Lecture 2
Section 3: Probabilistic Argumentation

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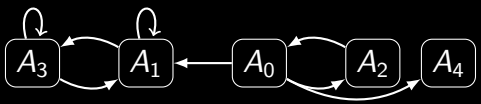
Argumentation

- Argumentation is a key element of intelligence (old topic!).
- Deductive argumentation is just one possibility.
- Argumentation may be non-monotonic, may involve persuasion, negotiation, preferences and decisions...
- It may be necessary to mine and to weigh arguments.

A bit of abstract argumentation

- Dung (1995): arguments and attacks.



- Many variants!
  - Preferences, probabilities, etc.
  - Supports: *bipolar* argumentation frameworks.

Labelings and semantics

- Arguments can be accepted (In), rejected (Out), undecided.
- Then, an *admissible* labeling is a conflict-free labeling such that the accepted arguments defend themselves against attackers.
- And a *complete* labeling is a conflict-free labeling whose accepted arguments cannot be further enlarged by the "defend" relation.

Other labelings

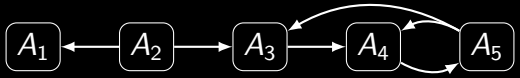
Grounded: complete with minimum number of accepted arguments.

Preferred: complete with maximum number of accepted arguments.

Stable: complete with no undecided arguments.

Semi-stable: complete with minimum number of undecided arguments.

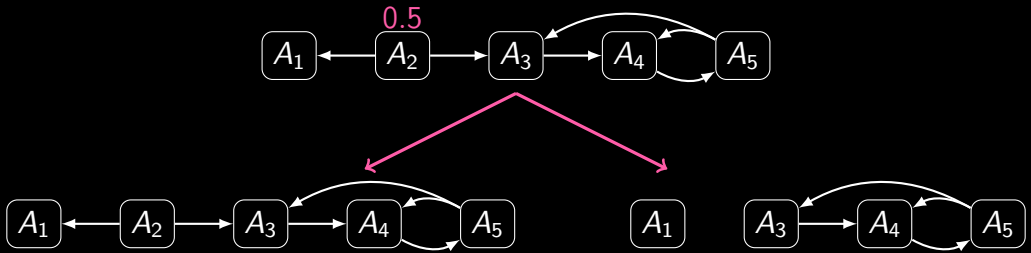
Example (Hunter et al. 2021)



Labeling	a_1	a_2	a_3	a_4	a_5	$\mathcal{AD}$	$\mathcal{CO}$	$\mathcal{GR}$	$\mathcal{PR}$	$\mathcal{ST}$
$\mathcal{L}ab_1$	undec	undec	undec	undec	undec	✓	×	×	×	×
$\mathcal{L}ab_2$	out	in	out	undec	undec	✓	✓	✓	×	×
$\mathcal{L}ab_3$	undec	undec	out	out	in	✓	×	×	×	×
$\mathcal{L}ab_4$	out	in	out	out	in	✓	✓	×	✓	✓
$\mathcal{L}ab_5$	out	in	out	in	out	✓	✓	×	✓	✓

Probabilistic argumentation: Constellation approach

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



Constellation approach

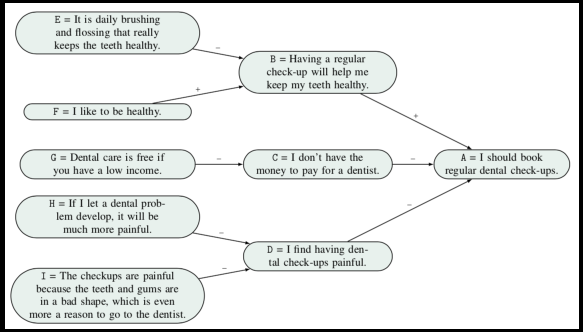
- Independence assumptions are almost always taken to guarantee point probabilities.
  - If not, we obtain a credal set over arguments (Fazzinga, Flesca, Furfaro 2022).
- Intuition: someone looking at an agent is evaluating her arguments.

Epistemic approach

- Each argument is associated with a probability.
  - That it is "true", or perhaps "accepted".
- Attacks impose probabilistic constraints.
  - For instance, if $A \to B$, then $\mathbb{P}(A) > 1/2$ implies $\mathbb{P}(B) \leq 1/2$ (the *rationality* constraint/postulate).
- If constraints are adopted, then they lead to probability bounds.
  - Many constraints can be connected with coherence notions (Baroni, Giacomin, Vicig 2014).

Epistemic graphs (Hunter, Polberg, Thimm 2020)

- Argumentation graph and a collection of probabilistic 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:
$$(p(\mathtt{B}) > 0.5 \vee p(\mathtt{C}) < 0.5 \vee p(\mathtt{D}) < 0.5) \leftrightarrow p(\mathtt{A}) > 0.5$$
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:
$$(p(\mathtt{B}) > 0.65 \rightarrow p(\mathtt{A}) > 0.8) \wedge (p(\mathtt{B}) > 0.8 \rightarrow p(\mathtt{A}) = 1)$$
3. This constraint states that if D is strongly disbelieved then A is at least moderately believed
$$p(\mathtt{D}) < 0.2 \rightarrow p(\mathtt{A}) > 0.65$$
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
$$(p(\mathtt{F}) > 0.5 \rightarrow p(\mathtt{B}) > 0.65) \wedge (p(\mathtt{F}) < 0.5 \rightarrow p(\mathtt{B}) < 0.5)$$
5. This constraint states that disbelief in C is proportional to belief in G
$$p(\mathtt{G}) + p(\mathtt{C}) \leq 1$$

Assumption-based argumentation

- Dung's abstract argumentation frameworks are perhaps *too* abstract.
- There are approaches where the structure of arguments is explicitly specified.
- Most (all?) of them are in essence equivalent to logic programming.
  - Their probabilistic versions can be viewed as versions of probabilistic logic programming...
  - what we saw there applies to assumption-based probabilistic argumentation.