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Toward an Evaluation Procedure for Generalized Argumentation Frameworks

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Overview

- Introduction
- Motivation & Objective
- Background & Contribution
- Strategy & Example
- Conclusions and Future Work

Introduction

- Traditional Abstract Argumentation focused only on the attack relation
- Extended with
  - Bipolarity
  - Weighted Attacks
  - Weighted Arguments
- Generalized Argumentation Frameworks (GAFs)
  - Bipolar and Weighted
  - Can simulate several other frameworks and their semantics

Introduction

- Generalized Argumentation Framework (GAF)
  - A 4-tuple $F = \langle A, S, w_A , w_R \rangle$, where:
    - A is a finite set of arguments,
    - S is a system providing external information on the arguments in A
    - $w_A : A \rightarrow [0, 1]$ assigns a weight to each argument, to be considered as its intrinsic strength, also based on S
    - $w_R : A \times A \rightarrow [-1, 1]$ assigns a weight to each pair of arguments, also based on S
  - Main features
    - Sign distinguishes attacks (+) from supports (–)
      - Sign rule for multiplication = reinstatement
    - Bounded, intuitive weights

Motivation & Objective

- No specific semantics to exploit the specific features of GAFs
  - AFs can be represented as graphs
  - Desiderata
    - Joins degrees of acceptability with clear assessment of defeat (extension, labeling, ranking)
    - Single extension
    - Takes into account all the direct and indirect influences among arguments
    - Can treat cyclic contributions
    - Avoids redundant contributions
    - Intuitive

Idea

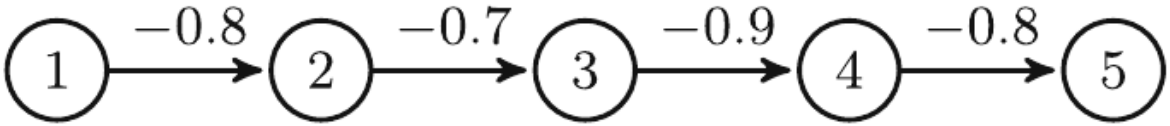
- 2 components
  - Justification propagation strategy
  - Weight combination functions
    - In depth
      - Justification spreading along arcs and paths
      - Different functions for attacks and supports
        - Attack → reinstatement
        - Support → accumulation
    - In breadth
      - Combination of justification contributions from arcs converging on an arguments
  - Every choice of a pair of functions in breadth and in depth defines a semantics

Background

- Previous work
  - Partial strategy
    - Propagation along sequences of arguments only
    - Arguments not weighted
  - Weight combination functions
    - Cumulative function for sequences of supports
    - (sign-based) Reinstatement-aware function for attacks
    - Statistical functions for combination in breadth
      - Min, Max, Avg
- Current Contribution
  - Graph factorization strategy to uniquely turn any graph into sequences

Background

- Previous work: sample cases of homogeneous sequences
  - Attacks



    - 1: (+)1.0; 2: (–)0.2, 3: (+)0.86; 4: (–)0.226; 5: (+)0.8192

$$\forall i = 1, 2, \cdots : \mathrm{ljm}_i(P) = \begin{cases} 1 - |p_1| & \text{if } i = 1 \\ 1 - \mathrm{ljm}_{i-1}(P) \cdot |p_i| & \text{if } i > 1 \end{cases}$$

  - Supports



    - 1: (+)1.0; 2: (+)0.8, 3: (+)0.94; 4: (+)0.994; 5: (+)0.9988

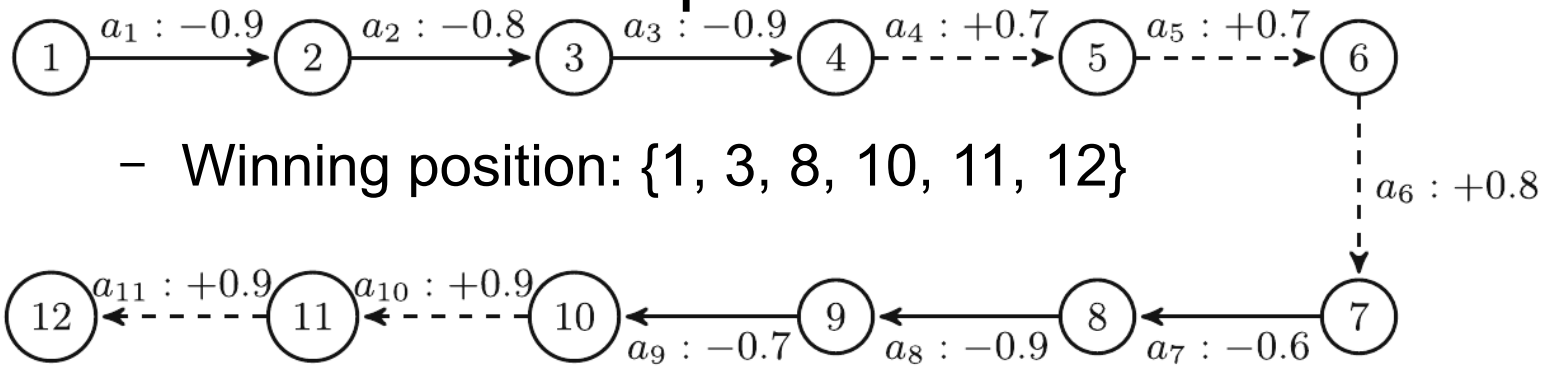
$$\forall i = 0, 1, 2, \cdots : \mathrm{ljm}_i(P) = \begin{cases} p_0 & \text{if } i = 0 \\ \mathrm{ljm}_{i-1}(P) + (1 - \mathrm{ljm}_{i-1}(P)) \cdot p_i & \text{if } i > 0 \end{cases}$$

Background

- Previous work: sample cases
  - John's story
    - Yesterday was a bank holiday
    - Yesterday was a working day for John, a high school teacher
    - Yesterday John was at home, sleeping all day
    - Yesterday morning John was hit by a bicycle
    - Yesterday John fell to the ground
    - Yesterday John’s glasses hit the ground
    - Yesterday John’s glasses got broken
    - Yesterday afternoon John was wearing his glasses
    - John is nearsighted
    - John enjoyed the fireworks
    - Yesterday there were fireworks
    - Yesterday there were flashes in the sky

Background

- Previous work: sample cases



  - Winning position: {1, 3, 8, 10, 11, 12}
    - Yesterday was a bank holiday and John enjoyed the fireworks
  - Other position also internally consistent, but defeated
    - High justification value for defeated arguments {5, 6, 7, 9}: the justification value of the arguments expresses how strong they are within the position they are consistent with

Argument	1	2	3	4	5	6	7	8	9	10	11	12
Subpath type	—	attacks			supports			attacks			supports	
Acceptance	+	−	+	−	−	−	−	+	−	+	+	+
Justification	1.0	0.100	0.920	0.172	0.752	0.926	0.985	0.409	0.632	0.558	0.956	0.996

Weight Combination Functions

- Definitions
  - Given an argument α in an argumentation graph G:
    - The linear justification multiplier for α through a linear path P converging on α in G is the value ljm(α, P) $\in$ [0, 1] representing the composition of attack/support strengths associated to arcs in P
    - The justification multiplier for α is the value jm(α) $\in$ [0, 1] representing the composition of the linear justification multipliers associated to all paths in G that converge on α.
    - The justification value for α is obtained by multiplying its justification multiplier for the intrinsic strength of the argument.

Graph Factorization Strategy

- Decompose the original argumentation graph into two complementary components that
  - together cover the whole graph
  - avoid redundancy (that would result in additional artificial justification contributions):
- Specifically:
  - an acyclic structure, that captures all strictly linear dependencies
  - a suitable collection of cycles, that capture precisely those argumentative interactions that cannot be embedded into the acyclic structure
    - Simple cycles

Graph Factorization Strategy

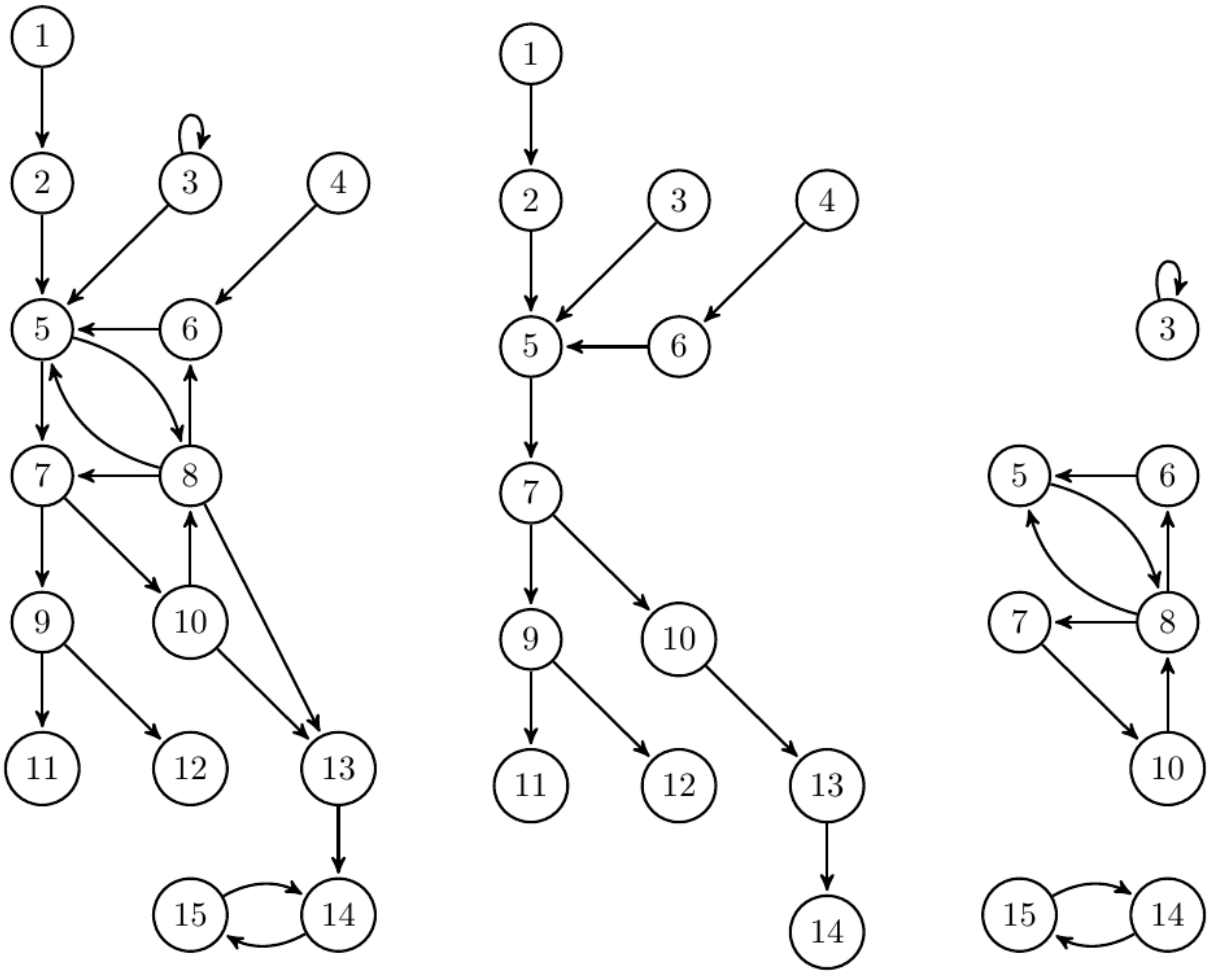
- Concepts
  - Source/sink node
    - Start and end of sequences
  - Source/sink cycle
    - Hide source/sink nodes, must be detached
  - Internal cycle
    - May create redunant contributions
  - (Isolated cycle)
- Each cycle treated as a set of sequences
  - Each obtained by "opening" the cycle in one of its nodes

Graph Factorization Strategy

- Algorithm (sketch)
  - Detach source/sink cycle leaving their 'interfaces'
  - For each cycle, for each of its nodes
    - Obtain a sequence by opening the cycle in the node
  - Build the stratified graph of the residual
    - Layer 0: source nodes
    - Layer *i*, *i*>0: nodes not belonging to previous layers all of whose incoming arcs belong to the previous layers
  - Evaluate all sequences using the functions in depth
  - Evaluate the arguments by composing their contributions in breadth

Graph Factorization Strategy

- Example



Conclusions

- No specific semantics for Generalized Argumentation Frameworks
  - Bipolar, weighted
- Proposed an evaluation strategy based on sequences obtained by a factorization of the argumentation graph
  - Express all relevant direct and indirect relationships among arguments while avoiding redundancy
- Future (current) work
  - Refine and complete the strategy
  - Define options for evaluation functions
  - Study of the formal properties of the strategy
  - Test the framework on artificial and real-world cases