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An Extension-Based Approach to Belief Revision in Abstract Argumentation

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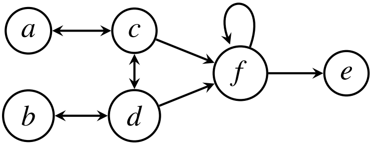
BUENOS AIRES

Introduction

- Abstract Argumentation Framework (AF) [Dung, 1995]:



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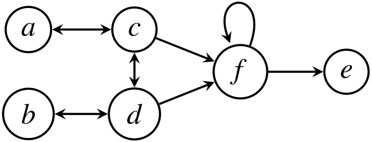

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- Extension: set of jointly acceptable arguments

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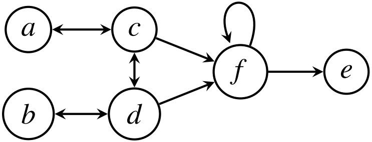

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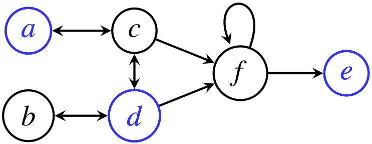

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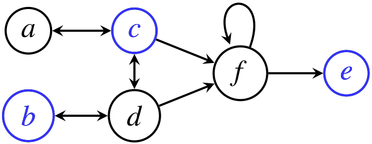

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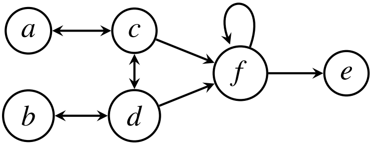

- Evaluation: argumentation semantics
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$$\textit{stable}(F) = \{\{a, d, e\}, \{b, c, e\}\}$$

- Further semantics: preferred, complete, semi-stabe, stage, ...

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Model-based revision	Extension-based revision
Knowledge base Model Revision formula	Argumentation framework Extension wrt. σ 1. Formula / 2. AF
Knowledge base	Argumentation framework

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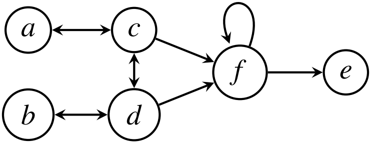

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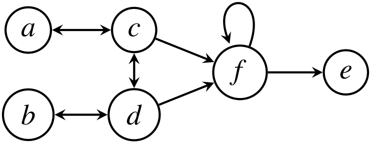

$$\{\{a, d, e\}, \{b, c, e\}, \color{red}{\{a, b, e\}}\}$$

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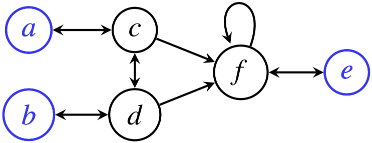

$$\textit{stable}(F') = \{\{a, d, e\}, \{b, c, e\}, \{a, b, e\}\}$$

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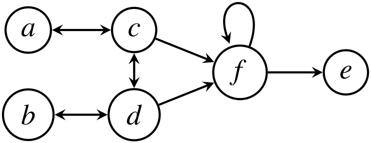

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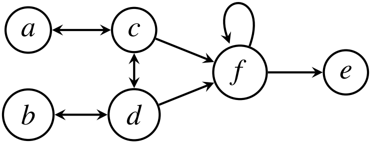

$$\{\{a, d, e\}, \{b, c, e\}, \color{red}{\{a, b\}}\}$$

There exists no argumentation framework having this extension-set under stable semantics!

Main Contributions

- Representation theorems: Correspondence between revision operators captured by rankings and revision operators given by (extended) set of AGM postulates.
- Revision by propositional formulas
  - $\star_\sigma : AF_{\mathfrak{A}} \times \mathcal{P}_{\mathfrak{A}} \mapsto AF_{\mathfrak{A}}$
- Revision by argumentation frameworks
  - $*_\sigma : AF_{\mathfrak{A}} \times AF_{\mathfrak{A}} \mapsto AF_{\mathfrak{A}}$

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Tool-Kit:

- Realizability results for AF semantics [Dunne et al., 2014]
  - Exact characterization of realizable extension-sets Σ_σ
- Horn belief revision [Delgrande and Peppas, 2015]
  - How to modify postulates and rankings in order to stay in the fragment

Covered Semantics

Definition (Proper I-maximal Semantics)

A semantics σ is called proper I-maximal if for each $\mathbb{S} \in \Sigma_\sigma$:

1. for all $S_1, S_2 \in \mathbb{S}$: $S_1 \subseteq S_2$ implies $S_1 = S_2$
2. for all $\emptyset \neq \mathbb{S}' \subseteq \mathbb{S}$: $\mathbb{S}' \in \Sigma_\sigma$
3. for all $\subseteq$-incomparable extensions S_1, S_2: $\{S_1, S_2\} \in \Sigma_\sigma$

Examples:

- stable semantics
- preferred semantics
- semi-stable semantics
- stage semantics

1. Revision by Propositional Formula

$\star_\sigma$: $AF_{\mathfrak{A}} \times \mathcal{P}_{\mathfrak{A}} \mapsto AF_{\mathfrak{A}}$:

(P⋆1) $\sigma(F \star_\sigma \varphi) \subseteq [\varphi]$.

(P⋆2) If $\sigma(F) \cap [\varphi] \neq \emptyset$ then $\sigma(F \star_\sigma \varphi) = \sigma(F) \cap [\varphi]$.

(P⋆3) If $[\varphi] \neq \emptyset$ then $\sigma(F \star_\sigma \varphi) \neq \emptyset$.

(P⋆4) If $\varphi \equiv \psi$ then $\sigma(F \star_\sigma \varphi) = \sigma(F \star_\sigma \psi)$.

(P⋆5) $\sigma(F \star_\sigma \varphi) \cap [\psi] \subseteq \sigma(F \star_\sigma (\varphi \wedge \psi))$.

(P⋆6) If $\sigma(F \star_\sigma \varphi) \cap [\psi] \neq \emptyset$ then $\sigma(F \star_\sigma (\varphi \wedge \psi)) \subseteq \sigma(F \star_\sigma \varphi) \cap [\psi]$.

[Alchourrón et al., 1985, Katsuno and Mendelzon, 1991, Coste-Marquis et al., 2014]

1. Revision by Propositional Formula

Definition (σ-compliance)

A pre-order $\preceq$ is σ-compliant if for every formula φ it holds that $\min([\varphi], \preceq)$ is realizable under σ.

Example ($\sigma \in \{$*stable*, *preferred*, *stage*, *semi-stable*$\}$)

- $\varphi = \neg(a \wedge b \wedge c)$
- $\{a, b, c\} \prec \{a, b\} \approx \{a, c\} \approx \{b, c\} \prec \{a\} \approx \{b\} \approx \{c\} \prec \emptyset$
  - $\min([\varphi], \preceq) = \{\{a, b\}, \{a, c\}, \{b, c\}\} \notin \Sigma_\sigma$
  - $\preceq$ is not σ-compliant
- $\{a, b, c\} \prec' \{a\} \approx' \{b\} \approx' \{c\} \prec' \{a, b\} \prec' \{a, c\} \prec' \{b, c\} \prec' \emptyset$
  - $\preceq'$ is σ-compliant
  - For instance, $\min([\varphi], \preceq') = \{\{a\}, \{b\}, \{c\}\} \in \Sigma_\sigma$

1. Revision by Propositional Formula

Definition

Given semantics σ and AF F, a pre-order $\preceq_F$ is a faithful ranking if it is total and for any sets E_1, E_2 and AFs F, F_1, F_2:

- (i) if $E_1, E_2 \in \sigma(F)$, then $E_1 \approx_F E_2$,
- (ii) if $E_1 \in \sigma(F)$ and $E_2 \notin \sigma(F)$, then $E_1 \prec_F E_2$,
- (iii) if $\sigma(F_1) = \sigma(F_2)$, then $\preceq_{F_1} = \preceq_{F_2}$.

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Theorem

An operator $\star_\sigma$ satisfies postulates P$\star$1 – P$\star$6 for proper I-maximal semantics σ

iff

there exists an assignment mapping each AF F to a faithful and σ-compliant ranking $\preceq_F$ such that $\sigma(F \star_\sigma \varphi) = \min([\varphi], \preceq_F)$.

2. Revision by Argumentation Framework

$*_\sigma$: $AF_{\mathfrak{A}} \times AF_{\mathfrak{A}} \mapsto AF_{\mathfrak{A}}$:

(A∗1) $\sigma(F *_\sigma G) \subseteq \sigma(G)$.

(A∗2) If $\sigma(F) \cap \sigma(G) \neq \emptyset$, then $\sigma(F *_\sigma G) = \sigma(F) \cap \sigma(G)$.

(A∗3) If $\sigma(G) \neq \emptyset$, then $\sigma(F *_\sigma G) \neq \emptyset$.

(A∗4) If $\sigma(G) = \sigma(H)$, then $\sigma(F *_\sigma G) = \sigma(F *_\sigma H)$.

(A∗5) $\sigma(F *_\sigma G) \cap \sigma(H) \subseteq \sigma(F *_\sigma f_\sigma(\sigma(G) \cap \sigma(H)))$.

(A∗6) If $\sigma(F *_\sigma G) \cap \sigma(H) \neq \emptyset$, then
$\sigma(F *_\sigma f_\sigma(\sigma(G) \cap \sigma(H))) \subseteq \sigma(F *_\sigma G) \cap \sigma(H)$.

(*Acyc*) If for $0 \leq i \leq n$ we have $\sigma(F *_\sigma G_{i+1}) \cap \sigma(G_i) \neq \emptyset$ and
$\sigma(F *_\sigma G_0) \cap \sigma(G_n) \neq \emptyset$ then $\sigma(F *_\sigma G_n) \cap \sigma(G_0) \neq \emptyset$.

2. Revision by Argumentation Framework

Definition

Given semantics σ and AF F, a pre-order $\preceq_F$ is an I-faithful ranking if it is I-total and for any $\subseteq$-incomparable sets E_1, E_2 and AFs F, F_1, F_2:

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*An operator $*_\sigma$ satisfies postulates A$*$1 – A$*$6 + (Acyc) for proper I-maximal semantics σ*

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$\Rightarrow$ standard model-based revision operators (e.g. [Dalal, 1988]) work.

Conclusion

Summary:

- Extension-based revision resulting in a single AF
- Combining recent results in argumentation and belief revision
- Different representation theorems:
  - Revision by propositional formulas
  - Revision by argumentation frameworks

Future work:

- Concrete operators
- Other semantics
- Minimal-change criteria for the realizing AFs
- Iterated revision of AFs

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