IIIb: Argument Strength and Probabilities

Topics:
Argument Strength and Probabilities

Goals:
Reflect on argument strength and probabilities
Reflect on the future of argumentation in Artificial Intelligence and Law

Literature:
Van Eemeren et al. (in preparation). Sections 11.12

Expert: “The probability is 1 in 342,000,000 that a nurse’s shifts coincide with so many unexplained deaths and resuscitations.”
Expert: "The probability is 1 in 342,000,000 that a nurse's shifts coincide with so many unexplained deaths and resuscitations."

Expert: "Dat kan geen toeval zijn." (That cannot be by chance.)

What went wrong?
Explanation 1
Lawyers don't understand statistics.

Explanation 2
Lawyers aren't statistical experts.

Explanation 3
Lawyers aren't statistical experts and statisticians aren't legal experts.

Explanation 4
There is a communication gap between lawyers and statistical experts.

What still goes wrong?

Three approaches
Argumentation
Scenarios
Probability

How can we close the communication gap between lawyers and experts?

For each, AI models exist.
Argumentation

- The suspect committed the crime
- The witness testifies she saw suspect
- The witness is mistaken

Scenarios

- The prosecution’s account of the facts
- The defense’s account of the facts

Scenarios

- The prosecution’s account of the facts
- The defense’s account of the facts

- Reasoning & dialogue
- Support, attack
- Rules & argumentation schemes
- Wigmore, Toulmin, Pollock
- Relation to logic & probability?

Scenarios

- Coherent sequences of events
- Sensemaking
- Inference to the best explanation
- Schank & Abelson, Pennington & Hastie
- Good stories push out true stories?
Fact: 95% of suspects who appear before a criminal court in the Netherlands are convicted.

<table>
<thead>
<tr>
<th></th>
<th>Suspect before court</th>
<th>Not suspect before court</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspect convicted</td>
<td>95%</td>
<td>0%</td>
</tr>
<tr>
<td>Not suspect convicted</td>
<td>5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Designing and Understanding Forensic Bayesian Networks with Arguments and Scenarios

www.ai.rug.nl/~verheij/nwofs/

- Probability distribution, Bayes' rule
- Graphical structure
- Combination of quantitative & qualitative elements
- Bayes, Wigmore, Pearl
- Design and explanation methods?
Legal idioms

- Reusable modeling building blocks
  Fenton, Neil, Lagnado’s legal idioms

Design method

Given a collection of scenarios, we produce a Bayesian network modeling all scenarios.

1. Collect all relevant scenarios
2. Model each scenario using the scenario idiom
3. Merge these idioms with the merged scenarios idiom
4. Add evidence
Forensic relevance

**Goal:**
realising the potential of statistical evidence in criminal prosecution and decreasing chance of mistakes

**Means:**
The project will contribute to forensic practice by providing methods for:
1 handling BNs in criminal proceedings, and
2 educating lawyers in handling BNs.

Explanation 5
We do not really understand the relation between fact-finding and decision-making.

Hypothesis:
We need an integrated theory of argumentation, logic and probability.

Issues in formal argumentation theory

- Relation to logic
- Relation to probability theory
- Argument strength
- Argumentation semantics

Dung’s abstract argumentation
**Argumentation semantics 1996**

![Diagram showing relations between types of argumentation stages]

Figure 1: Relations between types of argumentation stages

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**Argumentation semantics 2003**

![Diagram illustrating the structure of argumentation]

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**Integrating arguments and narrative**

One interpretation of the evidence

Another interpretation of the evidence

Evidence

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**Ampliation & deduction**

![Diagram illustrating ampliation and deduction]

Peirce, Toulmin

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**Ampliative argumentation 2010**

1. (Logical equivalence)
   
   If $\phi \vdash \psi$, $\Gamma \vdash \phi \leftrightarrow \phi'$ and $\Gamma \vdash \psi \leftrightarrow \psi'$, then $\phi' \vdash \psi'$.

2. (Restricted reflexivity)
   
   If $\phi \vdash \psi$, then $\phi \vdash \phi$.

3. (Antecedence)
   
   If $\phi \vdash \psi$, then $\phi \vdash \phi \land \psi$.

4. (Right weakening)
   
   If $\phi \vdash \psi \land \chi$, then $\phi \vdash \psi$.

5. (Conjunctive cautious monotony)
   
   If $\phi \vdash \psi \land \chi$, then $\phi \land \psi \vdash \chi$.

6. (Mutual attack)
   
   If $\phi \vdash \psi$, $\phi \vdash \chi$ and $\phi \land \phi \vdash \psi$, then $\phi \land \chi \vdash \psi$.

7. (Conjunctive cumulative transitivity; Conjunctive cut)
   
   If $\phi \vdash \psi$ and $\phi \land \psi \vdash \chi$, then $\phi \vdash \psi \land \chi$.

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**Integrating arguments, narrative and probability**

One interpretation of the evidence

Another interpretation of the evidence

$p(H_1|E)$

$P(H_1|E)$

Evidence
Ampliative argumentation 2012

(LE) If $\phi \vdash \psi$, then $\phi \leftrightarrow \psi'$.
(Ant) If $\phi \vdash \psi$, then $\phi \vdash \phi \land \psi$.
(PR) If $\phi \vdash \phi \land \psi$, then $\phi \vdash \psi$.
(R) $\phi \vdash \psi$.
(RW) If $\phi \vdash \phi \land \chi$, then $\phi \vdash \psi$.
(CCM) If $\phi \vdash \phi \land \chi$, then $\phi \land \psi \vdash \chi$.
(CCT) If $\phi \vdash \psi$ and $\phi \land \psi \vdash \chi$, then $\phi \vdash \psi \land \chi$.

Ampliative argumentation 2012

1. If $\vdash \phi \leftrightarrow \psi$, then $v(\phi) = v(\psi)$.
2. $v(\bot) \leq v(\phi) \leq v(\top)$.
3. $v(\phi) \geq v(\phi \land \psi) + v(\phi \land \neg \psi)$.
4. If $\psi \vdash \phi$, then $v(\phi) \geq v(\psi)$.
5. $\phi \vdash \bot$ if and only if $v(\phi) = 0$.
6. $\phi \vdash \psi$ if and only if $v(\phi) = 0$ or $\frac{v(\phi \land \psi)}{v(\phi)} > \frac{1}{2} - \epsilon$.
7. $\phi \vdash \psi$ if and only if $v(\phi) > 0$ and $\frac{v(\phi \land \psi)}{v(\phi)} < \epsilon$.

Related research (some)

- **KLM-nonmonotonic inference**
  - Axioms now allow alternatives
- **Bayesian Networks**
  - Structure now has a transparent meaning (reasons)
- **John Pollock’s OSCAR**
  - Argumentation is now compatible with probability theory
- **Probability theory**
  - This theory handles partial information
- **Paul Thagard’s coherence**
  - This theory is compatible with probability theory

Just a bunch of formulas?

No. This provides an integrated perspective on evidential reasoning.

Reasoning becomes rule application, while checking for exceptions.

The difficulty goes to having the **knowledge** that takes the form of rules and their exceptions.

Descriptive rules and exceptions can be found and tested as usual: by **statistics**.

Other rules and exceptions can be found in relevant examples and reliable sources.

My new position in AI

It is possible to have one’s cake and eat it too:

logic-based AI and probability-based AI

**Argumentation** provides the glue.

Reasoning becomes rule application, while checking for exceptions.

The difficulty is to have good knowledge of rules and their exceptions.
Tons of things to do

There is a world to win

(and the law shows how to go about that)

Unfair advantages

1. A fresh and productive perspective that
   - integrates proven AI techniques, and is
   - based on formal theory, and
   - with a natural interpretation

2. A grounding problem domain: the law

Ia Introduction
Ib Abstract Argumentation, Argument Structure
IIa Argument Schemes and Argumentation Dialogues
IIb Argumentation with Rules and with Cases
IIIa Reasoning with Evidence
IIIb Argument Strength and Probabilities

Argumentation in Artificial Intelligence, With Applications in the Law
Course at the Institute of Logic and Cognition, Sun Yat-Sen University
IIIb: Argument Strength and Probabilities

Bart Verheij
CodeX, Stanford University
Artificial Intelligence, University of Groningen

For more information on the forensic science project, see:
www.ai.rug.nl/~verheij/nwofs/

For more information on narratives in Bayesian Networks, see:

For more information on the logic of ampliative argumentation, see: