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Research Article

Forecasting of Food Refrigerated Transport Power System Based on Type-2 Fuzzy Construction Phase Space

Zhu Lin
School of Water Resource and Electric Power, Qinghai University, Xining, People's Republic of China

Abstract: The most critical aspect of the cold chain is refrigerated transport, appropriate transport conditions can guarantee the quality of perishable foods. This study introduces the interval type-2 fuzzy logic method to reduce the prediction error, presents an interval type-2 fuzzy logic model for the time series of one hour of power load forecasting and adopted the first modeling process model structure and then use back propagation algorithm to adjust the model parameters are determined by simulation. In view of the two type of fuzzy measure the importance of system identification in the field of fuzzy in type-2, the study of type-2 fuzzy measure, proposed the axiomatic definition of the ordinary type-2 fuzzy similarity and fuzzy inclusion degree, which is intuitive understanding of people axioms.

Keywords: Food refrigerated transport, reliability, total quantity of knowledge, Type-2 fuzzy sets

INTRODUCTION

The most critical aspect of the cold chain is refrigerated transport, appropriate transport conditions can guarantee the quality of perishable foods. The refrigerated vehicle simulation and analysis environment, it can generate the problem of deterioration of the goods during transport put forward some constructive solutions. Environmental issues refrigerated vehicle and simulation analysis, domestic and foreign scholars have launched a large number of scientific research. In a sense, the process of the different objects of the research process is to establish mathematics model of it (Mendel, 2007). The practical systems in the real world is mostly nonlinear complex system, in most cases, its mathematical model is unknown, the parameter may also change during normal operation, the system identification is produced in order to solve the modeling problem of this kind of complex system. The fuzzy system identification based on fuzzy logic it is an effective method for nonlinear system identification (Mizumoto and Tanaka, 2013; Karnik *et al*., 2013).

The classical forecasting methods such as consumption, trend extrapolation method, elastic coefficient method, the method of linear regression and time series prediction method has many shortcomings, it is often difficult to get an ideal prediction effect (Karnik and Mendel, 2001). Therefore, people give their attention to the gray system, artificial neural network, wavelet theory and fuzzy logic in artificial intelligence methods, including type-2 fuzzy logic has the extraordinary ability of dealing with uncertainty, in the time series prediction has advantage over the artificial neural network method and provides a new idea for forecasting of power load. Power load forecasting is based on historical load data as a basis for determining a series of work in the future when the load value (Cai *et al*., 2005). As an important basis for the reasonable planning and economic operation of power system, accurate power load forecasting can improve the electric power enterprise economic benefit and social benefit, plays an important role in promoting the healthy development of the electric power industry (Lian and Mark, 2005; Man *et al*., 2010).

This study foacuses on two types of fuzzy system identification, pointing out the deficiencies of stage presence, the type two fuzzy measure is applied to the two type of fuzzy system identification and eliminate the adverse effects caused by redundant fuzzy sets and redundant fuzzy rules as the goal, proposed the use of type two practical algorithm of fuzzy measure to cut two fuzzy rule base, to compensate for the lack of methods to streamline the existing fuzzy rule base, establish has the advantages of simple structure, small amount of calculation, two fuzzy models with better performance. Power load has strong randomness and difficult to accurately predict problems, the introduction of the two type fuzzy logic to improve the prediction precision. The establishment of interval type two fuzzy model for electric power load forecasting, reduction algorithm to reduce redundant model in the rule base of fuzzy sets and redundant fuzzy rules by using two type fuzzy system rules proposed in this study, the prediction performance forecast by the actual power load time series to test the streamlined performance reduction algorithm and the model.

RELATED METHOD AND THEORY

Type-2 fuzzy sets: Studies on two fuzzy system parameter identification is relatively small, in the above-mentioned parameters of a fuzzy system identification methods, BP algorithm in parameter identification of two fuzzy system more often, while the least squares method can not be used for two fuzzy systems the parameter adjustment, use other methods also be explored.

Defined on a continuous domain on X type-2 fuzzy set A can be expressed as:

$$\bar{A} = \int_{x\in X}\int_{u\in J_x} \mu_{\bar{A}}(x,u)/(x,u) \tag{1}$$

$\mu_{\bar{A}}(x,u) \in [0,1]$ is the membership function; $u \in J_x$ is the main membership values; Jx Union called the uncertainty of the trace. For type-2 fuzzy set theory any domain A point x = x', Two practice fuzzy membership function (x) with the plane x=x', the intersection. Called secondary membership function (Secondary MF), formula (2):

$$\mu_{\bar{A}}(x = x', u) = \mu_{\bar{A}}(x = x') = \int_{u\in J_{x'}} f_{x'}(u)/u \tag{2}$$

In it:

$$u \in J_{x'} \subseteq [0,1],\ \ 0 \le f_{x'}(u) \le 1$$

The corresponding lower limit set, membership function; formula in the discrete domain to replace the formula:

$$\bar{A} = \int_{x\in X}\int_{u\in J_x} 1/(x,u) \tag{3}$$

A can be expressed as a function of all times and set membership, such as the formula (3):

$$\bar{A} = \int_{x\in X} \mu_{\bar{A}}(x)/x = \int_{x\in X}\left[\int_{u\in J_x} f_x(u)/u\right]/x \tag{4}$$

Type-2 fuzzy logic fuzzy logic to make up for a lack of dealing with uncertainty and uncertainty can be modeled directly, uncertain objects contained stronger, application type-2 fuzzy logic more obvious advantages. Internationally there are a large number of scholars engaged in research in the field of type-2 fuzzy set theory to do a thorough exploration, made a lot of achievements, logical theory thus has been rapid development of secondary and fuzzy.

Triangle type-2 fuzzy logic system: A definition in the X domain of the type-2 fuzzy set is as follows:

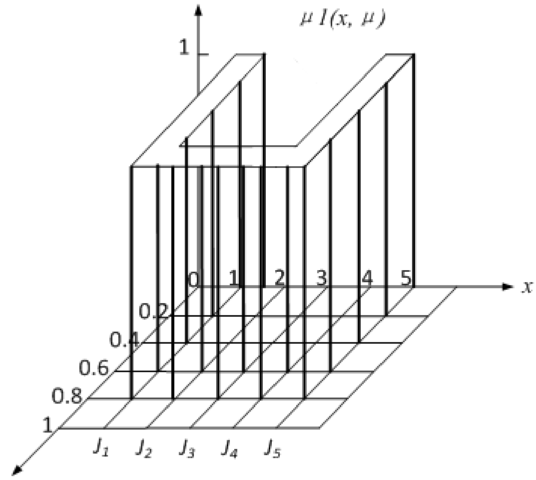


Fig. 1: The triangle type-2 fuzzy sets

$$\tilde{A} = \int_{x\in X}\left[\int_{u\in J_x} \mu_{\tilde{A}}(x)\right]/x = \int_{x\in X}\left[\int_{u\in J_x} f_x(\mathrm{u})/u\right]/x \tag{5}$$

where, u is the element of the X main membership values, Fx(U) is a membership value, the range of Jx u and the uncertainty of a trace (FOU), FOU, respectively, lower limit of the corresponding membership function (Chia-Hung *et al*., 2008).

Figure 1 is a triangle type-2 fuzzy sets: the domain x = [0, 5], when x = 3, the main membership is time interval [0.5, 1], membership function is a triangle function curve ACA correspondences.

The fuzzy set of interval type-2 is a simplified version of the type-2 fuzzy sets, avoids the choice of membership functions and the pay, compensation and calculation are greatly simplified, so it has practical value (Xu *et al*., 2007). The time interval of type-2 fuzzy set membership values are 1, as shown in the following formula:

$$\tilde{A} = \int_{x\in X}\left[\int_{u\in J_x} 1/u\right]/x \tag{6}$$

Interval type-2 fuzzy logic and common type-2 fuzzy logic have much in common, but also has its own characteristics, such as: play a major role in the general type-2 fuzzy set operation is the uncertainty of trace and minor membership function and in interval type-2 fuzzy set operation plays a major role in the! under the membership function. "So, during the study interval type-2 fuzzy measure and interval type-2 fuzzy system identification methods, must take full account of interval type-2 fuzzy set and interval type-2 fuzzy logic of their own characteristics, in order to give full play to the advantages of the constructed system with excellent performance.

Table 1: The fuzzy similarity listed

	$\tilde{A}_1$	$\tilde{A}_2$	$\tilde{A}_3$	$\tilde{A}_4$	$\tilde{A}_5$
$\tilde{A}_1$	1.0000	0.0029	0.0138	0.3282	0.0001
$\tilde{A}_2$	0.0029	1.0000	0.3973	0.0197	0.2069
$\tilde{A}_3$	0.0138	0.3973	1.0000	0.0702	0.0697
$\tilde{A}_4$	0.3282	0.0197	0.0702	1.0000	0.0015
$\tilde{A}_5$	0.0001	0.2069	0.0697	0.0015	1.0000

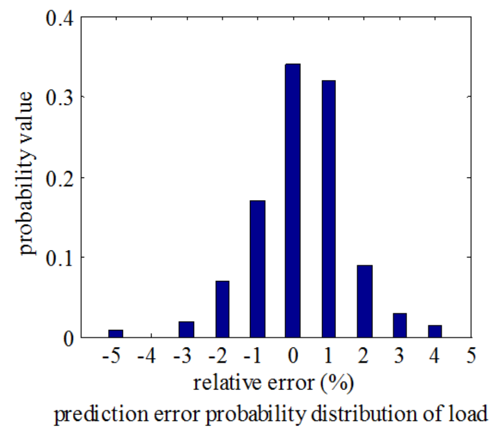


Fig. 2: The probability distribution of the fourth layer

After a similar calculation, get the fuzzy similarity to other, listed in Table 1:

Through the example to test the performance of the new measure and put the interval type two fuzzy similarity and clustering method combining cluster analysis used in Gauss interval type two fuzzy sets, results are obtained by hierarchical cluster tree reasonable, verified the rationality and validity of the new measure, laid the theoretical foundation for the application of the next step.

The correlation degree of p = 0.98, 3:00 interval prediction results median interval (469.77682.74) 576.255 as the deterministic forecasting results, belong to the same type and the fourth layer, according to the above calculation can get the probability distribution of different load level partition, the probability distribution of the fourth layer as shown in Fig. 2:

EXPERIMENTAL RESULTS

The simulation and verification: According to the input and output data for approach of fuzzy system identification has two kinds, one kind is the first by the input and output data to generate fuzzy IF THEN rules, then select the fuzzy inference machine, fuzzy controller and fuzzy solution is to construct fuzzy system, another is the first to identify the structure of fuzzy system and to make fuzzy system structure in a part or all of the parameters can be changed freely, then through some parameter learning algorithm to

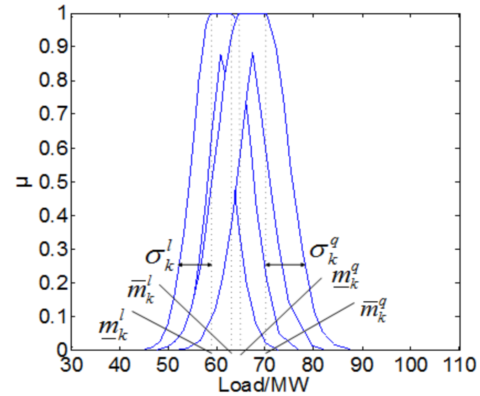


Fig. 3: FOUs of interval type-2 fuzzy sets

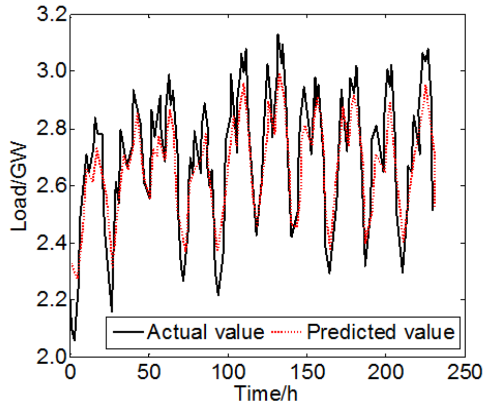
determine the free parameters. FOUs of interval type-2 fuzzy sets was shown in Fig. 3.

In the construction of a fuzzy logical system, if the selection of the singleton fuzzifier, Max product composition, product definition and highly defuzzifier, can be used to describe the system type:

$$y(x) = f_s(x) = \frac{\sum_{l=1}^{M} \bar{y}^l \prod_{k=1}^{p} \mu_{F_k^l}(x_k)}{\sum_{l=1}^{M} \prod_{k=1}^{p} \mu_{F_k^l}(x_k)} = \sum_{l=1}^{M} \bar{y}^l \varphi_l(x) \tag{7}$$

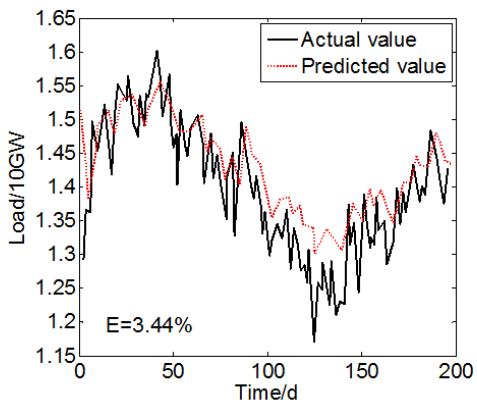
Winds characteristics are important factors wind farm wind turbine design and operation, accurate prediction of wind speed wind turbine predictive control and optimization Dispatching of great significance. However, changes in wind speed with strong stochastic and nonlinear characteristics, its accurate prediction of great difficulty. From the point of view of fuzzy similarity, fuzzy set of fuzzy rules library that is highly overlapping fuzzy sets highly similar, the same theory that domain, set different rules antecedent high degree of overlap the corresponding position, with the same or similar the membership values represent the same or similar meaning, leading to redundant and non-interpretable fuzzy rules fuzzy sets, an increase of unnecessary computation and complexity.

The design of the prediction modelvia type-2 fuzzy logic: From the modeling process and the prediction results can be known, non single valued type Mamdani fuzzy logic model with 3*3*3 = 27 rules, a total of 1*3 +2*3* 27+1*27 = 192 design parameters, including input set variance sigma K, before rule set of mean mlk and variance sigma LK, consequent of a rule set center of mass YL and the error between the true value of the predictive value of 3.67%. The consequents of the rules set Y-L and Y- the center of mass L, more adjustable parameters means more adjustable degree of freedom therefore, the prediction performance is improved, the error decreased to 3.18%. The prediction results of the two models are shown in Fig. 4.



Prediction results of the non single value type Mamdani fuzzy logic model

Fig. 4: The prediction results of the two models



Prediction results of model first

Fig. 5: The actual value of the average relative error value of 3.44%

From Fig. 5 can be seen, the prediction curves of the two models are better to track actual load curve. We can see from the process of modeling and simulation results: a model with 3 * 3 * 3 = 27 rules, a total of 1 * 3+2 * 3 * 27+1 * 27 = 192 design parameters, including input set variance parameter K, before rule set mean parameter m_{lk} and mean variance parameters sigma L_K, gauge after pieces of centroid parameters of YL set, the predictive value and the actual value of the average relative error between the absolute value of 3.44%.

In the interval type Mamdani fuzzy model, if by means of merger! Remove the fuzzy sets resulting library has blurred the equivalent k antecedent fuzzy rules, then simply leave them one and the remaining k-1 after member parameter fuzzy rules to delete and re-determine the retention rules. In this study, we take k fuzzy rules pieces left centroid, mean right point left vague as to retain the back piece, the right point.

In Fig. 6 in less than 500s. During normal operation of the network, star shaped network on the main path of flow and nodes contract rate has been, for 8000 bps. At this point the data packet without backup path forwarding, traffic on the backup path is 0. At this time network sales etc delay and monolayer artificially cobweb model, were maintained at around 64 ms. At this time, the star network communication performance and artificially cobweb model similar.

Pathway interval type fuzzy identification system parameters, there are two: First, some dependent method, first using a given input-output data for the identification of a fuzzy system via parameter learning algorithm parameters, then the parameter as a type of fuzzy systems the initial value to adjust the parameters interval type fuzzy systems; the second is all the independent, direct parameter identification interval type fuzzy systems, the initial values of the parameters

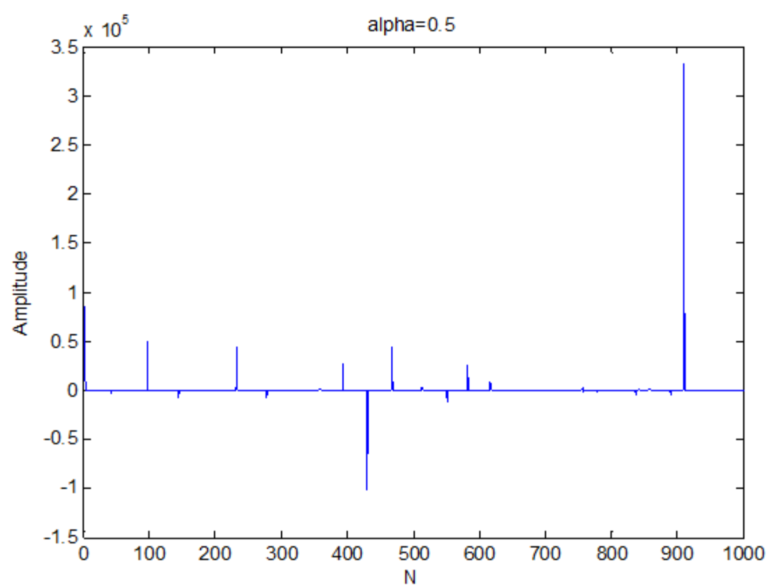


Fig. 6: The blue curve represent the flow of node1-hub1 node1-hub2

chosen arbitrarily. Relative to the second approach, the former gives way to perform interval type fuzzy system ideal initial value of the parameter identification and the results of a fuzzy system can be used as a standard test two fuzzy system performance, therefore selection partially dependent method.

After the adjusting process parameters by fuzzy rules often contains highly overlapping fuzzy sets, you can first use the fuzzy similarity to identify these sets, then merged to create a public collection and then use the common set of alternative, thus reducing the number of required fuzzy set of fuzzy rule base, fuzzy rules can be improved explanatory, reduces the computational complexity of a system. If the fuzzy sets with high redundancy, then reduce the number of fuzzy sets in at the same time, also can be the number of fuzzy rules is reduced by merging the way, without affecting the performance of the system, even if did not reduce the number of fuzzy rules, a fuzzy rule base has also been reduced, because the number of fuzzy sets of the required reduction. Here, to reduce the number of fuzzy sets is the primary target, the number of fuzzy rules may decrease.

CONCLUSION

Compared with the traditional type of fuzzy logic, the processing ability of type two fuzzy logic has more uncertainty, can be directly for uncertainty modeling, the robust control, signal processing and nonlinear system identification and other fields have broad application prospects, thus also suitable for electric power load forecasting. Accurate power load forecasting is the power system planning, construction, production, scheduling, maintenance and an important basis for the safe operation of the power load fluctuation and has strong uncertainty, it is difficult to predict, to find a reasonable method to improve the accuracy of power load forecasting is very important, because the ability of type two fuzzy logic treatment with excellent uncertainty and become the ideal choice.

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