A STUDY ON THE APPLICATION OF NEURAL NETWORKS IN FUZZY COMPREHENSIVE EVALUATION

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Abstract: In the paper, we would use neural network theory in fuzzy integrated evaluation, give a method of multiuse quantization evaluation based on three-layer neural network and study the structure of three-layer neural network, corresponding network learning procedure, computer implementation algorithm used in fuzzy integrated evaluation and applied examples.

Key words: Neural Network, B-P learning Algorithm, Fuzzy Integrated Evaluation, Computer Supervisory System.

0. INTRODUCTION

In many conditions, objective thing has fuzziness, that is, has no clear extension, the theory and method of fuzzy mathematics must be drown into the corresponding evaluation and policy-making work so that the policy-making effect is more close to reality and more accurate. In each management work, the theory and method of fuzzy integrated evaluation and fuzzy information decision in [1-3] had been had a more wide use and the better policy-making effect had been obtained. But these methods are all short of ability to study independently. In the process of decision, it is very difficult to extricated from the random, subjective indeterminacy and understanding fuzziness of policy--maker. For example, a different subjective decision had always been obtain from the same object in the different time and environment, even if it is done by the same expert.

In the paper, we use the theory of Artificial Neural Network into the fuzzy integrated evaluation and study a multiuse quantization evaluation model based on three-layer neural cell. The experience, knowledge, subjective decision of expert and the proportion coordination ability of objective importance are obtained by the study of known sample, which is science and rational evaluation and decision throughout gearing to actual circumstances. When we need to do the same fuzzy integrated evaluation, the experience, knowledge and intuitive thinking of expert would be reappear by using the network, so that the artificial imposed factor could be cut down and the objectivity of evaluation result could be assured better.

1. THE CONCEPTION OF ARTIFICIAL NEURAL NETWORK

Artificial neural network (simple neural network) is a structure of simulated biological neural system, and a unlinear self-adapted dynamic system composed by huge treatment unit. It has the ability of study, memory, calculation, wisdom management and information management imitated human brains in varying degrees and levels. It is noted for its unlinearness, unlocal property, the property of non-constant, and unconvex etc. The neural network system, which integrate construction with algorithm, can be regarded as a unity of hardware and software.This would make a great influenu in computer development. Research of neural network has formed a great mass fervor at home and abroad and its result has obtained use in pattern recognition, automatic control, image processing, linguistic recognition and so on.

Neural network solves a problem by expressing problem as unit proportion. An artificial neural cell (simple neural cell) is an unlinear unit construction formed by n difference inputs and m identical outputs (see Fig.1)

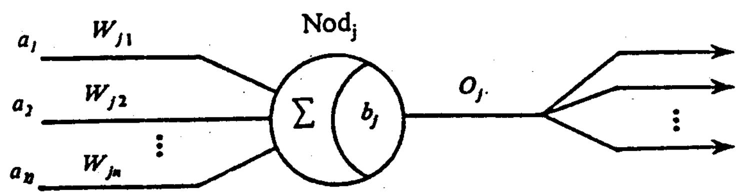


Fig.1 Aneural cell's construction.

Here, $a_1, a_2, \cdots, a_n$ represent the preceding output (or input signal of the 1th layer), respectively, w_{ji} the related coefficient (also proportion coefficient) of node between i and j.Multiply corresponding proportion coefficient w_{ij} by each a_i (i=1,2,...,n), and sum up then and minus b_j. Denote b_j the valve value (also offset term) in neural cell, net_j the net input value and O_j the output message of nod_j. Then

$$net_j = \sum_{i=1}^{n} a_i w_{ij} - b_j \qquad (1)$$

and $O_j = f(net_j)$. Where f is a change function between input and output, in general, is a non-increasing differentiable function. It can be one of the following function: linear, sine, hyperbolic tangent, valve value, increasing half trapezoid and Sigmoid type. Among them, Sigmoid type function (simple S-type change function) has huge use since it can adapt well both linear and nonlinear problem, it is expressed as

$$f(net) = 1/[1+\exp(-net)] \qquad (2)$$

In actual use, we can choose distinct change function according to particular problem.By compounding these simple functions, neural network finish change between input information and output message. To get the utmost complex function, it just need several times compound, Then the complex physical world is expressed.

2. THE PRINCIPLE OF MULTIUSE QUANTIZED EVALUATION BASED ON THREE-LAYER NEURAL NETWORK

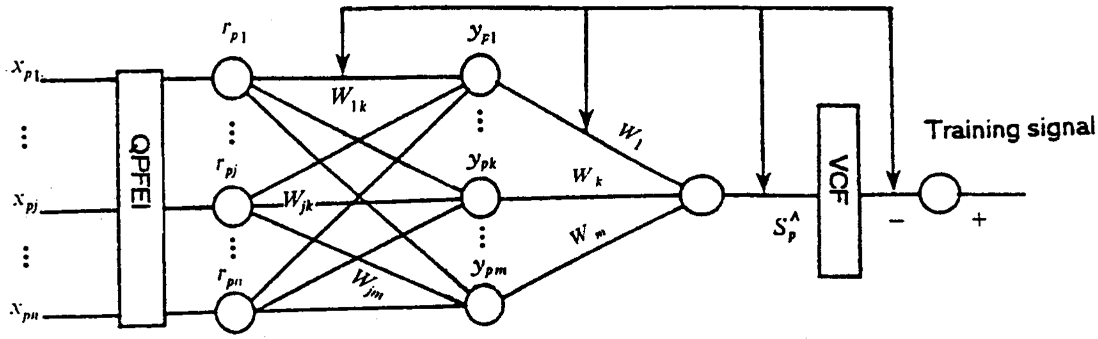
The principle of evaluating some problem by using the method of multiuse quantization evaluation based on three-layer neural network is that use information of descripting evaluated object feature as input vector of neural network and the value of corresponding integrated evaluation as output of neural network, takes enough examples to train the network such that different input vector obtains different output value. Then the value of proportional coefficient and valve holding by neural network are the correct inner expression by the self-adapted study of network. Well-trained neural network can be looked as an effective tool of fuzzy integrated evaluation to do corresponding integrated evaluation about different evaluated objects.

Since the information-compounded way of different fuzzy evaluation (policy) studying in the paper can use the quantization handled means which had beenproved in [1] and [2], we may take a neural network which has the same construction to handle our varied fuzzy evaluation (policy) problem.Here the neural network is designed in the light of the biggest dimension of input vector (information) of different evaluation in designed object. In specific training and use, the each layer neural cell's number of joining operation needs to determine at any time according to reality.

The principle of multiuse quantization evaluation based on three-layer is that, use an open type data processing to record data of different evaluated problem's proportional coefficient value, valve value and so on, respectively, store the proportional coefficient value and corresponding valve value et al. which are obtained by using the ith ($i=1,2,...,n$)fuzzy evaluation sample to train neural network (until convergence) into the ith data processing; let neural network initialize and then store the proportional coefficient, valve value and so on, which are obtained by using the ($i+1$)th fuzzy evaluated sample to train neural network, into the ($i+1$)th data processing; repeat the process before until all the different proportional coefficient, valve value et al. of N kinds fuzzy evaluation (policy) into open type data processing. When we use neural network to evaluate some problem, we just need to input evaluated type code according to related prompting, then the system let neural network initialize, determine each-layer neural cell's number of joining operation according to evaluated problem's code, autoassign the corresponding proportional coefficient, valve value et al. to neural network, last prompt user to input relevant information and the integrated evaluation's result will be given according to inputting information.

2.1 The Base Construction of Three-layer B-P Neural Network

Back-Propagation (abbr. B-P) learning theory of ahead multilayer neural network is posed by Werbos in 1974 in [4]. In 1985, learning algorithm of the B-P network is developed by Rumelhart et al. and imagine of Minsky multilayer network is accomplished. The B-P neural network has not only input and output cell, also one layer or multilayer implied cell [5]. When signal is inputted, it transmits to implied cell first and then output signal of implied cell is transmitted to input cell after through action function. The output result is given after process. In the paper, we use a three-layer B-P neural network having multiinput cell and single output cell. Its structure and theory of B-P learning procedure is showed in Fig.2. Input signal is successive processed from input layer to implied cell and is transmitted to output layer. Note that state of each layer neural cell just effect next one. If output layer can not obtain expectation output then turn to backward propagation and let error of output signal return along original connected path. The error signal would become a minimum (convergence) throught amending proportional value of each layer neural cell.



QPFEI------Quantization process function of evaluation index
VCF--------Value change function TS----Training signal
Fig.2 Theory of B-P learning procedure of a three-layer neural network

In Fig.2, n, m denote the neural cell number of input layer and implied one, respectively; $x_{p1}, x_{p2}, \cdots, x_{pn}$ the pth sample's evaluated index feature value of domain $U=\{u_1, u_2, \cdots, u_n\}$ in some kind policy. Let $\vec{X}=(x_{p1}, x_{p2}, \cdots, x_{pn})$, then the feature value matrix constructed by k samples is

$$x=[x_1, x_2, \cdots, x_k]^T=[x_{pi}]_{k\times n} \qquad (3)$$

Denote $r_p=(r_{p1}, r_{p2}, \cdots, r_{pn})$ the evaluation vector after $\vec{X_p}$ is quantized by corresponding slave function, w_{jh} (j=1, 2, ⋯, n. h=1, 2, ⋯, m) the connected proportional coefficient of the jth cell of input layer to the hth cell of implied one, y_{ph} (h=1, 2, ⋯, m) the output of the hth cell of implied layer of sample P, w_h (h=1, 2, ⋯, m) the connected proportional coefficient of the hth cell of implied layer to output one; S_p^n the output of sample P. Value change function can turn S_p^n to qualitative remark or quantization evaluation result of hundred-mark system according to the need of policy.

2.2 Quantization process of evaluation index

In fuzzy integrated evaluation (policy), there is no a common quantity standard in each feature index of evaluated object and the feature index obtained in many occasion is a qualitative description and not a value, so it is difficult to compare directly. If the feature value in (3) is used immediately, it is unfavorable to analysis and handle. So before doing integrated evaluation, all x_{pj} in (3) must be turned to range of [0, 1] first, that is, evaluated index feature value must be quantizated. Of course, since the type of evaluation index is always different, the method of its feature value quantization is also different.

For n evaluation indexes of U, suppose each range is $d_j=[m_j, M_j]$, where m_j, M_j represent the minimum and maximum of evaluation index u_j (j=1, 2, ⋯, n) respectively. Denote $r_{pj}=U_{dj}(x_{pj})$ (j=1,2, ⋯,n) is quantization representation of evaluation index u_j's feature value x_{pj} of sample P with $r_{pj} \in [0,1]$ and $U_{dj}(x_{pj})$ is called quantization process function of index u_j which is defined on d_j.

Multiuse neural network introduced in this paper is designed and trained according to the theory and method of the following 6 kinds fuzzy integrated evaluation (policy):

(1) Integrated evaluation of university benefit of running a school.

(2) Integrated evaluation of science teaching quality (Physics, Chemistry and Mathematics) in teachers training school.

(3) Integrated evaluation of liberal arts teaching quality (Chinese, Political, History and Arts) in teachers training school.

(4) Annual job's quantization evaluation of engineers and technicians.

(5) Quantization method of assessing personal work.

(6) Integrated evaluation of economic benefit in middle-and-small enterprise.

The quantization slave functions $U_{dj}(X_{pj})$ are different according to distinct kinds of evaluation (policy) problem. Here, they are defined in the light of conversion demand of evaluation index in [1], [2], [3] and [6], respectively.

Index feature matrix (3) can form the following slave matrix (fuzzy evaluation matrix) through corresponding quantization of slave function $U_{dj}(x_{pj})$:

$$R=[r_1, r_2, \cdots; r_k]^T=[r_{pj}]_{kxn}$$

2.3 Learning algorithm of B-P neural network

Characteristic of each nodes of B-P neural network showed in Fig.2 is Sigmoid type, that is, $f(net)=[1+\exp(-net)]^{-1}$. Let O_i be the output of any node i. Suppose there are k samples (x_j,s_j), $j=1,2,\cdots,k$. For some input x_j, let s_j be the output of network, O_{ij} the input of node i and the output of node r is

in which b_r is inner value $net_{rj}=\sum_r w_{ir}o_{ij}-b_r$ valve of node r. Defined error function between actual output S_j^n and execpation output s_j is $E_j=\left(S_j-S_j^N\right)^2/2$, then sum error of k samples is

$$E=\sum_{j=1}^{k}E_j$$

E_j and output error of the rth cell is

$$\delta_{rj}=\frac{\partial E_j}{\partial net_{rj}}$$

with $o_{rj}=f(net_{rj})$. So

$$\frac{\partial E_j}{\partial W_{ir}}=\frac{\partial E_j}{\partial net_{rj}}\cdot\frac{\partial net_{rj}}{\partial W_{ir}}=\frac{\partial E_j}{\partial net_{rj}}\cdot o_{ij} \tag{4}$$

When r is a output node, let $O_{rj}=S^n{}_j$ and then

$$\delta_{rj} = \frac{\partial E_j}{\partial S_j^n} \cdot \frac{\partial S_j^n}{\partial net_{rj}} = -(S_j - S_j^n) f'(net_{rj}) \qquad (5)$$

if r is not a output node, then

$$\begin{cases} \delta_{rj} = f'(net_{rj}) \sum_t \delta_{tj} W_{tr} \\ \dfrac{\partial E_j}{\partial W_{ir}} = \delta_{rj} o_{ij} \end{cases} \qquad (6)$$

Computer algorithmic step of three-layer B-P neural network learning procedure is show as follow.

Step 1. determinate texture parameter of evaluated learning neural network(the neural cell's number of input layer and implied layer et al.).

Step 2. assign initial value to connected proportional coefficient and neural cell's valve value of network.

Step 3. input feature value matrix X and expectation output vector $S=(S_1, S_2, \cdots, S_k)^T$ of sample.

Step 4. true X to evaluation matrix R using corresponding slave function according to evaluation type.

Step 5. calculate each cell's actual output value of implied and output layer of each sample.

Step 6. evaluate E_j and E.

Step 7. if $E \leq \varepsilon$ (ε is the given convergence value) then stop learning, else go to step 8.

Step 8. calculate δ of each node of implied and output layer by (5) and (6), respectively (the formula is different to implied and output layer).

Step 9. amend proportional value

$$W_{ir} = W_{ir} + \mu \frac{\partial E}{\partial W_{ir}} \qquad with \qquad \frac{\partial E}{\partial W_{ir}} = \sum_{i=1}^{k} \frac{\partial E_j}{\partial W_{ir}}$$

and $\mu > 0$ is learning step length.

Step 10. turn to Step 5.

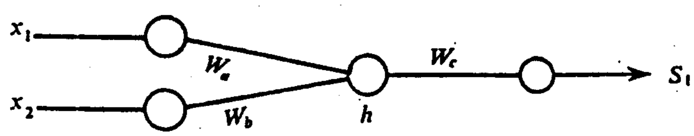


Fig.3 Asimple B-P network

We use Fig.3 as an example to show how the learning computer algorithm of B-P single sample is used.

Let E_i be the error function of the ith sample (x_i,s_i), then function error is $E = \sum_{i=1}^{k} E_i$. Calculate $\frac{\partial E}{\partial W}$

of the ith sample by $\frac{\partial E}{\partial W} = \sum_{i=1}^{k} \frac{\partial E_i}{\partial W}$ and delete subscript i, we have that

$$net_h = W_a x_1 + W_b x_2 \qquad o_h = f(net_h)$$
$$net_{s1} = W_c o_h \qquad o_{s1} = S_1^n f(net_{s1})$$
$$E_i = \frac{1}{2}(S_1 - S_1^n)^2$$

then the B-P propagated procedure is show as follow:

(1) calculate $\frac{\partial E}{\partial W}$

$$\frac{\partial E_i}{\partial W_a} = \frac{\partial E_1}{\partial net_h} \cdot x_1 = \delta_h \cdot x_1$$
$$\frac{\partial E_i}{\partial W_b} = \frac{\partial E_1}{\partial net_h} \cdot x_2 = \delta_h \cdot x_2$$
$$\frac{\partial E_i}{\partial W_c} = \frac{\partial E_1}{\partial net_{s1}} \cdot o_h = \delta_{s1} \cdot o_h$$

(2) propagated error signal

$$\delta_{s1} = -(S_1 - S_1^n) f'(net_{s1})$$
$$\delta_h = \delta_{s1} W_c f'(net_{s1})$$

$\frac{\partial E}{\partial W}$ can be calculated by given W_a, W_b, W_c and

then amend W by using steepest descent method:

$$W \leftarrow W - \mu \frac{\partial E}{\partial W} \qquad \mu \in [0,1]$$

3. EXAMPLE

3.1. Integrated evaluation of university benefit of running a school.

Calling well-trained neural network--assigning corresponding proportional coefficient and cell's valve value to network and according to feature index offered in 1988-1993, we re-evaluated 12 schools of 22 specialized schools in Guangdong, Henan, Hubei, Hebei, Sichuan and Shanxi et al. The comparison of evaluation result between using neural network and fuzzy integrated evaluation at that time is given in Table 1. Obviously, they are almost the same

Evaluation comparative table

SC	NE	FE	SC	NE	FE
G01	91.7	91.5	B02	87.2	87.3
G02	80.3	80.4	B03	83.2	83.1
G03	88.4	88.4	H01	90.3	90.3
N01	89.1	88.9	H02	79.1	79.2
N02	80.3	80.1	C01	80.8	81.2
B01	85.6	85.6	C02	92.3	92.3

With SC—School code NE—Network evaluation FE—Fuzzy evaluation

G—Guangdong N—Henan B—Hebei H—Hubei C—Sichuan

3.2 Other evaluation problems

According to quantization process method given in [1], [2], [3] and [6], contrast evaluation of different subject in 25 school is given by using neural network and feature index of teaching quality integrated evaluation of science and liberal arts of teachers training school in Guangdong, Henan, Hebei, Hubei and Sichuan et al. from 1988 to 1993. Its error is less than 0.5 by using hundred-mark system.

In the light of specific need and after training neural network respectively, we have achieved neural network evaluation about policy problems of "annual job's quantization evaluation of engineers and technicians", "integrated evaluation of economic benefit in a middle-and-small enterprise" and "quantization method of assessing personal work" et al. The results are almost the same as corresponding fuzzy integrated evaluation.

The above-mentioned results have showed that it was feasible by using neural network to learn corresponding knowledge of fuzzy integrated evaluation and then using it to do fuzzy evaluation about the same kind policy problem. The more close between awaiting evaluation object and model of sample, the more accuracy of evaluation result.

4. CONCLUSION

The whole procedure of multiuse quantization evaluation of neural network based on three-layer is written by Microsoft C^{++} 7.0 under the environment of Windows 3.1 and hardware configuration of system is over 486 compatible computer. The whole software is implemented by using structured programming method and object-oriented programming method. It has modularity, flexibility,generality, and portability et al. and has been loaded into system of "general quantization evaluation" to run. In the latter half of 1994, we used neural network module of the system to do quantization evaluation about integrated evaluation of economic benefit in the parts of middle-and-small enterprise and about engineers and technicians of some production unit(in grading the title of a technical) in Annoying. Good evaluation results had been obtained in these evaluations.

Comparing with fuzzy integrated evaluation, the method had quick operation, strong ability of tolerable error , and strong study independently.

The actual use showed that the method can simulate the whole procedure of expert evaluation fairly good and combine organically obtainment of knowledge, expert system and fuzzy inference function. Hence it has broad used prospects. But training samples of integrated evaluation method based on neural network come from the result obtained from used fuzzy integrated evaluation method. When a new evaluation problem is came across (such as index system is changed), fuzzy integrated evaluation method must be used.

REFERENCES

1.Wang Aimin , The current Quantized for assessment and the computer managements system,Dalian Maritime University publishing House,Dalian,china,1992.

2.Wang Aimin,Quanbtization Method and computer prooss in Managing work ,Dalian Scientific and Engineering Vniversity Publishing House,Dalian,China,1990.

3.Wang Aimin ,The study in Theory and practia of Fuzzy policy, Yindu Journal 95 (2) 1--5.

4.Werbos, P.J., Beyond regression New tools for prediction and analysis in the behavioral; sciences, Harvard Univ, 1974.

5. Hecht-Nielsen R.Theory of the Back-Propagation Neural Network, Proc. IEEE International Conference on Neural Network, Washington D.C., 1989, 593-605

6. Wang Aimin,One Hundred Sanples in Fuzzy integvated policy,Awaiting publication.