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HANDLING PRIORITY WITHIN A DATABASE SCENARIO

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Abstract. *The concept of priority is often used in real time systems. Priority t-norms are used to capture this concept. System called Prioritized fuzzy constraint satisfaction problems (pFCSP) uses priority t-norms. Usually, pFCSPs are used to model the concept of priority in real time systems In this paper we tested a pFCSP on a database scenario.*

1. INTRODUCTION

Priority is implemented within Prioritized fuzzy constraint satisfaction problem (pFCSP). pFCSP is actually a fuzzy constraint satisfaction problem (FCSP) in which the notion of priority is introduced. Perhaps, the key factors in that implementation are priority t-norms. They are introduced in such a way that the smallest value, usually the value with the biggest priority, has the largest impact on the result given by a priority t-norm. It is introduced by an axiomatic framework.

An aplication in Fuzzy relational databases is introduced in this paper.

2. PRELIMINARIES

In order to introduce pFCSP, let us define FCSP.

Definition 1 *A fuzzy constraint satisfaction problem (FCSP) is defined as a 3-tuple* (X, D, C^f) *where:*

1. $X = \{x_i | i = 1, 2, \cdots, n\}$ *is a set of variables.*
2. $D = \{d_i | i = 1, 2, \cdots, n\}$ *is a finite set of domains. Each domain* d_i *is a finite set containing the possible values for the corresponding variable* x_i *in* X.
3. C^f *is a set of fuzzy constraints. That is,*

$$C^f = \{R^f | \mu_{R_i^f} : (\prod_{x_j \in var(R_i^f)} d_j) \to [0, 1]$$

where $i = 1, 2, \cdots n\}$.

Now, we will shortly describe the axiomatic framework used for pFCSP. The first axiom states that a zero value of the local satisfaction degree of the constraint with the maximum priority implies a zero value of the local satisfaction degree. The second axiom states that, in the case of equal priorities, the pFCSP becomes a FCSP.

The third axiom captures the notion of the priority. If one constraint has a larger priority then, the increase of the value on that constraint should result in a bigger increase of the global satisfaction degree than when the value with the smaller priority has the same increase. It captures the concept of priority in a linear sense. For example take two investments where one of them results in a bigger profit (larger priority) then it is expected that it is better to invest in a more profitable investment then in a less profitable one, if the profit increase is linear to the investment sum. One of the interesting facts is the min-max system which is used most often in engineering does not satisfy the changed Axiom 3. On the other hand when the t-norm T_L is used together with the s-norm S_P we obtain the system that satisfies axiomatic framework 2. The global satisfaction degree in this system is calculated using the following formula:

$$\alpha_\rho(v_X) = \bigoplus_M \{ \frac{\rho(R^f)}{\rho_{max}} \diamond_M \mu_{R_i^f}(v_{var(R^f)}) | R^f \in C^f \},$$

where $\bigoplus_M(x, y) = T_L(x, y)$, and $\diamond_M(x, y) = S_P(1 - x, y)$.

The fourth axiom is the monotonicity property, and finally the fifth is the upper boundary condition.

Now, describe how a pFCSP works. Priority of every constraint R_f is evaluated by function $\rho : C_f \to [0, \infty)$. The larger the value of ρ is the larger the priority. After the normalization of the priority values which is done by dividing each priority by $\rho_{\max} = \max\{\rho(R_f), R_f \in C_f\}$ every priority gets a value in the unit interval. Standard implication aggregates priority of each constraint with its value. This is done in a way that the larger the priority, the more chance it has for the resulting value to stay the same as it was before aggregation. If the priority of constraint is small, then the aggregated value is closer to 1. This leads to greater values for constraints with the smaller priority. It makes sense, since when these aggregated values are again aggregated with a Schur-concave t-norm T, the smaller values have more impact on the result due to properties of Schur-concave t-norms. In [5], it has been proved that a concrete pFCSP the previously given axioms. Now we will describe how the global satisfaction degree of this system is calculated.

The function ρ represents the priority of each constraint. Operator $\diamond$ aggregates priority of each constraint with the value of that constraint. These are then aggregated by the operator $\bigoplus$, which results in the satisfaction degree of an evaluation.

In order to expand classical relational databases to model impression fuzzy relational databases (FRDB) are introduced. Classical databases store only precise information. For example if a persons height is not known but it is known that a person is a tall person classical databases cannot store this information. On the other hand FRDB through the concept of linguistic labels can have the value *tall* for attribute *height*. Besides storing imprecise values FRDB through FSQL can answer a broader set of queries. Take for example queries: *I need students* *of medium height that have good marks in PE* or *Give me people with average salaries and small housing capacity* etc.

Now we will see how data is stored in FRDB. In the model introduced in [1] two types of data are introduced:

1) Traditional database - traditional data with crisp and/or fuzzy attributes

2) Fuzzy meta knowledge base - information about attributes and their relations is stored in a relational format

Now we will give a short preview of FSQL. The main extensions of classical SQL are:

- linguistic labels: each label has a possibility distribution or a similarity relation with other labels. Mostly, trapezoidal possibility distributions are used.
- fuzzy comparators: fuzzy equal, fuzzy greater or lower etc. that can be either necessity or possibility comparators.
- fulfillment threshold: a value in the unit interval indicating that the condition should be fulfilled to a minimum degree
- fuzzy constants: unknown, undefined, trapezoidal values, approximately n, range [m,n] and null.

3. IMPLEMENTING pFSQL

Now we will give an idea how to implement priority queries into FRDB using pFSQL. This concept can be easily incorporated into FRDB. For example queries of type:

SELECT * FROM People
WHERE Height FEQ tall WITH priority HIGH
AND IQ GEQ 100 WITH priority MEDIUM
AND Sex EQ Male WITH priority LOW

can be handled in pFSQL. Fuzzy linguistic labels of an attribute are stored as triangular or trapezoidal fuzzy numbers on a particular domain. We will now describe a few interesting cases of handling priority fuzzy queries in FRDB. When a query is proccesed on a database each data row gets a value in the unit interval. This value is calculated based on the row attribute values. we need to distinguish several cases. If there are no fuzzy values pFSQL works the same as SQL. If there are fuzzy attribute values and crisp query constraints then the result obtained for that attribute is actually the possibility that this attribute value satisfies this condition. For fuzzy query constraints we find the membership function values of the crisp value. If both constrain and attribute value are fuzzy then we obtain the similarity relation stored in meta knowledge base. Each term is then aggregated with priority values using a pFCSP in order to obtain the final evaluation for this data row.

There are many technical and implementations details to be done in order for this concept to be implemented but we hope that they will be solved and we will have a pFSQL i.e. FSQL that can handle priority queries. A model of of fuzzy relational databases i.e databases that accept fuzzy atribute values (e.g. height=tall) is in the making process together with pFSQL, a meta language and data mining tool that queries fuzzy databases.

4. EXAMPLE

Imagine that our database consists of cars with fields model, price, comfort and size. Price is given in money (integer between 0-10000), size has a value in meters and comfort is a subjective value from the domain $\{bad, fair, good, verygood, excelent\}$.

We will represent the results of two queries one that asks for a clarge but also (if it is possible) a cheap car (query 1), and one that asks for a cheap but as comfortable as possible car (query 2).

Query 1
SELECT * FROM Cars
WHERE Size FEQ Large WITH priority 1
AND Price FEQ Good WITH priority 0.7

Query 2
SELECT * FROM Cars
WHERE Price FLO 10000 WITH priority 1
AND Comfort FEQ Good WITH priority 0.5

model	price	comfort	size	*Output*
Corsa	10000	Fair	3.3	0.43
Fiesta	10500	Good	3.4	0.44
Golf	22000	Exc	4.5	0.62
Peu307	21000	VG	4.3	0.62
Bentley	100000	Exc	6.3	0.48

Table 1. Evaluations for query 1

model	price	comfort	size	*Output*
Corsa	10000	Fair	3.3	0.76
Fiesta	10500	Good	3.4	0.82
Golf	22000	Exc	4.5	0.58
Peu307	21000	VG	4.3	0.56
Bentley	100000	Exc	6.3	0.18

Table 2. Evaluations for query 2

This is just one of the examples of what can be done with these pFCSP. Incorporating priority into FSQL gives more profound information about our database. Crisp priority handling(i.e. sorting criteria, lexisort) can only differ data-rows that are equal in all higher sorting criteria but our system aggregates values incorporating their priority which leads to better conclusions.

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