Using Event Progression to Enhance Purposive Argumentation in the Value Judgment Formalism

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ABSTRACT

This paper expands on the previously published value judgment formalism. The representation of situations is enhanced by introducing event progressions similar to actions in general AI planning. Using event progressions, situations can be assessed as to what facts they contain as well as what facts may ensue with some likelihood, thereby opening up a situation space. Purposive legal argumentation can be modeled using propositions and rules controlling the likelihoods of value-laden consequences. The paper expands the formalism to cover event progressions and illustrates the functionality using an example based on *Young v. Hitchens.*

Keywords

legal reasoning, argument schemes, event progression

1. INTRODUCTION

Starting with the seminal work of Berman and Hafner [13], formal models of legal argumentation have created different representations of the *relevance* of certain features of a legal case scenario. Why is the difference or similarity between case A and case B important? Which inferences should apply to a given case and why? Does a given rule scale well given a larger set of cases? Case based reasoning has mainly explored factor representations [4], a factor hierarchy [1], an issue-based model [5] or theory based models [12] to reason about relevance in tackling some of these questions.

In prior work, we have presented the *value judgment formalism* [18, 19], which presents a set of argument schemes for arguing about the influence of legal decisions (e.g. the decision to prohibit animals in a public park) and, more extensively, legal rules (e.g. the imposition of a $20 fine for taking a dog to a park) on a given factual situation in light of the applicable legal values such as protection of public health or freedom of movement. The central concept is that of a value judgment, which is a propositional construct stating that the positive effects of adding some fact or rule to a specific situation outweighs the negative effect on the applicable legal values, or vice versa.

The formalism uses argument schemes focusing on such balancing and pointing out positive and negative effects of modifying the situation. However, the formalism's representation of situations entailing these effects has been somewhat simplistic, meaning that an effect represented as a proposition would either be entailed by a situation or not, thereby staying fairly abstract and falling considerably short of something easily implementable.

In this paper we move the formalism closer to a computational implementation by adding the concept of *event progressions* [EP], which are similar to planning actions. These are transition operators that modify a given situation into a new situation in a certain way given certain circumstances and with a known likelihood. An available set of EPs allows for all possible consequences of a given situation to be computed into an EP space, which becomes a part of the main argument graph. Argument schemes connect to and influence the progression of events by generating arguments about which impact the adoption of a legal rule in a given situation has on the possible consequences and their likelihoods. This way, legal reasoning with values becomes similar to 'steering' the space of possible consequences.

The first part of this paper gives a full but only briefly explained definition of the current version of the value judgment formalism. For a more detailed explanation of the concepts involved and related work, see our prior work in [18, 19]. Section 3 will give a conceptual introduction of the EP extension along with formal definitions. Section 4 is a detailed example EP space construction and argument derivation based on *Young v. Hitchens.*

2. THE VALUE JUDGMENT FORMALISM

This section briefly introduces the value judgment formalism in its latest version. Several changes have been made since its last publication in [19], but none have restricted the functionality of the formalism and the small differences in notation should be intuitive. For space reasons, the narrative accompanying the definitions will be kept to a minimum.

2.1 Interests, Norms and Values

The formalism is built around the assumption that a legal system is in essence a coordination of the plurality of interests among the subjects and actors involved in the system. Interests can be individual or collective. The law provides a set of norms, that stem from legal sources and are applied to specific cases in a dialectic process, which we model as

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argumentation. The norms (or *legal rules*) themselves form a system which, through its interpretation and application, coordinate the interests by submerging some, enforcing others and so on. Interpretation and application of legal rules is governed by what legal theorists have labeled as *principles* among other names. We summarize these reasoning policies (which are essentially bundles of certain individual or collective interests) under the term *value*.

We do not take a stance with regard to the legal theory debates related to these concepts. Instead, our goal is to develop a coherent formalism that lends itself to a computational implementation and leads to a computer program capable of engaging in legal argumentation by taking into account values in reasoning *about* legal rules as opposed to blindly applying them.

2.2 Argumentation Environment

The formalism uses simple and compound propositions in a logical language. Propositions are denoted as labels starting with lowercase letters and are combined using the conjunction symbol (e.g. $p \wedge q$). An argument is denoted as $a_1 \wedge ... \wedge a_n \rightarrow c$, where a_1 through a_n are the argument's antecedent/premise propositions and c is the argument's conclusion proposition. Inference is conducted by instantiating argument schemes to assemble a full argument graph, similar to Carneades (e.g. demonstrated in [17]). The overall goal is not to prove entailment or infer argument acceptability in some semantics, but to construct an argument graph such as the example one in figure 2 further below.

2.3 The Core Formalism

The basic elements of the domain are facts. They can represent common sense concepts as well as legal concepts.

Definition 1. *A **fact** is an atomic or compound proposition representing a part of the domain of discourse. Let F be the set of all possible fact patterns.*

Notice that we have abandoned the formal subsumption relationship among facts (denoted $f_1 \sqsubseteq f_2$ in [18, 19]), which expressed that a general fact pattern f_2 contains a more specific one f_1. $f1 \sqsubset f_2$ is functionally equivalent to $s \cup f_1 \vdash f_2$ as the more specific pattern entails the general one in a certain situation which provides for the necessary ontological knowledge. Similarly, we abandoned the notion of facts being closed under union. A set of facts can be composed into a composite fact using a rule forming a legal or common sense concept.

Definition 2. *A **value** is a legal concept abstracting a set of one or more interests of individual or groups of actors in the legal system such that one can speak of a change in a certain fact pattern as promoting or demoting the given value. Let V be the set of values in the domain of discourse.*

Definition 3. *A **rule** is a compound proposition of the form $p_1 \wedge ... \wedge p_n \Rightarrow c$, assigning a conclusion proposition to conjunctive antecedent propositions. Let C be the set of common-sense-knowledge (CSK) inference rules and L be the set of legal rules stemming from sources of law. Legal rules shall be referred to as **norms**.*

Situations serve as 'container' elements. In our formalism, facts do not entail other facts. Rather, only situations entail facts using the assumed facts and rules they contain.

Definition 4. *A **situation** is an identifier for a tuple $\langle F_s, C_s, L_s \rangle$ where $F_s \subseteq F$ are the given facts, $C_s \subseteq C$ are the available CSK inference rules and $L_s \subseteq L$ are the applicable legal norms. Let S be the set of all possible situations.*

If $s \in S$ and proposition x is either a fact, common sense rule or norm (or set thereof), let $s' = s \cup x$ be a new situation created by adding x to the respective tuple element of s and $s'' = s \backslash x$ be a new situation by removing x from s.

A proposition p following argumentatively from a situation s is denoted $s \vdash p$. The notion of p not following argumentatively, either because of lack of an argument or because of the counterarguments defeating the supporting arguments according to the semantics of choice, is denoted $s \not\vdash p$.

As the entailment of propositions by situations is the most frequent rule antecedent, $p_1 \wedge ... \wedge p_n \Rightarrow_s c$ is a shorthand notation (notice the subscript s) for $s \vdash p_1 \wedge ... \wedge s \vdash p_n \Rightarrow s \vdash c$.

Arguing for or against a legal conclusion (e.g. deciding a case, adopting a rule, etc.) can be characterized as deciding if and how to legally 'modify' the situation at hand, thereby creating a new situation. In order to reason purposefully about such a decision, one needs to be able to compare two situations and argumentatively infer the differences between one situation and another in terms of how values are promoted and demoted. We use a qualitative scale as our working model to measure promotion and demotion of values.

Definition 5. *Assume $s_1, s_2 \in S$ and applicable values $V_s \subseteq V$. Then $\delta_{v_i}(s_1, s_2)$ shall be the **difference in manifestation** of value $v_i \in V_s$ in s_2 compared to s_1 as follows:*

$$\delta_{v_i}(s_1, s_2) = \begin{cases} +++ \text{, if } v_i \text{ is overwhelmingly promoted} \\ ++ \text{, if } v_i \text{ is greatly promoted} \\ + \text{, if } v_i \text{ is somewhat promoted} \\ \approx \text{, if } v_i \text{ remains unchanged} \\ - \text{, if } v_i \text{ is somewhat demoted} \\ -- \text{, if } v_i \text{ is greatly demoted} \\ --- \text{, if } v_i \text{ is overwhelmingly demoted} \end{cases}$$

*If $m \in F \cup L$ and $s_2 = s_1 \cup m$, then we speak of $e_{v_i}(m, s_1) = \delta_{v_i}(s_1, s_2)$ as the **effects** of imposing m on s_1. Also, let $E^{+}_{V_s}(m, s_1)$, $E^{-}_{V_s}(m, s_1)$ and $E^{\approx}_{V_s}(m, s_1)$ be the set of (value, effect) tuples of values positively, negatively and neutrally affected, respectively, by the imposition of m on s_1.*

In order to infer these qualitative effects on values, one needs to specify what constitutes a promotion and demotion. In our formalism, this is done using special rules (labeled 'specifications') whose consequent is an effect on a value.

Definition 6. *For a given value $v \in V$ and $x \in \{+++, ++, +, \approx, -, --, ---\}$, let D^x_v be the set of propositions specifying an effect on value v of characteristic c. Let the rule $c_1 \wedge ... \wedge c_n \Rightarrow s \vdash d$ be a **specification** of domain circumstances in situation s corresponding to an effect specified by proposition d. Each condition c_i may refer to the situation s if needed. Let D be the set of all specifications. Depending on the effect character of its consequent d, each specification is a member of one and only one D^x_v. Let D be the joint set of all specifications.*

Different from our previous publications of this formalism, value specifications are now conjunctions of proposition as opposed to fact patterns. This allows them to take into account multiple situations and relationships between them. For example, somebody's losing a claim from contract may have a negative effect on the value of protecting individual property interests. However, if this loss of the claim is accompanied by a possible different future compensatory claim, invalidating the contract claim may not amount to an invason of property interests. In order to incorporate this into the specification of private property protection, the specification needs to take recourse to what is likely to happen in the future. The extended example in sec. 4 will illustrate this in greater detail.

Definition 7. *Assume situation $s \in S$, $f_1, f_2 \in F \cup L$, applicable values $V_s \subseteq V$ and $x, y \in \{+, -\}$. A **value judgment** is a proposition comparing value effect sets of the form $E^x_{V_s}(f_1, s) > E^y_{V_s}(f_2, s)$. The relations $<, >$ expressing such preferences are hence defined only over pairs of value effect sets (i.e. not a strict partial ordering), stating that one set of effects is preferable over the other as asserted through argumentation. Let J be the set of all value judgments.*

Where appropriate, the V_s subscripts may be omitted in this paper. When verbalized, the value judgment $E^+(f, s) > E^-(f, s)$ means that the positive effects of imposing f on situation s outweigh the negative effects. $E^-(f, s) > E^+(f, s)$ states the opposite. In an argument, advocates will typically argue for such opposing value judgments.

The concept of a value judgment has been studied in legal theory, for example in [2]. Prior work on argumentative practical reasoning in the legal context [20] (see also recent work in [7]) uses contextual value promotion/demotion by actions, introduces a decision maker's preference between actions and provides corresponding argument schemes. [7] uses value-based argumentation frameworks for inference.

The value judgment formalism can be considered a conceptual and representational refinement of prior work with an aim to towards implementing a computer program able to generate and score value-based legal arguments from a knowledge base. We do not, however, agree with the notion that two conflicting arguments A_1 (promoting value v_1) and A_2 (promoting value v_2) can be evaluated by taking recourse exclusively to an abstract ordering of values (e.g. $v_1 > v_2$) without taking into account the specific facts of a situation. To the best of our understanding, this is the main conceptual difference between our work and a large portion of prior work on value based reasoning in AI&Law (e.g. value based argumentation frameworks [8] and related works, and theory construction [12]). We hence speak of *effects* on values outweighing others and introduce qualitative degrees of promotion and demotion. We intend to use an abstract weighting of values in conjunction with the degree of promotion/demotion to assess arguments as to their persuasiveness in our planned implementation. For further treatment of related work, see [18, 19].

2.4 Basic Argument Schemes

Definition 8. *If $p_1 \wedge ... \wedge p_n \Rightarrow c \in C$, then $p_1 \wedge ... \wedge p_n \rightarrow c$ is an **argument from common sense rule**.*

Definition 9. *If $p_1 \wedge ... \wedge p_n \Rightarrow c \in L$, then $p_1 \wedge ... \wedge p_n \rightarrow c$ is an **argument from norm**.*

Definition 10. *If $s \in S$ and $c_1 \wedge ... \wedge c_n \Rightarrow s \vdash d \in D$, then $p_1 \wedge ... \wedge p_n \rightarrow s \vdash d$ is an **argument for value effect**.*

3. THE EVENT PROGRESSION EXTENSION

3.1 Introduction

In our prior work on the formalism, we have presented argument schemes that reason with positive and negative consequences to support or oppose value judgments (e.g. definition 10 in [19]).By pointing out desirable or undesirable things that happen when a certain legal decision is made in a certain way or not, the decision making audience may be persuaded to make a certain determination about whether the advantages trump the disadvantages or vice versa.

The main purpose behind EP is to enhance the formalism's representation by including a discrete temporal model. It forms a situation space by applying event progressions (which are transition operators similar to traditional AI planning actions) to a starting situation up to a desired depth. The resulting data structure is functionally equivalent to a space of possible worlds following from the starting situation given the available EPs, domain knowledge, legal rules and argument schemes. A modification of the legal rules or factual assumptions will result in a different EP space, allowing argument schemes to use these differences to draw inferences about the impact of the modification and use them to advocate for and against value judgments.

For example, a basic situation in a public park might progress with a number of possible events. People will enter the park for various purposes and may bring animals of various kinds. If a situation arises where a person brings along a dog that is not on a leash, the dog might see a squirrel who happens to cross a walking path. In that situation, the dog might bark at the squirrel, get aggravated and possibly bite a child that is playing close by, severly injuring the child. All these events are plausible progressions of an ordinary situation in a public park and a chain of them might culminate in the injury of the child. The overall likelihood of this chain of events might lead someone to conclude that the unregulated park is a safety risk for children and consider prohibiting animals from the park. Once such a sign is put up, certain progressions of events are still plausible, such as people bringing dogs along in spite of the prohibition. However, the likelihood of such events as bringing dogs to the park will be much lower than if the prohibition were not in place, leading to a lower risk for the safety of children.

The event progression extension of the value judgment formalism is intended to capture this mechanism so that it can be used by rules and argument schemes, thus bringing the formalism one step closer to a computational implementation. Also, rules are not restricted to one particular instantaneous situation but instead may refer to future and past situations, further enhancing the expressiveness of the formalism.

3.2 Event Progression Space

EPs are defined similar to typical state space operators in classical artificial intelligence planning (going back to situation calculus in [23]). In its basic form (e.g. the landmark STRIPS planner [16]), action operators alter situations by adding or removing propositions (also called 'fluents'), thereby opening a state space which can be searched from a starting state to a goal state, constructing the plan along the way. As will be explained later, Figure 1 represents an example event progression space.

Similarly, EPs open the space of possible continuations of a starting situation in the domain of interest. This space is possibly infinite and can hence only ever be partially constructed during inference. Even in relatively self-contained domains like ‘no animals in the park’ the space of possible event chains can become extremely complex. However, planning has faced the same phenomena from its beginning in the early days of AI and has developed greatly since, leading to modern fast planning systems which are able to solve very complex planning problems efficiently using different search spaces (e.g. planning graphs) and inference methods (e.g. forward search with sophisticated heuristics [21] or planning as satisfiability [22]). One challenge is that the formalism presented here uses event progressions in an environment of argumentative inference, which is not as straightforward as existing planning representations. We are optimistic, however, that methods transfer to an extent that allows us to use EP space for purposes of modeling purposive legal argumentation. One remaining challenge is the argumentation-specific handling of the so-called ‘frame problem’, which we address below in section 6.2. Other than that, we leave the detailed transfer of planning systems into an argument inference environment for future work.

The EP space data structure is conceptually similar to the action transition system used in [10, 7] to model practical reasoning through argument schemes. There, an agent conducting a certain action in a given state has a contextual effect on values. The envirommnent is used to infer for practical reasoning purposes which actions should be performed. By contrast, the EP space used in this formalism rather represents a space of possible progressions of the domain as a whole and their likelihoods. Legal decisions (e.g. adopting a rule) influence this progression space, leading to value-based argument about which decision alternative is preferable in light of the consequences it likely incurs.

Also, EPs are structurally similar to the ‘generalizations’ as used in [14] to model argumentation about evidence, causation and stories in anchored narratives. There, generalizations are inference rules which function as warrants for causal and evidential argumentation in criminal cases. Structurally and semantically, EPs can be considered generalizations in the sense of their work. Functionally, both generalizations and EPs provide warrants for arguments about the domain. However, this approach uses EPs to inductively model a temporal representation of the domain in order to assess the impact of modifications to the domain, where [14] use generalizations for an (at least partially) abductive argumentative analysis of evidence, known facts and common sense knowledge with the goal of providing a theoretical foundation for sense-making in evidential reasoning. We reserve a deeper comparison of the two models (e.g. with regard to argumentative inference for conflicting EPs or generalizations) for future work once we have settled on a specific inference model for the planned implementation.

3.3 Basic Concepts

3.3.1 Likelihoods

Picture a public park in the morning. It is likely that someone will go for a walk in the park with her dog. Is it likely that a *blind person* comes to the park? It is possible, but less likely. Certain event progressions are more likely than others. We wish to capture that in our formalism and hence introduce a qualitative scale of likelihood which will be used in compound entailment propositions to represent that a situation is ‘likely’, ‘unlikely’ or perhaps ‘almost certain’ to lead to some other situation.

Definition 11. *The ordered tuple of possible* ***likelihoods*** *L is a qualitative scale. A certain event progression can, in ascending order of probability, be ‘negligible’, ‘unlikely’, ‘possible’, ‘likely’ or ‘almost certain’. For formalism abbreviations, use $L = (n, u, p, l, a)$.*

Presume that two given likelihoods can be compared using the operators $<, >, =$. Given a set of likelihoods L^*, let $min(L^*)$ be the minimum likelihood contained in the set.

If a situation s entails a proposition p with a certain likelihood l, it is denoted $s \vdash_l p$. If the entailment follows with a likelihood greater than, smaller than, at least as large as or at most as a certain likelihood l, it is denoted as $s \vdash_{>l} p$, $s \vdash_{<l} p$, $s \vdash_{\leq l} p$ and $s \vdash_{\geq l} p$, respectively.

It is important to understand that these likelihoods are not probabilities in the mathematical sense of the term, but rather rhetorical likelihood assumptions for purposes of constructing arguments. Most importantly, the formalism can consider them as part of a proposition, just as the entailment relation itself is a proposition (e.g. $s \vdash_l f$). This allows entailment of a fact with a certain likelihood to be a rule antecedent, thus making argumentation about different likelihoods possible. While combinatorics will be a challenge in the implementation, we consider an explicit qualitative and propositional likelihood model worth pursuing to enrich the expressiveness of the domain representation.

The likelihoods as presented in this paper are relatively coarse and only interact with each other through some basic comparison and minimum functions. Semantically, they represent a rhetorical intuition about how likely something is about to happen when lawyers reason about the future and compare likelihoods. The presented five-point qualitative scale is, of course, arbitrary and could be replaced with any granularity of choice. In our planned implementation, we plan an overall hybrid qualitative-quantitative inference control, but deem a qualitative scale for this particular aspect to be most adequate. We have chosen this qualitative scale because we think it strikes a good balance between being intuitive to work with from a knowledge engineering point of view while still allowing a fairly fine-grained determination that certain things are more or less likely than others, thereby informing rules, value specifications, argument schemes and possibly search and scoring heuristics.

3.3.2 Event Progressions

Definition 12. *An* ***event progression*** *is a tuple $(C, E_{pre}, P, E_{post}, A, D, l)$ where*

- *$C = \{prc_1, ..., prc_n\} \subset F$ is a set of factual preconditions which need to be entailed by a situation s in order for the event progression to follow;*
- *$E_{post} = \{e_1, ..., e_o\} \subset F$ is a set of factual pre-exceptions that may not be entailed for the event progression to follow;*
- *$P = \{pstc_1, ..., pstc_m\} \subset F$ is a set of factual post-conditions which need to be entailed by the progressed situation s' in order for the event progression to follow;*

- $E_{post} = \{e_1, ..., e_o\} \subset F$ *is a set of factual post-exceptions that may not be entailed by the progressed situation* s'*;*

- $A = \{a_1, ..., a_p\} \subset F$ *is a set of facts that the event adds to the situation* s*;*

- $D = \{d_1, ..., d_q\} \subset F$ *is a set of facts that the event removes from the situation* s*;*

- $l \in L$ *is the likelihood of that event happening in* s*.*

If the conditions of event progression p *are fulfilled in situation* s*, then applying* p *to* s *results in a new modified situation* s' *that differs from* s *in that it has new facts* A *and lacks old facts* D*. This relationship is propositional and denoted as* $s \times p = s'$*. Let* P *be the set of all event progressions.*

3.4 Postconditions and Post-Exceptions

Event progressions are slightly more complex than traditional planning operators in that they contain so-called 'postconditions' and 'post-exceptions'. They are like preconditions and pre-exceptions except that they need to (or may not) be fulfilled if the EP in question were actually applied. Post-exceptions prevent an event progression from being applied if they are entailed if the EP in question were to apply. By contrast, common AI planning actions typically feature only one list of propositions that are required to be true (or false) in order for the operator to apply. This rests on the domain assumption in most planning systems that the current knowledge against which the requirements are checked is sufficient to determine whether and how to apply the action operator as it is very foreseeable how the action will affect the situation. In our context of modeling legal reasoning, however, one commonly engages in ontological reasoning inside one instantaneous situation whose result is very influential on agent behavior. In planning this is commonly referred to as the *ramification problem.*

For example, a smoker is likely to throw a cigarette butt on the street if there is no fine associated with it. If doing so would incur a $100 fine, then some smokers may still do it, but it is much less likely. So in anticipation of the fine, a different event progression will be triggered, namely one with a lower likelihood and possibly a different action of throwing cigarette butts away only in hard-to-spot places. Of course, this fine can be represented as a precondition and hence does not necessarily need to be modeled as an post-exception or postcondition. With growing complexity of the representation, however, one will want to model the if-discarding-cigarette-then-fine regulation as a legal rule with antecedent and consequent. In order to be able to trigger event progressions according to what legal impact they may have once they apply in a situation, postconditions and exceptions become necessary.

From a technical point of view, we anticipate these additional conditions will not significantly inflate the complexity of the inference task. Also, depending on which model of negation is chosen in the implementation, exceptions and conditions may be collapsed into one list as exceptions could be considered negative conditions. Checking postconditions and post-exceptions for a situation and event-progression can be done by simply applying the progression to a duplicate situation and checking its preconditions. Of course, this all will depend on the specifics of the argument model chosen for an implementation and its semantics.

In our planned implementation, it will likely incur adding the required elements to the argument graph. This may lead to further expansion, but we hope to include it, or possibly, to reduce postconditions and post-exceptions to preconditions in combination with a suitable model of negation.

3.5 Representing Future Situations and Facts

DEFINITION 13. *Situation* s_2 *is* ***reachable with likelihood*** l *(write* $s_1 \rightsquigarrow_l s_2$ *where* $l \in L$*) from* s_1 *if there is a sequence of event progressions* $p_1, ..., p_n$ *such that* $s_1 \times p_1 \times ... \times p_n = s_2$*. This relationship is propositional.*

DEFINITION 14. *A situation* s_1 ***leads to*** *a fact* f *with likelihood* l *(write* $s_1 \succ_l f$ *where* $l \in L$*) iff* $s_1 \rightsquigarrow_l s_2$ *and* $s_2 \vdash f$*. Otherwise* $s_1 \not\succ_l f$*.*

This distinction of a situation *leading to* a fact as opposed to *entailing* it with some likelihood is the consequence of introducing the discrete time model between situations, which in turn are instantaneous 'snapshots' of the world. If some fact is arguably true in a given point-like situation, then it is entailed. If the same situation may develop into some new situation through some hypothetical progression of events happening with some likelihood and said fact is entailed in that new instantaneous, point-like situation, then the original situation *leads to* that fact with that likelihood.

3.6 Argument Schemes

DEFINITION 15. *Assume situations* s_1, s_1', s_2 *and event progression* $p = (\{prc_1, ..., prc_n\}, \{pstc_1, ..., pstc_m\}, \{epre_1, ..., epre_o\}, \{epost_1, ..., epost_p\}\ D, A, l)$ *such that* $s_1' = (s_1 \backslash D) \cup A$*. Then* $s_1 \vdash prc_1 \wedge ... \wedge s_1 \vdash prc_n \wedge s_1' \vdash pstc_1 \wedge ... \wedge s_1' \vdash pstc_m \wedge s_1 \not\vdash epre_1 \wedge ... \wedge s_1 \not\vdash epre_p \wedge s_1' \not\vdash epost_1 \wedge ... \wedge s_1' \not\vdash epost_o \rightarrow s_1 \times p = s_2$ *is an* ***argument for event progression****.*

DEFINITION 16. *Assume situations* s_1, s_2 *and event progression* ep*. Then* $s_1 \times ep = s_2 \rightarrow s_1 \rightsquigarrow_l s_2$ *is an* ***argument for (direct) reachability****.*

DEFINITION 17. *Assume situations* $s_1, ..., s_n$*. Then* $s_1 \rightsquigarrow_{l_1} s_2 \rightsquigarrow_{l_2} ... \rightsquigarrow_{l_{n-1}} s_n \rightarrow s_1 \rightsquigarrow_{l^*} s_n$ *where* $l^* = min(l_1, ..., l_{n-1})$ *is an* ***argument for (transitive) reachability****.*

3.7 New Schemes for Consequences

The following schemes show how differences in entailment or likelihood of entailent of value-relevant effects can be used to argue for value judgments. For prior work in legal theory on consequences and their relevance to values, see [15]. Related argument schemes can also be found in [10], where taking certain actions at different stages in a transition network promotes or demotes certain values and works towards a certain goal.

DEFINITION 18. *Assume* $s, s' \in S$*,* $f \subset F \cup L, h \subset F \cup L$ *such that* $s' = s \cup f \cup h$ *and* $v \in V$*. If* $d \in D_v^{+,++,+++}$ *then*

- $s \not\vdash d \wedge s' \vdash d \rightarrow E^+(f, s) > E^-(f, s)$ *is an argument from* ***desirable consequence*** *of* f *for the proposed value judgment in situation* s *(under hypothetical circumstances* h*).*

- $s \vdash_l d \wedge s' \vdash_{l'} d \rightarrow E^+(f,s) > E^-(f,s)$ *where* $l < l'$ *is an argument from* ***more likely desirable consequence*** *of f for the proposed value judgment in situation s (under hypothetical circumstances h).*
- $s \vdash_l d \wedge s' \vdash_{l'} d \rightarrow E^-(f,s) > E^+(f,s)$ *where* $l > l'$ *is an argument from* ***less likely desirable consequence*** *of f for the proposed value judgment in situation s (under hypothetical circumstances h).*

If $d \in D_v^{-,--,---}$ *then*

- $s \not\vdash d \wedge s' \vdash d \rightarrow E^-(f,s) > E^+(f,s)$ *is an argument from* ***undesirable consequence*** *of f for the proposed value judgment in situation s (under hypothetical circumstances h).*
- $s \vdash_l d \wedge s' \vdash_{l'} d \rightarrow E^-(f,s) > E^+(f,s)$ *where* $l < l'$ *is an argument from* ***more likely undesirable consequence*** *of f for the proposed value judgment in situation s (under hypothetical circumstances h).*
- $s \vdash_l d \wedge s' \vdash_{l'} d \rightarrow E^+(f,s) > E^-(f,s)$ *where* $l > l'$ *is an argument from* ***less likely undesirable consequence*** *of f for the proposed value judgment in situation s (under hypothetical circumstances h).*

4. EXAMPLE

This section presents an example of how we can use the EP extension to model purposive arguments in a case based on *Young v. Hitchens* using the value judgment formalism. It should be noted this paper deviates from prior representations of *Young v. Hitchens* in that the competition between fishermen is not addressed. An explanation of that aspect of the case and its relation to related cases is given in [9]. The example below is intended to show how a legitimate legal argument with interests could be made in the case using the functionality of the EP extension to the value judgment formalism. We plan to evaluate the adequacy of the model and its arguments in an upcoming empirical experiment and hence focus here on explaining the formalism concepts.

4.1 Case Facts

Young v. Hitchens [(1844) 6 QB 606] is a case that has been studied in AI&Law before (e.g. in [6]). The case took place in the UK of 1844, where fisherman Mr. Young had partially surrounded a school of fish with his net which was not closed yet. Defendant Hitchens rushed the gap in Young's net and caught the fish with his own net. The court decided in favor of Hitchens.

4.2 Constructing the Event Progression Space

In our basic situation s_1, the following facts can be assumed. Notice that we use a predicate-argument notation where lowercase terms without arguments are constants.

- $ocean(o)$: There is an ocean o.

In order to engage in temporal purposive reasoning, we need to construct the EP space. This is a space of all possible relevant situations that one wants to refer to while arguing about the case. Fig. 1 displays the space which we will use for the example. While it potentially is much larger, this part of it will suffice. It spans nine situations $(s_1, ..., s_n)$ and defines which situations lead to which other ones with what likelihood. In order to construct it, the following EPs need to be available as domain knowledge.

In defining the event progressions, we will make use of variables in the predicate terms. Similar to Prolog syntax, they begin with uppercase letters. Also, we only list the member sets (Preconditions, Postconditions, etc.) of event progressions that are not empty.

- Event progression ep_1: *In a normal situation where there is an ocean with fish in it, it is likely that some person will go fishing with a net there.*
  Preconditions: ocean(O)
  Additions: netFishing(P, O)
  Likelihood: likely

Presume that that the first two persons P introduced by ep_1 will be labeled as pA and pB. Compare the argument graph in figure 2.

Progression ep_1 is used in our space example to progress from s_1 to s_2 (which we denote $s_1 \times ep_1 = s_2$) as well as from s_2 to s_3. While two fisherman suffice for the case, notice that this progression technically applies to any of the situations in our space where there are still fish in the sea, resulting in a set of situations where any number of fisherman are actively engaged in fishing. While we do not show this in our example, this progression might be relevant to other legal norms such as limiting fishing licences. We can see that the space of possible situations can be virtually infinite and that a number of event progressions, once defined, can simulate the dynamics of the domain world to some extent.

We define the further progression of fishing activity:

- Event progression ep_2: *In a situation where some person P is currently fishing on a lake L, it is likely that P will catch a school of fish in her net and will be about to close the net accordingly.*
  PrcConditions: netFishing(P, O), ocean(O)
  Additions: closingNet(P, Fish)
  Likelihood: likely

Presume that the first *Fish* object introduced by ep_2 will be labeled as *schoolA* and *schoolB*. Compare figure 2.

- Event progression ep_3: *In a situation where some person A is currently fishing with a net, the net has fish in it and is being closed, it is almost certain that the net will be successfully closed and the fish are caught.*
  Preconditions: closingNet(P)
  Additions: netclosed(P), caught(P, Fish)
  Retractions: closingNet(A)
  Likelihood: almost certain
- Event progression ep_4: *In a situation where some person A has caught fish, that person can sell the fish.*
  Preconditions: caught(P, Fish)
  Additions: canSell(P, Fish)
  Likelihood: almost certain
- Event progression ep_5: *In a situation where some person A is currently fishing with a net, the net has fish in it and is being closed, it is still possible that another person B currently engaged in fishing in the same place will attempt to catch the same fish unless doing so would be legally wrongful.*

Preconditions: netFishing(P, L), closingNet(P), netFishing(Q, L),
Additions: attemptsCatch(Q, P, Fish)
Post-Exceptions: wrongful(intervene, Q, P)
Likelihood: possible

- Event progression ep_5^*: *In a situation where some person A is currently fishing with a net, the net has fish in it and is being closed, there is only a negligible possibility that another person B currently engaged in fishing in the same place will attempt to catch the same fish if doing so would be legally wrongful.*
  Preconditions: closingNet(P), netFishing(Q, L)
  Postconditions: wrongful(intervene, Q, P)
  Additions: attemptsCatch(Q, P, Fish)
  Likelihood: negligible

- Event progression ep_6: *In a situation where some person attempts to catch fish out of the net of someone who has previously attempted to catch the fish, it is possible that she succeeds in taking away the catch.*
  Preconditions: netFishing(P, L), closingNet(P), insideNet(P, Fish), netFishing(Q, L), attemptsCatch(Q, P, Fish)
  Additions: caught(Q, Fish)
  Retractions: attemptsCatch(Q, P, Fish)
  Likelihood: possible

Notice that ep_1, ep_2 and ep_4 are each used twice in the EP space. This is evidence that a limited number of defined EPs can produce a fairly complex space of possible situations which one can then query for purposes of generating arguments for or against certain legal rules or facts that influence the possible progressions and their likelihoods.

4.3 Arguments

For purposes of this example argument, the issue shall be whether the following rule r shall apply: *If a person (P1) has visibly commenced to acquire possession of one or more movable things (T), then any subsequent intervening acquisition (A) of possession by another person is wrongful.* We formalize this rule as:

Acquisition protection [AP] rule r^*:
commAcqPoss(P1, T)
$\wedge$intrvAcqPoss(P2, T)
$\Rightarrow$ wrongful(intervene, P2, P1)

Presume that the legal system at hand commands that any wrongful possession needs to be returned to the person commencing acquisition first, or that person needs to be compensated, respectively.

4.4 Target Arguments

The advocate for Mr. Young will argue that the rule should be adopted because its positive effects outweigh the negative effects: $E^+(r^*, s_1) > E^-(r^*, s_1)$. His opponent will submit that the negative effects of adopting r^* outweigh the positive effects: $E^-(r^*, s_1) > E^+(r^*, s_1)$.

We now model a set of value-based arguments the advocates are likely to make. Each argument is given in plain language and then formalized.

4.4.1 Protecting Livelihood

Argument a1: *Counsel for the plaintiff Mr. Young argues that his client has made efforts to maintain his livelihood by pursuing the fish with his net. It would be unjust not to grant him the reward and render his efforts futile. The rule should be adopted as it provides better protection of people's efforts to earn their livelihood. Without adopting the AP rule in this case, it is possible that a fisherman's efforts are rendered futile by others. Adopting the rule would virtually eliminate this risk.*

The value in focus here is the protection of livelihood PL. The advocate states that where a person makes efforts to secure his livelihood by hunting an animal [*efforts(Person, Activity)*] but is not able to gather the rewards [*cannotClaimRewards(Person, Activity)*], it amounts to, say, a medium demotion of the value of protecting livelihood. We define a value specification vs_1 accordingly:

$vs_1 \in D_{PL}^{--}$:
$s_i \vdash$ efforts(Person, hunting(Animal))
$\wedge s_j \vdash$ cannotClaimRewards(Person, hunting(Animal))
$\wedge s_1 \rightsquigarrow s_i$
$\wedge s_i \rightsquigarrow_x s_j$
$\Rightarrow$ futileEfforts(Person, hunting(Animal))

To connect this specification to the case facts, two common sense rules are needed. First, having fish in an almost closed net constitutes evidence of efforts to catch the fish:

csr_1 : closingNet(Person, Fish)
$\Rightarrow_s$ efforts(Person, catch(Fish))

Second, not being able to sell the animal bars a claim to the rewards of hunting it:

csr_2 : canSell(Person, Animal)
$\wedge Person \neq OtherPerson$
$\Rightarrow_s$ cannotClaimRewards(OtherPerson, hunting(Animal))

Also, in order to make rule r^* applicable to the case, the advocate will rely on two further conceptual legal inferences. First, having fish inside ones net constitutes a commencement of acquisition of possession of the fish swarm:
lr_1 : closingNet(Person, Fish)
$\Rightarrow_s$ commAcqPoss(Person, Fish)

Second, another person trying to catch fish inside a closing net constitutes an intervention to the ongoing acquisition of possession:

lr_1 : closingNet(Person, Fish)
$\wedge$attemptsCatch(AnotherPerson, Person, Fish)
$\Rightarrow_s$ intrvAcqPoss(AnotherPerson, Fish)

Knowing that $vs_1 \in D_{PL}^{--}$ we can formalize this argument using the scheme from more likely undesirable consequence (see def. 18) as follows.:

a1:
$s_1 \vdash_p$ futileEfforts(Person, hunting(Animal))
$\wedge s_1 \cup r \vdash_n$ futileEfforts(Person, hunting(Animal))
$\rightarrow E^+(r, s_1) > E^-(r, s_1)$

When verbalized, this argument means that situation s_1

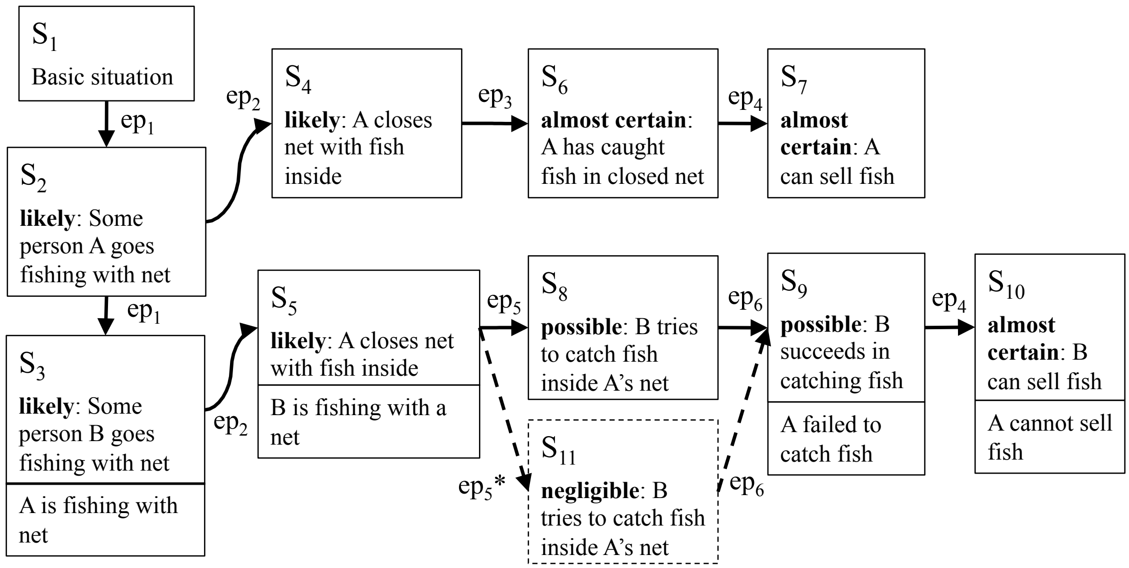

Figure 1: Example event progression space for the domain underlying *Young v. Hitchens*. Each box s_i is a situation. Added facts are shown along with their boldface likelihood. Other facts of interest are shown in separate boxes along with the situation. The dashed progression through s_{11} is only available when rule r^* is adopted.

possibly leads to (see $s_1 \vdash_{\mathbf{p}} ...$) the undesirable consequence of someone going fishing and not being able to claim the rewards along some line of progressing events. If one adopts r in s_1, however, that likelihood becomes negligible (compare $s \cup r \vdash_{\mathbf{n}} ...$). Hence, the undesirable demotion of protection of livelihood becomes less likely. This is evidence that its positive effects outweigh the negative effects, $E^+(r, s_1) > E^-(r, s_1)$.

Looking at figure 1, the decrease in likelihood is represented by situation s_8 becoming unavailable when the AP rule is added to s_1 because the exception of event progression ep_5 is fulfilled. However, an alternative event progression ep_5^* becomes available because its postcondition is fulfilled.

To illustrate the interaction between different argument schemes and the EP space, figure 2 shows the complete argument inference graph for example argument a1. Starting from the value judgment at the top, the argument graph can be constructed in a backward chaining fashion by instantiating argument schemes through search algorithms. All search branches eventually lead to certain propositions being true or false in a given situation according to their position in the event progression space. For example, the two reachability arguments on the left and right border make use of EP space reasoning to establish the path along the progression space. Also, the arguments at the bottom right corner and bottom middle both rely on EP space reasoning to infer that $s_5 \vdash$ closingNet(pA, schoolA) and $s_5 \vdash$ netFishing(pB) because they have been added to the situation by EPs.

4.4.2 The Claim of Generality of a Proposed Rule

An interesting observation can be made from this example. The EP space in figure 1 includes the possibility of person A simply going fishing without any intervention. As has been mentioned before, figure 1 is only a snippet of a large graph of possible EPs in that ocean. However, the rule in question is typically argued in a specific case context, which corresponds to one particular progression of events. *Young v. Hitchens* was decided for defendant. If the example argument were made, the decision would correspond to a denial of protection of 'pursued possession', thereby correponding to the progression $s_1, s_2, s_3, s_5, s_8, s_9, s_{10}$. However, it is in the nature of legal argument that cases shall be decided according to rules that generalize well in order to be good rules for deciding future cases or preventing conflict situations to begin with. This means that while the dispute may arise for one particular EP, the ensuing argument about which rule to apply takes place within the scope of virtually all possible progressions, albeit only a partition of them will actually be mentioned in the argument (e.g. in the form of hypotheticals). In this sense, the event progression space makes this claim of generality computationally tangible.

5. FURTHER RELATED WORK

EPs enable reasoning about the effects of adopting a proposed rule for deciding a case in terms of events that are more or less likely to ensue and the effects of those events on the underlying values. This work contributes a more detailed representation for reasoning about values underlying a legal rule than some of its predecessors. EPs allow one to reason about relevant facts by recourse to how facts and rules impact values in context and along a temporal dimension, which is a finer-grained representation than the factor representation used in [12]. As we have argued in [18], the contextual balancing expressed by value judgments abstracts the thresholds associated with values in [11]. Thresholds can be seen as intermediate legal concepts inside of legal rules, both as antecendents to determine the outcome of the case as a whole and as consequences of definitions of the threshold's concepts. These rules in turn can be reasoned about in the value judgment formalism by assessing their impact on the applicable values. The EP space allows for a higher level

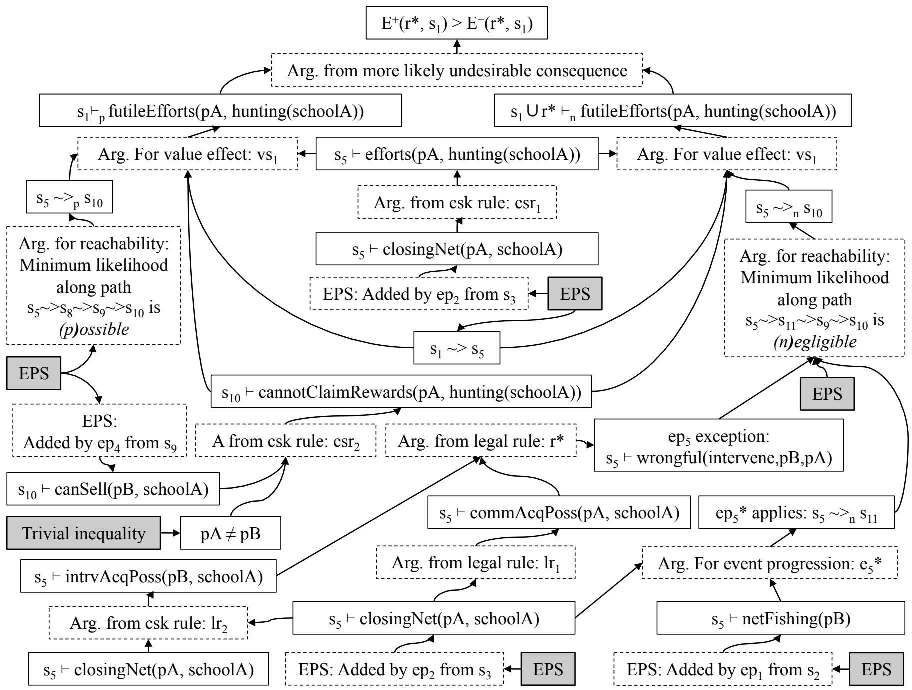

Figure 2: Example argument graph for argument a1. Boxes with solid lines represent statements while boxes with dashed lines represent arguments which mention their schemes. Statements connect to arguments as premises and in turn form conclusions of other arguments. The thick EPS-boxes are placeholders for subargument structures that function entirely within the event progression space. All variables in statements and arguments have been unified with the propositions that the inference algorithm would fill them with during backward chaining.

of granularity in the representation of such arguments and moves it one step closer to a computational implementation.

Reasoning about value effects with EPs is reminiscent of the Supreme Court arguments modeled in [24]. The Event Progressions, however, appear to be more generally applicable and computationally tractable than trying to reason about the effects of treating a stock dividend as taxable income in terms of basic mechanics of corporate finance.

Since they capture aspects of the temporal sequence of events in a case, EPs will play an important role in assessing case similarity. As observed in [26], "There is something about the common sequence of events that makes one case similar to the other ... If we distinguish, following [3], between deep and shallow analogies, a template that matches up the same sequence fitting two cases can reveal a deep similarity that is more significant, as opposed to a shallow similarity in which the two cases do not appear to be similar." Using EPs to model the temporal sequences of related cases will enable modeling the kinds of pedagogically useful arguments, such as those in [3], that use cases and hypotheticals to critique proposed rules like the one in sec. 4.3.

6. CHALLENGES AND FUTURE WORK

6.1 General

Having added a temporal dimension to our formalism's conception of consequences, we will move towards an implementation of a small set of domain worlds and design a suitable evaluation experiment to assess the 'intelligence' of the system's produced arguments. We also plan to use EPs to generate hypotheticals. We are not yet fully satisfied with the additional complexity EP adds to traditional planning actions by relying on post-exceptions and postconditions. We intend to find a more elegant solution to the problem of having EPs influenced by their impact on things to be inferred in the situation they lead to.

Implementing the extension will entail codifying many EPs, which is a significant knowledge engineering challenge. One way to reduce the number of EPs would be to define them in terms of general concepts that can be further specified. For example, instead of an EP defining that a fisherman will at some point go fishing, the EP will state that if someone has a profession she will probably engage in typical behavior associated with that profession, where this typical behaviour can be deduced from domain knowledge rather than from separate EPs for every profession. We intend to assess the feasibility of such an approach in our planned implementation.

Finally, as has been mentioned, we plan to use a combination of qualitative and quantitative measures to score arguments in and select arguments from the argument graph. In this context, we also plan to take into account insights from decision and utility theory if we find that they enhance the model in a meaningful and coherent way.

6.2 The Frame Problem in an Argumentation Environment

The *frame problem* in planning refers to the question of which fluents stay true from one situation to the next. Under the perfect closed world assumption, the event progressions describe the domain exhaustively. A proposition that does not get retracted stays true. A proposition that is not added stays false. In an argumentation environment containing many inference rules, however, this assumption is hard to maintain. Planning systems have developed different ways of accounting for nondeterministic effects, propagated effects and the like (e.g. [25]). The argumentation environment potentially mitigates the frame and ramification problem to some extent. This is because additions to and retractions from situations by EPs can be considered not as removals, but as grounds for arguments for or against entailment of a given fact in a situation. The system does not need to infer a fluent as true or not in a given situation, but just needs to construct an argument in case there are grounds to be believe it is either entailed by the situation or not. This aspect has not been fully specified in the formalism yet, but the state of the art in planning research gives us confidence in our ability to produce a reasonable implementation.

7. CONCLUSIONS

We have presented an extension to our previously published value judgment formalism which adds a discrete temporal dimension to the representation of consequences arising from adopting legal rules and decisions. We use planning-action-like event progressions to transition from one situation to a set of possible successor situations with a certain likelihood, thereby spreading open a space of possible continuations of a base situation. The adoption of legal rules influences the available transition links between situations and the likelihood with which they can be traversed. The generation of purposive legal arguments is then performed using argument schemes operating on individual situations and relationships between them in the even progression space.

8. ACKNOWLEDGMENTS

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