Database Research at La Trobe University

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1. Introduction

Research at the Database Research Laboratory, Applied Computing Research Institute, La Trobe University focuses on the development of intelligent database systems. Because the research conducted is primarily application oriented, all research is performed on commercial prototypes.

It is our view that the intelligent databases of the 1990's will not be all purpose problem solvers, but rather, will have distinctive features which will solve individual problems, and which may develop principles that can be used in solving similar problems.

Our work involves applications in law, health care planning, administration and travel. It involves cooperation with other Computer Science Departments (Royal Melbourne Institute of Technology and Victoria University of Wellington) the University of Melbourne Law School, the Family Court of Australia, the Hong Kong Government and the School of Nursing at La Trobe University.

Our prime work focuses on reasoning with data, so that raw data becomes knowledge. We use a variety of different reasoning paradigms to extract our knowledge. These include the use of rule based and case based reasoning and their integration (law and health care planning), the use of model based reasoning (health care planning and management), the use of qualitative reasoning (management) and deductive reasoning and goal optimisation (travel advice).

In addition we have considered more general database problems in the areas of concurrency control in distrbuted databases and how to construct intelligent user interfaces which help when a query to a database fails .

Tom Richards leads a team working on qualitative data analysis. Whilst this work is not conducted in the Database Research Laboratory, it is no doubt of great interest to database researchers, and is hence included in this report.

It should be noted that our work in the construction of legal expert systems has lead us to investigating rationales for the development of legal expert systems. We shall also discuss this issue in this paper.

For further papers, technical reports and other information, please contact the laboratory.

2. Integrating Rule Based and Case Based Reasoning

Traditionally, most reasoning from data has been in the form of deductive reasoning. Over the past decade there has been a growing emphasis on reasoning from experience (case based reasoning). It is our belief that intelligent systems need to reason with both rules (given as in statutes, or modelled as in heuristics) and experience (such as legal precedents or medical cases). Because medicine and the law provide excellent examples of the need to integrate rule-based and case-based reasoning, we use them as our application domains.

2.1. Legal Reasoning

2.1.1. IKBALS (Intelligent Legal Knowledge Based System)

Our current prototype ICAC++ (Interconnected Collection of Autonomous Cases), tackles the problems inherent in integrating rule-based and case-based reasoning. Rules are used to model statutes and regulations, as well as the causal background knowledge and domain specific knowledge needed to interpret the legislation. A hybrid architecture supporting object-orientation and analogy is used to support case-based representation. Case indexing and retrieval is accomplished by using a combination of a statistical similarity metric (a customised nearest neighbor algorithm) along with inductive clustering algorithm (customised ID3 algorithm). Case adaptation is performed by allowing the developer to encode adaptation rules for the domain model and by experimenting with ways of detecting and using configurations of attribute patterns in cases that might be influential in modifying a case.

Our distributed, cooperating heterogeneous approach overcomes the inherent problems identified when 'hard-wiring' indices into the system. It represents a radical departure from existing central 'rule-based' approaches to Case Based Reasoning in which rules fire to suggest indices to be used as handles to cases. Statistical nearest neighbor indexing is handled directly by case agents when assessing relevance. It is our intention to further develop the use of cooperating agents in constructing legal expert database systems.

Vossos, G., Dillon, T., Zeleznikow, J. and Taylor, G. "*The Use of Object Oriented Principles to Develop Intelligent Legal Reasoning Systems*", Australian Computer Journal, Vol. 23 (1) February 1991, pp. 2-10.

Zeleznikow, J. "*BUILDING INTELLIGENT LEGAL TOOLS - The IKBALS Project*", Journal of Law and Information Science, Vol 2 (2) 1991, pp. 165-184.

Vossos, G. and Zeleznikow, J. "*Improving Automated Litigation Support by Supplementing Rule-Based Reasoning with Case-Based Reasoning*", in Proceedings of Third International Conference on Integrating Expert Systems and Databases - Berlin, Springer Verlag, pp. 138-142, 1992.

Vossos, G., Dillon, T. , Zeleznikow, J. and Vossos, V. "*Integrating Case Based Legal Reasoning with Object-Oriented/Rule Based Systems: IKBALS II* ", Proceedings of Third International Conference on Artificial Intelligence and Law, Oxford, June 25-28 1991, ACM PRESS New York, pp. 31-41.

2.1.2. SPLIT UP (Property distribution advisor in Family Law domain)

SPLIT-UP is a rule-based expert system that determines the the property distribution a Family Law Court judge is likely to impose on parties to a marriage dissolution if the dispute were to be litigated. The current prototype, comissioned by the Family Court of Australia, reasons with statutes and expert legal knowledge.

We are building three different modules for SPLIT-UP:
- one that merely models legal expertise
- one that learns from cases using machine learning algorithms
- one that retrieves precedents using case based retrieval.

When completed, we will run these modules on existing casesbeing tried in the Family Court. This will give us important benchmark information about the uses as well as the suitability of each of these modules for modelling legal reasoning.

Stranieri, A. and Zeleznikow, J. *SPLIT-UP Expert system to determine Spousal Property distribution on Litigation in the Family Court of Australia*" , Technical Report and to appear in Proceedings of AI92, Springer Verlag Lecture Notes on Computer Science, 1992.

2.1.3. RATIONALES FOR THE DEVELOPMENT OF LEGAL EXPERT SYSTEMS

Unfortunately much work in the area of Legal Expert Systems has involved non-lawyers developing systems which naively attempt to mechanistically interpret statutes. They fail to use current developments in Case Based Reasoning and Qualitative Reasoning. Whilst the aforementioned production rule systems are of great use in judicial decision making, they are inadequate as a litigation support tools. We have investigated in what domains legal expert systems can be useful, what lawyers require, and what computer science can provide.

Zeleznikow, J. and Hunter, D. "*Rationales for the Continued Development of Legal Expert Systems*", Journal of Law and Information Science, Vol 3 (1) 1992 pp. 94-110.

2.2. FLORENCE (integrating model based and case based reasoning)

We have used a model of health care planning (represented by a model based reasoner) to provide health care diagnosis and planning. A typical situation is modelled by a series of production rules, together with stored standard and real cases. We are hence developing techniques to integrate model based and case based reasoing. To do this, we use a blackboard type architecture, using cooperating agents. An innovative methodology is the use of stored past cases to develop a forward prognosis of current case outcome.

Bradburn, C., Zeleznikow, J. and Adams A. "*FLORENCE: Synthesis of case-based and model-based reasoning in a nursing care planning system*", Technical Report and to appear in Journal of Computers in Nursing.

3. Model Based and Qualitative Reasoning

In modelling management decision making we have used the contigency theory of management as our basis for performing model based reasoning. Since most management advice is qualitative rather than quantitative, we need to integrate these two reasoning processes. We do this by developing an object oriented data model QASI (Qualitative Assimilation of Semistructured Intelligence) together with its associated Instance Abstraction Algebra.

Yuen, H.S., Ho, S. and Zeleznikow, J."*Adding Qualitative Reasoning to an Organizational Database for Management Decision Support*", in The Next Generation of Information Systems: From Data to Knowledge, Papazoglou, M and Zeleznikow, J. (eds,), Springer Verlag Lecture Notes in Computer Science, Vol. 611, 79-103, 1992.

4. Constraint Satisfaction and Goal Optimisation in Deductive Databases

In providing intelligent advice from a deductive database, we often wish to be given an optimal, (in the sense of meeting user criteria), plan which satisfies certain constraints and rules. Our prototype, L-CATA is a logic -based expert database system, which asks the user to input his query specification, constraints, rules and goals, and then outputs a list of flights meeting the user's specification. Further, L-CATA provides an alternative list which may not quite meet the user's specification, but optimises his goal(s). Current research involves allowing multiple goals within a query specification, prioritizing multiple goals and developing heuristics for handling violatable and non-violatable constraints.

Yan, S. and Zeleznikow, J. "*Query Evaluation and Goal Optimisation in Logic-Based Expert Travel System*", International Journal of Systems Research and Information Science, Vol 5 1991 pp. 3-11, Gordon and Breach Science Publishers

Yan, S. and Zeleznikow, J. "*L-CATA: A LOGIC-BASED EXPERT TRAVEL SYSTEM*", Computer Science in Economics and Management, Vol 4 1991 pp. 151-163, Kluwer Academic Publishers .

Cleary, D. and Zeleznikow, J. "*L-CATA: An Intelligent Logic Based Expert Travel Assistant* ", Proceedings of Eleventh International Workshop on Expert Systems and their Applications, Avignon France, May 27 - 31 1991, Volume 6, pp. 111-122.

Cleary, D. and Zeleznikow, J."*Building Expert Databases: L-CATA - An Intelligent Logic Based Travel Assistant* ", Proceedings of Second International Conference on Database and Expert Systems, Berlin, Springer Verlag, pp. 130-134, 1991.

5. Concurrency Control in Distributed Databases

In order to achieve robustness, high performance and availability in a distributed database system we are implementing replicated distributed databases. We use multi-recovery versions to keep the replicated data items consistent when site failures and network partitions occur.

6. INTELASST

A generic preprocessor, INTELASST is developed, using the inheritance concept of the object-oriented paradigm, to derive a taxonomy for relations in a relational database system. It translates the inter-relationships existing in the database into a taxonomy represented by a lattice. It is thus able to automatically modify vague and inadequate queries into the relevant computable queries.

Loo, S.L. *"A Taxonomy for an Intelligent Database"* in Srinivasan, B. and Zeleznikow, J. (eds.) "Research and Practical Issues in Databases" World Scientific Publishers, Singapore, 1992.

7. NUDIST

NUDIST is a system for the management of qualitative data analysis research projects typically carried out by social scientists, historians and business analysts. It supports the user in a variety of ways in the analysis and management of qualitative data. It is primarily oriented to supporting the development of theories (explanations, cohering accounts) from the data, using information structuring techniques derived from Grounded Theory research. It also provides methods of testing theories against the data.

NUDIST is now widely used in many sites. Current research involves improvement of the user interface and the development of more intelligent tools within the system.

Richards, T. and Richards, L. "*Database Organisation for Qualitative Analysis: the NUDIST system.*" in The Next Generation of Information Systems: From Data to Knowledge, Papazoglou, M and Zeleznikow, J. (eds,), Springer Verlag Lecture Notes in Computer Science, Vol. 611, pp. 116-133, 1992.

Richards, T. and Richards, L. "*The NUDIST Qualitative Data Analysis System*" Qualitative Sociology 14:4 (1991) pp. 307-324.

Richards, T. and Richards, L. "*The Transformation of Qualitative Method: Computational Paradigms and Research Pro, 1991.*

Richards, M.G. and. Richards, T. "*Computing in Qualitative Analysis: a Healthy Development?*" Qualitative Health Research 1:2. (May) 1991 pp.234-262