Future Generation Computer Systems 107 (2020) 286–292

Contents lists available at ScienceDirect

Future Generation Computer Systems

journal homepage: www.elsevier.com/locate/fgcs

Research on investment decision-making model from the perspective of "Internet of Things + Big data"

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ARTICLE INFO

Article history:
Received 15 August 2019
Received in revised form 4 January 2020
Accepted 1 February 2020
Available online 6 February 2020

Keywords:
Decision-making model
Internet of Things
Big data
Data processing platform

ABSTRACT

With the continuous improvement of the global securities market, the market competition is unprecedented fierce. In the aspect of investment decision support system, there is an urgent need to continuously absorb new information processing technologies and improve the scientific and standardization of decision-making, so as to achieve the goal of improving investment decision-making efficiency and stabilizing investment returns. Firstly, this paper introduces the defect that the database, model base and knowledge base are designed and implemented independently in the traditional decision support system. Then, constructing a unified and efficient data processing platform for Internet of Things based on DMFS technology, which realizes the integration of database and model, and innovatively establishes a data mining model facing market big data, dynamically analyzes and proposes investment decisions. Finally, the operating income data of a listed company in recent ten years are selected for simulation, which verifies the efficiency of the model system in processing dynamic data and the stability of investment income.

1. Introduction

With the continuous development of the global economy, the market situation is becoming more and more complex, and the investment decision-making of enterprises becomes more and more difficult [1]. As the most critical and important decision in all the decisions of an enterprise, mistakes in investment decisions will lead to huge losses for the enterprise. Investment decision usually refers to the investment decision made by the investor after investigation, analysis and demonstration of the enterprise or project [2]. Therefore, how to realize the accurate analysis of the investment prospect has become the research focus of most scholars [3]. He studied the investment decision-making optimization framework for energy-saving renovation of several buildings under the constraint of fiscal budget [4]. Proposing a multi-objective optimization model with economic objective as net present value and profit time and environmental objective as energy saving and emission reduction objective, and designing an intelligent optimization method combining particle swarm optimization and genetic algorithm, searching the investment strategy for transformation [5]. Gao constructed an analysis opinion model based on evidential reasoning rules, which taking stock reports of financial analysts as input and generates portfolio strategies through evidential portfolio [6]. Sevastianov and Dymova introduced Dempster–Shafer theory and fuzzy set theory into an expert trading system that simulates human decision-making process, providing suggestions for traders to buy and sell stocks or other financial instruments by considering factors such as price history, technical analysis indicators, and recognized trading rules [7]. Cho combines a new cost-sensitive loan state prediction model with an investment decision model specifically aimed at P2P loan market [8]. The practical contribution of this model is to provide a full loan forecasting mechanism based on Entropy Fuzzy Support Vector Machine, and to use a simple regression model to rank loans with high return on investment, and ultimately to portfolio high-grade loans. The emergence and development of the Internet of Things technology provides the possibility to acquire project or enterprise data in real time [9].

The Internet of Things uses a variety of sensors to realize the collection of basic-level data, and realizes data interaction through wired transmission and wireless transmission, thus realizing the connection between things [10]. Many scholars have introduced the Internet of Things into their research fields. Fafoutis et al. [11] proposed a disease monitoring platform based on Internet of Things, which is used to detect and prevent chronic diseases in living environment, including diabetes, obesity or depression. The platform installs cameras on human body and ecological sensors, and realizes instant perception and decision-making through machine learning technology. Li [12] proposed an on-line monitoring system of greenhouse Internet of Things based on wireless sensor network, and designed a remote monitoring system based on network, which allows users to access

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https://doi.org/10.1016/j.future.2020.02.003
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the acquired information through smart phones or personal computers, and is used to control environmental factors such as temperature, humidity, carbon dioxide and ammonia. Control the chicken coop environment through an efficient interactive user interface. Fu et al. [13] used grip-force and eye tracking sensors to track consumers online shopping behaviors, so as to serve for the intelligent decision-making systems. Sun and Ansari [14] provided a dynamic internet of things resource caching method by using COAP publish/subscribe in the application layer of smart city smart parking applications.

The Internet of Things technology has brought opportunities for the transformation of all walks of life. Firstly, this paper introduces the shortcomings of the traditional investment decision-making model, and then proposes the construction of an investment decision-making platform based on Internet of Things technology. With the help of Internet of Things technology, building an investment decision platform database to realize real-time update of data. And then, establishing a decision model based on data mining to complete the integration of database and decision model. Finally, taking an enterprise project as an example for data simulation to realize investment decision.

2. Establishment of Internet of Things investment decision platform database

The traditional investment decision-making methods commonly used in project economic evaluation mainly include Discounted Cash Flow (DCF), Decision Tree Analysis (DTA), Simulation Analysis (SA) and real option method [15,16]. In the current era of big data, the traditional decision-making model has low investment efficiency and slow information feedback, so it is necessary to incorporate new information processing technologies into the investment decision-making system to improve the scientific and normative decision-making.

2.1. Key technologies and advantages of Internet of Things

The Internet of Things technology is a kind of network technology that connects articles with the Internet of Things by means of various kinds of sensing equipment to carry out information exchange and communication so as to realize intelligent identification, positioning, tracking, monitoring and management [17]. The Internet of Things is an extension and expansion based on the convergence of Internet, telecommunication network and radio and television network, and the key to triple play is to realize full IP of triple play. Therefore, for the Internet of Things, based on the IP protocol, a layered network communication protocol similar to the Internet TCP/IP protocol [18] can be used to provide services for various applications in the upper layer, while the protocol allows various heterogeneous networks under the IP protocol to run on the optimized network. The hierarchical network of the Internet of Things can be divided into 4 layers:

(1) Network interface layer: responsible for collecting and capturing information, and effectively fusing and compressing information. The transmission media used are mainly radio waves, light waves, infrared rays, etc.

(2) Network layer: mainly responsible for the discovery and maintenance of M addressing and routing. In order to communicate with each other, various heterogeneous networks in the Internet of Things must perform very complex hardware address translation, which is almost impossible for each node in the heterogeneous network. But a unified IP address can solve such complicated problems. An IP-based terminal is established in the underlying network to optimize seamless link communication between network hosts and Internet of Things nodes.

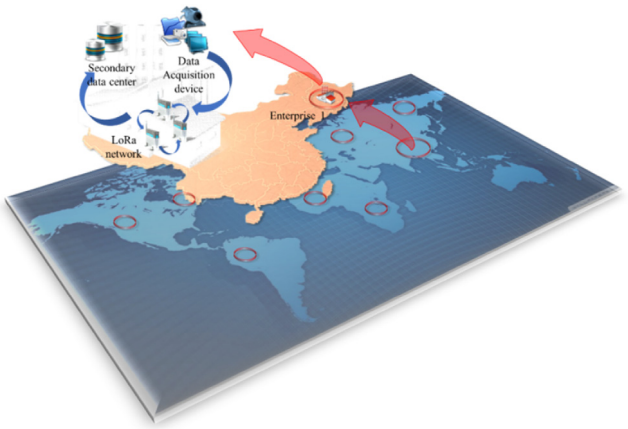

Fig. 1. The process of enterprise data collection and transmission.

(3) Transport layer: mainly responsible for data flow transmission control. It has the functions of division and reuse.

(4) Application layer: the highest layer in the architecture, this layer directly provides services for user application processes.

Investment decision-making in complex and changeable environment can be accomplished accurately and quickly if we can gain the advantage of data. Therefore, the Internet of Things technology becomes the key to the realization of a new investment decision-making model. The terminal equipment of the underlying network can complete the real-time monitoring of enterprise data and data acquisition. Then data transmission is realized by means of network layer and transport layer, IP network ensures the accuracy and security of data transmission to a certain extent. Finally, the data is transmitted to the data center to process and mine the data, thus providing support for investment decisions.

2.2. Data collection and data transmission based on enterprises

The enterprise data collection and transmission system based on Internet technology faces the entire domestic market and even the world market. Build a data acquisition network with sensors in the relevant enterprises, build a wireless transmission network, and set up a secondary data center to collect enterprise data in all directions. As shown in Fig. 1, within the enterprise, each data collector can access the Internet through WIFI. After the data is transmitted to the secondary data center through the Internet, it is initially sorted and then passed to the first data center:

The enterprise data acquisition and transmission module based on the Internet of Things is mainly composed of three parts: data collection node, data transmission network and data control center. Its specific functions are as follows:

(1) Data collection node: Use a variety of sensors inside the enterprise, including cameras, computers, scanners, etc., to collect data on the daily operations of the company. The data of its enterprise is transmitted to the secondary data center in real time through the LoRa wireless network [19]. It enables real-time monitoring of business conditions.

(2) Data transmission network: For the LoRa wireless network built in the enterprise, the software and hardware of the LoRa wireless network are designed and installed in each data collector, so as to realize real-time transmission of internal data of the enterprise.

(3) Secondary Data Control Center: Accept information from various data collection nodes on the LoRa wireless network and preliminary information. Then it transfers the organized data to the primary data center.

2.3. Data transmission based on Internet of Things database

(1) Multithreading

This paper uses Multithreading [20] to enable the platform to quickly switch between different threads. Multithreading Socket in this article is a Socket technology application based on multi-threaded background. It can support multi-terminal collection and internal data processing and application concurrently in many server resources.

(2) Communication technology

This paper uses the TCP/IP-based Socket communication mode [21]. Both ends of the communication must establish a Socket object. When communicating, firstly, establish a Server Socket object on the server side and wait for the connection of the terminal device. Then create a Socket object of the terminal device to make a connection request to the server. Finally, the server responds to the request and completes the communication.

(3) Protocol

The paper uses the TCP/IP protocol because it is an object-oriented and reliable connection. The sensor compiles the collected data according to the rules of the communication protocol, then send it to the server. The server sends the data packet to the client, and the client parses it according to the rules of the communication protocol, and then displays the data on the main interface with data that everyone can understand.

2.4. Big data storage based on Internet of Things technology

As a first data center, it always accepts data transmission from each enterprise's secondary data center. Its main task is to quickly and reasonably and efficiently integrate and store data packets from lower-level data centers to complete the establishment of a first database and lay the foundation for the formation of the final database. Therefore, efficient storage of massive amounts of data has become one of the key points.

Database construction based on the Internet of Things requires persistent storage of massive files. The current mainstream mass file storage systems, such as NoSQL database, in-memory database, distributed file system. The data request load in a big data environment is very large. These storage systems often have serious write and throughput bottlenecks when faced with the rapid storage pressure of massive files. For example, the existing HDFS architecture [22,23] has major problems such as low write throughput and large main node memory overhead for file storage, which cannot meet the write and throughput requirements of files in the Internet of Things. This paper adopts a massive file efficient storage system SensorFS for the Internet of Things big data environment. It adds a distributed memory file system to the underlying storage of the existing Hadoop Distributed File System. DMFS [24] mainly performs two tasks:

(1) "Write Cache": First, the write of the massive file is cached in the memory, and then the cluster write method is used to improve the write throughput rate of the massive file and reduce the communication cost of the node.

(2) "Cluster writing": The files from different secondary data centers are clustered, and the clustered files are merged into large files, and the large files are finally written to HDFS for persistent storage.

2.5. Database construction of decision-making platform based on Internet of Things technology

As shown in Fig. 2, firstly, based on the Internet of Things technology, the data collection network is arranged in the enterprise, and the data of the enterprise is collected by means of cameras, computers, scanners, etc. Then the data is gathered in the enterprise by means of the wireless network inside the enterprise. In the data center, the secondary data center performs preliminary processing on the data from each data collection node, and then transmits the data to the first data center through the mobile communication network. Massive files from each secondary data center pass through the DFMS layer and HDFS layer in the first data center, enabling rapid classification and storage of massive files. Then use the mobile communication network to transfer data to the final data center to complete the construction of the final database. It provides a data foundation for further data mining and provides data support for scientific investment decisions.

Fig. 2. Decision-making platform database construction process based on Internet of Things technology.

3. Investment decision model based on big data mining technology

Through the construction of Internet of Things platform, users' financial information is collected and stored. The stability and accuracy of data transmission and extraction process are also guaranteed. However, it is very important to build a reasonable data analysis platform, which can carry out efficient and rapid data processing and analysis about financial information, and provide users with the most appropriate investment management scheme. In the era of big data, users' life, travel, work and entertainment are generating data streams all the time. As a tool that can effectively analyze and explore the development laws of things, data mining technology establishes potential relationships between users' financial information and investment preferences, and provides users with the best investment decision-making scheme for reference [25,26].

3.1. Data mining technology in information age

With the development of computer technology and computing performance, data mining technology has gradually been widespread. In the stage of large amount of information data in generate, people have not only limited to simple access and query of personal or enterprise data in the traditional sense, hope to obtain the data relationship and prediction ability that generate benefits for individuals or enterprises through technical means. Data mining technology is considered to be a knowledge discovery process in the database. The knowledge is obtained from the database by using mining technology includes the basic

information of users, account management, fund inquiry, investment decision, etc. Therefore, data mining technology has been applied most frequently in the field of commercial investment since its birth, and then widely used in other fields, such as education, medicine, transportation, government, etc. Meanwhile, its technical means can play a full role in commercial investment. Data mining technology has been recognized in various fields and has shown a high utilization rate. At present, the research of data mining includes optimization, classification, recognition and prediction.

Data mining technology covers a wide range and develops interdisciplinary, including artificial intelligence, high-performance computing, machine learning, statistics, pattern recognition, etc. [27]. Common data mining models can be divided into linear and non-linear analysis, logistic regression analysis, univariate and multivariate analysis, time series analysis, nearest neighbor selection and clustering analysis from a statistical perspective [28]. These analysis methods can be used to sort out and explain the hidden relationship network behind the data, predict the market development rules and discover business investment opportunities by eliminating abnormal situations. However, data mining techniques dealing with knowledge are more prone to prediction and optimization algorithms. It includes artificial neural networks, genetic algorithms, association rules, decision trees and support vector machines.

Regression analysis, as one of the most commonly used methods for data processing [29], is often used to describe the linear regression of the overall relationship under the influence of a single variable, or to perform logarithmic regression on the predicted variables of the probability of something happening. Variance analysis is used as test emission to estimate the regression performance and the influence rate under the action of independent variables. The basic model and formula definition process of linear regression are as follows: firstly, independent variables $x = \begin{pmatrix} x_1, & x_2, & \dots & x_n \end{pmatrix}$, that is attribute basic values of objects, coefficient vectors $w = \begin{pmatrix} w_1, & w_2, & \dots & w_n \end{pmatrix}$ are defined, the constructed linear regression model and the determined regression function $f(x)$ are:

$$f(x) = w_1x_1 + w_2x_2 + \cdots + w_nx_n + b \tag{1}$$

b is constant in the formula, and the vector form of formula (1) is:

$$f(x) = w^Tx + b \tag{2}$$

Further determination of Linear Regression $f(x_i)$:

$$f(x_i) = wx_i + b, \qquad f(x_i) \cong y_i \tag{3}$$

For solving the regression model, that is determining the coefficients w and constants b, The key control point is to reduce the gap between $f(x)$ and y. Usually, the mean square deviation $E(w, b)$ is used for calculation, its principle is related to " Euclidean distance". The purpose is to minimize the sum of the sample and Euclidean distance points on the straight line.

$$E_{(w,b)} = \sum_{i=1}^{n}(f(x_i) - y_i)^2 \tag{4}$$

The formula (3) is brought into the formula (4), and the coefficients w and constants b are respectively differentiated so that their derivatives are 0, and the calculation results are as follows:

$$w = \sum_{i=1}^{n} y_i(x_i - \bar{x}) / \left(\sum_{i=1}^{n} x_i^2 - \frac{1}{n}(\sum_{i=1}^{n} x_i)^2\right) \tag{5}$$

$$b = (1/m)\sum_{i=1}^{m}(y_i - wx_i) \tag{6}$$

The least square method is used to estimate w and b, mark them as $\widehat{w} = (w, b)$, and express data set D as a matrix X of $mx(d + 1)$. The formula is as follows:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1d} & 1 \\ x_{21} & \cdots & x_{2d} & 1 \\ \vdots & \vdots & \vdots & 1 \\ x_{n1} & \cdots & x_{nd} & 1 \end{pmatrix} = \begin{pmatrix} x_1^T & 1 \\ x_2^T & 1 \\ \vdots & \vdots \\ x_n^T & 1 \end{pmatrix} \tag{7}$$

If the marker is written in vector form $y = (y_1, y_2, \dots, y_n)^T$, the solution equation can be obtained as follows:

$$E_{\widehat{W}} = (y - X\widehat{W})^T(y - X\widehat{W}) \tag{8}$$

By deriving $\widehat{W}$ and making its derivative 0, then $\widehat{W}^*$ is:

$$\widehat{W}^* = (X^TX)^{-1}X^Ty \tag{9}$$

Finally, the formula of multiple linear regression model is determined:

$$f\left(\widehat{x}_i^T\right) = (X^TX)^{-1}X^Ty \tag{10}$$

Linear regression is widely used in data mining technology and has a good matching effect for big data fitting and prediction. Therefore, this paper involves some linear regression in the process of data processing.

At the same time, this paper uses intelligent algorithms such as support vector machine in the process of operation. In data mining technology, the choice of methods determines the accuracy of the results. Therefore, there are many reference factors when selecting algorithms, combining with the big data collected and provided by the Internet of Things platform, the decision of users' investment will be achieved.

3.2. Construction of user investment platform based on data mining technology

Through the use of Internet of Things technology and data mining technology, the daily consumption, income, investment and other monetary circulation behaviors of users are uploaded to the Internet of Things platform in the form of information data by mobile communication equipment, computer network and portable imagine instruments. The data in the platform are complicated and lengthy. Therefore, the storage equipment needs strong data bearing capacity and good transmission performance. Mining technology is to extract, classify, analyze and predict the user's information data.

As shown in Fig. 3, the investment decision system based on big data mining technology is established. Users of the platform can use the platform to control their own financial information from a macro point of view, including enterprise management, etc. At the same time, the best scheme can be obtained through multi-level and multi-angle calculation and analysis in investment decision-making, which further realizes the real-time dynamic and experience intellectualization of user investment decision-making.

4. Example analysis

This paper chooses the financial data of a listed company from 2012 to 2017 as the research object. The data are divided into two parts, which are used to identify the enterprise life cycle and evaluate the return of securities investment.

The alternative observation indicators of investment income evaluation are divided into solvency: liquidity ratio, liquidity ratio, over speed ratio, asset–liability ratio, property right ratio and tangible net value debt ratio. Profitability: net sales interest rate, gross sales interest rate, net asset interest rate, return on

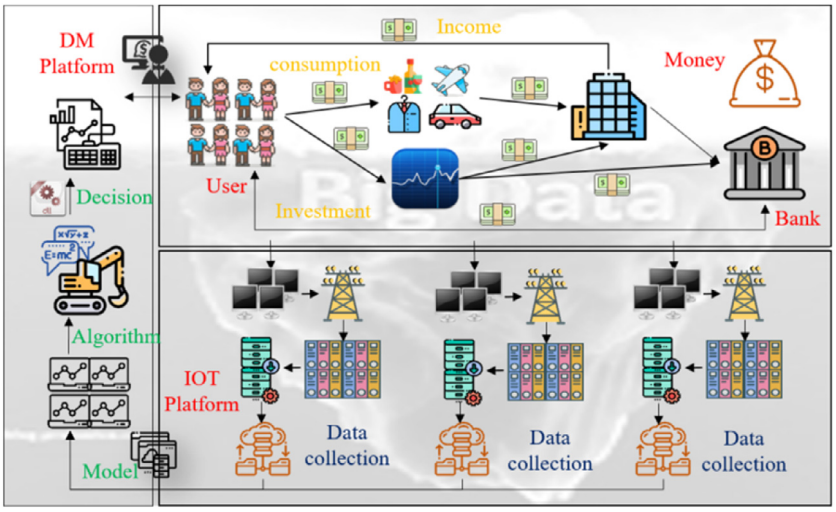

Fig. 3. Investment decision platform based on data mining technology.

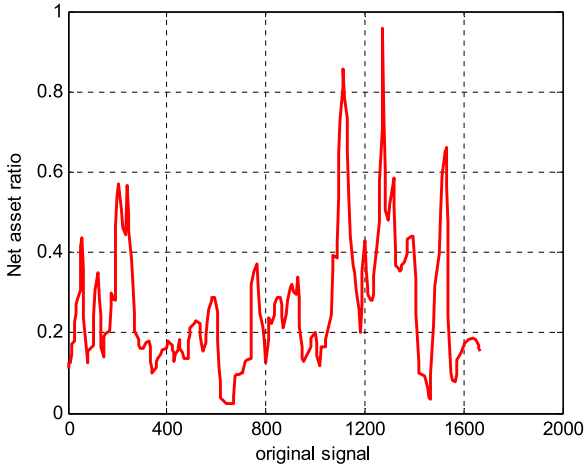

Fig. 4. Training sample of ROE.

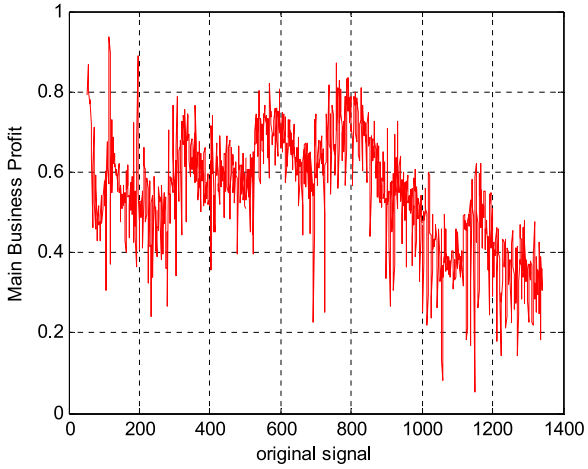

Fig. 5. Profit margin training sample for main business.

net assets, profit margin of main business. Business development ability: Increase rate of main business income, increase rate of main business profit, increase rate of total assets, increase rate of cash flow per share of operating activities, increase rate of net assets per share and increase rate of earnings per share. Asset management ability: inventory turnover, accounts receivable turnover, current assets turnover, total assets turnover, fixed assets turnover, shareholder equity turnover. Macroeconomic environment: the average monthly return of the Shanghai Stock Exchange Index in the first half of the year, a total of five types of observation indicators, as well as the final evaluation indicators: the average monthly return of each listed company in the first half of the next year. Figs. 4 and 5 are some data collected from ROE and profit margin of main business.

As shown in the figure above, the return on all net assets of the company is relatively smooth, while the profit margin of the main business fluctuates greatly. In this paper, the wavelet packet de-noising function wpdencmp in MATLAB is used for wavelet de-noising. The soft threshold is used for the threshold, and the general threshold method is used for the determination of the threshold. Then training and data mining are carried out under the Internet of Things platform, which includes real-time market database and company management database. As well as data interface module, data interface module is responsible for converting the above data into data warehouse. Metadata is the basis of data sharing and can be simply understood as data. Content is about the content, quality, conditions and other characteristics of data, and use is about the structured description of data for accurate understanding, search and processing of data. Metadata provides normative, universal descriptive methods and retrieval tools for various forms of digital information units and collection of resources, and provides integrated tools and links for the distributed and organic data sharing system composed of various digital resources. Because of the inherent unity, this new architecture solves the problem of cohesion. Figs. 6–9 shows the process and results of training using intelligent algorithms embedded in the Internet of Things platform.

Figs. 6–9 shows the training process and results of some indicators. It can be seen that the number of training times of the algorithm used is less than 200, and the training accuracy reaches about 10–3, which reflects the high efficiency of the Internet of Things platform. Data warehouse provides a reliable data base for OLAP. Data mining can find the required data from data warehouse and multi-dimensional database. The knowledge found in data mining can be directly used to guide the analysis and processing of OLAP, and the new knowledge obtained from OLAP analysis can also be immediately added to the knowledge base of the system. The data set of yield evaluation is divided into

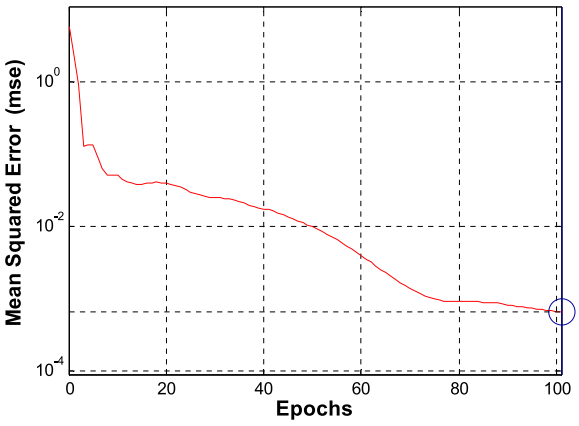

Fig. 6. The training process of ROE.

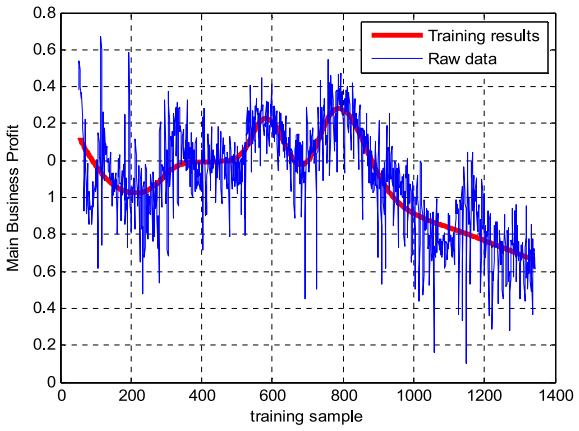

Fig. 9. Main business profit rate training results.

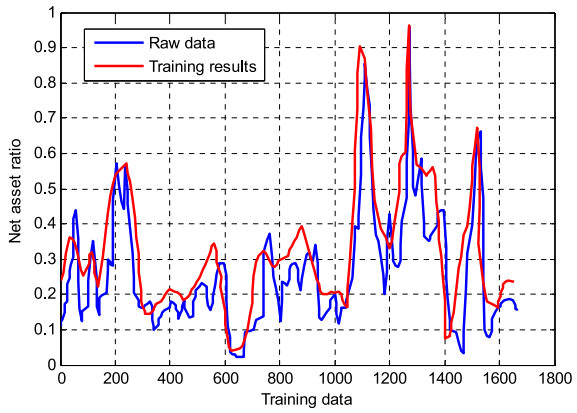

Fig. 7. Training result of return on net assets.

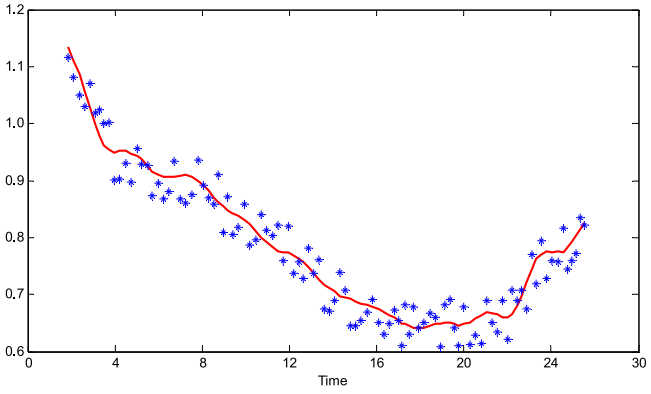

Fig. 10. Test results of average return in May 2017.

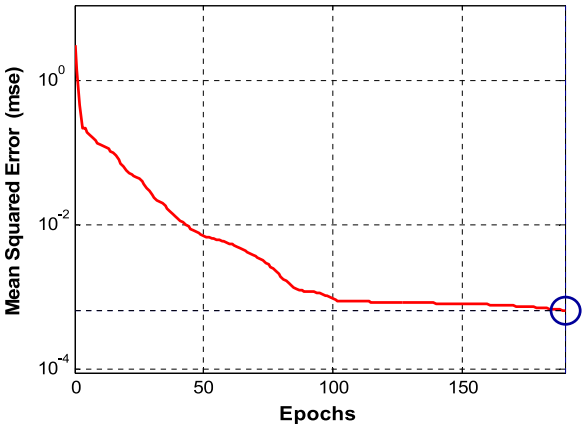

Fig. 8. Profit margin training process for main business.

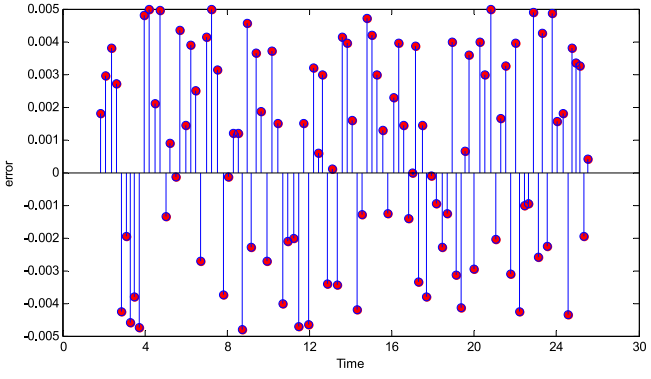

Fig. 11. Test results of average return in May 2017 and actual errors.

two parts: training set and test set. Figs. 10 and 11 is based on the above training results of each index to predict the test results and errors of the average yield in May 2017.

As shown in Figs. 10 and 11, under the Internet of Things platform, we use big data mining technology to evaluate the rise and fall of the company's average return in May 2017. It can be seen that data mining on the Internet of Things platform can basically evaluate the big trend, basically the rise and fall within a week, but the success rate of one day's rise and fall prediction is relatively low. The error between the predicted value and the actual value will not exceed five thousandths per day, which basically meets the accuracy requirements of practical application.

5. Conclusion

Now is an "information explosion" society, the growth rate of information has reached an unprecedented level, of course, the securities industry is the same. What kind of analysis methods are used to fully mine these historical data and extract useful information to guide investors has become a research hotspot. Based on the analysis of the traditional investment decision-making model, this paper explores and builds the investment platform of the Internet of Things, embeds the big data mining

algorithm, and carries out simulation, and draws the following conclusions.

(1) The data structure of the Internet of Things provides normative, universal descriptive methods and retrieval tools for various forms of digital information units and collection of resources, and provides integrated tools and links for the distributed and organic data sharing system composed of various digital resources. Because of the inherent unity, this new architecture solves the problem of cohesion.

(2) Based on the large data mining technology of the Internet of Things platform, an intelligent algorithm is embedded in the framework of the Internet of Things platform. The algorithm can obtain highly efficient and accurate fitting samples, and the training accuracy reaches 10^{-3}.

(3) This paper selects a listed company to test the data mining platform. The results show that the big data mining sense under the Internet of Things platform has good convergence, and the prediction error is no more than five thousandths.

(4) This paper verifies the accuracy of the data mining platform in the prediction of large trends, but the accuracy of the daily rate of return evaluation is relatively low, which needs to be improved in the future research.

Declaration of competing interest

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

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