www.cad-journal.net
Computer-Aided Design AND APPLICATIONS

Big Data Analysis and Decision Support System Based on Deep Learning

Yan Yan[1] and Huqun Yang[2]

[1]Department of Business, Hefei University of Economics, Hefei 230011, China, troop_again@hotmail.com
[2]School of Mechanical and Electronic Engineering, Zhongyuan Institute of Science and Technology, Zhengzhou, Henan 450000, China, 1011009@stu.zykj.edu.cn

Corresponding author: Huqun Yang, 1011009@stu.zykj.edu.cn

Abstract. With the advent of the era of big data (BD), people are facing the challenges of massive data and complex problems. These data and provide accurate and timely decision support for decision makers has become a hot issue in current research. Taking marketing decisions as an example, this article constructs a BD analysis and computer-aided decision support system (DSS) based on deep learning (DL). Firstly, the system extracts the features related to marketing from the original data through data preprocessing and feature extraction. Then, the DL model is used to learn and predict the characteristics, and the optimization scheme of marketing strategy is obtained. Finally, the practical application effect of the decision-making system is tested by simulation experiment, which proves the feasibility and superiority of the method. By adopting DL model, and comparing Fuzzy C Clustering (FCM) algorithm and Decision Tree (DT) algorithm, the algorithm in this article is the most stable in stability test, and can provide efficient and stable decision support. Moreover, the algorithm in this article also has great advantages in real-time analysis, which can quickly process a large quantity of data and meet the needs of real-time decision-making. These advantages make intelligent DSS based on DL have a wide application prospect and can provide strong support for practical decision-making problems.

Keywords: Deep Learning; Computer-Aided; Big Data Analysis; Decision Support System; Marketing Strategy
DOI: https://doi.org/10.14733/cadaps.2024.S13.62-74

1 INTRODUCTION

The intelligent medical decision support model utilizes artificial intelligence (AI) and big data technology to deeply mine and analyze massive medical data, providing accurate and timely decision support for decision-makers. These models can not only improve the quality and efficiency of medical services, reduce medical costs, but also increase patient satisfaction and create greater value for

medical institutions. Abdel et al. [1] aiming to address the shortcomings of existing medical decision support systems medical services. Soft computing is a computational method that solves complex problems in an imprecise manner, such as fuzzy logic, neural networks, etc. These methods have significant advantages in dealing with uncertain, nonlinear, and fuzzy medical problems. The Internet of Things is composed of various physical devices and sensors, which can achieve interconnectivity between devices and obtain a large amount of real-time medical data. By using soft computing technology to process and analyze from the Internet of Things, medical decision-making can be better supported.

Traditional data analysis methods are often unable to process such large-scale and complex data, detect valuable information from it, and provide accurate and timely decision support for decision makers. New algorithms and models are constantly emerging, providing more possibilities for the development of ML-CDSS. For example, deep learning technology can process more complex and high-dimensional data, providing more accurate diagnosis and treatment plans. The application of Clinical Decision Support Systems (CDSS) in medical practice is becoming increasingly widespread. ML-CDS) provides doctors with more accurate and personalized diagnosis and treatment plans by utilizing big data and machine learning algorithms. With the reform of the healthcare system and the increasing demand for patients, the demand for clinical decision support is increasing. Antoniadi et al. [2] have provided broad market and application prospects for the development of ML-CDSS. Meanwhile, with the improvement of data quality and data collection technology, the accuracy and reliability of ML-CDSS will also be improved. Therefore, new methods and tools are needed to meet the challenges in the era of BD. With its powerful processing power and high efficiency, distributed denial of service (DDoS) attacks have become a serious network security threat. DDoS attacks overload the target server through a large amount of request traffic, resulting in unavailability of its services. Therefore, developing a real-time and effective DDoS attack detection system is crucial for protecting the network services of enterprises and individuals. Awan et al. [3] explored how to use big data methods to build such a system. Using big data methods can effectively address the threats posed by DDoS attacks. By analyzing massive network traffic data, we can timely detect and prevent DDoS attacks, protecting the network security of enterprises and individuals. However, how to apply DL to BD analysis, especially to support DSS, is still a problem to be solved. Ghazal et al. [4] helps to formulate agricultural production plans and predict market prices. Optimize agricultural decision-making problems such as precision fertilization and irrigation, agricultural machinery path planning, etc. through machine learning technology to improve agricultural production efficiency and reduce costs. For example, using deep learning technology to learn soil moisture data and achieve precise irrigation.

Wireless sensor networks provide real-time and reliable environmental parameter monitoring and data collection methods for precision agriculture. And machine learning technology provides refined management basis and optimization decision support for agricultural production through the analysis market data and make timely response. The traditional marketing decisions method is often based on experience and manual analysis, and it can't handle large-scale data, nor can it dig out the potential value of data. Multi criteria decision-making theory is a widely used method for practical problem decision-making. In the selection of cloud services, multiple criteria need to be considered, such as price, performance, service quality, security, etc. Through multi criteria decision-making theory, weight allocation can be carried out on these criteria, and the advantages and disadvantages of each cloud service can be comprehensively evaluated, providing a basis for enterprises to choose the best cloud service. Rough set theory is a method of dealing with uncertain information, which classifies, processes, and induces data to uncover valuable information hidden within it. With the rapid development of cloud computing, cloud service selection has become a key link for enterprises to carry out information construction. How to select the most suitable service for oneself from numerous cloud services. Haqiq and Talbi [5] proposed a cloud proxy architecture based on multi criteria decision-making and rough set theory, aiming to provide enterprises with an effective method for selecting cloud services. This article proposes a DL-based BD analysis and computer-aided DSS, which can automatically detect valuable information from massive data and provide accurate and timely decision support for decision makers. By using DL technology, the system can process

large-scale data sets and mine potential laws and patterns, thus providing more comprehensive and in-depth decision-making basis for decision makers. The system aims to detect valuable information from massive data by using DL technology, provide accurate and timely decision support for marketing decisions, and improve the efficiency and accuracy of decision-making. The practical application effect of the decision-making system is tested by simulation experiments, which proves the feasibility and superiority of this method. The application of DL in BD analysis provides a new way and method for the construction of DSS, and also provides reference for BD analysis and decision support in other fields.

With the explosive growth of data in the biomedical field, how to effectively utilize these data has become a key issue. Tree based automatic machine learning (TBM) is a powerful method that can automatically select the most representative features from a large amount of data, thereby improving the performance of the classifier. Le et al. [6] introduced how to extend TBM to biomedical big data and explained its application scenarios and advantages. Feature selection is an important step, and enable machine learning algorithms to learn and predict more effectively. In the field of biomedicine, feature selection is particularly important, and predict the progression and prognosis of the disease, and provided accurate decision support and risk management scheme for investors and enterprises. The research has made the following innovations:

(1) DL technology has gradually become an important means of BD analysis with its powerful processing capacity and high efficiency. In this article, DL is introduced into BD analysis to provide new ideas and methods for DSS.

(2) Taking marketing decisions as an example, this article constructs a BD analysis and computer-aided DSS based on DL. Through data preprocessing and feature extraction, the system extracts the features related to marketing from the original data, and then uses DL model to learn and predict the features, and obtains the optimization scheme of marketing strategy.

(3) This in-depth data mining and analysis will help decision makers to better understand market trends and consumer demand, so as to make more accurate and timely decisions.

Firstly, this article introduces DL model and BD analysis, analyzes their theoretical basis, and analyzes their applications in computer-aided DSS. Then the realization method of computer-aided DSS BD analysis algorithm is expounded in detail. Then the application effect of this method is tested. Finally, the full text work is summarized.

2 THEORETICAL AND TECHNICAL BASIS

Wireless sensor networks provide real-time and reliable environmental parameter monitoring and data collection methods for precision agriculture. And machine learning technology provides refined management basis and optimization decision support for agricultural production through the analysis and learning of a large amount of data. The mutual promotion and organic combination of these two will further promote the development of precision agriculture and the improvement of intelligence level. Mekonnen et al. [7] used machine learning algorithms to classify and recognize agricultural environmental monitoring data, crop growth data, etc., providing a refined management basis for agricultural production. For example, automatic diagnosis and identification of crop diseases and pests can be achieved through image recognition technology. Based on machine learning algorithms, prediction of crop yield is achieved through learning and analyzing historical data. This helps to formulate agricultural production plans and predict market prices. Nallaperuma et al. [8] introduce an online incremental machine learning method for intelligent traffic management driven by big data, and explain its application prospects and development challenges. By utilizing historical and real-time traffic data, online incremental machine learning algorithms can predict future traffic flow in real-time, providing decision support for traffic scheduling and planning. By analyzing and learning historical data of traffic accidents, online incremental machine learning algorithms can be used to establish traffic accident warning models, identify potential traffic accidents in advance, and take corresponding safety measures. By analyzing road sensor data, traffic camera data, etc., online

incremental machine learning algorithms can be used to predict road congestion and provide congestion prediction and scheduling solutions for traffic management departments.

With the increasing awareness of environmental protection in society, environmentally friendly hotels have gradually become an emerging tourism industry. Environmentally friendly hotels emphasize sustainability and environmental protection, which gives their customer base a certain degree of specificity. Through big data analysis, we can better understand the needs, preferences, and behavioral patterns of these customer groups, thereby developing more accurate marketing strategies and customer service plans. Through this data analysis, we can better understand customers' needs and expectations, and develop marketing strategies and service plans that better meet their needs. For example, if the data shows that most customers prefer to enjoy local specialty cuisine during check-in. We can add more local specialty dishes to the menu or offer more local specialty products in the guest room. Nilashi et al. [9] explored the big social data analysis method for customer decision-making in environmentally friendly hotels, with the aim of providing reference for the development of environmentally friendly hotels. The customer base of environmentally friendly hotels mainly includes tourists, business people, and conference customers. These clients usually have a high educational background and income level, and have a high level of attention to environmental protection and sustainable development. In terms of customer decision-making, in addition to factors such as price, facilities, and services, customers also pay attention to the hotel's environmental protection measures and social responsibility. Therefore, how to use big social data analysis methods to mine customer needs and behavioral characteristics is a key issue in environmental hotel customer decision-making. Environmental and water resource management has gradually become the focus of global attention. Environmental issues are related to human survival, and the management of water resources directly affects the production and life of society. In this context, brought new solutions to environmental and water resource management. Sun et al. [10] aim to explore the applications, methods, and future directions of big data and machine learning in environmental and water resource management. Big data and machine learning play an important role in environmental and water resource management. Firstly, we need to collect data related to the environment and water resources, including but not limited to water quality data, meteorological data, geographic information data, etc. Then, it is necessary to use data processing technology to clean, organize, and standardize the data for subsequent analysis and application. Finally, machine learning algorithms are used to deeply learn and predict the processed data, providing decision support for environmental and water resource management. In today's highly informationized era, big data technology has become the key for enterprises to gain competitive advantages. Among them, patent data, as an important form of intellectual property, has a significant impact on enterprise research and development (R&D) decision-making. Patent metrology, as a discipline based on quantitative analysis, aims to explore valuable information in patent data and provide data support for R&D decisions of enterprises. Verma and Suri [11] explore the application of big data patent metrology in research and development decision-making, with the aim of providing new ideas and methods for enterprise R&D decision-making. By deeply mining the patent data of competitors, enterprises can understand their technical strength, research and development teams, and patent layout, providing reference for enterprises to formulate targeted competitive strategies. By mining and analyzing publicly available patent data, enterprises can find partners with common research and development interests and technological strength to reduce research and development costs and improve research and development efficiency.

Artificial intelligence technology can help logistics enterprises achieve automated decision-making and improve operational efficiency. For example, through machine learning and deep learning techniques, a large amount of historical data can be analyzed to predict future logistics needs and develop more accurate planning and scheduling plans. This can not only reduce logistics costs, but also improve customer response speed and service quality. Woschank et al. [12] explore the development trends and challenges of future intelligent logistics. Intelligent logistics refers to the process of achieving automation, intelligence. In the warehousing process, IoT technology and artificial intelligence algorithms can monitor environmental factors such as temperature, humidity, and lighting in real-time, ensuring that items are stored in a suitable environment. At the same time,

through machine learning and deep learning technologies, intelligent management of warehouse inventory can be achieved, achieving automatic replenishment and optimizing inventory layout. In the transportation process, artificial intelligence and IoT technology can optimize transportation routes and schedule vehicles, improving transportation efficiency. By using real-time traffic information and prediction models, congested road sections can be avoided and transportation time can be reduced. In the delivery process, artificial intelligence and machine learning technology can achieve intelligent delivery planning and optimization, automatically planning the optimal delivery route and time based on factors such as delivery address and traffic conditions. Meanwhile, through IoT technology, the location and status of goods can be tracked in real-time, improving the transparency and accuracy of delivery. As the core of intelligent logistics, provide more efficient, accurate, and intelligent solutions for the logistics industry. With the popularity of social media, people are increasingly using it to express their opinions, emotions, and behaviors. This makes social media an important source of information and has significant implications for risk emergency decision-making. Xu et al. [13] mining and analyzing social media data, assess the severity and scope of risks. We use techniques such as sentiment analysis and association rule mining to extract information such as the public's level of attention to risks, emotional attitudes, and possible influencing factors, providing reference for decision-makers. Based on risk assessment, develop corresponding emergency response measures. We use classification algorithms to classify different risks and propose corresponding emergency response strategies for different types of risks. In addition, we can also use recommendation algorithms to provide potential emergency resource recommendations and optimization suggestions. In today's information age, factor in enterprise decision-making and competition. The connection between information technology and decision-making is becoming increasingly close. Firstly, information technology is an important tool for obtaining, storing, and analyzing big data. There are various sources of big data, including internal business data, external market data, user data, and so on. Information technology can help enterprises quickly and accurately obtain these data, and efficiently and reliably process and analyze them. For example, enterprises can discover patterns and trends through data mining technology, classify and predict data through machine learning technology, thereby improving the accuracy and efficiency of decision-making [14].

Business models and decision-making systems are undergoing a revolution. The application of big data assisted social media analysis in business decision-making systems is becoming increasingly widespread, providing unprecedented opportunities and challenges for enterprises. Zhang et al. [15] explored the application and competition of big data assisted social media analysis business models in business decision-making systems, with the aim of providing valuable references for enterprises. The rise of social media has made the interaction between enterprises and consumers closer and more direct, while the development of big data technology has made it possible to process and analyze these massive data. In terms of business model, social media enables enterprises to interact directly with consumers, so as to better understand consumers' needs and feedback. This enables enterprises to adjust products and services more quickly, position the market more accurately, and promote and market more effectively. For example, social media advertising has become one of the main promotion channels of many enterprises. It can accurately deliver according to users' interests and behaviors, and improve the conversion rate and effect of advertising. The application of big data assisted social media analysis in business decision-making systems is becoming increasingly widespread, providing unprecedented opportunities and challenges for enterprises. This article aims to explore the application and competition of big data assisted social media analysis business models in business decision-making systems, in order to provide valuable references for enterprises. Zhang [16] can effectively integrate sports culture data from different sources, extract valuable information through data mining algorithms, and provide decision support and data analysis services for the sports field. For example, by using classification algorithms to predict the competitive level of athletes, we successfully predicted the performance of multiple athletes. By using prediction algorithms to predict the number of spectators in the event, we have provided accurate prediction results for the event organizers. By using clustering algorithms to classify athletes, we discovered multiple hidden group structures, providing valuable references for athlete training and event

scheduling. Strengthen the formulation and implementation of network security laws and regulations, improve the level of network security technology, and strengthen network security publicity and education. At the same time, we also need to improve our awareness of network security, strengthen our self-protection capabilities in network security, and jointly maintain network security and social stability, network security issues are also becoming increasingly prominent. Intrusion detection, as an important component of network security, for protecting network security. Zhong et al. [17] explored how to apply deep learning systems based on big data to intrusion detection and elaborated on the role of big data mining and analysis. After data preprocessing, we need to use data mining techniques to model and analyze the processed data. By mining network traffic and user behavior patterns, potential intrusion behavior and malicious users can be discovered.

3 IMPLEMENTATION OF DSS BD ANALYSIS ALGORITHM BASED ON DL

DL can be used to detect patterns and trends from data, thus providing data-driven suggestions for decision-making. For example, in the field of marketing, DL can analyze sales data, customer feedback and competitors' marketing strategies to identify market trends and opportunities and help enterprises formulate more effective marketing strategies. DL can be combined with reinforcement learning to build intelligent agents, automatically learn and optimize the decision-making process. Convolutional neural network (CNN) is a DL model specially used for processing data with similar grid structure, such as image and voice signals. Recurrent neural network (RNN) is a DL model for processing sequence data, which solves the problem that traditional neural network can't process sequence data by introducing memory unit.

BD analysis refers to the stage of collecting, storing, managing and analyzing large-scale data to detect valuable information and knowledge. Driven by BD, data has become a new resource, and BD analysis technology is an effective means to detect valuable information from massive data. Using BD analysis technology, the collected data is deeply mined and analyzed. By presenting the analysis results to decision makers in a visual way, decision support and decision-making are provided. The use of BD analysis in DSS can help enterprises better understand the needs of the market and consumers, improve the efficiency and accuracy of decision-making, and thus gain an advantage in the fierce market competition.

Through data reduction, we can remove redundant and irrelevant data, retain key information, make the data more concise, easy to understand, and enable faster data processing and analysis. Data reduction cannot change the distribution and characteristics of the original data, and must maintain the representativeness of the data. We cannot lose too much information and must retain key information and features. The results of data reduction should be interpretable and easy for people to understand and analyze. The results of data reduction should have a certain degree of stability, that is, for different datasets or processing methods, the results should be consistent. Feature extraction is one of the core technologies to detect valuable information from data. Through statistical analysis and pattern recognition of data, it extracts attributes that can reflect the characteristics of data, thus providing support for analysis such as classification, clustering and regression.

DSS is a tool to assist decision-makers, which improves the efficiency and accuracy of decision-making by providing information and knowledge. In the past decades, DSS has become one of the important tools in various fields, including enterprise management, medical health, financial investment and other fields.

DL-based BD analysis and DSS combine DL model with BD analysis technology to provide accurate and timely decision support for decision makers by automatically extracting valuable information from massive data. The system can automatically process and analyze large-scale data, find the distributed feature representation of data, provide more comprehensive and in-depth information, and provide accurate and timely decision support for decision makers has always been a difficult problem in BD analysis. Traditional data analysis methods often need manual intervention,

which is difficult to adapt to the scale and complexity of BD. Therefore, this section proposes a BD analysis and DSS based on DL, aiming at automatically extracting valuable information from massive data and improving the efficiency and accuracy of decision-making.

These are the key steps of data preprocessing. Data cleaning involves handling missing values, outliers, and redundant data. Data integration is the combination of data from multiple sources or datasets to provide more comprehensive information. Data transformation is the process of adapting data to specific analytical techniques or models, such as converting classified data into numerical form. Reducing data size can be achieved by sampling in large datasets or anonymizing data when processing sensitive data. According to the prediction results, a visual decision support report is generated to provide accurate and timely decision support for decision makers. The implementation flow of information classification algorithm combined with DL is shown in Figure 1.

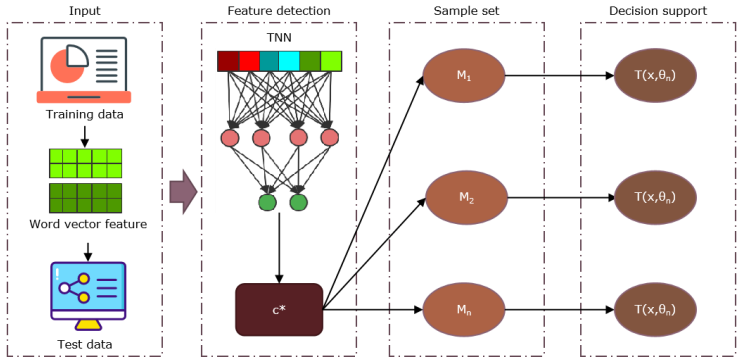

Figure 1: Execution flow of information classification algorithm.

At the beginning of each DM process, data need to be preprocessed. This process includes data cleaning, integration, conversion and reduction. By repeating this process, we can improve the quality and accuracy of data, thus reflecting the real world situation more accurately. When using DL model to detect features, the extracted features may be slightly different each time. By repeating this process, we can gradually detect more and more valuable features, so as to better understand the nature of data. In every DM process, the model needs to be trained and optimized. By repeating this process, the accuracy and generalization ability of the model can be gradually improved. By repeating the stage of forecasting analysis and decision support, the efficiency and accuracy of decision-making can be gradually improved. This can help us find the optimal solution more quickly when facing complex problems. This article adopts the mining model as shown in Figure 2.

Set sample set:

$$S = \{s_1, s_2, \ldots, s_m\} \tag{1}$$

The sample categories are:

$$C = \{c_1, c_2, \ldots, c_k\} \tag{2}$$

Then the calculation formula of the sample information entropy is as follows:

$$\begin{aligned} H(S) &= \sum_{j=1}^{k} \sum_{i=1}^{m} p(s_{ij}) \log \frac{1}{p(s_{ij})} \\ &= -\sum_{j=1}^{k} \sum_{i=1}^{m} p(s_{ij}) \log\, p(s_{ij}) \end{aligned} \tag{3}$$

$$A = \{a_1, a_2, \ldots, a_t\}^T \tag{4}$$

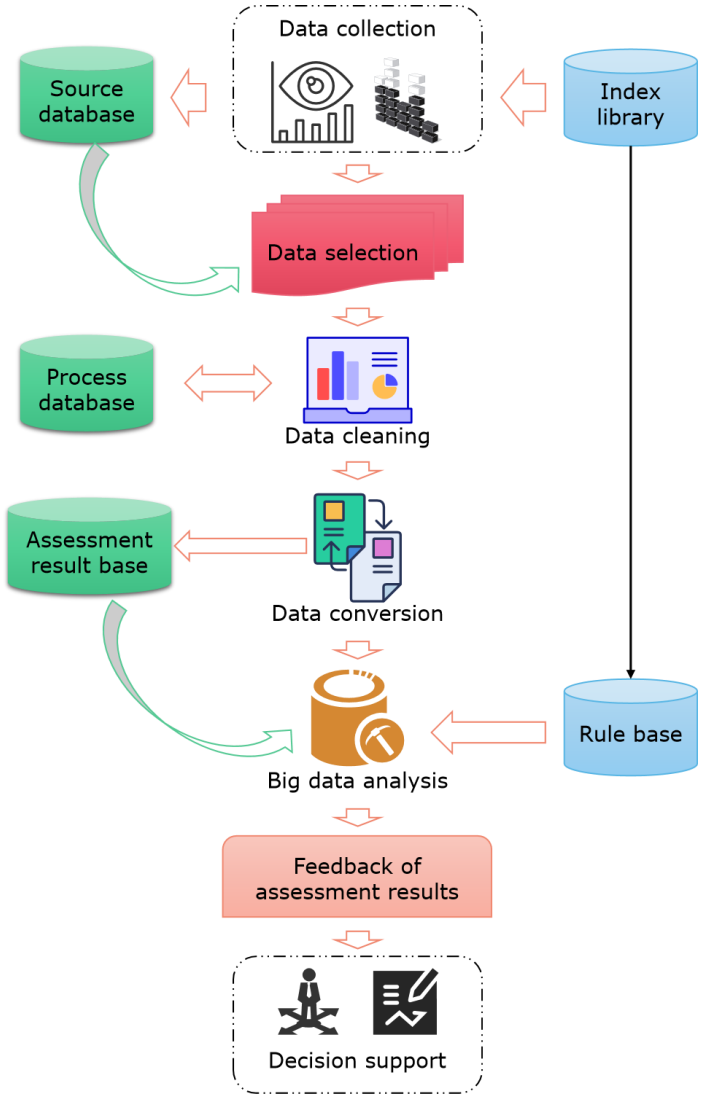

Figure 2: DM model of computer-aided DSS.

$$H(S|A) = -\sum_{j=1}^{k}\sum_{i=1}^{t} p(a_{ij})\log\, p(a_{ij}) \tag{5}$$

Features related to the target customers are extracted from the preprocessed data, such as customer's purchase frequency, purchase preference and social media behavior. Using Bayesian network model to build DSS. According to the extracted features, nodes and directed edges can be determined, thus constructing Bayesian network model. Bayesian network model is trained by using known data sets to determine the probability distribution between nodes. Use the trained model to predict and analyze the unknown data. According to the prediction results, corresponding decisions can be made, such as recommending products, sending marketing emails or providing coupons. According to the prediction results and actual feedback, the model is continuously optimized to improve accuracy and practicability. Suppose there is one user, and its corresponding Bayesian DM model is shown in Figure 3.

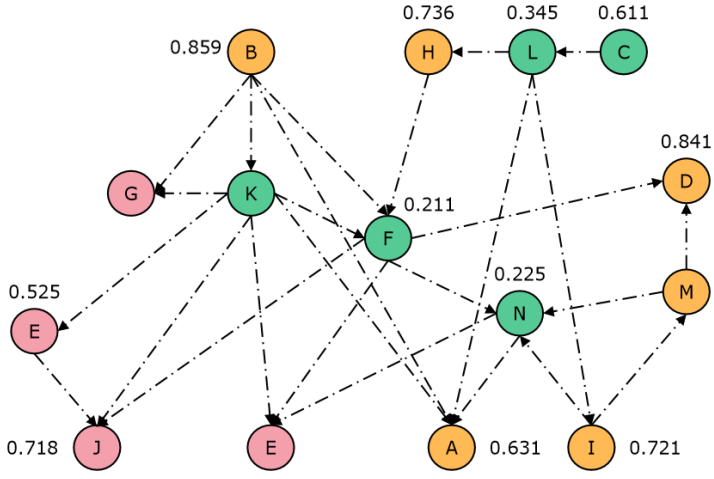

Figure 3: Bayesian model.

Independent batch normalization (IBN) is a normalization technique, which normalizes the data of each dimension separately, instead of jointly normalizing the data of all dimensions. This method has been widely used in DL model, especially when dealing with tasks with multidimensional input data. Firstly, the input data is divided into several small batches. In DL, only a small batch of data is usually processed at a time, which can save memory and prevent over-fitting. Then, the data of each dimension are standardized separately. For each dimension, the mean and standard deviation of the dimension are calculated, and then these statistics are used to standardize the data of the dimension. Linear transformation: after standardization, the data is transformed linearly. This step is to ensure the scale invariance of the data. Finally, the standardized and linearly transformed data are recombined. The data of each dimension has been normalized separately and has the same distribution.

The IBN is used to replace the joint normalization of each characteristic element:

$$\widehat{X}^{(k)} = \frac{x_i^{(k)} - E\left[x^{(k)}\right]}{\sqrt{\mathrm{var}\left[x^{(k)}\right]}} \tag{6}$$

$$y^{(k)} = \lambda^{(k)} \widehat{X}^{(k)} + \beta^{(k)} \tag{7}$$

$$L = J(w,e) - \sum_{i=1}^{N} a_i \left\{ w^T \varnothing(x_i) + b + e_i + y_i \right\} \tag{8}$$

The {} in the formula represents a decision sequence, which may be a continuous decision, such as a management decision on farmland over a period of time< {}>represents the expected value of a decision sequence. The w in the formula is a weight vector that is related to the feature vector and may be used to adjust the importance of each feature. B is a bias term that may be used to adjust the mean of the decision sequence. Finally, f (·) may be an activation function, such as the Sigmaid function or ReLU function, used to convert the output of the model into probability or predictive values.

4 EXPERIMENTAL RESULTS AND ANALYSIS

Firstly, relevant data are collected from public data sets or internal data of enterprises, and data cleaning and preprocessing are carried out, including data missing value filling, abnormal value

processing, data standardization and other operations, so as to facilitate subsequent model training and application. In this article, DL model is used for training, and through several rounds of iterative training, the model parameters are optimized to improve the accuracy and generalization ability of the model. The test set is used to assess the trained model to determine the superiority of the algorithm proposed in this article. Stability test: Through running experiments for many times, observe the stability performance of different algorithms in different experimental environments. Aiming at the application scenarios with high real-time requirements, a real-time test experiment is designed. By simulating the environment of large data flow, the real-time data processing and response time of different algorithms are tested to assess the performance of different algorithms in real-time decision support.

Using the data from 2001 to 2011 as training samples, using the data from 2012 to 2022 as test samples, and then using the trained DL model to predict the market development trend. The result of DT algorithm is shown in Figure 4, and the result of this algorithm is shown in Figure 5.

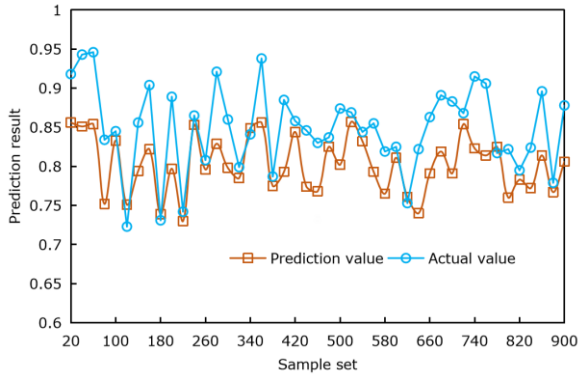

Figure 4: Simulation value and actual value of DT algorithm.

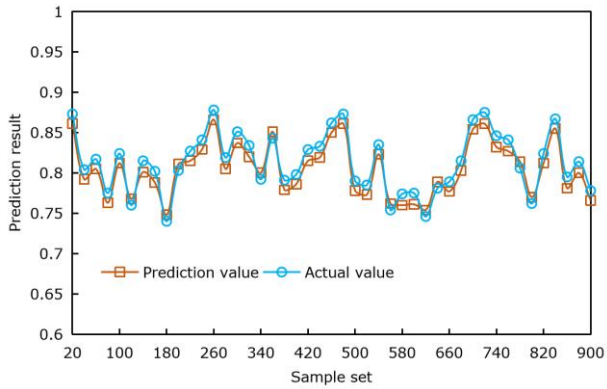

Figure 5: Simulation value and actual value of this algorithm.

Using the data from 2001 to 2011 as training samples, DL model learned the historical market trends and patterns, and improved the generalization ability of the model through optimization in the training process. By using the data from 2012 to 2022 as test samples, DL model predicts the market development trend. Compared with DT algorithm, DL model performs better in predicting results. This may be because DL model has stronger expressive ability and flexibility, and can better capture the complex changes of market trends and patterns. By observing the closeness between the predicted results and the actual results, we can find that the predicted results of DL model are more accurate. For example, in the prediction of some years, DL model can more accurately predict the

upward or downward trend of the market and the magnitude of the change. This shows that DL model can better capture the complex patterns and trends in the market, thus providing more accurate support for marketing decisions.

The stability test results in Figure 6 show the performance of different intelligent decision-making systems. From the results, it can be seen that this system performs best in stability, while the other two systems fluctuate greatly and cannot provide stable and efficient decision support.

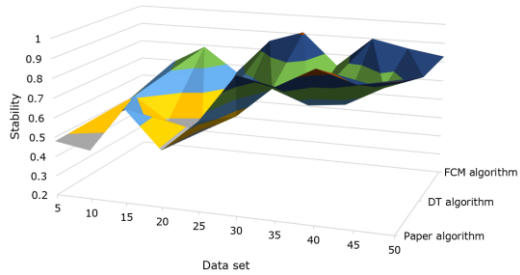

Figure 6: Stability of different intelligent decision systems.

In the stability test, except this system, the other two systems performed poorly. Specifically, they fluctuate greatly and have a high degree of curve dispersion. This shows that they may be disturbed in the stage of operation and cannot provide stable and efficient decision support. Good stability has important practical application value for intelligent decision-making system. In real life, both enterprises and government agencies want to have a stable and reliable DSS to assist the decision-making process. Through the stability test results of this system, it can be concluded that the system can provide more stable and reliable decision support in practical application. This advantage not only comes from the optimized algorithm design of the system, but also is closely related to the robustness of the system and the ability to handle abnormal data.

Figure 7 shows the real-time method of data processing in different systems. From the results, the intelligent decision-making system constructed in this article has more advantages in real-time data processing.

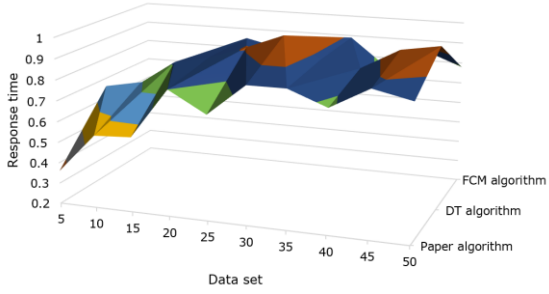

Figure 7: Response time of system processing data.

Real-time is one of the important indexes to measure the speed of data processing in the system. In real-time DSS, data streams usually come in continuously. Therefore, the system needs to have efficient data stream processing ability. The speed of this algorithm in data processing is obviously faster than FCM algorithm and DT algorithm. This shows that the system in this article has higher efficiency when dealing with a large quantity of data, and can provide decision support in a short time. FCM algorithm and DT algorithm may involve complex calculation and reasoning process when

processing data, but this algorithm reduces the complexity through optimization design. This optimization design is helpful to improve the real-time performance of the system, which enables the system in this article to provide decision support more quickly.

The architecture of the system is also optimized to improve the data processing speed. For example, a distributed computing framework is adopted, which can distribute data to multiple computing nodes for parallel processing; Moreover, cache technology is adopted to speed up the data processing. By comparing the real-time performance of different algorithms in data processing, the system in this article shows great advantages in data processing speed, algorithm complexity, data flow processing ability, abnormal data processing and system architecture optimization. This advantage makes the system in this article more efficient and accurate in real-time decision support, and can better meet the practical application requirements.

5 CONCLUSIONS

In today's highly information-based era, BD has become governments to make decisions. Traditional data analysis methods are often unable to process such large-scale and complex data, detect valuable information from it, and provide accurate and timely decision support for decision makers. This article proposes a DL-based BD analysis and computer-aided DSS, which can automatically detect valuable information from massive data and provide accurate and timely decision support for decision makers. By using DL technology, the system can process large-scale data sets and mine potential laws and patterns, thus providing more comprehensive and in-depth decision-making basis for decision makers. DL model performs well in dealing with massive data. By using a large quantity of historical data to train the model, valuable information can be automatically extracted to provide accurate and timely decision support for decision makers. This greatly reduces the time and energy of manual efficiency and accuracy of decision-making. The smallest fluctuation and the lowest standard deviation, and can provide stable and efficient decision support. This means that the system can maintain stable performance in continuous operation and is not affected by the external environment. It can quickly process a large quantity of data and meet the needs of real-time decision-making. Future research will continue to optimize the model structure, improve system performance, and combine it with more practical scenarios for verification and application promotion, which will provide strong support for solving more decision-making problems.

6 ACKNOWLEDGEMENT

This work was supported by 2022 Anhui Province Quality Engineering General Project, Research and Practice of Blended Teaching Model in Local Applied Undergraduate Universities--Take the Management Information Systems course as example, 2022jyxm1273; 2022 Anhui Teaching Innovation Team, Logistics Management Teaching Innovation Team, 2022cxtd118; 2023 Anhui Provincial Scientific Research Plan Project, Research on Putonghua Proficiency Test Based on Computer Aid, 2023AH052437.

Yan Yan, https://orcid.org/0009-0009-6427-0097
Huqun Yang, https://orcid.org/0009-0006-6016-5159

REFERENCES

[1] Abdel, B.-M.; Manogaran, G.; Gamal, A.; Chang, V.: A novel intelligent medical decision support model based on soft computing and IoT, IEEE Internet of Things Journal, 7(5), 2019, 4160-4170. https://doi.org/10.1109/JIOT.2019.2931647

[2] Antoniadi, A.-M.; Du, Y.; Guendouz, Y.; Wei, L.; Mazo, C.; Becker, B.-A.; Mooney, C.: Current challenges and future opportunities for XAI in machine learning-based clinical decision support

systems: a systematic review, Applied Sciences, 11(11), 2021, 5088. https://doi.org/10.3390/app11115088
[3] Awan, M.-J.; Farooq, U.; Babar, H.-M.-A.; Yasin, A.; Nobanee, H.; Hussain, M.; Zain, A.-M.: Real-time DDoS attack detection system using big data approach, Sustainability, 13(19), 2021, 10743. https://doi.org/10.3390/su131910743
[4] Ghazal, T.-M.; Hasan, M.-K.; Alshurideh, M.-T.; Alzoubi, H.-M.; Ahmad, M.; Akbar, S.-S.; Akour, I.-A.: IoT for smart cities: Machine learning approaches in smart healthcare—A review, Future Internet, 13(8), 2021, 218. https://doi.org/10.3390/fi13080218
[5] Haqiq, A.; Talbi, J.: A cloud broker architecture for cloud service selection based on multi-criteria decision making and rough set theory, International Journal of Computer Aided Engineering and Technology, 13(4), 2020, 448-464. https://doi.org/10.1504/IJCAET.2020.110481
[6] Le, T.-T.; Fu, W.; Moore, J.-H.: Scaling tree-based automated machine learning to biomedical big data with a feature set selector, Bioinformatics, 36(1), 2020, 250-256. https://doi.org/10.1093/bioinformatics/btz470
[7] Mekonnen, Y.; Namuduri, S.; Burton, L.; Sarwat, A.; Bhansali, S.: Review—Machine learning techniques in wireless sensor network-based precision agriculture, Journal of the Electrochemical Society, 167(3), 2019, 037522. https://doi.org/10.1149/2.0222003JES
[8] Nallaperuma, D.; Nawaratne, R.; Bandaragoda, T.; Adikari, A.; Nguyen, S.; Kempitiya, T.; Pothuhera, D.: Online incremental machine learning platform for big data-driven smart traffic management, IEEE Transactions on Intelligent Transportation Systems, 20(12), 2019, 4679-4690. https://doi.org/10.1109/TITS.2019.2924883
[9] Nilashi, M.; Minaei, B.-B.; Alrizq, M.: An analytical approach for big social data analysis for customer decision-making in eco-friendly hotels, Expert Systems with Application, 186(1), 2021, 115722. https://doi.org/10.1016/j.eswa.2021.115722
[10] Sun, A.-Y.; Scanlon, B.-R.: How can Big Data and machine learning benefit environment and water management: a survey of methods, applications, and future directions, Environmental Research Letters, 14(7), 2019, 073001. https://doi.org/10.1088/1748-9326/ab1b7d
[11] Verma, C.; Suri, P.-K.: 'Big data' patentometrics for R&D decision-making, Digital policy, regulation and governance, 23(4), 2021, 317-336. https://doi.org/10.1108/DPRG-09-2020-0126
[12] Woschank, M.; Rauch, E.; Zsifkovits, H.: A review of further directions for artificial intelligence, machine learning, and deep learning in smart logistics, Sustainability, 12(9), 2020, 3760. https://doi.org/10.3390/su12093760
[13] Xu, X.-H.; Yang, X.; Chen, X.: Large group two-stage risk emergency decision-making method based on big data analysis of social media, Journal of Intelligent and Fuzzy Systems, 36(3), 2019, 2645-2659. https://doi.org/10.3233/JIFS-18629
[14] Xu, Z.; Ge, Z.; Wang, X.: A Look at the focus on big data for information technology and decision making during 1994 to 2020, International Journal of Information Technology & Decision Making, 22(01), 2023, 7-35. https://doi.org/10.1142/S0219622022500298
[15] Zhang, H.; Zang, Z.; Zhu, H.: Big data-assisted social media analytics for business model for business decision making system competitive analysis, Information Processing & Management: Libraries and Information Retrieval Systems and Communication Networks: An International Journal, 59(1), 2022, 102762. https://doi.org/10.1016/j.ipm.2021.102762
[16] Zhang, J.: Reform and innovation of artificial intelligence technology for information service in university physical education, Journal of Intelligent & Fuzzy Systems, 40(2), 2021, 3325-3335. https://doi.org/10.3233/JIFS-189372
[17] Zhong, W.; Yu, N.; Ai, C.: Applying big data based deep learning system to intrusion detection, Big Data Mining and Analytics, 3(3), 2020, 181-195. https://doi.org/10.26599/BDMA.2020.9020003