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Chapter II

Fuzzy and Probabilistic Object Bases

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Abstract

Database systems have evolved from relational databases to those integrating different modeling and computing paradigms, in particular, object orientation and probabilistic reasoning. This chapter introduces an extension of the probabilistic object base model by Eiter et al. (2001), using fuzzy sets for representing and handling vague and imprecise values of object attributes. A probabilistic interpretation of relations on fuzzy set values is proposed to integrate them into that probability-based framework. Then, the definitions of fuzzy-probabilistic object base schemas, instances, and selection operation are presented. Other algebraic operations, namely, projection, renaming, Cartesian product, join, intersection, union, and difference of the probabilistic object base model are also adapted for its fuzzy extension.

Introduction

For modeling real-world problems and constructing intelligent systems, the integration of different methodologies and techniques has been the quest and focus of significant interdisciplinary research effort. The advantages of such a hybrid system are that the strengths of its partners are combined and are complementary to each other's weaknesses.

In particular, object orientation provides a hierarchical data abstraction scheme and an information hiding and inheritance mechanism. Meanwhile, probability theory and fuzzy logic provide measures and rules for representing and reasoning with uncertainty and imprecision in the real world. Many uncertain and fuzzy object-oriented models (e.g., George, Buckles, & Petry, 1993; Itzkovich & Hawkes, 1994; Rossazza, Dubois, & Prade, 1997; Van Gyseghem & De Caluwe, 1997; Bordogna, Pasi, & Lucarella, 1999; Dubitzky et al., 1999; Yazici & George, 1999; Blanco et al., 2001; Cross, 2003) were proposed and developed. However, only a few of them combine probability theory and fuzzy logic, in order to deal with both uncertainty and imprecision.

Early works on fuzzy extension of object-oriented models were done by George, Buckles, and Petry (1993) and Itzkovich and Hawkes (1994), which introduced inclusion degrees between classes in a hierarchy. An inclusion degree of one class to another could be computed on the basis of the fuzzy ranges of their common attributes. For example, Rossazza, Dubois, and Prade (1997) defined four inclusion degrees, depending on whether necessary ranges or typical ranges were used for each of the two classes.

Arguing for flexible modeling, Van Gyseghem and De Caluwe (1997) introduced the notion of fuzzy property as an intermediate between the two extreme notions of required property and optional property. Each fuzzy property of a class was associated with possibility degrees of applicability of the property to the class. Meanwhile, Yazici and George (1999) presented a deductive fuzzy object-oriented model but did not address uncertain applicability of properties. A general data model including fuzzy attribute values as well as uncertain properties was proposed by Bordogna, Pasi, and Lucarella (1999), where the treatment of uncertainty was, however, based on possibility theory rather than on probability theory.

As a first attempt to integrate both probabilistic and fuzzy measures into an object-oriented model, Dubitzky et al. (1999) assumed that each property of a concept had a probability degree for it occurring in exemplars of that concept. However, the method therein for computing a membership degree of an object to a concept, based on matching the object's properties with the uncertainty applicable properties of the concept, is in our view not justifiable. Also, the work