Day 2 Monday April 15

8:30   AI & Law - Modeling Legal Knowledge (Enrico Francesconi)
10:00  Break
10:30  Arguments, Rules and Cases in AI & Law (Bart Verheij)
12:00  Break
14:30  Argument and Story Strength - Bayesian vs. Qualitative Approaches (Floris Bex)
16:00  Break
16:30  Discussion
17:30
The two faces of Artificial Intelligence

Expert systems  Adaptive systems
Business rules  Machine learning
Open data  Big data
IBM’s Deep Blue  Watson
Complex structure  Adaptive structure

Knowledge

Foundation: logic
Explainability

Data tech

Foundation: probability theory
Scalability
Intelligent systems

Knowledge systems

Data systems

Argumentation systems

1950

1975

2000

2025
The law can be enhanced by artificial intelligence
Access to justice, efficient justice

Artificial intelligence can be enhanced by the law
Ethical AI, explanatory AI
Formalizing Arguments, Rules and Cases

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ABSTRACT
Legal argument is typically backed by two kinds of sources: cases and rules. In much AI & Law research, the formalization of arguments, rules and cases has been investigated. In this paper, the tight formal connections between the three are developed further, in an attempt to show that cases can provide the logical basis for establishing which rules and arguments hold in a domain. We use the recently proposed formalism of case models, that has been applied previously to evidential reasoning and ethical systems design. In the present paper, we discuss with respect to case-based modeling how the analogy and distinction between cases can be modeled, and how arguments can be grounded in cases. With respect to rule-based modeling, we discuss conditionality, generality and chaining. With respect to argument-based modeling, we discuss rebutting, undercutting and undermining attack. We evaluate the approach by developing a case model of the rule-based arguments and attacks in Dutch tort law. In this way, we illustrate how statutory, rule-based law from the civil law tradition can be formalized in terms of cases.

CCS CONCEPTS
- Computing methodologies → Artificial intelligence; • Theory of computation → Logic; • Applied computing → Law;

KEYWORDS
Argumentation, Rule-based reasoning, Case-based reasoning

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1 INTRODUCTION
Legislation and precedents are primary sources for the backing of legal arguments, and each of these two kinds is typically associated there can be an exception to an applying rule, and in case-based reasoning, adherence to a matching case can be overruled by another case that is a better match.

In Artificial Intelligence and Law, such defeasible reasoning backed by rules and cases has productively been modeled in terms of arguments for and against possible conclusions. Formal and computational models have been proposed that investigate relations between arguments, rules and cases in various ways. For instance, cases have been studied as the source of hypothetical arguments (Aleven and Ashley 1995; Ashley 1990; Rissland and Ashley 1987), rules and cases have been studied for the construction of explanations of decisions (Branting 1991, 1993), rules and cases have been used for the construction of arguments (Prakken and Sartor 1996, 1998), and cases and the values they promote have been used to establish rules (Bench-Capon and Sartor 2003).

This and related work has shown that the formal and computational relations between arguments, rules and cases are close. The present paper aims to further develop the close formal relations between arguments, rules and cases.

For this aim, we use the recently proposed case model formalism that was previously applied to evidential reasoning and ethical system design (Verheij 2016a,b, 2017). The case model formalism was developed in an attempt to answer the semantics and normative questions for reasoning with presumptive arguments (Verheij 2016a): How are presumptive arguments grounded in interpretations; and when are they evaluated as correct? In that work, the case model formalism is shown to have equivalent qualitative and quantitative characterizations, connecting to classical logic and probability theory. Hence the formalism is simultaneously 'with and without numbers', and the case model formalism could be applied to evidential reasoning, involving arguments, scenarios and probabilities (Verheij 2014, 2017). In contrast with Bayesian network approaches connecting arguments, scenarios and probabilities that require the specification of a full probability distribution (Fenton et al. 2013; Hepler et al. 2007; Timmer et al. 2017;
Introduction

**Argumentation semantics**

Legal sources: legislation and precedents

Case models

Tort law (damages and unlawful acts)

AI&Law
Abstract argumentation semantics (1996)

- Stable extension
  - Semi-stable extension
    - Grounded extension
    - Preferred extension
      - Complete extension
  - Stage extension

Dung 1995
Verheij 1996

Set theoretic and labeling semantics
Mary is original owner → Mary is owner

John is the buyer → John is owner

John was not bona fide

John bought the bike for €20

Pros

Cons
Combining support and attack

Starting with attack graphs, there are two ways to add support:

1. *The abstract argumentation approach*
   Treat nodes in an attack graph as abstractions of support structure

2. *The reason-based approach*
   Use two kinds of links, one for attack (con-reasons), one for support (pro-reasons)
Combining support and attack

Approach 1:
Dung’s abstract arguments have internal structure

Abstract version:  •←•→•
Combining support and attack

Approach 2:
Arguments can attack or support
Focus on attack
Also support
\[ \varphi \sim x \, \psi \]
\[ \varphi \rightarrow \psi \]

With nesting
\[ \varphi \rightarrow (\psi \rightarrow \chi) \]
\[ \varphi \sim x (\psi \rightarrow \chi) \]
\[ \varphi \rightarrow (\psi \sim x \chi) \]
\[ \varphi \sim x (\psi \sim x \chi) \]
Argumentation semantics (2003)

Stable
- $M$
- $E$
- $MPCC$
- $PCC$
- $MDJ$
- $MP$
- $P$
- $CCD.J$
- $DJ$

Stage
- $CC$
- $S$

Semi-stable

Preferred

Set theoretic and labeling semantics

DefLog Verheij 2003
Correct Grounded Reasoning with Presumptive Arguments

1. **The semantics question.** How are presumptive arguments grounded in interpretations? This question is about *grounded argumentation*.

2. **The normative question.** When are presumptive arguments evaluated as correct? This question is about *correct argumentation*.

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Argumentation semantics
**Legal sources: legislation and precedents**
Case models
Tort law (damages and unlawful acts)
AI&Law
Legislation and precedents

Legislation and precedents are primary sources for the backing of legal arguments.

Each is associated with a specific style of reasoning:

▪ legislation with rule-based reasoning, and
▪ precedents with case-based reasoning.
Legal traditions

- Civil law
  - *History*: Eastern Roman empire, 6th century, Codex Justinianus
  - *Emphasis*: codified law
  - *Primary source*: legislation

- Common law
  - *History*: England, Middle Ages, Magna Carta
  - *Emphasis*: judge-made law
  - *Primary source*: precedents
Magna Carta Libertatum 1215
Kinds of reasoning

In *rule-based reasoning*, rules backed by legislation are followed when they apply in the current case.

In *case-based reasoning*, cases with precedential authority are adhered to when they match the current case.
Defeasibility

Both kinds of reasoning are defeasible.

In rule-based reasoning, there can be an exception to an applying rule.

In case-based reasoning, adherence to a matching case can be overruled by another case that is a better match.
Defeasible reasoning backed by rules and cases has been modeled in terms of arguments for and against possible conclusions.

Formal and computational models have been proposed that investigate relations between arguments, rules and cases in various ways. Such work has shown that the formal and computational relations between arguments, rules and cases are close.

The ICAIL 2017 paper aims to further develop the close formal relations between arguments, rules and cases.
Artificial Intelligence and Law

- Cases have been studied as the source of hypothetical arguments (Rissland, Ashley, Aleven).
- Rules and cases have been studied for the construction of explanations of decisions (Branting).
- Rules and cases have been used for the construction of arguments (Prakken, Sartor).
- Cases and the values they promote have been used to establish rules and decision-making (Bench-Capon, Sartor, Atkinson).
Introduction
Argumentation semantics
Legal sources: legislation and precedents
**Case models**
Tort law (damages and unlawful acts)
AI&Law
Case models

We use the recently proposed case model formalism, previously applied to evidential reasoning and ethical systems design.

The case model formalism was developed in an attempt to answer the semantics and normative questions for reasoning with presumptive arguments:

- How are presumptive arguments grounded in interpretations?
- When are they evaluated as correct?
Case models

A series of New York tort cases about car accidents (Hafner, Berman)

Alfred Hitchcock’s ‘To Catch A Thief’
We discuss themes in case-based, rule-based and argument-based modeling, all using the same case model formalism.

- With respect to case-based modeling, we discuss the themes of analogies, distinctions and argument grounding.
- With respect to rule-based modeling, we discuss conditionality, generality and chaining.
- With respect to argument-based modeling, we discuss rebutting attack, undercutting attack and undermining attack.

The proposal is evaluated by modeling Dutch tort law. That is an example domain from the rule-based, civil law tradition, and we model it in terms of the case model formalism.
Common law and civil law

Comparative law research has shown that the roles of legislation and precedents as sources of arguments are closely connected in different legal systems, both in common law and in civil law (MacCormick & Summers).

By developing the formal relations between arguments, rules and cases, we contribute to the explanation of this fact.
Case models

Case models consist of a set of sentences and an ordering relation.

The cases in a case model are sentences that must be logically consistent, mutually incompatible and different; and the comparison relation must be total and transitive (a total preorder).

Arguments are interpreted in case models. Three kinds of argument validity are distinguished: coherence, presumptive validity and conclusiveness.
Definition 1. A case model is a pair \((C, \geq)\) with finite \(C \subseteq L\), such that the following hold, for all \(\varphi, \psi\) and \(\chi \in C\):

1. \(\not\models \neg \varphi\);

2. If \(\not\models \varphi \leftrightarrow \psi\), then \(\models \neg (\varphi \land \psi)\);

3. If \(\models \varphi \leftrightarrow \psi\), then \(\varphi = \psi\);

4. \(\varphi \geq \psi\) or \(\psi \geq \varphi\);

5. If \(\varphi \geq \psi\) and \(\psi \geq \chi\), then \(\varphi \geq \chi\).
Kinds of argument validity

Coherent arguments

\[(C, \geq) \models (\varphi, \psi) \text{ if and only if } \exists \omega \in C: \omega \models \varphi \land \psi.\]

Conclusive arguments

\[(C, \geq) \models \varphi \Rightarrow \psi \text{ if and only if } \exists \omega \in C: \omega \models \varphi \land \psi \text{ and } \forall \omega \in C: \text{ if } \omega \models \varphi, \text{ then } \omega \models \varphi \land \psi.\]

Presumptively valid arguments

\[(C, \geq) \models \varphi \bowtie \psi \text{ if and only if } \exists \omega \in C:\]

1. \(\omega \models \varphi \land \psi;\) and
2. \(\forall \omega' \in C : \text{ if } \omega' \models \varphi, \text{ then } \omega \geq \omega'.\]
Case models

Case 1: \( \neg p \)
Case 2: \( p \land q \)
Case 3: \( p \land \neg q \)

Case 1 > Case 2 > Case 3
Case models

Case 1: $\neg p$  
Case 2: $p \land q$  
Case 3: $p \land \neg q$

$p$: unlawful  
$q$: duty to repair

Case 1 > Case 2 > Case 3
Case models

Case 1: \( \neg p \)  \( p: \) unlawful
Case 2: \( p \land q \)  \( q: \) duty to repair
Case 3: \( p \land \neg q \)
Case 1 > Case 2 > Case 3

Coherent arguments:
\( (p, q), (p, \neg q) \)

Presumptively valid arguments:
\( (true, \neg p), (p, q) \)

Conclusive arguments:
\( (\neg p, \neg p), (q, p) \)
Case models

Case 1: \( \neg p \)  \( p: \) unlawful
Case 2: \( p \land q \)  \( q: \) duty to repair
Case 3: \( p \land \neg q \)
Case 1 > Case 2 > Case 3

Presumptively valid arguments:

\( (true, \neg p) \) has defeating circumstances \( p \)
\( (p, q) \) has defeating circumstances \( \neg q \)
Graphical representation of the case model

Graphical representation of the arguments
black arrows: presumptively valid
red arrows: defeating circumstances
Case models

The case model approach has equivalent qualitative and quantitative representations.

The approach has been applied to evidential reasoning for the modeling of argumentative, scenario and probabilistic analyses.

The approach has been applied to decision making for the modeling of value-guided choices (ethical systems design).
Definition 1. A *case model* is a pair \((C, \geq)\) with finite \(C \subseteq L\), such that the following hold, for all \(\varphi, \psi\) and \(\chi \in C\):

1. \(\not\models \lnot \varphi\);
2. If \(\not\models \varphi \leftrightarrow \psi\), then \(\models \lnot (\varphi \land \psi)\);
3. If \(\models \varphi \leftrightarrow \psi\), then \(\varphi = \psi\);
4. \(\varphi \geq \psi\) or \(\psi \geq \varphi\);
5. If \(\varphi \geq \psi\) and \(\psi \geq \chi\), then \(\varphi \geq \chi\).

\(\geq\) is a total preorder

i.e., a relation representable by a numeric function
Definition 1. A case model is a pair $(C, \geq)$ with finite $C \subseteq L$, such that the following hold, for all $\varphi, \psi$ and $\chi \in C$:

1. $\not\models \neg \varphi$;
2. If $\not\models \varphi \leftrightarrow \psi$, then $\models \neg (\varphi \land \psi)$;
3. If $\models \varphi \leftrightarrow \psi$, then $\varphi = \psi$;
4. $\varphi \geq \psi$ or $\psi \geq \varphi$;
5. If $\varphi \geq \psi$ and $\psi \geq \chi$, then $\varphi \geq \chi$.

$\geq$ is a total preorder

With and without numbers
Kinds of argument validity

Coherent arguments \( p(\psi | \varphi) > 0 \)

\((C, \geq) \models (\varphi, \psi) \) if and only if \( \exists \omega \in C: \omega \models \varphi \land \psi \). 

Conclusive arguments \( p(\psi | \varphi) = 1 \)

\((C, \geq) \models \varphi \Rightarrow \psi \) if and only if \( \exists \omega \in C: \omega \models \varphi \land \psi \) and \( \forall \omega \in C: \) if \( \omega \models \varphi \), then \( \omega \models \varphi \land \psi \).

Presumptively valid arguments \( p(\psi | \varphi) > t \)

\((C, \geq) \models \varphi \leadsto \psi \) if and only if \( \exists \omega \in C: \)

1. \( \omega \models \varphi \land \psi \); and
2. \( \forall \omega' \in C: \) if \( \omega' \models \varphi \), then \( \omega \geq \omega' \).
Properties of presumptive validity

**Proposition 8** Let \((C, \geq)\) be a case model. For all \(\varphi, \psi\) and \(\chi \in L\):

- **(LE)** If \(\varphi \vdash \psi, \models \varphi \iff \varphi'\) and \(\models \psi \iff \psi'\), then \(\varphi' \vdash \psi'\).
- **(Cons)** \(\varphi \not\vdash \bot\).
- **(Ant)** If \(\varphi \vdash \psi\), then \(\varphi \vdash \varphi \land \psi\).
- **(RW)** If \(\varphi \vdash \psi \land \chi\), then \(\varphi \vdash \psi\).
- **(CCM)** If \(\varphi \vdash \psi \land \chi\), then \(\varphi \land \psi \vdash \chi\).
- **(CCT)** If \(\varphi \vdash \psi\) and \(\varphi \land \psi \vdash \chi\), then \(\varphi \vdash \psi \land \chi\).

**Proposition 13** Let \((C, \geq)\) be a case model, and \(L^* \subseteq L\) the closure of \(C\) under negation, conjunction and logical equivalence. Writing \(\vdash^*\) for the restriction of \(\vdash\) to \(L^*\), we have, for all \(\varphi, \psi\) and \(\chi \in L^*\):

- **(Coh)** \(\varphi \vdash \varphi\) if and only if \(\exists \varphi^* \in L^*\) with \(\varphi^* \not\models \bot\) and \(\varphi^* \models \varphi\);
- **(Ch)** If \(\varphi \vdash^* \varphi\) and \(\psi \vdash^* \psi\), then \(\varphi \lor \psi \vdash^* \neg \varphi \land \psi\) or \(\varphi \lor \psi \vdash^* \varphi \land \psi\) or \(\varphi \lor \psi \vdash^* \varphi \lor \psi\) or \(\varphi \lor \psi \vdash^* \neg \varphi \lor \psi\);
- **(OC)** If \(\varphi \lor \psi \vdash^* \varphi\) and \(\psi \lor \chi \vdash^* \psi\), then \(\varphi \lor \chi \vdash^* \varphi\).
Case models

Can case models represent more complex argument structure as is typical in rule-based reasoning?

Challenge:
Construct a case model for a domain with a complex argument structure
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**Tort law (damages and unlawful acts)**
AI&Law
Art. 6:162 BW. 1. A person who commits an unlawful act toward another which can be imputed to him, must repair the damage which the other person suffers as a consequence thereof.

2. Except where there is a ground of justification, the following acts are deemed to be unlawful: the violation of a right, an act or omission violating a statutory duty or a rule of unwritten law pertaining to proper social conduct.

3. An unlawful act can be imputed to its author if it results from his fault or from a cause for which he is answerable according to law or common opinion.

For instance, if you bump into another car while parking, you typically must pay for the damages incurred.
Tort law (The Netherlands)

As specified in Art. 6:162.1 BW, a **duty to repair** someone's damages can be established when four conditions are fulfilled:

1. *Someone has suffered damages by someone else's act.* For instance, the car parked into has a dent in a door panel.
2. *The act committed was unlawful.* In the example, the unlawfulness follows from the ownership of the damaged car.
3. *The act can be imputed to the person that committed the act.* In the example, it can be said that causing damages because of bumping into another car is your own fault.
4. *The act caused the suffered damages.* The door panel was pristine, and now has a dent.
Tort law (The Netherlands)

Three kinds of **unlawful acts** are distinguished (Art. 6:162.2 BW):

1. *The act is a violation of someone's right*. In the example, the car owner's right to ownership was violated.

2. *The act is a violation of a statutory duty*. Examples are acts that are punishable in the sense of the Dutch criminal code or other statutes.

3. *The act is a violation of unwritten law against proper social conduct*. Supreme Court of the Netherlands, January 31, 1919, NJ 1919 (Lindenbaum-Cohen).
Art. 6:162.2 BW explicates an exception to unlawfulness: the existence of grounds of justification.

Examples: Force majeure, in particular a conflict of duties as they can occur in a life-endangering situation; commands by an authority such as a police officer.

This exception is phrased as applying to each of the three kinds of unlawfulness, but doctrine often takes it that it only applies to the first two (rights, statutory duties).
Tort law (The Netherlands)

dmg \land unl \land imp \land cau \rightarrow dut
vrt \rightarrow unl
vst \rightarrow unl
vun \rightarrow unl
ift \rightarrow imp
ila \rightarrow imp
ico \rightarrow imp
Tort law (The Netherlands)

Four conditions for duty to repair:

\[ \text{dmg} \land \text{unl} \land \text{imp} \land \text{cau} \rightarrow \text{dut} \]

Three kinds of unlawfulness:

\[ \text{vrt} \rightarrow \text{unl} \]
\[ \text{vst} \rightarrow \text{unl} \]
\[ \text{vun} \rightarrow \text{unl} \]

Three kinds of imputability:

\[ \text{ift} \rightarrow \text{imp} \]
\[ \text{ila} \rightarrow \text{imp} \]
\[ \text{ico} \rightarrow \text{imp} \]
Tort law (The Netherlands)

dmg \land \text{unl} \land \text{imp} \land \text{cau} \rightarrow \text{dut} \times \text{vst} \land \neg \text{prp}

\text{vrt} \rightarrow \text{unl} \times \text{jus}

\text{vst} \rightarrow \text{unl} \times \text{jus}

\text{vun} \rightarrow \text{unl}

\text{ift} \rightarrow \text{imp}

\text{ila} \rightarrow \text{imp}

\text{ico} \rightarrow \text{imp}
Tort law (The Netherlands)

Defeating circumstances
(Art. 6:163 purpose)

dmg \land unl \land imp \land cau \sim \dut \times vst \land \neg prp

vrt \sim unl \land jus

vst \sim unl \land jus

vun \sim unl

ift \sim imp

ila \sim imp

ico \sim imp

Defeating circumstances
(grounds of justification)
dut  There is a duty to repair someone’s damages
dmg  Someone has suffered damages by someone else’s act.
unl  The act committed was unlawful.
imp  The act can be imputed to the person that committed the act.
cau  The act caused the suffered damages.
vrt  The act is a violation of someone’s right.
vst  The act is a violation of a statutory duty.
vun  The act is a violation of unwritten law against proper social conduct.
jus  There exist grounds of justification.
ift  The act is imputable to someone because of the person’s fault.
ila  The act is imputable to someone because of law.
ico  The act is imputable to someone because of common opinion.
prp  The violated statutory duty does not have the purpose to prevent the damages.
Can case models represent more complex argument structure as is typical in rule-based reasoning?

Challenge:

Construct a case model for a domain with a complex argument structure
A case model for Dutch tort law
Case 1: There are no damages
A case model for Dutch tort law

Case 5: There are damages because of an unlawful right violation
A case model for Dutch tort law

Case 14: There is a ground of justification
A case model for Dutch tort law

\[(C, \geq) \models \text{dmg} \land \text{unl} \land \text{imp} \land \text{cau} \leadsto \text{dut} \times \text{vst} \land \neg \text{prp}\]

\[(C, \geq) \models \text{vrt} \leadsto \text{unl} \times \text{jus}\]

\[(C, \geq) \models \text{vst} \leadsto \text{unl} \times \text{jus}\]

\[(C, \geq) \models \text{vun} \leadsto \text{unl}\]

\[(C, \geq) \models \text{ift} \leadsto \text{imp}\]

\[(C, \geq) \models \text{ila} \leadsto \text{imp}\]

\[(C, \geq) \models \text{ico} \leadsto \text{imp}\]
Case models

Can case models represent more complex argument structure as is typical in rule-based reasoning?

Challenge:
Construct a case model for a domain with a complex argument structure

Yes we can!
Kinds of defeat (Pollock)

Rebutting attack Rebutting attack is a special kind of attack. Rebutting attack occurs when an argument is attacked, while supporting the opposite conclusion.

*Definition 5.2.* When circumstances $\chi$ successfully attack presumptively valid argument $(\varphi, \psi)$, the circumstances are *rebutting* when $(\varphi \land \chi, \neg\psi)$ is presumptively valid.

Undercutting attack Undercutting occurs when the attacking circumstances are not rebutting.

*Definition 5.5.* When circumstances $\chi$ successfully attack presumptively valid argument $(\varphi, \psi)$, and are not rebutting, the circumstances are *undercutting.*
Artificial Intelligence and Law

- Cases have been studied as the source of hypothetical arguments (Rissland, Ashley, Aleven).
- Rules and cases have been studied for the construction of explanations of decisions (Branting).
- Rules and cases have been used for the construction of arguments (Prakken, Sartor).
- Cases and the values they promote have been used to establish rules and decision-making (Bench-Capon, Sartor, Atkinson).
We discuss themes in case-based, rule-based and argument-based modeling, all using the same case model formalism.

- With respect to *case-based modeling*, we discuss the themes of analogies, distinctions and argument grounding.
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- With respect to *argument-based modeling*, we discuss rebutting attack, undercutting attack and undermining attack.

The proposal is evaluated by modeling Dutch tort law. That is an example domain from the rule-based, civil law tradition, and we model it in terms of the case model formalism.
Checking the validity of rule-based arguments grounded in cases: a computational approach

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Abstract. One puzzle studied in AI & Law is how arguments, rules and cases are formally connected. Recently a formal theory was proposed formalizing how the validity of arguments based on rules can be grounded in cases. Three kinds of argument validity were distinguished: coherence, presumptive validity and conclusiveness. In this paper the theory is implemented in a Prolog program, used to evaluate a previously developed model of Dutch tort law. We also test the theory and its implementation with a new case study modeling Chinese copyright infringement law. In this way we illustrate that by the use of the implementation the process of modeling becomes more efficient and less error-prone.

Keywords. Artificial Intelligence and Law, Rule-based Reasoning, Case-based Reasoning, Argumentation Modeling, Prolog
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Readings


