**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**

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## 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

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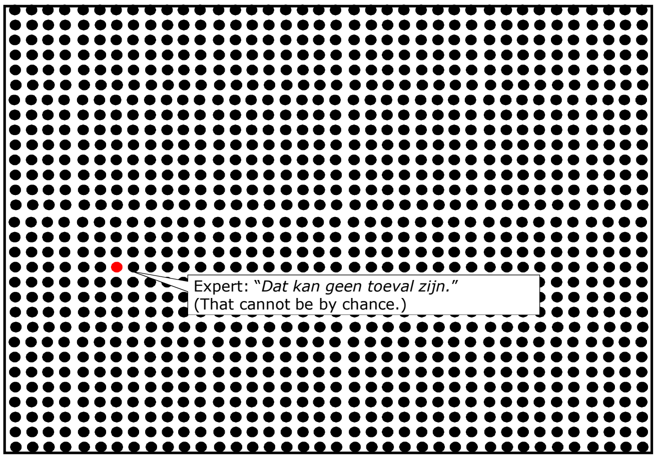
Expert: “The probability is 1 in 342,000,000 that a nurse’s shifts coincide with so many unexplained deaths and resuscitations.”

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?

## What *still goes* 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.

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

## Three approaches

Argumentation

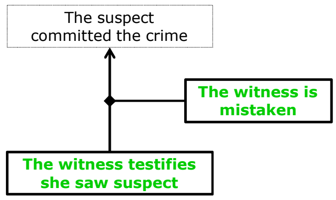
Scenarios

Probability

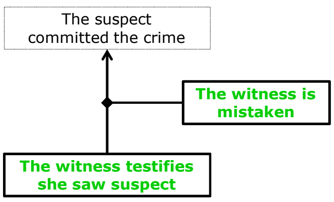
***For each, AI models exist.***

## Argumentation


## Argumentation

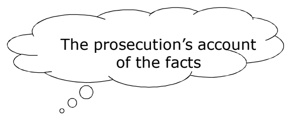



## Argumentation

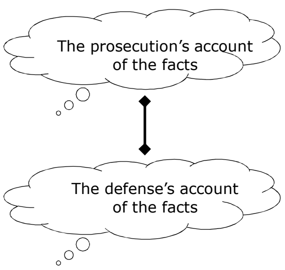



- Reasoning & dialogue
- Support, attack
- Rules & argumentation schemes
- Wigmore, Toulmin, Pollock
- Relation to logic & probability?

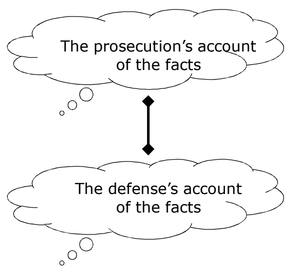
## Scenarios




## Scenarios




## Scenarios




- Coherent sequences of events
- Sensemaking
- Inference to the best explanation
- Schank & Abelson, Pennington & Hastie
- Good stories push out true stories?

## Probability

Suspect before court → Suspect convicted

Fact: **95%** of suspects who appear before a criminal court in the Netherlands are convicted.

## Probability

Suspect before court → Suspect convicted

| | Suspect before court | Not suspect before court |
|---|---|---|
| Suspect convicted | **95%** | 0% |
| Not suspect convicted | 5% | 100% |

| | |
|---|---|
| Suspect before court | 0.5% |
| Not suspect before court | 99.5% |

## Probability

Suspect before court → Suspect convicted

| | Suspect before court | Not suspect before court |
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| Suspect convicted | 95% | 0% |
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| | |
|---|---|
| Suspect before court | 0.5% |
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- Probability distribution, Bayes' rule
- Graphical structure
- Combination of quantitative & qualitative elements
- Bayes, Wigmore, Pearl
- Design and explanation methods?

## Probability

Suspect before court ← Suspect convicted

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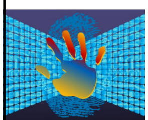
## Probability

Suspect before court ← Suspect convicted

| | Suspect convicted | Not suspect convicted |
|---|---|---|
| Suspect before court | 100% | ~0.025% |
| Not suspect before court | 0% | ~99.975% |

| | |
|---|---|
| Suspect convicted | 0.475% |
| Not suspect convicted | 99.525% |

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



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

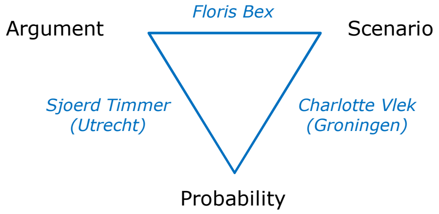
**www.ai.rug.nl/~verheij/nwofs/**

NWO

Netherlands Genomics Initiative

university of groningen

Universiteit Utrecht




Silja Renooij
Henry Prakken

WBOM
SSR

## Legal idioms

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

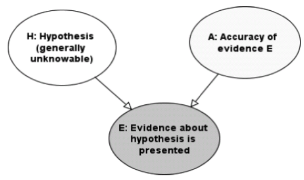
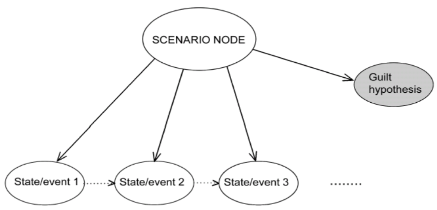



Fig. 6. General idiom to model evidence taking account of its accuracy.

## Legal idioms

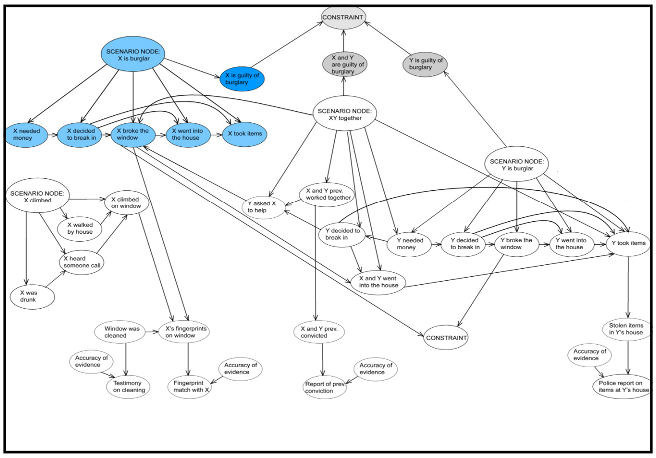
- Narrative idioms
  Our project

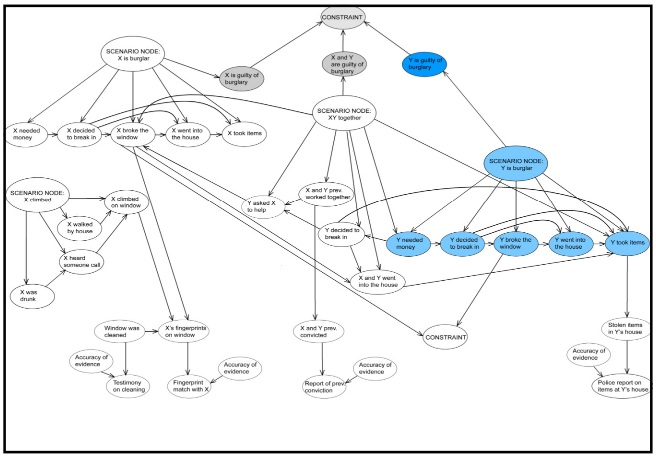


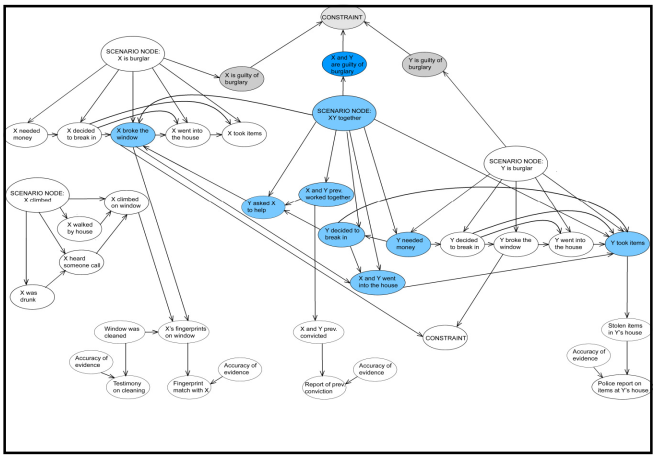

## Design method

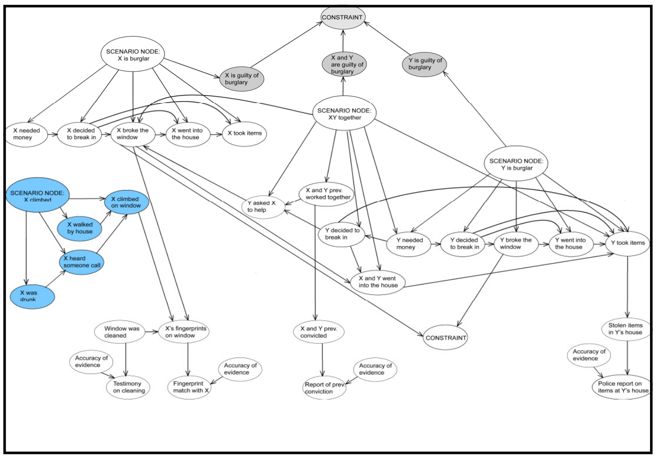
Given a collection of scenarios, we produce a Bayesian network modeling all scenarios.

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.

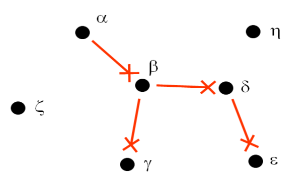
**Explanation 5**
We do not really understand the relation between fact-finding and decision-making.

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

## Issues in formal argumentation theory

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

## Dung's abstract argumentation



## Argumentation semantics 1996

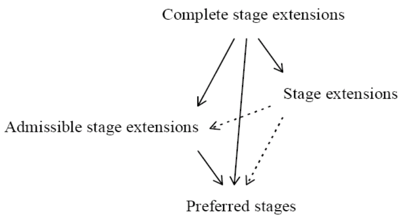
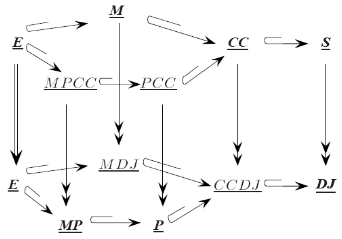
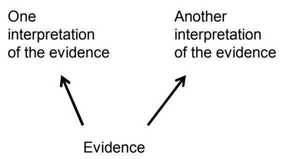



Figure 1: Relations between types of argumentation stages

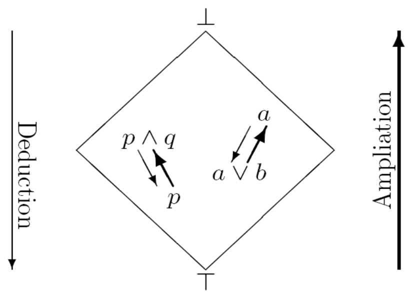
## Argumentation semantics 2003




## Integrating arguments and narrative




## Ampliation & deduction

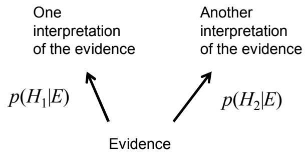



Peirce, Toulmin

## Ampliative argumentation 2010

1. (Logical equivalence)
   If $\phi \mathrel{|\!\sim} \psi$, $\vdash \phi \leftrightarrow \phi'$ and $\vdash \psi \leftrightarrow \psi'$, then $\phi' \mathrel{|\!\sim} \psi'$.
2. (Restricted reflexivity)
   If $\phi \mathrel{|\!\sim} \psi$, then $\phi \mathrel{|\!\sim} \phi$.
3. (Antecedence)
   If $\phi \mathrel{|\!\sim} \psi$, then $\phi \mathrel{|\!\sim} \phi \wedge \psi$.
4. (Right weakening)
   If $\phi \mathrel{|\!\sim} \psi \wedge \chi$, then $\phi \mathrel{|\!\sim} \psi$.
5. (Conjunctive cautious monotony)
   If $\phi \mathrel{|\!\sim} \psi \wedge \chi$, then $\phi \wedge \psi \mathrel{|\!\sim} \chi$.
6. (Mutual attack)
   If $\phi \mathrel{|\!\sim} \psi$, $\phi \mathrel{|\!\sim} \chi$ and $\phi \wedge \psi \mathrel{|\!\not\sim} \chi$, then $\phi \wedge \chi \mathrel{|\!\not\sim} \psi$.
7. (Conjunctive cumulative transitivity, Conjunctive cut)
   If $\phi \mathrel{|\!\sim} \psi$ and $\phi \wedge \psi \mathrel{|\!\sim} \chi$, then $\phi \mathrel{|\!\sim} \psi \wedge \chi$.

## Integrating arguments, narrative *and probability*



## Ampliative argumentation 2012

| | |
|---|---|
| (LE) | If $\phi \mid\!\sim \psi$, $\vdash \phi \leftrightarrow \phi'$ and $\vdash \psi \leftrightarrow \psi'$, then $\phi' \mid\!\sim \psi'$. |
| (Ant) | If $\phi \mid\!\sim \psi$, then $\phi \mid\!\sim \phi \wedge \psi$. |
| (PR) | If $\phi \mid\!\sim \phi \wedge \psi$, then $\phi \mid\!\sim \psi$. |
| (R) | $\phi \mid\!\sim \phi$. |
| (RW) | If $\phi \mid\!\sim \psi \wedge \chi$, then $\phi \mid\!\sim \psi$. |
| (CCM) | If $\phi \mid\!\sim \psi \wedge \chi$, then $\phi \wedge \psi \mid\!\sim \chi$. |
| (CCT) | If $\phi \mid\!\sim \psi$ and $\phi \wedge \psi \mid\!\sim \chi$, then $\phi \mid\!\sim \psi \wedge \chi$. |

## Ampliative argumentation 2012

1. *If* $\vdash \varphi \leftrightarrow \psi$, *then* $v(\varphi) = v(\psi)$.
2. $v(\bot) \leq v(\varphi) \leq v(\top)$.
3. $v(\varphi) \geq v(\varphi \wedge \psi) + v(\varphi \wedge \neg\psi)$.
4. *If* $\psi \vdash \varphi$, *then* $v(\varphi) \geq v(\psi)$.
5. $\varphi \mid\!\sim \bot$ *if and only if* $v(\varphi) = 0$.
6. $\varphi \mid\!\sim \psi$ *if and only if* $v(\varphi) = 0$ *or* $\frac{v(\varphi\wedge\psi)}{v(\varphi)} > \frac{1}{C} - \epsilon$.
7. $\varphi \not\mid\!\sim \psi$ *if and only if* $v(\varphi) > 0$ *and* $\frac{v(\varphi\wedge\psi)}{v(\varphi)} < \epsilon$.

## Related research (some)

**KLM-nonmonotonic inference**
- Axioms now allow alternatives

**Bayesian Networks**
- Structure now has a transparent meaning (reasons)

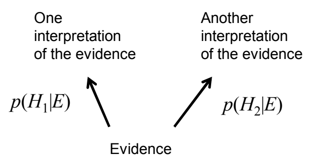
**John Pollock's OSCAR**
- Argumentation is now compatible with probability theory

**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)

**Argumentation Norms**

## 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**

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**IIIb: Argument Strength and Probabilities**

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

For more information on narratives in Bayesian Networks, see:
Vlek, C., Prakken, H., Renooij, S., and Verheij, B. (2013). Modeling crime scenarios in a Bayesian network. *The 14th International Conference on Artificial Intelligence and Law (ICAIL 2013). Proceedings of the Conference*, 150-159. New York (New York): ACM.

For more information on the logic of ampliative argumentation, see:
Verheij, B. (2012). Jumping to Conclusions. A Logico-Probabilistic Foundation for Defeasible Rule-Based Arguments. *Logics in Artificial Intelligence. 13th European Conference, JELIA 2012. Toulouse, France, September 2012. Proceedings (LNAI 7519)* (eds. L. Fariñas del Cerro, A. Herzig, J. Mengin), 411-423. Springer, Berlin.