SIMES DESIGNING BASED ON ECONOMIC FORECASTING MODEL WITH WAVELET NEURAL NETWORKS

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Abstract. From the consideration of the form of system, the function requirements, and the technical level, and aiming at the steel enterprise information construction and consulting the popular enterprise MIS, this paper presents the economic forecasting model based on the wavelet neural networks to get a new design of the steel enterprise MIS. It involves both function design and database design. The simulation result shows that this model is suitable for the practice, and can satisfy the demand of informational construction, and so can be used broadly.

Key Words. steel enterprise management information system; economic forecasting model; software engineering; wavelet neural network;

1. The need of the management information system (MIS) for the informational construction of steel enterprise

With the development of modern computer technology, more and more enterprises adopt computer management information systems (CMIS). Within this system, the Office Automation System can be developed; the LAN is connected with the Internet and the enterprise information is published on the Internet. It makes people browse their information conveniently. Based on the research of CMIS design for a certain corporation and with the wavelet networks economic forecasting model, this paper makes a detailed analysis about the system.

Traditionally a MIS is defined as the system which is made up by the human being and tools\cite{1}, which can collect, transfer, store, cure and use all the information. It is made for the purpose of effective enterprise management. The definition of traditional MIS has nothing to dog with computers, that means as long as there is enterprise there would be MIS, the different is whether it runs well or not.

With the development of computer and information technology, the MIS becomes a research subject. It is endowed with a new meaning, not only human beings, hardware and software of computers, the equipment of network transfer and other office equipments have also become parts of a MIS. So today’s MIS before us are systems that manages business by computers. As an enterprise normally consists of a technology department, a stock department, a manufacture department, a sale department, a finance department and a human resource department, the MIS also has its product data system, supply system, manufacture system, market system, finance system and human resource system.
The MIS has successfully been used in steel enterprises informational construction. The structure of a steel enterprise's information system has four sub systems: 1). manufacture process control system (PCS), which deals with the equipments checking, equipment driving and the whole manufacture process control; 2). the manufacture executive system, which is the link part of the control system and the management system, dealing with scheduling, planning, flow optimization and other related problems; 3). the enterprise resource management (ERP), just like the enterprise resource plan (ERP), which deals with the management of all the enterprise information; 4). the decision support system, which is the highest layer in the whole system, its major function is to obtain and manage the useful knowledge for the managers and decision-makers. The structure is showed as figure 1.

To today’s enterprises, the enterprise MIS is very important. It can fit all the basic data of the enterprise scientifically, then transfer them to the up-layer by the data-transfer network, then analyzes and manages it, and then provides some necessary information and method to the manager and decision-maker.

There are some basic factors of the enterprise MIS:

1). Advanced character: designing the system with advanced technology and methodology, making sure that it can be advanced in a certain period.

2). Stability and reliability: everyone knows that a good system should and must be a steady system, the MIS should be steady first. We should make sure it run stably, transfer data stably, and the most important one is that it can give us reliable decision based on analysis.

3). Security: safety is very important for the computer MIS, which involves the system itself, the operation system and the networks. Sometimes bugs of the system is dangerous such as the attack from the outside. How to ensure its safety? The system safety is made of the safety of hardware, the safety of networks and the safety of data. To the information system, the data is obviously the most important one. So an effective data safety management system is necessary.

4). Updating the old system: nowadays many enterprises have some systems which have some functions of complete MIS, even they are half-baked, but they are useful and there are much useful history data in them, so it is very economical to integrate old systems into new ones.

5). The interface with the future enterprise manufacture systems by computers: the enterprise information is a huge project, MIS is just one part of it. Once the
enterprise manufacture system is applied, certainly it should be a subpart of the whole MIS. So enough interface should be prearranged for the future subsystems.

Usually the MIS is just a store of data, without advanced optimization models and forecasting models, it could not use all the data well, and it could not make better advice to the manager and decision-maker. So the paper presents a new system to use economic forecasting models based on wavelet neural networks.

2. Economic Forecasting Model with Wavelet Neural Networks

2.1. Putting forward the economic forecasting model. The following mathematical model is considered:

\[
\begin{align*}
  x(t + 1) &= Ax(t) + Bu(t) \\
  y(t) &= Cx(t)
\end{align*}
\]

in equation (1), \(x(t)\) is the \(n\) dimensional state vector, \(u(t)\) is the \(m\) dimensional input vector, \(y(t)\) is the \(r\) dimensional output vector\[5\].

Based on the analysis of the movement of system, namely assume that the initialized condition \(x(0)\) and control decision \(u(0), u(1), \ldots, u(t - 1)\) are given, then the changing principle of the future condition \(x(t)\) would be forecasted. When \(x(t)\) is got by iteration, the following could be obtained from equation (1):

\[
x(1) = Ax(0) + Bu(0)
\]

Similarly,

\[
\begin{align*}
  x(t) &= A^tx(0) + \sum_{i=0}^{t-1} A^{t-i-1}Bu(i) \\
  y(t) &= CA^tx(0) + \sum_{i=0}^{t-1} Bu(i)
\end{align*}
\]

According to the above method, the forecasting method of the enterprise and the theoretic foundation of the SEMIS system development can be derived.

2.2. The Wavelet Transform. The wavelet transform enables analysis of data at multiple levels of resolutions (also known as scales). In addition, transient events in the data are preserved by the analysis. When the wavelet transform is applied to a sequence of signals in the time domain, the result is a two-dimensional, time-scale domain analysis of the signal. The transform has proven useful for many applications such as compression and analysis of signals and images\[6\].

The wavelet transform has shown great promise in recent years. It has been utilized in a wide array of applications, including: 1) image compression, e.g., the Federal Bureau of Investigation (FBI) uses wavelets for image compression of its human fingerprint databases 2) edge detection; 3) transient event detection, especially in the presence of noise; and 4) multiscale process monitoring. The wavelet transform (WT) provides an alternative family of basis functions that offer several advantages over classical Fourier-based techniques. The WT uses shifts, \(u\), and dilations, \(s\) of a prototype wavelet (normally referred to as a mother wavelet), given by Eqn (4):

\[
\psi_{u,s} = \psi\left(\frac{t - u}{s}\right)
\]

The choice of a specific wavelet is application-specific and generally depends on trade-offs between compactness and the required degree of approximation (i.e., the number of vanishing moments).
Wavelets are constrained to be well-localized in both the time and frequency domains and must satisfy the admissibility condition, given by Eqn. (5)

\[ C_\psi \int_0^{+\infty} \frac{|\hat{\psi}(\omega)|^2}{\omega} \, d\omega \]

In order for the integral in Eqn. (5) to be finite, the Fourier transform of the wavelet must have a zero component at zero frequency, which subsequently imposes that wavelets have zero mean,

\[ |\psi(\omega)|^2 \big| \omega = 0 \]

As a result, wavelets are inherently band-pass filters in the Fourier domain.

3. Wavelet Neural Network

The concept of wavelet neural networks derives from wavelet analysis. So first of all the wavelet and the wavelet analysis will be introduced[10][8].

Definition 1: assume \( \psi \in L^2(\mathbb{R}) \). Then following relation is satisfied:

\[ C_\psi = 2\pi \int_{-\infty}^{\infty} \frac{|\hat{\psi}(\omega)|^2}{\omega} \, d\omega \]

Furthermore Eqn.(9) is also satisfied.

\[ \int_{-\infty}^{\infty} \psi(x) \, dx = 0 \]

And the function \( \psi(x) \) is a basic wavelet. The dilations and the translation function (10) are also wavelets.

\[ \psi_{a,b}(x) = |a|^{1/2} \psi \left( \frac{x-b}{a} \right) \]

In Eqn. (10), when \( a = 2^i \), \( b = m \cdot 2^i \). Moreover assume that \( A \) and \( B \) satisfy the following relation:

\[ 0 < A \leq B < \infty \]

\[ A \leq \sum_{j=-\infty}^{+\infty} |f(\psi(\omega j x))|^2 \leq B \]

Then definition 2 can be obtained.

Definition 2: The continuous wavelet transform of the function \( f(x) \) is as follows:

\[ W_f(a,b) = \frac{1}{\sqrt{C_\psi}} \int_{-\infty}^{\infty} \psi \left( \frac{x-b}{a} \right) |a|^{1/2} \, dx \]

The adverse transform is Eqn. (13).

\[ f(x) = \frac{1}{\sqrt{C_\psi}} \int_{-\infty}^{\infty} W_f(a,b) |a|^{1/2} \psi \left( \frac{x-b}{a} \right) \, da \, db \]

The discrete wavelet transform can be derived in a similar way. In this paper we will not go into that issue. When it comes to the case of high-order signals, a mother wavelet function which is the product of one-dimension mother wavelet function will be selected.

Then the conception of wavelet neural networks can be put forward. Because an arbitrary function in \( L^2(\mathbb{R}) \) can be decomposed by the continuous wavelet transform or discrete transform a wavelet decomposition can approximate functions in \( L^2(\mathbb{R}) \). Similarly for \( L^2(\mathbb{R}^n) \), n-dimensional wavelet decompositions can be used to
approximate any function in it. N-dimensional wavelet approximation is discussed in the following section.

let 
\[ g_{NN}(x) = \sum_{m=1}^{N} \sum_{k=1}^{M} C(m, k) \psi_{m,k}(x) \] 
then 
\[ g(x) = \sum_{i=1}^{N} \omega_i \psi(D_i R_i (x - t_i)) + \bar{g} \]

In Eqn. (14) \( x \in \mathbb{R}^n \), \( D_i \) is a dilation matrix (diagonal matrix), \( R_i \) is a circummutation matrix, \( t_i \) is a translation parameter, \( \omega_i \) is a weight. So the network structure is derived and shown in Fig.2.

According the analysis of wavelet analysis conception above, a wavelet neural network (WNN) is a new Feedforward network based on wavelet analysis, that is to say, the Wavelet basis replace the usual nonlinear activation function of a neural network (such as the sigmoid function). Generally the mapping learning of high-order wavelet network will result in “dimension disaster”, i.e., as the input of the network increases the number of sample which will be used in network training increases exponentially. In this paper a wavelet neural network which is a high-order input on the basis of perception thought is built. Because the selected Wavelet function is a unitary function which avoids the “dimension disaster” problem in high-order Wavelets, it is thus a powerful tool. The structure of the multi-input and multi-output system is shown as follows:

The input of the network is \( X = [x_1, x_2, \cdots, x_n]^T \). The output is \( \hat{Y} = [\hat{y}_1, \hat{y}_2, \cdots, \hat{y}_p]^T \). The element \( G = [\bar{g}_1, \bar{g}_2, \cdots, \bar{g}_p] \) is the average of all the outputs. The ith output is

\[ \hat{y}_i = \frac{\sum_{j=1}^{k} \omega_{ij} \psi \left[ \frac{\sum_{l=1}^{n} (y_{il} x_l - \tau_j)}{a_j} \right] + \bar{g}_i} \]

In Eqn. (14) \( \psi(\cdot) \) is the wavelet basis function, \( \omega_{ij} \) is the weight factor, \( a_j \) is wavelet dilations factor, \( -\tau_j \) is the translation factor, \( n \) is the total number of wavelet basis, and \( k \) is the total number of input layer and output layer separately. The problem
Figure 3. The structure of wavelet neural network forecasting model

in Fig 2 can be described in the following form: The error function should be Eqn. (15)

\[ E = \frac{1}{2} \sum_{t=1}^{m} \sum_{i=1}^{p} (y^i_t - \hat{y}^i_t)^2 \]

Then network parameters must satisfy the requested precision according to the minimum \( k \). In Eqn. (15), \( y^i_t \) and \( \hat{y}^i_t \) are the expected output and the real output of group \( t \). \( m \) is the number of training sample group.

3.1. Build Wavelet Neural Network-WNN Based Economic Forecasting Models.

WNN is based on a mapping method which builds the model according to the input and output if the object without any transcendent acknowledge and the network will search the relation automatically according the input and output sampling data, also it has the ability of self-learning.

The WNN model in this paper uses the structure in Fig. 2. From the figure, all the problems should be solved can be seen, such as, the number of the network and the number of wavelet basis. The input and output number can be obtained from the given data. It should be equal to the input and output number of the data. All the parameters such as the weight and the translation factor can be got through training. The problem of determining the size \( k \) of the wavelet network, i.e., the number of wavelet basis functions in the model, can be viewed as a standard model order determination problem. Some of the standard approaches can be used including Akaike’s Information-theoretic Criteria (AIC), Akaike’s final forecasting error criterion (FPE), generalized cross-validation (GCV), statistical hypothesis test and Schwartz and Rissanen’s minimum description length (MDL) criterion.

Under certain assumptions, the generalized cross-validation (GCV) method gives an approximate estimate of the mean of square errors (MSE).

When a Wavelet Neural Network is used in a Economic forecast Model of enterprise, it is set in the following step:

1) Fix the numbers of the input and the output of the WNN;
2) Give the leaning samples;
3) Divide the leaning samples into two segments: the learning segment and the checking part;
4) Train the network, in order to minimize the squared sum error, fit the learning segment time sequence firstly;
5) Check the trained Network model by the checking segment data then make use of the model to forecast the future state.

3.2. Sub systems of SEMIS.
Generally a SEMIS system is consisted of subsystems listed below:
1) Produce management system: It mainly manages the factory operations. It deals with equipments management, technologies management and projects management.

2) Plan management system: It mainly manages the operation of project division. It comes down to production plan and statistical comparison.
3) Information query system for managers: It makes sure that people can get the integrated information in need.
4) Material management system: It is mainly for the managements of operation of material, such as raw material management, spare part management, bargain management, statistic management, store management and financing management.
5) Financial affairs management system: Using the existing financial management information system, it manages the operation of working departments.

4. The structure of database system
The data that a SEMIS system stores are numerous, with various kinds of format types and data styles, so the systems should have many functions. We can divide the database into three layers: the management model (classification management), the source of information (grade gathering), the operation mode and computer technology level. Every layer can run independently. The lower layer sends data information to the higher one, while the higher layer sends control information to the lower. The whole database system has a hierarchical structure. The sketch map of the database’s hierarchy is showed in figure 5.

5. Conclusion
Through the analysis of a SEMIS system, the system design method of a economic forecasting model based on the wavelet networks is obtained. The fieldwork shows us that the profit margin of enterprise raised 4.16% higher. A valuable insight for popularizing the system is given.
Figure 5. SEMIS database layer structure

References


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