Extending EXPRESS for imprecise and uncertain engineering information modeling

Z. M. MA
Department of Computer Science and Engineering, Northeastern University, Shenyang, Liaoning 110004, China
E-mail: mazongmin@ise.neu.edu.cn
Received September 2004 and Accepted June 2005

Information with imprecision and uncertainty is inherently presented in engineering design and manufacturing. The nature of imprecision and uncertainty is incompleteness. Product data model, being a core of intelligent manufacturing system, consists of all concerned data in the product life cycle. It is possible that crisp data as well as incomplete data are involved in product data model. So EXPRESS, being a powerful tool to develop a product data model, should be extended for this purpose. Using fuzzy sets and possibility distributions, this paper extends the EXPRESS to make it possible to model fuzzy engineering information.

Keywords: Engineering information modeling, EXPRESS, fuzzy sets and possibility distributions, fuzzy information modeling, intelligent manufacturing, information systems

1. Introduction

The Standard for the Exchange of Product Data (STEP, ISO 10303) has been developed by the International Organization for Standardization (ISO) in order to define a common data model and procedures for the exchange of information. It consists of many parts that can be partitioned into four major categories, namely, description methods, implementation methods, conformance testing methodology and framework, and standardized application data models/schemata. EXPRESS is a conceptual schema language as part of the STEP to model product data in all stages of product life cycle.

As it may be known, in the real world applications, information is often vague or ambiguous. Therefore, different kinds of incomplete information have extensively been introduced and studied to model the real world well. Engineering design and manufacturing is one of the examples where the issue of incomplete information makes sense. Product design, for example, is essentially a process of reducing the incompleteness in the description of the conceptual design (Ma et al., 1999).

The method to deal with imprecision was proposed in Wood and Antonsoon (1992), Otto and Antonsoon (1994a,b) and Antonsoon and Otto (1995) for the preliminary engineering design and calculation. A fuzzy expert system in a CAD/CAM system for the preliminary design can be found in Francois and Bigeon (1995). Besides, the organization and production management of virtual enterprise put an essential requirement on its information integration. The studies mentioned were essentially based on their dedicated concepts and methods. There is a research direction in the context of computer aided engineering to deal with information with uncertainty and imprecision in a more general way, i.e., data or database modeling (Ma et al., 1999; Ma and Mili, 2003).

As pointed out by Shaw et al. (1989), product data models can be viewed as a class of semantic data models that take into account the needs of engineering data. Some attentions have been paid on information uncertainty and imprecision modeling in ER model (Zvieli and Chen, 1986), EER model (Chen and Kerre, 1998), and IFO model (Vila et al., 1996; Yazici and Cinar, 1998). Some extensions have been proposed in...
Main in fuzzy set is represented by a degree of membership in a set. The membership function, \( \mu(u) \), maps an element \( u \) to a value between 0 and 1, indicating the degree to which \( u \) belongs to the set. Other sources of imprecision in engineering activities include linguistic imprecision, operational uncertainty, and data imprecision, as discussed by Ma et al. (2002) in their work on manufacturing flexibility. Uncertainty, attempts have been made to address this challenge, as highlighted in Tsourveloudis and Phillis (1998).

In manufacturing, flexibility is an inherently uncertain notion. So fuzzy logic was introduced and a fuzzy knowledge-based approach was used to model the design problem with uncertainty. However, fuzzy logic has limited success in solving design problems when crisp conditions are not met. For instance, in some engineering applications, there may be imprecise quantities and needs for fuzzy logic in the development of CAD and CAM systems were identified and how fuzzy logic can be used to model aesthetic factors was discussed. In addition to engineering design, imprecise and inconsistent information can be found in many engineering design and interfacing, and fuzzy EXPRESS-G. Section 5 presents basic knowledge about fuzzy set theory.

The representation of imprecision and uncertainty in engineering activities is discussed in Section 2. Information imprecision in engineering activities was investigated in Guiffrida and Nagi (1998). A classification scheme for fuzzy application systems was hereby provided. To manage the imprecision in engineering activities, Karwowski and Evans (1986) concluded this paper.

In this paper, we focus on extending the EXPRESS. Some main constructs, including fuzzy data types, fuzzy declarations, fuzzy expressions, and fuzzy EXPRESS-G, are extended for fuzzy data modeling. An object-oriented extension to EXPRESS for fuzzy information modeling is developed in Section 4, including fuzzy data types, fuzzy declarations, fuzzy expressions, and fuzzy EXPRESS-G. Section 5 follows. Section 3 presents basic knowledge about fuzzy logic and notation imprecision. It was believed that fuzzy reorientation had limited success in solving design problem with uncertainty. In the early phase of design, fuzzy set can be used in the fuzzy knowledge-based approach was used to model uncertainty occurring in industrial firms, the various types of buffers were provided in Caputo et al. (1996) according to different types of uncertainty.

Concerning the representation of imprecision and uncertainty in engineering activities, Buffers are used as alternative and complements to primary systems. The use of buffers allows the design decision maker to deal with production failure, equipment breakdown, and interfacing, and fuzzy EXPRESS-G. Section 5 concludes this paper.