Study of Economic Management Forecast and Optimized Resource Allocation Based on Cloud Computing and Neural Network

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Research

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Abstract

As various factors which affect the development of global market economy become increasingly uncertain, economy and commodity will become more and more fluctuating in economic operation. With its strong non-linear mapping capacity, artificial neural network has already been applied in many fields, time series analysis and trend prediction. Cloud computing can interact fast with service provider at the minimum management cost. This paper proposes an economic forecast and optimized resource allocation model based on cloud computing and BP neural network. Its main goal is to break down a complex prediction task into several sub-tasks, effectively reduce the workload of a single computer and enhance the operating efficiency. Simulation results show that the proposed method does not rely on gradient information, and has strong optimization calculation ability. At the same time, it can analyze and predict economic management, so as to provide strong decision support for decision makers.

Introduction

With more and more uncertain factors that affect the market economy worldwide, the fluctuation of economy and commodity will become increasingly significant in economic operation; so it is necessary to study relevant methods to predict the future trend of economy or commodity and how to optimize and allocate resources. At present, the frequently-used economic forecasting system is operating on the centralized platform of a single small-size computer, which has several problems when being used. Besides, different economic indicators use different prediction models and the results obtained are also different [1]. Government decision-makers don't know in advance which prediction model to adopt in order to get the optimal result; so they can only select a model for prediction based on their subjective feeling and the result may not be the best. However, loud-based economic forecasting system can automatically combine prediction indicators with all prediction models, predict every possibility, and automatically simulate and analyze the prediction result and the actual conditions in order to choose the optimal prediction [2]. With its large-scale parallel structure and distributed storage, neural network has not only strong capacities of function approximation and pattern classification, but also extraordinary self-organization, adaptivity and fault tolerance, making it very fit for handling practical engineering problems. As massive economic data consistently increase, the computing power of a single microcomputer will eventually become saturated. The continuously expanded capacity of storage devices will increase data transmission time and cost between new devices, which is very uneconomical. On the contrary, neural network which combines cloud environment and adaptive learning can avoid such problem. This combination can fully exert the self-organization, self-learning and high fault tolerance so that it can have unique performance and computing power in solving complex non-linear problems [3] [4].

The special contributions of this paper include :

- This paper studies the features, methods and steps of economic management forecast, including qualitative and quantitative prediction, computation and analysis of prediction error.

- This paper analyzes cloud-based economic forecasting system, including the construction of the overall architecture, cloud client, the maintenance of backend data, and display function.
- This paper studies the optimized structure of BP neural network, analyzes the optimization extent of network structure by using secondary descent and gradient descent, as well as the law of error change, and adopts adaptive learning rate to increase the number of neurons in hidden layer or the layers of network so as to get a proper neural network structure.
- This paper presents a BP neural network based on cloud computing and momentum-adaptive learning rate, realizes economic forecast and optimum allocation of resources, makes simulation experiment, and conducts analysis of the result. As shown in the result of the simulation experiment, this method can find a feasible solution within the designated generalization ability and approximate error range reliably and effectively.

The rest of this paper is organized as follows. Section 2 discusses related works, cloud-based economic forecast framework are outlined in Section 3. Economic prediction and optimized resource allocation of BP neural network based on momentum-adaptive learning rate is presented in Section 4. Section 5 shows the experimental test results, and Section 6 concludes the paper with a summary and proposed directions for future research.

Related Work

Cloud computing is the development of distributed computing, parallel computing and grid computing. It has scale effect, service virtualization, shared resource pool, fast and flexible deployment and on-demand services. Cloud computing has a pretty large scale and it allows its users to get service at any place with any terminal. The resource requested comes from the “cloud” instead of a fixed physical object. This application program operates somewhere in the “cloud”. The users don’t need to know the specific location of the app and they can get various services through network services. All resources in cloud computing system are gathered into a dynamic resource pool, which is provided to all clients in a multi-tenant mode to make sure that the services between users are isolated and free from interference. Neural network prediction method is a method to conduct economic forecast by using neural network. As most economic problems are non-linear and neural network model has excellent non-linear fitting, people have attached more and more importance to predict these complex problems [5]. The scale of neural network structure affects the learning capacity and generalization ability of neural network. If the structure is too small, the learning capacity is not sufficient; and if it is too big, the generalization ability is weakened. Structural optimization is to enable neural network to learn a proper structure, which maintains the best generalization while meeting the need of learning. This paper based on cloud computing platform, adopts BP neural network of momentum-adaptive learning rate and studies the economic management forecast and the optimization of resource allocation [6].

In October 2008, Ian Foster-the father of the Grid, hosted the 1st Cloud Computing and Applications Workshop (CCA’08). After that, all conferences about network computing have made cloud computing one of the themes, including Cluster 2009, International Symposium on Cluster Computing and the Grid (CCGrid 2009) and International Conference on Grid and Cooperative Computing (GCC 2009). Meanwhile, the cooperation between Google and University of Washington has launched the Academic Cloud Computing Initiative to promote the popularity and enhance the study of cloud computing. Back Propagation (BP) neural network is a multi-layer feed-forward neural network based on error back propagation. Such error feedback network model uses the forward propagation of signal and the back propagation of error to dynamically adjust the weight and threshold between nodes in every layer so as to achieve the purpose of learning and training. BP neural network is a multi-layer forward neural network which has been applied most widely [7, 8]. For a 3-layer BP neural network, one network with one hidden layer, it can approximate any continuous function in the bounded domain at any accuracy as long as there are sufficient hidden nodes. As the periodic fluctuation of macro-economy becomes increasingly obvious in economic operation, it is necessary to study and develop a framework to predict the future trend of economy or commodity [9]. At present, the frequently-used economic forecasting system is operating on the centralized platform of a single micro-computer where different economic indicators use different prediction models and the results obtained are also different. Decision-makers don't know which prediction model to use for economic indicators to get the optimal result in advance; so they can only choose the model based on their own feeling and the result may not be the best. The combination of cloud computing and neural network can automatically combine prediction indicators and prediction models, predict every possibility, automatically simulate and analyze the prediction result and the actual conditions so as to choose the best prediction. Then the model and result are returned to the decision-makers [10,11].

Cloud-based Economic Forecast Framework

3.1 Overall Architecture

Cloud-based economic forecast framework includes two levels, i.e. distributed computing layer and user interface layer.

(1) Cloud client: mainly used to display the prediction result, including the prediction result table, the prediction result graph of actual curve and the prediction curve fitting, for the decision-makers for make comparisons.

(2) Master server: mainly responsible for receiving requests from cloud client and decomposing a prediction task proposed by the client into multiple sub-tasks. It arranges and combines the economic indicators to be forecasted and all algorithms in the model table, and then assigns every possible combination to an idle computational node. Then the corresponding computational node proceeds with the prediction.

(3) Storage node cluster: made up of several computers with a huge storage function and mainly responsible for accessing digital resources and prediction model[12,13].

(4) Computational node cluster: composed of several computers and mainly responsible for handling all computation involving economic indicators and specific prediction models. It can avoid the problems caused by the economic prediction system based on a single microcomputer. As far as the computer speed is concerned, it will acquire higher computing power than the common computers with no bottleneck occurring in the storage capacity [14, 15].

The development and change of economic phenomena are subject to various factors, which are internally connected. The accuracy of economic forecast has its relativity and restrictions. The growth and change of economic phenomena are factor not only by the factors that are already known to and under the control of people, but also the factors that people don't know and can't control, e.g. major economic policies and major natural disasters which have a tremendous impact on economy. Therefore, the future development of economic phenomena is uncertain.The bias between economic prediction result and actual economic operation isn't equal to the failure of prediction. By analyzing the result of economic forecast, government departments or individuals can make necessary adjustments and interventions to economic activities, and adopt the corresponding economic measures to make economic activities go where harm can be avoided and lead to the development of economic activities. The forecast result does not coincide with the actual economic operations.

3.2 Function Analysis

The function of this framework includes two parts. One is the maintenance function of the backend data. After logging in with authentication, the Administrator can maintain the backend data. The maintenance of backend data includes the maintenance of economic indicators, data and prediction model. Among them, index maintenance means that the Administrator can check the existing indicators through page when the system is operating, edits and the existing indicators, add new indicators as required, and delete overdue indicators. Data maintenance is to store every value of indicator in the corresponding database. And model maintenance is to modify the existing prediction model in the system, add new model and delete the old model. The other is the function of interface display and it browses the prediction result of various indicators in the form of table or graph. In the prediction, the content includes the prediction of the major macro-economic indicators and in the display platform, it includes the prediction result table, the prediction curve of actual curve and the prediction curve fitting. In the analysis of the prediction result, it includes graphic and text description. Every indicator has many functions at the same time, e.g. the ability to inquire the prediction values in different periods of time and find the fitting of the corresponding prediction value.

Apart from a thorough knowledge of the history and status quo of the object to be forecasted, the accuracy of economic forecast also depends on the selection of scientific and rational forecasting methods, which rests with the in-depth understanding of economic activities and the mastery economic theories [16]. Qualitative forecasting method means that the predictor makes the judgment on the nature, direction and extent of economic development according what they have mastered, their practical experience and expertise. With qualitative forecast, suggestions can be made to provide evidence for the government and enterprises in formulate economic decisions, plan management and guidance. Quantitative forecasting method uses quantitative knowledge and mathematical model to conduct quantitative measure on the future economic phenomena. This kind of method mainly includes time series prediction method, regression analysis prediction method and tendency curve model prediction method [17].

Method

Due to technological limitations, the Method section is only available as a download in the supplementary files section.

Results And Discussion

5.1 Data Selection and Analysis

Regional gross domestic product (regional GDP) refers to the total final result of all units in this region to carry out production activities at a certain period of time (usually a year or a quarter) and the value of the labor. Regional GDP has great significance and it is deemed as a criterion to evaluate the development level and economic conditions of a region at this period of time. This paper collects valid data and uses Matlab software platform for BP neural network model simulation for a certain regional GDP.

We have chosen household consumption level, permanent population, average wage, registered urban unemployment rate, cargo volume, passenger volume, and data of medical and health institutions as the input samples of BP neural network and the regional GDP as the predicted output of the model.

5.2 Result and Analysis of Experiment Simulation

(1) Layers of network

It has bias and at least one S-shaped hidden layer and a linear output layer and it can approximate any rational number. To increase layers can further reduce errors and improve accuracy, but meanwhile it also makes the network more complex and increase the training time of network weight.

(2) Neurons in the hidden layer

In order to avoid the “over-fitting” phenomena as many as possible, and ensure sufficient network performance and generalization ability, the most fundamental principle to identify the number of nodes in the hidden layer is as follows: take as compact a structure as possible while meeting the accuracy demand, in other words, take as few nodes in the hidden layer as possible. Research shows that the number of nodes in the hidden layer are related to not only the nodes of the input/output layer, but also the factors such as the complexity of the problem to be solved, the type of the transfer function, and the property of sample data.

(3) Selection of initial weight

As the system is non-linear, the initial value is closely related to whether the learning can reach the local minimum, whether it can converge and the length of training time. Generally, it is hope that the output value of every neuron after initial weight is close to zero. In this way, the weight of each neuron is ensured that it is adjusted within the maximum change of their activation functions. So, the initial weight is a random number between (-1, 1).

(4) Learning rate

Learning rate decides the change of weight generated in every cyclic training. A big learning rate may result in uncertain system, but a small one may lead to a longer training time and a slow convergence. So it tends to choose a small learning rate to ensure the stability of the system. The value range of learning rate is (0.01, 0.8).

According to the number of input data, the number of nodes in the input layer is 7. According to the output data, the number of nodes in the output layer is set as 1. The number of nodes in the hidden layer is 10. The empirical equation for the number of nodes in the hidden layer is as follows:

See formulas 5 and 6 in the supplementary files.

In Fig. 3, X-axis is the number of training and the Y-axis is the Mean Squared Error (MSE). The curve shows the error change of the network model with the increase of trainings, and the dotted line reflects the error goal we set. It can be seen that after several trainings, the error has achieved the expected goal. As shown in Fig. 4, the functional relationship between the expected output and theactual output basically fluctuates around a straight line with good fitting effect and ideal training effect. Fig. 5 shows the change of gradient in the training process of the entire network. The prediction results is shown in the Tab.1.

Table 1. The prediction results

Year	Real value (RMB 100 million)	Predicted value (RMB 100 million)	Error value (RMB 100 million)	Accuracy (%)	Error rate (%)
2000	2975.63	3399.66	424.03	85.75	14.25
2001	3528.81	3198.51	330.30	90.64	9.36
2002	4633.56	5169.66	536.10	88.43	11.57
2003	5236.17	4823.04	413.13	92.11	7.89
2004	5941.82	5191.96	749.86	87.38	12.62
2005	7069.34	7996.13	926.79	86.89	13.11
2006	8308.25	6834.37	1473.88	82.26	17.74
2007	9934.37	8757.15	1177.22	88.15	11.85
2008	11595.68	10401.32	1194.36	89.7	10.3
2009	12542.23	14428.58	1886.35	84.96	15.04
2010	14206.45	12263.01	1943.44	86.32	13.68
2011	16020.8	17545.98	1525.18	90.48	9.52
2012	17658.34	20236.46	2578.12	85.4	14.6
2013	18842.2	21274.73	2432.53	87.09	12.91
2014	20431.66	23588.35	3156.69	84.55	15.45

As can be seen from Tab.1, the prediction accuracy is 87.34%, and the average error is 12.66%. The comparison results between the predicted value and the actual value are shown in Fig. 6.

In Fig. 6, the abscissa is the year and the ordinate is the output value. Among them, the output of the neural network is very close to the predicted output, and the predicted GDP is consistent with the actual GDP. The output result of neural network is very close to the expected output. The expected regional GDP basically coincides with the actual Regional GDP, as demonstrated in the Fig. 7 and Fig. 8.

After training, we have got the necessary network model, according to the design principle of additional momentum method, when a revised weight leads to a too big increase result in the error, the new weight shall be cancelled and shall not be adopted and the role of momentum shall be stopped so as to prevent the network from entering big error curved surface. When the new change rate of error exceeds the previously-set maximum change rate of error, the change of weight calculated shall also be cancelled. The maximum change rate of error can be any value bigger than or equal to 1. In BP neural network training of additional momentum method, conditions shall be be added to determine the use of its weight revision equation correctly.

Conclusion

Cloud computing has many strengths, e.g. convenience, economy, high expansibility and availability. Cloud computing environment can dynamically schedule resources and users can subscribe the corresponding resources based on their actual needs and the environment can also make adjustments at any time to cope with rapid changes when user needs change. Artificial neural networks can process parallel, learn automatically, and approximate any non-linear functions at any accuracy and it is suitable for modeling of complex systems and predictive analysis.This paper is based on cloud computing platform, and it adopts momentum-adaptive learning rate BP neural network, and studies economic management forecasts and resource allocation optimization. The simulation experiment has proven that the proposed algorithm has the following advantages: (1)it has strong optimized computing power; (2)it does not rely on gradient information; (3)it is applicable for solving highly complex non-linear problems; (4) it can conduct analysis and forecasts for economic management, and it can provide strong decision support for decision makers.

Declarations

Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Competing interests

The authors declare that they have no competing interests.

Funding

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Authors' contributions

Pinzhen He proposes the innovation ideas and draft the manuscript.

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Figures

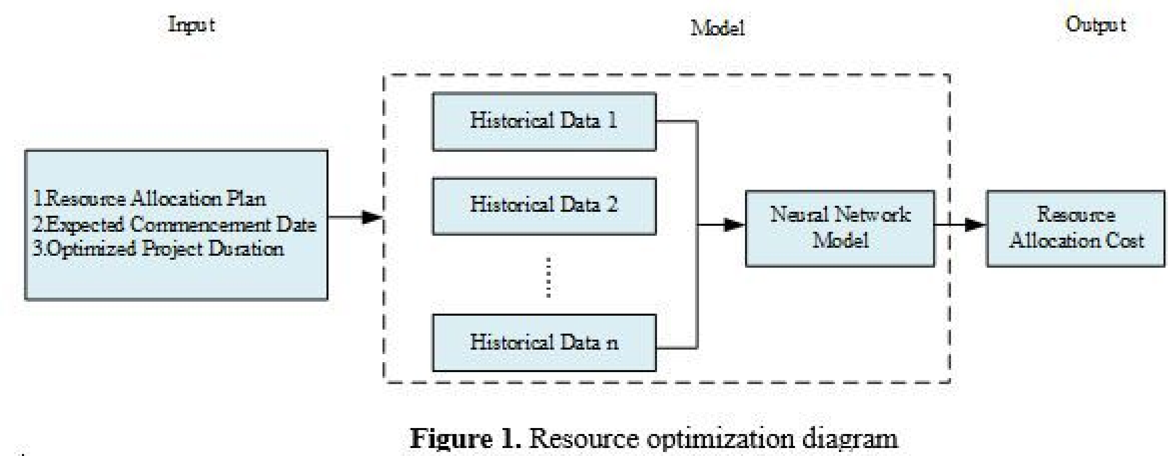

Figure 1

Resource optimization diagram

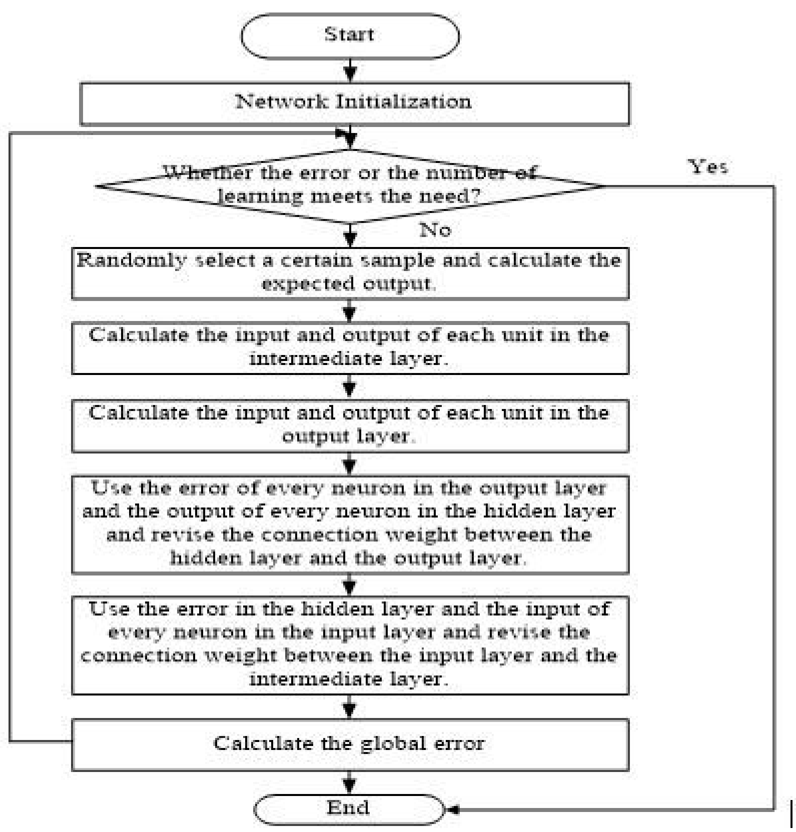

Figure 2

Flowchart of BP neural network based on momentum-adaptive learning rate

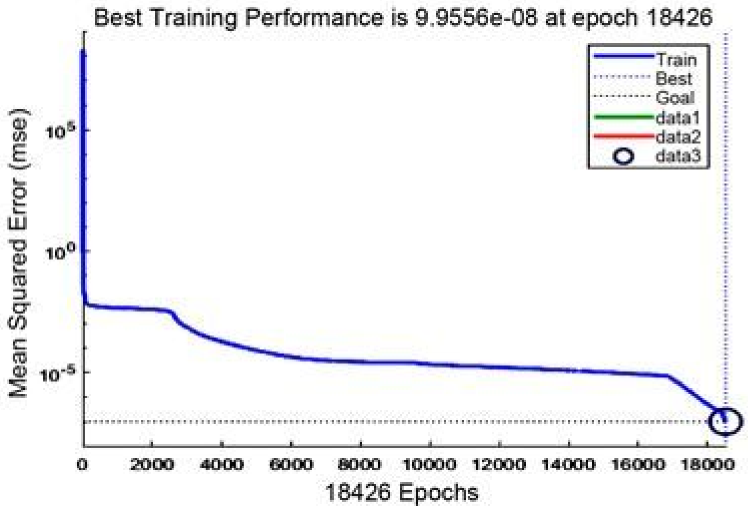

Figure 3

Performance analysis

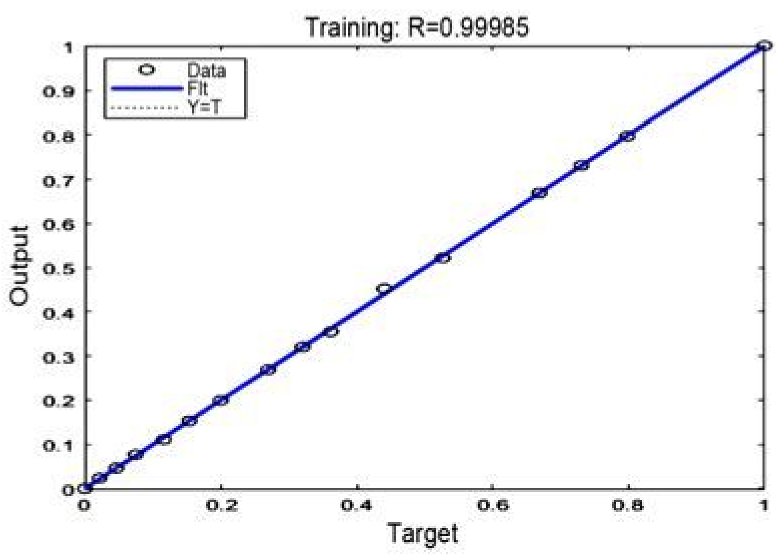

Figure 4

Error fitting

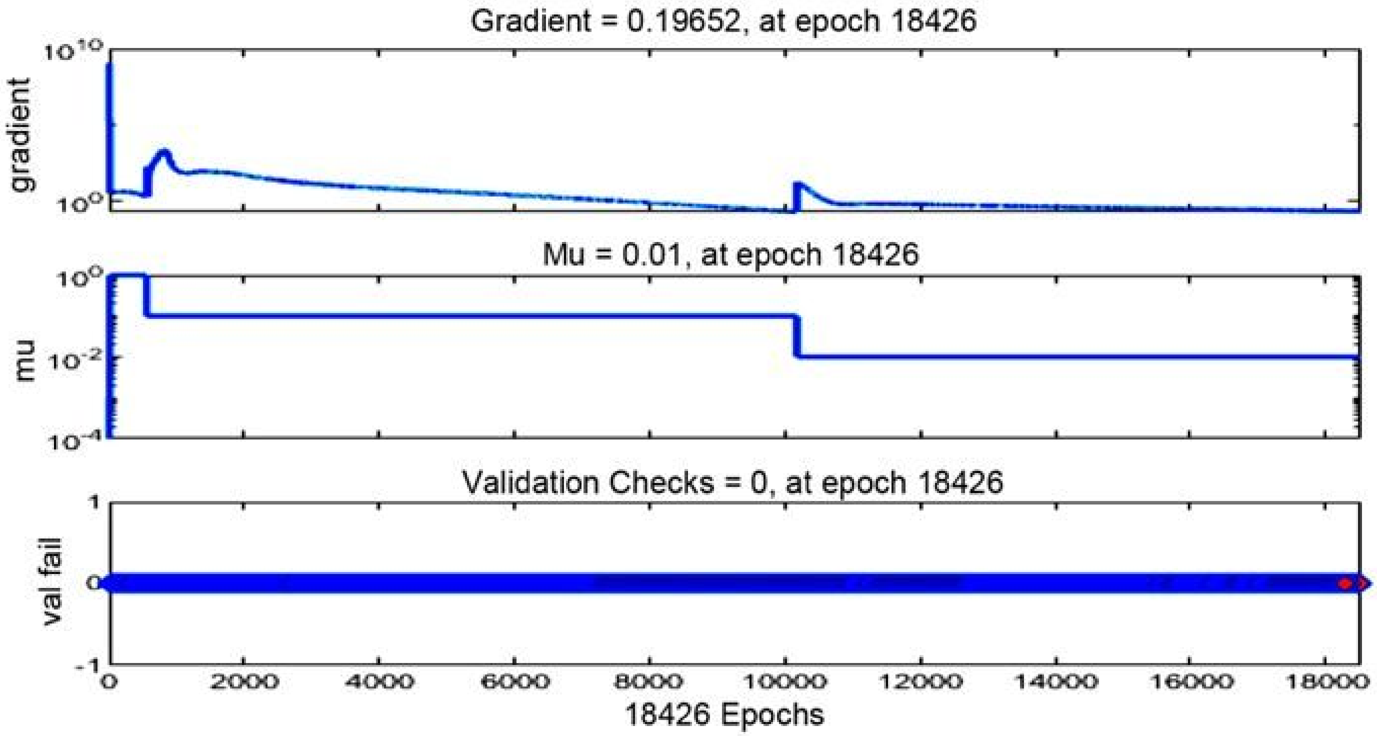

Figure 5

Change of training gradient

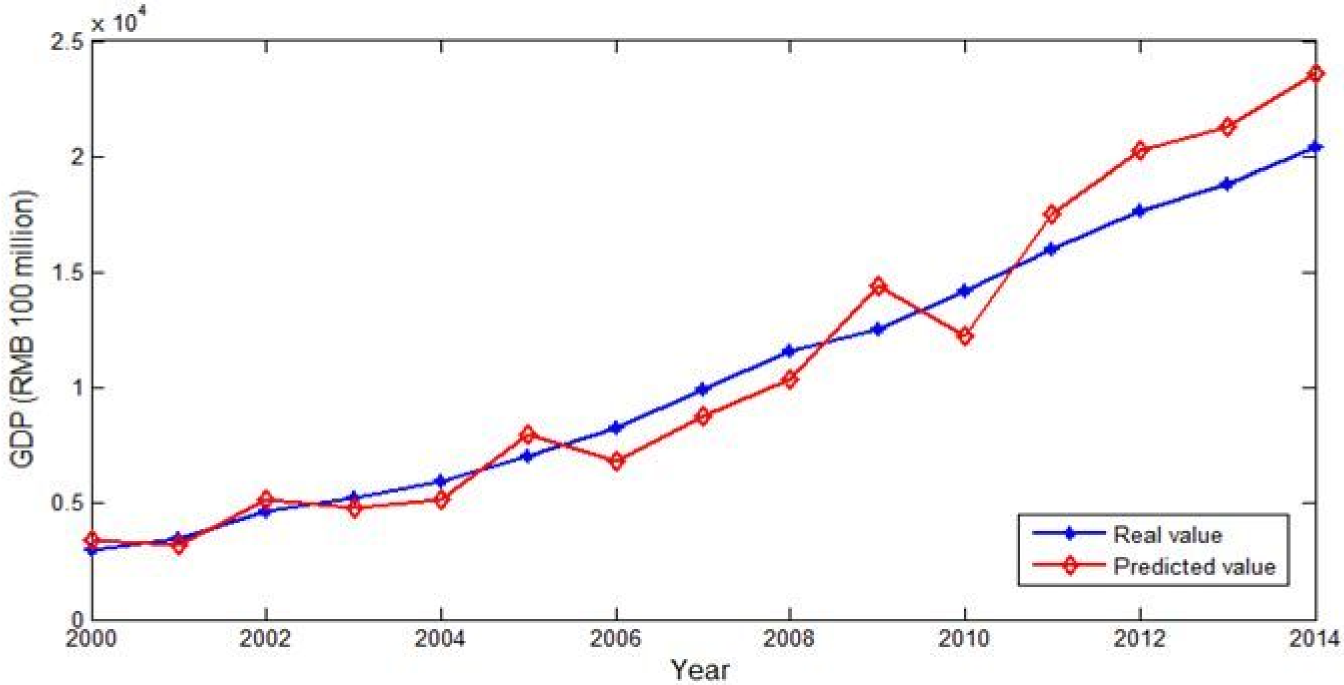

Figure 6

Comparison between predicted value and real value

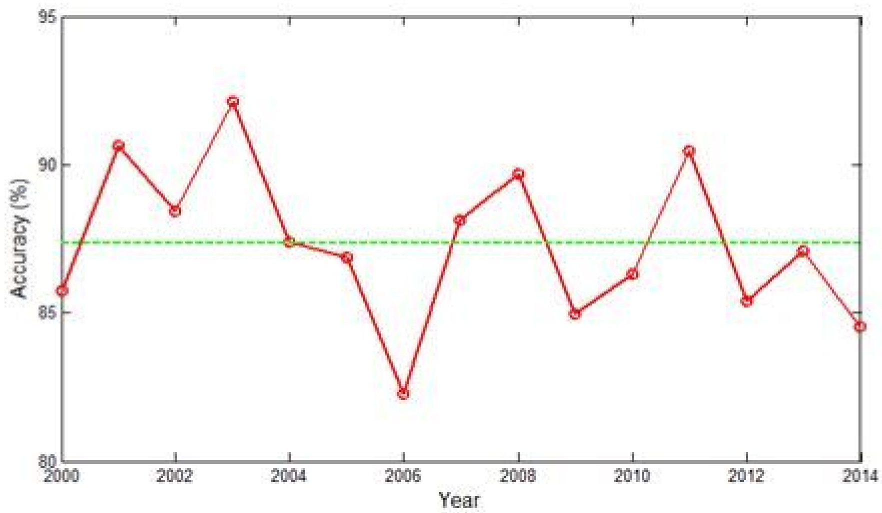

Figure 7

Network accuracy

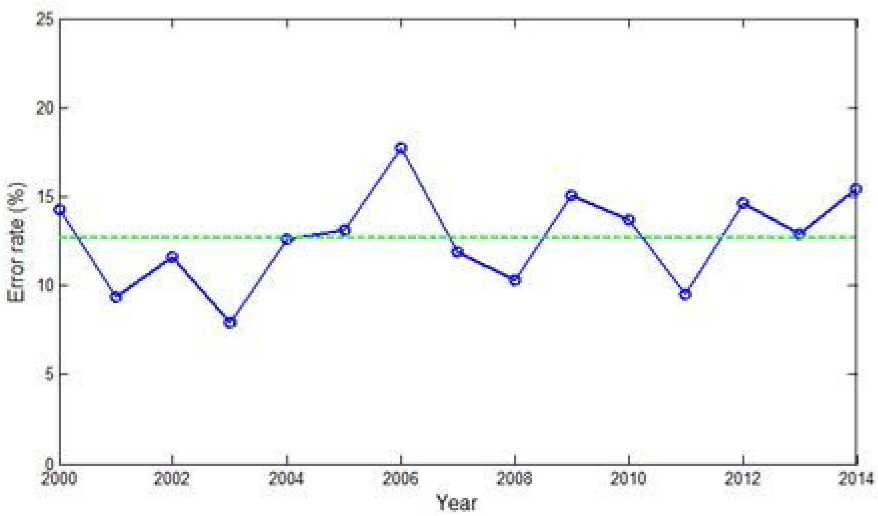

Figure 8

Network prediction error ratio

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Formulas5and6.docx
- Method.docx