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Research on Dynamic Analysis and Prediction System of Energy Economic Efficiency under Fusion Algebraic Equations

Abstract: - Energy is an important material basis for national economic development, and it plays a vital role in social development. As China's industrialization process and urbanization construction continues to accelerate, energy demand is also increasing, and the dependence on electricity is getting higher and higher. How to improve the electric energy efficiency under the guarantee of stable quality of power generation, transmission and distribution and meeting the requirements of users' electricity consumption is an important issue to be solved in the current power grid construction. However, the serious defects of the traditional binary hierarchy and the lack of scientific understanding have led to many current new problems with more and more new and complex features. This is accompanied by the emergence of a large number of nonlinear term coefficients and an increasing research workload, and the traditional linear programming methods cannot meet the practical needs. Therefore, this paper analyzes the eigenvalues of energy economic efficiency based on algebraic equations and predicts energy economic efficiency using EMD-BP neural network algorithm, and then carries out the design and research of economic energy system based on these two points.

Keywords: Algebraic equations; Algebraic equations; Energy economic efficiency; Analysis and prediction systems.

1. Introduction

In today's society, energy is an important basis for the development of a country, and for human beings, energy is an indispensable material resource for their survival and development, therefore, the development of energy has become an important symbol of the strength of a country and society's economic strength and modernization level. With the continuous progress of science and technology and the increasing concern for environmental issues, how to better improve the utilization of resources is the topic we are now facing. In the past, traditional teaching methods were usually used to teach students to understand the relevant knowledge, which often led to some wrong results [1]. In today's teaching, the introduction of new methods and principles can better improve the students' understanding of the knowledge and also make the teacher's teaching style more innovative [2].

Energy economy is a very complex system, which involves all aspects of social production, life and science and technology. In the history of human development, people have always been committed to the scientific and rational development and utilization of resources, and the development and utilization of resources has been carried out continuously, but the lack of scientific and rational utilization of natural resources has resulted in energy shortage and environmental pollution. With the progress of the times and the increasing demand of society, the energy productivity has been greatly strengthened, but at the same time, it has also brought a series of serious impacts and even endangered the whole national security problems: such as global warming caused by the oil crisis, sea level rise triggered the environmental pollution in the whole range, etc. These phenomena are all caused by the serious damage to the energy economic efficiency [3]. Therefore, the analysis and forecast of its energy economic efficiency should be combined with the actual situation to analyze the rational development and utilization of energy economy, so as to provide a scientific basis for the sustainable development of the country.

In energy economic efficiency analysis, the various types of eigenvalues of the energy economy are first analyzed, and then the combinations of the subproblems are calculated based on the eigenvalues to obtain the corresponding variables and observations in different matrices. The traditional eigenvalue analysis method uses the difference of eigenvalues to classify the same subproblem, but in practical applications there are often combinations of multiple types of matrices. Therefore, this paper introduces a way to calculate the eigenvalues of energy economic effects through algebraic equations. The eigenvalues of the kangaroo equation are determined based on the combination of subproblems, so the method can be borrowed to take the eigenvalues of the subproblems of energy economic efficiency as the basis, and the integration of algebraic equations is to study the interconnection between variables under different functions, and to analyze each independent variable by building a model [4]. In addition, the prediction and evaluation of energy economic efficiency is also a very important topic, which can not only provide a reliable basis for future scientific development, but also promote social economy and improve people's quality of life [5]. This paper introduces an energy efficiency prediction

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method based on EMD-BP neural network, which can simplify a complex nonlinear system and obtain an accurate and reliable prediction result, which presents a new idea for solving the energy economic efficiency problem.

Based on the above description, this paper studies the design and research of an economic energy system based on the combination of energy economic efficiency analysis based on algebraic equations and energy efficiency prediction based on EMD-BP neural network [6,7].

2. Eigenvalue analysis of economic efficiency based on algebraic equations

1) Eigenvalue analysis of algebraic equations

Eigenvalue analysis is a probability-based method that divides the object under study into several subclasses with the same or similar properties, and establishes a mathematical model by calculating the existence of some connection between the corresponding variables in these different types of subclasses, so as to predict the unknown data in the subclasses, and analyze these different types of variables by mathematical methods to finally obtain the overall functional expression.

The algebraic equations reflect the constraint relationship between different variables in the system, and for the same set of algebraic equations, the interdependence between different variables is not the same. In the same set of algebraic equations, each variable may have the same or similar degree. Therefore, looking at the algebraic equations from the perspective of eigenvalues can simplify the analysis of the problem and grasp the essence of the problem [8].

For any system of linear algebraic equations there is a relationship as shown in equation (1), and if the coefficient matrix is transformed in primary rows to obtain a number of similar coefficient matrices, each of which may contain a different algebraic equation at each order. Therefore, when performing mathematical modeling, the corresponding set of differential equations can be created according to their correspondence.

$$Ax = b \tag{1}$$

where A is the coefficient matrix of the equation, b is the algebraic matrix of the equation, and x is the solution of the equation. For the same system of linear equations, although there are several similar coefficient matrices, these matrices describe the same coordinate transformations, which can be seen that the coordinate transformations are the core of the system of linear equations and also the difficult point. In a multivariate system of linear equations, the matrices have different coordinate transformations and space curves for different discrete terms [9]. The eigenvalues and eigenvectors of the matrix are used to describe the most fundamental properties of the coefficient matrix. The eigenvectors are calculated by using the matrix to perform algebraic operations in space, and also to realize the function expressions and numerical solutions, which determine the direction of the coordinate system, and the eigenvalues represent the unit length of the coordinates. Therefore, the coordinate transformations expressed by the equations can be described visually using the eigenvalues and eigenvectors of the matrix [10].

The calculation of the eigenvalues of the coefficient matrix can be obtained from the above description as shown in equation (2).

$$\left|A - \lambda E\right| = 0 \tag{2}$$

where E is the unit matrix, and the eigenvalues of the matrix are shown in Equation (3), and the left and right eigenvectors corresponding to this eigenvalue are shown in Equations (4) and (5):

$$\lambda_i = \sigma_i \pm j\varpi_i \tag{3}$$

$$A\phi_i = \lambda_i\phi_i \tag{4}$$

$$\psi_i A = \lambda_i\psi_i \tag{5}$$

where ϕ_i is the right eigenvector corresponding to the eigenvalue and ψ_i is the left eigenvector corresponding to the eigenvalue. For these two eigenvectors there is the following property defined: i.e., for the left and right eigenvectors with different eigenvalues, their scalar product is zero, i.e., they are orthogonal, as shown in Equation (6), while for the left and right eigenvectors with the same eigenvalues, their scalar product is one, as shown in Equation (7).

$$\psi_i\phi_i = 0 \tag{6}$$

$$\psi_i\phi_i = 1 \tag{7}$$

Let the right eigenvector matrix be $\Phi = [\phi_1, \phi_2, \cdots \phi_m]$, the left eigenvector matrix be $\Psi = [\psi_1^T, \psi_2^T, \cdots \psi_m^T]^T$, and the eigenmatrix be $\Lambda = [\lambda_1, \lambda_2, \cdots \lambda_m]$, then the matrix A can be expressed as shown in Equation (8):

$$A=\sum_{i=1}^{m}\lambda_i\phi_i\psi_i^T \tag{8}$$

Since the matrix and its inverse matrix have mutually inverting eigenvalues, the same eigenvectors, then Equation (9) can be obtained.

$$A^{-1}=\sum_{i=1}^{m}\lambda_i^{-1}\phi_i\psi_i^T \tag{9}$$

Therefore, the solution of the linear system of equations expressed in Equation (1) can be expressed as shown in Equation (10).

$$x=\sum_{i=1}^{m}\lambda_i^{-1}\phi_i\psi_i^T\cdot b \tag{10}$$

2) The application of eigenvalues of algebraic equations in economic efficiency analysis

First of all, in economic analysis, we generally use algebraic equations to describe some problems, such as:the cost, output and rate of change of a production process, and by analyzing these data, we can obtain the corresponding quantitative relationships to understand what problems exist in the production process. Then, under the calculated functional model, we study the transformation coefficients between different variables under the mathematical equations, as well as between the same moment and between different locations. Secondly, in terms of mathematical modeling, by studying the linear programming model, a simple continuous stochastic system can be built using the discrete point method, or a discrete model can be defined to represent the existence of interdependencies or interactions and constraints between multidimensional variables, and some complex problems are also described by algebraic equations. For example: the relationship between linear and nonlinear planning problems and can also be described by algebraic equations.

3. EMD-BP Neural Network Based Prediction Method

1) BP neural network

(1) Neuron model. Neuron network is composed of many small units, which has many advantages, such as: simple, practical and so on. In real life, neural networks are used to simulate the human brain to process external information. The artificial neural network is a nonlinear system, so the neuron structure is more complex and diverse compared with some other linear models, for example, the multiple-input single-output model (P-S) can get more accurate results, and the BP artificial neural system is a multilayer structure, which has many layers, interconnection relationship between each unit, so it can perform a variety of operations. Therefore, neural networks have a lot of advantages and are widely used in many fields [11]. The neuron model is shown in Figure 1.

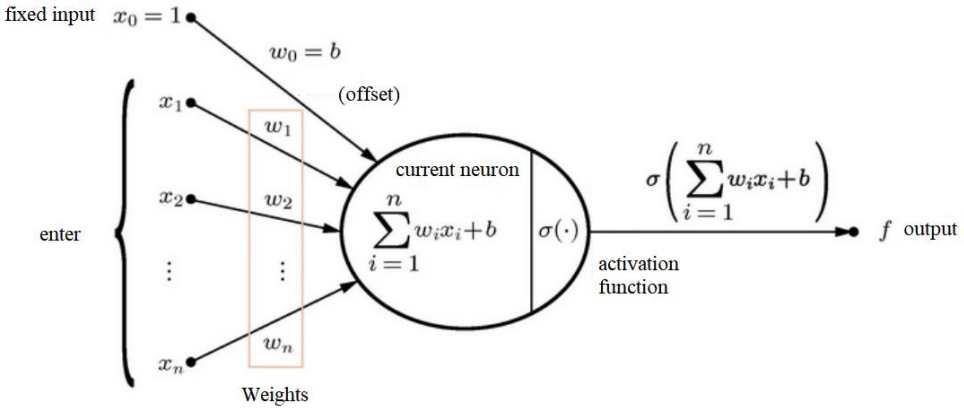

Figure 1 Neuron model

The neuron model in the above figure mainly uses the activation function, which is a common function optimization problem that can be used to deal with many complex nonlinear relationships in solving practical mathematical analysis. There are many activation functions, and the commonly used activation functions are shown in Table 1.

Table 1 Commonly used activation functions

activation function name	activation function expression
Threshold function	$f(x)=\begin{cases}1, x\geq 0\\ 0, x<0\end{cases}$

Linear function	$f(x)=kx$
Logarithmic Sigmoid Function	$f(x)=\frac{1}{1+e^{-x}}$
Tangent Sigmoid Function	$f(x)=\tanh(x)=\frac{e^{x}-e^{-x}}{e^{x}+e^{-x}}$

(2) BP neural network structure. BP neural network usually has one or more implicit layers and contains a three-layer forward BP neural network structure with one implicit layer, which is a complex nonlinear function mapped into a network, and the control of the system dynamic response process is achieved by an optimal combination of input and output layers in the model [12]. The network structure is shown in Figure 2.

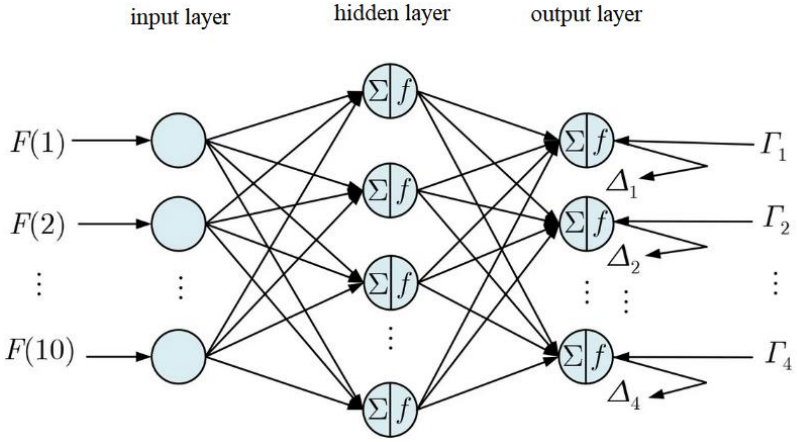

Figure 2 BP neural network structure

2) Forecasting method based on EMD-BP neural network

In the prediction of energy economic efficiency, it is necessary to analyze the relationship equations between various functions in order to produce more accurate, reasonable and comprehensive results. We use mathematical equations to calculate the corresponding values, so in order to make the model more accurate and scientific a "neural network" method (BP algorithm) can be used to achieve. This method mainly uses the energy generated by the linear transformation in the nonlinear system as the object of study, and then finds the output variables and input vectors and output coefficients by processing the function accordingly, and calculates the corresponding output results, and then processes the obtained data and finds the corresponding parameters by using the linear function method [13].

In this paper, a novel EMD-BP artificial neural network is proposed. The original sequence is first processed by EMD and used as a prediction model, and then the network is used to analyze the energy changes in each future season and predict the energy demand in each future season. The analysis revealed that the artificial neural network has more advantages in nonlinear systems. The overall process is shown in Figure 3.

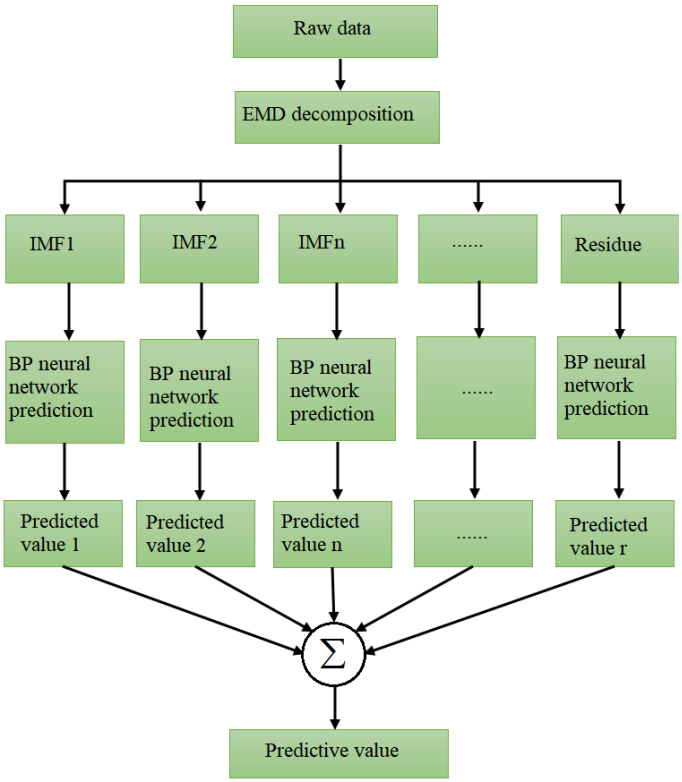

Figure 3 EMD-BP neural network prediction method flow

(1) EMD processing. Mathematical operations are the core of computing, which can help people to perform quantitative analysis to make predictions about future development trends. EMD is a screening process. The signal to be decomposed is applied to the screening algorithm in iterations again and again until it meets a certain stopping criterion and ends. The EMD processing process is shown in Figure 4.

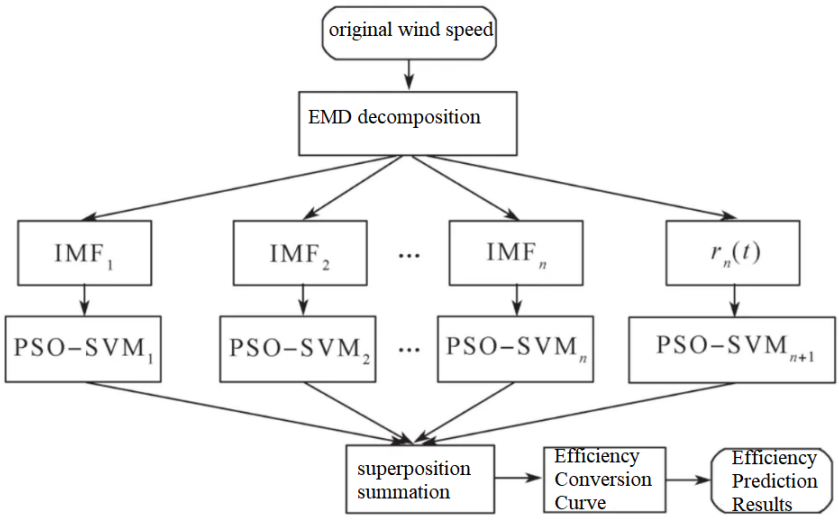

Figure 4 EMD processing process

The construction of historical data in neural networks. The study of neural networks is a very important field with applications in many areas, such as:computational intelligence, control algorithms, etc. It can be used for modeling and learning. For historical data: firstly, we must determine what is the correct use of time for work to complete the task; secondly, we must choose the information processing system and storage method that suits our own characteristics and the functions that need to be realized before we can start to use them. The ability of neural networks to analyze problems and then make decisions; Finally, in the analysis results, timely and effective measures are taken to the places where there are errors or defects [14].

The purpose of historical data construction is to construct an input and output data set that conforms to the artificial neural network prediction model, and then use it to predict various problems that the artificial neural network may have in future work, so as to provide people with a more accurate and reliable decision-making, here the method of processing time series is used to process historical data [15].

For the time series xt(t=1,2,... ,n), according to Takens' theorem, a suitable embedding dimension m can be

chosen to reconstruct the coordinate vector as shown in Equation (11).

$$X=\begin{bmatrix} X_1^T \\ X_2^T \\ \cdots \\ X_{n-m+1}^T \end{bmatrix}=\begin{bmatrix} x_1 & x_2 & \cdots & x_m \\ x_2 & x_3 & \cdots & x_{m+1} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n-m+1} & x_{n-m+2} & \cdots & x_n \end{bmatrix} \tag{11}$$

And there exists a smooth map VVV satisfying equation (12):

$$x_{m+i}=f(X_i)=f(\{x_i,x_{1+i},\cdots,x_{m+i-1}\}) \tag{12}$$

Artificial neural network is used for time series prediction, that is, under uncertain conditions, artificial neural network is used to simulate and predict space, which has high accuracy and practicability. Formula (12) is mainly used, and then the trained neural network is used. The network is used to derive future values, that is, the first m values of the time series are used to predict the next value. The specific description is as follows:

Suppose there exists any point X(t) in the space, which is represented as shown in Equation (13).

$$y(t)=\{x(t),x(t+1),\cdots,x([t+(m-1)])\} \tag{13}$$

The representation of its nearest neighbor XN(t) is shown in Equation (14).

$$y^N(t)=y(t')=\{x(t'),x(t'+1),\cdots,x([t'+(m-1)])\} \tag{14}$$

When the embedding dimension is m, the distance between the two points X(t) and XN(t) is calculated as shown in Equation (15).

$$k_m(t)=\left\|y(t)-y^N(t)\right\| \tag{15}$$

Then the calculation of the square of its distance can be obtained according to equation (15) as shown in equation (16).

$$\begin{aligned} k_{m+1}^2(t)&=\left\|y(t)-y^N(t)\right\|^2 \\ &=[x(t)-x(t')]^2+[x(t+1)-x(t'+1)]^2+\cdots \\ &+[x(t+(m-1))-x(t'+(m-1))]^2+[x(t+m)-x(t'+m)]^2 \end{aligned} \tag{16}$$

The final equation (17) is obtained.

$$k_{m+1}^2(t)-k_m^2(t)=[x(t+m)-x(t'+m)]^2 \tag{17}$$

And the pseudo-nearest neighbor point is judged based on the judgment as shown in Equation (18).

$$\frac{[k_{m+1}^2(t)-k_m^2(t)]^{\frac{1}{2}}}{k_m(t)}=\frac{\left|x(t+m)-x(t'+m)\right|}{k_m(t)}>k_d \tag{18}$$

From this, an input-output dataset of $\{X_i^T,x_{m+i}\}$ can be constructed, and an artificial neural network with input layer m and output layer 1 can be constructed based on this dataset.

4. Design of Energy Management System

1) Hardware system design

(1) Field sensor. Field sensor is an instrument that converts the sensing, measurement and control of the object to be measured into an electrical signal output, and can monitor the target position directly or indirectly. Environmental conditions are complex and variable, so there are many parameters that need to be used when performing analysis. For example, physical quantities such as temperature can be replaced by thermistors or thermocapacitive thixotropic resistors, humidity, wind speed and wind direction can also be used to achieve the detection of sound velocity sensors, there is also the location of the measured object can not be measured in the object covered by interference, these factors are one of the important reasons for the impact of energy economy. Therefore, the functional relationship equation is needed in the calculation process, and this paper combines it with traditional mathematical methods to establish a more suitable model for calculating energy economy [16].

(2) Data acquisition and transmission. The main work of data acquisition is to process and store the collected information. The data transmission process should ensure that the original signal is converted into a digital signal within a certain period of time and then transmitted to the calculator, which converts the signal into a numerical value within a certain period of time and then processes and stores the data to produce results. For the power system, the electricity is sent from the power plant to the equipment through various links will be affected by voltage fluctuations, current changes and other problems, due to a variety of non-linear factors

caused by the instability of the power grid and the complexity of the power supply network and a series of problems, these phenomena are very common and easy to occur in real life. Therefore, mathematical modeling of the power system can effectively solve the above problems and improve the stability and safety of the power supply network.

2) Software system design

The software system has two main parts, which are data acquisition and monitoring system and management system [17]. The system data flow diagram is shown in Figure 5.

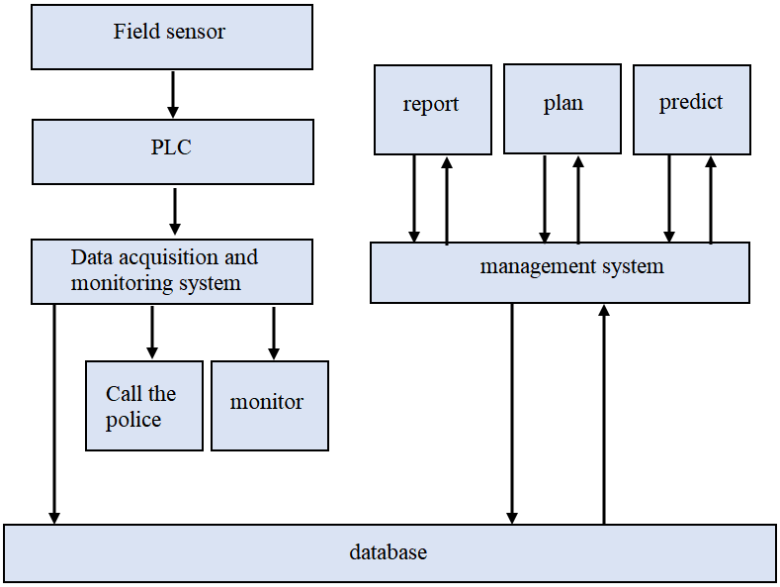

Figure 5 System data flow diagram

(1) Data acquisition and monitoring system software design. The data acquisition and monitoring system is based on WinCC configuration software, which can realize real-time data acquisition and monitoring. The system mainly adopts B/S structure, integrating each configuration function module on a chip, and it is designed and programmed based on software development environment, and the development of data acquisition and monitoring system is realized through the combination of hardware and software [18]. The WinCC system architecture is shown in Figure 6.

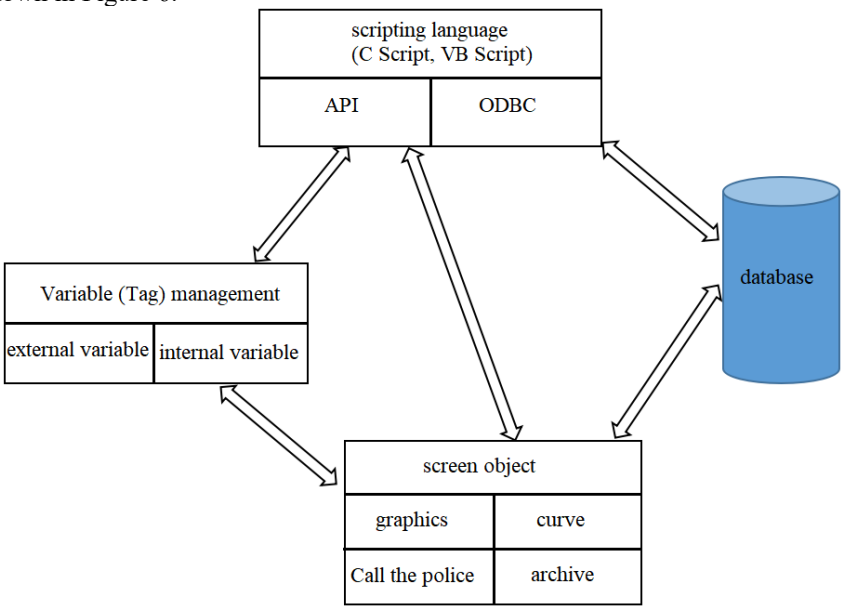

Figure 6 WinCC system architecture

(2) Management system software design. In the system, the software design is a very important part, which directly affects the whole system development and operation efficiency. The management system is developed in Microsoft Visual C# language, and the specific software architecture is shown in Figure 7.

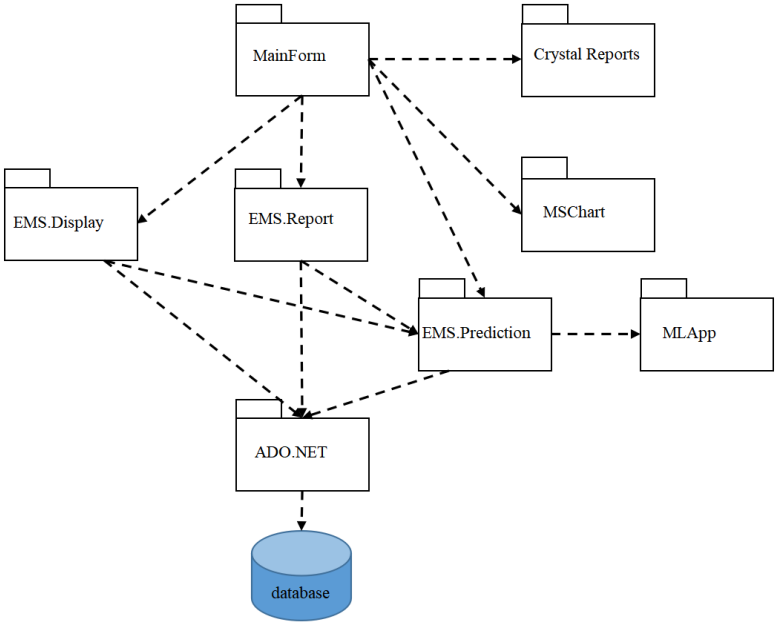

Figure 7 Software architecture diagram

5. Conclusion

To sum up, in the current process of social development, energy is the essential material basis of people's life. With the continuous improvement of economy and technology, more and more attention is paid to the utilization of new energy, and the development of energy is not only the performance of a country's economic level and comprehensive national power, but also a measure of the degree of development of social productivity and science and technology in the next few decades, which has a very important impact on our national economy and people's life. In this paper, we introduce algebraic equations for economic energy efficiency analysis and use EMD-BP neural network algorithm to predict the economic efficiency of energy, so that we can make some contributions to the future economic development direction of China.

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