Logical Models of Legal Argumentation

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Abstract

This article reviews logical models of legal argumentation as they are being developed in the field of artificial intelligence (AI) and law. One aim is to show that several aspects of legal reasoning which have often been claimed to escape formalisation can very well be formalised. First the limitations of logical deduction as models of legal reasoning are discussed. Then models of defeasible legal reasoning and legal argumentation, which focus on the generation and comparison of reasons or arguments for and against legal claims, are discussed. Models of rule-based defeasible reasoning address exceptions and rule conflicts. Models of legal interpretation emphasize the interplay between rules and cases and the role of principles, purposes and values. Models of legal proof account for the uncertainty in legal proof in three alternative ways: with Bayesian probability theory, with stories and with argumentation. Finally, dialogue models of legal argument address issues of procedural rationality and strategic choice.

1 Logic, Argumentation and Law

Models of rationality in the law must be diverse. In a legal case various types of decisions must be made, including determining the facts, classifying the facts under legal concepts, and deriving legal consequences from the classified facts, and each has its own modes of reasoning. Therefore in the law theoretical and practical reasoning must be combined. When determining the facts, the modes of reasoning are often probabilistic and may involve reasoning about causation and about mental attitudes such as intent. Classifying the facts under legal concepts involves interpretation. Here the prevailing modes of reasoning are analogy, appeals to precedent, and the balancing of interests, purposes and values. Finally, when deriving legal consequences from the classified facts, the main modes of reasoning are deductive but leave room for exceptions to rules and for the resolution of rule conflicts.

While legal reasoning is diverse, still a unified account can be given in terms of argumentation. A simple but naive model of legal reasoning sees it as logically deducing legal consequences from a precisely stated body of facts and legal rules. On this account, once a legal text and a body of facts have been clearly represented in a logical language, the valid inferences are determined by the meaning of the representations and so techniques of automated deduction apply. However, this mechanical approach leaves out much of what is important in legal reasoning. To start with, the law is not just a conceptual or axiomatic system but has social objectives and social effects, which must be taken into account when applying the law. For example, in the well-known *Riggs v. Palmer* case in American inheritance law (discussed by Dworkin 1977) a grandson had killed his grandfather and then claimed his share in the inheritance. The court made an exception to inheritance law based on the principle that one cannot profit from their own wrongdoing. Moreover, legislators cannot fully predict in which circumstances the law will have to be applied, so legislation has to be formulated in general and abstract terms, such as ‘duty of care’ or ‘misuse of trade secrets’, and qualified with general exception categories, such as ‘self defence’ or ‘unreasonable’. Such concepts and exceptions must be interpreted in concrete cases, which creates room for disagreement. This is the more so since legal cases often involve conflicting interests of opposing parties. The prosecution in a criminal case wants the accused convicted while the accused wants to be acquitted, and the plaintiff in a civil law suit wants to be awarded compensation for damages, while the defendant wants to avoid having to pay. These three

aspects of the law - the possibility that legal rules have unjust outcomes, the tension between the general terms of the law and the particulars of a case, and the adversarial nature of legal procedures - cause legal reasoning to go beyond the meaning of the legal rules. It involves appeals to precedent, principle, policy and purpose, as well as the consideration of reasons for and against drawing certain conclusions. Therefore law relies not just on deduction but on argument[1]. This chapter aims to show that these aspects of legal reasoning, which have often been claimed to escape formalisation (see e.g. Chapter 11.3 on legal logic of this handbook) can very well be formalised.

Accordingly, this article[2] reviews logical models of legal argumentation, which have mostly been developed in the field of artificial intelligence (AI) and law, as formal underpinnings of implemented AI systems for supporting legal argumentation and decision making. In reviewing the various approaches, we will focus more on their underlying ideas and concepts than on their technical particulars. First applications of nonmonotonic logics for dealing with rule exceptions and rule conflicts are discussed. Then argumentation-based models of legal interpretation that emphasize the interplay between rules and cases and the role of principles, purposes and values are reviewed. As regards fact-finding, argumentation-based, story-based and probabilistic models of legal proof are briefly compared. Finally, dialogical models of legal argument and their use in modelling legal-procedural notions are discussed.

2 A first challenge for deductive models: exceptions and rule conflicts

Any attempt to logically model reasoning with legal rules faces the challenge that legal rules can have exceptions and that several conflicting legal rules can apply to a case. One problem is that the law often makes legal effects dependent on the non-availability of evidence for exceptions. Consider a legal rule 'an offer and an acceptance create a binding contract' with an exception in case the offeree was insane when accepting the offer. As long as there is no evidence that the offeree was insane, the general rule can be applied to defeasibly conclude that there is a binding contract. If later evidence is provided that the offeree was insane, this conclusion must be retracted. The same holds for exceptions that come from sources other than statutes, as in the above-mentioned *Riggs v. Palmer* case, where a statutory rule was overridden by an unwritten principle. The making and retracting of such 'defeasible' inferences goes beyond standard deductive models of reasoning. Instead, non-monotonic logics[3] should be used. Such logics allow the making of inferences subject to evidence to the contrary, and the retraction of such inferences when evidence to the contrary comes in. They thus formalise one influential idea introduced by Toulmin (1958), namely, that 'good' arguments can be defeasible in that it is sometimes rational to accept all their premises but not their conclusion.

For representing legal rules and exceptions, two different logical techniques have been used. The first technique adds an additional condition 'unless there is an exception' to every rule and combines it with a nonprovability operator, such as logic-programming's negation as failure (Sergot et al. 1986). Thus, for example, the above legal contract rule and its exception can be represented as follows (where ~ stands for nonprovability).

r1: *Offer* & *Acceptance* & ~ *Exception*(r1) ⇒ *BindingContract*

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[1] See Chapters 5.5 and 5.6 of this handbook for introductions to argumentation theory and Feteris (2017) for an introduction to the theory of legal argumentation.

[2] Several parts of this chapter are taken or adapted from Bench-Capon et al. (2009), Prakken (2013) and Prakken and Sartor (2015). Trevor Bench-Capon and Giovanni Sartor gave useful feedback on a version of this chapter.

[3] Some ideas concerning nonmonotonic logics are reviewed in Chapters 5.2-5.4 and 6.1 of this handbook.

r2: *Insane* ⇒ *Exception*(r1)

r3: *Insane* & ~ *Exception*(r3) ⇒ *Not BindingContract*

The second technique states a priority between a general rule and an exception:

r_1: *Offer* & *Acceptance* ⇒ *BindingContract*

r_2: *Insane* ⇒ *Not BindingContract*

r1 < r2

Several nonmonotonic logics can also model reasoning about the resolution of rule conflicts. Legal systems have general principles for resolving rule conflicts, such as preferring the more specific or more recent rule or preferring the rule that is hierarchically superior (e.g. 'The constitution is superior to statutes'). Moreover, specific statutes can have specific conflict resolution rules such as 'rules concerning labour contracts override rules from general contract law'. If no clear conflict resolution principles apply or if these principles themselves conflict, then some approaches allow reasoning about which rule preference holds (e.g. Gordon 1994; Prakken and Sartor 1997; Verheij et al. 1998).

Although rule-based nonmonotonic techniques technically deviate from deductive logic, their spirit is still the same, namely, of deriving consequences from clear and un-ambiguous representations of legal rules and facts. The logical consequences of a representation are still clearly defined. While technically most nonmonotonic logics allow for alternative conclusion sets (see further Section 4 below), in legal practice statutory rule-exception structures and legislative hierarchies still usually yield unambiguous outcomes. More often, conflicts arise not from competing norms but from the variety of ways in which they can be interpreted. A real challenge for deductive accounts of legal reasoning is the gap between the general legal language and the particulars of a case. Because of this gap, disagreement can arise, and it will arise from the conflicts of interests between the parties.

3 A second challenge for deductive models: bridging the gap between legal language and the world

One might think that disagreements about interpretation are resolved in concrete cases by courts, so that additional rules can be found in case law. If different courts disagree on an interpretation, such disagreements could be represented with nonmonotonic techniques for handling conflicting rules. This was indeed the approach taken by Gardner (1987), who designed a program for so-called "issue spotting" in law school contract law exam problems. Given an input case, the task of the program was to determine which legal questions involved were easy and which were hard, and to solve the easy ones. If all the questions were found easy, the program reported the case as clear, otherwise as hard. The system contained domain knowledge of three different types: legal rules, commonsense rules (e.g. on the interpretation of utterances like "Will you supply … ?"), and rules extracted from cases. The program considered a question as hard if either "the rules run out", or different rules or cases point at different solutions, unless it had reasons to prefer one solution over the other. For example, it preferred case law rules over conflicting legal or commonsense rules.

A problem with such approaches is that rules derived from precedents are often specific to the case, so a new case will rarely exactly match the precedent, and techniques for handling conflicting rules fall short. Instead, reasoning forms are called for in which case-law rules can be refined and modified. Here factors and reasons play an important role, and analogies between cases are drawn and criticized. Such observations led to a shift in focus away from 'traditional' nonmonotonic logics and towards argumentation-based approaches, in part based on general AI models of argumentation such as Dung (1995), Pollock (1995)

and later Modgil and Prakken (2013). Another approach is Reason-Based Logic (Hage 1996; Verheij et al.; 1998), a nonmonotonic logic that models defeasible reasoning as the weighing of reasons for and against a conclusion, where rules are just one source of reasons, along with, for example, precedents or principles.

4 Intermezzo: logical models of argumentation

Logical models of argumentation as developed in AI view defeasible inference as an inherently dialectical matter: an argument warrants its conclusion if it is acceptable, and an argument is acceptable if, firstly, it is properly constructed and, secondly, it can be defended against counterarguments. They thus formalise the second influential idea introduced by Toulmin (1958), namely, that outside mathematics the validity of arguments does not depend on their syntactic form but on whether they can be defended in a rational dispute. Argumentation logics define three things: how arguments can be constructed, how they can be attacked by counterarguments and how they can be defended against such attacks. Argumentation logics are a form of nonmonotonic logic, since new information may give rise to new counterarguments against arguments that were originally acceptable.

The basis of much logical work reviewed below is Dung's (1995) famous abstract account of argumentation, which just assumes a set of *arguments* (whatever they look like) with a binary relation of *attack* (on whatever grounds). Dung's theory characterizes various sets *S* of arguments that are *admissible* in that

1. *S* is *conflict-free* (i.e., no argument in *S* attacks an argument in *S*); and
2. *S defends* all its members (i.e., all attackers of a member of *S* are attacked by a member of *S*)

Each admissible set is a coherent point of view. Reasoners are usually interested in subset-maximal points of view, called *extensions*. Sometimes a theory has a unique extension and sometimes multiple, mutually incompatible ones. Consider the following two example graphs, in which the nodes are arguments and the links are attack relations:

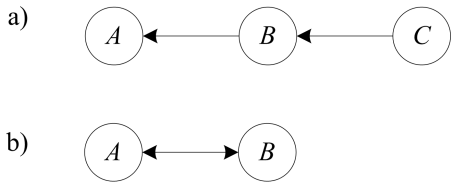

Figure 1: two abstract argumentation frameworks

In Figure 1a there is a unique maximal admissible set, namely, {*A,C*} ({C} and the empty set are also admissible but they are included in {A,C}). Note that {*A*,*B*} is not admissible since it is not conflict-free while {B} is not admissible and since it does not defend *B* against *C*. So in Figure 1a both *A* and *C* are warranted while *B* is not warranted.

In Figure 1b there are two maximal admissible sets, namely, {*A*} and {*B*}. In the first, *A* defends itself against *B* while in the second, *B* defends itself against *A*. Note that {*A*,*B*} is not admissible since it is not conflict-free. So in Figure 1b neither argument is warranted but both *A* and *B* are 'defensible' in that they belong to alternative coherent points of view.

As for the structure of arguments and the nature of attack various approaches exist. An early example is Prakken and Sartor's (1997) model of reasoning with legal rules mentioned above in Section 2. More recent approaches are inspired by the concept of

argument (or argumentation) schemes from argumentation theory[4] (cf. Walton 1996). Argument schemes model stereotypical forms of defeasible, or 'presumptive' reasoning, such as reasoning with defeasible legal rules, reasoning with defeasible generalisations, reasoning from expert or witness testimony, various forms of analogical, causal or temporal reasoning, and schemes for practical reasoning (in terms of goals fulfilled or violated by decision options). Each scheme comes with a set of 'critical questions', which point at possible exceptions to the scheme (e.g. does applying this legal rule violate its purpose? was the witness biased? are there also relevant differences between these analogous cases? are their better ways to fulfill the same goal?). In the ASPIC+ framework (Modgil and Prakken 2013) argument schemes can be modelled as deductive or defeasible inference rules and applications of such rules can be chained into tree-style arguments. All arguments can be attacked on their premises while arguments using defeasible rules can also be attacked on the use of these rules. Then a preference relation on arguments can be defined to see which attacks succeed as defeats, after which Dung's theory of abstract argumentation can be used with attacks replaced by defeats. There are similar approaches that are not within ASPIC+ or Dung's theory, such as Carneades (Gordon and Walton 2009).

5 Interpreting legal concepts with cases

Ways of reasoning 'when the rules run out' can be found in their most explicit form in common-law jurisdictions, which traditionally were not statute- but precedent-based. This lead to reasoning forms where legal rules are formulated by courts in the context of particular cases and are constantly refined and modified to fit new circumstances that were not originally taken into account. However, these reasoning forms can also be found in civil-law jurisdictions, since the concepts in statutory rules also have to be interpreted.

5.1 System-oriented work on legal case-based reasoning

A recent attempt to formalize traditional canons of statutory interpretation (see chapter 11.3 of this handbook on legal logic) with argument schemes is Walton et al. (2016). A limitation of this work is that interpretation canons are themselves often vague and conflicting. Much AI & law work on the interpretation of legal concepts instead centers around the notions of a *dimension*, introduced in the HYPO system of Ashley (1990) and the related notion of a *factor*, originating from the CATO system of Aleven (2003). For a detailed recent review see Bench-Capon (2017). Factors are abstractions of fact patterns that favour (pro factors) or oppose (con factors) a conclusion. Factors are thus in an intermediate position between the specific facts of a case and the legal predicates to which such facts may be relevant. For example, in CATO, which like HYPO argues about misuse of trade secrets, some factors pro misuse are that a non-disclosure agreement was signed, that the plaintiff had made efforts to maintain secrecy and that the copied product was unique; and some factors con misuse are that disclosures were made by the plaintiff in negotiations and that the information was reverse-engineerable. While in CATO factors are a basic notion, in HYPO they are defined in terms of *dimensions*, which can have a range of values. Examples of dimensions are the number of people to whom a trade secret has been disclosed and the severity of the security measures. Different dimension values can favour different sides and to varying degrees, depending on their place in the range of values. Factors are then dimension-value pairs that favour a particular side to some degree. Generally no clear rules can be given on how dimensions and factors relate to legal predicates, since each case can have different constellations of factors with different degrees of favouring a side. Hence the importance of past cases.

[4] See Chapters 5.5 and 5.6 of this handbook.

HYPO and CATO generate disputes between a plaintiff and a defendant of a legal claim concerning misuse of a trade secret. Each move conforms to certain rules for analogizing and distinguishing precedents given that cases contain sets of factors (in HYPO dimension-value pairs) for and against a decision, plus the decision that resolves the conflict between the competing factors. A precedent is *citable* for a side if it has the decision wished by that side and shares with the current case at least one factor that favors that decision. Thus citable precedents do not have to exactly match the current case, which is a way of coping with the case-specific nature of case law decisions. A citation can be countered by a *counterexample*, that is, by producing a citable precedent that has the opposite outcome. A citation may also be countered by *distinguishing*, that is, by indicating a factor in the current case that is absent in the cited precedent and that supports the opposite outcome, or a factor in the precedent that is missing in the current case and that supports the outcome of the cited case. Dimensions allow an additional way to distinguish a precedent, namely, on a shared pro-decision factor that more strongly favours the decision in the precedent than in the current case.

CATO (Aleven 2003) also has a 'factor hierarchy', which expresses expert knowledge about the relations between the various factors: more concrete factors are a reason for or against the more abstract factors to which they are linked. Thus the factor hierarchy can be used to explain why a certain decision was taken, which in turn facilitates debate on the relevance of differences between cases. For instance, the hierarchy positively links the factor *Security measures taken* to the more abstract concept *Efforts to maintain secrecy*. Now if a precedent contains the first factor but the current case lacks it, then the precedent can be distinguished on the absence of *Security measures taken* and this distinction can be emphasized by saying that thus no efforts were made to maintain secrecy. However, if the current case also contains a factor *Agreed not to disclose information*, then the factor hierarchy enables downplaying this distinction, since it also positively links this factor to *Efforts to maintain secrecy*: the party that cited the precedent can say that in the current case, just as in the precedent, efforts were made to maintain secrecy.

5.2 Logical accounts of legal case-based reasoning

Various logical accounts of factor-based reasoning with cases have been given. A key idea here is that case decisions give rise to conflicting rules (or conflicting sets of reasons) plus a preference rule expressing how the court resolved this conflict: In the notation of Prakken and Sartor (1998), inspired by Hage (1996) and Loui and Norman (1995):

r1: *Pro-factors* ⇒ *Decision*

r2: *Con-factors* ⇒ *Not Decision*

p: … ⇒ r1 > r2

The priority expresses the court's decision that the pro factors in the body of rule r1 together outweigh the con factors in the body of rule r2. Since the preference is expressed as a rule, arguments can be modelled about why one set of factors outweighs another set. This approach also allows for 'a fortiori' reasoning in that adding factors to a pro-decision rule or removing factors from a con-decision rule does not affect the rule priority. It allows for analogical uses of a pro-decision rule by deleting pro factors, which is called 'broadening a rule'. A broadened rule does not inherit the priority relations of the rule from which it is obtained. So if rule r1 in our schematic example is broadened to rule r1' by deleting one of the pro-factors in rule r1, then one cannot conclude from the priority r1 > r2 in precedent that r1' > r2, since the deleted factor might have been essential in preferring r1 over r2.

Later work has formalised these ideas in an argument-scheme approach. For example, Prakken et al. (2015) model argument schemes for deriving preferences between factor sets from cases, for citing cases, for distinguishing case citations and for downplaying distinctions within the ASPIC+ framework. Uses of these schemes yield a Dung-style argumentation framework that can be used for evaluating the arguments.

Horty (2011) addresses the issue of *precedential constraint*, that is, under what conditions is a decision in a new case allowed or forced by a body of precedents? Consider the *Keeble* case from the common law of property, part of a well-known series of cases on ownership of wild animals that are being chased. In *Keeble* a pond owner placed a duck decoy in his pond with the intention to sell the caught ducks for a living. Defendant used a gun to scare away the ducks, for no other reason than to damage plaintiff's business. Here the court held for plaintiff. The pro-plaintiff factors were that plaintiff was hunting for a living (*PlLiving*) and was hunting on his own land (*OwnLand*). The single pro-defendant factor was that the animals were not yet caught (*Not Caught*). The issue is whether plaintiff became the owner of the ducks (*Owner*). In the notation of Prakken and Sartor (1998) we have:

Keeble

k1: *PlLiving*, *OwnLand* ⇒ *Owner*

k2: *Not Caught* ⇒ *Not Owner*

⇒ k1 > k2

In another precedent, *Young*, both plaintiff and defendant were fishermen fishing in the open sea. Just before plaintiff closed his net, defendant came in and caught the fishes with his own net. Here not only the plaintiff but also the defendant was hunting for a living (*DefLiving*). Then we have

Young

y1: *PlLiving* ⇒ *Owner*

y2: *Not Caught*, *DefLiving* ⇒ *Not Owner*

To decide *Young* for plaintiff, the required priority y1 > y2 cannot be based on the precedent, since y1 lacks one antecedent of k1, and also since y2 adds a con factor to k2. However, deciding *Young* in accordance with *Keeble* is still allowed by *Keeble*, since that leaves the decision in the precedent unaffected. Horty calls this *following* the precedent.

The situation is different if the case base also contains a second precedent, which is almost like *Keeble* except that the defendant also hunted for a living and in which the defendant won.

Precedent 2

p1: *PlLiving*, *OwnLand* ⇒ *Owner*

p2: *Not Caught*, *DefLiving* ⇒ *Not Owner*

⇒ p2 > p1

The priority p2 > p1 then implies y2 > y1, since y2 has the same con-decision factors as p2 while y1 lacks one pro-decision factor of p1. But y2 > y1 is inconsistent with y1 > y2, so deciding *Young* as *Keeble* is not allowed by the extended case base, since it would amount to *overruling* the second precedent.

In Horty's approach not all deviations from a precedent are overrulings. Suppose that precedent 2 is not in the case base but is a new case, so its decision is not yet known. Then p2

> p1 is consistent with k1 > k2, so deciding the new case differently than in the precedent is allowed by the case base, since it leaves all decisions in precedents unaffected. Horty here says that deciding con the original decision in the new case *distinguishes* the precedent. Horty has thus given precise logical formalisations of the important common-law notions of following, distinguishing and overruling a precedent.

The work described so far does not address why factors are pro or con a decision. Berman and Hafner (1993) argued that often a factor favours a decision by virtue of the purposes served or values promoted by taking that decision because of the factor. Cases are thus not compared on the factors they contain but on the values they promote or demote through these factors. Bench-Capon & Sartor (2003) computationally modelled this approach and illustrated it with the series of cases from American property law on ownership of wild animals that are being chased. For example, plaintiff in *Keeble* could argue that people should be protected when pursuing their livelihood, since society benefits from their activities. He could also argue that he was hunting on his own land, so that the value of protection of property is another reason why he should win. Defendant in *Keeble* could argue that since plaintiff had not yet caught the ducks, he had no right to the ducks, since if such rights depended on who first saw the animals, there would be no clear criterion and the courts would be flooded with cases. Thus defendant argues that deciding for him promotes the value of legal certainty. Since plaintiff won in *Keeble*, we can on this interpretation of the case say that the court found that the combination of the values of protecting property and protecting the pursuit of livelihood outweighs the single value of legal certainty. This value preference can be cited in new cases where the same values are at stake.

The attention paid to the role of value and purpose led to accounts of legal interpretation as a decision problem, i.e., as a choice between alternative interpretations on the basis of the values promoted and demoted by these interpretations.[5] The same account can be given of the choice whether to follow a legal rule or to distinguish it by formulating a new exception. Philosophers call this practical reasoning. For example, deciding Young for the defendant can be reconstructed as follows. First practical-reasoning arguments for following or distinguishing *Keeble* are stated. Then the argument for distinguishing *Keeble* is preferred over the argument for following *Keeble*, on the ground that following *Keeble* only promotes the value of protecting livelihood while distinguishing *Keeble* in addition promotes the value of legal certainty. This account can be refined in terms of the relative preferences between goals or values and in terms of the extent to which they are promoted or demoted. This line of research has especially been pursued by Bench-Capon and Atkinson and colleagues, e.g. in Atkinson and Bench-Capon (2005).

6 Establishing the facts of a case

While legal education and scholarship mostly focuses on reasoning with and about the law, in practice most cases are decided on the facts, so insight as to how facts can be proven is crucial for legal practice. AI & law research has addressed two main questions: which model of rational proof can best be applied to the law, and what is the logical nature of important legal evidential constructs like burdens of proof and presumptions? We address these issues in turn.

6.1 Models of legal proof

Theoretical models of rational legal proof are generally of three kinds: probabilistic, story-based, or argument-based. (In Prakken et al. (2020) these three approaches and combinations of them are illustrated in several reconstructions of an actual Dutch murder

[5] See for decision theory Section 8 of this handbook.

case.) All three approaches acknowledge that evidence cannot provide watertight support for a factual claim but always leaves room for doubt and uncertainty, but they account for this in different ways. Probabilistic approaches express uncertainty in terms of numerical probabilities attached to hypotheses given the evidence. Often a Bayesian approach is taken, nowadays more and more with Bayesian networks (Fenton and Neil; 2011)[6]. Probabilistic approaches are by no means uncontroversial. One objection is that in legal cases the required numbers are usually not available, either because there are no reliable statistics, or because experts or judges are unable or reluctant to provide estimates of probabilities. Another objection is that probability theory imposes a standard of rationality that cannot be attained in practice, so that its application would lead to more instead of fewer errors. To overcome these limitations of probabilistic models, argumentation-based and story-based models have been proposed.

Story-based approaches go back to the work of the psychologists Bennett and Feldman (1981), who observed that the way judges and prosecutors tend to make factual judgments is not by probabilistic or logical reasoning but by constructing and comparing alternative plausible stories about what might have happened. In these approaches the story that best explains the evidence must, if it does so to a sufficient degree, be adopted as true. These approaches thus model forms of inference to the best explanation (Lipton 1991).

Both Bayesian and story-based approaches reason from hypotheses to the evidence in that, to assess alternative hypotheses, they model how likely the evidence is under the various hypotheses. In contrast, argumentation-based approaches reason from the evidence to the hypothesis, by stepwise building evidential arguments from the available evidence to the hypotheses. For example, Bex et al. (2003), inspired by Pollock's (1995) theory of defeasible reasons, model evidential reasoning as the application of various argument schemes, such as schemes for perception, memory, induction, applying generalizations, reasoning with testimonies, and temporal persistence.

6.2 Burdens of proof and presumptions

To deal with uncertainty and defeasibility, legal systems use such notions as presumptions and burdens of proof. Research has been done on modeling these notions with techniques from nonmonotonic logic and argumentation (Prakken and Sartor; 2009; Gordon and Walton; 2009, Governatori and Sartor 2010).

Legal presumptions obligate a fact finder to draw a particular inference from a proved fact. Typical examples are a presumption that the one who possesses an object in good faith is the owner of the object, or a presumption that when a pedestrian or cyclist is injured in a collision with a car, the accident was the driver's fault. Some presumptions are rebuttable while others are irrebuttable. Prakken and Sartor (2009) argue that rebuttable presumptions can be logically interpreted as defeasible rules in a nonmonotonic logic. They also argue that to fully understand notions of burden of proof, logical and dialogical models of argumentation must be combined. For example, they say that a so-called burden of persuasion for a claim is fulfilled if at the end of a proceeding the claim is acceptable according to the argumentation logic applied to the then available evidence. This brings us to the dialogical aspects of legal argument.

7 Legal reasoning and legal procedure

Legal reasoning usually takes place in the context of a dispute between adversaries, bound by legal procedures. This makes the setting inherently dynamic and multi-party. For example, the facts and opinions are not given at the start of a case, but the adversaries provide their

[6] Bayesian networks are discussed in Chapter 4.2 of this handbook.

evidence and arguments at various stages and the adjudicator can allocate burdens of proof before deciding the dispute. Thus the quality of a legal decision not only depends on its grounds but also on how it was reached, which raises issues of procedural rationality (cf. Toulmin 1958, Alexy 1978).

AI & Law research has studied these issues by combining defeasible-reasoning models and dialogue models of argumentation in formal models of legal-procedural notions. Thus properties of legal procedures can be formalised and verified. For example, relevance of dialogue moves can be formally characterized and it can be verified whether a procedure always allows the adducing of relevant information possessed by a dialogue participant. Insights thus obtained about formalised procedures can then be used in analyzing or even (re-)designing actual procedures.

An influential computational model of a legal procedure was Gordon (1994)'s Pleadings Game, which, inspired by Alexy (1978), formalised a normative model of pleading founded on first principles. It was meant to identify the issues to be decided at trial, given what the parties had claimed, conceded, challenged and denied in the pleadings phase and what (defeasibly) follows from it. Other games define the outcome in terms of whether the adversaries in the end agree on the main issue or in terms of a decision by an adjudicator.

The dynamic and multi-party setting of legal procedures also raises issues of strategic choice. They are addressed in a legal context by Riveret et al. (2008), who apply a combination of game theory and argumentation logic to the problem of determining optimal strategies in debates with an adjudicator. In such debates the opposing parties must estimate the probability that the premises of their arguments will be accepted by the adjudicator. Moreover, they may have preferences over the outcome of a debate, so that optimal strategies are determined by two factors: the probability of acceptance of their arguments' premises by the adjudicator and the costs/benefits of such arguments.

8 Conclusion

Logical models of legal argument aim to respect that the central notion in legal reasoning is not deduction but argument. Deduction has its place in legal reasoning, but only as part of a larger model of constructing, attacking and comparing arguments. Moreover, logical models of legal argument reflect that rules are not the only source of legal knowledge: the roles of cases, principles, purposes and values should not be ignored, and these models stress the importance of dynamics, procedure and multi-party interaction. While most work has addressed legal interpretation and normative determinations, some work addresses legal proof. Here too, deduction is just one of the tools, as part of probabilistic, argumentation-based or story-based approaches. A main concern here is developing models of legal proof that are rationally well-founded but respect the practical and cognitive constraints faced by the participants in court proceedings. Finally, dialogical models of legal argument can be used to address issues of procedural rationality and strategic choice.

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