

Modelling Arguments

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Overview

- Logic-based approaches – *Deductive argumentation*.
- Graph-based models *Argumentation Frameworks*. (AFs)
- Assumption-based frameworks (ABFs)

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Deductive Argumentation I

- Basic elements:
 - Language L (e.g. propositional logic)
 - Argument base $\Delta \subseteq L$
- An *argument* is a pair (Φ, α) with $\Phi \subseteq \Delta$ and $\alpha \in L$ that satisfies 3 properties:
 - Φ is *consistent*
 - α is a *consequence* of Φ , i.e. $\Phi \vdash \alpha$
 - Φ is a *minimal subset* of Δ satisfying (a,b)

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Deductive Argumentation II

- An argument (Φ, α) presents support (Φ) for the consequence (α) .
- Although studies have tended to concentrate on $\vdash$ as classical propositional derivation, this is not essential to the formalism: defeasible logics are equally applicable.

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Attacks in Deductive Schemes

- Given (Φ, α) and (Ψ, β) in what ways can the former “attack” the latter?
- *Undercuts*: $\alpha \Rightarrow \neg \psi$, i.e. (Φ, α) is an argument denying premise(s) in Ψ .
- *Rebuttals*: $\alpha \leftrightarrow \neg \beta$ is a tautology, i.e. *both* consequences cannot hold.

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Example

$\Delta = \{p, q, r, s, t,$
 $p \wedge q \wedge r \rightarrow \neg s, q \wedge t \rightarrow s, s \wedge t \rightarrow \neg p \wedge \neg q\}$

Arguments

- A. $(\{p, q, r, p \wedge q \wedge r \rightarrow \neg s\}, \neg s)$
- B. $(\{q, t, q \wedge t \rightarrow s\}, s)$
- C. $(\{s, t, s \wedge t \rightarrow \neg p \wedge \neg q\}, \neg q)$
- (B) is a *rebuttal* for (A)
- (C) *undercuts* (A) (and B)

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More about Deductive Systems

- Δ may contain *defeasible* rules.
- Not restricted to propositional logic.
- Variety of techniques for analysing systems:
 - Argument and Proof trees
- Concepts of *conservative* undercuts
 - *Warranted* arguments
 - Notions of "*believability*"
- Many of these are explored in work of Hunter, Besnard, Simari and others.

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Argumentation Frameworks

- Defined by two sets:
- X : finite set of *arguments* $X = \{x_1, \dots, x_n\}$
- A : finite set of *attacks* $A \subseteq X \times X$
- Modelled as a directed graph $H(X, A)$

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Arguments and Attacks I

- Arguments are viewed as *atomic*: no assumptions are made concerning their *internal structure*.
- The *attack relation* includes a notion of an argument x being "stronger" than an argument y .

$\langle x, y \rangle \in A$ read as " x attacks y "

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Arguments and Attacks II

- Introduced in work of Dung (1995).
- We focus on this model, its semantics and developments in greater depth later in the tutorial.
- A central idea – widely investigated – is the issue of what constitutes a “set of justified arguments in $H(X,A)$?”

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A related approach – assumption based frameworks

- In Dung “*arguments*” and “*attacks*” are atomic elements.
- Bondarenko *et al.* define a model in which these are derived from a set of “*assumptions*”.
- This approach provides a powerful tool for describing defeasible reasoning under a number of non-monotonic logics.

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Assumption Based Frameworks

- Start with a *deductive system* - $\langle L, R \rangle$
- L – a formal language, e.g. propositional formulae.
- R – a set of inference rules.
- An *assumption based framework* is a triple $\langle T, Ab, con \rangle$ with $T, Ab \subseteq L$ and con a mapping from Ab to L

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Assumption Based Frameworks

- T is called the *belief set*.
- Ab the *assumption set*.
- $\text{con}(\alpha)$ the *contrary* of α .
- Aim is to identify subsets, Δ of Ab that can be used to *extend* T without contradiction.
- That is $T \cup \Delta$ does not allow both α and $\text{con}(\alpha)$ to be derived in $\langle L, R \rangle$ for any $\alpha \in Ab$

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Assumption Based Frameworks

- Δ is *conflict-free* if it can extend T
- Δ is *maximal* if none of its supersets is conflict-free.
- Semantics similar to those of AFs can be developed.

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Advantages of Deductive and ABF Models

- Deductive systems and ABFs provide a natural approach to embedding formal logics into argumentation contexts.
- ABFs allow a unifying treatment of a wide-range of non-classical logics, e.g. Logic Programming (with negation as failure); Reiter's default logic; Poole's autoepistemic logic (AEL).

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and Disadvantages of Deductive and ABF Models

- Reasoning processes are committed to derivations of “consequences” within some logical language.
- This may raise quite significant computational demands.

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Advantages of AFs I

- Model is highly abstracted: arguments may describe quite intricate structures (e.g. the schemes from Toulmin, critical question structures of Walton). These, however, do not require explicit specification: the key relationship between arguments is whether one attacks another.
- Directed graph form offers the potential to import computational ideas from algorithmic graph theory in studying AFs.

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Advantages of AFs II

- Noting the basis of “attacks” in deductive and ABF approaches, both techniques can be implicitly modelled via some corresponding AF: AFs provide a common framework for all the models discussed.

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and Disdvantages of AFs I

- Model is highly abstracted: in mapping from putative “real-world” contexts some care must be taken.
- The focus on purely “binary attack” relations is not always “realistic”.
- Graph-theoretic machinery does not always result in computationally practical methods.

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and Disdvantages of AFs II

- The correspondences between ABFs and AFs do not mean that AFs are a suitable way of modelling ABFs: the graph structure may be infinite (or at best have size exponential in the assumption set).
- Similar issues arise in “natural” translations between deductive systems and AFs. Some discussion of the problems is given in work of Dunne, Wooldridge and Parsons (AAAI, 2006)

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