American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-4, Issue-8, pp-179-185
www.ajer.org
Research Paper Open Access

Innovative Concepts of Fuzzy logic which Improve the Human and Organizational Capabilities

Mehzabul Hoque Nahid[1]
[1](Faculty coordinator, Computer science and engineering Department, Royal University of Dhaka, Bangladesh)

ABSTRACT: *This thesis has been realized following a design science approach, it therefore aims at first creating innovative concepts which improve the actual human and organizational capabilities, secondly, at evaluating these concepts by providing concrete instantiations. According to this research paradigm, the objectives of this thesis are the following: The first objective of this thesis is to extend the querying ability of the fuzzy classification approach proposed by Schindler. By adding new clauses to the fuzzy Classification Query Language, the user should be given more powerful means for selecting elements within a fuzzy classification. The second objective of this thesis is convert classical value to fuzzy value which base on fuzzy membership function such as S shape membership function, Pi shape membership function and Z shape membership junction. The third objective is, considering the application domain specificities, to extend the original fuzzy queries approach by new concepts which provide additional capabilities to the system and proved that the proposed intelligent fuzzy query is faster than the conventional query and it provides the user the flexibility to query the database using natural language. The fourth and last objective is to also make a comparison between traditional database and fuzzy database by computing the time cost of classical query over classical database, fuzzy query over classical database and fuzzy query over fuzzy database.*

Keywords – *Fuzzy Database, Query, Boolean, Set, Function.*

I. CONCEPT OF FUZZY SETS

The fuzzy logic theory is based on fuzzy sets which are a natural extension of the classical set theory. A sharp set (also called crisp set) is defined by a bivalent truth function which only accepts the values 0 and 1 meaning that an element fully belongs to a set or does not at all, whereas a fuzzy set is determined by a membership function which accepts all the intermediate values between 0 and 1[1]. The values of a membership function, called membership degrees or grades of membership, precisely specify to what extent an element belongs to a fuzzy set, i.e. to the concept it represents. A fuzzy set is built from a reference set called universe of discourse. The reference set is never fuzzy. Assume that *U = fx*1*; x*2*; : : : ; xng* is the universe of discourse, then a fuzzy set A in U (*A ½ U*) is defined as a set of ordered pairs

f (*xi; ¹A*(*xi*))*g*

Where *xi 2 U*, *¹A: U!* [0*;* 1] is the membership function of A and *¹A*(*x*) *2* [0*;* 1] is the degree of membership of x in A.

Consider the universe of discourse *U = f*1*;* 2*;* 3*;* 4*;* 5*;* 6*g*. Then a fuzzy set A holding the concept 'large number' can be represented as

A = f (1*;* 0)*;* (2*;* 0)*;* (3*;* 0*:*2)*;* (4*;* 0*:*5)*;* (5*;* 0*:*8)*;* (6*;* 1) *g*

With the considered universe, the numbers 1 and 2 are not 'large numbers', i.e. the membership degrees equal 0. Numbers 3 to 5 partially belong to the concept 'large number' with a membership degree of 0.2, 0.5 and 0.8. Finally number 6 is a large number with a full membership degree [2]. It is important to note that the definition of the membership degrees is subjective and context dependent, meaning that each person has his own perception of the concept 'large number' and that the interpretation is dependent on the universe of discourse and the context in which the fuzzy set is used. In Example 2.2 for instance, the membership degrees of the elements would be quite different if the universe of discourse contained numbers up to 100 or even 1000. In a similar manner, the concept 'large profit' would have a distinct signification for a small and a large enterprise. Fuzzy sets are commonly represented by a membership function. Depending on the reference set, the membership functions are either discrete or continuous. Figure 2.3 shows the truth function of a sharp set in comparison to the membership functions of a discrete and a continuous fuzzy set.

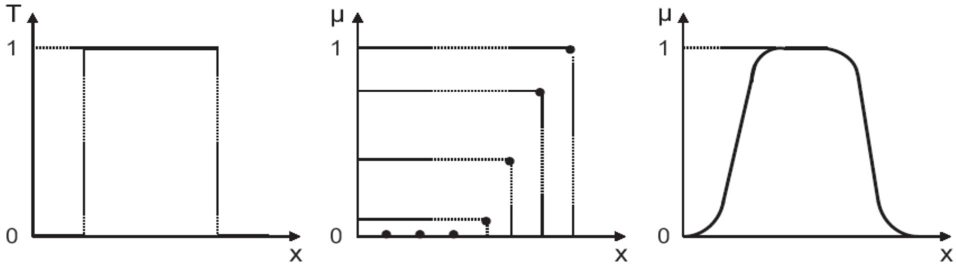

Figure 1: Truth function of a sharp set and membership functions of a discrete and a continuous fuzzy set

Usually, several fuzzy sets are defined on the same reference set forming a fuzzy partition of the universe. A linguistic expression from the natural language can label the fuzzy sets in order to express their semantics. In the case the reference set can hold the concepts 'young', 'middle-aged' and 'old' at the same time allowing a continuous transition between them (see Figure 2). This construct is essential in the fuzzy logic theory and is called a linguistic variable [3]. A linguistic variable is a variable whose values are words or sentences instead of numerical values. These values are called terms (also linguistic or verbal terms) and are represented by fuzzy sets.
A linguistic variable is characterized by a quintuple

$$(X; T; U; G; M)$$

where X is the name of the variable, T is the set of terms of X, U is the universe of discourse, G is a syntactic rule for generating the name of the terms and M is a semantic rule for associating each term with its meaning, i.e. a fuzzy set defined on U.

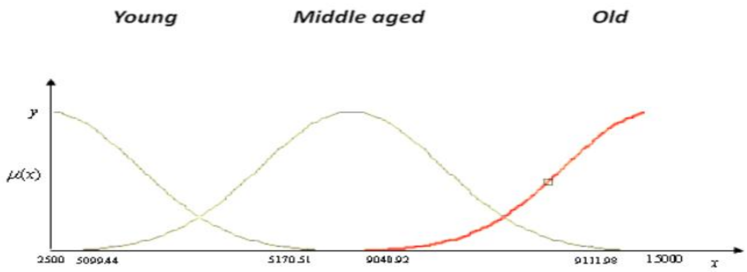

Figure 2: Fuzzy partition of the reference set with labeled fuzzy sets

The ability of giving a partial belonging to the elements allows a continuous transition between the fuzzy sets instead of having sharply fixed boundaries. This way, it is possible to better reflect the reality where everything is not black or white but often differentiated by grey values. The definition of a fuzzy set can therefore adequately express the subjectivity and the imprecision of the human thinking. Furthermore, the concept of linguistic variable is the basis for representing the human knowledge with within human oriented rules or queries which can be processed by computers.

II. FUZZY VS BOOLEAN

Fuzzy logic is extension of normal Boolean logic, which is extended to identifier partially truth. What means, something between absolute truth and absolute false. Advantage of fuzzy logic is mathematical ability catch up information described by words. This gives us possibility to work with ambiguous term like “small”, “near”, “far”, “about”, “very” and with number of other words used in human language. Basic problem is, how to handle words, which meaning is hard to define. Is close 50m, 100m or 1 kilometer. If 50m is close, so 51m is not? Is it far? Exactly number of ambiguous in common language represents problem, which cannot be solved by Boolean logic. To learn computer systems human speech, it is necessary to solve this problem. Fuzzy sets are probably one of solution. Boolean logic model become basement form of classic querying languages among which belong SQL (Structured Query Language)[4]. Boolean algebra brings logic operators and (conjunction), or (disjunction), and not (negation). By using these operators when searching with imprecise or not complete

information, it is not ensured that we get requested data. By using AND, some inaccuracy resides in problem of results, because information which do not match one of conditions or more than one conditions are the same. There is no differences between information, which meet different number of conditions in query.
Disadvantage of strict evaluations AND operator express in this situation: User is looking for information and he is sure that information exist in database. Conditions, which exactly identify searching data are composed into query using and operator. If user enters only one wrong condition, than result will not include requested information. User has to do corrections in his query. If there are no information meeting query conditions, than user will be pleased if he gets information which meet conditions with some degree. That is hardly handled by classic approach. In case of operator OR, there is no chance to differentiate information matching different number of conditions. Result consists of data, which meet one condition or two and more conditions. This can leads to huge number of tuples among which is wanted tuple.
Empirical research shows, that strict form of evaluation Boolean operators do not match human thinking, appreciation and decision. Human tolerance, displayed by do not eliminating solutions, which do not meet all his conditions is in contrast to strict evaluation and operator [5].
Basic difference between fuzzy approach and Boolean one is ability to get rated result, which can be ordered by real number from <0, 1> interval. User has chance to deal only by the most valuable information, what is not possible to handle by Boolean logic. Next difference is direct in query, where fuzzy statement can be used. It is allowed to use words like average, big, far, near.

III. PROPERTIES OF FUZZY SET

As the fuzzy set theory is an extension of the classical set theory, crisp sets are specific cases of the fuzzy sets. For this reason, the existing properties of the classical sets have to be extended and some new properties are introduced [6]. Among the extended properties of the classical sets are the definitions of emptiness, equality, inclusion and cardinality. In order to take the wider scope of the fuzzy sets into account, the definitions of convexity, support, ®-cut, kernel, width, height and normalization have been introduced.

A fuzzy set is considered to be empty if the membership degrees of all the elements of the universe are equal to zero.
A fuzzy set A, defined over a reference set U, is empty if

$$A = ?\ ,\ {}^{1}A(x) = 0;\ 8x\ 2\ U$$

Two fuzzy sets are equal if their membership degrees are equal for all the elements of the reference set, i.e. if the two fuzzy sets have the same membership function. The support of a fuzzy set A defined over a reference set U is a crisp subset of U that complies with

$$Supp(A) = fx\ 2\ U;\ {}^{1}A(x) > 0g$$

The ®-cut, resp. the strong ®-cut, of a fuzzy set is the crisp subset of the universe where the membership degrees are greater or equal, resp. greater, than the specified ® value.

IV. FUZZY MEMBERSHIP FUNCTION

The membership function values need not always be described by discrete values. Quite often these turn out to be as described by a continuous function. We know different types of fuzzy membership function such as S shape, Z shape, Pi shape, Trapezoidal, Triangle, Singleton membership function. But in this paper we use three membership function S shape, Z shape, and Pi shape membership function.

zmf - Z-shaped built-in membership function**,** this paper we classify this membership function in three linguistic terms such as S1= *very low*, S2= ***low*** and S3= *not so low*.

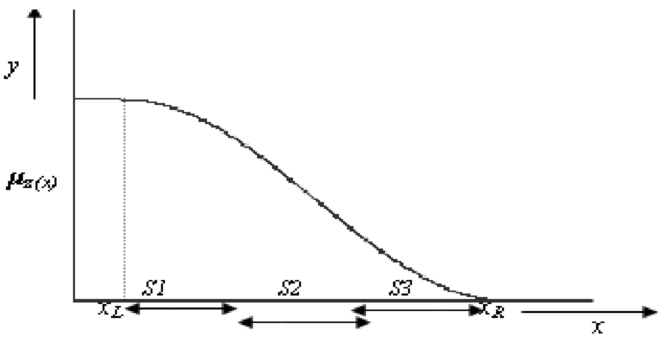

Figure 3: Z-shaped membership function

$$y_z = \begin{cases} \frac{1}{2} + \frac{1}{2}\cos\left(\frac{x_R - x}{x_R - x_L}\right)\pi, & \text{if } x_L \le x \le x_R \\ 0 & \text{if } x > x_R \\ 1 & \text{if } x < x_L \end{cases}$$

smf - S-shaped built-in membership function, this paper we classify S membership function in three linguistic terms such as S1= not so high, S2= high and S3= very high.

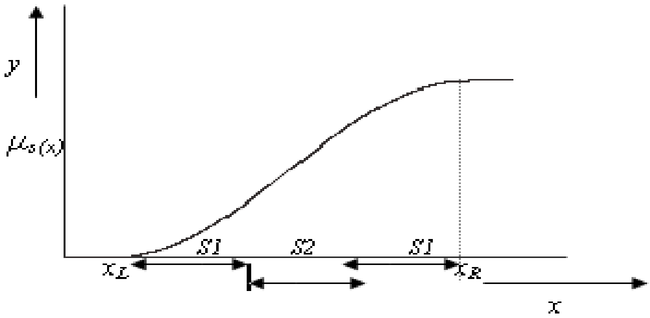

Figure 4: *S*-shaped membership function

$$y_s = \begin{cases} \frac{1}{2} + \frac{1}{2}\cos\left(\frac{x - x_L}{x_R - x_L}\right)\pi, & \text{if } x_L \le x \le x_R \\ 0 & \text{if } x < x_R \\ 1 & \text{if } x > x_R \end{cases}$$

pimf - Π-shaped built-in membership function, In this paper we classify this membership function in three linguistic terms such as XL,XR= not so medium, S1= medium and S3= very medium

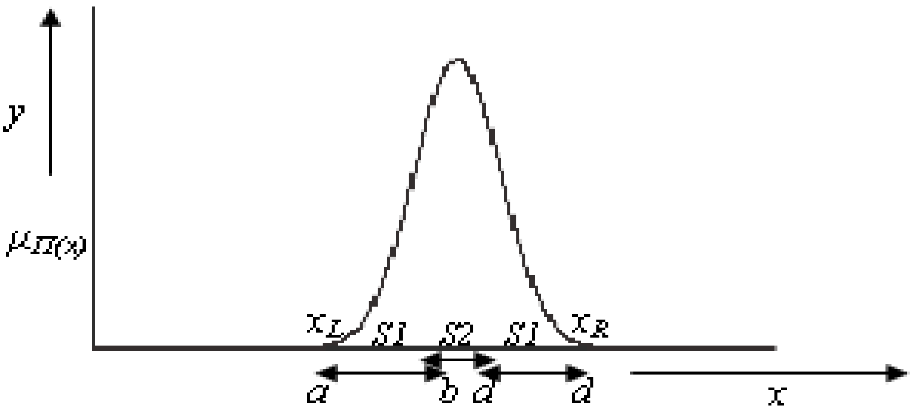

Figure 5: Pi-shaped membership function

$y_{\pi} \quad = (x, [a,b,c,d]\ )$

$$y_s = \begin{cases} 0 & \text{if } x = a \text{ or } x = d \\ 2\left(\dfrac{x-a}{b-a}\right)^2 & \text{if } a < x \le \dfrac{a+b}{2} \\ 1-2\left(\dfrac{x-b}{b-a}\right)^2 & \text{if } \dfrac{a+b}{2} < x < b \\ 1-2\left(\dfrac{x-c}{d-c}\right)^2 & \text{if } c < x \le \dfrac{c+d}{2} \\ 2\left(\dfrac{x-d}{d-c}\right)^2 & \text{if } \dfrac{c+d}{2} < x < d \\ 1 & \text{if } b \le x \le c \end{cases}$$

V. OPERATION OF FUZZY LOGIC

The operations of complement, intersection and union of the classical set theory can also be generalized for the fuzzy sets. For these operations, several definitions with different implications exist. This section only presents the most common operators from the Zadeh's original proposition [7]

The complement of a fuzzy set is 1 minus the membership degrees of the elements of the universe. This definition respects the notion of strong negation.

The complement of a fuzzy set a defined over a reference set U is defined as

$$\sim A = {}^1\!\sim\! A(x) = 1 \text{ ¡ } {}^1A(x);\ x\ 2\ U$$

For the intersection (resp. the union), Zadeh proposes to use the minimum operator (resp. the maximum operator). These operators have the advantages of being easily understandable and very fast to compute. The intersection (resp. the union) of two fuzzy sets is the minimum (resp. the maximum) value of the membership degrees of the two fuzzy sets for all the elements of the reference set.

The intersection of two fuzzy sets A and B defined over a reference set U is defined as

$$A \setminus B = {}^1A\backslash B(x) = {}^1A(x) \wedge {}^1B(x) = min\ ({}^1A(x);\ {}^1B(x));\ x\ 2\ U$$

The union of two fuzzy sets A and B defined over a reference set U is defined as

$$A\ [B = {}^1A\ [B(x) = {}^1A(x)\ \_\ {}^1B(x) = max\ ({}^1A(x);\ {}^1B(x));\ x\ 2\ U$$

Based on the intersection definition of two fuzzy sets, it is possible to introduce the notion of possibility (also called consistency or consensus) which is the fundament of the possibility theory which is briefly treated in Subsection 2.5.1. The possibility of two fuzzy sets, which determines the agreement degree between the concepts represented by the fuzzy sets, measures to what extent the fuzzy sets superpose each other and is defined as the highest membership degree of the intersection of these two fuzzy sets. In the case of Zadeh's definition of the intersection this operation is called the max-min operation since it considers the maximum of the minimum values of the fuzzy sets.

VI. APPLICATIOS FIELD

The fuzzy set theory has been successfully applied in various domains. The most important application areas are the fuzzy control, the fuzzy diagnosis, the fuzzy data analysis and the fuzzy classification. This section aims to explicit the implication of the fuzzy set theory in some of these domains [8]. First, Subsection introduces the possibility theory as a basis for the approximate reasoning which allows the integration of the natural language into the reasoning process. Based on the approximate reasoning, Subsection presents the fuzzy control theory in comparison to the modern control theory. Examples of fuzzy diagnosis and fuzzy data analysis areas are fuzzy expert systems depicted in Subsection and the fuzzy classification approach presented [9] Last but not least, Subsection presents different approaches which enable the representation and the storage of the imprecision, i.e. fuzzy databases systems.

Nowadays a large number of real-world applications take advantages of the approximate reasoning. Many other applications fields could have been discussed like the neural networks, the genetic algorithms, the evolutionary programming, the chaos theory, etc., but their presentation is beyond the scope of this thesis.

VII. Query Cost of Classical Query Over Classical Database

The necessary steps require to retrieve a record from classical database by suing fuzzy queries, this are given below,

```
Procedure find (value V)
    Set C=root node
    While C is not a leaf node begin

        Let Ki=smallest search key value, in any greater than V

        If there is no such value then begin

            Let m= the number of pointers in the node

            Set C= node pointed to by Pm

        End

            Else set C=the node pointed to by Pi

    End

    If there is a key value Ki in C such that Ki=V

        Then pointer Pi directs us to the desired record

        Else no record with key value k exists

    End procedure.
```

For example, the fuzzy query

Q "fined the all account numbers whose balance is very high"

The output of this query statement is shown in Table 1

Table 1: Output of query statement Q.1

A_no	A_name	B_name	Balance	F_Balance	L_Balance
2008	Karim	Chittagong	25000	1	Very high

In our example, k=2, n=4, m=1.

$$\text{The query cost} = \left(\log\left[\frac{4}{2}\right]2+1\right)\times(4+0.1)$$

$$= (1+1)\times(4+0.1)$$

$$= 2\times 4.1$$

$$= 8.2\text{ms}$$

As a result we can say that, classical query over classical database and fuzzy query over classical database require the same time for search a key. But our propose implication fuzzy query over fuzzy database reduce time for search a key.

VIII. Conclusion

Recently there exists a huge application of fuzzy sets and their properties and one of those is databases. Fuzzy sets represent basement of fuzzy database systems, which lead to further step of joining computer systems and human. They bring opportunity to query data by language close to human speech. This paper focuses on fuzzy query. We explained fuzzy sets, fuzzy logic form of storage fuzzy data, parallelism of query operators and fuzzy SQL. Current fuzzy database systems are extension to actual database systems, which allows applying fuzzy terms into the systems using Boolean logic. This paper designs classical query in classical database, fuzzy query in classical database and fuzzy query in fuzzy database and calculates the query cost. In classical database system, it has only one index file to save the information. If search a record in classical database, it search the approximately n records. As a result it requires more time than other query. Fuzzy query in classical database requires the same time as the classical query in classical database. This research proposes implication of fuzzy query in fuzzy database and creation of nine index files to save the records.. So if any record is required that is represented by the linguistic term not so moderate then it directly goes to not so moderate index file. So extra time to compute fuzzy value is not killed during search any record from the database. So, we can say that, searching time of one record from the fuzzy database using fuzzy query is also reduced. This time is more effective when the database is so large and the node size is also large.

IX. Acknowledgements

We are earnestly grateful to one our group member, Md. Galib Anwar, Graduated, Department of EEE, American International University-Bangladesh. For providing us with his special advice and guidance for this project. Finally, we express our heartiest gratefulness to the Almighty and our parents who have courageous throughout our work of the project.

REFERENCES

[1] Ndress Meier, Nicolas Werro, Martain Albrecht, Fuzzy Classification Query Language for Customer Relationship Management.
[2] Liberios Vokorokos, Anton Balaz, Norber Adam, Parallelism in fuzzy Database, Teach media, 5th Edition, 5th Edition, 2006.
[3] A. H. M. Sejedul Haque , Data Mining using Fuzzy Associative Rules.
[4] Rabindra Nath Shil & Subash Chandra Debnath, An Introduction to the Theory of Statistics.
[5] N. Werro, A. Meier, C. Mezger, and G. Schindler. Concept and Implementation of a Fuzzy Classification Query Language. In Proceedings of the International Conference on Data Mining, DMIN 2005, World Congress in Applied Computing, pages 208_214, Las Vegas, USA, June2005.
[6] N. Werro, H. Stormer, and A. Meier. Personalized Discount _ A Fuzzy Logic Approach. In Proceedings of the 5th International Federation for Information Processing Conference on eBusiness, eCommerce and eGovernment, I3E 2005, pages 375_387, Poznan, Poland, October 2005.
[7] Y. Takahashi. A Fuzzy Query Language for Relational Databases. In P. Bosc and J. Kacprzyk, editors, Fuzziness in Database Management Systems, volume 5 of Studies in Fuzziness, pages 365_384. Physica Publisher, Heidelberg, 1995.
[8] A. Meier, C. Savary, G. Schindler, and Y. Veryha. Database Schema with Fuzzy Classification and Classification Query Language. In Proceedings of the International Congress on Computational Intelligence _ Methods and Applications, CIMA 2001, pages 1-7, Bangor, UK, June 2001.
[9] A. Meier, G. Schindler, and N. Werro. Fuzzy Classification on Relational Databases. In J. Galindo, editor, Handbook of Research on Fuzzy Information Processing