December 2000

Knowledge Discovery for Decision Support in Law

Andrew Stranieri
LaTrobe University

John Zeleznikow
LaTrobe University

KNOWLEDGE DISCOVERY FOR DECISION SUPPORT IN LAW

Andrew Stranieri
John Zeleznikow
Donald Berman Laboratory
Department of Computer Science and Computer Engineering
LaTrobe University
Australia

Abstract

The Split Up project applies knowledge discovery techniques (KDD) to legal domains. Theories of jurisprudence underpin a classification scheme that is used to identify tasks suited to KDD. Theoretical perspectives also guide the selection of cases appropriate for a KDD exercise. Further, jurisprudence underpins strategies for dealing with contradictory data. Argumentation theory is instrumental for representing domain expertise so that the KDD process can be constrained. Specifically, a variant of the argumentation structure proposed by Toulmin is used to decompose tasks into independent sub-tasks in the data transformation phase. This enables a complex KDD exercise to be decomposed into numerous simpler exercises that each require less data and have fewer instances of missing values. The use of the structure also facilitates the development of information systems that integrate multiple reasoning mechanisms such as first order logic, neural networks or fuzzy inferences and provides a convenient structure for the generation of explanations. The viability of this approach was tested with the development of a system that predicts property split outcomes in cases litigated in the Family Court of Australia. The system has been evaluated using a mix of strategies that derive from a framework proposed by Reich.

1. RESEARCH OBJECTIVES AND QUESTIONS

The Split Up project aims to apply knowledge discovery from database (KDD) processes to law. Specific research questions are:

- Can theories of jurisprudence be applied to facilitate the selection of tasks in law that are suited to a KDD process?
- Can theories of argumentation be beneficially applied to integrate expert knowledge into the KDD process?

Knowledge discovery techniques have not been applied extensively in the legal domain despite potential benefits in the automated generation of legal knowledge from data. The absence of data in quantities collected in other fields, such as astronomy, in part accounts for this trend. However, for the most part, KDD has not been extensively performed with legal data because of a lack of clarity about how this can be done.

Theories of jurisprudence have proven indispensable for the analysis and development of computational models of legal reasoning. For example, the rule positivism of (Hart 1961) underpins the application of logic programming in law exemplified by (Sergot et al. 1986). The identification of jurisprudence theories that are particularly applicable to improve KDD and how they can be applied is the first objective of the current research.

In practice, a knowledge discovery from database process involves the incorporation of some domain expertise at each of the following KDD phases: data selection, preprocessing, transformation, mining, and evaluation. According to argumentation theorists, domain expertise can conveniently be represented as arguments for or against assertions. Therefore, we surmised that argumentation may provide a convenient framework for the representation of domain expertise so as to improve results from a KDD exercise.

The Split Up project applies KDD to predict property division decisions made by judges of the Family Court of Australia following a divorce. We aim to develop strategies that are applicable to other areas of law and, more broadly, to other domains. In this paper, we report the following findings to date:

- KDD is particularly suited to the discovery of knowledge in discretionary domains. Discretionary domains are defined by jurisprudence theories.
- The discernment of tasks suited to KDD from those more appropriately suited to other methods relies heavily on the jurisprudential concept of open texture.
- The argumentation theory proposed by Toulmin (1958) is used for the representation of domain knowledge in the data transformation phase. Further, the argument structure we use also facilitates the development of hybrid systems and the generation of explanations

In the next section we elaborate on the theoretical foundations that underpin these points.

2. THEORETICAL FOUNDATIONS

The concept of open texture is prevalent in law. This concept was introduced by Waismann (1951) to assert that empirical concepts are necessarily indeterminate. To use his example, we may define gold as that substance which has spectral emission lines X and is colored deep yellow. However, because we cannot rule out the possibility that a substance with the same spectral emission as gold but without the color of gold will confront us in the future, we are compelled to admit that the concept we have for gold is open textured. A definition for open textured terms cannot be advanced with absolute certainty unless terms are defined axiomatically, as they are, for example, in mathematics.

The concept of open texture is significant in the legal domain because new uses for terms and new situations constantly arise in legal cases. Prakken (1997) discerns three sources of open texture: reasoning, which involves defeasible rules; vague terms; or classification ambiguities. We add judicial discretion as conceptualized by Christie (1986) and Bayles (1990) to this list and argue that judicial discretion is a form of open texture distinct from the three listed above. According to this view, decision makers have some flexibility in weighing relevant factors when exercising discretion although articulating an assignment of weights is typically difficult. The KDD process is particularly useful for discovering the weights of relevant factors from a database of decided cases.

Domain expertise in family law is represented in the Split Up system as arguments. This enables an informed data transformation phase and also constrains the data mining. For the philosopher Toulmin (1958), practical reasoning, as distinct from analytical reasoning, involves the construction of an argument. Arguments, regardless of the domain, have a structure that consists of six basic invariants: claim, data, modality, rebuttal, warrant, and backing. Every argument makes an assertion based on some data. The assertion of an argument stands as the claim of that argument. A warrant justifies why the claim follows from the data. The backing supports the warrant and in a legal argument is typically a reference to a statute or a precedent case. The rebuttal component specifies an exception or condition that obviates the claim.

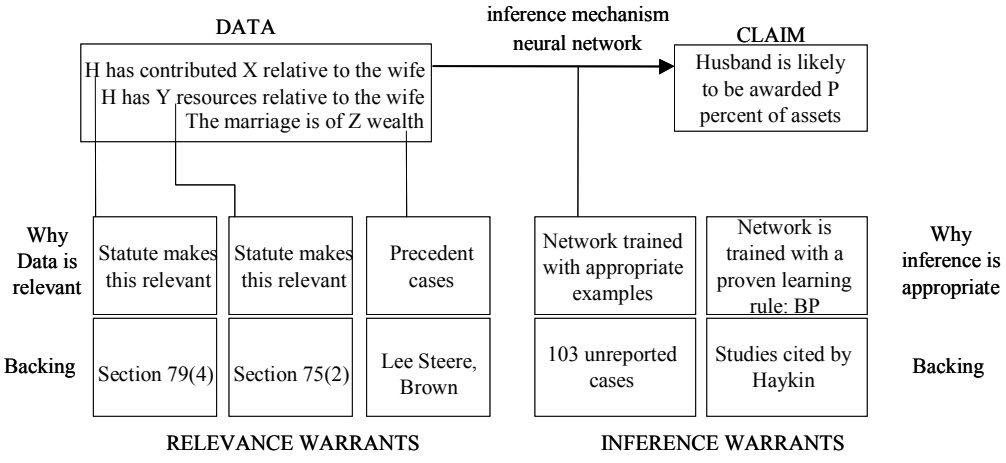

Figure 1. Toulmin Argument Structure for One of the Split up Arguments

The Toulmin argument structure has been used by a number of researchers in various fields to model reasoning. However, a survey by Stranieri and Zeleznikow (1999) illustrates that the majority of researchers vary the structure to suit their particular use. The variation that we used aimed to facilitate KDD. The structure is illustrated in Figure 1.

In the next section, we shall discuss how open texture and argumentation have been applied to legal reasoning in the Split Up project.

3. RESEARCH METHODOLOGY

3.1 Selection Phase Classification Scheme

The scheme illustrated in Figure 2 has two dimensions: open texture/well defined and bounded/unbounded.

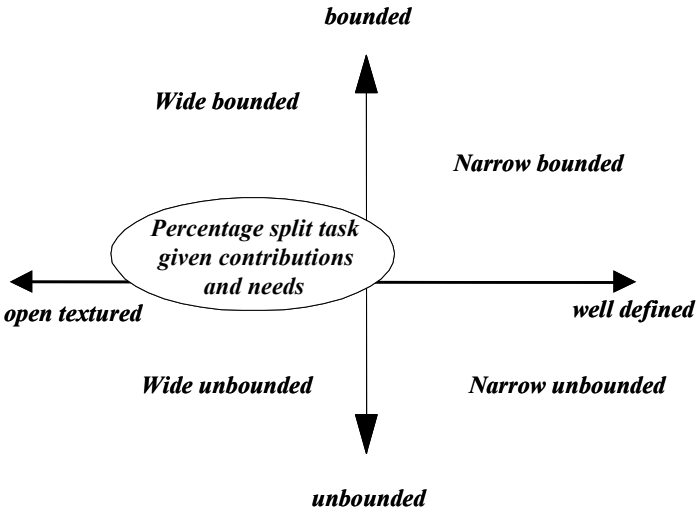

Figure 2. Classification of Percentage Split Task

The open textured/well defined axis reflects the extent to which experts believed factors known to be relevant in a prediction were open textured. Predicting a percentage split of marital assets was considered open textured by experts because of the high degree of discretion judges have. The bounded dimension refers to an expert's beliefs about the completeness of their knowledge of relevant factors. In Split Up, 94 variables were identified as relevant for predicting a percentage split of assets. Experts were of the view that few factors useful for a prediction were omitted from this list and, therefore, considered the task quite bounded.

Tasks that fall in the narrow bounded quadrant are well suited to implementation with heuristics elicited as rules because all terms are well defined and all variables relevant for the prediction are known. Discretionary tasks that fall in the wide bounded quadrant (top left in Figure 2) can be modeled using the KDD process. Unbounded tasks, whether or not they contain open textured terms, cannot be modeled adequately using KDD, since sufficient relevant factors cannot be determined. In family law, determining child custody was considered unbounded by experts.

In jurisprudence, cases that set a precedent and change future decision making (landmark cases) are discerned from common place cases. This distinction helps us to select cases for KDD training sets in that we claim that the KDD process is most appropriately applied to discover patterns of discretion in typical cases and not those that result in a change in law.

3.2 Preprocessing Phase

Data for the Split Up training set was collected by reading Family Court judgements and extracting values for relevant factors from each case. Many examples were contradictory. Contradictory examples are those that display different outcomes given the same or very similar inputs. In non-legal domains, these are often attributed to noise as erroneously recorded data. However, in discretionary domains of law, we expect some contradictions because individual judges have some latitude to weigh the relevant factors in their own way.

There are a number of ways to deal with contradictions. Most simply, the contradictions can be ignored. Wang and Gedeon (1995) note that a small proportion of noisy examples will not dramatically affect the performance of a neural network. In law, outcomes that contradict others may reflect judicial error and warrant removal from the database. Although this is subjective, we adopt the strategy of removing cases that domain experts consider erroneous. A metric to gauge the extent of similarity in inputs of multiple examples with the same outputs was developed in order to facilitate this.

3.3 Toulmin Structures for the Transformation Phase

According to data mining rules of thumb, the number of examples needed to identify useful patterns from 94 variables is in the many tens of thousands. Data from this number of cases is rarely available in the legal domain. Furthermore, few cases involve all 94 variables (e.g., childless marriages have no values for all variables associated with children), so a training set would be replete with missing values.

We used the Toulmin structure depicted above to decompose the task into smaller tasks, each of which involved a sufficiently small number of variables in order to facilitate KDD with the small number (103) of examples we had. Furthermore, the structure enabled the collation of training sets with no missing values. Figure 3 illustrates the claim and data items of three arguments. The claim of argument B was one of the data items for argument A. In total, the 94 variables were dispersed in 35 arguments. Twenty of these were classified "wide bounded," so training sets were assembled for KDD. Heuristics for the remaining 15 (classified narrow bounded) were sourced from experts for rule sets.

The Split Up system was evaluated using the strategies depicted in Table 1. These strategies are based on a framework put forward by Reich (1995). Results from evaluation trials suggest that the KDD process with the use of a Toulmin framework leads to the development of legal knowledge based systems that perform well and are acceptable to users. However, on some occasions, Split Up produced inferences quite at odds with those obtained from lawyers. In most of these cases, the small size of the training set was the most likely source of error.

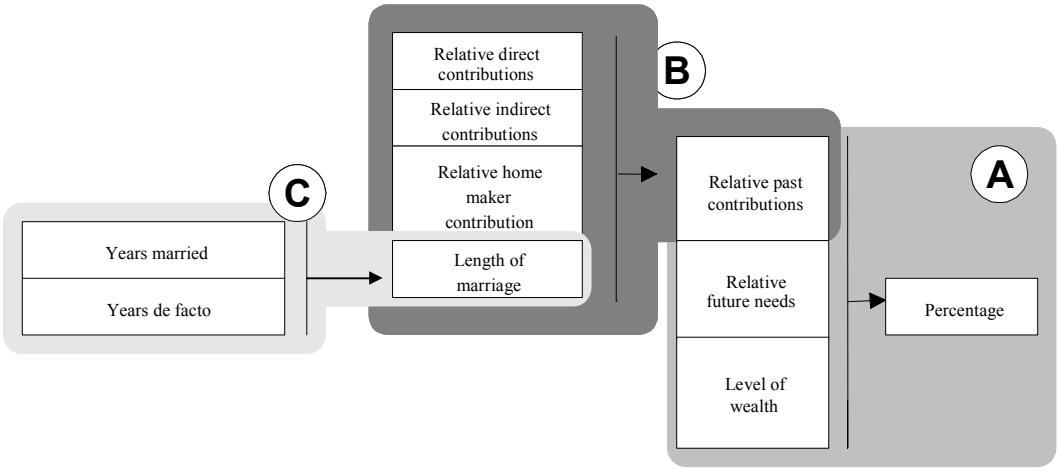

Figure 3. Data and Claim for Three Arguments in Split Up

Table 1. Evaluation Strategies Used in Split Up

	Qualitative	Quantitative
Structural view of knowledge	1. Domain expert assessment of the content and structure of knowledge base 2. Extent to which the knowledge base is ontologically specified	1. Extent to which a data mining technique has learned patterns in training data 2. Extent to which a data mining technique generalizes well from the training data
Functional view of knowledge	1. Domain expert assessment of the problem solving strategy adopted in Split Up 2. Extent to which the problem solving strategy is based on theoretical perspectives 3. Qualitative feedback from end users in different categories 4. Comparison of predictions made by Split Up with those reported in written judgements of cases	1. Comparison of predictions made by Split Up with those made by eight lawyers on facts from the same three cases

4. CURRENT STATUS

The classification scheme has been used to classify tasks in the domain of family law (Zeleznikow and Stranieri 1997), refugee law (Yearwood and Stranieri 1999), and intellectual property law (Stranieri and Zeleznikow 2000). Research is currently in progress to survey other domains in order to establish whether unsuccessful projects can been identified in part with the use of this scheme. Furthermore, current work is aimed at increasing the training set size tenfold.

To date, the argument structure has been tested in systems in family law (35 arguments), refugee law (200 arguments), copyright law (50 arguments), and eligibility for legal aid (eight arguments). Current research involves the development of an argumentation shell for this structure. This is being designed as an agent oriented program with discourse agents committed to engaging other agents in a dialogue so as to model how arguments rebut, extend, or support others.

5. CONCLUSION

We have described our experience in applying knowledge discovery from database techniques to data from the legal domain. The extensive use of jurisprudence theory from law and argumentation theory from philosophy has informed strategies and techniques we have developed to apply domain knowledge to KDD.

Acknowledgments

This research was funded by an Australian Research Council grant in collaboration with Software Engineering Australia and Victoria Legal Aid.

References

Bayles, M. D. *Procedural Justice: Allocating to Individuals*, Dordrecht: Kluwer Academic Publishers, 1990.

Christie, G. C. "An Essay on Discretion" *Duke Law Journal*, 1986, pp. 747-778.

Hart, H. L. A. *The Concept of Law,* Oxford: Clarendon Press, 1961.

Prakken, H. *Logical Tools for Modeling Legal Arguments: A Study in Defeasible Reasoning in Law*, Dordrecht: Kluwer Academic Publishers, 1997.

Reich, Y. "Measuring the Value of Knowledge," *International Journal of Human-Computer Studies*, (42:1), 1995, pp. 3-30.

Sergot, M. J., Sadri, F., Kowalski, R. A., Kriwaczek, F., Hammond, P., and Cory, H. T. "The British Nationality Act as a Logic Program," *Communications of the ACM* (29), 1986, pp. 370-386.

Stranieri, A., and Zeleznikow, J. "A Survey of Argumentation Structures for Intelligent Decision Support," in *Proceedings of the International Society for Decision Support Systems Fifth International Conference ISDSS'99*, R. Burstein (ed.), Monash University, Melbourne, Australia, 1999.

Stranieri, A., and Zeleznikow, J. "Copyright Regulation in Cyber-Space: The Case for a Knowledge Based Approach Using Argumentation," in *Proceedings of the AISB'00 Symposium on Artificial Intelligence and Legal Reasoning*, University of Birmingham, United Kingdom, 2000, pp. 1-9.

Toulmin, S. *The Uses of Argument*, Cambridge, England: Cambridge University Press, 1958.

Waismann, F. "Verifiability," in *Logic and Language*, A. Flew (ed.), Oxford: Blackwell, 1951.

Wang, P., and Gedeon. T. D. "A New Method to Detect and Remove the Outliers in Noisy Data Using Neural Networks: Error Sign Testing," *Systems Research and Information Science* (7:1), 1995, pp. 55-67.

Yearwood, J., and Stranieri, A. "The Integration of Retrieval, Reasoning and Drafting for Refugee Law: A Third Generation Legal Knowledge Based System," in *Seventh International Conference on Artificial Intelligence and Law, ICAIL'99*, New York: ACM Press, 1999, pp. 117-137.

Zeleznikow, J. and Stranieri, A. "Knowledge Discovery in the Split-Up Project," in *Proceedings of Sixth International Conference on Artificial Intelligence and Law*, New York: ACM Press, 1997, pp. 89-97.