Bilateral Gradual Semantics for Weighted Argumentation

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Overview

Bilateral gradual semantics for weighted argumentation

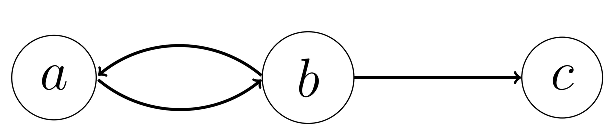
- Evaluate argument strength through a **bilateral** perspective
- Propose **desirable principles** for our semantics
- Provide three **well-behaved** semantics

Argumentation Graph

Abstract argumentation is a well-studied model for evaluating arguments in conflict situations.

An **Argumentation Graph** is a pair $\langle \mathcal{A}, \mathcal{R} \rangle$, where

- $\mathcal{A}$ is a finite set of arguments,
- $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$ is an attack relation between arguments.



a, b attacks each other, b attacks c

Extension Semantics:

- Select sets of arguments with desirable principles
- Accepts $\{a, c\}$ or $\{b\}$ but not $\{a, b, c\}$

Weighted Argumentation Graph

A **Weighted Argumentation Graph** is a triple $\mathbf{G} = \langle \mathcal{A}, w, \mathcal{R} \rangle$, where

- $\mathcal{A}$ is a finite set of arguments,
- w is a weighting function from $\mathcal{A}$ to $[0, 1]$,
- $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$ is an attack relation between arguments.

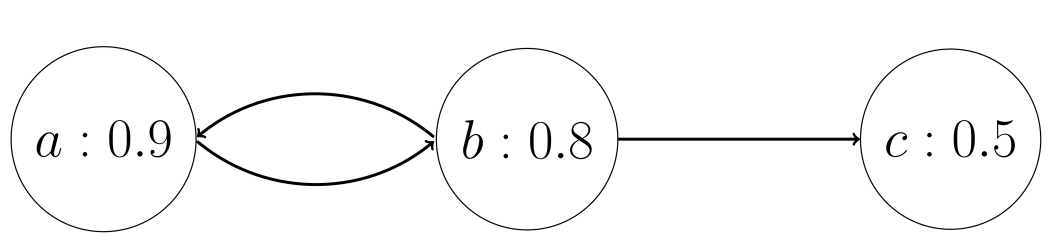
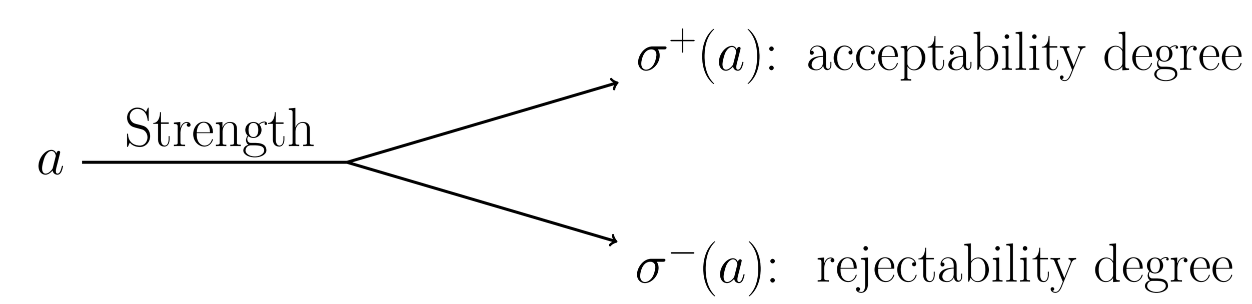


Figure. Arguments with basic weights

Gradual semantics assign each argument an **acceptability degree**, representing its **strength**, along with a set of desirable principles.

Bilateral Gradual Semantics

Motivation: Argument strength of *positivity* and *negativity* should be separately considered in the evaluative process.



A **Bilateral Gradual Semantics** (BGS) $\mathcal{S}$ transforms any WAG $\mathbf{G} = \langle \mathcal{A}, w, \mathcal{R} \rangle$ to a function $Deg^{\mathcal{S}}_{\mathbf{G}}$: $\mathcal{A} \to [0,1] \times [0,1]$. For any $a \in \mathcal{A}$, $Deg^{\mathcal{S}}_{\mathbf{G}}(a) = (\sigma^{+}_{\mathbf{G}}(a), \sigma^{-}_{\mathbf{G}}(a))$ where $\sigma^{+}_{\mathbf{G}}(a)$ and $\sigma^{-}_{\mathbf{G}}(a)$ represent the acceptability and rejectability degree of a respectively.

Non-reciprocity of BGS

Degree	Source of Strength
acceptability	• basic weight • acceptability degree of attackers • rejectability degree of attackers
rejectability	• acceptability degree of attackers

Principles for BGS

Basic items	Anonymity Equivalence	Independence Resilience	Directionality Proportionality
Symmetric	A-Neutrality R-Neutrality A-Reinforcement R-Reinforcement	A-Weakening R-Strengthening A-Weakening Soundness R-Strengthening Soundness	A-Counting R-Counting A-Maximality R-Minimality
Defense	Weakened Defense	Strict Weakened Defense	
Strategies	Quality Precedence	Cardinality Precedence	Compensation

- A-Counting: acceptability degree decreases as attackers increase
- R-Counting: rejectability degree increases as attackers increase
- **Quality Precedence** (QP) prioritizes the quality of attackers.
- **Cardinality Precedence** (CP) prioritizes the quantity of attackers.
- **Compensation** considers both the quantity and quality of attackers.

Foundations for Semantics

Quality Precedence Iterative Function	$f^i(a) = \frac{w(a)}{1+\max_{b\in Att(a)} \frac{f^{i-1}(b)}{1+g^{i-1}(b)}}$ $g^i(a) = \frac{\max_{b\in Att(a)} f^{i-1}(b)}{1+\max_{b\in Att(a)} f^{i-1}(b)}$
Cardinality Precedence Iterative Function	$f^i(a) = \frac{w(a)}{1+\lvert Att^*(a)\rvert+\frac{1}{n}\cdot\Sigma_{b\in Att^*(a)}\frac{f^{i-1}(b)}{1+g^{i-1}(b)}}$ $g^i(a) = \frac{\lvert Att^*(a)\rvert+\frac{1}{n}\cdot\Sigma_{b\in Att^*(a)} f^{i-1}(b)}{1+\lvert Att^*(a)\rvert+\frac{1}{n}\cdot\Sigma_{b\in Att^*(a)} f^{i-1}(b)}$
Compensation Iterative Function	$f^i(a) = \frac{w(a)}{1+\lvert Att^*(a)\rvert+\Sigma_{b\in Att^*(a)}\frac{f^{i-1}(b)}{1+g^{i-1}(b)}}$ $g^i(a) = \frac{\lvert Att^*(a)\rvert+\Sigma_{b\in Att^*(a)} f^{i-1}(b)}{1+\lvert Att^*(a)\rvert+\Sigma_{b\in Att^*(a)} f^{i-1}(b)}$

`Theorem`: All iterative functions converge as i approaches ∞.

Semantics

Three semantics for Quality Precedence, Cardinality Precedence, and Compensation, respectively.

- **AR-max-based Semantics** is defined as the limit of Quality Precedence Iterative Function.
- **AR-card-based Semantics** is defined as the limit of Cardinality Precedence Iterative Function.
- **AR-hybrid-based Semantics** is defined as the limit of Compensation Iterative Function.

	ARM	ARC	ARH
Anonymity	✓	✓	✓
Independence	✓	✓	✓
Directionality	✓	✓	✓
Equivalence	✓	✓	✓
Resilience	✓	✓	✓
Proportionality	✓	✓	✓
A-Neutrality	✓	✓	✓
R-Neutrality	✓	✓	✓
A-Maximality	✓	✓	✓
R-Minimality	✓	✓	✓
A-Weakening	✓	✓	✓
R-Strengthening	✓	✓	✓
A-Weakening soundness	✓	✓	✓
R-Strengthening soundness	✓	✓	✓
A-Counting	-	✓	✓
R-Counting	-	✓	✓
A-Reinforcement	-	✓	✓
R-Reinforcement	-	✓	✓
Weakened Defense	✓	✓	✓
Strict Weakened Defense	-	✓	✓
Quality Precedence	✓	-	-
Cardinality Precedence	-	✓	-
Compensation	-	-	✓

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