NIFS 11 (2005), 1, 28-32

A Method and Electronic Circuit for Intuitionistic Fuzzy Inference

M. Marinov* and K. Atanassov**

* FabLess Ltd (Bulgaria), e-mail:marin.marinov@fab-less.com

** CLBME-BAS, Bulgaria, e-mail:krat@bas.bg

Abstract

The present paper concerns a method and electronic circuit for intuitionistic fuzzy inference implementation, which could be utilized in knowledge processing systems, such as expert, decision support, image recognition and other systems.

Keywords: Inference, Intuitionistic fuzzy inference, Intuitionistic fuzzy set.

Introduction

A method, implementing an inference on fuzzy knowledge, described by production rules, is known. It is based on calculation of the minimum of conditions membership function and the maximum of conclusions membership functions.

The elements of such a fuzzy knowledge base, described by production rules of the type:

IF<condition>, THEN<conclusion>

are:

Rule 1: IF x is A1 AND y is B1 AND…. THEN z is C1

Rule 2: IF x is A2 AND y is B2 AND…. THEN z is C2

.

.

Rule n: IF x is An AND y is Bn AND…. THEN z is Cn where:

x, y and z are linguistic variables and

$A1, A2, \ldots An, B1, B2, \ldots Bn, C1, C2, \ldots Cn$ are membership function of the linguistic variables in conditions - (Ai, Bi) and in conclusion - Ci

and the inference procedure is based on a sequential calculation of $MIN(Ai,Bi)$ of all rules and then $MAX\ Ci$ on all conclusions.

The method, given above, has been implemented in fuzzy inference electronic circuits [1,2]. The circuits, described there consist of cascade connected modules, executing *MIN* and *MAX* functions. The difference between both implementation is in the way of linguistic variable membership function representation and processing – digital in [1] and analog in [3].

The drawback of both implementations is that they process knowledge, which represents simple fuzziness, described by only membership function.

While the heuristic knowledge, based on human intuition is much more complex, characterized by degree of certainty(membership), degree of uncertainty(non membership) and degree of intuition, which the above-mentioned circuit are not able to process. As a result it limits their application.

Intuitionistic fuzzy inference method

A method, permitting to process intuitionistic fuzzy knowledge will be described further in the present article. All notions and concepts related to intuitionistic fuzzy sets are used from [4].

A new functions of non membership of the conditions – Pi,Qi and Ri of the conclusions will be added to the production rules.

At that the sum of both function of membership and non membership is always less than 1, i.e the remaining part is the one, characterizing the intuition.

By the help of so described additional function, the intuitionistic fuzzy knowledge can be presented by following type of production rules (see also [5], where an intuitionistic fuzzy Prolog machine is described):

Rule 1: IF x is (A1;P1) AND y is (B1;Q1) ..... THEN z is (C1;R1)

Rule 2: IF x is (A2;P2) AND y is (B2;Q2) ..... THEN z is (C2;R2)

.

.

Rule n: IF x is (An;Pn) AND y is (Bn;Qn) ..... THEN z is (Cn;Rn)

where: *x, y* and *z* are intuitionistic fuzzy variables

A1,A2,…An and *B1,B2,…Bn* are conditions membership functions

C1,C2,…Cn – are conclusions membership functions

P1,P2,….Pn and *Q1,Q2,…Qn* are conditions non membership functions

R1,R2,…Rn - are conclusions non membership functions.

The inference procedure starts with an evaluation of the left parts of the rules in the following way. The current values of the membership function – *m* and non membership function – *n* of each variable are compared with the threshold values – *Ai, Pi,* and *Bi,Qi* respectively, as follows:

FOR EACH x
IF m >Ai OR (m=Ai AND n<Pi), THEN x=1
ELSE x=0

and

FOR EACH y
IF m >Bi OR (m=Bi AND n<Qi), THEN y=1
ELSE y=0

To obtain the conclusion, the conjunction of the evaluated left parts of the rules should be equal to 1, which means that the conclusion z is activated with the corresponding membership and non membership thresholds *Ci* and *Ri*.

Finally, the resulting values of thresholds should be calculated by taking a *MAX* of membership thresholds and *MIN* of non membership thresholds on the conclusions of all activated rules.

Hardware implementation

A hardware implementation of the described method for intuitionistic fuzzy knowledge inference is shown on fig.1.

The circuit is operating in following way. The evaluated condition membership and non membership current values are applied to the left inputs of the corresponding comparators. The respective threshold values, accessed from the memory, are applied to the comparators right inputs.

The membership function values comparator gives logic 1 to the logic OR circuit in following cases:

- when the current value m is greater than the threshold. In this case the membership comparator disables the non membership comparator.
- when the current value m is equal to the threshold. The non membership comparator is enabled and logic 1 is applied to the logic OR circuit if the current value of non membership function is lower than its threshold.

Otherwise logic 0 is always applied.

All other conditions are evaluated in the same way. The evaluated conditions are applied to the logic *AND* circuit, which sequentially multiplies condition values. The result is stored in the register, which enables *MAX* and *MIN* circuits for conclusion membership and non membership thresholds calculations.

Conclusions

A method for extension of production rules description power, permitting intuitionistic fuzzy knowledge description and inference to be performed.

A hardware implementation of the proposed method is shown.

The further work will cover design of the silicon version of the proposed circuit.

References

[1] M.Togai, H.Wanatabe. Expert system on a chip: An engine for real-time approximate reasoning. IEEE Expert, Fall 1986.

[2] T.Yamatake. A simple fuzzy computer hardware system employing min&max operations. A challenge of 6-th generation computers. Proc. of Second IFSA Congress, Tokyo, 1987.

[3] T.Yamatake. Fuzzy microprocessor. How it works. Proc. of Int. Workshop on Fuzzy System Application. Iisuka, Fukuoka,August 1988.

[4] K. Atanassov, Intuitionistic Fuzzy Sets. Springer Physica-Verlag, Berlin, 1999.

[5] K. Atanassov, M. Marinov, Z. Zlatev. An attempt to build an intuitionistic fuzzy Prolog machine. Notes on Intuitionistic Fuzzy Sets, Vol. 10 (2004), No. 1, 27-36.