Journal of University of Babylon, Pure and Applied Sciences, Vol.(26), No.(9): 2018

Sugeno Fuzzy Classifier for Iris Database

Zainab Falah Hasan

University of Babylon, Science Collage for Women / Computer science

zainab_ga@yahoo.com

ARTICLE INFO
Submission date: 4/6/2016
Acceptance date: 6/2/2017
Publication date: 14/1/2019

Abstract

Classification acts building model able to predict the class of objects whose class is unknown.

In this work, Sugeno fuzzy logic is presented for unsupervised classification database of iris flower. Forty four fuzzy rules are used to classify this database using 4 features (inputs) that are acted by three fuzzy sets using trapzoidal and triangular Membership functions .

The proposed classification system results proved its efficiency to classify the database using fuzzy rules.

Key words: Sugeno Fuzzy System, Classification, Patterns Recognition.

1. Introduction

The classification is a designing system able to recognize a class of dataset using its information.

A method to generate fuzzy rules by processing individual fuzzy attributes to treat with problem of Iris data classification was used by Hong [1].

A classifier presented [2] for Iris data using weighted fuzzy rules which were obtained from training data. It reduced the number of fuzzy rules by merging those fuzzy rules.

A method used [3] to classify Iris data depended on discovering patterns from examining petal and sepal size and the prediction was made from analyzing the pattern to form the class of IRIS plant. Artificial neural networks was applied to problems in pattern classification, function approximations, optimization, and associative memories.

Feed forward neural networks to identification of iris plants based on sepal length, sepal width, petal length, and petal width. A Neural Network (NN) was used for the classification of iris data set[4].

A classifier based on rule extraction problem by the real value coding that used artificial immune system algorithm to extract rules from dataset [5].

2. Introduction to Fuzzy Logic

Fuzzy logic is first proposed by Lotfi A. Zadeh at University of California at Berkeley in a 1965 paper, the concept of "linguistic variables" elaborated on his ideas in a 1973. Converting a given input to an output using fuzzy logic is called Fuzzy inference [6].

Fuzzy logic has many types of inference systems such as Mamdani type, Sugeno type, and Tsukamoto type.

The sugeno fuzzy model was proposed to generate fuzzy rules to develop a systematic approach from a given input-output data set. A fuzzy rule in a sugeno fuzzy model has the form:

If a is X and b is Y the c = f(a,b)

Where fuzzy sets in the antecedent are X and Y and a crisp function in the consequent is c = f(a,b) [7]. Fuzzy Set includes identifying :

1. The universe of discourse .
2. Many of fuzzy sets.
3. Membership functions.

Membership Functions are operation to quantify knowledge to convert linguistic description into values range from 0 to 1 representing membership degree of each input in the fuzzy set. There are many types of membership functions such as :
Triangular Membership Function: it is the simplest function[8]. A triangular MF uses three parameters as follows:

$$\text{Triangle}(s,x,y,z)=\begin{cases} 0 & s<x \\ \frac{s-x}{y-x} & x\le s\le y \\ \frac{z-s}{z-y} & y\le s\le z \\ 0 & z\le s \end{cases}$$

Trapezoidal Membership Function uses four parameters as follows[8]:

$$\text{Trapezoid}(s,x,y,z,d)=\begin{cases} 0 & s<x \\ \frac{s-x}{y-x} & x\le s\le y \\ 1 & y\le s\le z \\ \frac{d-s}{d-z} & z\le s\le d \\ 0 & d\le s \end{cases}$$

Gaussian Membership Function uses two operators as follows [9]

$$\text{Gaussian}(a, w, \sigma)= e^{(a-w/\sigma)2*(-0.5)}.$$

The input variables are transformed to linguistic ones using fuzzification operation that is done using membership functions that defining the range of input and membership degree[10].

The words are used to represent the operator's knowledge and, then linguistic rules are written to represent the rule base in the forms of the input-output data which are formulated using the observation of operator's actions [11].

Fuzzy logic quantifies each of the rules [12]. Fuzzy treats with AND operation using MIN function for the real numbers between 0 and 1. The OR operation is acted using the MAX Function.

After the result of each rule in the model is obtained, the fuzzy sets of consequent are implicated by cutting the membership functions of output in the point of y_coordinate equals to strength of rule[11]. The implicated fuzzy sets of all the active rules are aggregated into one fuzzy set by unifying the outputs of every rule. The fuzzy output is transformed to crisp value that represents converting decisions to actions using defuzzification methods.

Defuzzification can be resulted using several methods such as Height Method, Centroid method, First of Maxima method, Mean of Max method. In sugeno fuzzy system[13], The result is computed as follows**,** where wi acts rule strength , zi is crisp output of rule and N acts number of sugeno rules**:**

$$\textbf{Final output}=\frac{\sum_{i=1}^{N} wizi}{\sum_{i=1}^{N} wi}$$

3. Sugeno Classifier System

Dataset of iris flower consists of 150 instances , four features that are Sepal Length, Sepal Width, Petal Length and Petal Width and three classes are Iris setosa , Iris versicolor and Iris Verginica. This data set is created by Sir Ronald Aylmer Fisher in 1936.

In this System , rules of Sugeno fuzzy logic used to classify Iris database where database has four features representing premise(inputs)of fuzzy Rules and three classes representing output. Every input data(features)of premise fuzzy Rules is fuzzified by using fuzzy sets acted by trapzoidal Membership function or triangular membership functions. The fuzzified input data is applied on fuzzy Rules that are used for classification and the class is resulted by sugeno fuzzy System. The steps of the proposed system as follows:-

1- Designing the Membership functions for inputs and number of fuzzy sets for them.
2- Fuzzification of input data(features).
3- Fuzzy Rules inference for the output.
4- Conclusion the output using Sugeno fuzzy system.
5- Accuracy computation.

3-1 Membership Functions Designing:-

The inputs of System are four, every input is acted by three of fuzzy sets that are triangular and trapezoidal Membership functions. The MIN and MAX parameters for features of Iris that are used in membership functions designing are showed in the table1. Fuzzy sets of inputs are shown as follows:-

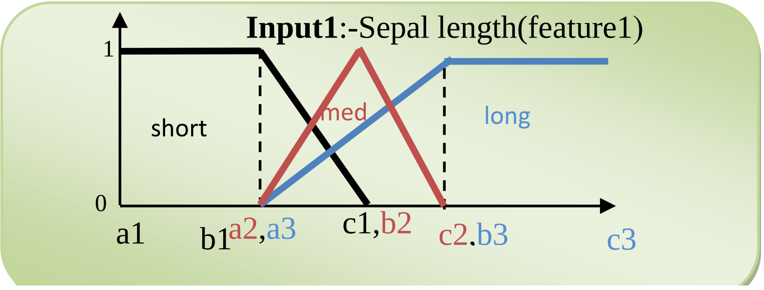

Fig. 1: Fuzzy Sets of Feature 1.

a1:minimum value of feature1 for Iris-setosa.
a2:minimum value of feature1 for Iris- versicolor.

a3: minimum value of feature1 for Iris- verginica.

b1:last value of feature1 belongs to Iris-setosa and does not belongs to Iris-versicolor or iris verginica.

b2:median value of feature1 belongs to Iris- versicolor.
b3: :first value of feature1 belongs to Iris-verginica and does not belongs to Iris-versicolor or iris setosa.

c1: max value of feature1 for Iris-setosa.
c2: max value of feature1 for Iris- versicolor.
c3: max value of feature1 for Iris- verginica.

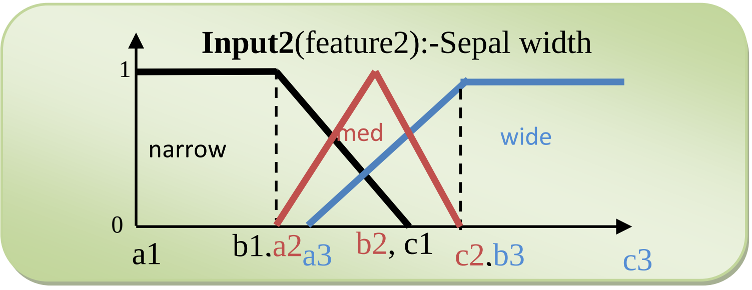

Fig. 2: Fuzzy Sets of Feature 2.

a1:minimum value of feature2 for Iris- versicolor.
a2:minimum value of feature2 for Iris- verginica.

a3: minimum value of feature2 for Iris- setosa.

b1:last value of feature2 belongs to Iris-versicolor and does not belong to Iris-setosa or Iris- verginica.
b2: median value of feature2 belongs to Iris- verginica.

b3: :first value of feature2 belongs to Iris-setosa and does not belongs to Iris-versicolor or iris verginica.

c1: max value of feature2 for Iris- versicolor.
c2: max value of feature2 for Iris- verginica.
c3: max value of feature1 for Iris- setosa.

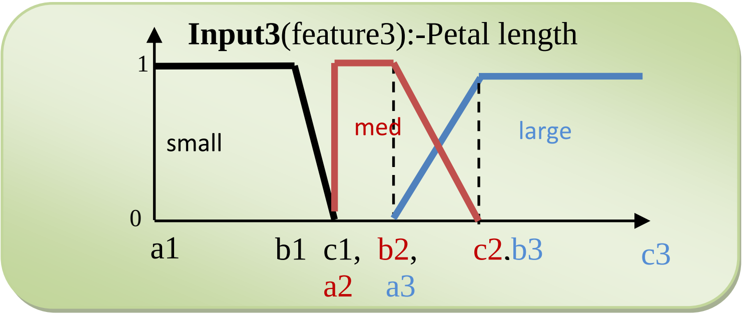

Fig. 3: Fuzzy Sets of Feature 3.

a1:minimum value of feature3 for Iris-setosa.

a2:minimum value of feature3 for Iris- versicolor.
a3: minimum value of feature3 for Iris- verginica.
b1:last value of feature3 belongs to Iris-setosa and does not belong to Iris-versicolor or Iris verginica.

b2:last value of feature3 belongs to Iris- versicolor and does not belongs to Iris-verginica.
b3:first value of feature3 belongs to Iris-verginica and does not belongs to Iris-versicolor or iris setosa.

c1: max value of feature3 for Iris-setosa.
c2: max value of feature3 for Iris- versicolor.
c3: max value of feature3 for Iris- verginica.

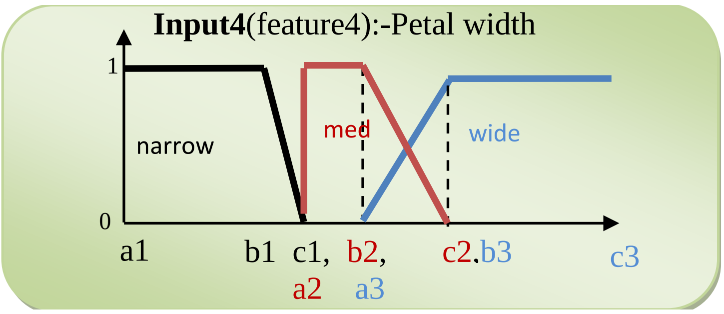

Fig. 4: Fuzzy Sets of Feature 4.

a1:minimum value of feature3 for Iris-setosa.

a2:minimum value of feature3 for Iris- versicolor.
a3: minimum value of feature3 for Iris- verginica.
b1:last value of feature3 belongs to Iris-setosa and does not belong to Iris-versicolor or Iris verginica.

b2:last value of feature3 belongs to Iris- versicolor and does not belongs to Iris-verginica.
b3:first value of feature3 belongs to Iris-verginica and does not belongs to Iris-versicolor or iris setosa.
c1: max value of feature3 for Iris-setosa.
c2: max value of feature3 for Iris- versicolor.
c3: max value of feature3 for Iris- verginica.

Table 1: The Parameters of Features for Three Types of IRIS Flowers.

Features	*Sepal length*		*Sepal width*		*Petal length*		*Petal width*	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Iris setosa	4.2	5.9	2.2	4.5	0.9	2.9	0	0.9
Iris versicolor	4.8	7.1	1.9	3.5	2.9	5.2	0.9	1.9
Iris Verginica	4.8	8	2.1	3.9	4.4	7	1.3	2.6

3-2 Fuzzification of Input Data(features):

In this step, every input is fuzzified using trapzoidal or triangular membership functions in three fuzzy sets. The fuzzified inputs are applied on fuzzy rules and the active rules are used to conclude the output.

3-3 Fuzzy Rule Inference for Output:-

The used rules for conclusion of the output are shown in the following, where f1 acts feature1, F2 acts feature2, F3 acts feature3 and F4 acts feature4 Cl1 acts Iris-setosa, Cl2 acts Iris-versicolor and Cl3 acts Iris-verginica.

Rule1: If (f1 is short, F2 is wide, F3 is small and F4 is narrow)then output is Cl1.
Rule2: If(f1 is short, F2 is wide, F3 is med and F4 is med)then output is Cl2.
Rule3:If(f1 is short, F2 is narrow, F3 is small and F4 is narrow)then output is Cl1.
Rule4: If(f1 is short, F2 is narrow, F3 is med and F4 is med)then output is Cl2.
Rule5: If (f1 is short, F2 is med , F3 is small and F4 is narrow) then output is Cl1.
Rule6: If (f1 is short, F2 is wide, F3 is large and F4 is wide) then output is Cl2.
Rule7: If(f1 is short, F2 is med , F3 is large and F4 is wide) then output is Cl3.
Rule8: If (f1 is short, F2 is narrow, F3 is large and F4 is wide) then output is Cl3.
Rule9: If (f1 is short, F2 is med, F3 is med and F4 is wide) then output is Cl3
Rule10: If (f1 is short, F2 is med , F3 is large and F4 is med) then output is Cl3.
Rule11: If (f1 is short, F2 is narrow, F3 is med and F4 is wide) then output is Cl2.
Rule12: If (f1 is short, F2 is narrow, F3 is large and F4 is med) then output is Cl2.
Rule13: If (f1 is short, F2 is med , F3 is med and F4 is med) then output is Cl2.
Rule14: If (f1 is short, F2 is wide, F3 is med and F4 is wide) then output is Cl2.
Rule15: If (f1 is short , F2 is wide , F3 is large and F4 is med) then output is Cl2.
Rule16: If (f1 is med, F2 is wide, F3 is small and F4 is narrow) then output is Cl1.
Rule17: If (f1 is med, F2 is wide, F3 is med and F4 is med) then output is Cl2.
Rule18:If(f1 is med, F2 is narrow, F3 is small and F4 is narrow)then output is Cl1.
Rule19: If(f1 is long, F2 is wide, F3 is small and F4 is narrow) then output is Cl1.
Rule20: If (f1 is long, F2 is med, F3 is small and F4 is narrow) then output is Cl1.
Rule21: If (f1 is long, F2 is wide, F3 is large and F4 is wide) then output is Cl3.
Rule22: If (f1 is long, F2 is med, F3 is med and F4 is med) then output is Cl2.
Rule23: If (f1 is long, F2 is med, F3 is large and F4 is med) then output is Cl3.
Rule24: If (f1 is med, F2 is narrow, F3 is med and F4 is med) then output is Cl2.
Rule25: If (f1 is long, F2 is med, F3 is large and F4 is wide) then output is Cl3
Rule26: If (f1 is med, F2 is narrow, F3 is med and F4 is wide) then output is Cl2.
Rule27: If (f1 is med, F2 is narrow, F3 is large and F4 is med) then output is Cl2
Rule28: If (f1 is med, F2 is med, F3 is med and F4 is med) then output is Cl2
Rule29: If (f1 is long, F2 is narrow, F3 is med and F4 is med) then output is Cl2.
Rule30: If (f1 is med, F2 is narrow, F3 is large and F4 is wide) then output is Cl3.
Rule31: If (f1 is med, F2 is med, F3 is large and F4 is med) then output is Cl3.

Rule32: If (f1 is med, F2 is med, F3 is med and F4 is wide) then output is Cl2.
Rule33: If (f1 is long, F2 is narrow, F3 is large and F4 is med) then output is Cl3.
Rule34: If (f1 is long, F2 is narrow, F3 is med and F4 is wide) then output is Cl3.
Rule35: If (f1 is med, F2 is med, F3 is large and F4 is wide) then output is Cl3.
Rule36: If (f1 is long, F2 is narrow, F3 is large and F4 is wide) then output is Cl3.
Rule37: If (f1 is long, F2 is med, F3 is med and F4 is wide) then output is Cl2.
Rule38: If (f1 is med, F2 is wide, F3 is large and F4 is wide) then output is Cl3.
Rule39: If (f1 is long, F2 is wide, F3 is med and F4 is wide) then output is Cl2.
Rule40: If (f1 is long, F2 is wide, F3 is large and F4 is med) then output is Cl3.
Rule41: If (f1 is long, F2 is wide, F3 is med and F4 is med) then output is Cl2.
Rule42: If (f1 is med, F2 is wide, F3 is large and F4 is med) then output is Cl2.
Rule43: If (f1 is med, F2 is med, F3 is small and F4 is narrow) then output is Cl1.
Rule44:If(f1 is long, F2 is narrow, F3 is small and F4 is narrow)then output is Cl1.

3-4 Conclusion of Output

Sugeno Fuzzy Logic gets the class of data as follows:

output(class)=$\frac{\sum(\text{strength of Rules} * \text{output of Rule})}{\sum \text{strength of Rules}}$

Strength of a Rule=Minimum value of(fuzzified input1, fuzzified input2, fuzzified input3 and fuzzified input4)

3-5 Accuracy of Classification:

The output is checked its class from database to get the accuracy of classification.

IF output=class(test state)THEN

No. (corrected classified states)= No.(corrected classified states) +1

loop these steps with other states from database until being finished from test all of data to get the Accuracy of classification.

Accuracy= ($\frac{\text{No.of corrected classified states}}{\text{No.of total states}}$)*100%

4. Results

The resulted accuracy using sugeno fuzzy system of iris data is 98% as shown in the following running figure, the language used for system is matlab :

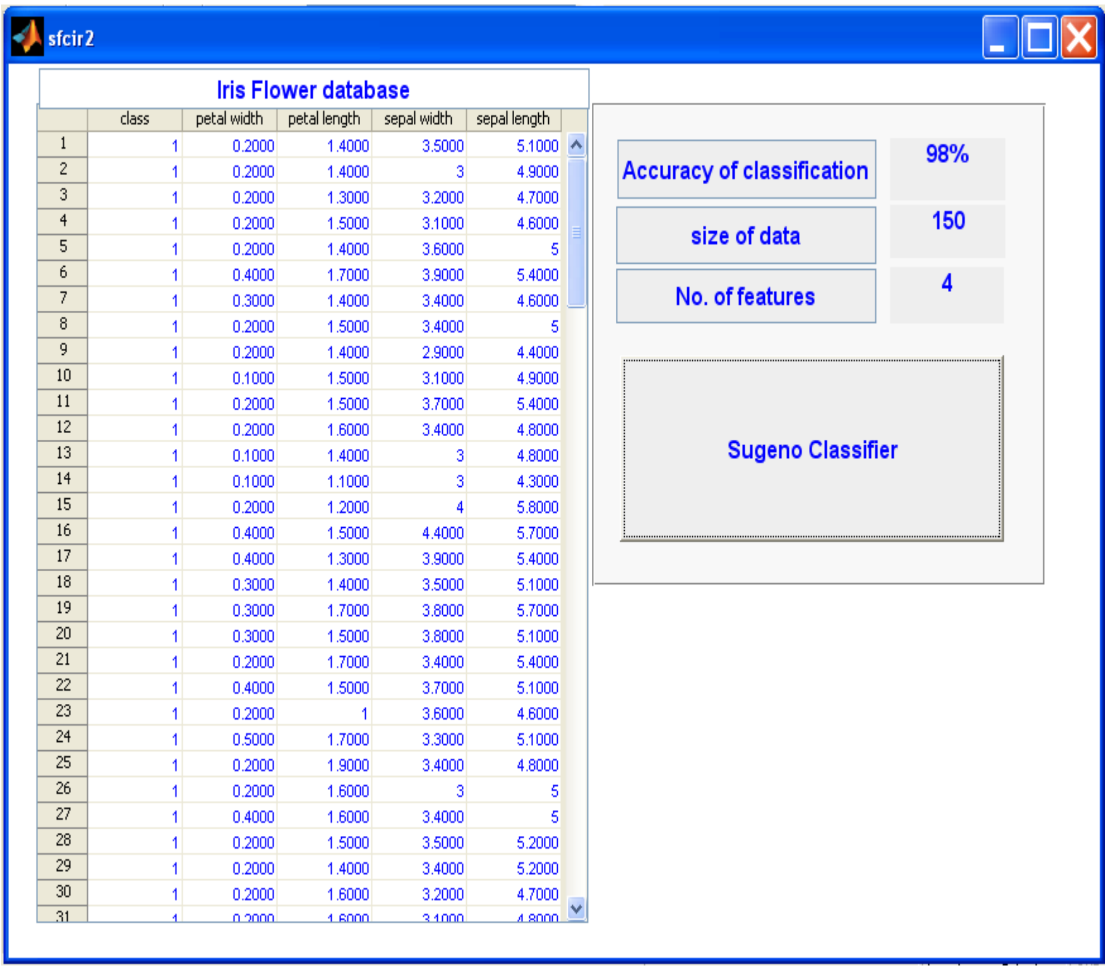

Fig. 5: Accuracy of Classification of Iris using Sugeno Fuzzy Logic.

5. Conclusions

Sugeno fuzzy system is efficiently classified the used database. The fuzzy rules in this classifier also proved its efficiency to obtain the classes of database.

Sugeno fuzzy inference system proved its efficiency in the classification problem so it can used for future works with other datasets.

In future works, new techniques can be added to minimize number of fuzzy rules that used to classify or to minimize the used features.

CONFLICT OF INTERESTS.

There are non-conflicts of interest.

6 References

[1] Hong, T. P. and Chen, J. B., "Processing individual fuzzy attributes for fuzzy rule induction", *Fuzzy Sets and Systems*, vol. 112, no. 1, pp. 127-140, May 2000.

[2] Yung-Chou Chena, Li-HuiWangb, and Shyi-Ming Chenc, "Generating Weighted Fuzzy Rules from Training Data for Dealing with the Iris Data Classification Problem", *International Journal of Applied Science and Engineering*, vol. 4, no. 1, pp. 41-52, Aug. 2006.

[3] Madhusmita Swain, Sanjit Kumar Dash, Sweta Dash and Ayeskanta Mohapatra, "An Approach For Iris Plant Classification Using Neural Network", *International Journal on Soft Computing (IJS)*, vol. 3, no. 1 , Feb. 2012.
[4] Shrikant Vyas and, Dipti Upadhyay, "Classification Of Iris Plant Using Feedforward Neural Network", *International Refereed Journal of Engineering and Science (IRJES)*, vol. 3, no. 12, pp.65-69 ,December 2014.
[5] Murat Koklu, Humar Kahramanli and Novruz Allahverdi, "A New Approach To Classification Rule Extraction Problem By The Real Value Coding", *International Journal of Innovative Computing, Information and Control*, Vol. 8, no. 9. pp. 6303–6315, Sep. 2012.
[6] Serge G., "Designing Fuzzy Inference Systems from Data: An Interpretability-Oriented Review", *IEEE Transactions on Fuzzy Systems*, vol. 9, no. 3, pp. 426-443, June 2001.
[7] S.R. Nikam, P.J.Nikumbh and S.P.Kulkarni, "Fuzzy Logic And Neuro-Fuzzy Modeling", *IJCA Proceedings on National Conference on Recent Trends in Computing NCRTC*, pp. 22-31, May 2012.
[8] Vamsi M. P., "Fuzzy Logic Controller for an Autonomous Mobile Robot", M.S. Thesis, Cleveland State University, India, May 2005.
[9] Krishan Kundu, "Image Denoising using Patch based Processing with Fuzzy Gaussian Membership Function", *International Journal of Computer Applications*, vol. 118, no. 12, pp. 0975 – 8887, May 2015.
[10] V. Varshavsky, V. Marakhovsky, I. Levin and H. Saito, "Multiple-valued Logic Approach to Fuzzy Controllers Implementation", *WSEAS Transactions on Electronics Manuscript*, vol. 4, no. 6, pp. 1109-9445, Feb 2007.
[11] Daniel Graupe, Ed. 2, *Principles Of Artificial Neural Networks*, River Edge, NJ, USA , World Scientific Publishing Co. Pte. Ltd., Apr 2007.
[12] Philip W., *Value determination of supply chain initiatives - A quantification approach based on fuzzy logic and system dynamics*, Germany, Niedermann Druck AG, St. Gallen, May 2010.
[13] Yue Wu, Biaobiao Zhang, Jiabin Lu and K. -L. Du, "Fuzzy Logic and Neuro-fuzzy Systems: A Systematic Introduction", *International Journal of Artificial Intelligence and Expert Systems (IJAE)*, vol. 2, no. 2, pp. 47 – 80, May 2011.

الخلاصة

التصنيف يمثل بناء نموذج قادر على التنبؤ بنوع العناصر التي نوعها غير معروف.

في هذا العمل, المنطق الضبابي لسوجينو مقدم لتصنيف غير مشرف عليه لقاعدة بيانات زهرة السوسن. اربعة واربعون قاعدة ضبابية استخدمت لتصنيف قاعدة البيانات هذه مع اربعة خصائص (مدخلات) مثلت باستخدام ثلاث مجاميع ضبابية بواسطة دوال العضوية شبة المنحرف و المثلثية.

نتائج نظام التصنيف المفترض برهنت كفاءته لتصنيف قاعدة البيانات باستخدام القواعد الضبابية.

الكلمات الدالة:نظام تصنيف سوجينو, التصنيف , تمييز الانماط.