The Value of Values: A Survey of Value-Based Computational Argumentation

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Abstract

Value-based argumentation has had a big impact in the computational argumentation literature and work in AI and Law. This paper presents a survey of this line of work that covers the seminal contributions on the topic by Trevor Bench-Capon and the subsequent lines of research that have been followed by others to make use of and extend Trevor's ideas.

1 Introduction

A fundamental concern of work in artificial intelligence is how to enable automated practical reasoning, which is reasoning about what to do. Over the past decade some researchers in the AI community have been addressing this issue using the notion of argument. In order to account for differing points of view in debates about what to do, it has been recognised that the parties within a debate will have different perspectives on what is important to pursue, according to their subjective aspirations and preferences. Trevor Bench-Capon has been central in developing analyses for representing and reasoning about *value-based arguments* in general and *value-based practical reasoning* in particular, whereby the social interests of debate participants are accounted for. Trevor's work in these areas touches on many different aspects, covering abstract argument systems to concrete representations. His work has been applied in a number of different domains, with a particular focus falling on work in AI and Law.

This paper provides a survey of the work of Trevor and his colleagues on value-based arguments, and also reviews other authors' work that has built on the main ideas. The paper is structured as follows. Section 2 discusses some of the work that has motivated Trevor's ideas on value-based argument, with a particular focus on philosophical background material. Section 3 recounts the use of values in abstract frameworks for representing and reasoning about argument, which is the first major contribution that Trevor made on the topic of value-based argument. Section 4 surveys past and current work on structured arguments that capture value-based reasoning. Section 5 discusses how value-based argument has been applied in a variety of domains, with a particular focus on work in AI and Law. Section 6 considers some open issues related to value-based argument and points to future work related to the topic.

2 Arguments and Values

Artificial Intelligence has made use of a wide range of concepts from philosophy and psychology about human reasoning processes. For example, one well-known model for constructing autonomous agents is the Belief-Desire-Intention model [39], which is intended to capture essential elements of reasoning [19]. Over the past decade it has been recognised that computational models of argument may provide a useful mechanism for automating reasoning in artificially intelligent systems [14]. As part of rational argument in practical reasoning, Trevor Bench-Capon has advocated the central role that social values play. Thus, we should briefly survey some of the motivations and sources from a diverse range of literature in philosophy, psychology, and law that have influenced Trevor's work on value-based argument.

What exactly is a value? Briefly, values are social interests that a person/agent wishes to promote. Values are often referred to in everyday reading material, such as newspapers, political party manifestos, religious material, and so on. Perhaps one of the best examples to cite of values is the French national motto "Liberté, égalité, fraternité" (Liberty, equality, fraternity). People widely recognise and understand such concepts. In Tom van der Weide's PhD thesis [43], he discusses the characterisation of values given in [40] and [41] whereby abstract values are deemed to have the following five features: 1) *Values are beliefs*; they are a conception of the desirable and are tied to emotions but are not objective beliefs. It is possible to discuss what a value means and what importance is given to values. 2) *Values are a motivational construct*; they describe desirable goals that people want to achieve. 3) *Values are what is called 'trans-situational'*; they transcend specific actions and situations and are therefore 'abstract goals'. The abstract nature of values distinguishes values from concepts like norms and attitudes, which usually refer to specific actions, objects, or situations. 4) *Values guide selection and evaluation of behaviour and events*; they serve as standards or criteria. 5) *Values are relatively ordered according to importance*; the values people pursue are structured in a value system in which each value is given a relative importance to other values. This hierarchical feature of values also distinguishes them from norms and attitudes.

For the important role of values in argument, we consider Chaim Perelman and Lucie Olbrechts-Tyteca's work [36], which influenced Floriana Grasso's research in AI on dialectical argumentation for the domain of health promotion and in turn motivated some of Trevor's work on value-based argument. In [29] Grasso et al. discuss that, following Perelman and Olbrechts-Tyteca's observations, that "people do not rely on what they know when they argue with an opponent, but rather they try to justify their views by appealing to the values and opinions of the people to whom they are addressing." The two important points to take from this are the *appeal to values* and the notion of an *audience* to whom the views are being addressed. These concepts are key to successful *persuasion*, which is a central aspect addressed by value-based argumentation. Values provide us with an explanation as to why it is not always possible to persuade others to accept an opinion simply by demonstrating facts and proofs. It may well be that a particular individual will accept the facts of a particular decision but she may reject the conclusion to act because it does not support the values she holds.

In addition to Perelman and colleagues' writing on the topic, the philosopher John Searle [42] recognises the instrumental role that values play in practical reasoning. In particular, Searle points out that disagreement between rational agents can occur precisely because different agents subscribe to different values; he argues that practical reasoning does, and should, typically involve the adjudication of conflicting desires, needs, commitments. However, classical models of rationality do not have any mechanism by which we can decide what constitutes the 'best' way to do something and how we can reconcile inconsistent conclusions of valid derivations.

While value-based argumentation has found application in a number of different domains, it is particularly important in the legal domain. The landmark paper [15] drew attention to the need to account for values in AI and Law research. The authors, Donald Berman and Carole Hafner, argue that, following the practice of legal professionals, computational accounts that are intended to model legal case-based reasoning need to take into account the *purposes* behind legal rules. They term such purposes the 'teleological component' that explains why one particular rule is preferable to another. Since the law is constructed to serve social ends, conflicts that arise about the application of rules in legal cases can be resolved by considering the purposes of the rules and their relative applicability to the case in question. This enables preferences amongst purposes to be revealed, and then the argument can be presented appropriately to the audience through an appeal to the social values that the argument promotes or defends. Some examples of such purposes, taken from the well-documented 'wild animals' cases that are discussed in [15], are: protection of right of property owners; protection of free enterprise and competition; and respect of the judiciary for the powers of the legislature.

Having introduced some of the key background literature and concepts related to values, some of which have influenced Trevor's work, in the following sections we discuss particular aspects in greater depth.

3 Value-Based Arguments in Abstract Frameworks

In this section, we look at the representation of, and reasoning with, values in computational argumentation through abstract argumentation frameworks. In the following section, we consider structured instantiations of arguments.

One of the landmark pieces of research in computational argumentation is Dung's abstract argumentation frameworks (AFs) [26]. The underlying idea of AFs is to model and evaluate arguments by considering how well they can be defended against other arguments that can attack and defeat them. The relationships between arguments can be modelled as directed graphs showing which arguments attack one another. No concern is given to the internal structure of the arguments; the status of an argument is evaluated by considering whether or not it is able to be defended from attack from other arguments with respect to a set of arguments. Essentially, an argument can be justified with respect to a set of arguments if it is not attacked by a member of that set, and all its attackers are attacked by a member of that set [26].

A number of extensions and variations to Dung's model have been proposed to handle preferences [2], probabilities [32], and a variety of other notions. Here we focus on Value-based Argumentation Frameworks (VAFs) [12], which are one of the seminal contributions that Trevor has made to the computational argumentation literature. VAFs are essentially an extension to Dung's argumentation frameworks to allow arguments to be evaluated not only in respect of the attack relation existing between arguments, but also in consideration of the values the arguments promote. The inclusion of values in such frameworks enables distinctions to be made between different audiences' preferences, in Perelman's sense as discussed in the previous section. Whereas in AFs an argument is always defeated by an attacker, unless that attacker can itself be defeated, in VAFs, attack is distinguished from *defeat for an audience*. This allows a particular audience to choose to reject an attack, even if the attacking argument cannot itself be defeated, provided that audience ranks the value associated with the attacked argument as more important than that associated with the attacker. Within a VAF, therefore, which arguments are accepted depends on the ranking that the audience (characterised by a particular preference ordering on the values) gives to the values. Other extensions to Dung's AFs to capture preferences have been set out, such as Amgoud et al.'s Preference-based Argumentation Frameworks [2], but in these frameworks the preference relation is entirely abstract; VAFs give more content to the notion of preferences by relating the strength of arguments to the values promoted by accepting them.

VAFs are clearly applicable for modelling scenarios where deciding how to act is the key concern since it is in practical reasoning that values play their important role. Trevor and his colleagues have shown in a variety of work how VAFs can be used to model scenarios involving practical reasoning, such as legal decisions [5, 54], moral problems [8], and political debates [4].

Since they were first introduced in 2002, VAFs have been used in other work that extends Dung's framework to give richer accounts of argumentation. In [33] Sanjay Modgil proposes Extended Argumentation Frameworks in which attacks between arguments can themselves be attacked. The idea is to provide a natural way to represent and reason about preferences (enabled through the representation of values) between arguments. Modgil and Bench-Capon build on this work in [34], where they formalise reasoning *about* argumentation within the Dung argumentation paradigm itself. As such, they distinguish between an object-level and a meta-level whereby a meta-level Dung argumentation framework is itself instantiated by arguments that make statements about arguments, their interactions, and their evaluation in an object-level argumentation framework. They show how Dung's theory, and object-level extensions of Dung's theory such as VAFs, can then be uniformly characterised by meta-level argumentation in a Dung framework.

There is also work that has investigated complexity issues related to VAFs, see e.g. [27], and many other authors have made use of VAFs in their work on computational argumentation; space precludes us giving the full list, so we leave here our discussion of abstract accounts of value-based argumentation. In the next section we turn our attention to instantiated value-based arguments.

4 Instantiating Value-Based Arguments

Abstract argumentation frameworks represent arguments as atomic entities, so they are not useful when we are concerned with the *internal structure and content* of the arguments, the relationships between the arguments in virtue of their content, and the application of argumentation. In this section, we discuss the theory of *instantiated argumentation*, where the internal structure and content of arguments is elaborated, while applications and some examples of instantiated argumentation are presented in section 5. The main focus of our discussion is how to use *semantic models* to *instantiate argumentation schemes* in order to *generate* value-based arguments; in particular, we discuss arguments using the *practical reasoning argumentation scheme with values* [9], which is key to the applications discussed in section 5 [53]. The section starts with a general overview about instantiated argumentation, moves to value-based practical reasoning, touches on how auxiliary schemes are represented, then concludes with a recent approach to structuring arguments in terms of the use of ASPIC+ [37]. It represents a synopsis of work by Trevor and his colleagues on instantiated argumentation [9, 4, 38, 48].

4.1 Instantiated Argumentation and Argumentation Schemes

Abstract argumentation treats arguments as atomic elements and attacks as relations between the elements. Instantiated argumentation considers the internal structure and content of the arguments. In the following, we take a neutral stance on terminological issues [37, 48] and particular theory of instantiated argument (see [37, 16, 28] among several others).

In classical propositional logic, an argument is an application of the classical syllogistic reasoning pattern of *Modus Ponens*: supposing propositional variables $\mathcal{P}$ and $\mathcal{Q}$, a rule $\mathcal{P} \rightarrow \mathcal{Q}$, where $\rightarrow$ is *strict implication*, $\mathcal{P}$ is the *antecedent*, $\mathcal{Q}$ is the *conclusion*, and the assertion that $\mathcal{P}$ holds, we infer $\mathcal{Q}$, where is the *claim*. Given a *knowledge base* (KB), e.g. $\mathrm{KB}_1 = \{\mathrm{P}, \mathrm{P} \rightarrow \mathrm{Q}\}$, we can generate an argument a_1 as an instance of *Modus Ponens* by substituting the variables in the syllogism with propositions from KB_1.

Argumentation frameworks were introduced and have been developed to reason *non-monotonically* and *defeasibly*. This is achieved by allowing arguments to be generated with respect to KBs that allow inconsistency, relating the arguments by attack, then reasoning with them at the abstract level. Broadly speaking, we can reason with inconsistency rather than ruling it out. For example, given $\mathrm{KB}_2 = \{\mathrm{P}, \mathrm{P} \rightarrow \mathrm{Q}, \mathrm{P} \rightarrow \neg\mathrm{Q}\}$, we generate arguments a_1 and a_2, which contradict with respect to their claims Q and $\neg$Q. In virtue of this, we say that a_1 and a_2 attack one another, and can use this information to reason in an abstract argumentation framework. One argument can attack another by having a claim that contradicts the claim of the other argument (rebutting), or a premise (undermining), or provides a reason to believe that the rule is inapplicable (undercutting). Such an example represents a simple, small illustration of *instantiated arguments* as found in the various approaches to instantiated argumentation.

In addition the KBs can have *strict rules*, indicated with $\rightarrow$, as well as *defeasible rules*, $\Rightarrow$: for strict implication, whenever the antecedents hold, the conclusion always holds, e.g. *Emus are birds*; in contrast, defeasible implications can be defeated by contrary examples, rules, or circumstances, e.g. *Birds typically fly*. Given KBs with strict and defeasible rules, we generate strict and defeasible arguments. In many approaches (e.g. [37, 35]), there is a *preference* relation between defeasible rules to resolve which argument "wins" where they otherwise equally attack one another. Given our focus in this section on instantiated arguments for value-based practical reasoning, we do not consider preferences or strict rules further.

We have, to this point, considered KBs based on propositions. As our objective is value-based argumentation related to practical reasoning, we turn to KBs expressed with predicate logic (without quantifiers). For instance, suppose a domain of disourse {a,b}, one-place predicates {P(x),Q(y)}, where P and Q each denote the set {a,b}, and $\mathrm{KB}_3 = \{\mathrm{P(x)}, \mathrm{P(x)} \Rightarrow \mathrm{Q(y)}, \mathrm{P(x)} \Rightarrow \neg\mathrm{Q(y)}\}$. The KB along with the domain of discourse and denotations of predicates constitute a *semantic model*. With respect to the semantic model, we can generate four arguments, for example: a_3, *P(a), P(a)* $\Rightarrow$ *Q(b), therefore Q(b)*; and a_4, *P(a), P(a)* $\Rightarrow \neg$*Q(b), therefore* $\neg$*Q(b)*. The arguments a_3 and a_4 are contradictory on their claims, so attack one another.

Argumentation schemes (ASs) [45, 46] are instantiated arguments of particular interest as they are the mechanism that has been used widely by Trevor and his colleagues in a variety of work to ground the arguments that appear in practical reasoning debates. An AS is a *stereotypical pattern of reasoning* in which the premises give a presumptive reason, indicated with $\Rightarrow$, to accept the conclusion. ASs can be used in a dialogical context as justifications for a conclusion and are subject to critiques that address points characteristic of the particular scheme. An interlocutor might offer a critique that elicits a response that either contradicts, reaffirms, or otherwise weakens the rhetorical force of the AS. Consider, for example, the well-known *Argument From Position to Know*, where E is a variable over individuals, P is a variable over propositions, and the predicates are *is in a position to know* and *asserts*.

- If E *is in a position to know* P; and
- E *asserts* P.
- Therefore P.

While this is *not a logically sound* argument, it is nonetheless widely used and often accepted. It can be rebutted, undermined, or undercut. For example, supposing we ground the variables for the first premise as *Prof. Hayes is in a position to know that eggs are rich in cholesterol.*; we can undermine the argument with the claim that *Prof. Hayes is not in a position to know that eggs are rich in cholesterol*, justifying it by pointing out that Prof. Hayes is not a nutritionist.

4.2 Practical Reasoning with Values

With the context set, we can consider a particularly well-developed and applied instantiated argumentation scheme that has featured in a focussed line of work of Trevor and his colleagues for over a decade; this is the *practical reasoning argumentation scheme with values* (PRAS), developed in a series of papers [3, 5, 9, 7, 4]. The scheme is used to systematically and transparently argue about actions; given a range of actions that might be carried out by an agent, which one should be selected and how is the selection justified? As there can be several agents with conflicting action selections and justifications, arguments can arise. *Values* play a key role in practical reasoning since agents can debate what values are promoted by a given action. In this section, we outline the PRAS and how it is instantiated with respect to a semantic model. We also relate the PRAS to auxiliary schemes that can be used to justify particular components of the PRAS. As discussed in section 5, the scheme and associated semantic model are very useful in representing and reasoning about public policy-making. Our presentation here is a summary of [4].

The PRAS proposes an argument for an action that should be done, based on an understanding of the current situation, the consequences of actions, a goal, and the desire to promote particular social values. For our purposes, the relevant part of the scheme is:

> PRAS
>
> In the current circumstances R, we should perform action A, which will result in new circumstances S, realise goal G, and promote value V.

In this scheme, an action that realises a goal is proposed that *promotes* a social value; a similar scheme can be given that recommends *not* to perform action A since this would *demote* a social value. A variety of critiques can be made of this scheme, some transparent (e.g. *The current circumstances are not as stated*) and some implicit (e.g. *There are unintended consequences of the action*).

To use instantiations of the schemes in computational systems, the PRAS has been represented formally in a computational model based on the Action-Based Alternating Transition System with Values (AATS+V); AATSs were introduced in [47] and extended in [7, 4] to AATS+V in order to represent social values. The PRAS is recast in terms of the AATS+V. The AATS+V is then given a model, i.e. denotations of the components of the system, which is in turn used to instantiate the PRAS, generating arguments for or against a proposed action. The arguments that can be generated are, in principle, all and only those that represent instantiations of the PRAS relative to a given semantic model, though in a given exercise, one might only use a selection of the arguments. In section 5, we use the PRAS and a semantic model to generate arguments.

In this section, we have reviewed some of the key elements of work by Trevor and his colleagues on instantiated value-based and related argumentation schemes, semantic models, and how the schemes are used together with the models to generate instances of the schemes. In the next section, we outline how such instances of schemes are applied.

5 Application Areas for Value-Based Argumentation

In 4, we introduced key elements of instantiated value-based argumentation. In this section, we focus on how such argumentation has been applied to legal case-based reasoning and policy-making, focussing primarily on recent developments.

5.1 Legal Case-based Reasoning and Values

In Artificial Intelligence and Law, reasoning with cases has been one of the main lines of investigation, where the issue is to decide a current undecided case with respect to prior cases, e.g. precedents. In a series of papers culminating in [11] and followed by implementations and experiments [22], legal case-based reasoning (LCBR) is presented as *theory construction*. As disputation is an essential aspect of LCBR, subsequent approaches turned to implemented argumentation, particularly *LCBR using argumentation schemes with values* [5, 50, 51, 52, 38, 10]. In this section, we give an overview of each of these approaches.

LCBR and Theory Construction Reasoning with cases is seen as the process of *constructing and using a theory of the rules* that are derived from the cases and that bear on a legal decision. Where conflicts amongst the rules arise, the purposes of the law are invoked, which are the *social values* that the rule promotes or defends; such values may be ordered with respect to preferences.

Precedent cases represent, in effect, prior application of a rule, implying (or explicitly giving) the social value that is promoted or defended. The precedent cases themselves present *abstract fact patterns*, factors, that are compared and contrasted and that contribute to the decision for one party or the other: given a constellation of factors and a legal rule that bears on the factors, a legal decision for a party is given. The significance of the factors can be *emphasised* or *downplayed* in relation to other factors in the case. As the rules are themselves subject to dispute, they are *defeasible*. Following the legal principle of *stare decisis*, a current undecided case with the same factors as a precedent case is decided in the same way. However, should the current case vary in certain ways, then other, relevant precedents are invoked and used to argue about the relative importance of the different factors, legal rule, and case decision. As the factors and decision reflect social values, the argument thus is an argument about those values.

To construct a theory, a knowledge background is given of: cases, factors, outcomes, values, factor descriptions, and case factor-based descriptions. Cases are described in terms of the factors that are present in the case, where the factors are associated with the party that they strengthen in the decision. The analysis of cases in terms of factors is taken as a given. The outcomes are those for the plaintiff Π or for the defendant Δ, and values are linked to factors. Factor descriptions are constructed from factors, outcomes and values. Case factor-based descriptions are the set of cases that are described by the factors that hold of a case and the outcomes; a case base that is used to reason about the cases can be given by such descriptions. Legal rules associate a set of factors with a decision for a party, where the factors themselves are associated with a decision and the social value that is promoted. Legal rules can attack one another should the outcomes be complementary, and there can be asymmetrical preferences of one rule over another such that one rule is said to defeat the other. A theory is an explicit selection of material from the background, containing: descriptions of all the cases considered relevant by the proponent of the theory; descriptions of all factors chosen to represent those cases; all rules available to be used in explaining the cases; and all preferences between rules and values available to be used in resolving conflicts between rules. A variety of means are described to construct theories from an initial (perhaps empty) theory by including cases, factors, rules, and preferences.

The objective is to construct a theory for a current case, using the resources provided by the case background, to explain the desired outcome of the case. Informally, a case is explained if: (a) given some of the factors of the case, f_1, and a rule, r_1, with f_1 as antecedent gives the outcome of the case, o_1; and (b) there is set of factors of the case, f_2, and a rule, r_2, with the outcome of the case, o_2, such that r_2 defeats r_1.

One example of a theory is from the analysis of *wild animal* cases, e.g. *Pierson v Post*, *Keeble v Hickeringill*, and *Young v Hitchens*, which are used in [15]. In the following, we use prefix π for plaintiff and δ for defendant; Π and Δ are for respective outcomes. In *Pierson v Post*, π was fox hunting on open land when δ killed and carried off the fox; π was held to have no right to the fox because he had not possessed it; δ won. In *Keeble v Hickeringill*, π owned a pond and made a living by attracting ducks to the pond with decoys, shooting them, and selling them for food. δ scared the ducks away from the pond. In this case π won. In *Young v Hitchens*, both parties were fisherman. Just as π was closing his nets on the fish, δ sped into the gap, spread his net, and caught the fish. In this case δ won. We represent some aspects of these cases with the following factors and values:

Factors:

πLiv = π was pursuing his livelihood, favouring π;

πLand = π was on his own land, favouring π;

δNposs = δ was not in possession of the animal, favouring δ;

δLiv = δ was pursuing his livelihood, favouring δ.

Values:

Llit = Less Litigation;

Prop = Enjoyment of property rights;

Mprod = More productivity

From this information, we can construct a theory **T2** (where T1 is a precursor), which is a structure that has the following constituents:

cases: {<Young, {πLiv, πNposs, δLiv}, Π >, <Pierson, {πNposs}, Δ >, <Keeble, {πLiv, πNposs, πLand}, Π >}

factor descriptions: {< πNposs, Δ, Llit>, < πLiv, Π, Mprod>}

rules: {<{πNposs}, Δ >,<{πLiv}, Π >}

rule preferences: {rpref(<{πLiv}, π >,<{πNposs}, Δ >)}

value preferences: {vpref(Mprod,Llit)}

We suppose that *Young* is an as yet undecided case, but want to construct a theory that can successfully explain that it should be decided for the plaintiff Π. Amongst the cases, we have *Pierson*, which was decided in favour of the defendant, and *Keeble*, which was decided in favour of the plaintiff. The cases have different arrangements of overlapping factors. How can we decide *Young*? In *factor descriptions*, we see the relationship between factors, outcomes, and values; in *rules*, we are given the inference from factors to outcomes. If we just followed the rules, we might expect there to be a conflict in *Keeble*, deciding both for Δ and for Π, since each of the rules applies to the factors, but this is not so, as *Keeble* is decided for Π. This follows from the rule preferences, where π *was pursuing his livelihood, favouring* π trumps δ *was not in possession of the animal, favouring* δ. Applying this same reasoning to *Young*, the decision is for Π. Thus, precedents are used to reason for a decision in an undecided case. Other theories can be constructed to argue for different outcomes, until the background of cases is fully exploited.

In [11], there are several ways to evaluate alternative theories as well as various argument moves. The approach was subsequently developed, implemented, and experimented with in [22].

LCBR with Argumentation Schemes and Values Recent work in AI and Law by Trevor and his colleagues has examined how argumentation schemes with values can be represented precisely and formally in ASPIC+ [37] as part of a well-developed framework for LCBR [50, 52, 38]. A formalisation in ASPIC+ means that the analysis is precise and unambiguous and that formal properties can be demonstrated.

For [38], ASPIC+ contains a first-order logical language with equality, classical negation, and strict and defeasible rules. The knowledge base contains axioms and ordinary premises. Arguments are built from the knowledge base; attacks are determined as outlined previously. LCBR is represented in terms of the logical language, a knowledge base, and argumentation schemes for reasoning about the decisions of the cases. Cases are represented in terms of sets of factors; various partitions of factors are used to support or undermine a plaintiff's argument that a current case should be decided in favour of the plaintiff. In addition, a *factor hierarchy* [1] enables reasoning about relationships *between* factors such that one factor may, for example, be substituted for another. Preferences between sets of factors are also expressed. Instantiated argumentation schemes are used, with respect to sets of factors, the factor hierarchy, preferences, to reason about combinations of and counter-balancing between factors in the cases. While this is a well-developed analysis of LCBR in terms of argumentation frameworks, values are not represented or reasoned with.

LCBR with values and instantiated argumentations schemes appears in [30, 51, 10]. The case *Popov v. Hayashi*, which concerns disputed possession of a baseball, is modelled using the PRAS discussed in section 4.2 (though not with respect to a semantic model) [51]. For example, parts of the judge's reasoning in the case can be represented informally using PRAS: If the interruption of Popov completing the catch of the baseball was illegal (due to an assault on him), the case should be decided for Popov, which would prevent assault being rewarded and promote the value of public order. Other patterns of reasoning in the case can be modelled, giving rise to an argumentation framework of arguments in attack relations. However, such reasoning patterns are informal.

To systematically argue about values in LCBR, several argumentation schemes are formalised in ASPIC+ [10] such as: one to establish a value preference from a precedent case, one to apply a value preference to a new case, and one to establish that a value is promoted by deciding a case for a particular party when a given factor is present. These schemes are linked, such that premises of the main scheme *VAS1* are justified by subsidiary schemes. We present the first two schemes informally to illustrate the approach:

VAS1: Decision Based on Value Scheme

Promotion Premise 1: Decision for party 1 in current case promotes value1

Promotion Premise 2: Decision for party 2 in current case promotes value2

Preference Premise: Value1 is preferred to value 2

Conclusion: Decide current case for party 1

Another scheme is used to establish the promotion premises of *VAS1* (either 1 or 2 depending on how it is instantiated):

VAS2: Promotion Scheme

Factor Premise: Factor is present in case

Value Premise: Decision for party when factor is present promotes value

Conclusion: Decision for party in case promotes value

Additional schemes establish the preference order, critique the applicability of the preference order, and introduce ways of comparing sets of values. The analysis is used to illustrate various examples of reasoning about cases.

5.2 Policy-making Using Instantiated Argumentation Schemes with Values

Trevor and his colleagues have fruitfully applied their work on practical reasoning with values to a domain that has risen to prominence over the past decade or so, namely e-Democracy and e-Participation [3, 21, 20, 4, 53, 6]. In this section, we discuss some of the key points and outline recent tools for *Structured Consultation* and *Critique* that show how some of the formal theories developed in value-based argumentation can be applied.

The theory and tools address the question *What should be the process of formation of political will*? A current view is that the political will, where the government serves as the agent of the citizenry, is achieved by *deliberative democracy*, where citizens are not only *recipients* of government policies made by well-informed officials who work in the interests of society, but are also *producers* of political information and policies by participating in political processes and debate. A citizen identifies and publicizes issues of personal or social concern as well as argues with other citizens for and against various policy options; thus, in *deliberative democracy*, citizens pool their judgements about what should be done, passing these judgements to government officials for further action.

However, deliberative democracy requires communication between the government and the people. To meet the communication needs, governments leverage technologies, e.g. the Internet, to give the public greater access to government information, to offer virtual venues for public discussion and feedback, and to respond to public enquires. A variety of systems are available such as e-voting, web-based questionnaires, discussion boards, crowd-sourced legislative proposals, and e-petitions [21]. While useful, the information from these systems is often not sufficiently structured to facilitate fine-grained analysis of just what participants agree to or desire as alternatives. For example, in an e-petition, a citizen may be asked to agree or disagree with a particular policy-making proposal, e.g. *smoking should be banned from all public buildings*, whereas the signatory has a range of concerns about just what the facts are, how the ban will be implemented, what counts as a public building, and so on. In order for a government's policy to be effective, the specific concerns of the effected parties must be understood and addressed. More generally, given the volume and complexity of the information received from the public, issues arise about how to analyse, evaluate and respond to the volume of data gathered. In addition, tools for facilitating such interactions have to be easy to use.

Tools for Deliberation To facilitate fine-grained, well-structured consultations about policy-making proposals, easy to use prototype web-based tools have been developed. The first tool developed by Trevor and his colleagues was *Parmenides*, which implemented argumentation schemes such as the PRAS and aspects of Argumentation Frameworks [20]. Parmenides was re-engineered into the *Structured Consultation Tool* (SCT) and *Critique Tool* (CT), making use of a wider variety of argumentation schemes along with semantic models and giving the tools greater underlying structure, precision and flexibility [4, 53, 6, 49].

The SCT and CT address complementary issues. The government may provide a policy proposal and wish to understand what specific components citizens agree with or object to; for this, the SCT provides the means to serve a survey type list of well-structured questions. Alternatively, a citizen may wish to make her own proposal, then understand how it compares to the government's own policy proposal; for this, the CT facilitates input of a citizen's proposal, which is then systematically critiqued. At the end of a session using the CT, a citizen has aired her proposals, understood their implications, and received a critique in relation to the government's position.

The SCT and CT use and present argumentation schemes such as Practical Reasoning, Credible Source, and Value Recognition that have been formalised and grounded in semantic models [7, 4], providing a systematic way to structure, investigate, and critique the policy proposal. Given the argumentation schemes, the various associated critiques either guide the structure of presentation (for the SCT) or provide feedback to the user (for the CT). Among the critiques from [7], we have:

1. Is the action possible?
2. Does the action promote the value?
3. Are there negative side effects?
4. Do the other agents do what they are supposed to do?

The PRAS is taken as the main scheme, while subsidiary schemes relate to particular challenges; the *Credible Source* scheme (CS) examines the justification for circumstances or consequences of the action, while the *Value Credible Source* (VCS) and *Value Recognition* (VR) schemes justify the values in different ways. The tools are web-based applications written in PhP; they access the same MySQL database, though with different queries.

Structured Consultation Tool The SCT is designed for a consultation where the policy-maker presents a policy to citizens as a survey and solicits their opinion on the particulars of the policy. The consultation has a *main* line and *digressions*. The main line is structured by the components of the Practical Reasoning scheme, which are presented with default responses (e.g. *agree* or *demote*) that represent the position of the policy-making body. Should the user select something other than the default, a digression opens, wherein the user can investigate further the justification for the defaults, then return to the main line. Digressions are structured around the constituents of the relevant subsidiary argumentation schemes justifying the statement disagreed with.

Each proposition in the circumstances and consequences has a digression with respect to the CS; each of the values has a digression with respect to either the VCS or the VR. For each of the digressions, the user indicates what she accepts or rejects the default (thereby justifying why she did not accept the main line statement). In this way, the user gives a fine-grained, structured opinion about the circumstances, consequences, and values along with her justifications for these opinions.

Critique Tool For the CT, the citizen *interactively creates* her own policy proposal by selecting from a menu of choices, which is then critiqued from the standpoint of the government's policy proposal.

The program generates the logical space of justifications of actions from the database representation of the semantic model. Menus are formed to solicit the user's beliefs as to the current state, a proposed action, the state the user believes will be reached as a consequence of the action, and the value the action will promote. For each part of the user's proposal, the program applies some of the critiques in [7], and where appropriate, offers the corresponding criticism or *caveat* to the user. The user then freely chooses from a menu of alternatives, which are checked against the policy-maker's proposal. The policy-maker's proposal is only incrementally revealed to the user over the course of the interview. In this way, the user gets the opportunity to represent what she believes to be the case, what can be done, what the consequences are, and whether values are promoted (demoted, unaffected), receiving in the end a thorough analysis of implications of her proposal.

5.3 Application in General AI and Multi-Agent Systems

We now turn to the field of multi-agent systems, which is a natural application area for formal frameworks for representing and reasoning about value-based arguments. The AATS+V model mentioned above has been applied in a variety of different work. In [13] Trevor and colleagues showed how it can be used to model scenarios from experimental economic studies, the Dictator Game and the Ultimatum Game, in which it must be decided how a sum of money will be divided between the players in the games. Studies have been conducted into how humans act in such games, and the results are not explained by a decision-model that assumes that the participants are purely self-interested utility-maximisers. The AATS+V representation has been shown to effectively model behaviour in the scenarios, precisely because of the use of value-based argument in the representation and reasoning.

Black and Atkinson have used value-based argumentation to investigate dialogical interactions in agent systems where agreement needs to be reached on how to act [17]. In [18] they present a dialogue system that lets agents agree to an action that each finds acceptable, but does not necessarily demand that they resolve differing preferences that might occur. As part of their system they develop a mechanism with which an agent can develop a model of another's preferences, which is a concern in persuasion scenarios. Further in the agents literature, Tom van der Weide's work [44] provides automated support for decision making in complex scenarios, using argumentation, decision theory, and values as part of a formal dialogue framework. Dechesne at al. investigate the relationship between norms, values and culture to study norm acceptance and norm compliance [24]. They report on agent-based simulations that account for all these concepts in order to explain the differences in uptake of policies in different cultures. They apply their model to the introduction of the anti-smoking legislation. It has also been shown how value-based argumentation can be used to address the issue of ontology alignment between autonomous agents [31]. Since agents differ in the choice of vocabulary used to represent concepts, as represented in their domain ontologies, they need to be support with mechanisms to enable them to align their ontologies. This is achieved through a process of argumentation using VAFs in which candidate correspondences are accepted or rejected, based on the ontological knowledge and the agents' preferences. Similar issues have been investigated in [25]. Finally, we note that research has been conducted into showing how VAFs can be translated into neural networks [23]. An algorithm to perform this translation is presented with the aim of facilitating learning capabilities in VAFs, since arguments may evolve over time with respect to their strength, and also to enable the parallel computation of argumentation frameworks by making use of the machinery of neural networks.

Our survey of the use of value-based argumentation in the variety of domains discussed above is not exhaustive, but gives a flavour of the rich and diverse types of problem that Trevor's work has been used to address.

6 Concluding Discussion

Over the course of this paper, we have discussed what values are, how they appear in abstract and instantiated argumentation, and how they have been applied to support reasoning in legal and political domains. Trevor's work took up, initiated, and developed ideas about values and argumentation, influencing many others to develop related or distinct lines of research. There is clearly scope for continued research. In the legal and political domains, one might reason about values using quantitative, statistical approaches, e.g. data mining or neural net systems, rather than the sorts of symbolic, heuristic approaches that have been discussed above. There are advantages and disadvantages of each: quantitative approaches gain applications over large, extensible volumes of data, but lose transparency and explanatory force; the symbolic approaches are crafted for small, constrained domains, gaining transparency and explanatory force. Perhaps some integration would be of use. Another general consideration is the relationship between the factors and the values in legal cases as factors vary widely in form and meaning while the values may be implicit in a decision. In current work on values in legal reasoning, values may be ranked in preference orderings, but there may be richer ways of reasoning about values such as giving them weights and reasoning by accrual. Finally, for many applications, it will be important to find the means to scale up information extraction from legal case decisions or policy consultations to identify arguments, factors, and values.

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