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Research Article

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The asymmetry-center probabilistic fuzzy set for forecasting of pledging by warehouse receipt financing in agricultural products

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ABSTRACT

The probabilistic fuzzy set (PFS) is designed for handling the uncertainties in both stochastic and nonstochastic nature. However, the previous probabilistic fuzzy set is constructed through randomizing the center of the symmetric fuzzy set, and the asymmetric probabilistic fuzzy set is higher than symmetric one's in variability and malleability. So in this paper, an asymmetry-center probabilistic fuzzy set is proposed by randomly varying the center of asymmetric Gaussian membership function. Then the PFLS with this asymmetric probabilistic fuzzy set is constructed and applied to forecasting of pledging by warehouse receipt financing in agricultural products. The results show that the asymmetry-center probabilistic fuzzy set improves the accuracy of such system. This work will broaden the application of the probabilistic fuzzy set.

Keywords: asymmetric probabilistic fuzzy set, probabilistic density function, probabilistic fuzzy logic system, Pledging by Warehouse Receipt Financing, Agricultural Products

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INTRODUCTION

There often exist many uncertainties in real-world applications. Although these uncertainties come from various sources, they share common feature that is stochastic or non-stochastic nature. For stochastic uncertainties, it can be captured well by the probabilistic modeling [1]. On the other hand, for fuzzy uncertainties, type 1 fuzzy set [2] is able to model linguistic variable and it can deal with imprecise and vague information. It is noted that the crisp membership grade is used in this set. However, when the uncertainties are very complex, it may not be suitable to use a crisp membership grade in [0, 1], so type-2 fuzzy set [3] blurs the boundary of type 1 FS to directly model the uncertainty of linguistic expression. As such, the grades of membership in type 2 FS themselves are fuzzy set, thus able to capture the uncertainties in membership function. Currently, type-1 and type-2 fuzzy set have been successfully applied in many fields such as decision making [4], function approximation [5] and so on. However, in most of real-world applications, both stochastic and deterministic uncertainties exist simultaneously, so it would be valuable to integrate the probability theory with the fuzzy theory. In recent years, several assumption on integrating the probability theory with the fuzzy theory [6-7] have been studied. Based on the assumption of introducing the stochastic uncertainties into the fuzzy system, the probabilistic fuzzy set (PFS) is proposed and developed by introducing the probabilistic theory into the traditional fuzzy set described by center and width [8-9]. In probabilistic fuzzy set, the fuzzy grade becomes a random variable described by the secondary probability density function (PDF), which makes a 3-dimention membership function including the fuzzy dimension and the probabilistic dimension hinted in the probabilistic fuzzy set. Recently, based on probabilistic fuzzy set, the probability fuzzy logic system is proposed and it has been applied for stochastic modeling [10] and control [11], pattern recognition problem [12] and so on.

However, research about probabilistic fuzzy sets still remains at the beginning phase. The previous probabilistic fuzzy set is constructed through randomizing the center of the symmetric fuzzy set and it is symmetric. In fact, asymmetric fuzzy set is discussed and used in fuzzy logic system to improve its modeling capability. So it would be interesting to construct asymmetric PFS and applied to system modeling.

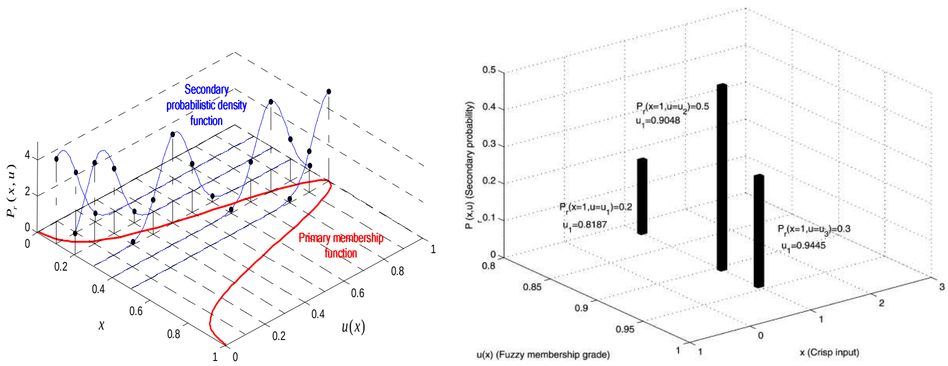
In this paper, an asymmetric probabilistic fuzzy set is proposed by randomizing the center of asymmetric Gaussian fuzzy set. Then the related probabilistic fuzzy logic system is constructed and it is applied to forecasting of pledging by warehouse receipt financing in agricultural products problem. It shows that the asymmetric probabilistic fuzzy set improves the accuracy of probabilistic fuzzy logic system, with more variability and malleability than those of the symmetric probabilistic fuzzy set.

This paper is organized as following: the problem formulation is presented in section II. In section III, an asymmetric probability fuzzy set is constructed. Forecasting of pledging by warehouse receipt financing in agricultural products is studied in section IV. Finally, the conclusion is given in section V.

EXPERIMENTAL SECTION

Probabilistic fuzzy set

The concept of probabilistic fuzzy sets have been proposed to capture uncertainties with both stochastic and fuzzy features [8] by introducing probability into the traditional fuzzy set described by center and width. Based on considering the random variation from the center of the traditional Gaussian fuzzy set, the probability distribution of fuzzy degrees can be obtained. So in probabilistic fuzzy set, for an input x, there no longer is a single value or values for the membership function; instead, the membership function becomes a random variable that can be described by the secondary PDF as shown in Fig.1 (a).



(a) **(b)**

Fig.1 (a): symmetric probabilistic fuzzy set in continue case; (b): symmetric probabilistic fuzzy set in discrete case

As such, a 3-dimention membership function including the fuzzy dimension and the probabilistic dimension is hinted in the probabilistic fuzzy set as shown in Fig.1 (b), which makes it able to handle the information with both fuzzy and stochastic uncertainties existing in the process.

Probabilistic fuzzy logic system

Similar to the ordinary fuzzy logic system, the PFLS [17] still has operations of fuzzification, inference engine and defuzzification. Different to the ordinary fuzzy logic system, the PFLS uses the probabilistic fuzzy set that is described by a three-dimensional MF.

The systematic design procedure which is given to design the probabilistic fuzzy logic system for process modeling is as follows:

Step 1) the fuzzy c-mean variance (FCMV) algorithm is used to obtain the clustering results. The ellipses denote the clustering, the c_i is the fine clustering center, where n is the number of cluster partition.

Step 2) Cluster centers are projected to $x1$ and $x2$ axis to obtain the Gaussian membership function of each clustering. With the clustering result, the secondary PDF can be determined by considering the variation from the mean of Gaussian function.
Step 3) the inference in PFLS is based on the fuzzy rules as follows:

$$Rule\ j: If\ \ x_1\ is\ \tilde{A}_{1,j}\ and\ ...\ and\ x_i\ is\ \tilde{A}_{i,j}\ and\ ...and\ x_n\ is\ \tilde{A}_{n,j},\ \ Then\ \ y\ \ is\ \ \tilde{B}_j \tag{1}$$

where $\tilde{A}_{i,j}\ (i=1,2,...,n)\ (j=1,2,...,j)$ and $\tilde{B}_j$ are probabilistic fuzzy sets.

Step 4) The defuzzification operation in the PFLS is concerned with the probabilistic fuzzy set instead of ordinary fuzzy sets. The probabilistic defuzzification improves the traditional defuzzification method with the probabilistic processing method.

As well known, asymmetric membership functions has been studied and used in fuzzy logic system, with the results showing that using asymmetric membership functions improves the modeling capability. So the asymmetry is introduced into the probabilistic fuzzy set.

Construction asymmetry-center probabilistic fuzzy set
Different from the typical used symmetric probabilistic fuzzy set, a new asymmetric probabilistic fuzzy set will be proposed in this section.

The asymmetric Gaussian function is used as the primary fuzzy MF:

$$u=\begin{cases} e^{(-\frac{(x-c)^2}{2\varsigma_{(l)}{}^2})} & for\ \ x \le c \\ e^{(-\frac{(x-c)^2}{2\varsigma_{(r)}{}^2})} & for\ \ x > c \end{cases} \tag{2}$$

where c is the center of *n*th clustering, $\varsigma_{(l)}$ is the left variance of *n*th clustering and $\varsigma_{(r)}$ is the right variance of *n*th clustering. According to random sample theory, the center is regarded as random variables following normal distribution described as Fig.2.

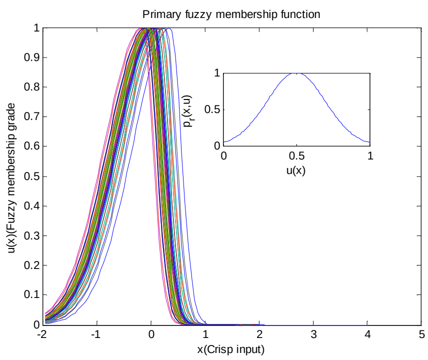


Fig.2.Fuzzy membership function of asymmetry-center PFS

$$c \sim N(\gamma,\sigma) \tag{3}$$

The fuzzy grade u becomes a random variable U with a certain distribution, and the probabilistic distribution of U for input x can be obtained as following:

$$F_U(u)=\begin{cases} 1-\int_{x-\sqrt{-2\varsigma_{(l)}^2 \ln u}}^{x+\sqrt{-2\varsigma_{(l)}^2 \ln u}} \Phi(c)dc, & 0<u<1\ and\ \ x<c \\ 1-\int_{x-\sqrt{-2\varsigma_{(r)}^2 \ln u}}^{x+\sqrt{-2\varsigma_{(r)}^2 \ln u}} \Phi(c)dc, & 0<u<1\ and\ \ x>c \\ 0 & otherwise \end{cases} \tag{4}$$

Furthermore, the secondary PDF of U is:

$$Prob_A(U)=\begin{cases}\dfrac{1}{2\sqrt{2\pi}u\sigma}\sqrt{\dfrac{-2\varsigma_{(l)}^2}{\ln u}}e^{(-1/2)(\frac{x+\sqrt{-2\varsigma_{(l)}^2\ln u}-\gamma}{\sigma})^2+(-1/2)(\frac{x-\sqrt{-2\varsigma_{(l)}^2\ln u}-\gamma}{\sigma})^2} & 0<u<1 \text{ and } x<c\\ \dfrac{1}{2\sqrt{2\pi}u\sigma}\sqrt{\dfrac{-2\varsigma_{(r)}^2}{\ln u}}e^{(-1/2)(\frac{x+\sqrt{-2\varsigma_{(r)}^2\ln u}-\gamma}{\sigma})^2+(-1/2)(\frac{x-\sqrt{-2\varsigma_{(r)}^2\ln u}-\gamma}{\sigma})^2} & 0<u<1 \text{ and } x>c\\ 0 & \text{otherwise}\end{cases} \quad (5)$$

The asymmetry-center probabilistic fuzzy logic system

Similar to the ordinary probabilistic fuzzy logic system, the asymmetry-center PFLS still has operations of fuzzification, inference engine and defuzzification as shown in Fig.3. Different to the ordinary probabilistic fuzzy logic system, the asymmetry-center PFLS uses the asymmetry-center probabilistic fuzzy set instead of ordinary probabilistic fuzzy set during the inference process.

These asymmetry-center PFS based rules are usually expressed as *IF–THEN* statement as follows.

$$Rule\ j: If\ \ x_1\ is\ A_{1,j}\ \ and\ ...\ and\ \ x_i\ is\ A_{i,j}\ and\ ...and\ x_n\ is\ A_{n,j}, Then\ \ y\ \ is\ \ B_j \quad (6)$$

where $A_{i,j}$ $(i=1,2,...,n)$ $(j=1,2,...,J)$ is an antecedent in terms of the jth input variable x_j in the ith rule, and B_j is a consequent part related to the output variable y. Here all the antecedent part $A_{i,j}$ and consequent part B_j are asymmetry-center model of probabilistic fuzzy set instead of ordinary probabilistic fuzzy set.

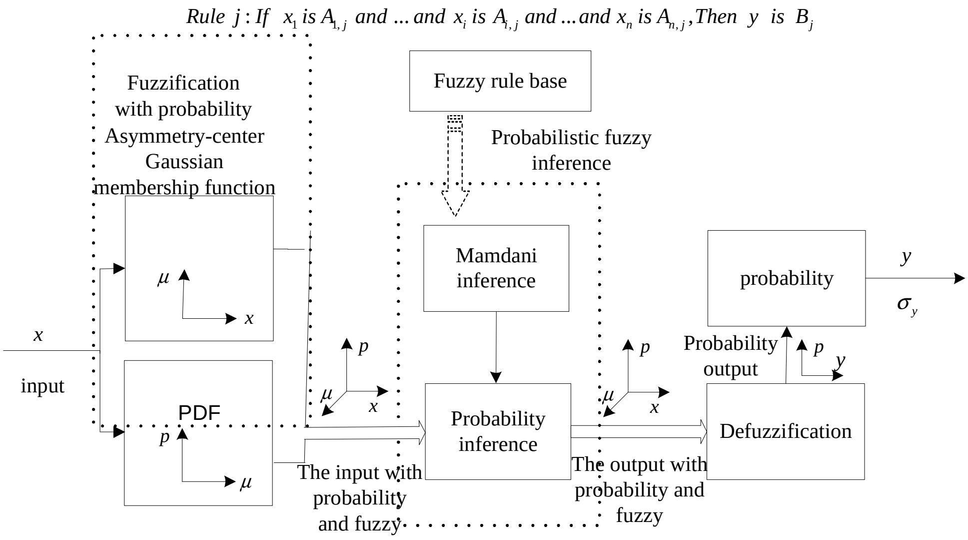


Fig.3: The asymmetry-center probabilistic fuzzy logic system

RESULTS AND DISCUSSION

Forecasting of pledging by warehouse receipt financing in agricultural products

Pledging by warehouse receipt is a new financing technique which strives to carry out in our third-party logistics companies [13]. Agricultural production and processing enterprises are facing the problem of financing, to a certain extent, these problems can be ease up by warehouse receipt pledge financing loan of agricultural product logistics [14]. Furthermore, forecasting the amount of money the bank provide to the third-party logistics company who lend it to the agriculture enterprises of farmer is a very important problem. The most applicable methods for forecasting include the ones of increase rate forecast, exponential smoothing, grey forecast, regression analysis and elastic coefficient forecast, etc. The former 3 ones are of time sequence analysis. And the latter 2 ones are of cause and effect. This paper uses the probabilistic fuzzy logic method to forecast the total amount of money of pledging by warehouse receipt of agriculture product logistics in a certain area in a period of time. It does not demand too many original data, without too many data like mathematical statistics ways, or too many relevant factors. Therefore, the information is easily accessed. It is more correct for short and middle term forecast. It also can be used for long term forecast [15].

When bank loan the amount of money to enterprises which produce and process agriculture goods or farmer, they did not lend money directly to them but through a third-party logistics company, the total amount money the bank grant to the 3PL should take a lot of factors into account. According to some studies[13,14], there are some factors such as x_1 which stands total amount of social production of agriculture foods in an area one month (unit: billion-Yuan), x_2 which stands total amount of agriculture products which all the third-party logistics companies store in this area one month (unit: 10-thousand-Ton), x_3 which stands total amount of people in this area (unit: million-people)etc. y here which stands total amount money the bank grant to the 3PL's one month in the area (unit: billion-Yuan). Table 1 shows x_1, x_2, x_3, y in a certain area in 7 month lastly, as original data, forecasting the total amount of money the banks grant to the 3PL enterprise of pledging by warehouse receipt of agriculture product logistics in the area with the proposed asymmetric probabilistic fuzzy logic system, so that the rural economy can develop stably and rapidly by the supporting loan which the banks provide.

Table 1 Data of pledging by warehouse receipt of agriculture product logistics in 7 month lastly

Year(month)	*2014(04)*	*2014(05)*	*2014(06)*	*2014(07)*	*2014(08)*	*2014(09)*	*2014(10)*
x_1 *(bi-Yuan)*	63.766	69.067	73.045	77.481	83.064	90.185	95.186
x_2 *(10-thou-Ton)*	2442.73	2501.30	2700.30	2809.98	2856.55	2901.18	2909.89
x_3 *(mi-People)*	6.389	6.465	6.668	7.044	7.115	7.221	7.342
y *(bi-Yuan)*	39.146	41.183	41.234	43.138	43.158	49.855	58.686

A nonlinear modeling is used to approximate the change process of the amount of loan the banks provide for 3PL companies by the means of pledging by warehouse receipt of agriculture product logistics.

$$y(k) = f(x_1(k-1), x_2(k-1), x_3(k-1), ..., x_1(k-m), x_2(k-m), x_3(k-m)) \tag{7}$$

where $y(k)$ is the output variable, denoting total amount money the bank grant to the 3PL's one month in the area, and x_1, x_2, x_3 are the input variables which mentioned above, f is the desired Innuendo relationship.

Based on the proposed PFS, the related asymmetry-center PFLS is constructed to forecast total amount money the bank grant to the 3PL's by warehouse receipt pledging of agriculture product logistics one month in the area. The input–output data are $n = 82$, with 75 for training and 7 for testing. The number of clustering center is $\tilde{c}=5$. The $l-th$ rule in PFLS is:

$$Rule\ l : if\ x_1\ is\ A_{l1}, x_2\ is\ A_{l2}\ and\ x_3\ is\ A_{l3}\ then\ y\ is\ b_l \tag{8}$$

The simulation comparison of Gau_{center} -based PFLS and the asymmetry-center PFLS is carried out. RMSE is used here as:

$$RMSE = \sqrt{\frac{1}{v}\sum_{k=1}^{n}(y(k) - y_e(k))^2} \tag{9}$$

where v is the number of testing data, $y(k)$ is the desired output and $y_e(k)$ is the estimated output.

The mean-squared error comparison of Gau_{center} -based PFLS and the asymmetry-center PFLS is 5.3455e-004 and 5.2627e-004 respectively. The simulation comparison is based on statistical results. The average parameters are obtained from 100 Monte Carlo simulations. It is clearly that the asymmetric probabilistic fuzzy set improves the modeling capability of such system. The reason is that the asymmetry-center PFLS has the better potential ability to handle uncertainties than Gau_{center} -based PFLS under certain stochastic circumstance. The results are shown as Fig.4.

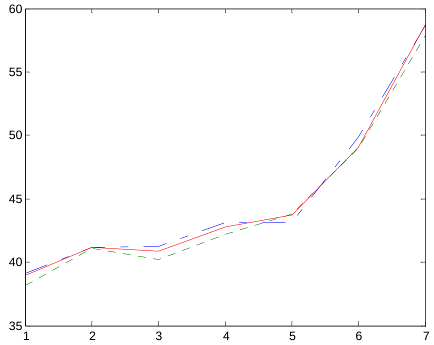


Fig. 4: The approximation accuracy comparison Gau_{center} -based PFLS (dotted line) and asymmetric PFLS (solid line)

CONCLUSION

In this paper, the asymmetry-center probabilistic fuzzy set is proposed by randomly varying the center of asymmetry Gaussian membership function, and the related asymmetry probabilistic fuzzy logic system is conduced. Finally, the asymmetry probabilistic fuzzy logic system is applied to a modeling problem to study its stochastic modeling capability. It is proved that the asymmetry probabilistic fuzzy logic system with asymmetry PFS can perform better than the symmetry ones under certain stochastic circumstance, because the asymmetry-center probabilistic fuzzy set improves the accuracy of such system. This work will broaden the application of the probabilistic fuzzy set.

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REFERENCES

[1] J. C. Pidre; C. J. Carrillo; A. E. F. Lorenzo, *IEEE Trans. Power Syst.*, **2003**, 18(2), 761-768.
[2] L. A. Zadeh, *Inform.and control*, **1965**, 8(10), 338-353.
[3] Mendel, J.M., Univ. Southern California, Rep., **1998**, (10) http://sipi.usc.edu/˜mendel/report.
[4] J. L. Chaneau; M. Gunaratne; A. G. Altschaeffl, Artificial Intelligence and Decision Systems, **1987**, 12(2), 16-22.
[5] Nilesh N. Karnik; Jerry M. Mendel; Qilian Liang, *IEEE Transations on Fuzzy Systems*, **2006**, 8(6), 808-821.
[6] M. Laviolette; J. W. Seaman Jr, Fuzzy Syst., **1994**, 2(1), 38-42.
[7] L.A.Zadeh, Mathematical Analysis and Applications, **1968**, 23(2), 18-28.
[8] Z. Liu; H.X. Li, IEEE Trans Fuzzy Systems, **2005**, 13(6), 848-859.
[9] Han-Xiong Li; Zhi Liu, IEEE Trans. Fuzzy Syst., **2008**, 16(4), 384-390.
[10] Geng Zhang; Han-Xiong Li, *IEEE International Conference on Systems Man and Cybernetics (SMC)*, **2011**,1837-1842.
[11] Geng Zhang; Han-Xiong Li; Min Gan, *IEEE transaction on industrial informatics*, **2012**, 8(4), 139-149.
[12] Wen-jing Huang; Geng Zhang; Han-xiong Li, *Pattern recognition letters*, **2013**, 34(12), 2157-2165.
[13] Gonzalez-Feliu; Basck; Morganti, *European Transport*, **2013**, 54(08), 334-343.
[14] Wuttke, D.A.; Blome, C.; Foerstl, K. etl, *Journal of Business Logistics*, **2013**, 34(06), 72-90.
[15] Wei Li; Haibo Kuang, *International Journal of Digital Content Technology and its Applications*, **2012**, 6(08), 17-23.