Normalization of Neutrosophic Relational Database

Smita Rajpal[1], Pariza kamboj[1]
[1]ITM University, Gurgaon , India
smita_rajpal@yahoo.co.in , pariza@gmail.com

***Abstract*:** In this paper authors have presented a method of normalizing a relational schema with Neutrosophic attributes into 1NF.This Method is called as Neutrosophic-First Normal Form(1NF(N)) a revision of First normal Form in Relational database. Authors are taking the Neutrosophic Relational database [3, 1] which is the extension of Fuzzy and Vague database to define the Neutrosophic- First Normal form.

***Keywords*:** Neutrosophic Normal Form, Query language, Vague Set, Fuzzy Set, Neutrosophic 1NF

1. INTRODUCTION

The normalization process takes a relation schema through 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 it can be in any form like it can be in natural language, any imprecise data or you can say Neutrosophic data .Consequently if, at least one data is Neutrosophic, the relation schema can not be called to be in 1NF. The quest to manage imprecision's is equal to major driving force in the database community is the Ultimate cause for many research areas: data mining, semi structured data, and schema matching, nearest neighbor. Processing probabilistic data is fundamentally more complex than other data models. Some previous approaches sidestepped complexity.

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 Neutrosophic viz. "Approximately 5000", then it can not be called an atomic value.

In this paper authors study this problem and suggest a method to normalize such relational Schemas into 1NF. Such a normal form we shall call by Neutrosophic-1NF or 1NF (N).

2. PRELIMINARIES

Out of several higher order fuzzy sets, Vague sets and Neutrosophic Sets the concept of Neutrosophic sets 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, Author presents some preliminaries on the theory of Neutrosophic sets (NS) which will be required for the progress of this paper. The failure of the RDBMS is due to the presence of imprecise constraints in the query predicate which can not be tackled due to the limitation of the grammar in standard query languages which work on crisp environment only. But these types of queries are very common in business world and in fact more frequent than grammatical-queries, because the users are not always expected to have knowledge of DBMS and the query languages. Consequently, there is a genuine necessity for the different large size organizations, especially for the industries, companies having world wide business, to develop such a system which should be able to answer the users queries posed in natural language, irrespective of the QLs and their grammar, without giving much botheration to the users. Most of these type of queries are not crisp in nature, and involve predicates with fuzzy (or rather vague) data, fuzzy/vague hedges (with concentration or dilation). Thus, these types of queries are not strictly confined within the domains always. The corresponding predicates are not hard as in crisp predicates. Some predicates are soft because of vague/fuzzy nature and thus to answer a query a hard match is not always found from the databases by search, although the query is nice and very real, and should not be ignored or replaced according to the business policy of the industry. To deal with uncertainties in searching match for such queries, fuzzy logic and rather vague logic [7] and Neutrosophic logic by Smarandache [3] will be the appropriate tool.

Fuzzy set theory has been proposed to handle such vagueness by generalizing the notion of membership in a set. Essentially, in a Fuzzy Set (FS) each element is associated with a point-value selected from the unit interval [0,1], which is termed the grade of membership in the set. A Vague Set (VS), as well as an Intuitionistic Fuzzy Set (IFS), is a further generalization of an FS. Now take an example, when we ask the opinion of an expert about certain statement, he or she may say that the possibility that the statement is true is between 0.5 and 0.7, and the statement is false is between 0.2 and 0.4, and the degree that he or she is not sure is between 0.1 and 0.3. Here is another example, suppose there are 10 voters during a voting process. In time t1, three vote "yes", two vote "no" and five are undecided, using neutrosophic notation, it can be expressed as x(0.3,0.5,0.2); in time t2, three vote "yes", two vote "no", two give up and three are undecided, it then can be expressed as x(0.3,0.3,0.2). That is beyond the scope of the intuitionistic fuzzy set. So, the notion of neutrosophic set is more general and overcomes the aforementioned issues. In neutrosophic set, indeterminacy is quantified explicitly and truth membership, indeterminacy-membership and falsity-membership are independent. This assumption is very important in many applications such as information fusion in which we try to combine the data from different sensors. Neutrosophy was introduced by Smarandache [7].

Neutrosophic set is a powerful general formal framework which generalizes the concept of the classic set, fuzzy set [2], Vague set [1] etc.
A neutrosophic set A defined on universe U. x = x(T,I,F) ε A with T,I and F being the real standard or non-standard subsets of]0-,1+[, T is the degree of truth-membership of A, I is the degree of indeterminacy membership of A and F is the degree of falsity-membership of A.

Definition 2.1
A Neutrosophic set A of a set U with $t_A(u)$, $f_A(u)$ and $I_A(u)$, $\forall u \in U$ is called the α- Neutrosophic set of U, where α $\in$ [0,1].

Definition 2.2
A Neutrosophic number (NN) is a Neutrosophic set of the set R of real numbers.
A tuple in a neutrosophic relation is assigned a measure. Will be referred to as the *truth* factor and will be referred to as the *false* factor. The interpretation of this measure is that we believe with confidence and doubt with confidence that the tuple is in the relation. The truth and false confidence factors for a tuple need not add to exactly 1. This allows for incompleteness and inconsistency to be represented. If the truth and false factors add up to less than 1, we have incomplete information regarding the tuple's status in the relation and if the truth and false factors add up to more than 1, we have inconsistent information regarding the tuple's status in the relation.
In contrast to vague relations where the grade of membership of a tuple is fixed, neutrosophic relations bound the grade of membership of a tuple to a subinterval $[\alpha, 1-\beta]$for the case, $\alpha + \beta \leq 1$.. The operators on fuzzy relations can also be generalized for neutrosophic relations. However, any such generalization of operators should maintain the belief system intuition behind neutrosophic relations.
Definition 2.3
A neutrosophic relation on scheme R on $\sum$ is any subset of $\tau(\sum) \times [0,1] \times [0,1]$, Where $\tau(\sum)$ denotes the set of all tuples on any scheme $\sum$.
For any t $\in \tau(\sum)$,we shall denote an element of R as $\langle t, R(t)^+, R(t)^- \rangle$,where , $R(t)^+$ is the truth factor assigned to t by R and $R(t)^-$ is the false factor assigned to t by R.Let V($\sum$) be the set of all neutrosophic relation on $\sum$.

Definition 2.4
A neutrosophic relation on scheme R on $\sum$ is consistent if $R(t)^+ + R(t)^- \leq 1$, for all t $\in \tau(\sum)$ .Let C($\sum$)be the set of all consistent neutrosophic relations on $\sum$ .R is said to be complete if $R(t)^+ + R(t)^- \geq 1$, for all t $\in \tau(\sum)$. If R is both consistent and complete, *i.e.* $R(t)^+ + R(t)^- = 1$, for all t $\in \tau(\sum)$. Then it is a *total* neutrosophic relation, and let T($\sum$) be the set of total neutrosophic relation on $\sum$.

2.1 Operator Generalizations
It is easily seen that neutrosophic relations are a generalization of vague relations, in that for each vague relation there is a neutrosophic relation with the same information content, but not *vice versa*. It is thus natural to think of generalizing the operations on vague relations such as union, join, and projection etc. to neutrosophic relations. However, any such generalization should be intuitive with respect to the belief system model of neutrosophic relations. We now construct a framework for operators on both kinds of relations and introduce two different notions of the generalization relationship among their operators.
An n-ary operator on fuzzy relations with signature $\langle \sum_{1,\ldots\ldots,} \sum_{n+1} \rangle$ is a function Θ :F($\sum_1$) $\times \ldots \times$ F($\sum_n$)→ $\sum_{n+1}$,where $\sum_{1,\ldots,}$ $\sum_{n+1}$ are any schemes. Similarly An n-ary operator on neutrosophic relations with signature $\langle \sum_{1,\ldots\ldots,} \sum_{n+1} \rangle$ is a function Ψ :V($\sum_1$) $\times \ldots \times$ V($\sum_n$)→V($\sum_{n+1}$).
Definition 2.5
An operator Ψ on neutrosophic relations with signature $\langle \sum_{1,\ldots\ldots,} \sum_{n+1} \rangle$ is *totality preserving* if for any total neutrosophic relations $R_{1,\ldots}R_n$ on schemes $\sum_{1,\ldots,}$ $\sum_{n+1}$, respectively. Ψ ($R_{1,\ldots}R_n$) is also total.
Definition 2.6
A totality preserving operator Ψ on neutrosophic relations with signature $\langle \sum_{1,\ldots\ldots,} \sum_{n+1} \rangle$ is a *weak generalization* of an operator Θ on fuzzy relations with the same signature, if for any total neutrosophic relations $R_{1,\ldots}R_n$ on schemes $\sum_{1,\ldots,}$ $\sum_n$, respectively ,we have

$$\lambda_{\sum n+1}(\Psi(R_{1,\ldots}R_n)) = \Theta(\lambda_{\sum 1}(R_1),\ldots.., \lambda_{\sum n}(R_n)).$$

The above definition essentially requires Ψ to coincide with Θ on total neutrosophic relations (which are in One-one correspondence with the vague relations). In general, there may be many operators on neutrosophic relations that are weak generalizations of a given operator Θ on fuzzy relations. The behavior of the weak generalizations of Θ on even just the consistent neutrosophic relations may in general vary. We require a stronger notion of operator generalization under which, at least when restricted to consistent neutrosophic relations, the behavior of all the generalized operators is the same. Before we can develop such a notion, we need that of 'representation' of a neutrosophic relation.
We associate with a consistent neutrosophic relation R the set of all (vague relations corresponding to) total neutrosophic relations obtainable from R by filling the gaps between the truth and false factors for each tuple. Let the map be $reps_{\sum}$:C($\sum$)→$2^{F(\sum)}$.is given by ,

$$reps_{\sum}(R)=\{Q \in F(\sum) \mid \Lambda_{t_i \in \tau(\sum)} (R(t_i)^+ \leq Q(t_i) \leq 1-R(t_i)^-)\}.$$

The set $reps_{\sum}$(R) contains all fuzzy relations that are 'completions' of the consistent neutrosophic relation R .Observe that $reps_{\sum}$ is defined only for consistent neutrosophic relations and produces sets of fuzzy relations. Then we have following observation.
Proposition 2.1 For any consistent neutrosophic relation R on scheme $\sum$, $reps_{\sum}$ (R) is the singleton { $\lambda_{\sum}$ (R)}, iff R is total.
Proposition 2.2 If Ψ is a strong generalization of Θ , then Ψ is also a weak generalization of Θ.

2.2 Generalized Algebra on Neutrosophic Relations

In this section, we present one strong generalization each for the vague relation operators such as union, join, and projection. To reflect generalization, a hat is placed over a vague relation operator to obtain the corresponding neutrosophic relation operator. For example, ∞ denotes the natural join among fuzzy relations, and $\hat{\infty}$ denotes natural join on neutrosophic relations. These generalized operators maintain the truth system intuition behind neutrosophic relations.

2.3 Set-Theoretic Operators

We first generalize the two fundamental set-theoretic operators, union and complement.

Definition 2.7 Let R and S be neutrosophic relations on scheme $\sum$. Then, The union of R and S, denoted R $\hat{\cup}$ S , is a neutrosophic relation on scheme $\sum$,given by

R $\hat{\cup}$ S=

$$\left\langle \max\{R(t)^{+}, S(t)^{+}\}, \min\{R(t)^{-}, S(t)^{-}\} \right\rangle \text{ for}$$

any t $\in \tau(\sum)$.

(a) The complement of R ,denoted by $\hat{-}$R ,is a neutrosophic relation on scheme $\sum$,given by

$(\hat{-}R)(t)=\langle R(t)^{+},R(t)^{-} \rangle$,for any t $\in \tau(\sum)$.

An intuitive appreciation of the union operator can be obtained as follows: Given a tuple *t*, since we believed that it is present in the relation *R* with confidence $R(t)^+$ and that it is present in the relation *S* with confidence $S(t)^+$, we can now believe that the tuple *t* is present in the "either -*R* or - *S* " relation with confidence which is equal to the larger of $R(t)^+$ and $S(t)^+$. Using the same logic, we can now believe in the absence of the tuple *t* from the "either - *R* - or - *S* " relation with confidence which is equal to the smaller (because *t* must be absent from both *R* and *S* for it to be absent from the union) of $R(t)^-$ and $S(t)^-$.

Proposition 2.3 : The operator $\hat{\cup}$ and $\hat{-}$ on neutrosophic relation are strong generalization of the operators $\cup$ and unary – on vague relations.

Definition 2.8 Let R and S be neutrosophic relations on scheme $\sum$. Then, The intersection of R and S denoted as $\hat{\cap}$, is a neutrosophic relation on scheme $\sum$,given by

$$R \hat{\cap} S(t)=\langle \min\{R(t)^{+},S(t)^{+}\},\max\{R(t)^{-},S(t)^{-}\} \rangle \text{, for any}$$

t $\in \tau(\sum)$ .The difference of R and S denoted as R $\hat{-}$ S, neutrosophic relation on scheme $\sum$,given by

$$(R \hat{-} S)(t) =\langle \min\{R(t)^{+},S(t)^{-}\},\max\{R(t)^{-},S(t)^{+}\} \rangle ,$$

any t $\in \tau(\sum)$.

The following proposition relates the intersection difference operators in terms of the more fundamental theoretic operators union and complement.

Proposition 2.4 : For any neutrosophic relation on the sa scheme

$$R \hat{\cap} S = \hat{-}(\hat{-}R \hat{\cup} \hat{-}S) \text{ and}$$

$$R \hat{-} S = \hat{-}(\hat{-}R \hat{\cup} S).$$

The important issue of closeness can not be addressed with the crisp mathematics. That is why author have used the Neutrosophic tools[1].

3. NEUTROSOPHIC-1NF OR 1NF (N)

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

A_1	A_2	A_3	A_4

Table 1:Relational Schema R

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

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 2

Suppose that $A_{\tilde{2}}$ is the primary key here, all the data are precise except $\tilde{a}$, which is an Neutrosophic number. Thus all the data except $\tilde{a}$ is atomic. This is not in 1NF because of the non atomic data $\tilde{a}$ **.**

An Neutrosophic number is an Neutrosophic 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: {x1, x_2,.. x_n} and the Neutrosophic number $\tilde{a}$,
Proposed by a database expert is an NS (Neutrosophic Set) given by:

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

Then theTable2 can be replaced by the following table:

A_1	A_2	A_3	A_4
A_{11}	A_{21}	A_{31}	A_{41}
A_{12}	A_{22}	A_{32}	$\{(X_i , \mu_i, V_i),(X_1, \mu_1,V_1),\ldots\ldots\ldots..(X_n, \mu_n,V_N)\}$
A_{13}	A_{23}	A_{33}	A_{43}
A_{14}	A_{24}	A_{34}	A_{44}

Table 3: The Relation Instance r

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

A_1	A_2	A_3	A_4
A_{11}	A_{21}	A_{31}	A_{41}
A_{12}	A_{22}	A_{32}	A_{42}
A_{13}	A_{23}	A_{33}	A_{43}
A_{14}	A_{24}	A_{34}	A_{44}

Table 4: The Relation r_1

In table 5 we have all the attributes of the primary-key of r (here only one attribute A_2), the Neutrosophic 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.

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_4
A_{23}	**A_{43}**	**1**	0
A_{24}	A_{44}	1	0

Table 5: The Relation r_2

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

4. RESULTS

We study the method here by an example with hypothetical data. Consider a relation schema FRUIT as shown below whose primary key is FCODE and the attribute YEARLY-PRODUCTION is an Neutrosophic attribute.

FNAME	FCODE	YEARLY-PRODUCTION (in million of tones)

Table 6: The Relation Schema FRUIT

Consider a relation instance of this relation schema given by the following Table 7

FNAME	FCODE	YEARLY-PRODUCTION (in million of tones)
APPLE	**F001**	4563
MANGO	**F002**	6789
GUAVA	**F003**	Approximately 56
BANANA	F004	8987

Table 7

In this instance FNAME and FCODE are crisp attribute whereas YEARLY-PRODUCTION is attribute values for FNAME are atomic; all the attribute values for the attribute FCODE are atomic. But all the attribute values for the attribute Yearly Production are not atomic. The data" approximately 56" is an Neutrosophic number $\tilde{56}$.Suppose that for this relation, a database expert proposes the Neutrosophic number $\tilde{56}$ as an NS given by $\tilde{56}$ ={**(55,.8,.1),(56,.9,.03),(56.5,.7,.10)}.**

Therefore Table 7 could be replaced by the following Table 8

FNAME	FCODE	YEARLY-PRODUCTION (in million of tones)
APPLE	**F001**	4563
MANGO	**F002**	6789
GUAVA	**F003**	**{**(55,.8,.1),(56,.9,.03),(56.5,.7,.10)}
BANANA	F004	8987

Table 8

Now remove the Neutrosophic attribute YEARLY-PRODUCTION (YP) for this instance and divide it into two relations given as:

FNAME	FCODE
APPLE	F001
MANGO	F002
GUAVA	F003
BANANA	F004

Table 9: FRUIT-1 Relation

FCODE	YP	MV(YP)	NMV(YP)
F001	**4563**	**1**	0
F002	**6789**	**1**	0
F003	**55**	**.8**	.1
F003	**56**	**.9**	.03
F003	**56.5**	**.7**	.10
F004	8987	1	0

Table 10: FRUIT-2 Relation

Clearly, it is now in 1NF, called by 1NF (N). For FRUIT-1, the Primary Key is FCODE, but for the newly created FRUIT-2 the Primary Key is {FCODE, YP}. Let us present below the sequence of steps for Neutrosophic normalization of relation schema into **1NF(N).**

5. ALGORITHM

(l) Remove all the Neutrosophic-attributes from the relation.
(2) For each Neutrosophic-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 Neutrosophic attribute put MV=1 and NMV=0.

Thus, if there is m number of attributes in the relation schema then, after normalization there will be in total (m+l) number of relations .In special case, when the hesitation or in deterministic parts are nil for every element of the universe of discourse the Neutrosophic number reduces to fuzzy number. In such cases, the attribute NMV (Z) will not be required in any reduced tables of 1NF.In future work I will consider this part.

6. CONCLUSION

In this paper we have presented a method of normalization of a relational schema with Neutrosophic attribute in 1NF (N). We have implemented the method by an example given in section 4 which proves that how the imprecise data can be handle in relational schema using First Normal Form of Neutrosophic databases. We claim that the algorithm suggested in section 5 is totally a new concept which can easily handle the neutrosophic attributes of First normal Form.

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Author Biographies

Ms. Smita Rajpal is working as an Assistant Professor Computer Science and Engineering at ITM University, Gurgaon (India). She is specialized in Soft Computing and RDBMS. She is a Life Time member of ISTE, SCIP, IACSIT, WASET. She is working as an Editor / Reviewer/Technical member of various International Journals and Conferences. She is an active member of IEEE. Her biography is a part of Marquis who's who in 2010.Her total Research publications are 18 and book chapters -5. She has published two books.

Ms. Pariza Kamboj is working as an Assistant Professor Computer Science & Engg. at ITM university, Gurgaon (India). She is specialised in Mobile Ad hoc Networks and Soft Computing. Currently she is pursuing her Ph.D. in Computer science. She has published a total of 14 research papers in various International/ National Journals and Conferences. She is a Life time member of Indian Society of Technical Education (ISTE) and International Association of Computer Science and Information Technology (IACSIT). She is also serving as an Reviewer /Editor/Technical Member of various International Committee and Journals.