AN OVERVIEW OF FUZZY DATABASE MODELLING USING LOGICAL DATABASE MODELS

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ABSTRACT:

Imperfect, incomplete, ambiguity, uncertain, imprecision, inconsistence and vague data present in the database is handled by fuzzy logic. Fuzzy database models are used to deal with such data. In this paper a number of logical database models that are used to deal with uncertain data are presented. Logical database model is of two types: relational database models and object-oriented database models. Some more data models that deals with uncertain and imprecision data is also presented in this paper.

Keywords: Fuzzy, Vague, Imprecision, GEFRED, FTRDM, FSQL, FOODBs

[1] INTRODUCTION

In a normal database crisp and perfect information is stored in the database. But real world problems deal with a variety of data including incomplete and imperfect data. Data is stored in the databases in a number of applications and there exists an imprecise data in these databases. The various application areas where there is a need to solve the problem of uncertain data lies in the areas of engineering, multimedia, expert systems, scientific technology and many more. Fuzzy database deals with imperfect, incomplete, uncertain, inconsistent and ambiguous data present in the database. Inconsistency is term related to the presence of multiple values for the same data type that may be present at different places in the same database or in different database. For example age of smith can be stored as 25 and 28 simultaneously. Imprecision relates to the choices that should be made from a given range of values or a set of values but we do not know the exact value for the data item. For example, age of Smith is a set {20, 21, 25, 26}. Uncertainty relates to the approximation or percentage, for example, age of smith may be 25, 98% sure. The ambiguous data means that some of the data elements in the database are deficient in complete semantics leading to a number of possible interpretations. There are different ways by which flexibility can be added to the fuzzy database. Fuzzy database allows a query mechanism to deal with fuzzy data. There are a number of ways to deal with this data like replacing missing values with nulls. But the degree of uncertainty present in these databases is more than the expectation and special approaches are required to handle such form of data. There are different database models that are used to deal with uncertain data; these are called fuzzy database models. The
data models that deal with fuzzy logic is mainly of two types; first is conceptual data model and the second is logical data model. Logical data models can be further classified as relational data models and object oriented data models. In this paper a number of relational and object oriented fuzzy data modelling techniques are presented. The relational fuzzy database models deals with an imprecise data that are present in the database in the form of relations and there are attributes and entities and a number of relations that exists between the relationships. A number of approaches are given by researchers in this area to give a variety of relational fuzzy data models that can be used efficiently to solve the real life problems. The query mechanism is added in these fuzzy relational database models in order to assist the process of managing and manipulating the database. Fuzzy temporal database model deals with the fuzzy time stamped data and a temporal query language can be used for the purpose of querying the data. Object-Oriented models consider everything under objects and there are classes where the attributes are defined, subclasses inherit some features from their superclass. To handle imprecise and uncertain information present in the database of object-oriented models there is a need to provide a mechanism to handle the imprecise data using fuzzy logic. A number of fuzzy object-oriented approaches are presented in this paper which deals with the vague and uncertain data in the database using proper query mechanism. The fuzziness should be applied at different levels in the FOOD models.

[2] FUZZY RELATIONAL DBMS (FRDBMS) MODELS

Relational model store the information in the form of tables and to store the values of attributes in the database that are uncertain. To handle the uncertain information in the relational database, fuzziness is added to the values of the attributes. Thus the attributes are allowed to have values from the domain set that are fuzzy sets. The introduction of fuzziness to the relational databases gives a new model called fuzzy relational database model. Zadeh, 1965 proposed such approach to introduce fuzzy logic in the relational database. In the fuzzy relational database model fuzzy attributes are added in the databases that are associated with the entities and the relations between them. The first implementation of the fuzzy database system was given by Umano, 1982. A mechanism of querying the data in database has been introduced in this system along with the fuzzy data model. In this approach Enhanced Entity-Relationship model with fuzzy logic i.e. FEER can be used to model the databases and then the fuzzy knowledge can be modelled using the fuzzy EER model. This proved to be a new approach which is efficient to deal with the uncertain data that exists in the database.

In 1994 Medina et al. proposed another advance model to deal with fuzzy data based on the relational data model. This database model has given a name GEFRED, the Generalised Model of Fuzzy Relational Database. This model allows the possibility distribution in the attribute domain and it refers to the domains that are generalised and have fuzzy values associated with them. That’s why the model has been named as Generalised Model of Fuzzy Relational Database. Uncertain data that are previously known, have null values or missing values or remained undefined in the database have considered and notion for these data types has been given in this data model. The domains associated with the attributes with which this data model deal is not of numeric type, but it contains scalars of any type.
FRDBMS is a new design based on the study of GEFRED model proposed by Touzi and Hassine, 2009. FRDBMS is Fuzzy Relational Database Model, the principle on which it works based on the weak coupling with RDBMS Oracle. All the functionalities of a classical Database management system including the manipulation instructions and the mechanism for query are included in the Fuzzy Relational Database Model. This model suits best to handle the uncertain data which have imprecise information. The imprecise data in the database can be stored using the fuzzy logic and then a query mechanism can be used for interrogation purpose to deal with uncertain data. The SQL used in the relational database is included in this model along with the capability of fuzzy logic and this query language is known as FSQL. This model describes the various functions performed by this model, these functions are as explained:

A. First of all Data Definition Language is used to describe the overall structure of the database, the database type, various attributes and the domain for the attributes. These data description is added with the functionality of the fuzzy logic to deal with imprecise data.

B. Data Manipulation Language is used to manipulate the data; it includes the description of the mechanism required for the data storage, data retrieval using queries and updation of data in database.

C. Various integrity rules are defined which are essential to deal with fuzzy data in the FRDB. The integrity rules assure that the uncertain data must be according to the constraints defined for database.

D. The security of database is assured in this methodology by allowing the database to use the verification mechanism and allows the user to maintain confidentiality for his database.

E. In case of any system breakdown recovery mechanism is given in this system by providing the backup.

F. The last and the most important function explained in this methodology is to provide the help to the users for providing assistance in their work so as to efficiently deal with uncertain data in the database.

Temporal database are those that deal with the data that are distinguished by time they associated with, that is a time value is associated with such data types. Some data items are static and some are dynamic in nature. To deal with temporal database a model, Fuzzy Temporal Relational Database Model (FTRDM) was proposed by Chaudhry and et al., 1999 which is an extension of relational model. This data model deals with uncertain data whether imprecise or vague in nature and is associated with time in the form of a relation. Advancement in the fuzzy temporal relational database is done when Mahmood and Burney, 2011 gave a temporal query language to deal with uncertain temporal data in the relational databases. In this model a number of approaches are introduced that deal with the fuzziness, one such approach is to introduce fuzziness at different levels like relation, in attributes, in relationships and at the constraint level.

Hsieh and et al., 2004 defined extended fuzzy relational model which is a generalised form of conventional relational database model. In this model uncertain data is expressed by using the first order logic. Different concepts of relational database are applied in this database model to deal with uncertainty in the data. The concept used in this data model is to
decompose the extended fuzzy relation into a number of smaller schemas and then the schemas are rejoined by using the projection and selection operations. A method for measuring the quality of answers to Select-Project-Join (SPJ) queries is described in this model which determines the extent to which how much satisfactory information is provided, and how much extra information is required to a query.

[3] FUZZY OBJECT-ORIENTED DATABASE MODELS (FOOD)

In object-oriented database everything is defined in terms of objects and when there is uncertain data in the database then to deal with that database some fuzzy logic is applied to the attribute values, this approach of using fuzzy logic with object-oriented approach is known as fuzzy object-oriented model. A number of FOOD models are given from time to time, each deal with the concept of fuzziness in the attribute values. Fuzziness in object-oriented databases is given at class level and object instance level. As in object-oriented approach there is a hierarchy in classes so the fuzziness is described at the hierarchy level also.

A possibility theory is given by Dubois & et al., 1991 in which the uncertain data and vague data are represented in the class hierarchies. In it the superclass is restricted by the ranges given by fuzzy logic in the derived subclass attributes. The fuzzy ranges of attributes of both classes define the inclusion of a subclass in the superclass. A set is used to give the possible values that can be assigned to an attribute. The actual values of the attributes lie in this range which is defined by the set and this range is used to define the membership degree assigned to an object of a class. It is this values which can be used to find whether the class hierarchy is strong or weak. Strong or weak class hierarchies is a function of monotonically increase or decrease in the values of the membership degrees of subclass in its superclass (George & et al., 1996).

A new object oriented model in which fuzzy logic can be used is given by Umano and et al. in 1998. This model is known by FOODB model in which a new term ‘factor’ is given which is related to the fuzzy attributes value. FOODB is Fuzzy Object-Oriented Database model and for the manipulation of the data, SQL language is given. This model defines how the SQL manipulation language is used for the data manipulation.

Object Management Group (OMG) standardized some notations that can be used frequently in the object oriented database, for this purpose Unified Modelling Language (UML) is given which is proposed by Booch and et al., 1998. UML is lacking of some semantics like no proper mechanism to deal with imprecise and uncertain data in the database.

A new model, UFO (uncertainty and fuzziness in object-oriented) database model is proposed by Gyseghem & Caluwe, 1998. In UFO model two types of fuzzy data are considered; first is uncertain data which can be handled by the conjunctive data sets and the second is fuzziness in the data which can be handled by the generalized sets. In this model the structure of the objects is not clearly defined and the object behaviour is incomplete in its description. A number of fuzzy hierarchies are permitted in this model. It allows that a subclass to inherit from its superclass using simple inheritance, multiple inheritances,
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conditional inheritance and also the partial inheritance. An approach given by Lee and et al., 1999 in their study also lies on introducing the concept of fuzziness in object-oriented approach. Fuzzy logic is introduced to deal imprecise data in the database and the fuzziness is introduced along four dimensions. At class level fuzziness is included to define fuzzy class; fuzzy class relationship is defined for the relationship that exists between the classes; to define various associations that may exist between the classes fuzziness has given and the last one is to define fuzzy rules that should be applied to the data in object oriented approach. To define the fuzzy rules some linguistic terms are used that describes the various relationships that exist between the attributes.

Martin and et al., 2001 proposed work is based on two different strategies, one is to add the fuzziness in the FOODBs to deal with the vague structure and the second strategy is to introduce the concept of fuzziness at class level. It is this mechanism that defines the rules to inherit the properties of one class by another class. It also defines how the objects should be instantiated using fuzzy rules. The vagueness and uncertainty is handled by the possibility theory approach and the knowledge is represented by using fuzzy IF-THEN structure in the classes. To deal with the fuzzy data various rules defined in the methodology includes mechanism for the data processing and querying the data. The extension to this methodology was proposed by Bordogna and Pasi, 2001 by introducing the concept of graph based operations to manage the crisp and fuzzy information. In this methodology linguistic qualifiers are introduced to associate them with the various instances of the relationships and the class objects. The linguistic qualifiers are used to define the various hierarchies that exist between the classes and thus introduced the concept of fuzziness in the OO model.

In 2003 Tre and Caluwe presented a new technique of object-oriented database modelling based on the level-2 fuzzy set. This technique deals effectively and uniformly with the imperfect and perfect information that exist in the real world. Introduction of level-2 fuzzy set with object-oriented approach made this approach more advantageous to effectively manage the uncertain data that otherwise would not be so easy to deal with.

Galindo and et al., 2004 defined the various fuzzy constraints to manage the imperfect data in the object-oriented database. The various constraints defined in the model deals with the various concepts of object-oriented approach by introducing fuzzy logic. The constraints defined are able to deal with the cardinality ratio of the relationship; participation constraint with fuzzy extensions; for class representation fuzzy completeness constraints; for class specialization concept fuzzy overlapping and disjoint constraints to handle fuzziness at union level, for the classes that are shared in the multiple inheritances.

Chakhar and Tetmoudi, 2004 introduced Fuzzy Semantic Model (FSM) to find the fuzziness present in the database. This model also finds the real world semantics that are present in these databases. It proved to be an efficient tool that efficiently deals with the uncertain data as expected by the human perception. In this model entity is simultaneously assigned to a number of classes as its member. This participation of the entity to several classes gives the degree of its membership and this membership degree confirms the properties related to attributes and semantics of the various classes. Bouaziz and et al., 2007 proposed some advancement in the FSM by defining the way through which the member functions can be defined in the Fuzzy Semantic Model. This approach defines the schema for
the FSM and mechanism to use a query language to deal with the fuzzy data that exists in the database.

Shukla and et al., 2010 proposes that there are different places in the object-oriented database where uncertainty exists. The main consent is to focus on these areas to handle the uncertain data in the database. Various constraints are defined in this methodology that effectively helps in managing the uncertain data.

Dwibedy and et al., 2013 proposed a generalized framework for fuzzy constraints applied to the classes in the class hierarchy. In their work they defined a new structure for the fuzzy classes in order to handle imprecise data in the database. Exception handling is the new concept described in this methodology by adding the fuzzy logic to give power to the system. This innovative approach of adding fuzzy logic to exception handling mechanism along with various other constraints are properly defined in this data model.

[4] FUZZY SQL MODELS

SQL is a Structured Query Language used for the data definition and manipulation purpose in the databases. This query mechanism is used in the database system from a long time and proved to be very helpful for data handling. The introduction of fuzzy logic in the database system had laid a platform to add fuzzy logic in the SQL language. When this fuzzy SQL language is used in the fuzzy database to handle imprecise data then the model is known as FSQL model. FSQL is a flexible query language which supports the database a query mechanism.

To support this, there is a number of research work done in this area, one such approach given by Medina et al., 1995 which proposed a new architecture to handle imprecise data, the FIRST (Fuzzy Interface for Relational System) architecture. The architecture describes the procedure for the manipulation and representation of the uncertain data. In this architecture Fuzzy Meta-knowledge Base to store the information required for the manipulation of the data is represented in a tabular form. This extends the relational database management dictionary which was originally defined for the RDBMS. All queries described in the SQL are also included in the FSQL, for this reason Fuzzy Structured Query Language is considered to be authentic approach to handle imprecise data. Galindo, 2005 improved FIRST architecture and renamed as FIRST-2. In this architecture Galindo added the FSQL Server component to assure flexible queries translations which are defined in the FSQL in a language given by the SQL database management system.

Skrbic and et al., 2011 added a number of new elements to the classical SQL by introducing the various possibilities for specifying the priority to the statements in fuzzy concept. The query language so formed has given a name, Priority Fuzzy Structured Query Language (PFSQL). A fuzzy relation has been returned by this priority fuzzy SQL on the database. A value is assigned to each and every possible tuple that are included in the query from the unit interval by using the concept of fuzzy logic operations.

[5] CONCLUSION

In this paper a number of logical data models are presented. Logical database models are mainly of two types: relational data models and the object-oriented database models.
When the fuzzy logic is added to the data models then these fuzzy data models deal appropriately with the imprecise information. Fuzzy Relational Database Models deals with the entities, attributes and relationships with fuzzy logic and a query mechanism to deal with the database queries. A number of fuzzy object-oriented database models are presented in this paper and in each model a proper query mechanism is used to deal with the uncertain data. Fuzzy SQL models deals with the Structured Query Language with fuzzy logic to manipulate the data in the database.

REFERENCES


Author[s] brief Introduction

Deepti received her Master of Computer Science and Applications (MCA) degree from MDU, Rohtak. M.Phil in Computer Science from CDLU, Sirsa. She is having 4 years of teaching experience. Her areas of interest are Data Mining, Data warehourse and Database Management System.