Deciding Acceptance in Incomplete Argumentation Frameworks

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Motivation: The study of computational models of argumentation is an active and vibrant area of modern AI research. Incomplete argumentation frameworks generalize Dung's argumentation frameworks for reasoning under uncertainty. Algorithmic techniques for deciding acceptance in incomplete argumentation frameworks have not been studied to date.

Contributions: Complexity analysis of new variants of skeptical acceptance: exclude nonempty (sets of) extensions to avoid counterintuitive solutions. Design of algorithms for acceptance in IAFs based on SAT solving: make use of observations regarding redundant changes in IAFs. Implementation and empirical evaluation: promising results in terms of practical performance.

INCOMPLETE ARGUMENTATION FRAMEWORKS

Argumentation Framework (AF)
A directed graph \( AF = (A,R) \), where
- \( A \) is the set of arguments
- \( R \subseteq A \times A \) is the attack relation

Semantics define extensions
- Required to be conflict-free (CF)
- \( S \in CF(AF) \) is admissible (AD) if \( S \) attacks every attacker of \( S \)
- \( S \in CF(AF) \) is stable (ST) if \( S \) attacks everything outside \( S \)

Argument accepted credulously (CA) if it is in some extension, skeptically (SA) if it is in all extensions.

Incomplete Argumentation Framework (IAF)
A tuple \( IAF = (A,A',R,R') \), where
- \( A \) and \( R \) are definite arguments and attacks
- \( A' \) and \( R' \) are uncertain arguments and attacks

A standard AF containing all definite elements and any uncertain elements is called a completion.

Example incomplete argumentation framework.

COMPUTATIONAL COMPLEXITY

|                      | s-ESXA | s-PSA | s-PExSA | s-NSA | s-NEXSA |
|----------------------|--------|-------|---------|-------|---------|
| \( CF \subseteq \)   | in P   | in P  | in P    | in P  | in P    |
| \( AD \subseteq \)   | DP-c.  | \( \Sigma^P\)-c. | \( \Sigma^P\)-c. | coNP-c. | \( \Pi^2\)-c. |
| ST                   | DP-c.  | \( \Sigma^P\)-c. | \( \Sigma^P\)-c. | coNP-c. | \( \Pi^2\)-c. |

SAT-BASED ALGORITHMS FOR ACCEPTANCE IN IAFS

Input: \( IAF = (A,A',R,R'), a \in A, s \in \{\text{AD, ST}\} \)
For s-PCA and s-NSA, a single call to a SAT solver suffices.

\[
\begin{align*}
\varphi(a)(IAF) &= \bigwedge_{s \in A} y_s \land \bigwedge_{s \in A} \neg r_{s,s'} \land \bigwedge_{a \in A} \left( \neg y_a \land \bigwedge_{s \in \{a,s',r_{s,s'}\}} \neg r_{s,s'} \right) \\
\varphi_u(IAP_x)(IAF) &= \bigwedge_{s \in A} \left( \left( \bigwedge_{s \in \{a,s',r_{s,s'}\}} \neg r_{s,s'} \right) \land \bigvee_{s \in \{a,s',r_{s,s'}\}} (x_s \land y_s) \right) \\
\varphi_u(IAP_y)(IAF) &= \bigwedge_{s \in A} \left( \left( \bigwedge_{s \in \{a,s',r_{s,s'}\}} \neg r_{s,s'} \right) \land \bigvee_{s \in \{a,s',r_{s,s'}\}} (x_s \land y_s) \right) \\
\varphi(IAF) \land \varphi_u(IAP_x)(IAF) \land x_s \text{ is SAT if } s-PCA \text{ is accept} \\
\varphi(IAF) \land \varphi_u(IAP_y)(IAF) \land \neg x_s \text{ is UNSAT if } s-NSA \text{ is reject}
\end{align*}
\]

EMPIRICAL EVALUATION

NP encodings
- AD-PCA
- ST-PCA
- NEAD-NSA
- ST-NSA

CEGAR for PExSA
- NEAD (strong)
- ST (strong)
- NEAD (trivial)
- ST (trivial)

REFERENCES
Phan Minh Dung. On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and non-person games. Artif. Intell., 77(2):321–357, 1995.
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