Evidential and Legal Reasoning in AI – the role of argumentation

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Lecture overview

• 14 April: a logical model of stories and arguments in evidential reasoning

• 15 April: the strength of stories and arguments - introducing probabilities

• 16 April: reasoning with data – and the role of stories and arguments
  – Includes machine learning ;-)
Reasoning with evidence

• The process of proof
  – Reasoning with evidence and commonsense knowledge to determine the facts of the case
Stories vs. Arguments

- Stories are “holistic”
- Stories provide an overview
- Stories encapsulate causal reasoning
- Stories represent how humans order a mass of evidence

- Arguments are “atomistic”
- Arguments provide a means of detailed analysis
- Arguments encapsulate evidential reasoning
- Arguments represent how humans talk about individual evidence
A hybrid model

• Combining stories and arguments
  – Hybrid model

• Arguments from the evidence to conclusions

• Stories explaining the (hypothetical) situations in a case
Argumentation

- The premise provides a reason to believe the conclusion
- In this way, pieces of evidence (e.g. a witness testimony) can be reasons for particular facts of the case
Evidential Arguments

• Arguments based on sources of evidence
  – Given the evidence…

  Witness testimony: “I saw the suspect in London”

  Expert testimony: “The blood on this knife is the victim’s blood”
Evidential Arguments

• Arguments based on sources of evidence
  – …we can infer conclusions

  - The suspect was in London
  - Witness testimony: “I saw the suspect in London”

  - The blood on this knife is the victim’s blood
  - Expert testimony: “The blood on this knife is the victim’s blood”
Complex arguments

- Chains of reasons
  - Conclusions inferred from earlier conclusions

- Witness testimony
  - “I saw the suspect in London”
  - The suspect was in London
  - The suspect was not in Changsha
Complex Arguments

- Linked arguments: both pieces of evidence needed

A knife with the victim’s blood on it was found near the crime scene

- The blood on this knife is the victim’s blood
- The knife was found near the crime scene

Expert testimony

Police report
Commonsense knowledge

• Generalizations: statements about how we think the world around us works
  – the impact of a hammer can break a person’s skull
  – witnesses under oath usually speak the truth
  – Police reports can be trusted
  – Chinese people are smaller than Dutch people
Generalizations

• Generalizations are not always true!
  – Exceptions

• Qualify generalizations with words such as *usually, sometimes*
Generalizations as warrants

The suspect was in London

If a witness says $P$, we can infer that $P$

Witness testimony: “I saw the suspect in London”

The blood on this knife is the victim’s blood

If an expert says $P$, we can infer that $P$

Expert testimony: “The blood on this knife is the victim’s blood”

The knife was found near the crime scene

If a police report states that $P$, we can infer that $P$

Police report: “The knife was found near the crime scene”
Generalizations as warrants

The suspect was not in China

The suspect was in London

London is not in China

Witness testimony: “I saw the suspect in London”
Source of Generalizations

• Generalizations have a source
  – Law
  – Scientific research
  – General Knowledge
  – Prejudice
  – Folk beliefs and superstition

• The source provides a backing for the warrant
Source of Generalizations

The suspect was in London

If a witness says $P$, we can infer that $P$

Witness testimony “I saw the suspect in London”

Federal rules of evidence
Source of Generalizations

The suspect was in London

If a witness sees someone who looks like $x$, the witness saw $x$

Witness testimony
“I saw someone who looked like the suspect in London”

It is general knowledge that if a witness sees someone who looks like $x$, the witness saw $x$”
Counterarguments

• Arguments may be attacked on each of their elements.
  – Counterargument against a premise
    • Not against evidence!
  – Counterargument against a conclusion
  – Counterargument against a warrant
    • exceptions to generalizations
  – Counterargument against a backing
Conclusion attack

The suspect was not in Beijing

The suspect was in London

Witness testimony “I saw the suspect in London”

Witness testimony “I saw the suspect in Beijing”
The suspect was in London

The suspect was not in Beijing

Witness testimony: “I saw the suspect in London”

The suspect’s passport does not show he entered the UK

The suspect was not in London
The suspect was in London

If a witness says $P$, we can infer that $P$

Witness testimony “I saw the suspect in London”

The witness is lying
The witness misremembers
The witness is blind
The evidence is not admissible
Stories

• Stories are coherent sequences of events that explain the evidence in a case
• Tina, a baker’s daughter, had a relationship with John, a small-time criminal
• After breaking up, Tina and her parents go to John’s house to pick up some of her belongings
• A fight develops, which ends in the death of Tina’s father
• Coherent sequence of events

• “We entered John’s house to get some of Tina’s clothes. John became angry and started pushing father. Father tried to protect his daughter and told John to stop. John was so angry that he pulled out a gun and shot father”
Stories

• Coherent sequence of events

  Fight  
  John takes out his gun  
  John shoots father  
  Father dies
Stories

• Coherent sequence of events
  – Causally connected \((c \text{ is a cause for } e)\)
  – Causal connections may remain implicit

Fight \quad \rightarrow \quad \text{John takes out his gun} \quad \rightarrow \quad \text{John shoots father} \quad \rightarrow \quad \text{Father dies}
Explaining evidence

• Coherent sequence of events that explains the observed evidence

1. Fight
2. John takes out his gun
3. John shoots father
4. Father dies

Forensics report
Explaining evidence

• Coherent sequence of events that predicts possible evidence

Fight → John takes out his gun → John shoots father → Father dies

Bullet casings? → Forensics report
Story coherence

• A story is *coherent* if it conforms to our world knowledge

• World knowledge can be encoded as rules/generalizations
  – If you shoot someone they might die

• World knowledge can be encoded as scripts
  – person \( x \) has a motive \( m \) to kill person \( y \)
  – person \( x \) kills person \( y \) (at time \( t \)) (at place \( p \)) (with weapon \( w \))
  – person \( y \) is dead
Generalizations in stories

- A fight might cause someone to take out their gun
- If $x$ shoots $y$, then this might cause $y$ to die

Fight → John takes out his gun → John shoots father → Father dies
Story scripts

**Story Scheme**
- **Motive**
- **Actions**
- **Consequences**

**Actions**
- John takes out his gun
- John shoots father
- Father dies

**Motive**
- Fight
Alternative explanations

• Hypothesize alternatives and compare
Alternative explanations

- Hypothesize *alternatives* and compare

Fight → John takes out his gun → John shoots father → Father dies

Fight → Mother takes out her gun → John pushes gun away → Gun goes off
Alternative explanations

• Inference to the best explanation

Father dies

- John shot father
- Mother (accidentally) shot father
Alternative explanations

- Inference to the best explanation
  - How to compare?
    - Completeness
    - Evidence
    - Plausibility

Father dies

- John shot father
- Mother (accidentally) shot father

choice
Combining arguments & stories

- Stories: “what happened”?
- Arguments: “what is the evidence”?
- Connection: Arguments based on evidence support and attack events in the story
Critical reasoning with evidence

1. There is no coherent story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. Important elements of the story are not supported by evidence.
5. Evidential arguments have not been analysed.
6. Counterarguments to the story have not been taken into consideration.

• These pitfalls are the critical questions for the hybrid theory
1. There is no complete story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. Important elements of the story are not supported by evidence.
5. Evidential arguments have not been analysed.
6. Counterarguments to the story have not been taken into consideration.
1. Complete story

• **Good:** “We entered John’s house to get some of Tina’s clothes. John became angry and started pushing father. Father tried to protect his daughter and told John to stop. John was so angry that he pulled out a gun and shot father”

• **Bad:** “We were in the house and suddenly John shot father”
Story completeness

John takes out his gun → John shoots father → Father dies

Motive → Actions → Consequences

Story script
Story completeness

<table>
<thead>
<tr>
<th>Story Scheme</th>
<th>Motive</th>
<th>Actions</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>John takes out his gun</td>
<td>John shoots father</td>
<td>Father dies</td>
</tr>
</tbody>
</table>

John takes out his gun → John shoots father → Father dies
Pitfalls

1. There is no complete story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. Important elements of the story are not supported by evidence.
5. Evidential arguments have not been analysed.
6. Counterarguments to the story have not been taken into consideration.
2. The story is implausible

- “The fight between father and John started, Tina’s mother pulled a small gun out of her handbag and aimed the gun at John, who tried to push the gun away. The gun accidentally went off and father was hit in the head and died”
2. The story is implausible

• “The fight between father and John started, Tina’s mother pulled a small gun out of her handbag and aimed the gun at John, who tried to push the gun away. The gun accidentally went off and father was hit in the head and died”

• Baker’s wives usually do not carry guns
The story is implausible

“The fight between father and John started, Tina’s mother pulled a small gun out of her handbag and aimed the gun at John, who tried to push the gun away. The gun accidentally went off and father was hit in the head and died”

- Baker’s wives usually do not carry guns
- The chances of a gun accidentally going off and hitting the father are small
2. The story is implausible

Fight → Mother takes out her gun → John pushes gun away → Gun goes off → Father dies

Baker’s wives do not have guns

Chances of gun going off are small
Pitfalls

1. There is no complete story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. Important elements of the story are not supported by evidence.
5. Evidential arguments have not been analysed.
6. Counterarguments to the story have not been taken into consideration.
3. Alternative stories

- Watch out for *tunnel vision*!

- Prosecution’s story
- Defence’s story
- The truth
Pitfalls

1. There is no complete story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. **Important elements of the story are not supported by evidence.**
5. Evidential arguments have not been analysed.
6. Counterarguments to the story have not been taken into consideration.
4. Support story with evidence

Fight

John takes out his gun

John shoots father

Father is hit in the head

Father dies

Forensic report: father was hit by a bullet

Forensic report: father died because of a bullet in his head
4. Support story with evidence

Fight

John takes out his gun

John shoots father

Father is hit in the head

Father dies

Police report: John had a gun

Tina’s testimony: John shot my father

Forensic report: father was hit by a bullet from John’s gun

Forensic report: father died because of a bullet in his head
Pitfalls

1. There is no complete story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. Important elements of the story are not supported by evidence.
5. **Evidential arguments have not been analysed.**
6. Counterarguments to the story have not been taken into consideration.
Fight

John takes out his gun

John shoots father

Father is hit in the head

Father dies

Police report: John had a gun

Tina’s testimony: John shot my father

Forensic report: father was hit by a bullet from John’s gun

Forensic report: father died because of a bullet in his head

5. Analyse Arguments
John takes out his gun

John shoots father

Father is hit in the head

Father dies

Police report: John had a gun

Tina’s testimony: John shot my father

Forensic report: father was hit by a bullet from John’s gun

Forensic report: father died because of a bullet in his head

The witness is lying
Pitfalls

1. There is no complete story about the facts.
2. The story is implausible.
3. Alternative stories have not been considered.
4. Important elements of the story are not supported by evidence.
5. Evidential arguments have not been analysed.
6. Counterarguments to the story have not been taken into consideration.
6. Counterarguments to the story

Fight

Mother takes out her gun

Mother aims at John, John pushes mother

Gun goes off

Father is hit in the head

Father dies

John’s testimony

Forensic report: father died because of a bullet in his head
6. Counterarguments to the story

Fight

Mother takes out her gun

Mother aims at John, John pushes mother

Gun goes off

Father is hit in the head

Father dies

Police report: Mother did not have a gun

John’s testimony

Forensic report: father died because of a bullet in his head
Stories & arguments

• Stories and arguments can be captured as separate structures
  – Stories: causally coherent chains of events
  – Arguments: chains of reasoning from evidence or other propositions to conclusion
Evidential reasoning

One account of the facts

Another account of the facts

Arguments

Evidence

Test:
critical questions
Legal reasoning

One legal account of the case

Another legal account of the case

Arguments

Facts

Test: critical questions
One legal account of the *case*

Another legal account of the *case*

**Facts**

One account of the *facts*

Another account of the *facts*

**Arguments**

Test: *critical questions*

**Evidence**
One legal account of the case

Another legal account of the case

Test: critical questions

Arguments

Facts

One account of the facts

Another account of the facts

Arguments

Evidence

Test: critical questions
Evidence – facts – law

LEGAL ACCOUNT

J killing f was premeditated
J intended to kill f
J killed f

STORY

J made plans to kill f
J shot f
J’s gun

EVIDENCE

f died

f was shot with J’s gun
Start with evidence
Start with evidence

LEGAL ACCOUNT

J killing \( f \) was premeditated
J intended to kill \( f \)
J killed \( f \)

STORY

J made plans to kill \( f \)
J shot \( f \)
f died

EVIDENCE of plans

Gun EVIDENCE

\( f \) was shot with J’s gun
J made plans to kill f

J shot f

f died

f was shot with J’s gun
J killed f

J intended to kill f

J killing f was premeditated

J killed f

f was shot with J’s gun

J made plans to kill f

J shot f

f died

LEGAL ACCOUNT

EVIDENCE

STORY
LEGAL ACCOUNT

J killing f was premeditated

J intended to kill f

J killed f
Start with indictment

LEGAL ACCOUNT

J killing f was premeditated
J intended to kill f
J killed f

STORY

J made plans to kill f
J shot f
f died
f was shot with J’s gun

EVIDENCE

EVIDENCE
Theory building

f died

f was shot with J's gun

EVIDENCE
J shot f → f died

J shot f → f was shot with J’s gun

EVIDENCE
Theory building

LEGAL ACCOUNT
- J killing f was premeditated
- J intended to kill f
- J killed f

STORY
- J made plans to kill f
- J shot f
- f died
- f was shot with J’s gun

EVIDENCE
Theory building

**LEGAL ACCOUNT**

- J killing f was premeditated
- J intended to kill f
- J killed f

**STORY**

- J made plans to kill f
- J shot f
- f died
  - f was shot with J’s gun

**EVIDENCE**
A theory construction perspective on legal reasoning
Conclusion

• Evidential and legal reasoning both use arguments, stories and cases
  – They are very similar

• Arguments, stories and cases are central to all AI & Law