FUZZY INFORMATION AND KNOWLEDGE-BASED SYSTEMS

developed

at the L.S.I. laboratory of the University Paul Sabatier of Toulouse (France)

In the last three years, the research group "Artificial Intelligence & Robotics - Communication, Decision, Reasoning" of the laboratory "Langages & Systèmes Informatiques" (Univ. P. Sabatier, 118 route de Narbonne, 31062 Toulouse Cédex, France) has developed various database management and inference systems, based on fuzzy sets and possibility theory for dealing with the uncertainty and the imprecision of the available information or of the expert knowledge. These systems are briefly described in the following and the main references about them, where details are given, are appended.

A system for dealing with incomplete or uncertain information in a relational database has been developed in the setting of possibility theory (Prade and Testemale, 1984) and implemented (system STRIIR, Testemale, 1984). Precisely, partially, or fuzzily-known values are allowed for single-valued as well as multiple-valued attributes, and are represented by means of [0,1]-valued possibility distributions. The basic operations of relational algebra have been extended to deal with partial information and queries involving fuzzy specifications of properties. In the associated query language, a request is answered in terms of two fuzzy sets : the set of items which (more or less) possibly satisfy the request and the set of items which (more or less) certainly satisfy it. More recently, a method for taking into account the relative importance of the elementary patterns in a compound pattern expressing a multi-criteria requirement, has been proposed in the framework of possibility theory (Dubois, Prade, Testemale, 1986) and implemented in the system SIMCAIR (see Andrès et al, 1986).

The design of the inference engine SPII (Martin-Clouaire, Prade, 1986) has been motivated by the need for a sufficiently general inference system able to i) deal both with the imprecision and the uncertainty pervading factual and expert knowledge ; ii) combine symbolic reasoning with numerical computation. SPII-2 is capable of treating pieces of information (facts or rules) which are imprecise (since they are expressed by means of vague predicates) or uncertain (since their truth is not fully guaranteed). SPII-2 works in backward chaining. Possibility theory is used for representing imprecision in terms of possibility distributions and uncertainty by means of a pair of possibility and necessity measures. More technically, SPII-2 i) propagates uncertainty and imprecision in the reasoning process via deductive inferences, (see Dubois, Prade, 1985a, b) ; ii) estimates the degree of matching between facts and condition parts of rules in presence of vagueness ; iii) combines imprecise or uncertain pieces of information relative to the same matter ; iv) performs computation on ill-known numerical quantities using fuzzy arithmetics (Dubois, Prade, 1985b). SPII-2 is developed and experimented on a prospect appraisal problem in petroleum geology (Lebailly et al.). SPII-2 is written in LELISP and is running on a VAX 11-780 computer as well as a Macintosh micro computer.

DIABETO (Buisson, Farreny, Prade, 1986a) is a medical expert system, accessible from the French videotex network TELETEL, which is a decision-aid tool for the treatment of diabetes. In DIABETO-III, imprecise / uncertain rules and facts are represented in an unified manner using possibility distributions. Practically, DIABETO-III makes use of natural approximation of the pattern of inference known as the "generalized modus ponens" introduced by Zadeh (Buisson, Farreny, Prade, 1986b). Presently the knowledge base contains about 300 rules (the full knowledge base will contain about 1 000 rules). The system is designed for being used by sick people themselves. It is implemented in NIL (dialect of LISP) on VAX 11-780.

The inference engine TAIGER (Farreny, Prade, Wyss, 1986) is not only able to handle uncertain rules but also imprecise and uncertain factual pieces of knowledge concerning the values of logical or numerical variables. The possibilistic representation of uncertainty which is used is somewhat similar to the MYCIN one, but the chaining and combination operations of the possibility theory-based approach somewhat differ from the empirical choice (obtained as distorted probabilistic laws) made in MYCIN. Besides, imprecision is dealt with in the same possibilistic framework in TAIGER. TAIGER manipulates numerical values pervaded with imprecision and uncertainty, while inference engines like the one of MYCIN treat uncertain rules and facts only. TAIGER maintains a representation of imprecise or uncertain facts in terms of possibility distributions, while the uncertainty of a rule is modelled by attaching the numbers appearing in a 2 x 2 matrix representation of the rule (Farreny, Prade, 1986). TAIGER works in backward chaining. TAIGER, is currently implemented on a micro-computer IBM-PC in MULISP. The system is experimented on knowledge bases in financial analysis. TAIGER is commercialized by the company SIRIA (9 rue de l'Echelle, 75001 Paris).

A more systematic treatment of uncertain reasoning in the setting of possibility theory has been investigated in the style of logic programming. A possibilistic version of the resolution principle has been established and is the basis of a refutation technique working on uncertain databases (Dubois, Prade, 1987). A linear strategy has been implemented. It is an automated reasoning procedure based on heuristic search with a non-additive heuristic function, applying results by Yager on possibilistic production systems (Dubois, Lang, Prade, 1987).

A more general reasoning technique based on Shafer's theory of evidence has been devised (Chatalic et al., 1986). Facts and rules are represented by instantiated formulas in predicate logic, attached with a degree of belief and / or a degree of plausibility, which can be particularized to a necessity / possibility pair or a degree of probability. The reasoning methodology consists in a conjunctive pooling of available information, followed by a projection on the universe of the query. The pooling step is based on an unnormalized version of Dempster rule. The resulting system called MIRACLE is implemented in LELISP (Chatalic et al., 1987). The reasoning strategy consists in constructing a query-dependent evaluation tree which performs a decomposition of the knowledge base and obviates a brute force application of Dempster rule.

The OPAL system for job-shop scheduling (Bensana et al., 1986) is able to integrate two kinds of knowledge about the production process : theoretical knowledge (using the scheduling theory) which deals with time constraint propagation, and practical knowledge (provided by the shop-floor manager) about specific technological constraints which must be satisfied. The latter constraints are usually not taken into account at a theoretical level, because they vary from one case to another and are often pervaded with vagueness as they take the form of pieces of advice expressed in natural language. This knowledge is implemented in a set of fuzzy decision rules about the opportunity of an operation preceding another on a machine. These fuzzy rules compete with one another and a fuzzy voting procedure is implemented to evaluate the best supported decision. The OPAL system is written in Commonlisp and runs on a Texas Explorer Lisp Machine.

Another direction has been explored by M.C. Jaulent (1986) : the interface between imprecise queries and a vision system. It is another application of fuzzy pattern matching (Cayrol et al., 1982), and the methodology is suggested in (Farreny, Prade, 1984). A query processing system has been implemented. The idea is to define a fuzzy model of an object out of the query, and to match contours of existing regions in a 2 D-picture against this fuzzy model. The shape analysis problem is considered in (Dubois, Jaulent, 1985) where a fuzzy shape classifier is described. The overall system, written in MACLISP, runs on a DPS8 computer.

Didier DUBOIS - Henri PRADE

Laboratoire L.S.I., Université P. Sabatier
118 route de Narbonne, 31062 Toulouse Cédex

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