An Enhanced ER Conceptual Data Modelling for Fuzzy Object-Oriented Database Models (FOODBMs)

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Abstract— Fuzzy conceptual data modelling is concentrated in this paper. Based on dealing with imprecise and uncertainty super class-subclass relationships, a conceptual data model ER is enhanced. Different levels of fuzziness are introduced and the corresponding super class-subclass relationships representations are given. ER data model is thus enhanced to fuzzy ER data model denoted EER. Where that could store, retrieve, and manipulate the imprecise and uncertain complex data is stored in the form of objects with fuzzy techniques applied on it to encapsulate the impreciseness and uncertainty. In this paper, the attention is pain on the fuzzification of attributes, and objects, especially on that of super class-subclass relationships.

Keywords— ER/EER conceptual data model, Fuzzy object oriented database model, Imprecise and Uncertainty data, Super class-subclass relationships

I. INTRODUCTION

The Entity-relationship model was introduced by Chen in 1976 [1]. The ER model graphically represents data as entities, relations, and attributes. Entities are objects that exist in the real world and are represented in the model by rectangles. Relationships relate different entities to each other and are represented with diamond shapes. Both entities and relationships can have different attributes. The EER model allows us to extend the description of the entities with new types (super class, subclass, specialization, generalization, and aggregation). A sub class is a specialization of a super class, so that each member of a subclass must be a member of the super class. A super class is a generalization of one or several sub classes [2]. Impression embraces several meanings between which we should differentiate. For example, the information we have may be incomplete or “fuzzy” (diffuse, vague), or we may not know if it is certain or not (uncertainty), or perhaps we are totally ignorant of the information (unknown). We may know that information cannot be applied to a specific entity (undefined) [3]. The modeling and manipulation of complex object and imprecise information together are emerging as leading problems to the database research. The involvement of complex object & uncertainty measures in the data or attribute values make the existing relational data models unanswered. Object oriented data models are capable enough to handle complex objects but are restricted towards the representation of imprecise or uncertain data. These problems in the database world bring the innovative concept of object based fuzzy data model by extending the object oriented data model and applying fuzzy techniques to it. The fuzzy object data model is being continuously prototyped with the objective that it evolves into a powerful knowledge representation methodology with inherent fuzzy reasoning techniques for problem solving in complex and uncertain environment [4].

Remainder of this paper is organized as the 2nd section presents fuzzy object-oriented database models, 3rd section contains management of vagueness, 4th section presents fuzzy conceptual object oriented data models, 5,6,7,8th section presents fuzzy conceptual database modeling techniques that contains four sections specialization super class-subclass on relationships, generalization super class-subclass on relationships, categorization super class-subclass on relationships, and aggregation super class-subclass on relations, 9th section presents related work, and 10th section concludes the paper.

II. FUZZY OBJECT ORIENTED DATABASE MODELS (FOODBMS)

Database make possible the storage, retrieval and manipulation of multiple different variety of imprecise, ambiguous, and incomplete complex information in the form of data to explore such database, researchers blends the concept of database with object-oriented and fuzzy theory, and evolved the concept of fuzzy object oriented databases.

Figure 1: Fuzzy Object-Oriented Database Systems
It has several concepts, definition, models, operations, applications, and query language have been proposed by researchers. FOODBs is a type of database that could store, retrieve and manipulate the imprecise and uncertain complex data, where complex data is stored in the form of objects with fuzzy techniques applied on it to encapsulate the impreciseness and uncertainty. Different levels where vagueness can arise: (1) uncertain and (2) imprecise attributes values. The non-traditional applications focus on database models for modeling complex information and uncertainty at the conceptual data model. Conceptual data modeling is the first step of the top-down database development process and analysis stage of the system. It provides conceptual schema of the data of the inter-relationship existing among data, kinds of entities, aggregation, association and other related issues are represented in this conceptual modeling. It presented very comprehensive such as:

- (1) FER models (Fuzzy ER models)
- (2) FEER models (Fuzzy EER models),

Where classes are classified effective manner. Conceptual modeling to fuzzy techniques permits the representation and manipulation of imprecise and uncertain information at conceptual level. It has five characteristic such as:

- (1) Fuzziness in level
- (2) Fuzzy constraints
- (3) Representation of fuzziness
- (4) Graphical representation, and
- (5) Algebra/operations.

III. MANAGEMENT OF VAGUNESSION

It has three types of imperfect information may appear in an attribute value.

- The value may be ill-defined
- It may be affected by uncertainty, and
- Both things may happen at the same time.

A. Imprecise attribute domain

Attribute value can be ill-defined may be assorted from an actual ill-knowledge of the datum, till an imprecision in nature affecting the domain of the attribute.

Example,

Mike’s prospects are good.
The mark of mike is good.
Mike is in his final academic years, mark of mike is possibility distribution, it may happen real attribute value is a combination of such values.

B. Uncertainty in attributes values

Data besides being imprecise may be uncertain think about those situations where data may be perfectly defined, but we are not sure whether they are true or not (i.e., it is very possible that mike lives in Granada) for these values a level of truth must be considered.

C. Uncertain objects relationships

How to deal with the vagueness affecting to the functional connection among objects. However if the relationship must be presented by means of an aggregation construct.

IV. FUZZY CONCEPTUAL OBJECT ORIENTED DATA MODELS

Conceptual modelling to fuzzy techniques permits the representation and manipulation of imprecise and uncertain information at conceptual level.

A. Fuzzy ER conceptual data models

Fuzzy ER model is fuzzy extension of classical entity-relationship model and it includes fuzziness in attributes, entity, objects, and relationship. All the major concepts of ER model, these components may have a membership degree to the ER model.

- Fuzziness in attributes (value of attributes)
- Fuzziness in entities
- Fuzziness in relationships

Fuzzy occurrences of entities and relationship and fuzzy values of a attributes are also included in fuzzy entity relationship models. Fuzziness is represented through the probabilistic theory and operations are performed through the ER algebra.

B. Fuzzy EER conceptual data models

Enhance/Extended entity relationship model is a conceptual data model that includes all the concepts of ER model and additional includes the concepts of

- Super class
- Sub class
- Specialization
- Generalization
- Categorization
- Aggregation
Advanced applications such as CAD/CAM, CASE, and GIS etc. do not found the ER model sufficient for representation of data of their domain, so the new concepts are included into the ER model and the picture of EER model came into existence with the idea of specialization, generalization, categorization, and aggregation.

V. FUZZY SPECILIZATION SUPERCLASS-SUBCLASS ON RELATIONSHIPS

Let $S$ be an entity type with attributes $\{K, A_1, A_2, ..., An\}$, where $K$ is the key. Let entity type $S_1$ with attributes $\{A_{11}, A_{12}, ..., A_{1k}\}$ and entity type $S_2$ with attributes $\{A_{21}, A_{22}, ..., A_{2m}\}$ be the subclasses of $S$. Since $S_1$ and $S_2$ are subclasses of $S$, there are no keys in $S_1$ and $S_2$. At this point, $S$ is mapped into the relational schema $\{K, A_1, A_2, ..., An\}$, and $S_1$ and $S_2$ are mapped into schemas $\{K, A_{11}, A_{12}, ..., A_{1k}\}$ and $\{K, A_{21}, A_{22}, ..., A_{2m}\}$, respectively [6].

VI. FUZZY GENERALIZATION SUPERCLASS-SUBCLASS ON RELATIONSHIPS

Let $E_1$ with attributes $\{K_1, A_1, A_2, ..., A_k\}$ and $E_2$ with attributes $\{K_2, B_1, B_2, ..., B_m\}$ be generated to form super type $S$. Assume $\{A_1, A_2, ..., A_k\} \cap \{B_1, B_2, ..., B_m\} = \{C_1, C_2, ..., C_n\}$. $E_1$ and $E_2$ are mapped into schemas $\{K_1, A_1, A_2, ..., A_k\} - \{C_1, C_2, ..., C_n\}$ and $\{K_2, B_1, B_2, ..., B_m\} - \{C_1, C_2, ..., C_n\}$, respectively. As to the transformation of $S$, depending on $K_1$ and $K_2$, we distinguish the following two cases.

(a) $K_1$ and $K_2$ are identical. Then $S$ is mapped into the schema $\{K, C_1, C_2, ..., C_n\}$, where $K$ is the same as $K_1 / K_2$.

(b) $K_1$ and $K_2$ are different. Then $S$ is mapped into the relational schema $\{K, C_1, C_2, ..., C_n\}$, where $K$ is the surrogate key created by $K_1$ and $K_2$ [5].

Considering the fuzziness in entities, the following cases for the transformations of the generalization are distinguished:

(a) $E_1$ and $E_2$ are both crisp. Then $E_1$ and $E_2$ are transformed to relations $r_1$ and $r_2$ with attributes $\{K_1, A_1, A_2, ..., A_k\} - \{C_1, C_2, ..., C_n\}$ and $\{K_2, B_1, B_2, ..., B_m\} - \{C_1, C_2, ..., C_n\}$, respectively. $S$ is transformed to a relation $r$ with attributes $\{K, C_1, C_2, ..., C_n\}$.

(b) When there is the fuzziness of instance/schema level in $E_1$ and (or) $E_2$, being similar to case (a) also, relation $r$, as well as relations $r_1$ and $r_2$, are formed. Note that $r$, $r_1$ and (or) $r_2$ created by $E_1$ and (or) $E_2$ with the instance/schema level of fuzziness should include attribute $f^p$.

(c) When there is the fuzziness of schema level in $E_1$ and (or) $E_2$, relation $r$, as well as relations $r_1$ and $r_2$, are formed. But the fuzziness at this level cannot be represented in the created relations [6].
VII. FUZZY CATEGORIZATION SUPERCLASS-SUBCLASS ON RELATIONSHIPS

The categorization in the EER model is concerned with the issue of selective inheritance. Essentially, the categorization shows the uncertainty that which entity in the categorization will take place in the schema is unknown currently. The entities, fuzzy or not, in the categorization can respectively be mapped into the relations following the methods given above. The categorization entity also follows the same transformation. Some additional attributes, however, should be added into the corresponding relation. These attributes are a set of all attributes of the entities in the categorization [6].

Figure 3: Generalization super class-subclass on relationships

Figure 4: Categorization super class-subclass on relationships
VIII. FUZZY AGGREGATION SUPERCLASS-SUBCLASS ON RELATIONSHIPS

Each aggregation in the fuzzy EER model can be mapped into a relation of the fuzzy nested relational schema with relation-valued attributes. Depending on the component entities, the aggregation entity may be crisp or fuzzy. As we know, there are four kinds of entities in the fuzzy EER model. The fuzziness of the component entities only on attribute values does not influence the relation mapped from the aggregation entity. If there is the fuzziness of the component entities at instance/schema level, namely, the fuzziness at the second level, however, an additional attribute must be added to the relation mapped from the aggregation entity, indicating the aggregation degree of the tuples. The fuzziness of the component entities at schema level, i.e., the fuzziness at the first level, however, cannot be modeled in the relation mapped from the aggregation entity [6].

![Diagram of aggregation super class-subclass on relationships]

IX. RELATED WORK

The existing “fuzzy” object-oriented database models are the following:

The object-centered model of Rossazza et al. This model (Rossazza, 1990; Rossazza et al., 1997), all information is contained in objects that are completely described by a set of attributes for these objects, no behaviour is defined. Objects with the same attributes are collected in classes that are organized in class hierarchies. A range of allowed values and a range of typical values are specified for the attributes. These ranges may be fuzzy. Various kinds of inclusion relations can be defined between classes. The object-oriented model of Tanaka et al. This model, fuzziness is considered on both structural and behavioural aspects of objects (Tanaka, Kobayashi, & Sakanoue, 1991). Attribute value can be fuzzy predicates. Furthermore, fuzziness is considered at the levels of instantiation of inheritance, and of the relationships between objects by introducing extra special classes. The similarity-based model of George et al. The capability of this model, to facilitate an enhanced representation of different types of imprecision is derived by utilizing a similarity relation to generalize equality to similarity (George, 1992: George et al., 1997). Similarity permits the representation of impreciseness in data and impreciseness in inheritance. An object algebra based on extensions of the five “classical” operators (union, difference, product, projection, intersection, selection, and division) is provided. The FOOD model of Bordogna et al. This model (Bordogna, Lucarella, & Pasi, 1994; Bordogna, Pasi, & Lucarella, 1999) is based on a visualization paradigm that supports the representation of the semantics and the direct browsing of the information. It was defined as an extension of a graph-based object model, in which the database scheme and instances are represented as directed labelled graphs. A prototype of the model was implemented (Bordogna, Leporati, Lucarella, & Pasi, 2000).

The UFO model (Van Gyselghem, 1998) was an attempt to extend an object-oriented database model as generally as possible in order to be able to deal with fuzziness as well as with uncertainty. Different model levels were extended (attributes, methos, objects, classes, inheritance, instantiation, etc).
X. CONCLUSIONS

Fuzzy object oriented conceptual database modeling is a type of database, it could store, retrieve and manipulate the complex objects based on imprecise and uncertain information are emerging together as well as leading problems to the database research, where the complex data is stored in the form of objects based with fuzzy techniques applied. The involvement of complex objects, imprecise, vague, uncertain, ambiguous, incomplete, and inconsistent data measures in the objects data, attributes value, entities, and relations make the existing relational data model unanswered. This object data model are capable enough to handle a complex objects, but are restricted towards the representation of imprecise or uncertain data. We investigated and considered in the paper to solved the techniques is that relationships based fuzzy data model in conceptual database model. It is a powerful knowledge representation methodology with inherent (relationships) fuzzy reasoning technique for solve in complex object and uncertain environment, there are four types of fuzzy techniques as like specialization super class-subclass on relationships, generalization with super class-subclass, categorization with super class-subclass, aggregation with super class-subclass.

In this paper, we have presented the fuzzy enhanced entity-relationship (FEER) model to cope with imperfect as well as complex objects in the real world at a conceptual level. Also a nested relational database model has completely been extended for modeling the extended possibility-based fuzzy data. In particular, we have provided the formal approach to mapping a fuzzy EER model to a fuzzy nested relational database schema.

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