

Dealing with Uncertain Arguments in Artificial Intelligence

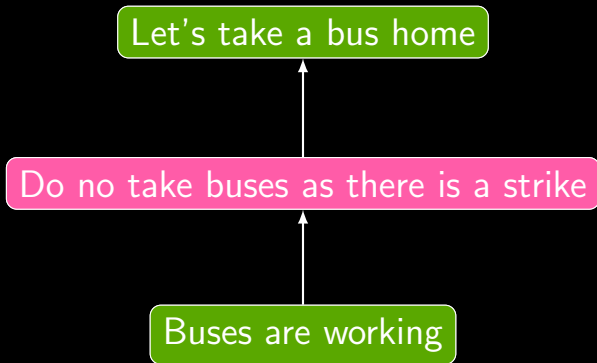
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Argumentation and Artificial Intelligence



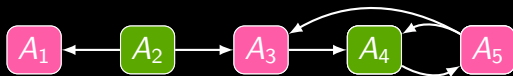
- ▶ Argumentation is a key element of intelligence.
 - ▶ Related to decision making, persuasion, negotiation...
 - ▶ Deductive argumentation is just one possibility.
- ▶ At least since 1995, hot topic within AI (but rather narrow...).
 - ▶ Focusing on abstract arguments and their representation.
 - ▶ Mining them from documents.

An abstract argumentation framework, Dung-style

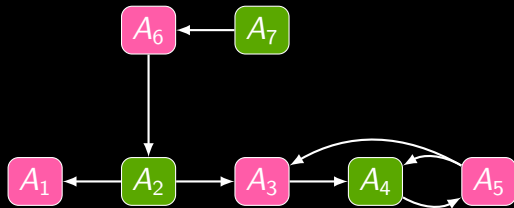


A bit of abstract argumentation, Dung 1995

- Arguments and attacks
(arguments can be propositional formulas, logic programs).
- Since then: supports, preferences, probabilities, etc.



Playing defense



Semantics: labelings

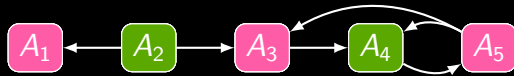
Admissible: conflict-free, accepted arguments defend themselves.

Complete: conflict-free, set of accepted arguments cannot be enlarged by “defend” relation.

Grounded: complete with minimum number of accepted arguments.

Stable: complete with no undecided arguments.

Example



admissible



complete



grounded



stable



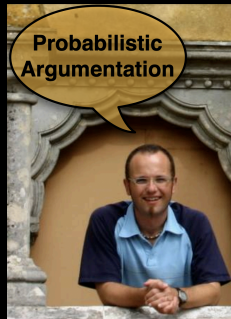
Probabilistic argumentation, Haenni et al 2003...

- Probabilistic *assumptions* and arguments:

$$\mathbb{P}(\text{fever}) = 0.2, \quad \mathbb{P}(\text{rain}) = 0.4.$$

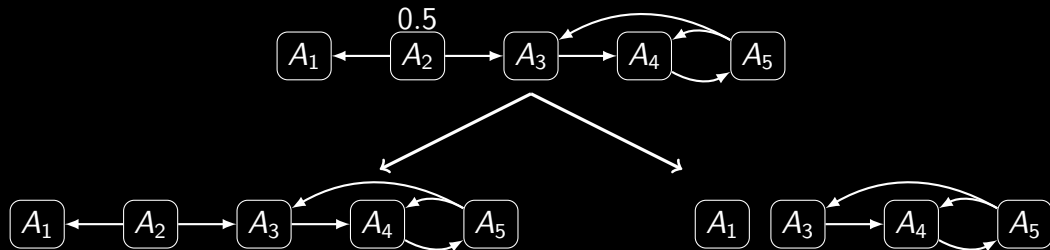
$$\boxed{\neg \text{fever} \wedge \neg \text{rain}} \rightarrow \text{party}.$$

- Degree of support as the probability that at least one argument implies proposition (interpretation: Dempster-Shafter theory).



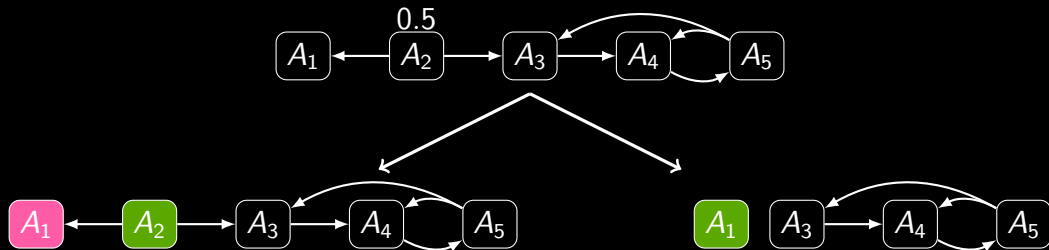
Probabilistic argumentation, Li et al 2011

- Here an argument (and perhaps an attack) has a probability that it is in the argumentation graph.

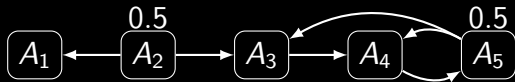


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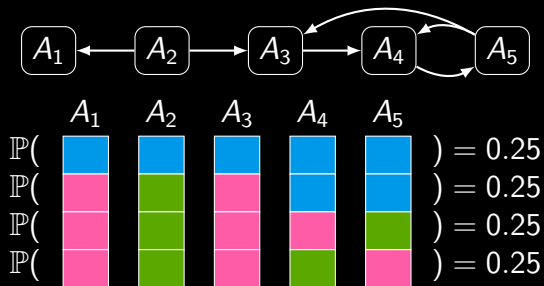
Constellation approach



- ▶ Without independence assumptions, a credal set over arguments (Fazzinga, Flesca, Furfaro 2022).
- ▶ Intuition: someone looking at an agent is evaluating her arguments.

Epistemic approach, Thimm 2012

- ▶ A probability measure is specified over the set of labelings.
- ▶ Example with 5 arguments (5^3 possible labelings).



Epistemic approach: credal sets

- ▶ Attacks impose restrictions on probabilities.
- ▶ For instance, if B attacks A , we might require

$$\mathbb{P}(A) \leq 1 - \mathbb{P}(B). \quad [\text{Property of "coherence" (!)}]$$

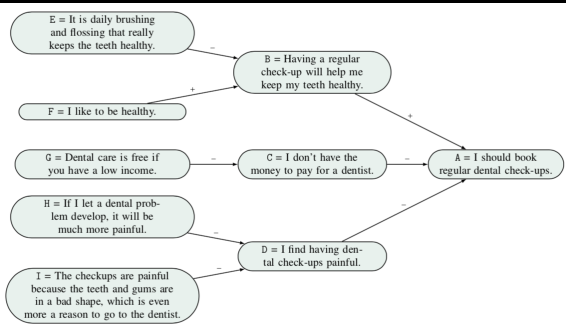
- ▶ For a graph with attacks, the set of probability measures that satisfies "coherence" is closed convex.
 - ▶ Proposal by Thimm (2012): use maximum entropy solution.

Probabilistic extensions

- ▶ An argumentation graph is given, together with constraints.
 - ▶ For instance: A is accepted iff $\mathbb{P}(A) > 0.5$.
 - ▶ For instance: if B attacks A , then $\mathbb{P}(B) > 1/2$ implies $\mathbb{P}(A) \leq 1/2$.
- ▶ We may build the credal set that satisfies constraints.

Epistemic graphs: Hunter, Polberg, Thimm 2020

► Argumentation graph and a collection of constraints.



1. This constraint states that if B is believed or C is disbelieved or D is disbelieved, then A is believed and vice versa:

$$(p(B) > 0.5 \vee p(C) < 0.5 \vee p(D) < 0.5) \leftrightarrow p(A) > 0.5$$

2. This constraint states that if B is at least moderately believed then A is strongly believed, and if B is at least strongly believed then A is completely believed:

$$(p(B) > 0.65 \rightarrow p(A) > 0.8) \wedge (p(B) > 0.8 \rightarrow p(A) = 1)$$

3. This constraint states that if D is strongly disbelieved then A is at least moderately believed

$$p(D) < 0.2 \rightarrow p(A) > 0.65$$

4. This constraint states that if F is believed then B is at least moderately believed and if F is disbelieved, then so is B

$$(p(F) > 0.5 \rightarrow p(B) > 0.65) \wedge (p(F) < 0.5 \rightarrow p(B) < 0.5)$$

5. This constraint states that disbelief in C is proportional to belief in G

$$p(G) + p(C) \leq 1$$

What are these probabilities?

- ▶ Probability/Belief that argument is “true”?
- ▶ Probability/Belief that argument is “accepted”?

Probabilistic argumentation, Dung and Thang 2010

- Set of independent propositions associated with probabilities, and set of rules.

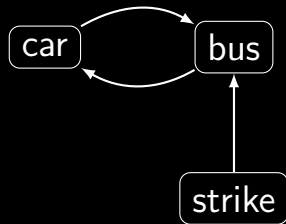
$$\mathbb{P}(A_1) = 0.8, \quad \mathbb{P}(A_2) = 0.75.$$

$$A_1, \text{drivingFast} \rightarrow \text{negligentDriver}.$$

- A prescription to determine attacks amongst arguments.

Argumentation and the credal semantics

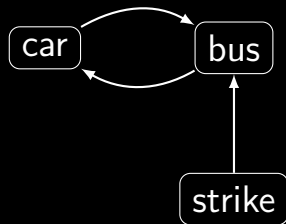
- ▶ $\text{car} :- \text{not bus.}$
- ▶ $\text{bus} :- \text{not car, not strike.}$
- ▶ $\mathbb{P}(\text{strike}) = 0.5.$



- ▶ $\mathbb{P}(\text{car}) = ??$

Argumentation and the credal semantics

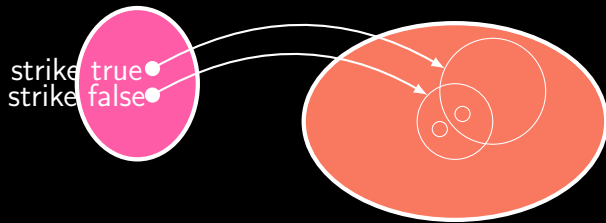
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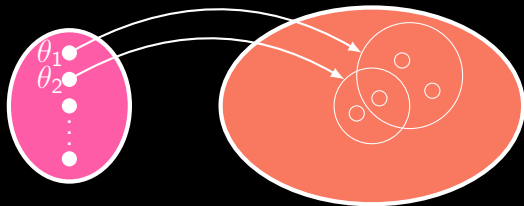
strike	bus	car
true	false	true
false	?	?

$$\underline{\mathbb{P}}(\text{car}) = 0.5, \overline{\mathbb{P}}(\text{car}) = 1.0.$$

Understanding the credal semantics



The credal semantics



- ▶ We have a random set.
- ▶ Lower probabilities: infinitely monotone Choquet capacity.
- ▶ (Inference: IJAR2020; Consistency: KR2022.)

The Blue Amazon

- Key region, not well-known.



Short detour: The BLue Amazon Brain (BLAB)

Language
Português ▾

BLUE AMAZON BRAIN
BLAB

O Blue Amazon Brain incorpora informações sobre a costa marítima brasileira, conhecida como Amazônia Azul. **Saiba mais!**

ChatBot

Um agente especializado na Amazônia Azul

Robô Jornalista

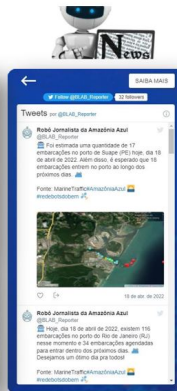
Um robô que gera notícias sobre a Amazônia Azul

Wiki

Uma wiki especializada em temas da Amazônia Azul

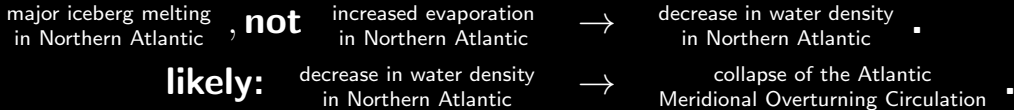
CTRL+F2

Reporter, Chat, Wiki

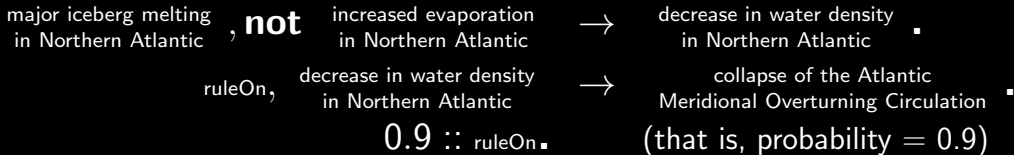


Argumentation about ocean and climate

► State of affairs:



► Modeling through probabilistic facts:



The Atlantic Meridional Overturning Circulation

- ▶ About 18×10^3 tons of water/second.
- ▶ It regulates climate.
- ▶ It has weakened.
- ▶ It is “*very likely*” to decline over the next decades.¹
- ▶ Its collapse is “*likely*” to reduce precipitation in tropical areas.



¹As discussed by: Intergovernmental Panel on Climate Change, Report 2021 (Chapter 9).

Argumentation mining, etc

- ▶ Dealing with given arguments is a part of the whole story.
- ▶ One must extract arguments/attacks/probabilities from sources.
- ▶ And there are specific tasks such as argument classification.

- ▶ Example: dataset IBMD; BERT-based classifier: 95.7% accuracy.
- ▶ Looks good! But graph extraction is still a *huge* challenge.

DISPUtool, Villata et al 2019



The image shows the header and main banner of the DISPUtool website. The header is white and contains the logos of 'uni.lu' (Université du Luxembourg) and 'cnrs' (Centre National de la Recherche Scientifique) on the left, and 'UNIVERSITÉ CÔTE D'AZUR' with a circular logo of dots on the right. To the right of the university names are navigation links: 'Home', 'Explore' (with a dropdown arrow), 'Test Model', 'Legal Notice', and 'Contact'. The main banner features a collage of historical US Presidential election images, including John F. Kennedy, Lyndon B. Johnson, and Barack Obama. Overlaid on this collage is a dark rectangular box containing the text 'DISPUTool' in large white letters, and below it, 'A tool for Mining and Exploring arguments in US Presidential Election Debates From 1960 to 2016' in smaller white text.

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Home Explore ▼ Test Model Legal Notice Contact

DISPUTool

A tool for Mining and Exploring arguments in US Presidential
Election Debates From 1960 to 2016

Conclusion

- ▶ AI research has been interested in flexible representations for uncertainty:
 - ▶ Probabilistic logic (many variants).
 - ▶ Credal networks, causal reasoning.
- ▶ Probabilistic argumentation often relies on credal sets and the like.
 - ▶ Abstract argumentation frameworks (constellation/epistemic).
 - ▶ Probabilistic assumption-based argumentation.
 - ▶ A proposal: arguments based on rules and probabilistic facts.