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Approaching Factors and Dimensions with Explanation-Based Argumentation

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Abstract. Current research in legal argumentation theory tries to bridge the gap between representations of the arguments brought by parties, and representations of factors and dimensions, as used in case-based reasoning frameworks. The present paper targets the same objective, but taking an alternative approach. Instead of reasoning in terms of attack or support relationships between claims, we consider the relation of the collected messages with alternative interpretations of the case, thus referring to *explanation-based argumentation* (EBA). This shift of perspective allows us to start an alternative investigation into some of the questions raised in the literature. A prototype application is presented along with the paper.

Keywords. Explanation-Based Argumentation, Justification, Factors, Dimensions, Pierson vs Post, Answer Set Programming

Introduction

According to a shared approach in AI & Law concerning adjudication (see e.g. [3]), legal reasoning practically consists of a progression:

- (i) from *evidence* to *facts*,
- (ii) from *facts* to *factors*,
- (iii) from *factors* to *legal consequences*.

Evidently, factors play a central role in this scheme. In (ii), factors allow to express generalizations about a certain domain, disengaging from the problem of providing definitive extensional definitions. In (iii), factors synthesize stereotypical collections of facts, that, according to legal experts, have consequences on the outcome of a case. This is the definition used in case-based frameworks like CATO [1]. Here, factors are assigned *outside of* the adjudication process: the analyst is required to interpret the case and to create a synthetic model through the identification of the relevant factors. Equivalently, this means that CATO focuses only on the step (iii).

Recent works as [3] express the urge to make explicit the connection between the selection of factors and the adjudication process, and specifically by considering the arguments involved the case. In particular, the proposal of Atkinson et al. is based on the projection of facts on *dimensions*, following HYPO [2], integrating the formal argumentation framework ASPIC+ [14]. We agree on the necessity of defining factors and magnitude on factors, and therefore we support the integration of the dimension concept. However, instead of reasoning in terms of attack or support relationships between claims, as in traditional argumentation theory, our contribution builds upon an *explanation-based argumentation* (EBA) framework, first introduced in [18], considering the relation of mes-

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sages with alternative explanations of the case and of the process of construction of the case. In doing this, we are pushing further the requirement of “depth” of representation.

The primary motivation behind this innovation is expressed by the following question: *why* a certain claim brought by one party is in contrast with the claim brought by another party? Apart from simple “syntactic” attacks, any response requires an interpretation of what the claim means, in the overall economy of the argumentation and its underlying knowledge, and this meaning, *just as the attribution of factors*, may differ amongst analysts. Our objective is therefore to go deeper in the modeling, touching the structural components defining the interpretations of the case, and considering the argumentation as a constructive process interacting with such interpretations.²

This change of perspective allows us to try alternative research directions to approach some of the questions raised in the literature, e.g. the three at the end of [3]:

1. how to differentiate the strength of factors in reaching a conclusion?
2. how to relate facts to the points on a dimension?
3. how to assign facts on the basis of (possibly conflicting) evidence?

1. Cased-based reasoning: fundamental concepts

The elements involved in case-based reasoning may be synthesized as follows (cf. [10]):

- A *fact* f is a justified grounded true belief. As this is shared within the court, for simplicity we consider it as a simple true proposition. The argumentation process starts usually with some facts, e.g. evidence, and grows along two epistemic intertwined directions: story reconstruction (the *matter of fact*) and legal interpretation (the *matter of law*). Decisions are taken after a justification process, and creates new facts.
- A *rule* r is a conditional statement relating a *premise* with a *conclusion*.
- A *situation* Σ is a set of facts: $\Sigma = \{f_1, f_2, \dots, f_n\}$.
- A *case* c consists of a situation, a rule and a conclusion: $c = \langle \Sigma, r, \phi \rangle$. The conclusion is an assertion decided on the basis of that rule, applied on part of the facts accounted in or implied by the situation. The *applicability* condition of a rule r in a certain situation Σ is expressed by $\Sigma \models \text{Premise}(r)$.
- Such sub-set of facts $R^\phi = \{f_1^\phi, f_2^\phi, \dots, f_m^\phi\} \subseteq \Sigma$ is also called the *reason* for the conclusion ϕ . Its components are also called *factors* for ϕ , i.e. legally significant facts holding in the case.³
- Considering similar cases, such factors can be regrouped and abstracted, so as to identify *patterns of facts*. Given a certain case, *factors* hold, or do not. They favour the plaintiff or the defendant.
- In contrast, *dimensions* are defined by a sequence of points, distributed within along two opposite outcomes: they are still pro-plaintiff or pro-defendant, but up to a certain *degree*. The point of passage from supporting the plaintiff or the defendant is generally the core issue in a trial.⁴

²As structuralism is an important perspective in narratology, we are currently investigating our framework in terms of narrative concepts as well, e.g. in [19].

³The semantic implication makes explicit the domain abstraction provided by factors.

⁴The existence of such criticality let some authors suggest to consider the points of dimension as mere facts, rather than factors.

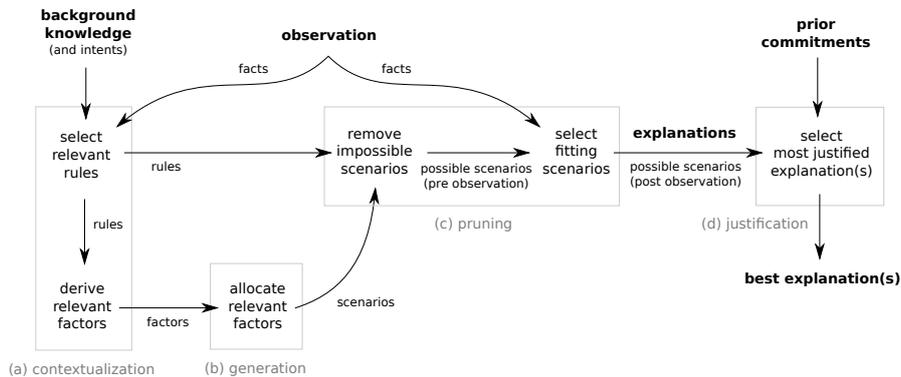


Figure 1. Proposed operationalization of explanation-based reasoning.

2. Explanation-based argumentation⁵

Argumentation can be seen essentially as a *dialectic process*.⁶ The presumption of conflict between the parties motivates the *epistemic function* of argumentation, i.e. to establish (more definite) conclusions, via justification and grounding. Parties produce *messages* and receive others' messages, interpreting and evaluating them. Sometimes these messages are collected by a third-party adjudicator, entitled to interpret the *case* from a neutral position. The set of collected messages forms an **observation**.

Considering the description of a case, we distinguish two sets of events: the reported events, i.e. the matter of the case (the *story*), which do not occur in front of the court, and the events of reporting, which conversely bring up and construct the case (the *meta-story*). Given a disputed case, an **explanation** is a possible *scenario* compatible with the content of the provided messages *and* with the generation process of the messages as well. An explanation is *valid* if it reproduces the messages collected in the observation. Evidently, the nature of such scenarios is that of a *multi-representation* model [16]: they may integrate physical, intentional, socio-institutional, and abstract domains.

The definition of an adequate *search space* of explanations is inflected in two main steps: *generation*, via the allocation of relevant factors, and *pruning*, depending on certain *constraints*, i.e. applicable rules concerning practical and legal domains.⁷ Therefore, instead of being a static entity, the space of hypothetical explanation is *incrementally constructed* along with the observation. The motivation behind *explanation-based argumentation* (EBA) lies here: in the intuition that *agents make claims in order to manipulate the explanatory search space*.

In addition to the explicit *foreground* given by the observation, the full picture includes common and expert knowledge about the world (as *background*), consisting of *rules* and *facts*, together with *strengths of epistemic commitment*. This background is the result of a framing process: the foreground activates certain facts and rules known by the recipient agent, determining in a second instance which are the *factors* relevant to the case, and, when applicable, act as constraints in pruning the explanations.

Extending the reasoning model given in [18], we recognize four operational steps:

⁵This section and the following extend the results first presented in [18].

⁶An overview of contributions focusing on the dialogical aspect of argumentation can be found in [6, 2.1].

⁷Argumentation frameworks based on default reasoning may be seen as covering these steps as well, but focusing on the *inferential* aspect of the problem, rather than the selection of an adequate search space.

- (a) *contextualization*: the facts explicitly given by the case (concerning the story and the meta-story) activate known rules, and identify the factors which are relevant to reach a decision about a certain conclusion;
- (b) *generation*: relevant factors are grounded into *scenarios*, allocating all permutations of factors to situations;
- (c) *pruning*, divided in two sub-steps: (I) impossible scenarios are removed, leaving the set of *possible scenarios*; (II) possible scenarios fitting the observation are selected as *explanations*;
- (d) *justification*: the relative position of explanations is evaluated according some measure of epistemic commitment, determining which are the *best explanations*.

The main difference between (c) and (d) is matter of certainty (in a way similar to the difference between *strict* and *defeasible* rules): they both represent a refinement over (b). After some *confirming* message, the relative weights of explanations will change, and, consequently, stronger explanations will emerge from the set of hypothesis. Conversely, when messages transport conflicting claims, they are actually *disconfirming* certain explanations, equilibrating their relative weight. The matter becomes raw again.

It is worth to observe that messages play a crucial role also in (a). The introduction of new facts, and new rules, brings in new factors and constraints, which eventually modify the result of the generation and pruning steps.

3. Generating, pruning and justifying explanations

In this section, we will translate the four steps of explanations-based reasoning in a concrete computational setting, leveraging the capabilities of *answer set programming*⁸ and providing some modeling guidelines.⁹ Even if part of the modeling remains necessarily responsibility of the analyst it is our objective to discriminate which representational components are needed for a scalable application.

A prototype application implementing this operationalization, named *aspj* – *Answer Set Programming Justificator*, is currently running on <http://justinian.leibnizcenter.org/aspj> (comments are welcome). At the moment, it invokes *lparse* (an ASP parser) and *smodels* (solver). It has been used to compute the results presented in the paper.

⁸*Answer set programming* is a declarative programming paradigm based on the *stable-model semantics* [9] – applying ideas of *auto-epistemic* logic of Moore [15] and default logic of Reiter [17]) – oriented towards difficult (NP-hard) search problems. In ASP, similarly to Prolog, the programmer models a problem in terms of rules and facts, instead of specifying an algorithm. The resulting code is given as input to a solver, which returns multiple *answer sets* or *stable models* satisfying the problem. The main operational difference to Prolog is that all variables are *grounded* before performing search, and unlike SLDNF resolution, ASP solvers algorithms always terminate. Our intuition behind the integration with EBA is that this approach is very similar to the allocation in phase (b).

⁹In the full version of EBA, explanations and observations would be built upon *multi-agent systems* based on *agent-roles* [7], in order to take into account intentional and institutional layers, and multiple figures for *speech acts*. For simplicity, we will consider here only a generic *emission* of propositional content, and neglect all intentional and causal components, leaving them to future extensions.

3.1. Integrating ASP with Explanation-Based Argumentation

Our idea is to take advantage of the search capabilities of ASP solvers, so as to effectively perform the *generation* and *pruning* steps at once. Three main types of statements are used for explanation-based argumentation:

- *facts*, modeling shared assumptions,
- *rules*, modeling a conditional shared assumption.
- *allocation choices*, grounding permutations of relevant factors.

Facts Facts are written as in Prolog. For instance, “Post was in hot pursuit of a fox” and “the fox has not been wounded” can be written as:¹⁰

```
hot_pursuit.
-wounded.
```

Rules A rule gives a property of the world (and then acts as a constraint on possible worlds). It consist of a *head* (conclusion) and a *body* (premise). For instance, the rule that the hunter acquires ownership when he takes physical possession of the animal, described by $R_1 : possessed \rightarrow ownership$, can be written similarly to Prolog as:

```
ownership :- possessed.
```

Rules can be also described at a meta-level, i.e. introducing an evaluation of the context to check their applicability. This condition, external to the “primary” content of the rule, triggers the constraint that the rule *posits* on the world. Using the material implication ($a \rightarrow b \Leftrightarrow \neg a \vee b$), we can translate R_1 as $\neg possessed \vee ownership$. Anchoring the rule to this factor $r1$ (to be read as *the rule R_1 applies*, or *R_1 is applicable*), we can write it as:

```
1{-possessed, ownership} :- r1.
```

If $r1$ is not grounded, i.e. the applicability of R_1 is matter of debate, we count it as a relevant factor and not as a fact.

Allocation choices Differently from the traditional modeling with Prolog, our objective is to *ground* all relevant factors, so as to generate all scenarios, possible and impossible, and then pruning the impossible ones, with the application of the posited rules. In ASP, a factor f can be allocated using the *choice* operator¹¹, and precisely by instantiating the principle of non-contradiction (f holds or it doesn’t: $f \oplus \neg f$). To correspondent code is:

```
1{f, -f}1.
```

We consider the following *allocation principle*: all factors in the rules of the observation and in the background knowledge have to be allocated. Note that, considering the whole system of rules, an individual rule may generate a conclusion which may be relevant factor for another rule. Therefore, with our approach, both *premises* and conclusions of rules are handled as factors. Applying the principle on the first R_1 , we have:

¹⁰For simplicity we use atomic formulas, rather than predicates; the extension is possible however.

¹¹The syntax of ASP logic operators in `lparses+smodels` is:

OR $a_1 \vee \dots \vee a_N \Leftrightarrow 1\{a_1, \dots, a_N\}$

XOR $a_1 \oplus \dots \oplus a_N \Leftrightarrow 1\{a_1, \dots, a_N\}1$

AND $a_1 \wedge \dots \wedge a_N \Leftrightarrow a_1, \dots, a_N$ (only in the body of rules) or $N\{a_1, \dots, a_N\}N$ (body and head).

```

1{possessed, -possessed}1.
1{ownership, -ownership}1.
ownership :- possessed.

```

Reported facts and reported rules When someone reports something, he may tell the truth or not, i.e. what he says may hold or not, considering truth as a successful *word-to-world* alignment. In addition, the *confidence* attributed to the source is usually a sufficient condition to consider the content of the message as holding.¹² The fact that we have no confidence towards an agent does not imply that he is necessarily lying¹³, but, if we consider him to be *not* trustworthy, it is perfectly acceptable that what he says does not hold. The case of conflicting messages is analyzed with a certain detail in [18], investigating an interesting puzzle proposed by Pollock [11] about probability and argumentation. We will return to this in the conclusion. In this paper, we focus on reported rules.

In *Pierson vs Post*, the judge Tomkins refers to Justinian, and specifically to a rule that the jurisprudential tradition associates to decisions concerning property on wild animals (for the sake of an example, let us imagine it corresponds to R_1). As observers, we receive a message encapsulated twice: *Tomkins says that Justinian says that R_1* . In reality, Tomkins is not only stating something about the *speech act* of Justinian, but also about its applicability. In order to model the applicability condition related to these meta-levels, we follow a simple naming convention:

```

1{-possessed, ownership} :- justinian.
justinian :- tomkins.

```

We have introduced two new factors, *justinian* and *tomkins*; *justinian*, for instance, labels the *belief that what Justinian said is applicable, or being confident that what Justinian said holds*.¹⁴

Incremental knowledge components In contrast to the normal use of ASP programs, we are interested in modeling the incremental aspect of argumentation. We need an operator distinguishing a message from another; in order to maintain backward compatibility, we rely on the comment operator ‘%’ to create new operators. Therefore, we choose to separate the messages in the code by using the ‘%%’ construct at the beginning of line. For instance, in order to separate the contribution of Justinian from that of Pufendorf, we write (neglecting the allocations):

```

%%
1{-possessed, ownership} :- justinian.
%%
1{-capture_inevitable, ownership} :- pufendorf.

```

Furthermore, we need to distinguish in the model the *foreground knowledge*, explicitly presented in the case, from the *background knowledge*, associated by the case analyst, often with the help of domain experts. In this case, we utilize the ‘%--’ construct at the beginning of line. Considering for instance the dimensional model of *pursuit* proposed in [3], we have:

¹²Consider the case of direct perceptions. In general we are practically certain of the reliability of our senses.

¹³The relation “being reliable” has at this point no direct reference with the real intent of the emitter/assertor.

¹⁴From the program perspective, the two rules can be easily read as the fact that Justinian said R_1 , and the fact that Tomkins says that what said by Justinian holds.

```

%%%
hot_pursuit.
-wounded.

%--
seen :- chase_started.
chase_started :- hot_pursuit.
hot_pursuit :- wounded.
wounded :- capture_inevitable.
capture_inevitable :- possessed.

```

The proposed rules translate the ordering constraints contained in the dimension.

3.2. ASP execution cycle in *aspj*

Considering a certain case, we observe the following correspondences between the components in the program and output of the solver:

input given as ASP program	ASP solver output — EBA phase
only allocations	scenarios (possible and impossible) — (b)
allocations and background rules, facts	possible scenarios — (c, I)
allocations, background rules and observation	possible scenarios fitting with the observation, i.e. the <i>explanations</i> — (c, II)

Being independent from the observation, the code generating (c, I) can be interpreted as the *deep model* of the domain ascribed by the analyst to the case.

The extensions proposed in the previous paragraph allow us to divide the program in incremental parts, in order to explore the progress of argumentation stepwise. To exploit this capability, *aspj* integrates two components:

- a code splitter, which generates from the initial code the programs for the intermediate observations, further divided in *pre* and *post* observation components.
- a parser of the outputs of the ASP solver, used to record the stable models associated to the scenarios in an internal representation to be used to compute the justification.

3.3. Computing justification

The remaining problem is to decide how to evaluate explanations, or, equivalently, how to measure their *degree of justification*. Pollock presents in [11] a lucid analysis about the problems at stake; inspired by his work, we analyzed the problem in more detail in [18]. This section will only summarize the principles behind our proposal.

In traditional formal argumentation frameworks, justification is defined only in discrete terms: an argument is justified or not, and if justified, it can be skeptically or credulously justified (e.g. in extension-based semantics for argument systems [4]). A more fine-grained determination is however necessary in most practical cases [11].

Following the subjective interpretation of Bayesian probability, probability can be used as a measure of the *strength of belief*. Therefore, in this line of thought, a certain probability assigned to arguments can be considered as a proxy for their strength. In the

literature, some authors, as for instance [13], propose to integrate probability to Dung’s abstract framework; others target more applied contexts, as evidential reasoning [12], in the legal domain [8,21,22].

Even if this contribution shares the same mathematical framework, there is a crucial difference with these approaches. While the latter generally insist on the computation of *posterior probabilities*, we handle *confirmation measures* over explanations. The objective behind this is to *make the role of prior commitments more explicit* in the reasoning model, as subjective assumptions taken *after* having faced the manifold possibilities expressed by the domain model.¹⁵ In practice, we compute an ordinal judgment of explanations. Given an observation O , and an explanation E , we consider at the moment the following *confirmation measure*:

$$c(O, E) = \frac{P(O|E) - P(O|\neg E)}{P(O|E) + P(O|\neg E)} \quad (1)$$

Put in words, an observation confirms an explanation if it fits with the explanation *and* discriminates the explanation from its alternatives.¹⁶ Once calculated for all explanations, confirmation values can be used to order them.

4. Case example and results

In this section, we refer to a simplified model of the well-known *Pierson vs Post* case (the full code is reported in the appendix). We consider 8 different incremental steps, here synthesized in a readable form:

0. Post was in hot pursuit, and the fox was not wounded (ground facts). (This step includes the relevant *background knowledge*, e.g. the *pursuit* dimension.)
1. Justinian says that ownership occurs only when there is physical possession.
2. Pufendorf says that an inevitable capture is sufficient to ownership.
3. Tomkins brings in Justinian’s contribution.
4. Tomkins brings in Pufendorf’s contribution.
5. Tomkins says that hot pursuit is not sufficient to ownership.
6. Livingston says that hot pursuit is sufficient to ownership.
7. Livingston attacks the applicability of Justinian’s contribution.

Running the proposed model on `aspj`, we obtain:

	# relevant factors	# allocations	# possible scenarios	# explanations
step 1	9	512	18	2
step 2	10	1024	36	3
step 3	11	2048	72	6
step 4	12	4096	144	8
step 5	12	4096	144	7
step 6	12	4096	144	7
step 7	13	8192	288	9
step 8	13	8192	288	9

¹⁵Furthermore, we think there is a high criticality in using posterior probability (constructed over “objective” information on aggregates) to judge an individual case.

¹⁶Tentori et al. [20] suggest that the above is the psychologically most plausible confirmation measure of those proposed in the literature.

Outcomes of justification Apart from a quantitative point of view, the previous analysis is not very insightful. The quality of the explanations, i.e. the actual scenarios they describe, is what matters for the parties and for the adjudicator. The *union*¹⁷ of the 9 explanations says just a bit more about the case: all factors remains undecided, apart from `seen`, `chase_started`, `hot_pursuit` and `effort` which are true, and `wounded`, `capture_inevitable` and `possessed` which are false.

Let us therefore consider the case in which we hold a higher commitment towards what judges Tomkins and Livingston say. We associate to the factors `tomkins` and `livingston` a prior probability of e.g. 0.6.

In principle, each factor can be considered as a target claim. The change of its truth value in the union of best explanations can be used to understand which is the impact of a certain argument (brought in a certain step of the argumentation) in its respect. We consider three axes of change. The first two are incremental, i.e. they consider the current step and the previous one. The first axis (I) concerns the possible scenarios and reflects a change in the deep model of the domain, or in the commitments (not investigated yet). The second axis (II) is about the explanations (post observation): it is a measure of the incremental impact of the new argument to what said until now. The third axis (III) represents the impact of the full observation within a fully established background: i.e. given a certain step, it is about the change occurring between the possible scenarios before the whole observation (and not the last incremental step), and after the observation. It gives an information about the overall conclusion. The result computed by `aspj` is summarized in the following table:

axis of change	step 1			step 2			step 3			step 4			step 5			step 6			step 7			step 8		
	I	II	III																					
<code>seen</code>			+			+			+			+			+			+			+			+
<code>chase_started</code>			+			+			+			+			+			+			+			+
<code>hot_pursuit</code>			+			+			+			+			+			+			+			+
<code>wounded</code>			-			-			-			-			-			-			-			-
<code>capture_inevitable</code>			-			-			-			-			-			-			-			-
<code>possessed</code>			-			-			-			-			-			-			-			-
<code>effort</code>			+			+			+			+			+			+			+			+
<code>successful_effort</code>									-			-			-			-			+			-
<code>ownership</code>									-			-			-			-			+			-
<code>justinian</code>									+			+			+			+			-			-
<code>pufendorf</code>															+			+			-			-
<code>tomkins</code>									+			+									-			-
<code>livingston</code>																					+			+

The “+” in the I column shows only that the factor is introduced at that moment in the possible scenarios, and, as we have a higher commitment than a neutral position, it is positively characterized after its introduction. The “+” and “-” in the III column show what claims are respectively supported or attacked by the observation considering the commitment configuration reached at that step. The “+” and “-” in the II column are more similar to the usual meaning of the support and attack relationships used in argumentation. The first intervention of Tomkins (step 4), which supports the applicability of Justinian’s claim, automatically attacks the `ownership` and `successful_effort` factors. Vice-versa, when Livingston claims his interpretation of the case, he attacks Tomkins, Justinian and Pufendorf’s claims, and, as we are equally committed to both judges, we return to a condition of neutrality about the matter of ownership. The *majority opinion*

¹⁷The *union* of explanations is a simple summary representation: factors assume an *undecided* value if conflicting between explanations, otherwise take the common truth value.

used in courts can be seen as a direct consequences of an equal prior commitment to judges' opinions.

5. Conclusion

The paper presented an initial investigation on the integration of factors and dimensions in an *explanation-based argumentation* (EBA) framework, operationalized via *answer set programming* with `aspj`. With this approach, factors turn out to be all the propositions which are *relevant* to the domain rules.

In pragmatics, relevance is associated to the alignment of the informational content with the intents of the speaker/listener. Considering the epistemic intent of the adjudication, relevance corresponds to the impact of a certain claim in reaching a definite conclusion. This is coherent with the proposed operationalization.

Even without referring to legal realism, however, we can plausibly affirm that adjudication is not a “pure” epistemic process. According to value-based theories of legal adjudication [5], for instance, judges choose the conclusion which best responds to some general principles (even more when facing *hard cases*); consequently, values guide (implicitly or explicitly) the choices in detecting the applicable rules. The same holds for the parties, which, rather than general values, have specific interests. In principle, a full account of EBA should allow to take into account all these “deeper” intentional interpretations within the model, and can be used to evaluate the impact of facts in correspondence to those factors.

This definition of factors is wider than the traditional one (we thank the anonymous reviewer for the important remark): we have factors which are present only in this specific case (e.g. `tomkins`) and factors which are recurrent in other cases (e.g. `hot_pursuit`). We attempt an explanation. Case-based reasoning is built upon many cases occurred in time and of each case it considers only the rule finally applied for the decision. Thus, the importance of certain factors in a certain legal domain results from a selection performed at *inter-case* level. In this work, we are considering only one judgment, and we take into account all arguments, even those which were not integrated in the final decision. The importance of certain factors in the final decision is consequent to the selection occurring *inter-argument*. Only the factors surviving at intra-case level have access at the inter-case level arena.

A similar analysis can be performed on the definition of dimensions. In this work, they have been implemented as chains of dependency rules. The dimensions about factual matters (e.g. actual metric dimensions, different phases in a course of action) are in practice shared assumptions, and intervene already at intra-case level. The dimensions about legal matters are less evident, but they can plausibly be extracted as recurring enchainings of factors in *deep models* of similar cases, characterized as well with a certain legal conclusion (pro-plaintiff, pro-defendant). This remains to be investigated.

In *Pierson vs Post*, the explicit conflict is about the applicability of rules, but our approach covers also the interpretation of facts after conflicting evidence. We specifically address this problem in [18], using a previous version of EBA on a puzzle given by Pollock [11]. It can be found as well on the online version of `aspj`.

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A. *Pierson vs Post*, simplified model for aspj

The following code, modeling the argumentation process of the *Pierson vs Post* case, runs on the ASP solver `lparse+smodels`. In order to be fully exploited, however, it should be used with `aspj`, the web-based application presented in this paper, which provides intermediate pre- and post-processing functions on top of the ASP solver. `aspj` is a computational framework implementing *explanation-based argumentation*. A running version is available at <http://justinian.leibnizcenter.org/aspj>.

```
%%% step 0
hot_pursuit.
-wounded.

%-- background knowledge
seen :- chase_started.
chase_started :- hot_pursuit.
hot_pursuit :- wounded.
wounded :- capture_inevitable.
capture_inevitable :- possessed.
effort :- chase_started.
successful_effort :- ownership.
ownership :- successful_effort.

1{seen, -seen}1.
1{chase_started, -chase_started}1.
1{hot_pursuit, -hot_pursuit}1.
1{wounded, -wounded}1.
1{capture_inevitable, -capture_inevitable}1.
1{possessed, -possessed}1.
1{effort, -effort}1.
1{successful_effort, -successful_effort}1.
1{ownership, -ownership}1.

%%% step 1
1{-possessed, ownership} :- justinian.
1{possessed, -ownership} :- justinian.
1{justinian, -justinian}1.

%%% step 2
1{-capture_inevitable, ownership} :- pufendorf.
1{pufendorf, -pufendorf}1.

%%% step 3
justinian :- tomkins.
1{tomkins, -tomkins}1.

%%% step 4
pufendorf :- tomkins.

%%% step 5
1{-hot_pursuit, -ownership} :- tomkins.
```

```
%%% step 6
1{-hot_pursuit, ownership} :- livingston.
1{livingston, -livingston}1.
```

```
%%% step 7
-justinian :- livingston.
```