Levels of reasoning as the basis for a formalisation of argumentation

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Abstract

Artificial reasoners that represent uncertain knowledge as arguments are useful in the legal domain. A model of argumentation proposed by Toulmin has recently been the basis of a representation of knowledge in the domain of family law in Australia. The Toulmin model has limitations in that there is no way for a knowledge based system to construct a new argument to deal with an unanticipated situation. This paper outlines a model of argumentation which is based on the notion that an argument can be represented at a number of levels. The reasoning which generates an assertion is the base level. The justification for the reasoning used is the meta level. Reasoning about justifications involves the meta meta level. We demonstrate with the use of simple arguments how the meta-level can also be used to create an argument for a hypothetical case which had not previously been encountered or anticipated.

1 Introduction

Many problems in real world domains are characteristically indeterminant. Berman and Hafner [4] were among the first commentators to recognise that indeterminacy due to the prevalence of open textured terms presents particular difficulties for the application of artificial intelligence paradigms to problems in the legal domain. According to Bench-Capon [2], a term is open textured if its extension cannot be determined in advance of its application. This means that it is impossible to code a series of rules, logical predicates or case representations that can resolve any fact scenario relating to the open textured term.

A hypothetical rule representing a university ordinance prohibiting firearms is as follows:

has-firearm(x,y),university(z)→ prohibited(x,z)
Rule 1: A person, x who carries a firearm, y is prohibited from the grounds of the university, z.

The terms in Rule 1 may not seem obviously indeterminate, however situations inevitably arise that instil uncertainty. A policeman entering the university is likely to claim an exemption from the ordinance. A theatre performer with a toy firearm is not likely to consider that the ordinance might apply in his case.

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Many notable approaches in dealing with the indeterminacy inherent in law focus on the construction of arguments for and against possible interpretations. Rissland and Ashley [12] have developed a case based reasoner in the domain of trade secrets law which retrieves and adapts past cases in order to interpret a current case in more than one way. Branting [5] adopts exemplar based reasoning to construct explanations for or against a conclusion or possible interpretation. Prakken [11] demonstrates the use of default logic to construct arguments in a manner which is quite different from the previously mentioned approaches, yet can be seen to similarly outline a number of possible interpretations.

The use of argumentation to represent reasoning in real world domains draws support from the work of two prominent philosophers. Perelman [10] in France and Toulmin [14] in England both assert that the manner in which we construct arguments for everyday reasoning is quite different to logical reasoning. Although both Toulmin [14] and Perelman [10] assert that practical reasoning is different to syllogistic reasoning, Perelman's theory does not immediately provide a framework by which arguments may easily be modelled. In order to analyse practical reasoning Toulmin examined arguments from a variety of domains and concluded that all arguments, regardless of the domain can be seen to conform to a consistent structure.

Toulmin argument structures consist of six basic invariants: claim, data, warrant, backing, modality and rebuttal. Every argument makes an assertion based on some data. The assertion of an argument stands as the claim of the argument. Knowing the data and the claim does not necessarily convince us that the claim follows from the data. A mechanism is required to act as a justification for the claim. The justification is known as the warrant. The backing supports the warrant and in a legal argument is typically a reference to a statute or a precedent case. The claim is made with a degree of certainty known as the modality. This is expressed with qualifiers like 'certainly', 'probably' and 'possibly'. Furthermore, an argument may be rebutted. A Toulmin argument depicting the university ordinance represented in Rule 1 is presented in Figure 1.

Toulmin Argument structures have been used in the field of artificial intelligence and law to represent legal arguments

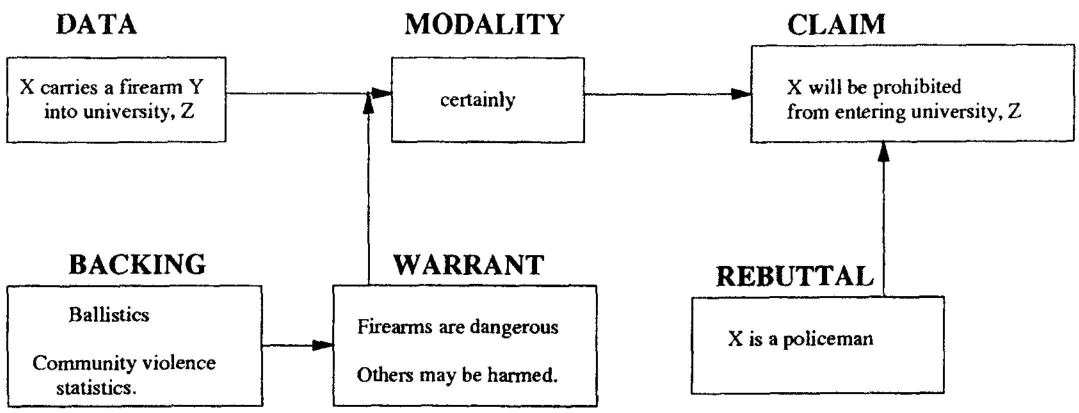

Figure 1: Entry with firearms to university is prohibited

by Dick [7] and by Marshall [9]. Branting [6] has proposed an extension of Toulmin warrants as a basis for a model of ratio decidendi. Gordon [8] uses conditional entailment to adapt a theory of argumentation in law proposed by Alexy [1] and the Toulmin formulation in order to formalise pre-trial bargaining known as pleadings. Bench-Capon et al [3] use Toulmin structures to generate explanations for their logic programs. Stranieri et al [13] have shown that the structures are useful for decomposing a family law task into sub tasks in a way that accommodates explanations even when neural networks are used to infer claims. In the next section we illustrate this approach and highlight its limitations. We then illustrate how the notion of levels of reasoning can be used to overcome some of these limitations.

2 Split - Up

A judge of the Family court of Australia is required to determine the percentage of the marital assets each party to a marriage receives once a divorce has been granted. A rule based approach is made difficult in that the knowledge necessary for a percentage split determination cannot be obtained from the divorce laws themselves. Whilst the main statute, the Family Law Act (1975) specifies a number of factors that a judge must consider in determining a percentage split of the assets, it allows much latitude in the combining and weighting of these factors. Further, heuristics in the domain are complex and numerous, due to the discretionary nature of the statute.

Stranieri et al [13] model the task of determining a percentage split as a Toulmin argument which has, as its claim, the percentage to be awarded to both parties. Data for this argument derives from the claim of other arguments which have themselves data elements that derive from the claims of other arguments. Thus a tree of argument structures models the entire task of determining a percentage split. Each argument structure includes an inferencing mechanism and a rationale for the inference of that argument. For some arguments the inferencing mechanism is a rule set while for others neural networks are used. The warrant and backing for each argument has been elicited from domain experts. Further details of this system, known as Split-Up can be found in Zeleznikow and Stranieri [15].

The Split - Up system was limited in that explanations were passive and played no direct role in the reasoning. Furthermore, the argument structures were relatively rigid. New arguments could not be created in response to a fact scenario not previously encountered. Arguments asserting contradictory claims from the same initial data could be made but there was no mechanism for determining which argument was more plausible. The current formalisation outlines the approach we have adopted in overcoming these limitations.

3 An informal description of an argument based model

We believe that Toulmin argument structures are an elegant and useful representation of practical reasoning because the warrant and the backing are distinguished from the rest of the argument. We interpret this as separating reasoning from the justification for the reasoning. The data, inference, claim and rebuttal can be seen as components of one system; the reasoning system. The warrant and backing are components of another system; the meta reasoning system. The meta- reasoning system provides reasons, or justifications for the data, inference, claim and rebuttal components of the reasoning system. Meta reasoning is required in order to interpret open textured terms. If a new case arises which does not obviously correspond to a previous case we would like to interpret inferences drawn in previous similar cases in a way that will cover the new case. This can be done if we have access to the reason underlying the previous decision.

To illustrate this, we imagine a court which has decided to ban persons who have tested positive for the HIV virus from knowingly participating in contact sports. Rule 2 represents the decision.

Rule 2: HIVpositive(x),contact-sport(y) $\rightarrow$ forbid-play(x,y)
A person, x who tests positive for the HIV virus is not permitted to participate in the contact sport, y.

Rules make no mention of underlying reasons for their existence. By Rule 2, we know that HIVpositive contact sport players are forbidden from playing. We do not know why this should be so nor do we know why firearm carriers cannot enter the university though Rule 1 indicates that they cannot. If our task involves applying anticipated fact scenarios to existing rules then the reasons underlying the rules are not needed. However, if an unanticipated fact scenario arises as it does in open textured domains, then access

R1	Data	has-firearms, university			
	Inference	has-firearms, university → prohibited			
	Claim	prohibited			
	Rebuttal	policeman			
R2	Wf factor warrant	data subset	has-firearms	university	
		factor reason	potentially fatal	safe place for learning	
		factor backing	ballistics	university mission	
		claim subset	prohibited	prohibited	
R2	Wi inference warrant	inference reason	modus ponens	harm others	ordinance
		inference backing	modus ponens is sound	community violence statistics	ord no. 12

Figure 2: Argument 1. Persons carrying firearms are prohibited from the university grounds

to the reasons underlying rules is indispensable.

We can easily imagine a scenario where a person who has tested positive for the HIV virus enters the university grounds. Common sense tells us that an argument for the exclusion of the HIV positive person could be made for the same reasons that persons carrying firearms are forbidden entry. Both HIV and firearms are potentially fatal and can harm others. We know that testing positive for the HIV virus is potentially fatal because this is the reason underlying Rule 2, the prohibition on HIVpositive players from contact sports.

More formally, we represent an argument as a tuple. This model is conceptually, infinite. However, in practice we do not provide explanation for some Rn and hence the argument can be represented as the n-tuple:

$$A = (R1, R2, R3,..Rn.)$$

R1 is called Reasoning One and includes the data, claim, inference mechanism and rebuttal of an argument. R2 includes the warrant or rationale for the components of R1. Thus R2 can be said to explain R1. In general Rn explains Rn-1. Figure 2 illustrates an argument which represents the reasoning underlying Rule 1. This figure and the remaining discussion is restricted to R1 and R2. Predicate variables have been omitted for clarity.

3.1 Reasoning One.

R1 is labelled Reasoning One. This describes the claims made, the data used, the inference mechanism and rebuttal of the argument. Reasoning One can reason from data to claim but cannot represent justification for any of these elements in an argument. Reasoning One is described as a tuple:

$$R1 = (D, I, C, R).$$

D is labelled the data element of R1. The data in Argument 1 are the predicates (has-firearms) and (university). These are the facts used to assert the claim that the person with firearms is prohibited from the university grounds. C is labelled the claim of an argument. The claim of Argument 1 is the assertion that entry should be refused.

I is labelled the inference procedure. This refers to the procedure, rule or method used to infer the claim of the argument from the values of the data elements. In Argument 1, the inference procedure is the rule that expresses the implication: a person is prohibited from the university grounds if he posseses firearms. Alternatively, the inference procedure may represent jurimetric techniques, rules from default or modal logics or, as the case in many Split - Up arguments, neural networks.

R is labelled the rebuttal of an argument. The rebuttal represents a fact that will invalidate the claim of the argument. Thus, if the person entering the university was a policeman then the claim that entry is prohibited is not valid.

3.2 Reasoning Two. Meta reasoning

Reasoning Two is labelled meta-reasoning or R2. Reasoning Two justifies the elements of Reasoning One and is described as a tuple with two components, the factor warrant (Wf) and the inference warrant (Wi) respectively. The factor warrant represents why the data is relevant in determining the claim. This justifies the inclusion of the data element. In contrast, the inference warrant represents a reason for the use of the inference method.

$$R2 = (Wf, Wi)$$

where the factor warrant, Wf is described as a set of tuples:

$$Wf = ((d1, f1, b1,c1), (d2, f2, b2,c2),. ..(dk, fk,bk,ck),.(dm, fm,bm,cm))$$

dk in a factor warrant tuple is labelled the data subset. This represents the set (or a subset) of data elements included in the argument and depicted in R1. The set (has-firearms) is a subset of the data elements of Argument 1. So also is (university). ck is labelled the claim subset and represents the set or a subset of the claim depicted in R1. fk is labelled the factor reason. This describes reasons for the relevance of the data item subset, dk. The data element subset (has-firearms) in Argument 1 is relevant to the claim of that argument because a firearm is potentially fatal. The reason that the predicate (university) is relevant is that the university is a safe haven for the pursuit of learning.

bk is labelled the factor backing. This depicts the supporting evidence for the reason, fk. The factor backing corresponds to the Toulmin backing. The supporting evidence for the potential danger inherent in firearms comes from ballistics reports. Supporting evidence that the university is a safe haven comes from the university mission statement.

The second component of Reasoning Two, the inference warrant, Wi depicts reasons and backing for the relevance of the inferencing method represented in Reasoning One. For example, the inference in Argument 1, has-firearms,university → prohibited is appropriate for three reasons. It is appropriate because the inference drawn is based on modus ponens.

The supporting evidence or backing for this is an indication that modus ponens is a sound inference rule. The inference in Argument 1 is also appropriate because the rule derives directly from a university ordinance. The backing is the actual ordinance number. The third reason for the prohibition of firearm carriers is that others may be harmed if firearms are freely admited.

Thus, Wi = ((i1, b1), (i2, b2),...,(ik, bk),.(ip, bp))

The symbol, ik, represents reasons for the relevance of the inferencing method used in Reasoning One and is labelled the inference reason. bk is labelled the inference backing and represents supporting evidence for the reason for the inference.

4 Sample reasoning

We illustrate the following reasoning tasks that may be accomplished with the use of the model presented here.

1. the construction of a new argument to reason with a fact scenario not directly represented by arguments existing in an argument base.
2. the representation of arguments that assert contradictory claims.
3. the creation of a new argument which asserts that an existing argument, A is more plausible than a contradictory argument, B.

4.1 Fact scenario 1: Constructing new arguments

Figure 3 illustrates Argument 2 made by a fictitious court that contact sports persons cannot be HIV positive. The reason that the data subset (HIVpositive) is relevant in this argument is that the HIV virus is potentially fatal. The backing for this is medical research reports. The fictitous judge has justified his decision on the grounds that other players may be harmed.

Our argument base at this point thus consists of two arguments, 1 and 2. Let us imagine we are presented with the problem of determining whether an argument can be made prohibiting a person who has tested positive for the HIV virus from being on the university grounds. The data set for this fact scenario (HIVpositive, university) does not match the data sets of any argument in the current argument base. However a new argument, Argument 3, can be created because Arguments 1 and 2 share a common reason.

Argument 3 represented in Figure 4 depicts the new argument created to determine whether the HIV positive person can enter the university. The data subset (HIVpositive) in Argument 2 and (has-firearms) in Argument 1 are relevant to their respective arguments because they are both potentially fatal. Two inference reasons in Argument 1 and 2 are identical: that others may be harmed. The new argument is based on Argument 1 but has substituted the occurrences of the data item (has-firearms) with (HIVpositive).

The data item (HIVpositive) is relevant to Argument 3 for the same reason it was relevant to Argument 2 and (has-firearms) was relevant to Argument 1: that it is potentially fatal. The data item (univeristy) remains relevant for the same reason it was relevant in Argument 1. Note however that the new argument, Argument 3, cannot necessarly maintain the same inference reason and backing of Argument 1. The user must be prompted to ascertain whether the Argument 1 inference reasons, that the inference uses modus ponens, that others may be harmed and that a university ordinance exists, are applicable for the new argument. Argument 3 in Figure 4 reflects the users response indicating that a university ordinance does not exist to justify this inference. Modus ponens does however justify the new argument's inference as does the potential for causing harm to others. The backing for this latter reason is an appeal to medical studies.

4.2 Fact scenario 2: Contradictory arguments

Argument 4 in Figure 5 illustrates an argument that was made by a judge in deciding that a hypothetical and publicaly funded fitness club did not have the right to exclude patrons who carried firearms. We can imagine that Argument 4 is added to the argument base as a matter of course. It is a new argument which has been created by a human judge. Unlike Argument 3, this argument is not the result of a combination of existing arguments.

The judge responsible for the reasoning represented in Argument 4 admits that firearms are potentially fatal yet draws on the fact that the fitness club, being publicaly funded is a public place. The right to bear arms in public is a constitutional right enshrined in the Bill of rights. Thus the relevance of the data subset (has-firearms) to this argument is that firearms are potentially fatal. Ballistics evidence supports this. The reason that the fitness club is relevant is that it is a public place. The backing for this is public funding receipts. One reason for the inference that entry is allowed is that an individual has the right to bear arms.

Argument 5 asserts that the university hosts community events each year. The reason for this is that the university is a public place. Supporting evidence draws on the government funding that the university attracts each year.

The addition of these two arguments to the argument base presents a potential contradiction. We can easily imagine that a campus gun lobby group intent on having the ordinance of Argument 1 repealed would create a further new argument legitimizing the bearing of firearms on campus. This new argument is represented as Argument 6 in Figure 7. This argument is based on Argument 4 which permits firearms in fitness clubs because they are public places. Argument 5 has a factor reason indicating that the university is a public place. Therefore, using the same methodology presented in the preceding section, we substitute occurances of the predicate (fitness club) with (university) in order to create the new argument.

Argument 1 can be seen to directly contradict Argument 6. The former asserts that firearms are prohibited on campus while the latter claims that they are allowable.

4.3 Fact Scenario 3. Creation of a new argument to assert that an argument, is more plausible than a contradictory argument.

As illustrated above Argument 1 has a claim which contradicts that of Argument 6. The contradictory claims come about because the Reasoning Two level components differ.

R1	Data	HIVpositive,contact-sport		
	Inference	HIVpositive,contact-sport → forbid-play		
	Claim	forbid-play		
	Rebuttal			
R2	Wf factor warrant	data subset	HIVpositive	
		factor reason	potentially fatal	
		factor backing	medical research	
		claim subset	forbid-play	
R2	Wi inference warrant	inference reason	modus ponens	harm others
		inference backing	modus ponens is sound	court decision

Figure 3: Argument 2. Persons who have tested positive for the HIV virus cannot participate in contact sports

R1	Data	HIVpositive, university		
	Inference	HIVpositive, university → prohibited		
	Claim	prohibited		
	Rebuttal	policeman		
R2	Wf factor warrant	data subset	HIVpositive	university
		factor reason	potentially fatal	safe place for learning
		factor backing	medical research	university mission
		claim subset	prohibited	prohibited
R2	Wi inference warrant	inference reason	modus ponens	harm others
		inference backing	modus ponens is sound	medical studies

Figure 4: Argument 3. Persons who have tested positive for HIV are prohibited from the university grounds

R1	Data	has-firearms, fitness-club		
	Inference	has-firearms, fitness-club → entry-allowed		
	Claim	entry-allowed		
	Rebuttal			
R2	Wf factor warrant	data subset	has-firearms	fitness-club
		factor reason	potentially fatal	public place
		factor backing	ballistics	government funding
		claim subset	entry-allowed	entry-allowed
R2	Wi inference warrant	inference reason	modus ponens	right to bear arms
		inference backing	modus ponens is sound	constitution

Figure 5: Argument 4. A person carrying firearms is permitted in a fitness club

R1	Data	university, community events, annual maximum		
	Inference	Decision support system model		
	Claim	university hosts public events		
	Rebuttal			
R2	Wf factor warrant	data subset	university	community events
		factor reason	public place	benefit community
		factor backing	government funded	local government response
		claim subset	university hosts public events	university hosts public events
R2	Wi inference warrant	inference reason	modus ponens	university mission statement
		inference backing	modus ponens is sound	mission statement clause 35

Figure 6: Argument 5. The university hosts many public events

R1	Data	has-firearms, university		
	Inference	has-firearms, university → entry-allowed		
	Claim	entry-allowed		
	Rebuttal			
R2	Wf factor warrant	data subset	has-firearms	university
		factor reason	potentially fatal	public place
		factor backing	ballistics	government funding
		claim subset	entry-allowed	entry-allowed
R2	Wi inference warrant	inference reason	modus ponens	right to bear arms
		inference backing	modus ponens is sound	constitution

Figure 7: Argument 6. A person carrying firearms is permitted in the university grounds

R1	Data	community violence statistics, ordinance, constitution			
	Inference	compare(community violence statistics,ordinance,constitution)→constitution carries more weight			
	Claim	Constitution carries more weight than community violence statistics or ordinance			
	Rebuttal	-			
R2	Wf factor warrant	data subset	community violence statistics	ordinance	constitution
		factor reason	community violence statistics are empirical measures	applies to university	confers rights to all residents
		factor backing	statistical reports	university charter	constitution
		claim subset	Constitution carries more weight than community violence statistics or ordinance	Constitution carries more weight than community violence statistics or ordinance	Constitution carries more weight than community violence statistics or ordinance
R2	Wi inference warrant	inference reason	utilitarian jurisprudence		
		inference backing	historically popular ideal		

Figure 8: Argument 7. Argument 6 allowing HIV carriers to enter the university is more plausible than Argument 1 which forbids their entry

Selection of the most plausible argument involves the creation of an argument to assert that one argument is more plausible than the other. An argument, A is more plausible than another argument, B if:

1. the factor reason of A carries more weight than the factor reason of B.
2. the factor backing of A carries more weight than the factor backing of B.
3. the inference reason of A carries more weight than the inference reason of B.
4. the inference backing of A carries more weight than the inference backing of B.

Argument 7 illustrated in Figure 8 claims that the argument which asserts that firearms at university are allowable (Argument 6) is more plausible than the contrary argument (Argument 1). This is so because the inference backing for Argument 6 carries more weight than that for Argument 1. The data items for this argument are the inference backing for the contradictory arguments. The backing (modus ponens is sound) has been ommitted as it is common to both. The claim is that the Constitution carries more weight than the university ordinance and community violence statistics. The inference method calls a comparision method called 'compare' which may be a rule set, or any other inferencing method that will yield the claim desired.

The first inference backing, community violence statistics is relevant to this argument because these statistics are empirical measures. The factor warrant for the relevancy of the constitution is that as a document, a nation's constitution declares some rights to be so fundamental and inalienable that modification can only be achieved through a difficult process. The relevancy of the university ordinance is that it is a statute which has jurisdiction within the university.

The reason for the inference can be summarised as a kind of utilitarian jurisprudence: that the greatest good be distributed to the greatest number. In this light, a Constitution confers rights and thus attempts to shape the world. A univerity ordinance is not as important as a constitution because it attempts to shape less of the world. Statistics are even less important because they seek only to reflect the state of the world.

5 Conclusion and further research

We have illustrated that artificial reasoners which represent and generate arguments for and against possible conclusions are useful in domains characterised as indeterminate. Reasoning in property determination within family law in Australia has previously been modelled with the use of argument structures proposed by Toulmin. That work has been extended by the presentation of a model of argumentation that is based on, but not identical to, Toulmin argument structures. Our point of departure from the Toulmin model is the view that Toulmin warrants and backing are one step removed from the reasoning and can be viewed as meta-reasoning. We use the meta-reasoning level to generate explanations for the reasoning. We also use the meta level to construct new arguments in a way that is not possible were we only to focus on the reasoning.

Some but not all of the arguments used in Split - Up have been encoded into the representation presented here. Further work will continue to encode all arguments in the present schema. Once this has been completed, thorough evaluation studies can be conducted.

Research is also in progress toward the operationalisation of procedures for utilising meta reasoning to construct new arguments. One operation, presented above in fact scenario 2, involves substituting predicates at the reasoning level that we know have the same justification at the meta reasoning level. Research in progress aims to apply legal theory to the design and definition of meta level operations.

Reasoning Three level reasoning requires reasoning about justifications for reasoning. Current work focuses on outlining the requirements of this level of reasoning in order to operationalise the model to the meta-meta level.

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