The Application of the Fuzzy Neural Network Control in Elevator Intelligent Scheduling Simulation

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***Abstract*-Because of the diversity of target about the elevator group control system and inherent randomness and non-linear of the elevator system, so it is very difficult to improve the performance of the elevator control system through the traditional control methods .In the elevator group control system it is feasible that the system coordinate the operation of multiple elevators by use of the fuzzy BP neural network and the optimized control strategy, which can increase the transport efficiency and service quality. This paper has set up the gauss member function of customer's waiting elevator satisfactory and customer's riding elevator satisfactory and customer's energy compulsions satisfactory, construct the model of the fuzzy BP neural network through the intelligent scheduling characteristics of the elevator. The different weights have been given through the different patterns of the running elevator and the simulations of the elevator intelligent dispatching has been achieved.**

Keywords- the fuzzy BP neural network ; elevator group control system ;weights

I. INTRODUCTION

Since the Fuzzy Logical was used in the elevator at first, the number of using of the elevator group system increased rapidly. To satisfy the traffic demands about people, much modern architecture concentrate concentration and optimize schedule for several elevator group system so as to decrease the time of the riding elevator and the waiting elevator and the energy consumption. This paper constructs a new membership function to evaluate the waiting elevator satisfaction and the riding elevator satisfaction and the energy consumption satisfaction while the elevator scheduled intelligently and comply the intelligent scheduling of the elevator group system in different traffic models.

II. THE ELEVATOR GROUP SYSTEM'S MATHEMATICAL MODEL BASED ON FUZZY BP NEURAL NETWORK

The mathematical model of the elevator group system is of great significance to the reasonable distribution of the elevator. This elevator system is composed of the data process and fuzzy BP neural network control unit and comparison and so on, it is shown in figure 1.

III. REPRESENTATIONS FOR STATE SPACE

A. Descriptions for elevator feature

Descriptions for elevator feature is a set, here set={ elevator number, running direction, present room floor number, set for the external call signal responded, target floor set, crowded degree ,current moment}

Where the set for the external call signal responded means the signal that the system has assigned the elevator to serve but has not done. When an external call signal has been completed, it will be moved from the set for the external call signal, a new external call signal responded will be added to the set for the external call signal. The target floor set will be set up like this.

Here present room floor number = (current moment-moment of the last stop elevator-time for stop elevator)* running velocity for elevator/height for independent floor +floor number for last stop elevator

B. Descriptions for the external call signal

Descriptions for the external call signal is a set, here set= {Direction, call time, current floor number staying}

The external call signal means the new call responded which the system has not assigned the elevator to serve.

C. Descriptions for the internal call signal

Descriptions for the internal call signal is a set, here set= {Floor to enter, target floor}

D. Descriptions for floor

Descriptions for floor are a set, here set= {Floor numbers, weight, signal set}

The signal set means that the external call signal set of this floor. Which is expressed with the form such as (0 1 2 3), where 0 means that this floor does not have the call signal,1 means that this floor has signal up only,2 means that this floor has signal down only,3 means this floor has signal up and down.

E. Descriptions for control

Descriptions for control are a set, here set= {Elevator number, current floor number staying which responded}

F. Basic control rules

978-0-7695-4360-4/10 $26.00 © 2010 IEEE
DOI 10.1109/ISISE.2010.129

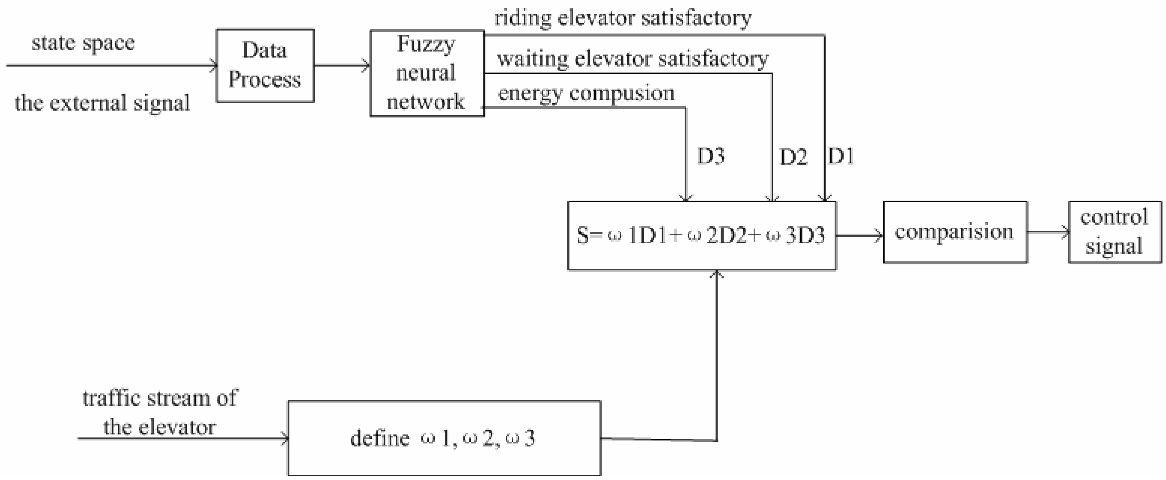

Figure1. Elevator group control system model

In the fuzzy neural network control in elevator intelligent scheduling simulation there are some rules defined .

Firstly, the elevator thinks the higher same running direction signals than itself only and ignore the lower signals than itself.

Secondly, only when the responded set for the elevator is empty, it can think the signal of the opposite direction.

Thirdly, while the elevator is in the opposite direction, the system is processed according the first two steps

Fourthly, when the elevator reaches the last target floor and has no responded signal again, this elevator stops in this floor.

G. *Rules for dispatch the elevator*

Rules for dispatch the elevator: for a call signal. All of the elevators have a calculation, among the values the elevator which has the largest value is the responded elevator of this signal.

IV. DEFINITE OF THE FUZZY FUNCTION

This paper defines the gauss member function [1] as follows:

$$\mu_{ij}=exp(-(x_i-c_{ij})^2/\delta_{ij}^2)\ (i=1,2...n,j=1,2...m) \tag{1}$$

Where cij means the center of the function; δij means the width of the member function. For these fuzzy rules, the center value and width are selected appropriately so as to satisfy the reduced requirements for the waiting elevator satisfactory and the riding elevator satisfactory and the energy consumption satisfactory. We may study the mutative center value and width for the member function of the fuzzy neural network, where the sets for the Gauss member function are shown as follows.

A. *Fuzzy set for waiting elevator time in Java*

1) The function expression of the short waiting elevator time

fuzzyAwt.one.setMF(Math.Exp(((double)1/(double)2)* Math. Pow (awt /(double)20,2)));

2) The function expression of the middle waiting elevator time

fuzzyAwt.two.setMF(Math.Exp(((double)1/(double)2)* Math. Pow ((awt-(double)30)/(double)10,2)));

3) The function expression of the long waiting elevator time

fuzzyAwt.three.setMF(Math.exp(((double)1/(double)2)* Math. pow ((awt-(double)60)/(double)20,2)));

Where fuzzyAwt is a object name about the class of the waiting elevator time , setMF is a float data type, awt is variable for waiting elevator time, the number of one, two and three is a time data type of the waiting elevator time, their values are the short ,middle and long time for waiting elevator time respectively.

B. *Fuzz set of the distance in Java*

1) The function expression of the short waiting elevator time

fuzzyDis.one.setMF(Math.exp(((double)1/(double)2)* Math.pow((dis)/(double)((floorNum/3-1)*h), 2)));

2) The function expression of the middle waiting elevator time

fuzzyDis.two.setMF(Math.exp(((double)1/(double)2)* Math.pow((dis(double)(floorNum/2*h))/(double)(floorNum/ 6*h), 2)));

3) The function expression of the long waiting elevator time

fuzzyDis.three.setMF(Math.exp(((double)1/(double)2)* Math.pow((dis(double)((floorNumfloorNum/6)*h))/(double) (floorNum/6*h),2)));

Where fuzzyDis is a object name about the class of the distance , setMF is a float data type, dis is variable for the distance, floorNum is a variable for the current floor level, the number of one, two and three is a time data type of the distance, their values are the short ,middle and long distance respectively.

C. Fuzz set of the congestion about the elevator in Java

1) The function expression of the low congestion about the elevator

```
fuzzyJam.one.setMF(Math.exp(((double)1/(double)2)*
Math.pow(jam/(double)0.3,2)));
```

2) The function expression of the middle congestion about the elevator time

```
fuzzyJam.two.setMF(Math.exp(((double)1/(double)2)*
Math.pow((jam-(double)0.5)/(double)0.2,2)));
```

3) The function expression of the high congestion about the elevator time

```
fuzzyJam.three.setMF(Math.exp(((double)1/(double)2)*
Math.pow((jam-(double)1)/(double)0.3,2)));
```

Where fuzzyJam is a object name about the class of the congestion, setMF is a float data type, jam is variable for the congestion, the number of one, two and three is a time data type of the congestion, their values are the low ,middle and high congestion respectively.

D. Fuzz set of start and stop times in Java

1) The function expression of the short start and stop times of the elevator

```
fuzzySst.one.setMF(Math.exp(((double)1/(double)2)*Math.
pow((sst)/(double)(floorNum/3-1), 2)));
```

2) The function expression of the middle start and stop times of the elevator

```
fuzzySst.two.setMF(Math.exp(((double)1/(double)2)*
Math.pow((sst(double)(floorNum/2))/(double)(floorNum/6),
2)));
```

3) The function expression of the long start and stop times of the elevator

```
fuzzySst.three.setMF(Math.exp(((double)1/(double)2)*
Math.pow((sst(double)(floorNumfloorNum/6))/(double)(floo
rNum/6),2)));
```

Where fuzzySst is a object name about the class of the start and stop times, setMF is a float data type, floorNum is a variable for the current floor level, the number of one, two and three is a time data type of the start and stop times , their values are the short ,middle and long start and stop times respectively.

E. Fuzz set of long waiting elevator in Java

1) The function expression of the short waiting elevator time

```
fuzzyLwp.one.setMF(Math.exp(((double)1/(double)2)*
Math. pow (lwp/(double)0.05,2)));
```

2) The function expression of the middle waiting elevator time

```
fuzzyLwp.two.setMF(Math.exp(((double)1/(double)2)*
Math.pow((lwp-(double)0.065)/(double)0.015,2)));
```

3) The function expression of the long waiting elevator time

```
fuzzyLwp.three.setMF(Math.exp(((double)1/(double)2)*
Ma-th.pow((lwp-(double)0.08)/(double)0.01,2)));
```

Where fuzzyLwpis a object name about the class of the long waiting elevator, setMF is a float data type, lwp is a variable for the long waiting elevator, the number of one, two and three is a time data type of the long waiting elevator,, their values are the short ,middle and long waiting elevator time respectively.

F. Fuzz set of riding elevator time in Java

1) The function expression of the short riding elevator time

```
fuzzyTripTime.one.setMF(Math.exp(((double)1/(double)2)
*Math.pow(tripTime/(double)15,2)));
```

2) The function expression of the middle riding elevator time

```
fuzzyTripTime.two.setMF(Math.exp(((double)1/(double)2)
*Math.pow((tripTime-(double)20)/(double)5,2)));
```

3) The function expression of th the long riding elevator time

```
fuzzyTripTime.three.setMF(Math.exp(((double)1/(double)2
)*Math.pow((tripTime-(double)30)/(double)5,2)));
```

Where fuzzyTripTime is a object name about the class of the riding elevator time , setMF is a float data type, triptime is a variable for the riding elevator time, the number of one, two and three is a time data type of the riding elevator time,their values are the short ,middle and long riding elevator time respectively.

V. CREATION FOR FUZZY BP NEURAL NETWORK MODEL

The fuzzy BP neural network is a five layer network, such as input layer, fuzzy layer, fuzzy condition layer, fuzzy judgments layer and defuzzification layer ,it is shown in Figure 2.[2,3,4].

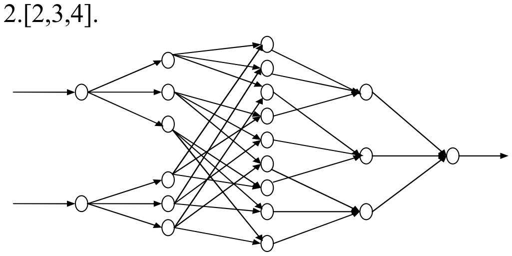

Figure 2. Fuzzy BP neural network model

The first layer is the input layer, every node represent a input variable, where $P_i^1 = O_i^1 = x_i$, its superscript expresses layer sequence,1 means the first layer.

The second layer is fuzzy layer, it will fuzzy the variable input through the corresponding member function shown in Eq(2).

$$O_j^2 = w_{ij}^2 P_i^1, P_j^2 = f(O_j^2) \tag{2}$$

Where f() means corresponding member function.

The third layer means fuzzy condition layer, this layer have combined with fuzzy rules of the condition component so as to complete multiplication of the each input fuzzy value.

$$O_l^3 = P_j^2, P_l^3 = \prod w_{jl}^3 O_l^3 \tag{3}$$

The fourth layer means the fuzzy judgments layer, the connectivity of the nodes in this layer and the nodes in the third layer represents the fuzzy conclusion; obtain the fuzzy value of the corresponding output nodes.

$$O_k^{\,4} = \sum_l w_{lk}^{\,4} P_l^3, P_k^{\,4} = \min(1, O_k^{\,4}) \qquad (4)$$

The fifth layer means defuzzification layer, this layer implement the defuzzification and make the output value from the fuzzy value of the reduce the value, complete the output clarity.

$$O^5 = \sum_k w_k P_k^{\,4} = \sum (m_k \sigma_k) P_k^{\,4}$$
$$y = P^5 = \frac{O^5}{\sum_k \sigma_k P_k^{\,4}} \qquad (5)$$

Where O_i^k and P_i^k means the input and output of the I-k-layer neurons respectively, $w_{ij}^{\,k}$ means the connection weights of the I-(k-1)-layer neurons and the j-k-layer neurons, m_k, σ_k means the center value and width of the member function respectively, except the fourth and fifth layer, the connection weights of the each network layer is 1.

A. Design of the fuzzy neural network's training algorithm[5,6]

1) Changes in the output layer weights

$$\Delta W_K = -\eta \frac{\partial E}{\partial W_k} = -\eta \frac{\partial E}{\partial y} \times \frac{\partial y}{\partial W_K} = \eta (a-y) f_2' \qquad (6)$$

Where η is the learning rate of the neural network, a is expectation is the output value, f_2' is the derivative of the last layer activation function.

2) Changes in the output layer weights[5,6]

$$\Delta w_{lk}^{\,4} = -\eta \frac{\partial E}{\partial w_{lk}^{\,4}} = -\eta \frac{\partial E}{\partial y} \times \frac{\partial y}{\partial P_k^{\,4}} \times \frac{\partial P_k^{\,4}}{\partial w_{lk}^{\,4}}$$
$$= \eta \sum_{k=1}^{3} (a-y) f_2' w_k f_1' P_k^{\,4} \qquad (7)$$

Where f_1' is the derivative of the fourth layer activation function.

3) Changes of the learning rate

$$\eta(k+1) = \begin{cases} 1.05\eta(k) \ldots\ldots\ldots\ldots\ldots\ldots SSE(k+1) < SSE(k) \\ 0.7\eta(k) \ldots\ldots\ldots\ldots SSE(k+1) > 1.04 SSE(k) \\ \eta(k) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{其它} \end{cases} \qquad (8)$$

Where $SSE(k)$ means the network error.

4) Training target

$$\min(\hat{E}) = \frac{1}{2}(a-y)^2 \qquad (9)$$

VI. PATTERN RECOGNITION OF THE ELEVATOR GROUP CONTROL

The elevator traffic pattern is divided into the following three, in each case the corresponding weights is not same. According the equation of the waiting elevator satisfactory, riding elevator satisfactory, energy compulsion satisfactory the weight distribution of the three pattern [7,8]as follows:

Upward peak: W=（0.6 0.1 0.3） (10)

Downlink peak: W=（0.6 0.2 0.2） (11)

Normal running state: W=（0.4 0.4 0.2） (12)

Where w is the weight of the pattern weight distribution. The method that using the number of weight instead of personal numbers is more convenient to monitor in fact because of using the electronic scale. It is defined as the peak when the call weights of a moment reach 60% of the total weights. In this pattern there are some definitions as follows.

Firstly, if not only the first floor of the elevator weight accounted is accounted over 90% of the total call weight, but also there is a call-up signal on the first floor, then it is defined as the upward peak.

Secondly, if the call signal of the downlink direction is accounted for more than 90% of the total signals, it is defined as the downlink peak.

Thirdly, other cases are defined as the normal running state.

Fourthly, the definition about the rule of the dispatching elevator is that there is a calculation among all of the elevators to a call signal, the elevator which has the max calculation is the elevator responded to the call signal.

VII. CALCULATION OF THE SINGLE OF THE SIGNAL FOR THE ELEVATOR GROUP CONTROL SYSTEM

A. Initial state of the Five elevators randomly

We selected the initial state of the five elevators randomly which are shown in table 1.

where the external call signal is caused on the three floor, the direction is downward, the digital 1 is expressed as the upward direction, the digital 0 is expressed as the downward direction.

B. Evaluation value of the five elevators in the three different patterns

The evaluation value of the five elevators in the three different patterns is expressed in the table 2.

Where the digital 0 is expressed as that the elevator doesn't compute this signal. From the table 2 in the peak the fourth elevator responds the external call signal, in the normal running state the third elevator responds the external call signal, the thing is the same as what we expected, so all of the data has explained that this algorithm can reach the desired results.

VIII. CONCLUSION

According to the actual different running patterns of the elevator and the demands of the riding elevator satisfactory and waiting elevator satisfactory and energy compulsion satisfactory, this system established a comprehensive

TABLE 2 FIVE ELEVATORS EVALUATION VALUE OF THE THREE DIFFERENT MODELS

	Elevator 1	*Elevator 2*	*Elevator 3*	*Elevator 4*	*Elevator 5*
Upward peak	0	0	0.8761	0.8986	0
Downlink peak	0	0	0.8769	0.8939	0
Normal running state	0	0	0.9148	0.9131	0

evaluation which is the satisfaction of the Gaussian membership function. By using of the adaptive optimal scheduling algorithm based on the fuzzy BP Neural Network Theory, it has reached the aim to improve the service quality of the elevator and the performance of elevator operation.

ACKNOWLEDGMENT

This work is supported by the key projects in the national science and technology pillar program (Grant: 2009BAI78B00).

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TABLE1 THE INITIAL STATE TABLE OF THE FIVE ELEVATORS

	Set for the external call signal responded	*Set for target layer*	*Current floor of the elevator*	*Congestions*	*The direction of the external call signal responded*	*the direction of the elevator*
Elevator 1	1、4、5	2、4、6	1	0,.5	1,1,1	1
Elevator 2	4、5、6、7	2、4、6	3	0,.8	1,1,1,1	1
Elevator 3	1、4、6、9、15	2、5、9、20	2	0.,2	1,1,1,1,1	0
Elevator 4	9、11、12、15	15、13、9、6	1,6	0,.3,8	0,0,0,0	0
Elevator 5	22、23	21、2 4	2,,0	0,.6	1,1	1