Argumentation Meets Computational Social Choice

PART I: Preservation of Semantic Properties
Verifying Semantics in Incomplete AFs

PART II: Gradual Acceptance in Argumentation

PART III: Rationalization
Discussion and Outlook

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Value-based Argumentation Framework
Audience-specific value-based argumentation framework (AVAF)

\[ a \text{ defeats } b \iff (a, b) \in \mathcal{R} \text{ and } \text{val}(b) \not> \text{val}(a) \]

AVAF - Individual Views
Audience-specific value-based argumentation framework (AVAF)

AVAF:

- $AF = \langle A, R \rangle$ with:
  - $A$: arguments
  - $R \subseteq A \times A$: attack relation
- $Val$: finite set of values
- $val : A \rightarrow Val$, assigns a label to each argument
- $(>_{1}, \ldots, >_{n})$: preference orders of the agents on $Val$.

- Agents can express preferences over arguments
- Each agent has an individual view on the given AF
- Attack relation is not the only possible truth
- Agents can declare forbidden values
Rationalization
Given the individual AFs of the agents, can they be derived from some master AF?

Possible choices:

- Values and assignment to arguments
- Individual preferences over the values
- Master attack relation

Motivation:

- Agents become aware of a subset of the arguments
- They choose the attacks from the master AF that do not contradict with their preferences
- Rationalizability is a justification to aggregate the underlying preferences and then infer the aggregated defeats from the master attack relation.

Without constraints rationalization is always possible.

- Master AF equals individual AF
- Values can be chosen arbitrarily
- Preference is indifferent between any two values.

Constraints involving only Val or val are also trivial.
⇒ Non-trivial instances: constraints on the master attack relation.
Rationalizability with a **fixed master attack-relation** can be decided in polynomial time. ⇒ Compatibility of a given AF with some ground truth

Possible choices:
- Values and assignment to arguments
- Individual preferences over the values

Single AF is rationalizable if and only if
- there are no new edges in the individual AF,
- the preference order has to delete all edges not contained in the individual AF, and
- the preference order does not delete edges that should stay.
Rationalizability with a **fixed master attack-relation** and **fixed value-labeling** can be decided in polynomial time.

Possible choices:
- Individual preferences over the values

Single AF is rationalizable if and only if
- there are no new edges in the individual AF,
- the preference order has to delete all edges not contained in the individual AF, but attacks between arguments with the same label cannot be removed, and
- the preference order does not delete edges that should stay.
Rationalizability can be decided in polynomial time in the following case:

- single agent,
- fixed master attack-relation,
- upper bound on the number of values, and
- complete preference order.

Proof by an integer program with at most two variables per inequality.

**Open question:** incomplete preferences
Can the positive results from the single agent case be transferred to the multiagent case?
Is it possible to decompose the problem into single-agent rationalizability problems?

Only the master attack-relation is fixed $\Rightarrow$ solve problems independently, verify global solution

Only the master attack-relation and the value-labeling are fixed $\Rightarrow$ solve problems independently, verify global solution
Deciding rationalizability is NP-complete for the following case:

- fixed master attack-relation
- upper bound on the number of values ($\geq 3$)

Proof by a reduction from Graph Coloring.  
*The proof constructs complete preferences.*

**Open question:** upper bound of 2 on the number of values  
(Graph Coloring with 2 colors is in P)

**Open question:** all agents are aware of the same arguments  
(In the above proof different agents may be aware of different sets of arguments)

BUT: Deciding rationalizability is in P for the following case:

- fixed master attack-relation
- upper bound on the number of values ($\leq 2$)
- there is a common set of arguments
Rationalizability under Expansion Semantics

**Standard semantics:**

1. agents consider a subset of all arguments
2. attack relation: inferred from master attack-relation with individual preferences

**Expansion semantics:**

1. reduce master-attack relation according to individual preferences
2. choose a subset of the arguments

*For the same set of arguments both definitions coincide.*

Rationalizability under expansion semantics:

- expansion of each individual AF that contains all arguments
- rationalize set of expansions under standard semantics
Rationalizability under Expansion Semantics

EXPANSION

\[ \begin{align*}
  a & \rightarrow b & \rightarrow c \\
  d & \rightarrow e & \rightarrow f \\
\end{align*} \]

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\end{align*} \]
Expansion

If there are no constraints on the expansion it holds:

\[
\text{rationalization is possible under standard semantics} \iff \text{rationalization is possible under expansion semantics.}
\]

Types of expansion:

- **Maximal expansion**: accept all attacks from the master attack-relation involving unreported arguments

- **Minimal expansion**: accept no attacks from the master attack-relation involving unreported arguments

For the case of maximal expansions and complete preferences standard semantics and expansion semantics may differ.

For a fixed master attack-relation and maximal expansions it holds again:

\[
\text{rationalization is possible under standard semantics} \iff \text{rationalization is possible under expansion semantics.}
\]
Discussion and Outlook
Argumentation theory can benefit from COMSOC methods:

- by preserving semantic properties when aggregating argumentation frameworks
- by verifying semantics in *incomplete* argumentation frameworks
- by applying social welfare functions to rankings obtained through ranking semantics
- by rationalizing a given set of argumentation frameworks

Results include:

- Characterization results: Which aggregation rule satisfies which combination of semantic properties? Under which conditions is rationalization possible?
- Impossibility results: Only dictatorships can preserve the most demanding semantic properties
- Complexity results: Completeness of natural problems in the lower levels of the polynomial hierarchy
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- **Connection between AF aggregators** and social welfare functions for given ranking semantics
- **Decide rationalizability**
  - for a single agent with a fixed master attack-relation, an upper bound on the number of values and incomplete preferences
  - in the multiagent case with a fixed master attack-relation and a maximum of two values
  - in the multiagent case with a fixed master attack-relation and a common set of arguments for all