On the Revision of Argumentation Systems: Minimal Change of Arguments Statuses

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Introduction

Abstract Argumentation [Dung 1995]

- An argumentation framework is a pair $\langle \mathcal{A}, \mathcal{R} \rangle$ with $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$:

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- An extension is a set of arguments that can be accepted together thanks to some properties (*e.g.* conflict freeness)
  - Different semantics: Complete, Stable, Preferred, etc.
- The aim is to know whether an argument is accepted or refused (w.r.t. the chosen semantics σ).
  - An argument $\alpha \in \mathcal{A}$ is (skeptically) accepted iff it belongs to every extension of the argumentation framework for the chosen semantics σ:

$$AF \mid\!\sim_{\sigma} \alpha$$

AGM Framework for Belief Change

- Principles of belief change:

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- Set of postulates proposed for belief change operations: to characterize an operator which has a "good" behavior

  [Alchourrón, Gärdenfors and Makinson 1985, Katsuno and Mendelzon 1991]
- Representation theorem: "An operator satisfies the postulates iff it is an instance of a given class."

Belief Change Operations [Gärdenfors 1988]

- A formula α can have three different epistemic statuses in the belief base B of an agent:
  - $B \vdash \alpha$: the agent accepts the information α
  - $B \vdash \neg\alpha$: the agent refuses the information α
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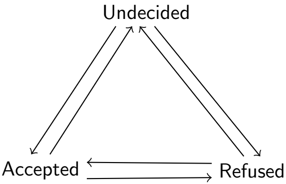
- Belief change operators = transitions between statuses



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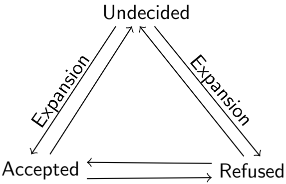

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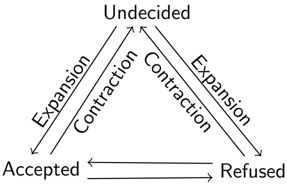

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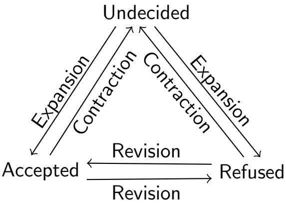

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Dynamics of Abstract Argumentation

- Two components of an argument framework:

  Arguments Statuses | Attacks

- Question: What are the fundamental pieces of information for argumentation?
  - What are the revision inputs ?

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  - What change do we minimize ?

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    - Enforcement [Baumann, Brewka 2010],[Baumann 2012]

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- A two-step process:

$$AF \longrightarrow \text{extensions} \longrightarrow AFs$$

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Definition of the Revision of Argumentation Systems

Revision Formulae

- Formulae on the Arguments

$$\Phi ::= \alpha | \neg\Phi | \Phi \wedge \Phi | \Phi \vee \Phi$$

- Candidate Extension

  A *candidate* or *candidate extension* (CE) is a set of arguments.

- Satisfaction of a Formula by a CE
  - $\varepsilon {\mid\!\sim} \alpha$ iff $\alpha \in \varepsilon$
  - $\varepsilon {\mid\!\sim} \neg\varphi$ iff $\varepsilon \not{\mid\!\sim} \varphi$
  - $\varepsilon {\mid\!\sim} \varphi \wedge \psi$ iff $\varepsilon {\mid\!\sim} \varphi$ and $\varepsilon {\mid\!\sim} \psi$
  - $\varepsilon {\mid\!\sim} \varphi \vee \psi$ iff $\varepsilon {\mid\!\sim} \varphi$ or $\varepsilon {\mid\!\sim} \psi$
- Satisfaction of a Formula by an Argumentation Framework

$$AF {\mid\!\sim}_{\sigma} \varphi \text{ iff } \forall \varepsilon \in Ext_{\sigma}(AF), \varepsilon {\mid\!\sim} \varphi$$

Postulates Expressed with the Extensions

Notation

A_φ denotes the set of the CE which satisfy φ.

Postulates

- **(AE1)** $Ext(AF \star \varphi) \subseteq A_\varphi$
- **(AE2)** If $Ext(AF) \cap A_\varphi \neq \emptyset$ then $Ext(AF \star \varphi) = Ext(AF) \cap A_\varphi$
- **(AE3)** If φ is consistent, then $Ext(AF \star \varphi) \neq \emptyset$
- **(AE4)** If $\mathcal{A}_\varphi = \mathcal{A}_\psi$, then $Ext_\sigma(AF \star \varphi) = Ext_\sigma(AF \star \psi)$
- **(AE5)** $Ext(AF \star \varphi) \cap A_\psi \subseteq Ext(AF \star \varphi \wedge \psi)$
- **(AE6)** If $Ext(AF \star \varphi) \cap A_\psi \neq \emptyset$ then $Ext(AF \star \varphi \wedge \psi) \subseteq Ext(AF \star \varphi) \cap A_\psi$

Representation Theorem (1)

A faithful assignment is a mapping from an argumentation framework $AF = \langle A, R \rangle$ (given a semantics σ) to a total pre-order $\leqslant^{\sigma}_{AF}$ on the set of CE s.t.:

- if $\varepsilon_1 \in Ext_{\sigma}(AF)$ and $\varepsilon_2 \in Ext_{\sigma}(AF)$, then $\varepsilon_1 \simeq^{\sigma}_{AF} \varepsilon_2$
- if $\varepsilon_1 \in Ext_{\sigma}(AF)$ and $\varepsilon_2 \notin Ext_{\sigma}(AF)$, then $\varepsilon_1 <^{\sigma}_{AF} \varepsilon_2$

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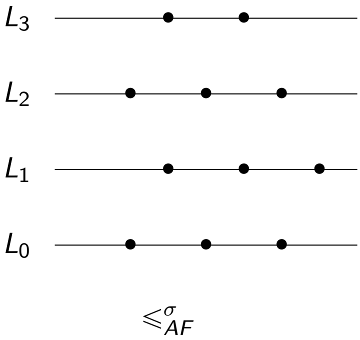
Representation Theorem (2)

Theorem

Given a semantics σ, a revision operator $\star$ satisfies the rationality postulates **(AE1)-(AE6)** iff there exists a faithful assignment which maps every argumentation framework $AF = \langle A, R \rangle$ to a total pre-order $\leqslant_{AF}^{\sigma}$ s.t.:

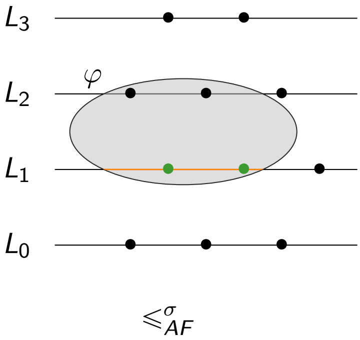
$$Ext_{\sigma}(AF \star \varphi) = \min(A_{\varphi}, \leqslant_{AF}^{\sigma})$$

Example of Pre-Order



- Every point represents a CE
- Level L_0 = σ-extensions of AF
- Other levels = other CEs sorted by "distance"

Choice of Minimal CE



- Shaded area: A_φ
- Green points: minimal elements of A_φ

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A Two-step Process

Distance-based Revision Operators (1)

- Pre-order between CE
  Let AF be an argumentation framework and σ be a semantics. Given d a distance between CE, one defines $\leqslant_{AF}^{\sigma,d}$ by

$$\varepsilon \leqslant_{AF}^{\sigma,d} \varepsilon' \text{ iff } d(\varepsilon, Ext_\sigma(AF)) \leqslant d(\varepsilon', Ext_\sigma(AF))$$

- Example of distance: Hamming Distance
  - $d_H(\varepsilon, \varepsilon') = |(\varepsilon \backslash \varepsilon') \cup (\varepsilon' \backslash \varepsilon)|$
  - $d_H(\varepsilon, \{\varepsilon'_1, \ldots, \varepsilon'_n\}) = \min_{1 \leqslant i \leqslant n} d_H(\varepsilon, \varepsilon'_i)$

Distance-based Revision Operators (2)

- Distance-based Revision Operator
  Let σ be a semantics, and d be a distance between CE.
  The distance-based operator $\star^d$ is defined as

$$Ext_\sigma(AF \star^d \varphi) = \min(A_\varphi, \leqslant_{AF}^{\sigma,d})$$

- Every distance-based operator satisfies the postulates **(AE1)**-**(AE6)**.

Example

- Framework to revise

  $AF =$ (a) (b) (c) $\qquad \varphi = (a \vee b) \wedge (\neg a \vee \neg b)$

- Its (single) stable extension
  - $\{a, b, c\}$
- Revised extensions
  - $Ext_{st}(AF \star \varphi) = \{\{a, c\}, \{b, c\}\}$

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Generation of Corresponding Argumentation Frameworks

- **Remember.** A two-step process:

AF → extensions → AFs

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- **Remember.** A two-step process:

$AF \longrightarrow$ extensions $\longrightarrow AFs$

  - Generation Operator
    A generation operator $\mathcal{AF}_\sigma$ is a mapping from a set of CE $\mathcal{C}$ to a set of argumentation frameworks s.t. $Ext_\sigma(\mathcal{AF}_\sigma(\mathcal{C})) = \mathcal{C}$.
  - Basic Revision Operator

$$AF \star \varphi = \mathcal{AF}_\sigma(\min(A_\varphi, \leqslant^\sigma_{AF}))$$

$\rightarrow$ satisfies the postulates.

Generation of Corresponding Argumentation Frameworks

- **Remember.** A two-step process:

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AFs Generation and Minimality

AF → extensions → *AFs*

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What is minimality in the generation step?

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- Minimal change of the attack relation
- Minimal cardinality of the result

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AF → extensions → *AFs*

Minimal change in the revision step: arguments statuses

What is minimality in the generation step?

- Minimal change of the attack relation
- Minimal cardinality of the result
- Combination of both

Minimal Change of the Attack Relation

- dg: a distance between graphs
- $\mathcal{C}$: a set of CE
- σ: a semantics
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either

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or

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Minimal Cardinality

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Example (2)

$AF =$ 

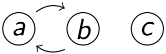
- $\varphi = (a \vee b) \wedge (\neg a \vee \neg b)$
- $Ext_{st}(AF \star \varphi) = \{\{a, c\}, \{b, c\}\}$

Minimal change of attack relation

AF_1

AF_2

Minimal cardinality



AF_3

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Discussion

Discussion

- The result is a set of AFs (not a single AF)
- Meaning of changing/removing/adding an attack between arguments

The result is a set of AFs

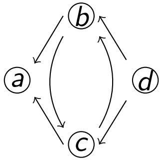
AF → extensions → AFs

The result is a set of AFs

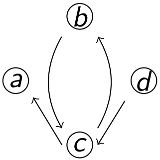
$$AF \curvearrowright \text{extensions} \curvearrowright AFs$$

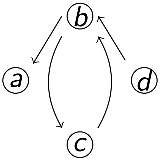
- Usual in Belief Revision!
  - Partial meet contraction functions: $K - \alpha = \bigcap \gamma(K \perp \alpha)$ [Alchourrón, Gärdenfors and Makinson 1985]
  - Flocks [Fagin,Ullman,Vardi 1983]

The result is a set of AFs : Avoid Arbitrary Choices

$AF =$ 

- $\sigma =$ preferred, $Ext(AF) = \{\{a, d\}\}$
- $\varphi = b \vee c$
- b and c play symmetric roles
- Two CEs are at a distance equal to 1 from the extensions of AF: $\{a, b, d\}$ and $\{a, c, d\}$
- 2 solutions:

$AF_1 =$ 

$AF_2 =$ 

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Meaning of changing/removing/adding an attack

- Abstract setting: we do not suppose that the agent knows an underlying logical base
- Preferential Argumentation Framework (PAF)
  - Change in the attacks can be performed by changing the preference relation
- Enthymemes
- More generally, in some situations, it is more conceivable to change the attacks than to “create” a new argument

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Conclusion and Future Work

Conclusion

- Definition of a language to express complex informations about acceptance statuses
- Formal definition of the revision of argumentation systems via an adaptation of the AGM framework
  - Definition of rationality postulates
  - Representation theorem
- Definition of revision operators which satisfy the postulates
  - First step: revision of the extensions, minimal change of arguments statuses
  - Second step: AFs generation, minimal change of the attacks / minimal cardinality
- The paper also present revision operators built from labellings-based distances

Future Work

- Encoding operators in logic, use of SAT
- Study of the generation problem with CE and labellings
  - Realizability [Dunne, Dvořák, Linsbichler, Woltran]
- Study of other kind of revision:
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  - minimal change on the graph
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Thank you for your attention!

Changing Attacks vs Adding Arguments

Social Issues: Taxation

Every possible argument about taxation has been stated:

- pro:
  - The state needs it
  - Allows to protect weakest people
  - ...
- cons:
  - Personal freedom / responsability
  - Rich people prefer leaving the country rather than paying high taxes
  - ...

- In this kind of situations, it is more conceivable to change the attacks than to "create" a new argument

Application Example

Gabbriellini et Torroni 2013 MS Dialogues: Persuading and getting persuaded, A model of social network debates that reconciles arguments and trust

- Two agents A and B debate on a social network, each has her own "internal" argumentation system
- A uses an argument a which is not accepted by B, but B considers that A is trustworthy: B must revise her argumentation system to incorporate a in the accepted arguments wrt her internal system
- This process can be extended to formulae