Preservation of Semantic Properties during the Aggregation of Abstract Argumentation Frameworks

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Outline

When a group of agents are engaged in a debate, they may disagree on many details. Meanwhile, they may agree on high-level ideas.

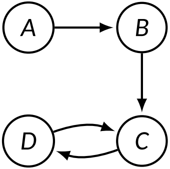
How should we model such scenarios?

- we formulate a model for the study of aggregation of AFs
- we define several semantic properties
- we study the interaction of semantic properties, aggregation rules and its properties

Background: Abstract Argumentation Frameworks

An abstract *argumentation framework (AF)* is a pair $AF = \langle Arg, \rightharpoonup \rangle$, where,

- *Arg* is a finite set of *arguments*
- $\rightharpoonup$ is an irreflexive binary *attack-relation* on *Arg*



A is not attacked by any argument, *B* is *attacked* by *A*,

C, *D* *attack* each other.

P.M. Dung. On the Acceptability of Arguments and its Fundamental Role in NMR, LP and *n*-Person Games. *Artificial Intelligence*, 77(2):321–357, 1995.

Background: Semantics

Given an AF, we say that $\Delta \subseteq Arg$ is:

- *conflict-free* if there exist no arguments $A, B \in \Delta$ such that $A \rightharpoonup B$
- a *grounded extension* if it is the least fixed point of the characteristic function of AF

Terminology: The *characteristic function* of *AF* is the function $f_{AF} : 2^{Arg} \longrightarrow 2^{Arg}$ with $f_{AF} : \Delta \longmapsto \{A \in Arg \mid \Delta \text{ defends } A\}$.

Other semantics: *stable* extension, *preferred* extension, *complete* extension, etc.

Collective Argumentation

Fix a set of *arguments*. Given n *agents* and a *profile* of attack relations $\rightharpoonup = (\rightharpoonup_1, \ldots, \rightharpoonup_n)$. How should we *aggregate* this information?

Semantic Properties

What AF-properties are preserved under aggregation?

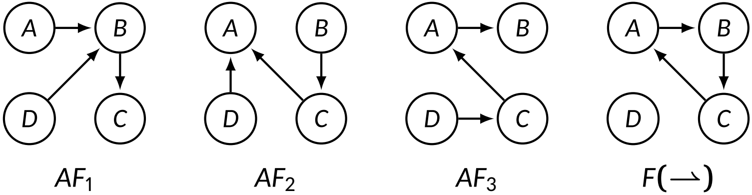
We are interested in *semantic properties* such as:

- *acyclicity*
- *nonemptiness* of the grounded extension
- $\Delta \subseteq Arg$ *being an extension* (according to a given semantics)

So, in case all agents agree on one of them being satisfied, we would like to see it preserved under aggregation.

Example

Let F be the *majority rule*. Consider the following example:



Observations:

- *acyclicity* is not preserved
- *nonemptiness* of the grounded extension is preserved

But does the latter result hold in general?

Preservation of Conflict-Freeness

Theorem 1 Every aggregation rule F that is *grounded* preserves *conflict-freeness*.

Proof Idea

- no grounded aggregation rule would *invent* an attack between two arguments

Terminology: an aggregation rule F is called *grounded* if $F(\rightharpoonup_1, \ldots, \rightharpoonup_n) \subseteq (\rightharpoonup_1) \cup \cdots \cup (\rightharpoonup_n)$ for every profile $\boldsymbol{\rightharpoonup}$.

Preservation of Grounded Extensions

Theorem 2 For $|Arg| \geqslant 5$, any unanimous, grounded, neutral, and independent aggregation rule F that preserves *grounded extensions* must be a *dictatorship*.

Proof Idea

- the proof of this theorem makes use of a technique developed by Endriss and Grandi for graph aggregation which is a generalisation of Arrow's seminal result for preference aggregation

U. Endriss and U. Grandi. Graph Aggregation. *Artificial Intelligence*, 245:86–114, 2017.

K.J. Arrow. Social Choice and Individual Values, 2nd ed., John Wiley and Sons, 1963. First edition published in 1951.

Preservation of Acyclicity

Acyclicity is associated with the existence of a *single extension*.

Theorem 3 If $|Arg| \geqslant n$, then under any neutral and independent aggregation rule F that preserves *acyclicity* at least one agent must have *veto powers*.

Proof Idea

- the proof of this theorem relies on a result for a more general property which we call k-exclusiveness
- acyclicity is a k-exclusive property

Terminology: Agent $i \in N$ has *veto powers* under aggregation rule F, if $F(\rightharpoonup) \subseteq (\rightharpoonup_i)$ for every profile $\rightharpoonup$.

Preservation Results

Property	**Rule(s)**
Argument acceptability	
(Holds for all four semantics)	dictatorships
Conflict-freeness	all grounded rules
Admissibility	nomination rule
Grounded extension	dictatorships
Stable extension	nomination rule
Coherence	dictatorships
Nonempty of the GE	veto rules
Acyclicity	veto rules

Summary

In this talk, we have:

- defined a model for aggregation of AFs
- defined desirable semantic properties of AFs
- drawn a picture of the capabilities and limitations of aggregation of AFs

Things that could be done in the future:

- study the preservation of preferred and complete extensions
- study further semantic properties of AFs, going beyond the four classical semantics
- ...