A Bibliography on Uncertainty Management in Information Systems

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This is an evolving bibliography of documents on uncertainty and imprecision in information systems. By uncertainty and imprecision, we mean the representation of and query support for information that is fuzzy, unknown, partially known, vague, uncertain, probabilistic, indefinite, disjunctive, possible, maybe, incomplete, approximate, erroneous or imprecise. Currently, the bibliography concentrates almost exclusively on database and knowledge-base systems, with few references on other kinds of information systems.

In contrast to other chapters in this book which anticipate future research directions, the bibliography is a look back at past work. The bibliography is organized into nine sections: survey papers, null value papers, logic and deductive database papers, fuzzy set and possibility theory papers, probability theory papers, query-level papers, schema-level papers, complexity papers, and miscellaneous papers. The sections loosely reflect some topics of past research. Papers that relate to a particular research area are listed in the relevant section. If a paper applies to more than one research area then it is cross-referenced in all the appropriate sections. Since these research topics may be unfamiliar to some readers, we briefly describe the unifying theme of each section.

The survey section lists papers that give an overview of the field, or even a part of the field. Few surveys exist.

The null value section references two kinds of papers. First, this section ostensibly references papers on null values. Much of the research on imprecision in database systems has focussed on null values, consequently there are many papers listed. But this section also contains references to papers which are not concerned exclusively with null values, but concentrate on "unweighted" information, such as an exclusive-or disjunction of facts or tuples. What these two kinds of papers have in common is that they make no use of numbers, preferences or weights to handle degrees of uncertainty or imprecision.

Support for disjunctive and indefinite information in logic and deductive databases is also unweighted information, but is a distinctive enough subset to be given its own section. The

logic section also includes work on the application of non-Horn clause and nonmonotonic logics to uncertain and imprecise information management.

Sections 4 and 5 list papers that support uncertain and imprecise information within the framework of fuzzy set or possibility theory and probability theory, respectively. In general, both of these related, yet distinct, frameworks make use of "weighted" information to support varying degrees of uncertainty and imprecision.

The section on query-level papers cites papers relating to approximate querying and data mining. Some of these papers also use probability or possibility theory but are placed here (and cross-referenced to the appropriate section) because they add uncertainty and imprecision to the query rather than to the underlying data.

Uncertainty could also exist in the meta-data, concerning how the data is stored and organized, rather than in the data itself. Papers that address schema-level uncertainty are listed in Section 7. Again, some of these papers adopt fuzzy set, logic, or probabilistic approaches, but are listed in this section, because of their narrower topic.

Adding support for uncertain and imprecise information is sometimes costly. Research that characterizes the time or space complexity of various approaches appears in the section on complexity.

Finally, papers that defy simple categorization appear in the miscellaneous papers section.

Figure 1 shows a histogram of the papers in the bibliography plotted by the year of publication. The figure indicates that interest in uncertainty management in information systems, as measured by the number of publications, dramatically increased during the eighties. We suspect that the slight downward trend in the last three years is due to delays in the propagation of publication information.

Our goal is to make a comprehensive bibliography so contributions, corrections, and/or suggestions are both welcomed and encouraged. Please contact the author of this article about any desired changes or additions. We wish to sincerely thank those who have contributed to the bibliography: all the participants of UMIS; especially Amihai Motro, Esteban Zimányi, Henri Prade, Patrick Bosc, Alex Borgida, and Roberto Zicari; as well as others in the community; William Mansfield, Angela Dappert-Farquhar, Birgit Boss, Ole J. Anfindsen, Werasak Kurutach, and Richard T. Snodgrass. The bibliography is available as a bibliographic database through anonymous ftp at `cs.arizona.edu` (file `bib/incomplete.bib`). It is also available as both a LaTeX document (file `bib/incomplete.tex`) and a POSTSCRIPT document (file `bib/incomplete.ps`). This work was supported by NSF grant IRI-8902707 and by IBM contract #1124.

1 Surveys

This section lists the few papers that give an overview of some area in uncertainty management.

[1] Chisholm, P., G. Chen, D. Ferbrache, P. Thanisch and M. H. Williams. "Coping with indefinite and negative data in deductive databases: A survey." *Data & Knowledge Engineering*, 2 (1987), pp. 259–284.

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2 Null values

This section lists papers on null values in database systems and, more generally, papers that make no use of weights or preferences to represent varying degrees of uncertainty and imprecision. Figure 2 shows the publication history for null value approaches. The figure shows that the field is old (for uncertainty management) but continues to be researched. Related work can be found in

- Section 3 — [128,150]
- Section 4 — [187]
- Section 5 — [253,254,258]
- Section 6 — [268]
- Section 8 — [289,290,291]

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[24] Date, C. J. "NOT is Not 'Not'! (notes on three-valued logic and related matters)," in Relational Database Writings 1985 - 1989. Reading, MA: Addison-Wesley, 1989. Chap. 8. pp. 217–248.

[25] Date, C. J. "EXISTS is Not 'Exists'! (some logical flaws in SQL)," in Relational Database Writings 1985 - 1989. Reading, MA: Addison-Wesley, 1989. Chap. 13. pp. 339–356.

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3 Logic

Logic-based approaches to uncertainty management are common. We do not include references on logics for uncertainty reasoning, such papers are beyond the limited scope of this bibliography. Figure 3 shows the publication history for logic-based approaches. The last ten years have witnessed significant interest in this area. Related work can be found in

- Section 1 — [1]
- Section 2 — [39,42,70,71,72,73,74,75,81,82,83,105]

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5 Probabilistic Approaches

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- Section 3 — [125]
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6 Query-level

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7 Schema-level

Uncertainty and imprecision can also exist in the schema, that is, in how the data is organized. In some cases, this is a by-product of schema evolution, although the general topic of schema evolution is beyond the scope of this bibliography. Related work can be found in

- Section 2 — [115]
- Section 3 — [139]
- Section 4 — [243]
- Section 9 — [315]

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9 Miscellaneous Papers

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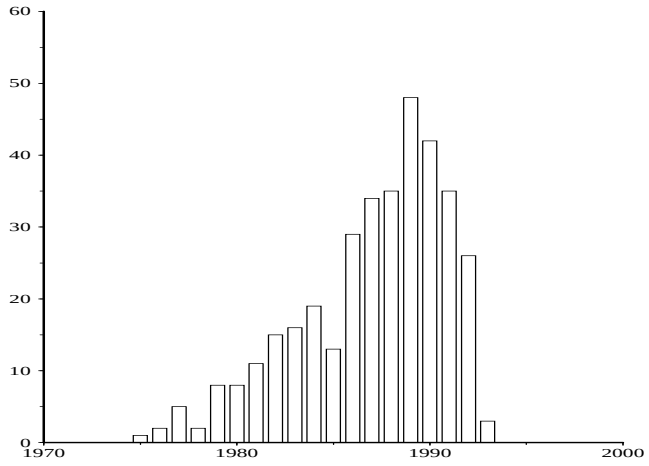

Figure 1: Publication history of every paper

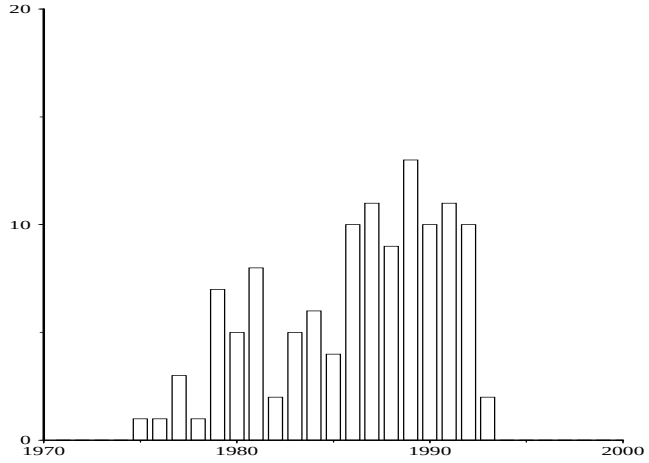

Figure 2: Publication history of unweighted approaches

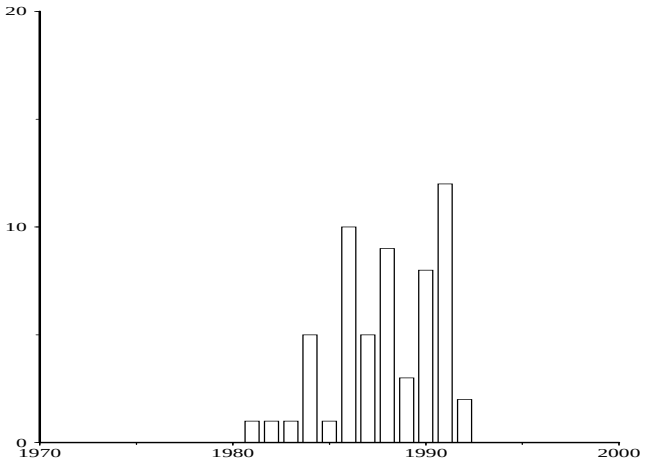

Figure 3: Publication history of logic-based papers

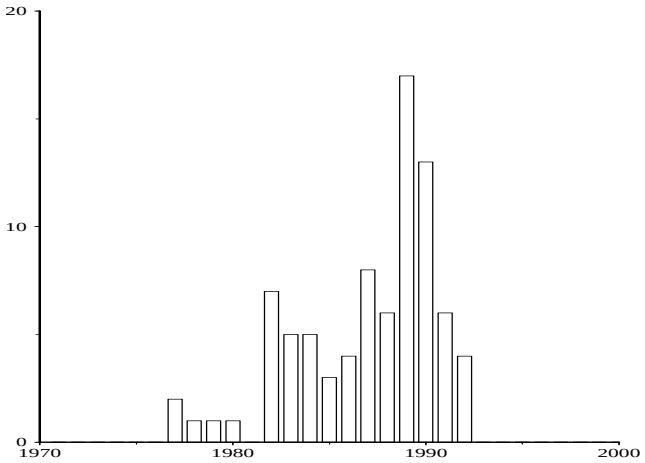

Figure 4: Publication history of fuzzy set and possibility theory approaches

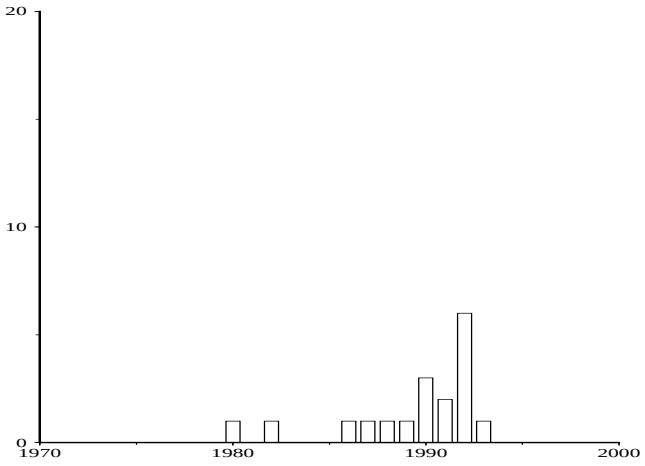

Figure 5: Publication history of probability theory approaches

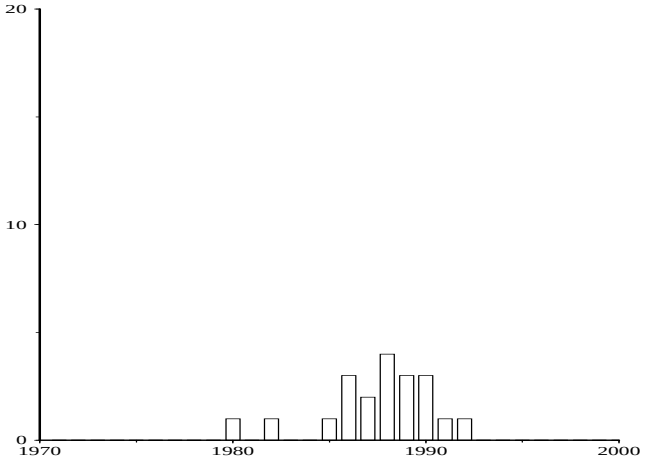

Figure 6: Publication history of query-level papers