Encoding Legal Balancing: Automating an Abstract Ethico-Legal Value Ontology in Preference Logic

Christoph Benzmüller, David Fuenmayor, Bertram Lomfeld
Dep. of Mathematics and Computer Science & Dep. of Law
Freie Universität Berlin

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ABSTRACT
Future intelligent autonomous systems (IAS) are inevitably deciding on moral and legal questions, e.g. in self-driving cars, health care or human-machine collaboration. As decision processes in most modern sub-symbolic IAS are hidden, the simple political plea for transparency, accountability and governance falls short. A sound ecosystem of trust requires ways for IAS to autonomously justify their actions, that is, to learn giving and taking reasons for their decisions. Building on social reasoning models in moral psychology and legal philosophy such an idea of «REASONABLE MACHINES» requires novel, hybrid reasoning tools, ethico-legal ontologies and associated argumentation technology. Enabling machines to normative communication creates trust and opens new dimensions of AI application and human-machine interaction.

CORE OBJECTIVES
• enabling argument-based explanations & justifications of IAS decisions,
• enabling ethico-legal reasoning about, and public critique of, IAS decisions,
• facilitating political and legal governance of IAS decision making,
• evolving ethico-legal agency and communicative capacity of IASs,
• enabling trustworthy human-interaction by normative communication,
• fostering development of novel neuro-symbolic AI architectures.

LONG-TERM VISION: To enable machines to give and take normative reasons for their decisions and actions capacitates them to engage in communicative action within social systems.

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Motivation and Contribution

Bigger Vision:

▶ **Reasonable Machines: A Research Manifesto**
  (Benzmüller & Lomfeld, KI’2020, http://dx.doi.org/10.1007/978-3-030-58285-2_20)

Enabling machines to legal balancing

▶ Challenges: which logic? which value ontology? how to encode? interaction with other legal/world knowledge? which expressivity?
  ▶ LogiKEy-Solution: holistic, pluralistic framework; simultaneous modeling at different abstraction layers ... until reflective equilibrium is reached

Main Contributions:

A: Universal (Meta-)Logical Reasoning and LogiKEy approach
  ▶ first-time application to support legal balancing
  ▶ first-time encoding of preference logic by vanBenthem et al.

B: Lomfeld’s Value Ontology
  ▶ first-time operationalization on the computer
  ▶ in combination with preference logic by vanBenthem et al.

C: Combining A&B to model legal balancing in “Wild Animal Cases”
How to Tame the Logic Zoo?
(A) LogiKEY Methodology

[Artificial Intelligence (2020) vol. 287]
(A) LogiKEY Methodology

[Artificial Intelligence (2020) vol. 287]
(A) Universal (Meta-)Logical Reasoning in Isabelle/HOL

[Science of Computer Programming (2019) vol. 172]
(B) Value Ontology and Preference Logic

Choice of Value Ontology:
Discoursive Grammar of Justification
[Lomfeld (2015/2019)]

Choice of Formalization Logic:
(Modal) Logic for Preferences
[vanBenthemGirardRoy(2009), JPL]
Legal reasoning is seen as practical argumentation with a two-level model of (more abstract) values & principles and (more concrete) legal rules.

Legal rules (or common-law precedents) can be reconstructed as *conditional* preference relations between conflicting underlying value principles (cf. Alexy 2000; Lomfeld 2015)

**Example:** “In view of events $E_1$ (a virus pandemic occurs) and $E_2$ (voluntary shut-down fails) countrywide lock-down becomes sanctioned, since health security outweighs freedom to move.”

Application of a rule $R$ involves balancing value principles $A$ (SECURITY) and $B$ (FREEDOM) *in context* (conditions $E_1$ and $E_2$):

$$R : (E_1 \land E_2) \rightarrow A > B$$

Acts as justification for the rule’s legal consequence (e.g. sanctioned lock-down).
(B) Encoding using a Logic of Preferences:

Choice of Formalization Logic: [vanBenthemGirardRoy(2009)JPL]
(B) Value Ontology

But which value principles are to be balanced? [Lomfeld (2015), (2019)]

In our case studies: a decision promoting a particular value (over others) corresponds to ruling for a certain party. (Values are indirectly ‘assigned’ to particular parties/actors using ‘factors’.)
## (B) Value Ontology

Comparison between some relevant value-based approaches in the literature [Lomfeld (2020)]

| VALUES & legal principles | Berman & Hafner 1993 | Bench-Capon et al 2005 | Bench-Capon 2012 | Gordon & Walton 2012 | Prakken 2002 | Sartor 2002 (Sartor 2010) |
|---------------------------|----------------------|------------------------|------------------|----------------------|-------------|--------------------------|
| **FREEDOM**               |                      |                        |                  |                      |             |                          |
| - Free choice (WILL)      | “Protect from interference” | “Court should not make law” | “Reward”        |                      |             | (“Liberty”)               |
| - Responsibility (RESP)   |                      |                        |                  |                      |             |                          |
| **SECURITY**              |                      |                        |                  |                      |             |                          |
| - Stability (STAB)        | “Certainty”          | “Clear law”            | “Legal certainty” | “Security”           | “Legal certainty” | (“Security”)               |
| - Reliance (RELI)         |                      |                        |                  |                      |             | “Less litigation” |
| **EQUALITY**              |                      |                        |                  |                      |             | “Sec. possession” |
| - Fairness (FAIR)         | “Property rights”    | “Property”             | “Fairness”       | “Fairness”           | “Property rights” |
| - Equity (EQUI)           | “Public land”        |                        | “Equity”         |                      |             |                          |
| **UTILITY**               |                      | “Useful” & “Economic activity” | “Utility” | “Econ. valuable” | “Productivity” |
| - Efficiency (EFFI)       | “Free enterprise and competition” |                      |                  |                      |             |                          |
| - Personal gain (GAIN)    |                      |                        | “Utility”        | “Personal gain”      |             |                          |

**Ambition:**

- To consistently cover existing value sets from formal argumentation and AI & Law accounts on value-based reasoning, e.g. (Berman and Hafner 1993; Bench-Capon 2012; Gordon and Walton 2012; Sartor 2010).
Maybe the most famous property law case in American legal history:

*Post, a fox hunter, was chasing a fox through public land when Pierson came across the fox and, knowing it was being chased, killed the fox and took it away. Post sued Pierson for damages against his possession of the fox. Post argued that giving chase to the fox was sufficient to establish possession.*
A local court first ruled in favour of Post.

However, Pierson appealed the ruling to the New York Supreme Court of Judicature, who reversed the decision.

The court ruled in favor of Pierson; citing ancient and modern precedents: “pursuit alone vests no property” (Justinian); and “corporal possession creates legal certainty” (Pufendorf).
In our framework:

- The decision in favour of Pierson implies: STAB(ility) > WILL.
- **For “wild animal cases”**: the legal certainty created by corporal possession (STAB) has preference over “pursuit alone” (WILL).
- Notice the context of validity for the value preference above. Alternatively, Post might argue against this being a “wild animal case”.

(C) Case Study: Pierson vs Post
Another famous property law case concerning (wild?) animals:

*Chester, a parrot owned by the ASPCA (animal shelter), escaped and was recaptured by Conti. The ASPCA found this out and reclaimed Chester from Conti.*
In this case, the court ruled in favour of the ASPCA:

- For **domestic animals** the value preference relation as in Pierson's case does not apply,
- For a **domestic animal** it is sufficient that the owner did not neglect or stopped caring for the animal, i.e. give up the responsibility for its maintenance (RESP).
- This, together with ASPCA’s reliance (RELI) in the parrot’s property, outweighs Conti’s corporal possession (STAB) of the animal.
Isabelle/HOL Encodings & Tests

- Preference Logic
- Preference Logic Tests
- Value Ontology
- Value Ontology Tests
- General (World) Knowledge
- Pierson Case
- Conti Case

Following

[vanBenthemGirardRoy(2009)JPL]
A/B/C: Demo

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Following [Lomfeld(2019)KritischeJustiz]

Benzmüller, Fuenmayor, Lomfeld
A/B/C: Demo

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Following [Lomfeld(2019)KritischeJustiz]

Nitpick found a model for card $i = 1$:

Types:
\[ c = \{d, p\} \]
\[ c \text{ VAL} = \{\text{FREEDOM d, FREEDOM p, UTILITY d, UTILITY p, EQUALITY d, EQUALITY p, SECURITY d, SECURITY p}\} \]

Constants:
\[ \text{BR} = (\lambda x. \_)((i_1, i_1) := \text{True}) \]
\[ \text{For} = (\lambda x. \_)((d, i_1) := \text{False}, (p, i_1) := \text{True}) \]
\[ \text{I} = (\lambda x. \_)((i_1, \text{FREEDOM d}) := \text{False},
    (i_1, \text{FREEDOM p}) := \text{True},
    (i_1, \text{UTILITY d}) := \text{False},
    (i_1, \text{UTILITY p}) := \text{True},
    (i_1, \text{EQUALITY d}) := \text{False},
    (i_1, \text{EQUALITY p}) := \text{True},
    (i_1, \text{SECURITY d}) := \text{False},
    (i_1, \text{SECURITY p}) := \text{True}) \]
\[ \text{other} = (\lambda x. \_)(d := p, p := d) \]

Benzmüller, Fuenmayor, Lomfeld
A/B/C: Demo

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Following [Lomfeld(2019)KritischeJustiz]

```
thory ValueOntologyTestLong (** Benzmüller, Fuenmayor & Lomfeld, 2020 **) import ValueOntology begin

lemma "True" nippick[satisfy, show_all, card = 10] oops (*contingent*)
lemma "[INCONS^p]" nippick[satisfy, card = 4] oops (*contingent*)
(*ext/int operators satisfy main properties of Galois connections*)
lemma G: "B ⊆ A" ⦵ A ⊆ B" by blast
lemma G1: "A ⊆ A" by simp
lemma G2: "B ⊆ B" by simp
lemma G3: "A ⊆ A; A ⊆ A" by simp
lemma G4: "B ⊆ B; B ⊆ B" by simp
lemma cl1: "A ⊆ A" by blast
lemma cl2: "B ⊆ B" by blast
lemma dualla: "[A; A] = [A; A; A]" by blast
lemma duallb: "[B; B; B] = [B; B; B; B]" by blast
lemma "[A; A] ⊆ [A; A; A]" nippick oops
lemma "[B; B; B] ⊆ [B; B; B; B]" nippick oops
lemma dualla2: "[A; A; A] ⊆ [A; A; A; A]" by blast
lemma duallb2: "[B; B; B; B] ⊆ [B; B; B; B; B]" by blast

(*Note: two different but logically equivalent notations*)
lemma "[WILL^p] = [WILL^p]" by simp
lemma "[WILL^p @ STAB^p] = [WILL^p @ STAB^p]" by simp

********** value ontology tests ************

lemma "[REL^p] ∧ [WILL^p] → [INCONS^p]" by simp
lemma "[INCONS^p] → [REL^p] ∧ [WILL^p]" by simp
lemma "[REL^p] ∧ [WILL^p]" nippick[satisfy] nippick oops (*contingent*)
lemma "[FAIR^p] ∧ [EFFI^p] nippick[satisfy] nippick oops (*contingent*)
lemma "[~INCONS^p] ∧ [FAIR^p] ∧ [EFFI^p] nippick[satisfy] nippick oops (*contingent: p & d independent*)

(*values in two non-opposed quadrants (neg): consistent*)
lemma "[WILL^p] ∧ [STAB^p] → [INCONS^p]" nippick oops (*countermodel found*)
lemma "[WILL^p] ∧ [GAIN^p] ∧ [EFFI^p] ∧ [STAB^p] → [INCONS^p]" nippick oops

(*values in two opposed quadrants: inconsistent*)
lemma "[RESP^p] ∧ [STAB^p] → [INCONS^p]" by simp

(*values in three quadrants: inconsistent*)
lemma "[WILL^p] ∧ [EFFI^p] ∧ [REL^p] → [INCONS^p]" by simp

(*values in opposed quadrants for different parties: consistent*)
lemma "[EQUI^p] ∧ [GAIN^p] → ([INCONS^p] ∨ [INCONS^p]) nippick oops (*ctnmdl*)
lemma "[RESP^p] ∧ [STAB^p] → ([INCONS^p] ∨ [INCONS^p]) nippick oops (*ctnmdl*)

(*value preferences tests*)
lemma "[WILL^p] ≪ [WILL^p @ STAB^p] nippick nippick(satisfy) oops (*contingent*)
lemma "[WILL^p] ≪ [WILL^p @ STAB^p] nippick nippick(satisfy) oops (*contingent*)
lemma "WILL^p ≪ [WILL^p @ STAB^p]
lemma "WILL^p ≪ [WILL^p @ STAB^p]
lemma "WILL^p ≪ [WILL^p @ STAB^p] using rBR by auto
lemma "[WILL^p] @ STAB^p ≺ [WILL^p] @ STAB^p by auto

Benzmüller, Fuenmayor, Lomfeld
A/B/C: Demo

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Following [Lomfeld(2019)KritischeJustiz]

theory Conti (** Benzmüller, Fuenmayor & Lomfeld, 2020 **)
imports GeneralKnowledge
begin (** ASPCA v. Conti "wild animal" case **) (*case-specific 'world-vocabulary'*)
consts α::"e" (*appropriated animal (parrot in this case) *)
consts Care::"c⇒e⇒σ" Prop::"c⇒e⇒σ" Capture::"c⇒e⇒σ"
consts α::"e" (*case-specific taxonomic (legal domain) knowledge*)
axiomatization where

CW1: "(Animal α ∧ Pet α → Domestic α)" and
CW2: "(∃c. Capture c α ∧ Domestic α) → appDomAnimal α" and
CW3: "∀c. Care c α → Mtn c" and
CW4: "∀c. Prop c α → Own c" and
CW5: "∀c. Capture c α → Poss c"

lemma True nitpick[satisfy,card i=4] oops (*satisfiable*)

(* *************** pro-ASPCA's argument *************** *)
abbreviation "ASPCA_facts ≡ [Parrot α ∧ Pet α ∧ Care p α ∧ Prop p α ∧ (¬Prop d α) ∧ Capture d α]"

(* decision for defendant (Conti) is compatible with premises*)
lemma "ASPCA_facts ∧ [¬INCONS] ∧ [¬INCONSd] ∧ [For p ≺ For d]" nitpick[satisfy,card i=4] oops (* (non-trivial) model found*)

(* decision for plaintiff (ASPCA) is compatible with premises*)
lemma "ASPCA_facts ∧ [¬INCONS] ∧ [¬INCONSd] ∧ [For d ≺ For p]" nitpick[satisfy,card i=4] oops (* (non-trivial) model found*)

(* decision for plaintiff (ASPCA) is provable*)
lemma aux: assumes ASPCA_facts shows "[(STABd ≺ RELIPRESP)]" using CW1 CW2 W assms R3 by fastforce

(* while a decision for the defendant is refutable*)
thm assumes ASPCA_facts shows "[For d ≺ For p]

lemma assumes ASPCA_facts shows "[For p ≺ For d]" nitpick[card i=4] oops (* (non-trivial) counterexample found*)
end

Benzmüller, Fuenmayor, Lomfeld
Models and Countermodels are particularly helpful!

Nipkow found a counterexample for card $e = 1$ and card $i = 4$:

Skolem constant:
\[ \lambda x. \varphi = (\lambda x. \varphi)(11 := 14, 1 := 11, 14 := 11, 11 := 14) \]

Types:
\[ c = (d, p) \]
\[ c = i [boxed] = (c, 1), (c, 1, i), (c, 1), (c, 1) \]
\[ c = - = [FREEDOM d, FREEDOM p, UTILITY d, UTILITY p, EQUALITY d, EQUALITY p, SECURITY d, SECURITY p] \]

Constants:

Capture =
\[ \lambda x. \gamma = (\lambda x. \gamma)(11 := True, (d, e, 1) := True, (d, e, 1) := True, (d, e, 1) := True, (p, e, 1) := False, (p, e, 1) := False, (p, e, 1) := False) \]

Care =
\[ \lambda x. \eta = (\lambda x. \eta)(11 := False, (d, e, 1) := False, (d, e, 1) := False, (d, e, 1) := False, (p, e, 1) := True, (p, e, 1) := True, (p, e, 1) := True, (p, e, 1) := True) \]

Prop =
\[ \lambda x. \mu = (\lambda x. \mu)(11 := False, (d, e, 1) := False, (d, e, 1) := False, (d, e, 1) := False, (p, e, 1) := True, (p, e, 1) := True, (p, e, 1) := True, (p, e, 1) := True) \]

\[ \alpha = \theta \]

Animal =
\[ \lambda x. \gamma \eta = (\lambda x. \gamma \eta)(11 := True, (e, 1) := False, (e, 1) := True, (e, 1) := True) \]

Domestic =
\[ \lambda x. \gamma \mu = (\lambda x. \gamma \mu)(11 := True, (e, 1) := False, (e, 1) := True, (e, 1) := True) \]

Fox =
\[ \lambda x. \eta \mu = (\lambda x. \eta \mu)(11 := False, (e, 1) := False, (e, 1) := False, (e, 1) := False) \]

FreeRoaming =
\[ \lambda x. \mu \nu = (\lambda x. \mu \nu)(11 := False, (e, 1) := False, (e, 1) := False, (e, 1) := False) \]

Intent =
\[ \lambda x. \eta \gamma = (\lambda x. \eta \gamma)(11 := False, (d, i) := True, (d, i) := True, (d, i) := True, (p, i) := False, (p, i) := False, (p, i) := True, (p, i) := False) \]

Liv =
\[ \lambda x. \eta \gamma \mu = (\lambda x. \eta \gamma \mu)(11 := False, (d, i) := True, (d, i) := False, (d, i) := False, (p, i) := False, (p, i) := False, (p, i) := False) \]

Mtn =
\[ \lambda x. \eta \gamma \mu \delta = (\lambda x. \eta \gamma \mu \delta)(11 := True, (d, i) := False, (d, i) := True, (p, i) := False, (p, i) := True, (p, i) := True, (p, i) := True) \]

Own =
\[ \lambda x. \eta \gamma \mu \nu = (\lambda x. \eta \gamma \mu \nu)(11 := True, (d, i) := False, (d, i) := True, (p, i) := True, (p, i) := True, (p, i) := True) \]

Parrot =
\[ \lambda x. \eta \gamma \mu \nu \gamma = (\lambda x. \eta \gamma \mu \nu \gamma)(11 := True, (e, 1) := True, (e, 1) := True, (e, 1) := True) \]

Pet =
\[ \lambda x. \eta \gamma \mu \nu \gamma \gamma = (\lambda x. \eta \gamma \mu \nu \gamma \gamma)(11 := True, (e, 1) := True, (e, 1) := True, (e, 1) := True) \]

Poss =
\[ \lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma = (\lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma)(11 := True, (d, i) := True, (d, i) := True, (d, i) := True, (p, i) := False, (p, i) := False, (p, i) := False) \]

appAnimal =
\[ \lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma \gamma = (\lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma \gamma)(11 := True, (i := True, i := True, i := True, i := True, i := True) \]

appDomestic =
\[ \lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma \gamma \gamma = (\lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma \gamma \gamma)(11 := True, (i := True, i := True, i := True, i := True, i := True) \]

appObject =
\[ \lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma \gamma \gamma \gamma = (\lambda x. \eta \gamma \mu \nu \gamma \gamma \gamma \gamma \gamma \gamma)(11 := True, (i := True, i := True, i := True, i := True, i := True) \]

BR =
\[ \lambda x. \gamma \delta = (\lambda x. \gamma \delta)(11 := True, (i := True, i := False, i := False, i := False) \]

For =
\[ \lambda x. \gamma \delta \gamma = (\lambda x. \gamma \delta \gamma)(11 := False, (d, i) := True, (d, i) := False, (p, i) := True, (p, i) := False, (p, i) := False) \]

I =
\[ \lambda x. \delta \gamma = (\lambda x. \delta \gamma)(11 := False, (i := True, i := True, i := True, i := True, i := True) \]

other =
\[ \lambda x. \gamma (d := p, p := d) \]
Conclusion and Related Work

Contributions:

▶ Feasibility study for **legal balancing on the computer**
▶ Embedding of Preference Logic in HOL
▶ Demonstrated formalization&use of **Lomfeld’s value ontology**
▶ Successful application of
  – LogiKEy methodology and
  – Universal (Meta-)Logical Reasoning in HOL
▶ **Flexibility, Expressiveness** and ready to use **ATP Support**!

Related work:

▶ Constructive interpretation in law, including model of value balancing: [Maranhão&Sartor(2019)ICAIL]
▶ Models to quantify legal balancing: [Alexy(2003), Sartor(2010)]

Bigger Vision:

**Reasonable Machines: A Research Manifesto**
(Benzmüller & Lomfeld, Kl’2020, http://dx.doi.org/10.1007/978-3-030-58285-2_20)