Application of E-commerce Human-Computer Interaction Based on AI-Powered CAD and Big Data Analysis in Sustainable Agriculture

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Abstract. This study explores the application of e-commerce human-computer interaction (HCI) frameworks, enhanced by AI-powered Computer-Aided Design (CAD) and big data analysis, in promoting sustainable agriculture practices. As the agricultural sector increasingly embraces digital transformation, effective HCI design becomes crucial for facilitating user engagement and decision-making among farmers and stakeholders. Moreover, with the support of recommendation algorithms and big data technology, this paper constructs a sustainable agricultural e-commerce system, constructs the basic framework and system process of a sustainable agricultural e-commerce system, and analyzes the functional structure and its implementation process. In addition, this paper uses a recommendation algorithm to recommend user-interested agricultural products, changes the operation mode of the traditional e-commerce system, and improves the operational efficiency of the sustainable agricultural e-commerce system. Finally, this paper tests the sustainable agricultural e-commerce system constructed in this paper through experiments. The research results show that the sustainable agricultural e-commerce system based on big data constructed in this paper has reached the basic expected requirements of building the system.

Keywords: Big data; e-commerce; sustainable agriculture; AI-Powered CAD; Human-Computer Interaction;
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1 INTRODUCTION

From the current economic development status and future economic development trends, the integration between the market and information technology is getting stronger and stronger, and the development trends of e-commerce and the Internet economy are irreversible [16]. This is both an opportunity and a challenge for green agriculture. It provides new ideas for the development of green agriculture, but it also makes the development of green agriculture face more risks and temptations. How to scientifically and rationally use opportunities and the advantages of the times to form a green agricultural e-commerce development model with unique Chinese characteristics is very important. Therefore, the exploration of this subject has great practical significance.

In recent years, with the rise and popularization of the Internet, rural e-commerce has entered a period of rapid development, and the overall development trend has continued to increase. With the popularization of computers and smartphones in rural areas, more and more villagers have begun to learn to use the Internet to buy things on the Internet, pay for life and other operations, and even sell their own-grown or farmed agricultural products through the Internet [13]. The number of Chinese rural Internet users is showing a rapid growth trend. Therefore, the development space of China's rural e-commerce is vast, with unlimited possibilities, but at the same time, it also has unlimited challenges.

China is in a critical period of agricultural economic development and transformation at this stage. Changes in demand for farm products in the market, adjustments in the financial situation, and changes in agricultural economic development have all impacted green agriculture. For this reason, it is necessary to consider how to adapt to the times and develop innovative development models from the perspective of the long-term development of green agriculture. At the same time, it is necessary to build a scientific green agricultural e-commerce development model that can solve the current predicament of green agricultural development, seek new development ideas, and innovate development models for it. Specifically [4], first, the construction of the green agricultural e-commerce development model is to follow the trend. The Internet and information technology are two essential material achievements of modern civilization. In the more extended development period, their integration with social development will deepen, and their role and influence will become increasingly apparent. If the agricultural economy derails from them, they will be gradually eliminated by the market and society. The second is the changes in people's needs and demands. Young people like online shopping and overseas shopping more and more. The Internet has deeply influenced their consumption methods and shopping concepts, and they no longer like chaotic vegetable and agricultural products markets. Therefore, to fully exploit customer resources, the green pastoral development method should be adjusted according to customer needs and demands[1].

In the development of green agricultural e-commerce, whether to use the existing trading platform or independently create an e-commerce trading platform is an urgent problem that needs to be solved. From the perspective of the development characteristics of green agriculture, due to the inconsistency of the characteristics of agricultural resources in various regions, the development of the existing trading platform cannot highlight its characteristics. Still, the cost of developing a new e-commerce trading platform based on the county or village is relatively high [18]. This article combines big data technology to construct a sustainable agricultural e-commerce system, which provides a reference for the subsequent diversification of agricultural economic development. Moreover, it emphasizes the importance of Human-Computer Interaction (HCI) in ensuring user-friendly interfaces and seamless interactions within the e-commerce platform, enhancing user experience, and facilitating the growth of green agricultural e-commerce.

2 RELATED WORK

E-commerce refers to business activities conducted through information networks and computer technology. There needs to be a unified standard for defining the connotation of e-commerce. Many politicians, scholars, and entrepreneurs have given different understandings of e-commerce based on their professional perspectives and roles in e-commerce [3]. It is worth pointing out that e-commerce and electronic business are two different concepts. Although people in different countries and fields have different understandings of e-commerce, from the perspective of technology and equipment, e-commerce is always a business model inseparable from supporting related electronic equipment and network information technology [7]. E-commerce is an evolving concept, and humans have had different understandings of it throughout history. Among them, the early e-commerce was online shopping. However, with the rapid development of e-commerce and the change in the concept of e-commerce by human beings, peripheral supporting services have also been included in e-commerce, including logistics distribution, after-sales service, and other peripheral supporting services [15]. It is generally believed that e-commerce is divided into two types: broad sense and narrow sense. In a broad sense, it refers to commercial transactions conducted through various electronic devices, and e-commerce, in a narrow sense, refers to business activities using a network platform provided by the Internet [6]. The two are different, but no matter which kind of understanding, e-commerce has two characteristics. One is that there must be an Internet to provide a platform. With the Internet, e-commerce could be called. The second is that using the Internet is a business activity. In a narrow sense, e-commerce refers to business transaction activities carried out on a global scale using information technology, communication technology, etc. [5], realized on a platform provided by the Internet using electronic devices such as computers, televisions, and telephones. This business activity is established based on a computer network, including the relevant behaviors of merchants, consumers, and third parties in online commerce [10]. People usually understand e-commerce in a narrow sense. In a broad sense, e-commerce refers to the sharing of information resources within a company, suppliers, consumers, and partners through a platform provided by the Internet under the conditions of various electronic devices and related technologies, which improves the efficiency of cooperation and communication between all parties, makes the production, storage, sales, and capital turnover of the enterprise more closely linked, and improves the efficiency of enterprise business development [17].

The popularity of the Internet has stimulated the development of agricultural e-commerce. The use of e-commerce has brought new competitive pressures to American agricultural workers, and more and more people have turned from doubts and wait-and-see to bold use and have tasted its sweetness. The U.S. Department of Agriculture, the Department of Commerce, and the U.S. Small Business Administration also jointly established the "Small Business E-Commerce Working Group" to promote the development of e-commerce, including small agricultural enterprises, to effectively use resources and avoid duplication of labor [9]. It can be said that e-commerce promotes the flow of agricultural information, improves market transparency and market coordination, crosses the distance of time and space, improves the strategic customer positioning of enterprises, broadens the sales channels of agricultural products, reduces transaction links and transaction costs, and brings unprecedented convenience to the development of agricultural economy [12]. The Japan Agricultural Cooperative Association website introduces agricultural products' production technology and market conditions. The website provides a comprehensive and detailed introduction to the fine varieties of agricultural products, cultivation techniques, agricultural machinery and equipment, market information, offices, and service projects of the Japan Agricultural Association in various places in Japan [8]. Through the information provided on the website, producers can learn from valuable experience, learn from advanced methods, and adopt appropriate technologies to improve the quality and labor productivity of their agricultural products. In addition, consumers can choose satisfactory products from them to have a real treat [2].

3 AGRICULTURAL E-COMMERCE RECOMMENDATION ALGORITHM BASED ON BIG DATA

Several evaluation indicators are needed to evaluate the recommendation system's performance. The selection of evaluation indicators is different for different recommendation tasks. Considering the importance of Human-Computer Interaction (HCI), it's essential to include metrics that assess user satisfaction, engagement, and usability alongside traditional performance indicators. These HCI-focused metrics can provide valuable insights into how effectively the recommendation system interacts with users, ultimately enhancing the overall user experience. Some indicators can be assessed quantitatively, while others can only be evaluated qualitatively. The authoritative classification method divides the recommendation task into a top-N recommendation, optimal utility, and score prediction.

Top-N recommendation: This type of recommendation task is the most common recommendation system, which generates a personalized user recommendation list.

Recommendations are the most effective: For example, in an e-commerce company's recommendation system, the recommendation results should prioritize whether the recommendation list can increase sales, which will also involve the long tail problem.

Rating prediction: predict the user's interest in an item, such as predicting the user's rating of a movie.

Corresponding to these three recommended tasks, evaluation indicators used are listed below.

When a recommendation system provides a service, it often generates a list of recommended items. This method is called the Top-N recommendation. Introduce the retrieval system's precision and recall into the recommendation system's evaluation [19].

We assume that $R\ u$ be the recommended list shown to the user based on the user's behavior on the training set.

The accuracy measure refers to the ratio of hit items to the total number of recommended items.

The precision of the recommended results is defined as:

$$Precision = \frac{\sum u \in U \left| R\ u\ \cap T\ u \right|}{\sum u \in U \left| R\ u \right|}. \tag{1}$$

The recall rate calculates the proportion of hits in the theoretical maximum number of hits.

The recall rate of recommended results is defined as[14]:

$$Recall = \frac{\sum u \in U \left| R\ u\ \cap T\ u \right|}{\sum u \in U \left| T\ u \right|} \tag{2}$$

It should be noted that the precision and recall indicators often conflict with each other.

E-commerce platforms generally allow users to rate items. After obtaining the user's scoring, the user's interest model can be learned from it. When the user encounters an item that has not been scored before, the system can predict that the user will rate the item. This is the scoring prediction.

The root mean square error generally calculates the prediction accuracy of scoring prediction, the average absolute error, and the standardized average absolute error. For user u and item i in the test set, r_{ui} is the actual score of user you on item i, and the predicted score given by the recommendation system is $\hat{r}_{ui}$.

1. RMSE. The root square error is susceptible to very large or very small mistakes in a group of measurements, so the root mean square error can well reflect the precision of the measurement. The RMSE calculation formula is defined as follows[11]:

$$RMSE = \frac{\sum u, i \in T \ \ r_{ui} - \hat{r}_{ui}}{\left|T\right|} \quad (3)$$

2. MAE. It is the most basic and one of the most widely used evaluation criteria. The MAE calculation formula is as follows:

$$MAE = \frac{\sum u, i \in T \left|r_{ui} - \hat{r}_{ui}\right|}{\left|T\right|} \quad (4)$$

3. NMAE. The MAE needs to be normalized to facilitate the cross-domain comparison of MAE and eliminate the influence of the scoring range. The calculation formula of NMAE is as follows:

$$NMAE = \frac{MAE}{rmin_{max}} \quad (5)$$

NMAE is normalized to the range of 0-1. The smaller the RMSE and MAE values, the more accurate the system's user prediction scores are.

With the rise of e-commerce, another recommendation task has gradually been given attention: profit maximization. Therefore, the system recommends that users extend their online time and maximize their benefits. This requires consideration of recommended items and how they are presented to users.

The half-life utility scoring method assumes that the likelihood of a user selecting a related item decreases exponentially with the ranking of the item in the list. After a recommendation list is given, Breese et al. assume that the user will browse the recommended items from the beginning and then provide the formula for calculating the probability of the item being browsed:

$$p_k = \frac{1}{2^{\ k-1 \ \ \alpha-1}}. \quad (6)$$

In the binary recommendation system, the calculation formula of the half-life utility is as follows[20]:

$$R_u = \sum j \in I_u \frac{1}{2^{\ idx \ \ j \ -1 \ \ \alpha-1}}. \quad (7)$$

$$R = \frac{\sum uR_u}{\sum^{\sum} uR_u^{max}}. \quad (8)$$

Among them, $idx \ \ j$ is the ranking position of item j in the recommendation list, I_u. is the set of items you are interested in, and R_u^{max} is the most significant value among all possible recommendation rankings of user u.

Other indicators

1. Coverage. It reflects the ability of a recommender system to solve long-tail problems. Coverage measures the proportion of items the system recommends to the total items. Suppose the user set is U, and the recommendation system recommends a list of items $R \ \ u$ of length N to each

user. In that case, the coverage of the recommendation system can be calculated by the following formula:

$$coverage = \frac{\left| \cup_{u \in U} R\ u \right|}{\left| I \right|} \tag{9}$$

Algorithms with high coverage can better mine long-tail items, but such judgments could be more precise. Moreover, a system with a coverage rate of 100% can have countless item popularity distributions. If all items appear in the recommendation list, and the number of occurrences is similar, then the recommendation system's ability to discover the long tail is excellent. Therefore, the ability of the recommendation system to mine the long tail can be described by studying the distribution of the number of occurrences of items in the recommendation list.

2. Diversity. Users' interests may involve different fields. For example, users who like to watch Japanese anime also like to watch European and American action movies. Currently, the recommendation list must cover the users' different areas of interest, meaning the recommendations' results must be diverse.

Since diversity is to describe objects of interest in different fields, it is precisely the opposite of the concept of similarity. We set

$$sim\ i,j\ \in \left[0,1\right] \tag{10}$$

Represents the similarity between item i and item j. At this time, the diversity of the user's recommended item list $R\ u$ can be defined as follows:

$$Diversity = 1 - \frac{\sum i,j \in R\ u\ ,i \neq j sim\ i,j}{\frac{1}{2}\left|R\ u\right| \left|R\ u\ -1\right|} \tag{11}$$

If we need to calculate the diversity of a system as a whole, we can average the diversity of the recommendation list of all users:

$$Diversity = \frac{1}{\left|U\right|}\sum_{u \in U} Diversity\ R\ u \tag{12}$$

4 SUSTAINABLE AGRICULTURAL E-COMMERCE SYSTEM BASED ON BIG DATA ANALYSIS

This paper builds a sustainable agricultural e-commerce system using a recommendation algorithm and big data technology. Figure 1 shows the agricultural e-commerce platform's modules and components. The software structure diagram of the platform is shown in Figure 2.

According to the results of the demand analysis, the system mainly includes agricultural product information management, matching transaction management, auction transaction management, order management, settlement management, and SMS reminders. Integrating Human-Computer Interaction (HCI) principles into designing and implementing these system components is crucial to ensure user-friendly interfaces, smooth interactions, and effective communication between users and the e-commerce platform. This approach enhances usability and overall user satisfaction, contributing to the success of the agricultural e-commerce system.

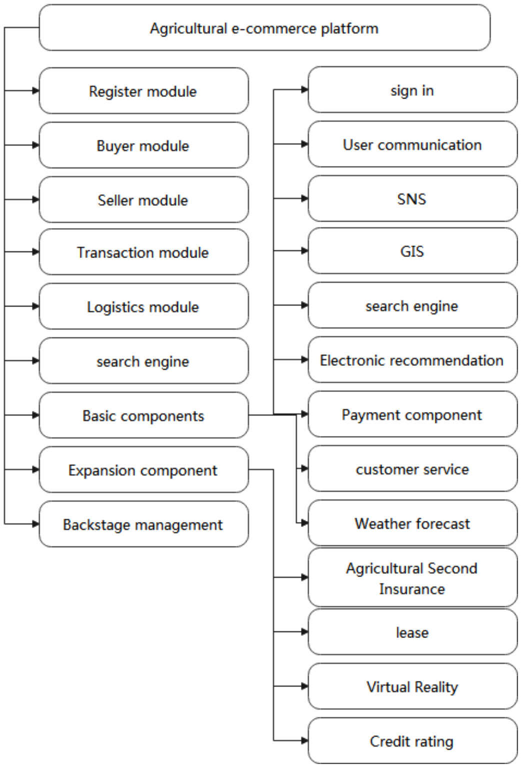

Figure 1: Module and component diagram of the platform.

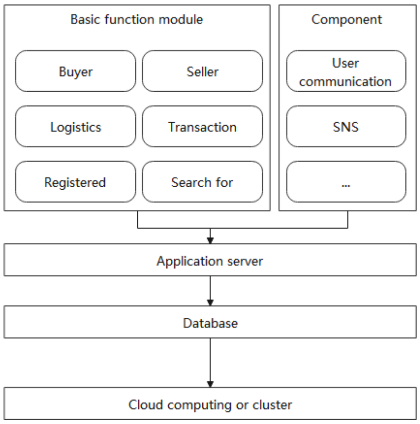

Figure 2: The software system structure diagram of the platform.

HCI considerations should permeate every aspect of the system's development, from interface design to transaction processes, to ensure that users can easily navigate the platform and complete transactions with minimal friction. By prioritizing HCI, the agricultural e-commerce system can provide a seamless and enjoyable user experience, fostering trust and encouraging continued engagement with the platform. The top-level data flow diagram of the system in Figure 3 illustrates the data flow relationship between the logical processes in the system.

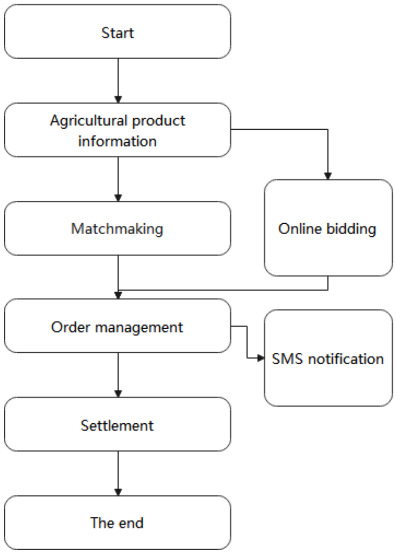

Figure 3: Top-level data flow diagram of the system.

The system uses the user-customized transaction constraint rules to guide the system in operating according to the user's wishes during automatic transaction processing. To meet the various needs of users, it needs to provide users with the ability to define flexible trading rules. At the same time, the trading rule system formulated by the user must be able to correctly parse it and enable the running result of the trading rule to act on the transaction correctly. To ensure the flexibility of transaction rules, it adopts reflection-like technology so that all relevant information in the transaction can be used in the transaction rules, and at the same time, it effectively guarantees the processing ability of the rule inference engine to analyze all transactions correctly. The actual content of the element.

The system structure design of the agricultural product electronic transaction subsystem refers to the national e-commerce overall design framework. According to the theory of hierarchical architecture, this paper combines the technical development trend of e-commerce platform construction and the characteristics of this project to design a "five-tier three-system" architecture system. Figure 4 shows the system structure diagram of the agricultural product trading platform.

1. The presentation layer is the portal website of the agricultural product transaction subsystem of the agricultural e-commerce platform, which provides a hierarchical display interface for both parties of agricultural product transactions.

2. The application layer mainly includes the agricultural product information management module, order management module, online bidding module, matching transaction module, settlement module, SMS reminder module, and other system business modules.

3. The application support layer is a collection of various technical components and business components that support the design, development, deployment, testing, and operation of the application system, including the website front-end page framework bootstrap, the web document editor for users to edit agricultural product information, and the editor component.

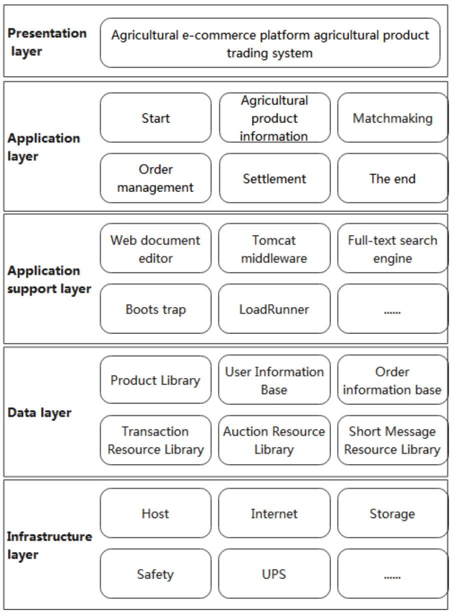

Figure 4: System framework of agricultural product trading platform.

The Tomcat middleware that publishes Java programs, the full-text search engine component that obtains Internet information on the user site, and the LoadRunner test tool component that conducts system stress testing, etc., ensure that the functional indicators and performance indicators of each module of this project meet actual business requirements.

4. The data layer is a data resource library created based on the system database software to support the data storage of each system module. This mainly includes the agricultural product information database, order information database, user information database, matchmaking transaction resource database, auction transaction resource database, short message resource database, etc.

5. The infrastructure layer mainly includes the server host, Internet connection, storage, backup, security, operating system, and other essential equipment required for this project's operation.

6. The three significant systems include a standard and normative system, a safety guarantee system, and an operation and maintenance system, all of which include relevant construction standards, management systems, work procedures, and application technologies.

The agricultural product trading system uses a B/S application architecture and an MVC design mode. It is divided into a three-layer structure, as Figure 5 shows the system technology architecture. Agricultural products electronic trading subsystem can be divided into the following modules according to their functions: (1) Agricultural product information management module; (2) Order management module; (3) Online bidding module; (4) Matching transaction module; (5) Settlement module; (6) SMS reminder module. Figure 6 shows the system function module diagram.

The overall design and implementation of the agricultural e-commerce platform requires the effective collaboration of many managers, designers, and developers to achieve accurate design under effective management. Based on such considerations, it is necessary to use appropriate development methods to develop e-commerce platforms in the entire agricultural field.

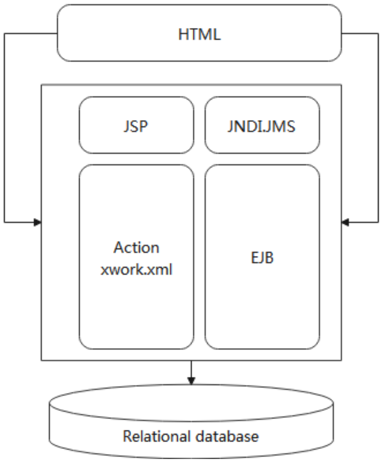

Figure 5: Technical architecture diagram of agricultural product trading system.

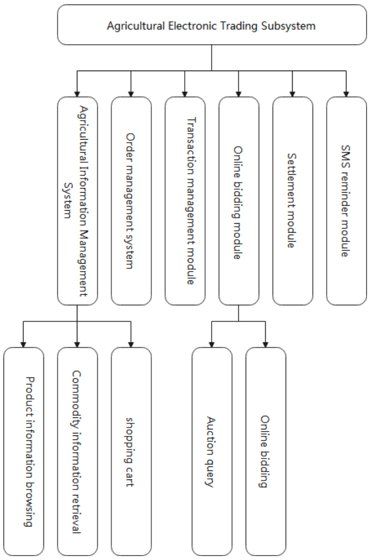

Figure 6: Functional module diagram of agricultural product trading system.

Nowadays, more techniques are being developed in the field of software engineering. However, for such a platform that uses service-oriented architecture (SOA) and a large number of components, after comparing and researching various development methods, it is considered that a service-oriented system development method that uses multi-model-driven, multi-view synchronization, and multi-role collaboration is more appropriate. Figure 7 is an engineering platform designed to implement this development method.

This method can effectively solve the problems faced in developing SOA and component collaborative work and the communication problems caused by business consultants and developers due to different backgrounds.

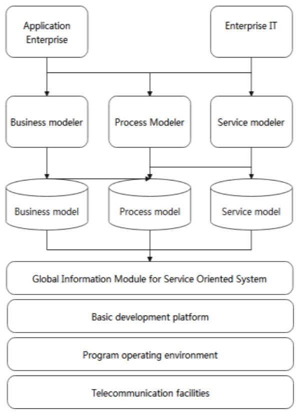

Figure 7: The overall structure of the service-oriented engineering platform.

5 PERFORMANCE VERIFICATION OF SUSTAINABLE AGRICULTURAL E-COMMERCE SYSTEM BASED ON BIG DATA ANALYSIS

After constructing a sustainable agricultural e-commerce system based on big data technology, this paper verifies the performance of the system model built in this paper. This article improves the agricultural product recommendation algorithm and systematically improves the traditional agricultural e-commerce system. Therefore, this paper mainly investigates the recommendation algorithm and e-commerce satisfaction during system performance verification. First, this paper conducts an experimental study on the accuracy of the recommendation algorithm, and the results are shown in Table 1 and Figure 8.

NO.	*Accuracy*	*NO.*	*Accuracy*	*NO.*	*Accuracy*
1	*93.71*	*28*	*92.44*	*55*	*90.63*
2	*92.19*	*29*	*91.17*	*56*	*91.95*
3	*90.54*	*30*	*93.08*	*57*	*88.27*
4	*91.39*	*31*	*92.97*	*58*	*88.93*
5	*90.92*	*32*	*89.78*	*59*	*88.64*
6	*88.65*	*33*	*92.13*	*60*	*91.36*
7	*88.09*	*34*	*91.82*	*61*	*90.53*
8	*89.96*	*35*	*92.21*	*62*	*93.89*
9	*90.24*	*36*	*90.42*	*63*	*91.91*
10	*88.40*	*37*	*93.25*	*64*	*88.81*
11	*90.49*	*38*	*90.48*	*65*	*90.54*
12	*88.59*	*39*	*88.59*	*66*	*90.49*
13	*92.64*	*40*	*91.59*	*67*	*89.30*
14	*91.51*	*41*	*92.98*	*68*	*92.53*
15	*92.00*	*42*	*90.82*	*69*	*91.18*
16	*89.63*	*43*	*90.43*	*70*	*88.66*
17	*89.60*	*44*	*93.59*	*71*	*93.55*
18	*91.31*	*45*	*93.58*	*72*	*88.21*

19	*89.13*	*46*	*88.82*	*73*	*90.32*
20	*89.98*	*47*	*89.01*	*74*	*89.67*
21	*93.11*	*48*	*89.46*	*75*	*90.83*
22	*89.68*	*49*	*88.79*	*76*	*91.67*
23	*88.72*	*50*	*89.45*	*77*	*88.53*
24	*91.56*	*51*	*93.53*	*78*	*89.64*
25	*88.97*	*52*	*91.30*	*79*	*89.74*
26	*93.36*	*53*	*90.56*	*80*	*93.09*
27	*89.07*	*54*	*91.14*	*81*	*93.69*

Table 1: Statistical table of the accuracy of the e-commerce recommendation algorithm.

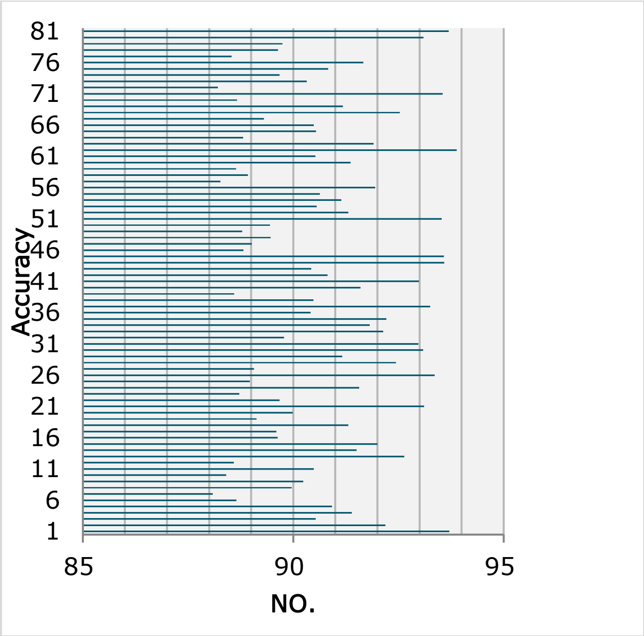

Figure 8: Statistical diagram of the accuracy of the e-commerce recommendation algorithm.

From the above research, the sustainable agricultural e-commerce system based on big data technology constructed in this paper can effectively recommend agricultural products to needy users. This paper conducted a satisfaction survey of the e-commerce system, and the results obtained are shown in Table 2 and Figure 9.

NO.	*Satisfaction*	*NO.*	*Satisfaction*	*NO.*	*Satisfaction*
1	*86.80*	*28*	*91.48*	*55*	*84.77*
2	*91.80*	*29*	*87.56*	*56*	*91.99*
3	*89.02*	*30*	*87.29*	*57*	*85.98*
4	*89.17*	*31*	*91.62*	*58*	*83.48*
5	*83.23*	*32*	*87.16*	*59*	*90.94*
6	*90.85*	*33*	*84.78*	*60*	*86.27*

7	*87.13*	*34*	*88.69*	*61*	*91.97*
8	*85.66*	*35*	*91.82*	*62*	*87.71*
9	*91.75*	*36*	*83.18*	*63*	*91.42*
10	*87.08*	*37*	*86.26*	*64*	*86.57*
11	*87.75*	*38*	*83.57*	*65*	*86.52*
12	*89.56*	*39*	*87.62*	*66*	*88.38*
13	*83.34*	*40*	*87.69*	*67*	*91.03*
14	*86.74*	*41*	*84.73*	*68*	*87.51*
15	*88.65*	*42*	*89.90*	*69*	*84.43*
16	*88.47*	*43*	*90.98*	*70*	*89.98*
17	*91.77*	*44*	*88.62*	*71*	*86.72*
18	*90.17*	*45*	*86.16*	*72*	*84.22*
19	*90.97*	*46*	*89.21*	*73*	*84.76*
20	*84.55*	*47*	*84.79*	*74*	*90.74*
21	*90.25*	*48*	*91.21*	*75*	*90.58*
22	*86.96*	*49*	*91.51*	*76*	*86.34*
23	*87.58*	*50*	*86.02*	*77*	*90.78*
24	*84.02*	*51*	*85.83*	*78*	*89.38*
25	*91.46*	*52*	*84.20*	*79*	*90.95*
26	*85.91*	*53*	*85.47*	*80*	*89.03*
27	*85.77*	*54*	*90.11*	*81*	*84.79*

Table 2: Statistical table of user satisfaction of e-commerce system.

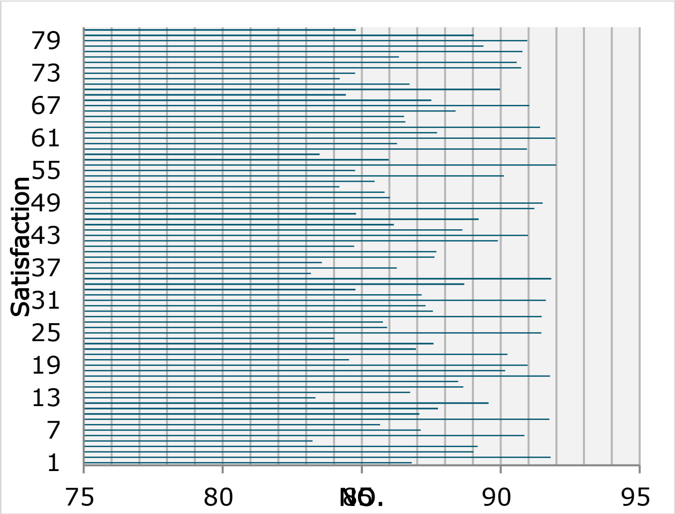

Figure 9: Statistical diagram of user satisfaction of e-commerce system.

The above research shows that the agricultural, cultural e-commerce system based on big data constructed in this paper has reached its basic expected requirements.

6 CONCLUSIONS

Judging from the current development, the chances of choosing an existing trading platform are greater. However, redefining the characteristics of green agriculture requires careful consideration of the development situation, development strategy, and marketing model of the e-commerce platform. At the same time, it is necessary to reach in-depth cooperation with e-commerce platforms and form an agricultural product marketing module from the unique perspective of farm products and tourism resources so that consumers can understand the situation and information of agricultural products. By incorporating Human-Computer Interaction into e-commerce platforms, we can provide consumers with the tools and information they require to make informed decisions, optimize farming practices, and contribute to a more sustainable future. This article combines big data technology to construct a sustainable agricultural e-commerce system, which provides a reference for the subsequent diversification of agricultural economic development. This article improves the agricultural product recommendation algorithm and systematically improves the traditional agricultural e-commerce system. In addition, when performing system performance verification, this paper mainly investigates the recommendation algorithm's accuracy and the e-commerce algorithm's user satisfaction. Through experimental research, it can be known that the sustainable agricultural e-commerce system based on big data constructed in this paper has reached the basic expected requirements of the construction of the system.

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