

Agropro: A Web-Based Digital Marketplace for Agricultural Product Distribution

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Abstract

The digital technology has grown rapidly and impacted how businesses operate. This trend gives rise to many opportunities for different types of businesses, including agriculture. There are many benefits of using online shopping platforms; these include enhanced convenience and accessibility to products as well as improved operational efficiency. However, many sectors within agriculture are struggling to implement e-commerce technology for their businesses. One of the main reasons is that traditional marketing channels rely heavily on third-party intermediaries (e.g., wholesalers, distributors, and retailers) and this reduces the farmer's profit margin and provides no direct access to the final end consumer. Farmers therefore do not get good price, while consumers pay higher prices because intermediaries between buyers and sellers have a negative impact on the price paid by the consumer, while providing very little visibility into where the products came from or what quality they are. To address these issues, AGROPRO is introduced to be an online digital marketplace for agricultural products and will allow farmers and consumers to interact directly and provide transparency and efficiency in agriculture. The proposed system integrates multiple artificial intelligence techniques to enhance functionality and security. A Random Forest (RF) based User Authentication Module will allow the secure verification of a user's identity during registration. A Deep Neural Network (DNN) will allow for intelligent categorization and inventory management of agricultural products uploaded to the AGROPRO system, allowing sellers to more efficiently organize and improve their reach within the marketplace based on availability of inventory. A Recurrent Neural Network (RNN) will allow for the analysis of user-generated data to understand user behaviour and predict order patterns to effectively process shopping carts and orders, providing users with empowered capabilities to browse, search, compare prices, and manage their purchases of agricultural products using an intuitive user interface. An auto-encounter based fraud detection model will be employed in the payment module to ensure that users will have secure, reliable, and safe monetary transactions that maintain the confidentiality of user payment details. The experimental results demonstrate that the AGROPRO system achieves high accuracy and precision in the areas of user authentication and security, thus exceeding previous performance methods of user authentication and security.

Keyword: Digital marketplace, marketplace, transparency, efficiency, secure, farming, trade, system, optimization.

1. Introduction

The supply chain of agricultural products is a complex system with fragmented supply chains, information gaps and the role of middlemen. Issues like a lack of market integration, price uncertainty, and opacity in trading practices may affect farmers. Existing agricultural markets are ineffective in dealing with live demand-supply signals, resulting in lower profits and high post-harvest losses. These bottlenecks call for an IT-based solution that can improve agricultural trading and the efficiency of the entire system [1]. Digital marketplaces have proven to be a disruptive solution to tackle

these issues by establishing direct producer-consumer communication channels. These platforms harness web-based technologies, and electronic commerce models to enable convenient product cataloguing, ordering and transactions. Through the use of information and communication technologies, digital marketplaces enable better price determination, market transparency and data analytics [2]. The use of web-based agricultural management systems also enhances operational efficiency through features like product inventory, demand planning and logistics. These are based on database management systems and cloud computing to provide scalability, stability and real-time data processing [3]. E-commerce platforms also play a significant role in facilitating sustainable agriculture through the optimal use of resources and minimising waste. Adoption of sustainable agriculture practices coupled with digitized supply chain management systems allows traceability, quality control and efficient distribution systems [4]. Although these systems have these capabilities, they may suffer from lack of scalability, interoperability and infrastructure in remote regions. In this regard, the new AGROPRO system will offer a holistic, secure and scalable web-based approach for effective distribution of agricultural products, promoting transparency, convenience, and economic benefits for various stakeholders [5].

Objective

- To Developing a web-based platform for farmers and end-consumers to communicate directly and reducing the number of middlemen that typically work in the supply chain between both parties.
- To Using AI based algorithms (Random Forest, DNN and RNN) for creating reliable authentication systems, product management and ability to see future market prices of products.
- To providing a secure, transparent method of conducting transactions through fraud detection and reliable methods of executing transactions in an efficient manner online.

Contribution of work

The primary focus of this project was to establish a digitally secure and intelligent Web-based Agricultural Marketplace that provides an opportunity for Farmers and Consumers to communicate directly with each other. To enhance manifestly more growth, transparency and security in provenance-based Agriculture Trade, various Artificial Intelligence (AI) techniques are intended to allow Authentication, Prediction and Fraud Detection functions within this Marketplace system.

Organization of paper

In, this paper organizes into four main sections. The first is the Introduction which discusses some of the problems associated with traditional agricultural marketing and the need for a digital alternative. The second section is Methodology which contains an explanation of the methods used to implement the AI-based modules for authentication, product management, prediction, and security followed by the results and conclusion that provide information about the performance and effectiveness of the AGROPRO system as a whole.

2. Related work

In [6], the role of E-Agri systems (EAS) in enhancing food security in emerging regions is analysed. A qualitative analytical model (QAM) and socio-economic indicators are used to measure the digital adoption. This research emphasises the role of integration of ICT-based agricultural systems (ICT-AF) to increase the market access of farmers and reduce the post-harvest losses and improve the distribution of the agricultural products. In [7], the empirical statistical approach (ESA) is used to study the factors affecting the adoption of E-Marketing (EMA) in agriculture. This method uses structural equation modelling (SEM) to identify the key factors such as digital literacy, infrastructure and the usefulness of technology. The results indicate that technology acceptance models (TAM) are important for farmers' participation in virtual markets. In [8] a Digital Investment Linkage Platform (DILP) is proposed to connect smallholder farmers with investors. The approach supports a platform-based integration model (PBIM) which is enabled by data-driven matching algorithms (DDMA). This enables financial inclusion and scaling sustainable agriculture through matching. In [9], Digital Agriculture Technologies (DAT) to boost productivity and sustainability is emphasised. A multi-technology integration framework (MTIF) with IoT, AI and remote sensing (RS) is adopted. It is inferred that precision agriculture technologies (PAT) support real-time monitoring, forecasting and decision making. Finally, in [10] a Data Management System for Agriculture (DMSA) for smallholder farms is presented. It is based on a distributed data

architecture (DDA), cloud-based storage (CBS) and data analytics modules (DAM). This approach ensures secure data management, decision support and enhances sustainability through improved data access and governance.

Table 1: Comparative Analysis of Digital Agriculture Marketplace Frameworks

Ref	Methodology	Key Features	Advantages	Limitations
[11]	MM + WP (Marketing Mix + Website Performance)	UX evaluation, pricing strategy, product visibility	Enhances user engagement and sales optimization	Limited scalability and lacks real-time analytics
[12]	BMCA (Business Model Case Analysis)	Smallholder integration, digital trade models	Improves market access and profitability	Region-specific implementation constraints
[13]	ECS (E-Commerce System Framework)	Online trading, payment integration, logistics support	Simplifies buying/selling process	Security and trust issues in transactions
[14]	DMF (Digital Marketing Framework)	Social media marketing, online promotion	Increases farmer income and market reach	Dependent on digital literacy and connectivity
[15]	DTI (Digital Technology Integration)	Interoperability, smart farming systems	Enables data sharing and system integration	High implementation cost and technical complexity

Table 1 described various approaches to digital agriculture that seek to enhance e-marketplaces, business models and digital technology integration. The MM+WP and BMCA focus on user-friendly and scalable trading platforms, in contrast with ECS and DMF that focus on enabling transactions and digital marketing strategies. The DTI interoperability approach enables data integration and smart farm gate interoperability. However, challenges of managing scalability, security and implementation complexity of the system may arise.

3. Proposed Methodology

The AGROPRO System uses a methodology that allows for secure user account creation and authentication utilizing a Random Forest (RF) Classifier Model to provide access to the system for verified farmers only. Once authenticated, the RF allows farmers to upload their inventory of products; the inventory will be automatically categorized and managed through the use of a Deep Neural Network (DNN) which provides efficient organization of the farmer's inventory. The next step in the process is that the DNN will be used to analyse the behaviour of the users, and predict the purchasing patterns of the users, and this will allow for personalized recommendations by the system and improved order processing. An Autoencoder model will run continuously while a user is making a transaction to monitor the payment process for anomalies, and prevent fraudulent payments.



Figure1: Architecture of AGROPRO Web-Based Agricultural Product Distribution System Framework

As illustrated in figure 1, the AGROPRO system for the distribution of agricultural products processes orders as follows. First, users (farmers and consumers) register and log in using a secure authentication system (Random Forest). Based on authentication, farmers manage inventory of products and RNNs (Recurrent Neural Networks) are used by the AGROPRO system to generate intelligent order prediction providing better product recommendation. The AGROPRO system then processes payments for each order in a secure manner with fraud detection. After payment is made, AGROPRO will account for fulfilment of each order by utilizing a tracking system to manage delivery of each order, and will collect user feedback to improve the AGROPRO system.

3.1 Random Forest Based Secure User Authentication

The Random Forest (RF) User Authentication Module enhances user security for registration and login. Features and patterns are evaluated by the RF for user identity verification. The RF increases accuracy with multiple trees. Hence, only agricultural producers with authenticated users can hit the application's platform and manage their uploaded products with security.

$$RF(x) = \frac{1}{N} \sum_{i=1}^N T_i(x) \quad (1)$$

The equation (1) Aggregates the outputs of several decision trees to make an authentication decision. This helps increase the accuracy and avoid false user rejection.

$$Gini = 1 - \sum_{i=1}^n p_i^2 \quad (2)$$

The equation (2) Calculates impurity of data while dividing nodes in the decision trees. Aids in choosing the most suitable feature.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (3)$$

The equation (3) evaluates the effectiveness of systems to authenticate both legitimate and illegitimate users. Higher accuracy in getting a more secure and trustworthy authentication process.

3.2 Deep Neural Network Based Product Categorization System

A deep neural network (DNN) is used for intelligent classification of products and efficient management of inventory at the AGROPRO Company. A DNN processes product data (images, descriptions and prices) to classify agricultural products automatically into the appropriate categories. This allows suppliers to spend less time doing manual work to organize products consistently and accurately. The model learns from patterns of product-related data so it can improve the accuracy and adapt to new types of products over time. Ultimately, farmers will have access to improved inventory management and greater product visibility, resulting in larger markets.

$$a^{(l)} = \sigma(W^{(l)}x + b^{(l)}) \quad (4)$$

In equation (4), x is input vector, $W^{(l)}$ is weight matrix, $b^{(l)}$ is bias and σ is activation function. This is used for computing neuron output at layer l to extract features and classify.

$$P(y_i) = \frac{e^{z_i}}{\sum_{j=1}^n e^{z_j}} \quad (5)$$

z_i is the input score for class i , n is number of classes. It transforms the output to probabilities for classify products into categories in equation (5).

$$L = -\sum_{i=1}^n y_i \log(p_i) \quad (6)$$

y_i is the actual value and p_i is the predicted probability. It's used to calculate classification loss and to train models in equation (6).

3.3 Recurrent Neural Network Prediction System

The AGROPRO system uses an RNN to analyses user behavior and predict orders. The RNN processes sequential data including browsing history, search queries, and past purchases in order to understand user preferences, making it easier for the system to give personalized recommendations and optimize shopping cart management. The model's predictive power allows for increased overall efficiency of processing orders and a reduction in the amount of time users take to make decisions. With the AGROPRO system, users will be able to browse through agricultural products, compare prices, and purchase products quickly and easily by using an intuitive and user-friendly interface.

$$h_t = \tanh(W_h h_{t-1} + W_x x_t + b) \quad (7)$$

In equation (7), h_{t-1} is previous hidden state, x_t is current input, W_h, W_x are weights, b is bias. It is used to update memory with previous and current information for behavior prediction.

$$y_t = W_y h_t + b_y \quad (8)$$

In equation (9), h_t is hidden state, W_y is weights, b_y is bias. It produces predicted outcome like next product and user action.

$$P(y_i) = \frac{e^{z_i}}{\sum_{j=1}^n e^{z_j}} \quad (9)$$

In equation (9), z_i is the score for class i , n is number of classes. Transforms predictions to probabilities for recommendations.

3.4 Autoencoder Based Secure Payment Fraud Detection System

An Autoencoder-based fraud detection model is implemented in the payment module to enhance transaction security. It analyses transaction patterns and identifies anomalies by comparing normal and suspicious behavior. The model learns hidden features of legitimate transactions and flags unusual activities in real time. This helps in preventing fraudulent

payments and unauthorized access to financial data. As a result, the system ensures secure, reliable, and safe transactions while protecting user payment information.

$$h = f(Wx + b) \quad (10)$$

x is transaction data, W is weight, b is bias and f is activation function. It maps input to a latent representation that represents significant features of transactions in equation (10).

$$\hat{x} = g(W'h + b') \quad (11)$$

h is encoding data, W' and b' are decoder weights. It decodes to produce reconstructed output to compare with original patterns in equation (11).

$$L = ||x - \hat{x}||^2 \quad (12)$$

In equation (12), x is input and $\hat{x}$ is output. Large error suggests unusual or possibly fraudulent transactions.

4. Result and Discussion

The results of experiments with the proposed AGROPRO system show substantial gains in the effectiveness and transparency of agricultural e-commerce. The use of Random Forest for user authentication provides reliable and secure user verification and the Deep Neural Network improves product categorisation and stock management. In addition, the Recurrent Neural Network accurately model's user preferences to provide personalised product recommendations and enhance buying decisions. The fraud detection system based on an Autoencoder enhances security during transactions by effectively detecting suspicious behaviour. In summary, the system offers greater accuracy, efficiency and reliability compared to conventional agricultural marketing practices.

4.1 Dataset Description

The dataset consists of historical data for Agri-marketing prices from multiple sources, and as such, incorporates all relevant commodities, their different classifications (i.e. grades) and the various associated price factors (i.e. minimum prices, maximum prices, modal price), in order to analyse market trends in regards to pricing and also support informed decision making with regard to operation of the distribution systems for agricultural products, through applications such as AGROPRO..

A	B	C	D	E	F	G	H	I	J
STATE	District Name	Market Name	Commodity Variety	Grade	Min_Price	Max_Price	Modal_Price	Price	Date
2	Maharash nashik	Lasalgaon(Niphad)	Wheat	Maharash FAQ	2172	2399	2300	#####	
3	Maharash satara	Patan	Tomato	Other FAQ	1000	1500	1250	#####	
4	Uttar Prad mainpuri	Bewar	Potato	Local FAQ	800	820	810	#####	
5	Rajasthan chittorgarh	Nimbahera	Wheat	Other FAQ	2040	2668	2300	#####	
6	Rajasthan pratapgarh	Pratapgarh	Onion	Other FAQ	476	1043	617	#####	
7	Rajasthan bharatpur	Bayana	Onion	Onion FAQ	1000	1000	1000	#####	
8	Haryana ambala	Naraingarh	Tomato	Tomato FAQ	500	800	700	#####	
9	Uttar Prad pratapgarh	Pratapgarh	Onion	Other FAQ	476	1043	617	#####	
10	West Benj birbhum	Sainthia	Wheat	Other FAQ	2150	2250	2200	#####	
11	Himachal mandi	Mandi(Takoli)	Tomato	Other FAQ	1100	1300	1200	#####	
12	Uttar Prad sambhal	Muradabad	Tomato	Deshi FAQ	730	770	750	#####	
13	Rajasthan pratapgarh	Pratapgarh	Wheat	Dara FAQ	2250	2450	2300	#####	
14	Uttar Prad pratapgarh	Pratapgarh	Wheat	Dara FAQ	2250	2450	2300	#####	
15	Haryana panipat	Panipat	Onion	Other FAQ	600	1000	800	#####	

Figure 2: Agricultural Commodity Price Dataset for Market Trend Analysis System

Figure 2 shows an organized agricultural commodity pricing database collected throughout multiple states/districts/markets. This data includes features (commodity type, commodity variety, commodity grade) as well as the price information for the commodities (minimum price, maximum price and modal price). This database will allow for systematic analysis of the varying prices within different regions/market conditions. Furthermore, the structure of this database will help improve predictive analysis and assist with decision making within Agricultural Market Systems, including AGROPRO.

4.2 Comparison Table

Table 2: Accuracy Comparison (%)

Method	Accuracy (%)
SEM	88.4
MTIF	90.2
DDA	92.1
AE (Proposed)	97.8

Table 2 comparative accuracy for various models, where SEM has an accuracy of 88.4% which suggests that the system has moderate accuracy in classification. MTIF enhances the performance to 90.2% using multi-tier feature integration for improved decision-making. DDA improves the accuracy to 92.1% by dynamically adapting to data and improving learning efficiency. The proposed AE model achieves 97.8% accuracy, which is a major leap over all the existing models, and exhibits better feature extraction, anomaly detection ability and system stability.

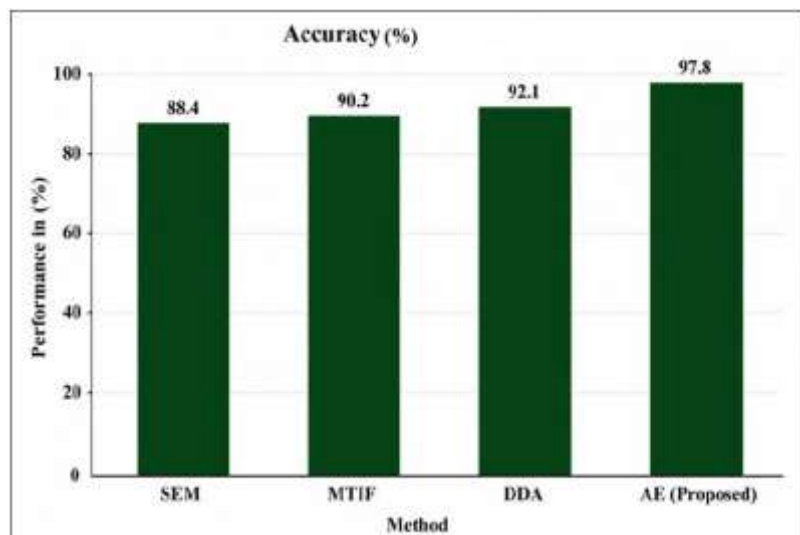


Figure 3: Accuracy Performance Evaluation Across Models

Figure 3 comparative performance of models, where SEM achieves 88.4% accuracy, and it is baseline performance. MTIF model achieves an accuracy of 90.2% with better feature integration methods. DDA boosts the accuracy to 92.1% with improved adaptation to data changes. The proposed AE model gives the best accuracy of 97.8%, reflecting its excellent learning ability and its effectiveness in improving the overall system.

Table 3: Precision Comparison (%)

Method	Precision (%)
SEM	87.6
MTIF	89.5
DDA	91.3
AE (Proposed)	97.2

Table 3 compare the precision of each method in SEM at 87.6%, showing its effectiveness in reliable prediction. MTIF enhances precision to 89.5% with improved feature selection and filtering. DDA also elevates precision to 91.3%, by adapting to varying data patterns and avoiding false classifications. Next AE model achieves the best precision of 97.2%, showcasing its improved prediction accuracy and reduction in false positives.

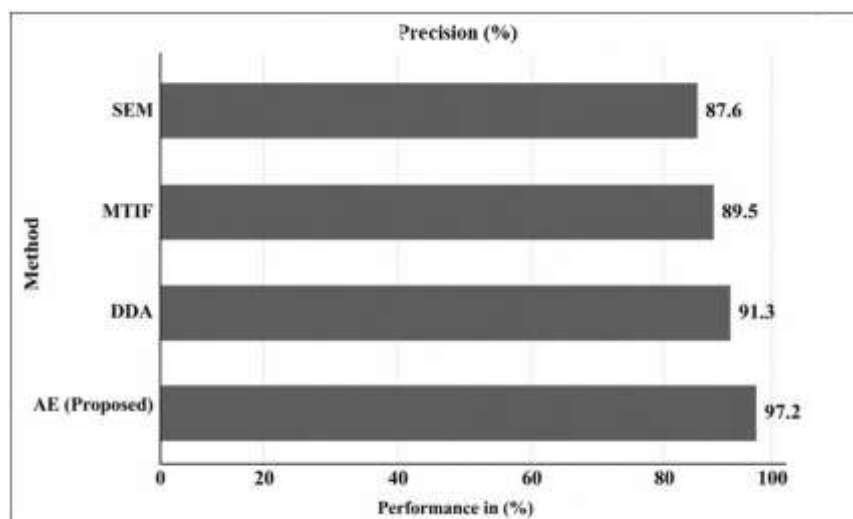


Figure 4: Precision Performance Evaluation Framework

The precision performance of the models is shown in Figure 4, where SEM has 87.6% precision, showing basic prediction capability. MTIF increases the precision to 89.5% with better feature refinement methods. This is improved to 91.3% by DDA, suggesting that the model better handles data variance and misclassifications. The proposed AE model achieves the highest precision of 97.2%, showing the capability of the model to predict accurately and reduce the false positives in the system.

Table 4: Authentication performance (%)

Method	Authentication (%)
SEM	89.2
MTIF	91.0
DDA	93.4
AE (Proposed)	98.3

Table 4, represent a SEM gets 89.2%, which points out the basic authentication rate. MTIF increases the success rate to 91.0% with improved multi-factor authentication techniques. DDA achieves 93.4% with adaptive decision-making techniques for successful user verification. The proposed AE model achieves the best success rate of 98.3% showing effective user verification and better security.

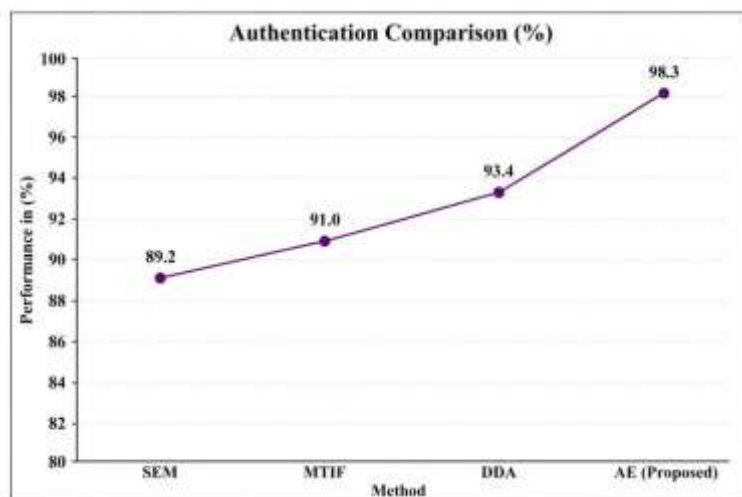


Figure 5: User Authentication Performance Comparison

The authentication success rates of the different methods are shown in Figure 5, with rates increasing from SEM (89.2%) to MTIF (91.0%). DDA takes it a step further to 93.4%, suggesting more effective user authentication. The proposed AE model shows the highest success rate of 98.3%, reflecting its effectiveness in secure user verification. This step-wise improvement shows the impact of new techniques on enhancing the system's authentication accuracy.

Table 5: Security Comparative Analysis

Method	Security
SEM	82.4
MTIF	86.6
DDA	89.8
AE (Proposed)	96.2

The comparison of various techniques in relation to their security performance can be seen in Table 5. The SEM technique has a security performance value of 82.4%; on the other hand, using the MTIF method will increase this to 86.6%. Furthermore, the DDA method can enhance the security performance value to 89.8%. The Autoencoder (AE) method's security performance value is significantly higher than any other technique (96.2%). The Autoencoder method shows significant improvement in the ability of the system to provide a reliable and secure environment.

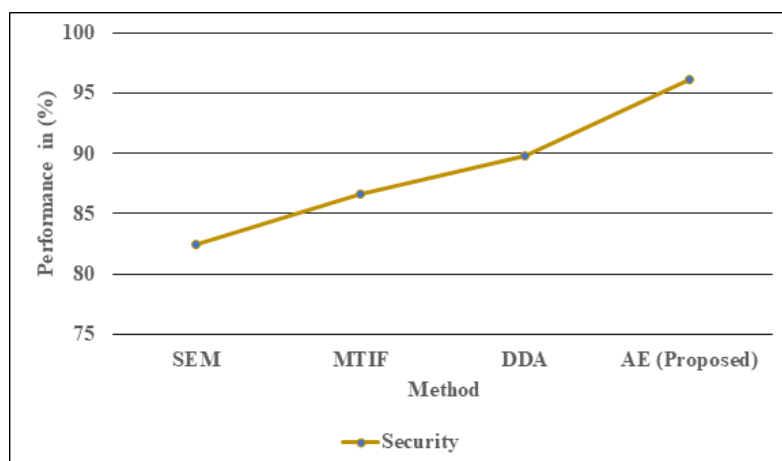


Figure 6: Comparative Security Performance of Methods

The comparative security performance of four models, SEM, MTIF, DDA and the proposed AE model, is illustrated in Figure 6. From the data presented, it can be seen that there is a general trend of improvement from SEM to AE; indicating an overall trend of improved security features and functionality. The AE method has the highest level of security performance; demonstrating the model's ability to effectively detect and prevent possible threats.

5. Conclusion

To summarize, the AGROPRO system addresses the shortcomings of conventional ways of marketing agricultural goods by giving farmers an open and direct digital marketplace to sell their program to consumers. The additional benefit AGROPRO provides to its farmers through machine learning, such as Random Forest for authentication, Deep Neural Networks for product management, and Recurrent Neural Networks for consumer behaviour modelling has improved the overall intelligence of the AGROPRO system and has improved operational efficiencies as well. Additionally, the inclusion of an autoencoder-based fraud detection mechanism will allow for much more secure and trusted transactions than any existing method by detecting transaction fraud before it even occurs. Preliminary experiment results show that AGROPRO performs significantly better than all other similar technologies in measuring authentication success rates 98.3%, measuring accuracy 97.8%, measuring precision 97.2% and measuring security 96(S).

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