From Structured to Abstract Argumentation: Assumption-Based Acceptance via AF Reasoning

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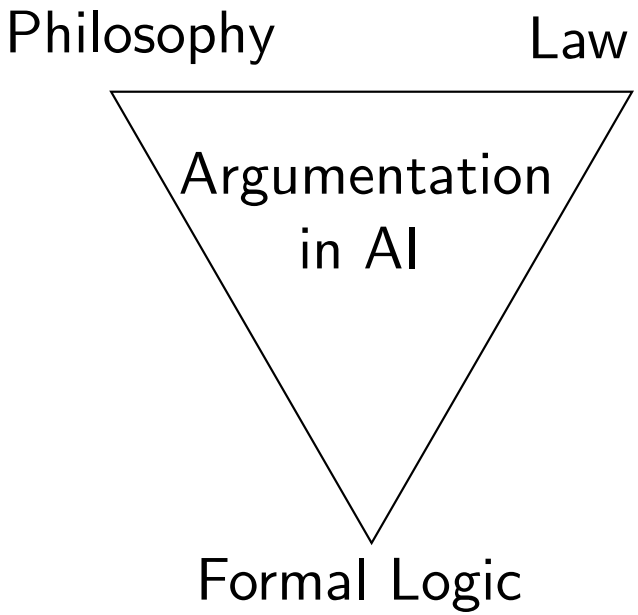
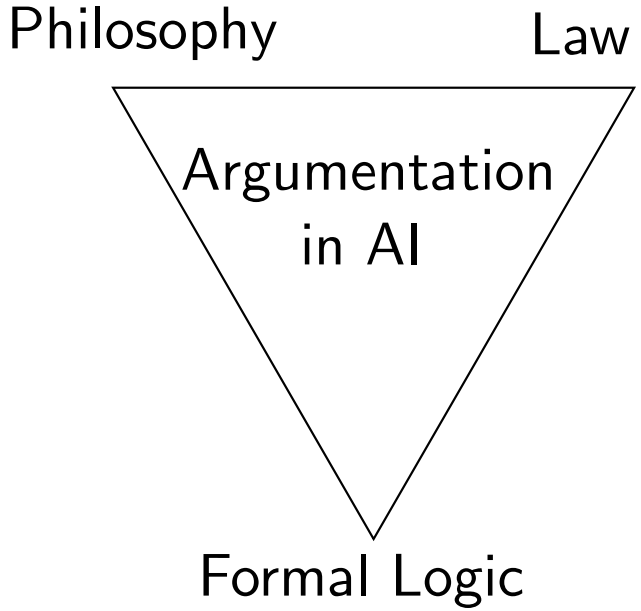
Argumentation in AI



Argumentation in AI

E-Democracy tools

Parmenides
SUPPORTING DEMOCRATIC DECISION-MAKING



Argumentation in AI

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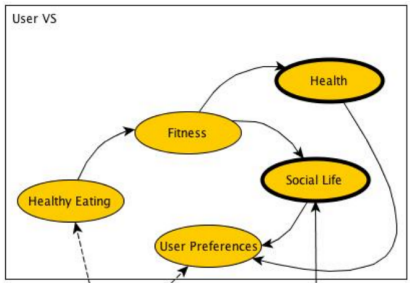
Philosophy

Law

Argumentation in AI

Formal Logic

E-Health tools



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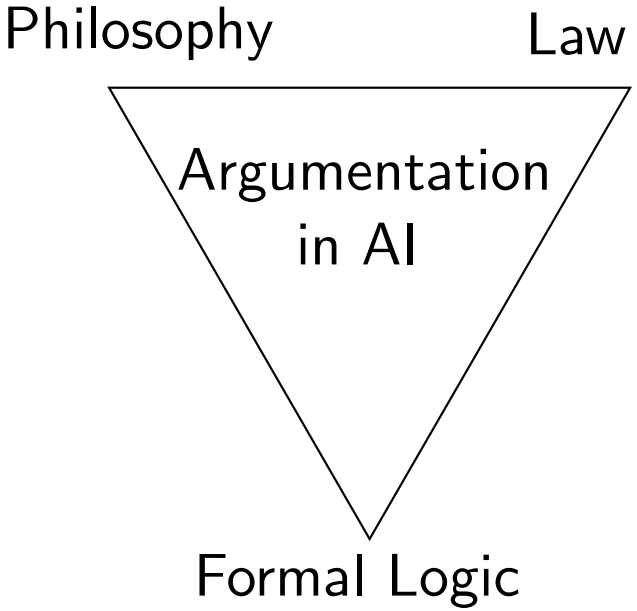
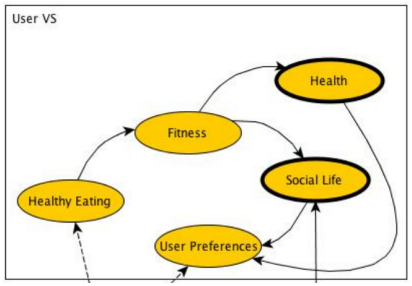


E-Health tools



Workshop series

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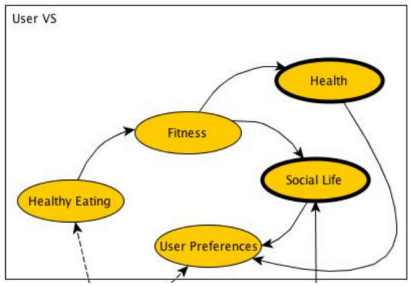


Workshop series

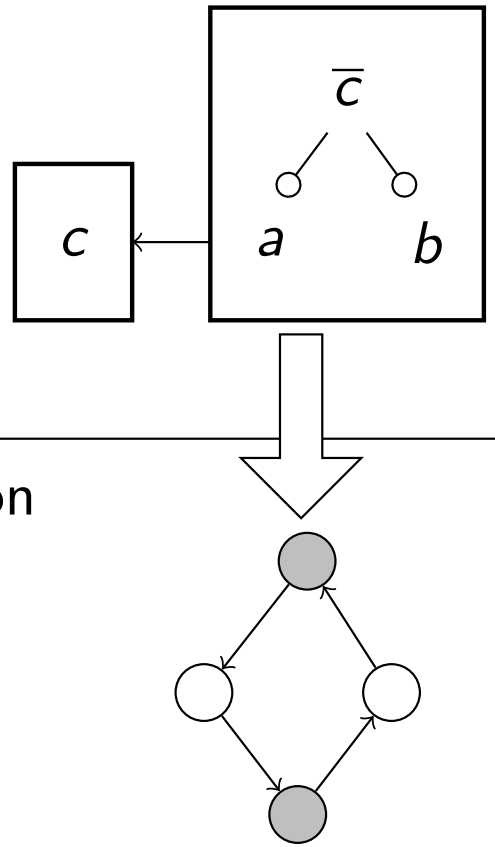
Further applications

- Decision support
- Medical sciences
- Legal reasoning

Formal Argumentation

Structured argumentation

$\overline{c} \leftarrow a, b$
$e \leftarrow d$



- ASPIC+
- Assumption-based
- DeLP
- Deductive argumentation
- Carneades

Abstract argumentation

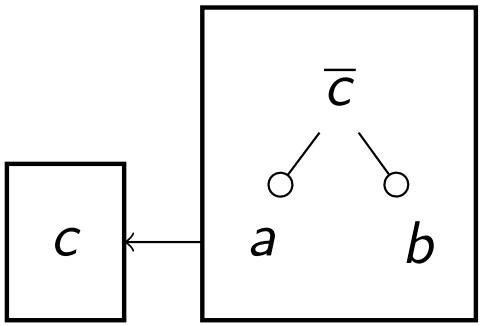
Main formalism:

- Dung's argumentation frameworks

Computational Perspective

Assumption-based argumentation

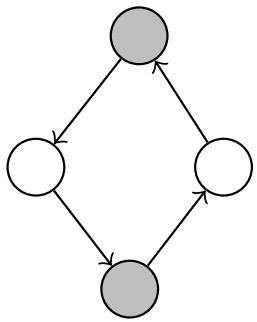
$\overline{c} \leftarrow a, b$
$e \leftarrow d$



- CaSAPI
- proxdd
- grapharg
- abagraph

Argumentation frameworks

?



- ICCMA'15, ICCMA'17
- ASPARTIX
- ArgSemSAT
- ArgTools
- cegartix
- ConArg
- ...

Contributions and outline

Goal

Feasibility of 2-step ABA computation via AFs

- 1st step: construct AF
- 2nd step: solve AF

Formal results

- Restriction on generated arguments "relevant arguments"
- High complexity to compute restriction exactly
- Heuristic algorithm

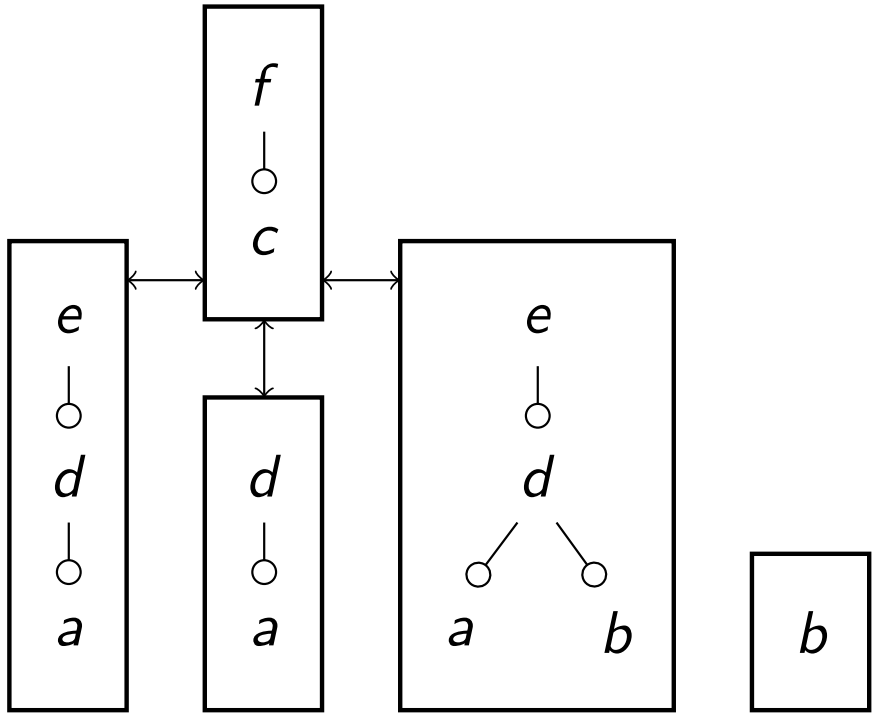
Empirical results

- Implementation
  - Java-based AF translator
  - modified ASPARTIX
- Experiments

Assumption-based argumentation

- Assumptions
- Rules
- Contradictories

$d \leftarrow a$	$A = \{a, b, c\}$
$d \leftarrow a, b$	$\overline{a} = f$
$e \leftarrow d$	$\overline{c} = d$
$f \leftarrow c$	



- Assumption set Δ is
- Conflict-free: assumption set not self-attacking
- Admissible: cf and countering attackers
- Stable: cf and attacks all other assumptions
- Preferred: $\subset$-maximal admissible

AF semantics: similar fashion on abstract arguments

Computational tasks

- Credulous reasoning
- Skeptical reasoning

	ABA		AF	
semantics	cred	skept	cred	skept
admissible	NP-c	P-c	NP-c	trivial
stable	NP-c	coNP-c	NP-c	coNP-c
preferred	NP-c	Π_2^p-c	NP-c	Π_2^p-c

Translating ABA to AF

- Existing translations of ABA to AF without computational perspective
- Care needed:
  - not too many arguments (redundancy)
  - not too few arguments (correctness)
- In the literature: forms of minimality, again without computation

Relevant arguments

- Assumptions: sentence derivable, but not from any proper subset

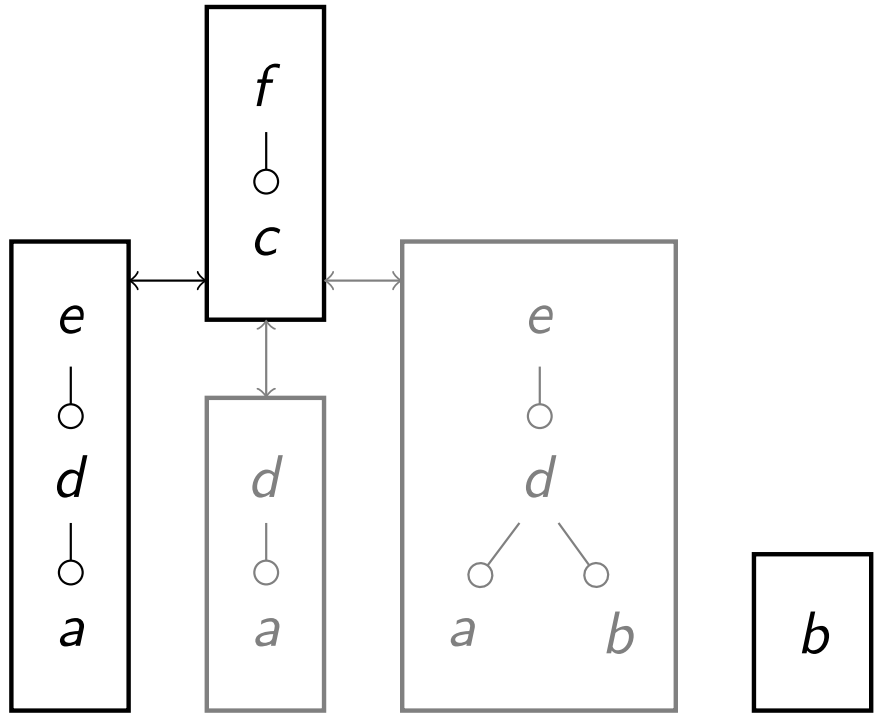
$$\bigcup_{\Delta' \subset \Delta} Th_{\mathcal{R}}(\Delta') \subset Th_{\mathcal{R}}(\Delta)$$

- Sentences: derivable from assumptions, not from a proper subset

$$Th_{\mathcal{R}}(\Delta) \setminus (\bigcup_{\Delta' \subset \Delta} Th_{\mathcal{R}}(\Delta'))$$

Relevant arguments example

$d \leftarrow a$ $\quad A = \{a, b, c\}$
$d \leftarrow a, b$ $\quad \overline{a} = f$
$e \leftarrow d$ $\quad \overline{c} = d$
$f \leftarrow c$



Relevant arguments

- Assumptions: sentence derivable, but not from any proper subset $\bigcup_{\Delta' \subset \Delta} Th_{\mathcal{R}}(\Delta') \subset Th_{\mathcal{R}}(\Delta)$
- Sentences: derivable from assumptions, not from a proper subset $Th_{\mathcal{R}}(\Delta) \setminus (\bigcup_{\Delta' \subset \Delta} Th_{\mathcal{R}}(\Delta'))$

Formal Results

- Construct AF with
  - set of arguments = relevant arguments
  - attacks: based on contrariness of ABA

Correspondence

- Δ σ-assumption-set $\Rightarrow$ $E = \{(L, \Delta') \in A \mid \Delta' \subseteq \Delta\}$ σ-extension
- E is a σ-extension $\Rightarrow$ $\Delta = \bigcup_{(L,\Delta')\in E} \Delta'$ is a σ-assumption-set
- Sentences derivable correspond

Theorem

Counting the number of relevant arguments is #P-complete under subtractive reductions.

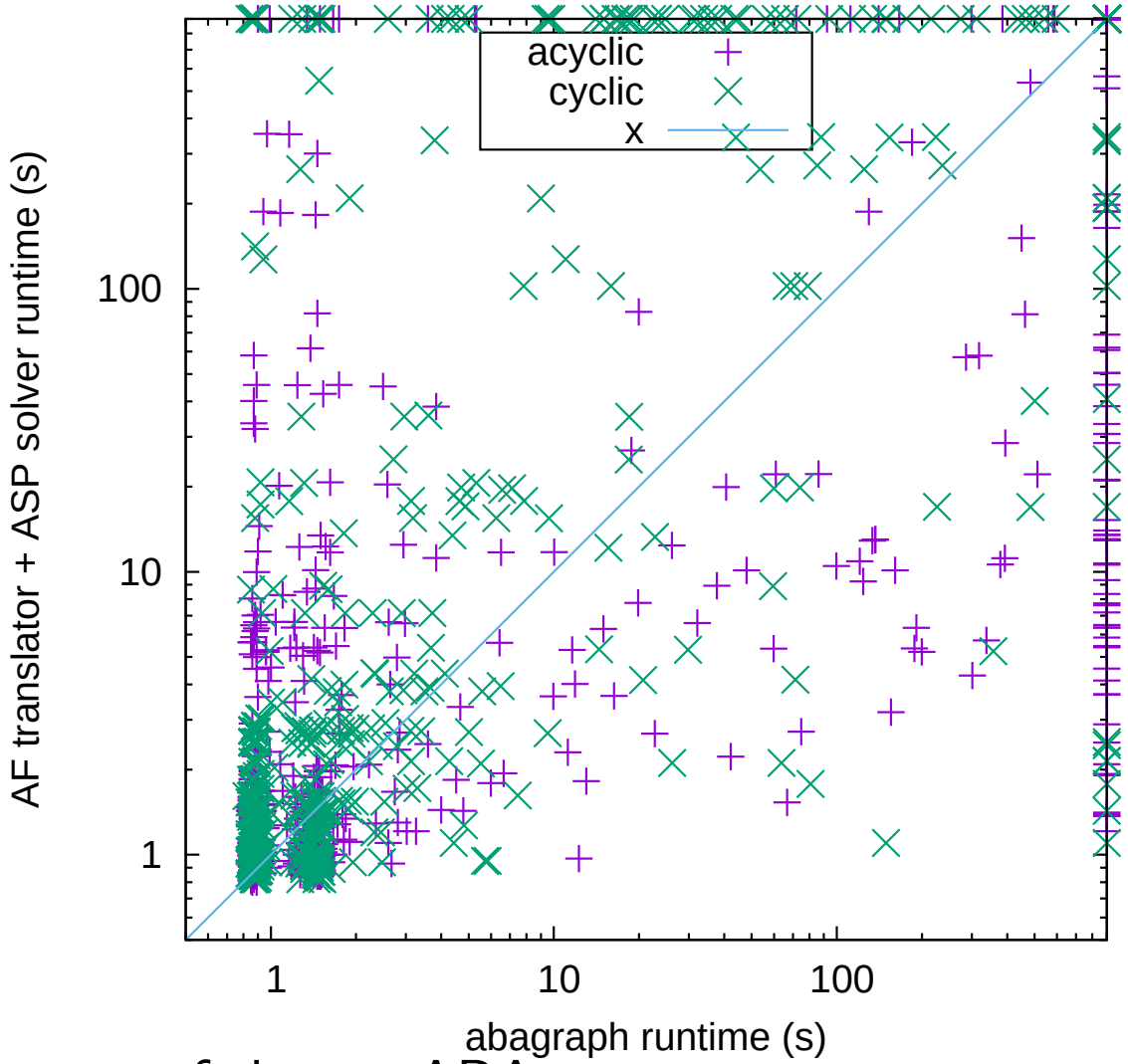
Heuristic algorithm

- Basic principle: backward-chain from sentences to assumptions
- Acyclic rules: start from sinks
- Cyclic rules: starting points in SCCs
- Heuristic:
  - May construct more arguments (non-relevant)
  - May include more derivable sentences in arguments
- Correctness not affected

Shortcuts and second step

- Shortcuts during AF construction
  - Queried sentence never derivable
  - Queried sentence only in self-attacking arguments
  - More in the paper!
- Second step (AF-solver): ASPARTIX
- Experiments showed: high number of attacks
- Modify ASPARTIX: consider non-attacks (shrinks size)
- Credulous/skeptical reasoning: in ASPARTIX encodings

Experiments



- abagraph: state-of-the-art ABA system
- Benchmark instances: from abagraph evaluation
- Task: all admissible sets containing queried sentence

Timeouts and skeptical reasoning

Task: all admissible sets containing queried sentence
Timeout: 600s

	Timeouts		**Uniquely solved**	
	abagraph	us	abagraph	us
acyclic	93	**56**	20	**57**
cyclic	**394**	402	**86**	78

Skeptical reasoning under stable

- not supported by abagraph
- solved 6228 of the 6710 instances
- per-instance runtime < 10 s on over 6000 instances
- majority of runtime in the AF translation (on most instances: 80% of the total runtime)
- ASPARTIX part: efficient (within 65 s)

Paper Summary

Contributions

- Computational approach to ABA that exploits AF solvers
- Notion of support minimality
  - Complexity
  - Heuristic Algorithm
- Implementation and Experimentation
  - Complementary to existing abagraph
  - `https://www.cs.helsinki.fi/group/coreo/aba2af/`

Future work

- Performance:
  - Theoretical
  - Heuristical
  - Implementation
- Further structured formalisms
- Comparison to recent (unpublished) system: ABAPlus

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