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Normalization of Intuitionistic Fuzzy Relational Databases

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Abstract : In this paper the authors present a method of normalizing a relational schema with intuitionistic fuzzy attributes into 1NF.

Keywords: Intuitionistic fuzzy set, intuitionistic fuzzy database, intuitionistic fuzzy number, Intuitionistic fuzzy attribute, 1NF(IF).

1. Introduction

The normalization process takes a relation schema though a series of tests to check up whether it satisfies a certain normal form. Consider an instance of a relation schema. In real life situation, the data available are not always precise or crisp, rather intuitionistic fuzzy. Consequently, if at least one data is intuitionistic fuzzy, the relation schema can not be called to be in 1 NF. For example consider an attribute SALARY (in $) of a relation schema Employee.

If a tuple value for this attribute SALARY is precise, viz. 5000, then it is a single atomic (indivisible) value. But if a tuple value is intuitionistic fuzzy, viz, "approximately 5000", then it can not be called an atomic value.

In this paper we study this problem and suggest a method to normalize such relational schemas into 1NF. Such a normal form we shall call by Intuitionistic Fuzzy 1NF or 1NF(IF).

2. Preliminaries

Out of several higher order fuzzy sets the concept of intuitionistic fuzzy sets introduced by Atanassov [2] has been found to have enormous potential to deal with vague or imprecise data in case of engineering or technological or economical or mathematical analysis, to list a few only. In this section, we present some preliminaries on the theory of intuitionistic fuzzy sets (IFS) which will be required for the progress of this paper.

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3. Intuitionistic Fuzzy 1NF or 1NF(IF)

In this section we will explain the method of normalizing a relational schema (with intuitionistic fuzzy attributes) into 1NF. For the sake of simplicity, we consider a relation schema R with only one intuitionistic fuzzy attribute, all other three attributes being crisp. By "intuitionistic fuzzy attribute" we mean that at least one attribute value in a relation instance is intuitionistic fuzzy.

A_1	A_2	A_3	A_4

Table 1: Relation schema R

This relational schema R has four attributes of which A_4 is the only intuitionistic fuzzy attribute (say). Consider a relation instance r of R given by:

A_1	A_2	A_3	A_4
$\mathbf{a}_{11}$	$\mathbf{a}_{21}$	$\mathbf{a}_{31}$	$\mathbf{a}_{41}$
$\mathbf{a}_{12}$	$\mathbf{a}_{22}$	$\mathbf{a}_{32}$	$\tilde{\mathbf{a}}$
$\mathbf{a}_{13}$	$\mathbf{a}_{23}$	$\mathbf{a}_{33}$	$\mathbf{a}_{43}$
$\mathbf{a}_{14}$	$\mathbf{a}_{24}$	$\mathbf{a}_{34}$	$\mathbf{a}_{44}$

Table 2

Suppose that A_2 is the primary key here, all the data are precise except $\tilde{\mathbf{a}}$ which is an intuitionistic fuzzy number. Thus, all the data except $\tilde{\mathbf{a}}$ is atomic. This is not in 1NF because of the non atomic data $\tilde{\mathbf{a}}$.

An intuitionistic fuzzy number is an intuitionistic fuzzy set of the set R of real numbers. The universe of discourse R is an infinite set. But, in our method of normalization we shall consider a finite universe of discourse, say X, whose cardinality is N.

Let us suppose that $X = \{ x_1, x_2, \ldots\ldots\ldots\ldots, x_N \}$ and the intuitionistic fuzzy number $\tilde{\mathbf{a}}$ proposed by a database expert is an IFS given by:

$$\tilde{\mathbf{a}} = \{ (x_i, \mu_i, V_i) : x_i, \in X , \ I = 1,2,3,\ldots\ldots N \}$$

Then, the Table 2 can be replaced by the following table:

A_1	A_2	A_3	A_4
$\mathbf{a}_{11}$	$\mathbf{a}_{21}$	$\mathbf{a}_{31}$	$\mathbf{a}_{41}$
$\mathbf{a}_{12}$	$\mathbf{a}_{22}$	$\mathbf{a}_{32}$	$\{ (x_i, \mu_i, V_i), (x_1,\mu_2,V_2),\ldots, (x_N, \mu_N, V_N) \}$
$\mathbf{a}_{13}$	$\mathbf{a}_{23}$	$\mathbf{a}_{33}$	$\mathbf{a}_{43}$
$\mathbf{a}_{14}$	$\mathbf{a}_{24}$	$\mathbf{a}_{34}$	$\mathbf{a}_{44}$

Table 3: The relation instance r

Now remove all the IF attributes (here A_4 only), from Table 3. Replace Table 3 by the following two tables:

A_1	A_2	A_3
a_{11}	a_{21}	a_{31}
a_{12}	a_{22}	a_{32}
a_{13}	a_{23}	a_{33}
a_{14}	a_{24}	a_{34}

Table 4: The relation r_1

A_2	A_4	MV (A_4)	N MV (A_4)
a_{21}	a_{41}	1	0
a_{22}	x_1	μ_1	v_1
a_{22}	x_2	μ_2	v_2
a_{22}	x_3	μ_3	v_3
...	...	...	...
a_{22}	x_N	μ_N	v_N
a_{23}	a_{43}	1	0
a_{24}	a_{44}	1	0

Table 5: The relation r_2

In Table 5 we have all the attributes of the primary-key of r (here only one attribute A_2), the IF attribute A_4 and two new attributes which are MEMBERSHIP_VALUE(A_4) or MV(A_4) and NONMEMBERSHIP_VALUE(A_4) or NMV(A_4). Corresponding to all precise values of A_4, the MV(A_4) value is put 1 and the NMV(A_4) value is 0.

Now we see that the relation schema is in 1NF. Such a method of normalization is called Intuitionistic fuzzy normalization and the normal form is called Intuitionistic fuzzy 1NF or 1NF(IF).

Example : We study the method here by an example with hypothetical data. Consider a relation schema VEGETABLE as shown below whose primary key is VCODE and the attribute YEARLY-PRODUCTION is an intuitionistic fuzzy attribute.

VNAME	**VCODE**	**YEARLY-PRODUCTION** (in millions of tones)

Table 6: The relation schema VEGETABLE

Consider a relation instance of this relational schema given by the following table:

VNAME	**VCODE**	**YEARLY-PRODUCTION**
Rice	RI 005	5284
Potato	PO 012	9823
Potato	PO 003	Approximately 56
Brinjol	BR 004	425

Table 7

In this instance, VNAME and VCODE are crisp attribute whereas YEARLY-PRODUCTION is an intuitionistic fuzzy attribute. All the attribute values for VNAME are atomic; all the attribute

values for the attribute VCODE are atomic. But all the attribute values for the attribute Yarly-Production are not atomic. The data "approximately 56" is an intuitionistic fuzzy number $\tilde{56}$. Suppose that for this relation, a database expert proposes the intuitionistic fuzzy number $\tilde{56}$ as an IFS given by $\tilde{56}$ = {(55, .8, .1), (56,.9,.02), (56.5, .7, .15)}

Therefore, Table 7 could be replaced by the following table:

VNAME	VCODE	YEARLY-PRODUCTION
Rice	RI 005	5284
Potato	PO 012	9823
Potato	PO 003	{ (55, .8, .1), (56,.9,.02), (56.5, .7, .15) }
Brinjol	BR 004	425

Table 8

Now remove the intuitionistic fuzzy attribute YEARLY-PRODUCTION (YP) from this instance and divide it into two relations given by:

VNAME	VCODE
Rice	RI 005
Potato	PO 012
Potato	PO 003
Brinjol	BR 004

Table 9: VEGETABLE - 1 relation

VCODE	Y P	MV (YP)	NMV (YP)
RI 005	5284	1	0
PO 012	9823	1	0
PO 003	55	.8	.1
PO 003	56	.9	.02
PO 003	56.5	.7	.15
BR 004	425	1	0

Table 10: VEGETABLE - 2 relation

Clearly, it is now in 1NF, called by 1NF(IF). For VEGETABLE-1, the Primary Key is VCODE, but for the newly created VEGETABLE-2 the Primary Key is {VCODE, YP}. Let us present below the sequence of steps for intuitionistic fuzzy normalization of relation schema into 1NF(IF).

Algorithm:

(1) Remove all the IF-attributes from the relation.
(2) For each IF-attribute, create one separate table with the following attributes:
    (i) all attributes in the primary key
    (ii) MV(Z)
    (iii) NMV(Z)

(3) For every precise value of the IF attribute, put MV = 1 and NMV = 0.

Thus, if there are m number of IF attributes in the relation schema, then after normalization there will be in total (m+1) number of relations. In special case, when the hesitation or indeterministic parts are nil for every element of the universe of discourse, the intuitionistic fuzzy number reduces to fuzzy number. In such cases, the attribute NMV(Z) will not be required in any reduced tables of INF. We will make a separate study for this special case in our future work..

Conclusion

In this paper we have presented a method of normalization of a relational schema (with IF attribute) in 1NF(IF). We have explained the method by an example. The major disadvantage of this method of normalizing a relational schema with IF attributes is that it requires a lot of space to store the newly create tables.

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