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Research Article

An Overview of Fuzzy Object-Oriented Database

Shivam Singh, Kavita Agarwal, Jameel Ahmad

Department of Computer Science, Integral University, Lucknow, India

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Abstract: The object-oriented databases are considered better than the relational and other databases because it provides the better and easy approaches to deal with complex data, complex relationship existing among such data and applications which deal with large data. But the available data in data sources are often inaccurate and imprecise. To solve this problem, fuzzy logic has been used to extend the object- oriented databases. The purpose of introducing fuzzy logic in object oriented databases is to enhance its capabilities to represent and manipulate uncertain and imprecise data. This paper provides an overview of fuzzy object-oriented database and how it represents and manipulates the fuzzy data.

Keywords: Object-Oriented Database, Fuzzy Logic, Fuzzy Object-Oriented Database

INTRODUCTION

The object-oriented databases are most suitable for modern database applications like CAD/CAM (Computer Aided Design/ Computer Aided manufacturing), GIS (Geographical information system), spatial databases, office automation etc. Most of the real world applications deal with data which are imprecise and inexact[1]. To deal with fuzzy data, fuzzy logic has been extensively to extend the features of object-oriented database. The major goal behind introducing fuzzy logic in object-oriented databases is to improve its capabilities to manipulate fuzzy data[2]. Many researchers have already proved that the object-oriented paradigm fits itself best to the requirements of the fuzzy system.

Over the past three decades, a significant body of research has been developed in the area of fuzzy database modelling and remarkable gain is hereby accomplished in this area. Since classical relational database do not satisfy the requirements for manipulating fuzzy data, so currently fuzzy object-

oriented database models have gained the focus of many researches in order to deal with complex objects and uncertain data together. Various fuzzy database models for object-oriented databases have been proposed, and some major issues related to these models have also been investigated[3].

The remainder of this paper is organized as follows. Section 2 gives a brief introduction on imprecise information and fuzzy sets theory. Section 3 gives the description of fuzzy relational database system. Section 4 describes the object-oriented databases and how they meet the requirements of fuzzy databases. Section 5 provides an overview on the fuzzy object-oriented database and how fuzzy logic enhances the capabilities of object-oriented database to deal with imprecise data. The last section concludes this paper.

INEXACTNESS OF INFORMATION AND FUZZY SET THEORY

The management of uncertainty in database systems is a very important problem[4] as the information is often vague. Motro states that fuzzy information is content-dependent and he classifies it as follows:

Uncertainty: It not possible to determine whether the information is true or false. For example, "Smith may be 27 years old".

Imprecision: The information available is not specific enough. For example, "Smith may be between 27 and 33 years old", — disjunction — "Smith is 24 or 43 years old", — negative — "John is not 37 years old", or even unknown. Imprecision is related to the content of values.

Vagueness: The model includes elements (predicates or quantifiers) which are inherently vague, for example, "John is in his early years", or "John is at the end of his youth". However, once these concepts have been defined, this case would match the previous one (imprecision).

Inconsistency: It contains two or more pieces of information, which cannot be true at the same time. For example, "John is 37 and 43 years old, or he is 35 years old"; this is a special case of disjunction.

Ambiguity: Some elements of the model lack a complete semantics (or a complete meaning). For example, "It is not clear whether they are annual or monthly salaries".

In this section a brief introduction to some concept of fuzzy sets also given[5].

Let U be a classical set of objects, called the universe of discourse, and let x denote an element of U. a fuzzy set F in a universe of discourse U is characterized by a membership function :μ_F :u [0,1] where $\mu_F(x)$ for each $\mu \in U$ denotes the grade of membership function of x in F. The fuzzy sets F may be denoted as:

$F = \{(\mu(x_1))/x_1, (\mu(x_2))/x_2 \ldots (\mu(x_n))/x_n\}$

Where $x_i \in U$ and $\mu(x_i)$ is grade membership of x_i in the fuzzy set F, for i=1, 2, 3…., n. Here some set operations union and intersection are also defined for fuzzy set A and fuzzy set B by

$\mu_{A\cup B}(x) = \max(\mu_A(x), \mu_B(x))$ and

$\mu_{A\cap B}(x) = \min(\mu_A(x), \mu_B(x))$

How the fuzzy logic works is explained in Algorithm 1.

Firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions.

This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step.

ALGORITHM 1 FUZZY LOGIC ALGORITHM

Initialization:

- Define the linguistic variables and terms
- Construct the membership functions
- Construct the rule base

Fuzzification:

- Convert crisp input data to fuzzy values using the membership functions

Inference:

- Evaluate the rules in the rule base
- Combine the results of each rule

Defuzzification:

- Convert the output data to non-fuzzy values.

In order to exemplify the usage of a FLS, consider an air conditioner system controlled by a FLS (**Figure 2**). The system adjusts the temperature of the room according to the current temperature of the room and the target value.

The fuzzy engine periodically compares the room temperature and the target temperature, and produces a command to heat or cool the room.

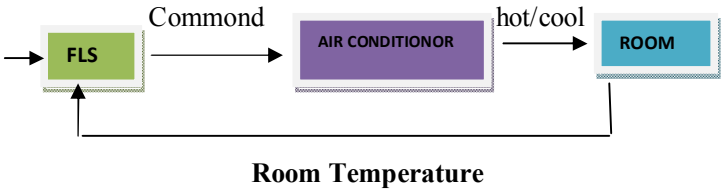

Figure 2: A Simple FLS to Control an Air Conditioner

FUZZY RELATIONAL DATABASE

Fuzzy relational database (FRDB) is a database allows imprecise and vague data in database. The imprecise information is incorporated in fuzzy database in the form of fuzzy attributes and fuzzy entity[4]. It is important that the fuzzy database which incorporates imprecision be able to appropriately propagate the level of uncertainty associated with answers and conclusions based on data .It is desirable to represent fuzzy data in the database, so that it can be used to answer queries of interest as much as possible. Many researchers have given proposals for extending relational database system, yet little work has been done in modeling uncertainty at the conceptual schema level and in standardizing the fuzzy data in fuzzy relational database.

OBJECT-ORIENTED DATABASE

Relational databases cannot handle complex data very well, which in turn resulted in the development of object-oriented databases which can handle complex data like multimedia data and electronic designing in much efficient way than relational databases[4, 6]. These complex data have their own unique characteristics and are defined by unique identifiers known as object identifiers, unique object

name, lifetime and structure. The state (current value) of a complex object may be constructed from other o objects by using certain types of constructor. It can be represented by (i, c, v) where I is unique ID, c is a type of constructor, v is the object state.

The complex objects in object-oriented databases are represented and manipulated by using object query language (OQL). OQL is a declarative query language based on SQL and has an additional flexibility of querying with user defined operators and types unlike structured query language (SQL)[7,8]. The following example presents the difference between OQL and SQL. There is a simple query "what are the names of black products?" and this query is represented as SELECT distinct P.name FROM Product P WHERE P.Color ="black". It is valid in both SQL and OQL but the results will be different. Suppose the original table is **Table 1.**

Table-1: Details of products

Product no.	Product name	Color
P1	Ford figo	Black
P2	Volkswagen polo	Green
P3	Maruti 800	black

The results of SQL are:

Table-2: Results of SQL

Name
Ford figo
Maruti 800

The above results in **Table 2** show that the statement queries a relational database and returns a table with rows.

The results of OQL are:

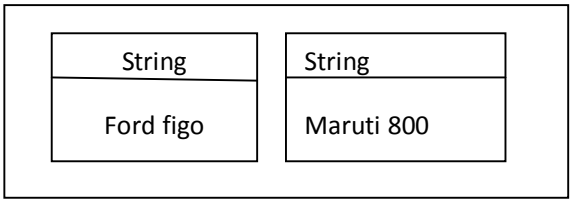

Figure 1: Results of OQL

The above results show that the statement queries an object-oriented database and returns a collection of objects.

FUZZY OBJECT-ORIENTED DATABASE

Fuzzy object-oriented databases (FOODB) deal with the uncertainty and vagueness of information in object-oriented database. This allocation can happen in three levels i.e. entity, attributes and class[6].

- **First level:** fuzzy attribute, an attribute which gets its amount from fuzzy sets such as age which can be old, young, middle age or height which can be tall , short ,medium etc,
- **Second level:** here classes can be fuzzy and a class can be recognized with a membership degree to a range [0, 1] as a subclass of superclass.

- **Third level:** in this level objects can be assigned to one or some classes in a range of [0,1].in order to represent fuzzy class, class is provided with a membership degree for example employee, class can be a fuzzy class if class employee has membership degree of 0.8.

In the fuzzy OODB, the following four situations can be distinguished for-object-class relationships[9].

a. Crisp class and crisp object: this situation is the same as the OODB, where the object belongs or not to the class certainty (such as for example the objects *Car* and *Computer* are for a class *Vehicle*, respectively).
b. Crisp class and fuzzy object: although the class is precisely defined and has the precise boundary, an object is fuzzy since its attribute value(s) may be fuzzy. In this situation, the object may be related to the class with the special degree in [0,1] (such as for example the object whose *position* attribute may be *graduate, research assistant,* pr *research assistant professor* is for the class *Faculty*).
c. Fuzzy class and crisp object: being the same as the case in (b), the object may belong to the class with the membership degree [0, 1] (such as for example a Ph.D. student is for the Young student class).
d. Fuzzy class and fuzzy object: in this situation, the object also belongs to the class with the membership degree in [0, 1].

The object-class relationships in (b)-(d) above are called fuzzy object-class relationships. In fact, the situation in (a) can be seen as the special case of fuzzy object-class relationships, where the membership degree of the object to the class is one. It is clear that estimating the membership of an object to the class is crucial for the fuzzy object-class relationship when class is instantiated.

It should be noted that in fuzzy object-class relationship, only the inclusion degree of object values with respect to the class domains is not accurate for the evaluation of the membership degree of an object to the class. The attributes may play different roles in the definition and identification of a class [10]. In a general comparison, the relationship among relational database, object-oriented database and fuzzy object oriented database is shown in **Figure 2**[10].

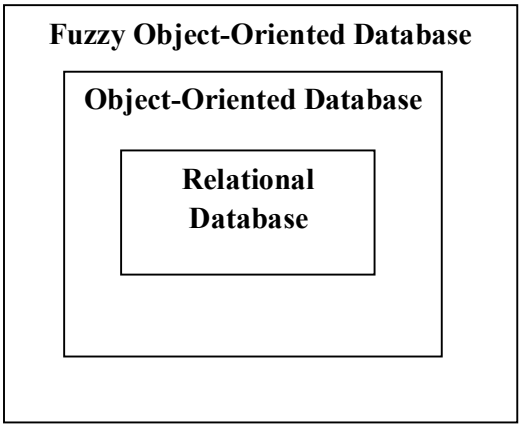

Figure 2: Relationship among different databases

CONCLUSION AND FUTURE SCOPE

In this paper we have discussed how a fuzzy object-oriented database deals with imprecise and inexact information and how it is better from other classical databases like relational database and object-oriented database in its capabilities to deal with the fuzzy information.

Over the past thirty years many researchers have proposed fuzzy data modeling for relational database and object oriented database yet there is very little research done in modeling fuzziness at conceptual data level in fuzzy object-oriented database. So the future scope of our work will be to determine how conceptual modeling will be done in fuzzy object oriented database.

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***Corresponding Author: Shivam Singh;** Department of Computer Science, Integral University, Lucknow, India

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