On the Structure and Soundness of AI & Law Objects

Clara Smith
Facultad de Informática, Universidad Nacional de La Plata, Argentina
csmith@info.unlp.edu.ar

1 Introduction

We present a (meta)theory that serves as a framework where case-based or statute-based models and systems can be understood, compared and prototyped. Central to our approach is the organization of theories under a notion of covering. This view helps to identify a disposition of elements based on a well-recognized underlying algebraic structure where theory definitions are reified and included in the same set together with their extensions and practical implementations.

2 The Nature of AI & Law Objects and a Logic for their Construction

We believe AI & Law objects of study are not legal intelligent systems or models for legal systems *alone*: they are the *relation* established between a legal domain or system of concepts and a corresponding computational specification (a "translation" where a given system of concepts is somehow transformed in another one), relation we call reduction.

The set of possible reductions can be defined as the cartesian product $Law \times AI_{\perp}$. Law is a compound domain (i.e. it can be a cartesian product itself) encompassing a wide variety of denotable values referring to ideal, factual, prescriptive and descriptive phenomena: legislation, facts, cases, court decisions, *et cetera*. $AI_{\perp}$ is a domain holding formal specifications [1] e.g. well-formed constructions established mainly at symbolic levels ($AI_{\perp}$means AI holds an "undefined" element). Stated as denotable values, elements in Law can be organized under a notion of *covering*, a relation organizing knowledge with respect to their "definedness", i.e. with respect to their "knowledge content" [2] (for example: $< name, age, course >$ has less content than $< ``Bob'', 24, Logics >$). $AI_{\perp}$ specifications can also be ordered under their "definedness" [1] (e.g. a many-sorted signature with respect to a single-sorted signature holding just one of those sorts.) Provided this, we define

Def. 1. *Covering relation for reductions: Let $r =< l, a >\in Law \times AI_{\perp}$. Let $r', r'' \in Law \times AI_{\perp}$. Let $(Law, \leq), (AI_{\perp}, \leq)$ be covering relations based on the notion of "definedness" of denotational semantics over both Law and $AI_{\perp}$. Then $(Law \times AI_{\perp}, \leq)$ is a covering relation over reductions if and only if $< l, a >\leq< l', a' >$ implies $l \leq l'$ or $a \leq a'$ (or both) for every $< l, a >, < l', a' >\in Law \times AI_{\perp}$.*

Definition 1 says "more abstract" AI & Law objects (e.g. theories) are placed above their extensions, instantiations and practical implementations. Therefore under this denotational semantics view the same object is an instance of the object(s) above and a class of all objects located below (figure 1.) The $\leq$ relation is an induced *partial order* over reductions as it verifies [3]: reflexivity ($< l, a >\leq< l, a >$), antisymmetry ($< l, a >\leq< l', a' >$ and $< l', a' >\leq< l, a >$ imply $< l, a >=< l', a' >$) and transitivity ($< l, a >\leq< l', a' >$ and $< l', a' >\leq< l'', a'' >$ imply $< l, a >\leq< l'', a'' >$). Now let $\wedge$ denote a generalization operation over denotational definitions (i.e. some knowledge is *removed*) and let $\vee$ be a specialization operation over definitions (i.e. knowledge is *joint together* and/or *added*):

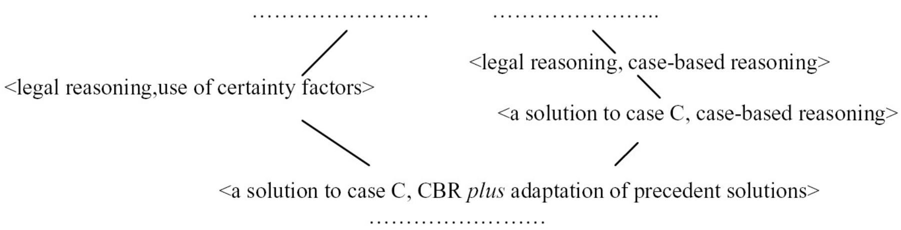

Figure 1: A sketch of a *Hasse diagram* for the reductions' poset.

then the following properties are easily verifiable on $(Law \times AI_{\perp}, \leq)$: conmutativity ($< l, a > \vee < l', a' > = < l', a' > \vee < l, a >$ and $< l, a > \wedge < l', a' > = < l', a' > \wedge < l, a >$), associativity ($< l, a > \vee (< l', a' > \vee < l'', a'' >) = (< l, a > \vee < l', a' >) \vee < l'', a'' >$ and $< l, a > \wedge (< l', a' > \wedge < l'', a'' >) = (< l, a > \wedge < l', a' >) \wedge < l'', a'' >$), idempotence ($< l, a > \vee (< l', a' > \vee < l'', a'' >) = (< l, a > \vee < l', a' >) \vee < l'', a'' >$ and $< l, a > \wedge (< l', a' > \wedge < l'', a'' >) = (< l, a > \wedge < l', a' >) \wedge < l'', a'' >$) and absorption ($< l, a > = < l, a > \vee (< l, a > \wedge < l', a' >)$ and $< l, a > = < l, a > \wedge (< l, a > \vee < l', a' >)$). This way we identify an algebra for AI & Law objects in its own right. It can be seen as a logic of construction of AI & Law objects. The theory proposal method in [4] is an example of $\wedge$-use.

Comparisons among objects can be performed by analysing their relative positions in the poset. *Is-a* relationships can be discovered following paths in the poset.

3 The Interdisciplinary Validity Problem (IVP)

We are interested in AI outcomes to be accepted as *legal* answers, that is: *"outcomes must not only be checked for (specification) correctness but also confronted to expected legal results"* Stated this way, IVP establishes a relation connecting a "low level" AI interpreter and a "high level" legal interpreter. Given a reduction $< l, a >$, given $vm(Law), vm(AI_{\perp})$ available validation methods for Law and $AI_{\perp}$ elements respectively, and being $eval$ an evaluation relation, we have the following IVP schema

Def. 2. $IVP(< l, a >, vm(l), vm(a)) : eval(vm(l), l)) \approx eval(vm(a)a); eval(vm(l), a))$

In IVP the relation among l and a through $vm(l)$ is what counts. Def. 2. holds when the evaluation of l through legal methods agrees (under some criteria abstractly denoted $\approx$) with outcomes obtained when evaluating a using the same methods used for l, given a correct.

4 Definition of a Reduction (meta)Theory

Def. 3. *A Reduction Theory is a tuple:* $< (Law \times AI_{\perp}, \leq), vm(Law), vm(AI_{\perp}), IVP >$

The Reduction Theory models AI & Law objects as relations among legal phenomena and specifications; models generalization/specialization relationships among reductions through an induced notion of covering, and it includes an IVP axiom schema (which we believe is a truly AI & Law-sensitive feature) that works as a tool for legal accuracy measurement.

References

[1] D. Schmidt. Denotational Semantics. A Methodology for Language Development. Allyn and Bacon, 1986, MA.

[2] M. Kifer, G. Lausen. F-Logic: A Higher-Order Language for Reasoning about Objects, Inheritance and Scheme. ACM 1989.

[3] S. Burris, H. Sankappanavar. A Course in Universal Algebra. Graduate Texts in Mathematics, Springer 1981.

[4] T. Bench-Capon, G. Sartor. A Model of Legal Reasoning with Cases Incorporating Theories and Values. Artificial Intelligence. Kluwer, 2003.