# Chapter 1.7
# A Literature Overview of Fuzzy Database Modeling

**Z. M. Ma**
*Northeastern University, China*

## ABSTRACT

Fuzzy set theory has been extensively applied to extend various data models and resulted in numerous contributions, mainly with respect to the popular relational model or to some related form of it. To satisfy the need of modeling complex objects with imprecision and uncertainty, recently many researches have been concentrated on fuzzy semantic (conceptual) and object-oriented data models. This chapter reviews fuzzy database modeling technologies, including fuzzy conceptual data models and database models. Concerning fuzzy database models, fuzzy relational databases, fuzzy nested relational databases, and fuzzy object-oriented databases are discussed, respectively.

## INTRODUCTION

A major goal for database research has been the incorporation of additional semantics into the data model. Classical data models often suffer from their incapability of representing and manipulating imprecise and uncertain information that may occur in many real-world applications. Since the early 1980s, Zadeh's fuzzy logic (Zadeh, 1965) has been used to extend various data models. The purpose of introducing fuzzy logic in databases is to enhance the classical models such that uncertain and imprecise information can be represented and manipulated. This resulted in numerous contributions, mainly with respect to the popular relational model or to some related form of it.

Also rapid advances in computing power have brought opportunities for databases in emerging applications in CAD/CAM, multimedia and geographic information systems (GIS). These applications characteristically require the modeling and manipulation of complex objects and semantic relationships. It has been proved that the object-oriented paradigm lends itself extremely well to the requirements. Since classical relational database model and its extension of fuzziness do

not satisfy the need of modeling complex objects with imprecision and uncertainty, currently many researches have been concentrated on fuzzy object-oriented database models in order to deal with complex objects and uncertain data together.

Database modeling can be carried out at two different levels: conceptual data modeling and database modeling. Therefore, we have conceptual data models (e.g., ER/EER and UML) and logical database models (relational databases, nested relational databases, and object-oriented databases). Logical database models are often created through mapping conceptual data models into logical database models. This conversion is called conceptual design of databases. Since fuzzy database approaches were first created in the late 1970s by several research groups, a significant body of research in the area of fuzzy database modeling has been developed over the past 30 years. Although there have been a lot of fuzzy database papers, ones only find few comprehensive review papers of fuzzy database modeling (Yazici, Buckles, & Petry, 1992; Kerre & Chen, 1995). It has been nearly 10 years since a latest comprehensive overview paper has appeared in this area (Kerre & Chen, 1995). This chapter aims to provide a literature overview of fuzzy database modeling to satisfy the obvious need for an updating. The topics of the literature referred in the chapter include fuzzy logical database modeling, fuzzy conceptual data modeling, and design and implementation of fuzzy databases. It should be noticed that, however, it does not means that this chapter covers all publications in the research area and gives complete descriptions.

The remainder of this chapter is organized as follows. The second section gives the basic knowledge about imperfect information and fuzzy sets theory. Issues about fuzzy logical (relational, nested relational, object-oriented, and object-relational) database models are described in the third section. The fourth section investigates issues about fuzzy conceptual data (ER/EER, IFO, and UML) models. The fifth section discusses issues about design and implementation of fuzzy databases, including the conceptual design, indexing techniques, and prototypes. The last section concludes this chapter.

## IMPERFECT INFORMATION AND FUZZY SETS THEORY

Inconsistency, imprecision, vagueness, uncertainty, and ambiguity are five basic kinds of imperfect information in database systems in (Bosc & Prade, 1993). Inconsistency is a kind of semantic conflict, meaning the same aspect of the real world is irreconcilably represented more than once in a database or in several different databases. Information inconsistency usually comes from information integration. Intuitively, the imprecision and vagueness are relevant to the content of an attribute value, and it means that a choice must be made from a given range (interval or set) of values but we do not know exactly which one to choose at present. In general, vague information is represented by linguistic values. The uncertainty is related to the degree of truth of its attribute value, and it means that we can apportion some, but not all, of our belief to a given value or a group of values. The random uncertainty, described using probability theory, is not considered in the paper. The ambiguity means that some elements of the model lack complete semantics leading to several possible interpretations. Generally, several different kinds of imperfection can co-exist with respect to the same piece of information. Imprecision, uncertainty, and vagueness are three major types of imperfect information. Vagueness and uncertainty can be modeled with possibility theory (Zadeh, 1978). Many of the existing approaches dealing with imprecision and uncertainty are based on the theory of fuzzy sets (Zadeh, 1965).

Smets (1997) presents some aspects of imperfection, in which *imprecision, inconsistency,* and *uncertainty* are the major groups. Imprecision

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