}^{m} \left(c_{\beta,j}.ST_j\right) \quad (6)$$

The storage cost of the pulses is $c_{\beta,j}$ with the stock level of processor as ST_j. The penalty met while the demand is not satisfied can be defined as,

$$C_{Pe} = c_{Peu}. \textstyle\sum_{j=1}^{m} \left(D_j - ST_j\right) \quad (7)$$

The penalty of the pulses per kg is c_{Peu}. The total profits of pulses production are estimated as,

$$Profits = Total - CTr_{St_{Pe_{Pr}}} \quad (8)$$

Thus, the problem is stated for the proposed work.

5. Proposed AlexNet structure-based supply chain management of agri-products

The proposed AlexNet framework is used for enhancing the production of pulses and improving the storage capacity for the higher profitability. The proposed framework is elucidated in the following section.

5.1 AlexNet structure

In this study, there different layers are presented in the AlexNet structure based on CNN. From this, five convolutional and remaining three are fully connected layer. Apply initiation operation of ReLU, 3×3 size of kernel, 32 as filter size of the convolutional layer. The classic CNN based AlexNet with the data limit the size. The classic AlexNet

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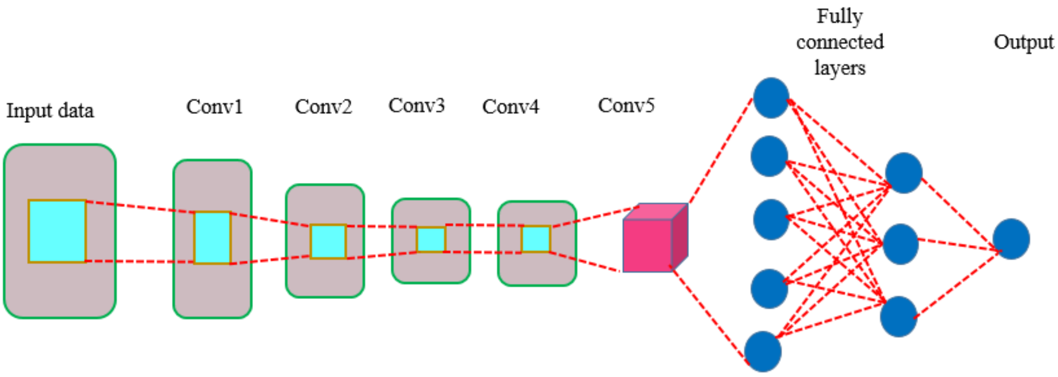

Figure. 2 Structure of AlexNet model

structure required a parametric adjustment. The error value among the real and predicted result is minimized. AlexNet model utilizes data input and merge the data from two procedures. Next to the model of fully connected layer, add Dropout. In each situation, set the proportion of every neuron unit training. During the process of training, certain probability with hidden node output to zero. While node updating node weights, update the weights during the process of training.

$$R = n * b(Mu) \tag{9}$$

Based on above expression, the matrix dimension is $(D \times m)$ and the column vector dimension is M. Where, $b(x) = 0$ satisfies the function of excitation is $b(x)$. The corresponding elements multiplies $b(Mu)$ and n.

The data performs non-linear transformation is activation function. The neuron from the input to the next layer send the transformation output [10]. Where, 0.2 is for dropout value, 2×2 as the max pooling layer size. The second convolutional layer apply the output of initial convolutional layer. Similar number of outputs and inputs with each supply chain to the layer of flatten. The dense layer input utilizes flatten layer output. There is the values of 128 units of second hidden layer and 64 for initial hidden layer. According to the hidden layer, ReLu as the function of activation and the function of activation has 10 units.

According to the ranges of [0, 1], the predictions or distribute learning outputs from the existing layers are served via softmax. The CN predicts the softmax that produces highest values. Following equations express the softmax function formula. All elements with the total number are M and each element index is i.

$$\beta(x)_i = \frac{e^{x_i}}{\sum_{i=1}^{M} e^{x_i}}, i = 1,2,..,M \tag{10}$$

The best CNN model is determined by utilizing the number of layers depending upon various investigations that demonstrates the prediction outcomes of supply chain. It also manages the production outcomes, storage capacity both processor and retailers, and transportation cost. Figure 2 describes the general architecture of AlexNet model.

6. Experimental investigation

The proposed blockchain based deep learning model with its evaluation is validated in this section thereby providing comprehensive results based on comparative investigation by four classic approaches namely SCM [5], FCN [6], DR-SCM [8] and CBTB [9]. The RAM 8.00GB DDR4 and Intel CoreTM i7 CPU @2.30 GHz with Windows 1064-bit construct the simulation environments. The real-world data settings to Python 3.6 to implement three various experimental investigation. The storage cost, capacity, production cost and fixed maximal production level with one scenario is accomplished.

The single retailer is selected in this scenario and it results are represented in Table 1. Where, $SC = 27tons$ is the storage capacity, $st_{cost} = 0.26k$ is the storing pulses cost of retailer. Set $tr_{cost} = 0.6kRMB/truck$ is for shipping pulse struck cost depending upon retailer factory.

Table 1. Single retailer with simple scenario

Parameters		Values
Trucks	Truck-1	$SC = 27tons$ and $st_{cost} = 0.26k$
	Truck-2	No
	Truck-3	No
Retailers	Retailer-1	$tr_{cost} = 0.6kRMB/truck$
	Retailer-2	No
	Retailer-3	No

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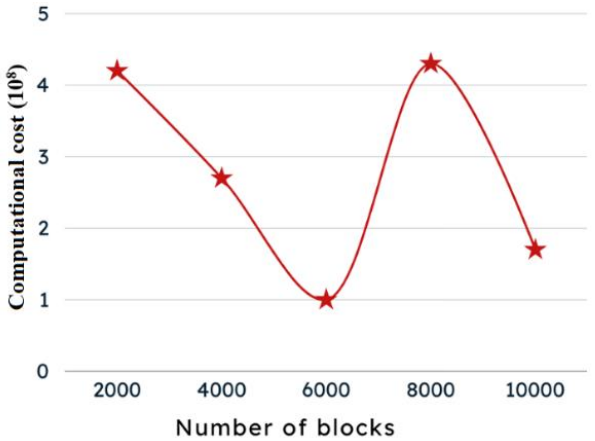

Figure. 3 The number of blocks with respect to the computational cost

Figure 3 plots the number of blocks with respect to the computational cost. To provide tracing data, the proposed blockchain-based scheme efficiency is computed. According to blockchain, various numbers of blocks with the hashes based on average computational cost is computed and plotted. While executing the operation of hashing, enlarger computational resources are consumed with blockchain network that we obtained from the results. The unique and consistent tracing data in which the global consensus is ensured. For agricultural products, the decentralized security is guaranteed the framework of blockchain.

The comparative study based on the number of episodes with respect to the profits is as shown in Figure 4. The methods namely SCM [5], FCN [6], DR-SCM [8] and CBTB [9] is compared with proposed model to analyze the profits of each method in retail industry. Generally, grows the number of episodes by increasing various methods with its reward or profits. The operations are controlled by predefined threshold that utilizes based on the comparative methods. The proposed work attains higher profits than other SCM [5], FCN [6], DR-SCM [8] and CBTB [9] methods.Figure 5 illustrates the overall accuracy. The number of episodes changed from 2000 to 10000 in which the accuracy is also get increased gradually depending upon the episodes. The methods such as SCM [5], FCN [6], DR-SCM [8], CBTB [9]and proposed work provided the accuracy levels of 80%, 85%, 88%, 90% and 96.1% due to 10000th episodes. The accuracy values of proposed work are higher than that of existing SCM, FCN, DR-SCM and CBTB methods.

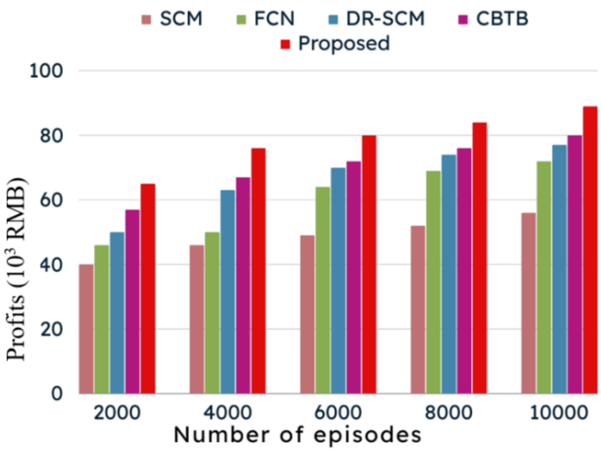

Figure. 4 Comparison based on the number of episodes with respect to the profits

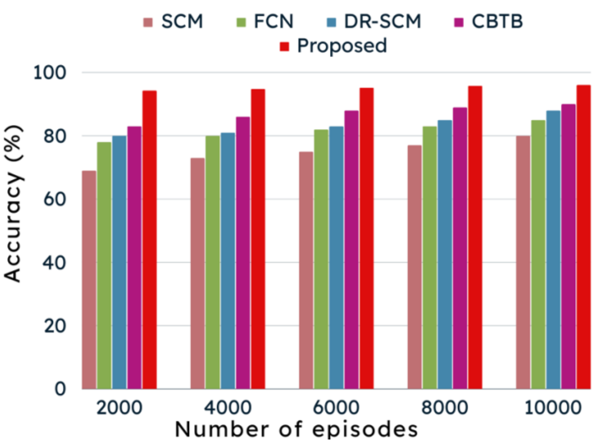

Figure. 5 Comparison based on the number of episodes with accuracy

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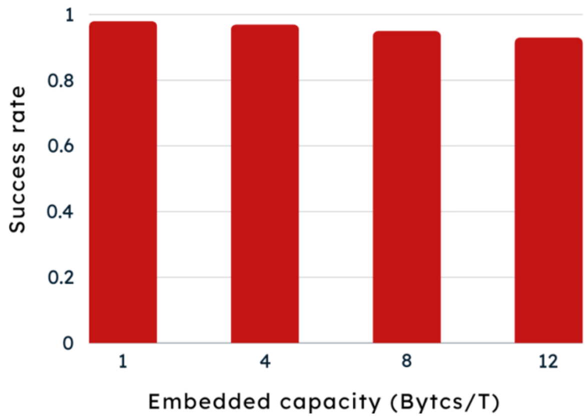

Figure. 6 Comparison based on the success rates Vs embedding capacity

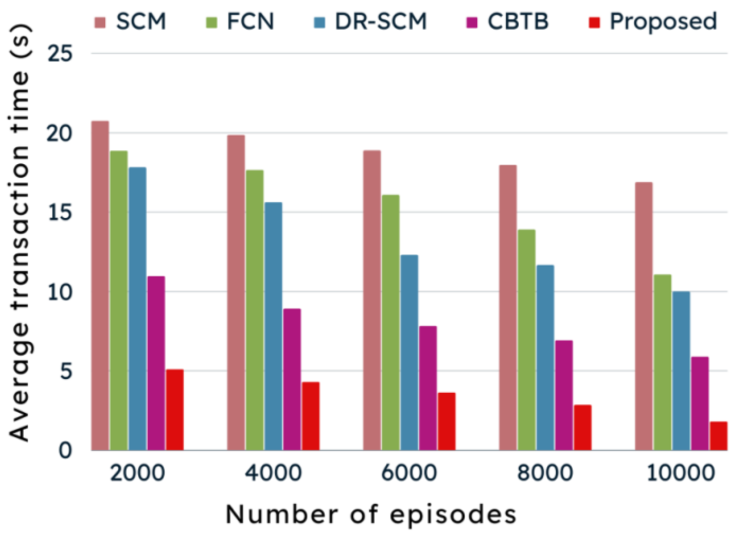

Figure. 7 Comparison based on the average transaction time Vs number of episodes

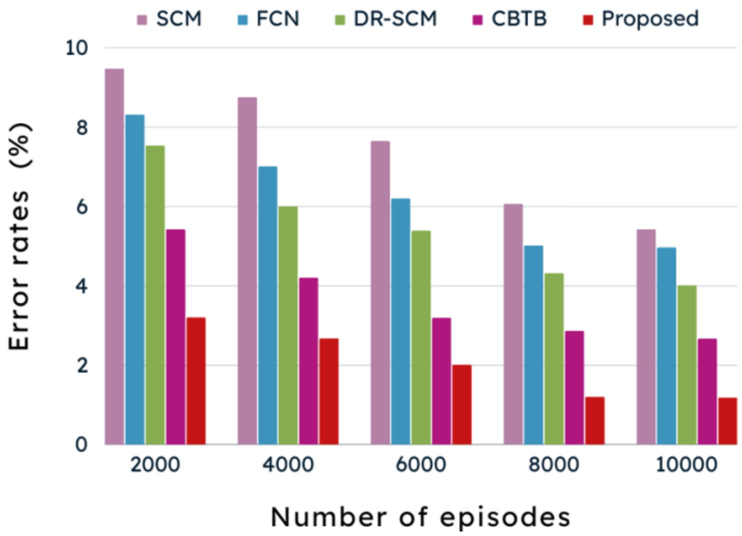

Figure. 8 Comparison based on the average transaction time Vs. error rates

Figure 6 delineates the state-of-art results of success rates Vs embedding capacity. The information is retrieved and embedded using proposed method. The embedded capacity is 1 to 12 Bytcs/T. The embedding success rate is calculated in this plot and it reveals better results based on 1Bytcs/T as 0.98%, 4 Bytcs/T as 0.97%, 8 Bytcs/T as 0.95% and 12 Bytcs/T as 0.93% accuracy levels.

The state-of-art result of average transaction time with the number of episodes as shown in Figure 7.

The number of episodes changed from 2000 to 10000 in which the transaction is get varied gradually based on the episodes. The methods such as SCM [5], FCN [6], DR-SCM [8], CBTB [9] and proposed work provided the transaction time of 16.75s, 11.32s, 9.93s, 5.87s and 1.96% at 10000th episodes. An average transaction time values of proposed work is smaller and it is less than that of previous SCM, FCN, DR-SCM and CBTB.

Figure 8 depicts the state-of-art results depending upon the average transaction time Vs error rates. Alter the episodes from 2000 to 10000 that is used for the calculation of error rates based on comparative approaches like SCM [5], FCN [6], DR-SCM [8], CBTB [9] and proposed method. Based on the graphical plot, it reveals that the error rate of proposed is minimal to SCM, FCN, DR-SCM and CBTB methods.

7. Conclusion

In a nutshell this work is to manage the agri-product supply chain with AlexNet technique. The major purpose of this work is to enhance the productivity and profitability of the farmers and for that we analyzed the cost of transportation, storage, shipping, penalty, and shipping. Moreover, the safety of the production much important and for that transaction is made with blockchain based secured transmission. The work considered the production of pulses and analyzed the demand by the consumers and the retailers. If the demand is not satisfied then penalty will be given and to avoid this, we suggested increasing productivity, storage of processor and retailers. For analyzing the productivity and profitability AlexNet technique has been used. Further, experimental investigation was made and compared the profitability of different works along with the transaction time, error rates and concluded that the proposed work surpasses all the other works.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

The following statements should be used as follows: “Conceptualization, Ramya Thatikonda and Bhuvanesh. A; methodology, Reshmi Tatikonda; software, Ragupathi Thota; validation, Ramya Thatikonda, Bhuvanesh. A, and Reshmi Tatikonda; formal analysis, Ragupathi Thota; investigation, Ramya Thatikonda; resources, Bhuvanesh. A; data curation, Reshmi Tatikonda; writing—original draft preparation, Ragupathi Thota; writing—review and editing, Ramya Thatikonda; visualization, Bhuvanesh. A; supervision, Reshmi Tatikonda; project administration, Ragupathi Thota; funding acquisition, Ramya Thatikonda”, etc.

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