Structured Argumentation

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Structured Argumentation

See Argument & Computation, Vol 5 No 1, 2014 for a set of tutorials on Structured Argumentation.

Why?: From Arg&Comp (5)1, 2014

In abstract argumentation, each argument is regarded as atomic. There is no internal structure to an argument. Also, there is no specification of what is an argument or an attack. They are assumed to be given. This abstract perspective provides many advantages for studying the nature of argumentation, but it does not cover all our needs for understanding argumentation or for building tools for supporting or undertaking argumentation.

From Arg&Comp (5)1, 2014

In structured argumentation, we assume a formal language for representing knowledge and specifying how arguments and counterarguments can be constructed from that knowledge.

An argument is then said to be structured in the sense that normally, the premises and claim of the argument are made explicit, and the relationship between the premises and claim is formally defined (for instance, using logical entailment).

Argumentation: Conceptual View

Definition of Status of Arguments

Definition of Defeat among Arguments

Definition of Conflict among Arguments

Definition of Argument

Definition of the Underlying (Logical) Language

Logical Argumentation

Besnard, P., Hunter, A.: A Logic-Based Theory of Deductive Arguments. Artificial Intelligence 128(1-2), 203–235 (2001)

Besnard, P., Hunter, A.: Elements of Argumentation. MIT Press (2008)

A few examples in this part were taken with permission from a Tutorial on Argumentation Systems given by Anthony Hunter in KR'08 in Sydney, Australia.

See Argument & Computation Vol 5 No 1, 2014 for a set of tutorials on Structured Argumentation.

Argumentation: Conceptual View

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Logical Argumentation

- *This system, introduced by P.Besnard & A.Hunter, is based in Classical Propositional Logic.*
- *The premises and the conclusion of an argument are expressed in the logical language of Propositional Logic.*
- *The reasoning (or inference method) is limited to deductive inference (as defined in the Logic).*
- *In that manner, the arguments in the system are always deductive arguments.*
- *Thus, the conclusion is a deductively valid classical consequence of the premises.*

Logical Argumentation: Knowledge Base

- *Assumes given a finite set of formulæ Δ, possibly inconsistent, that is regarded as a large information base from which arguments for and against a given claim can be constructed.*

- *Also, assumes every subset of Δ is given an enumeration (arbitrary, but fixed),*

$$\langle \alpha_1; \ldots; \alpha_n \rangle \text{ (canonical enumeration)}$$

- *The enumeration indicates the order in which the formulæ in any subset Δ should be conjoined to make a formula logically equivalent to that subset.*

Argumentation: Conceptual View

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Logical Argumentation: Arguments

An argument is a pair $\langle\Phi, \alpha\rangle$, where Φ is a minimal consistent set of formulæ from Δ such that α can be classically derived, i.e.:

1. $\Phi \vdash \alpha$
2. $\Phi \nvdash \perp$
3. Φ *is a* $\subseteq$*-minimal subset of* Δ *satisfying 1,2.*

For ex., from $\Delta = \{ \alpha, \alpha\rightarrow\beta, \gamma, \neg\gamma, \neg\gamma\rightarrow\neg\beta \}$

these arguments

$\langle\{\alpha, \alpha\rightarrow\beta\}, \beta\rangle$, $\langle\{\alpha, \neg\gamma\}, \alpha\wedge\neg\gamma \rangle$,

$\langle \{\neg\gamma, \neg\gamma\rightarrow\neg\beta , \alpha\rightarrow\beta \}, \neg\alpha \rangle$ *follow.*

Logical Argumentation: Arguments

An argument is a pair $\langle \Phi, \alpha \rangle$, where Φ is a minimal consistent set of formulæ from Δ such that α can be classically derived, i.e.:

1. $\Phi \vdash \alpha$
2. $\Phi \nvdash \bot$
3. Φ *is a $\subseteq$-minimal subset of Δ satisfying 1,2.*

- *An argument $\langle \Phi, \alpha \rangle$ is equivalent to an argument $\langle \Psi, \beta \rangle$ iff*
  - Φ *is logically equivalent to Ψ, and*
  - α *is logically equivalent to β.*

Argumentation: Conceptual View

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Logical Argumentation: Defeaters

- *Given argument $\langle \Phi, \alpha \rangle$ built from Δ, two types of counterarguments or defeaters are introduced:*
  - *A rebuttal* for $\langle \Phi, \alpha \rangle$ *is an argument* $\langle \Psi, \beta \rangle$ built from Δ *such that* $\beta \vdash \neg\alpha$.
  - *An undercut for* $\langle \Phi, \alpha \rangle$ *is an argument* $\langle \Psi, \beta \rangle$ *such that*

    $\beta \equiv \neg(\phi_1, \ldots, \phi_n)\rangle$ *and* $(\phi_1, \ldots, \phi_n) \subseteq \Phi$.

Conservativeness

- *An argument* $\langle\Phi, \alpha\rangle$*, built from* Δ *is more conservative than an argument* $\langle\Psi, \beta\rangle$ *iff* $\Phi \subseteq \Psi$ *and* $\beta \vdash \alpha$.
- *An argument* $\langle\Phi, \alpha\rangle$ *is strictly more conservative than* $\langle\Psi, \beta\rangle$ *iff and there is no* $\langle\Phi', \alpha'\rangle$ such that $\Phi' \subseteq \Phi$ *and* $\alpha \vdash \alpha'$.
- $\langle\Psi, \beta\rangle$ *is a maximally conservative defeater of* $\langle\Phi, \alpha\rangle$ *iff* $\langle\Psi, \beta\rangle$ *is a defeater of* $\langle\Phi, \alpha\rangle$ *and no defeater of* $\langle\Phi, \alpha\rangle$ *is strictly more conservative than* $\langle\Psi, \beta\rangle$

Canonical Undercuts

- *An argument* $\langle \Psi, \beta \rangle$, $\beta \equiv \neg(\phi_1, \ldots, \phi_n)) \rangle$ *is a canonical undercut for* $\langle \Phi, \alpha \rangle$ *iff it is a maximally conservative undercut for* $\langle \Phi, \alpha \rangle$ *and* $(\phi_1, \ldots, \phi_n)$ *is the canonical enumeration of* Φ.

- *We adopt a simpler notation, writing* $\langle \Psi, \Diamond \rangle$ *for a canonical undercut of* $\langle \Phi, \alpha \rangle$*; the symbol* $\Diamond$ *represents* $\neg(\phi_1, \ldots, \phi_n)$ *where* $(\phi_1, \ldots, \phi_n)$ *is the canonical enumeration of* Φ.

Argumentation: Conceptual View

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Logical Argumentation: Argument Tree

An argument tree for α is a tree where the nodes are arguments such that:

1. *The root is an argument for α.*
2. *For no node $\langle \Psi, \beta \rangle$ with ancestors nodes $\langle \Psi_1, \beta_1 \rangle, \ldots, \langle \Psi_n, \beta_n \rangle$ is a subset of $\Psi_1 \cup \ldots \cup \Psi_n$*
3. *The children nodes of a node N consist of all canonical undercuts for N that satisfy 2.*

Logical Argumentation: Argument Tree

$$
\begin{tikzcd}
& \langle\{\beta, \beta \rightarrow \alpha\}, \alpha\rangle & \\
& \langle\{\gamma, \delta, \delta \wedge \gamma \rightarrow \neg\beta\}, \Diamond\rangle \arrow[u] & \\
\langle\{\phi, \phi \rightarrow \neg\gamma\}, \Diamond\rangle \arrow[ur] & & \langle\{\psi, \psi \rightarrow \neg\delta\}, \Diamond\rangle \arrow[ul] \\
\langle\{\neg(\phi \rightarrow \neg\gamma)\}, \Diamond\rangle \arrow[u] & &
\end{tikzcd}
$$

Logical Argumentation: Argument Tree

$$\langle \{\beta, \beta \rightarrow \alpha\}, \alpha \rangle$$

$$\langle \{\gamma, \delta, \delta \wedge \gamma \rightarrow \neg\beta\}, \Diamond \rangle$$

$$\langle \{\phi, \phi \rightarrow \neg\gamma\}, \Diamond \rangle \qquad \langle \{\psi, \psi \rightarrow \neg\delta\}, \Diamond \rangle$$

$$\langle \{\neg(\phi \rightarrow \neg\gamma)\}, \Diamond \rangle \; U$$

Logical Argumentation: Argument Tree

$$\langle \{\beta, \beta \rightarrow \alpha\}, \alpha \rangle$$

$$\langle \{\gamma, \delta, \delta \wedge \gamma \rightarrow \neg\beta\}, \Diamond \rangle$$

$$\langle \{\phi, \phi \rightarrow \neg\gamma\}, \Diamond \rangle \quad \text{D}$$

$$\langle \{\psi, \psi \rightarrow \neg\delta\}, \Diamond \rangle \quad \text{U}$$

$$\langle \{\neg(\phi \rightarrow \neg\gamma)\}, \Diamond \rangle \quad \text{U}$$

Logical Argumentation: Argument Tree

$$
\begin{tikzcd}
 & \langle\{\beta, \beta \rightarrow \alpha\}, \alpha\rangle & \\
 & \langle\{\gamma, \delta, \delta \wedge \gamma \rightarrow \neg\beta\}, \Diamond\rangle \ \textcolor{red}{\mathrm{D}} \arrow[u] & \\
\langle\{\phi, \phi \rightarrow \neg\gamma\}, \Diamond\rangle \ \textcolor{red}{\mathrm{D}} \arrow[ur] & & \langle\{\psi, \psi \rightarrow \neg\delta\}, \Diamond\rangle \ \textcolor{green}{\mathrm{U}} \arrow[ul] \\
\langle\{\neg(\phi \rightarrow \neg\gamma)\}, \Diamond\rangle \ \textcolor{green}{\mathrm{U}} \arrow[u] & &
\end{tikzcd}
$$

Logical Argumentation: Argument Tree

$\langle \{\beta, \beta \rightarrow \alpha\}, \alpha \rangle$ U

$\langle \{\gamma, \delta, \delta \wedge \gamma \rightarrow \neg\beta\}, \Diamond \rangle$ D

$\langle \{\phi, \phi \rightarrow \neg\gamma\}, \Diamond \rangle$ D

$\langle \{\psi, \psi \rightarrow \neg\delta\}, \Diamond \rangle$ U

$\langle \{\neg(\phi \rightarrow \neg\gamma)\}, \Diamond \rangle$ U

ASPIC$^+$ framework: overview (simplified)

Prakken, H.: An abstract framework for argumentation with structured arguments. Argument and Computation 1, 93–124 (2009)

S.J. Modgil & H. Prakken, A general account of argumentation with preferences. Artificial Intelligence 2013, in press.

Definition: *An argumentation system is a tuple* $AS = (\mathcal{L}, \overline{}, \mathcal{R}, n)$ *where*:

- $\mathcal{L}$ *is a logical language*
- $\overline{}$ *is a contrariness function from* $\mathcal{L}$ to $2^{\mathcal{L}}$ *such that*:
  - φ *is contrary of* ψ if $\varphi \in \overline{\psi}$ *and* $\psi \notin \overline{\varphi}$;
  - φ *is contradictory of* ψ (*denoted* $\varphi = -\psi$,
    if $\varphi \in \overline{\psi}$, $\psi \in \overline{\varphi}$;
  - *each* $\varphi \in \mathcal{L}$ *has at least one contradictory*.
- $\mathcal{R} = \mathcal{R}_{\mathrm{s}} \cup \mathcal{R}_{\mathrm{d}}$ *is a set of strict* ($\mathcal{R}_{\mathrm{s}}$) *and defeasible* ($\mathcal{R}_{\mathrm{d}}$) *inference rules of the form* $\varphi_1,\ldots,\varphi_n \rightarrow \varphi$ *and* $\varphi_1,\ldots,\varphi_n \Rightarrow \varphi$, *respectively* (*where* $\varphi_1,\ldots,\varphi_n$, φ *are meta-variables ranging over wff in* $\mathcal{L}$), *and* $\mathcal{R}_{\mathrm{s}} \cap \mathcal{R}_{\mathrm{d}} = \varnothing$.
- $n : \mathcal{R}_{\mathrm{d}} \rightarrow \mathcal{L}$ is *a naming convention for defeasible rules.*

Definition (ASPIC+ knowledge base). A knowledge base in an argumentation system $(\mathcal{L}, \overline{\ \ }, \mathcal{R}, n)$ is a set $\mathcal{K} \subseteq \mathcal{L}$ consisting of two disjoint subsets $\mathcal{K}_n$ (the axioms) and $\mathcal{K}_p$ (the ordinary premises).

Definition (ASPIC+ arguments). An argument A on the basis of a knowledge base $\mathcal{K}$ in an argumentation system $(\mathcal{L}, \overline{\ \ }, \mathcal{R}, n)$ is:

1. φ if $\varphi \in \mathcal{K}$ *with*:
   Prem(A)$=\{\varphi\}$; Conc(A)$=\varphi$; Sub(A)$=\{\varphi\}$; Rules(A)$=\emptyset$;
   TopRule(A) = undefined.
2. $A_1, \ldots, A_n \rightarrow \psi$ if $A_1, \ldots, A_n$ *are arguments such that there exists a strict rule* Conc(A_1),…,Conc(A_n) $\rightarrow \psi$ *in* $\mathcal{R}_{\mathrm{s}}$.
3. $A_1, \ldots, A_n \Rightarrow \psi$ if $A_1, \ldots, A_n$ are arguments such that there exists a defeasible rule Conc(A_1),…,Conc(A_n) $\Rightarrow \psi$ in $\mathcal{R}_{\mathrm{d}}$.

Prem(A) $=$ Prem(A_1) $\cup \cdots \cup$ Prem(A_n), Conc(A) $= \varphi$
Sub(A) $=$ Sub(A_1) $\cup \cdots \cup$ Sub(A_n) $\cup \{A\}$
DefRules(A)$=$DefRules(A_1) $\cup \cdots \cup$ DefRules(A_n) $(\cup \{A_1, \ldots, A_n \Rightarrow \varphi\})$

$\mathcal{R}_s$:

$p, q \rightarrow s$

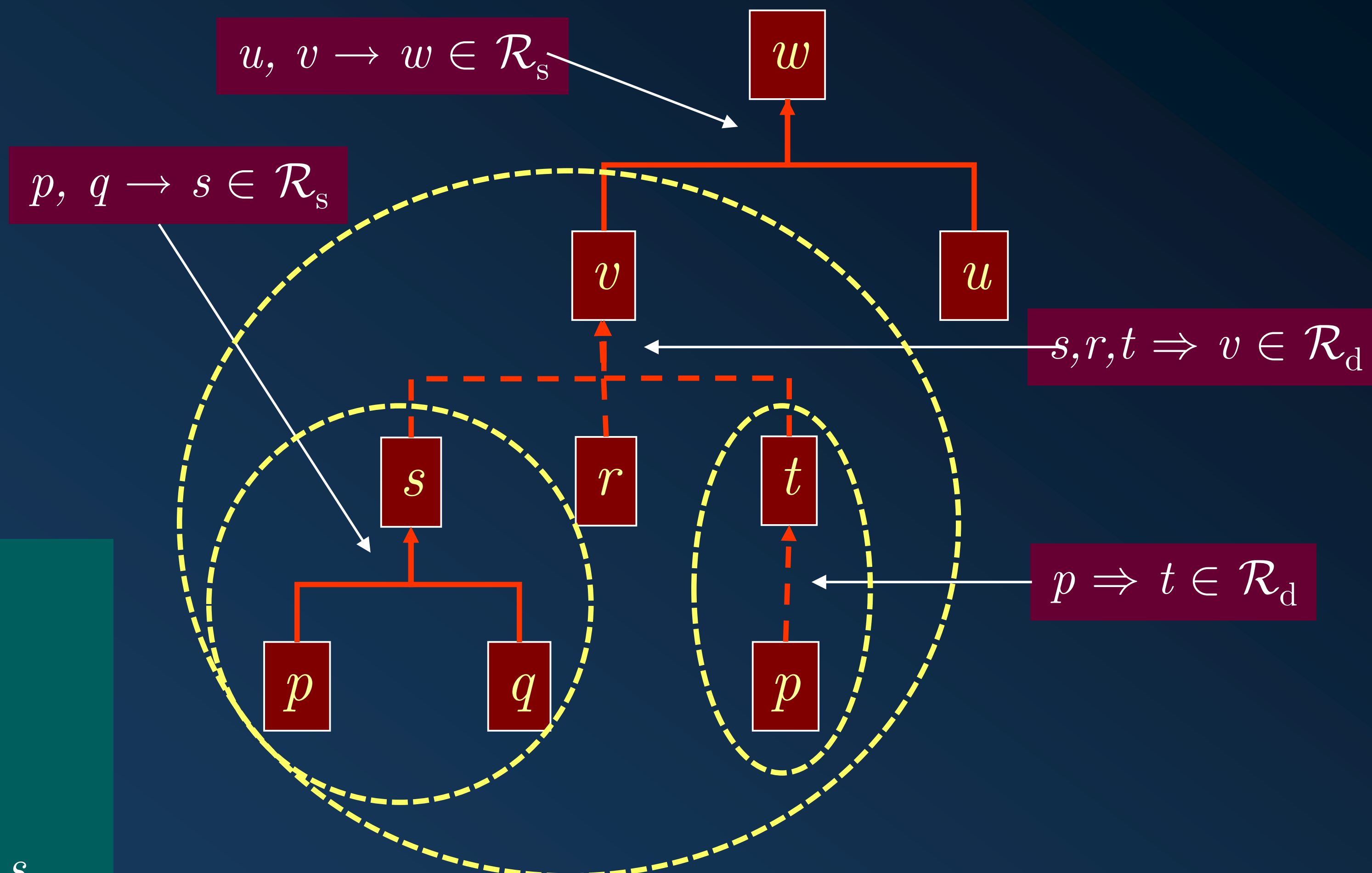
$u, v \rightarrow w$

$\mathcal{R}_d$:

$p \Rightarrow t$

$s, r, t \Rightarrow v$

$\mathcal{K} = \{p, q, r, u\}$



$A_1 = p$

$A_2 = q$

$A_3 = r$

$A_4 = u$

$A_5 = A_1 \Rightarrow t$

$A_6 = A_1, A_2 \rightarrow s$

$A_7 = A_5, A_3, A_6 \Rightarrow v$

$A_8 = A_7, A_4 \rightarrow w$

From the talk *Abstraction in argumentation: necessary but dangerous* given by H.Prakken at ISIS/TAI colloquium, Feb 20, 2013

Attack

$-\varphi = \neg\varphi$ *if* φ *does not start with a negation*

$-\varphi = \psi$ *if is of the form* $\neg\psi$

$n(r)$ *names defeasible rule* r *in* $\mathcal{L}$

- A *undermines* B (*on* φ) if
  Conc(A) = $-\varphi$ *for some premise* φ *of* B
- A *rebuts* B (*on* B') *if*
  Conc(A) $=$ $-$Conc(B')
  for some subargument B' *of* B *with a defeasible top rule*
- A *undercuts* B (*on* B') *if*
  Conc(*A*) = $-n(r)$
  for some subargument B' *of* B *with defeasible top rule* r
- A *attacks* B *iff* A *undermines* or *rebuts* or *undercuts* B.

ASPIC+ overview (simplified)

Arguments are trees where

- *Nodes are wff of a logical language* $\mathcal{L}$ *closed under negation*

- *Links are applications of inference rules*

  $\mathcal{R}_{\mathrm{s}} =$ *Strict rules* $(\varphi_1,\ldots,\varphi_n \rightarrow \varphi)$; *or*

  $\mathcal{R}_{\mathrm{d}} =$ *Defeasible rules* $(\varphi_1,\ldots,\varphi_n \Rightarrow \varphi)$

- *Reasoning starts from a knowledge base* $\mathcal{K} \subseteq \mathcal{L}$

Defeat: attack on premises, defeasible conclusion, or defeasible inference, + preferences.

Argument acceptability based on Dung (1995)

Assumption-Based Argumentation

Bondarenko, A., Dung, P.M., Kowalski, R.A., & Toni, F. (1997). An abstract, argumentation-theoretic approach to default reasoning. Artificial Intelligence, 93, 63–101.

A tutorial on assumption-based argumentation, Francesca Toni, Argument and Computation, 2014, Vol. 5, No. 1, 89–117,

Assumption-Based Argumentation (ABA)

- *Assumption-Based Argumentation (ABA) is a computational framework conceived to encompass existing approaches to default reasoning in the early 90s.*

  Because ABA is an instance of abstract argumentation, all semantic notions introduced in that area for determining the "acceptability" of arguments, also apply to sets of arguments built in ABA.

Assumption-Based Argumentation (ABA)

- *ABA is a general-purpose argumentation framework that can be instantiated to support various applications and specialized frameworks, including: most default reasoning frameworks and problems in legal reasoning, game-theory, practical reasoning, and decision-theory.*

- *However, ABA builds actual arguments as deductions supported by assumptions by using inference rules in an underlying logic.*

Assumption-Based Argumentation (ABA)

An ABA framework is a tuple ($\mathcal{L}$, $\mathcal{R}$, $\mathcal{A}$, $\mathcal{C}$) where:

- *($\mathcal{L}$, $\mathcal{R}$) is a deductive system, with*
- *$\mathcal{L}$ the language and*
- *$\mathcal{R}$ a set of rules of the form $s_0 \leftarrow s_1,\ldots,s_m$ $(m \geq 0)$;*
- *$\mathcal{A} \subseteq \mathcal{L}$ is a (non-empty) set, referred to as assumptions;*
- *$\mathcal{C}$ is a total mapping from $\mathcal{A}$ into $\mathcal{L}$, where $\mathcal{C}(a)$ is referred to as the contrary of a.*

Given a rule ρ of the form $s_0 \leftarrow s_1,\ldots,s_m$, s_0 is referred as the head and $s_1,\ldots,s_m$ as the body, $Head(\rho) = s_0$ and $Body(\rho) = \{s_1,\ldots,s_m\}$; assumptions do not occur in the head of a rule.

Assumption-Based Argumentation (ABA)

In ABA, arguments are deductions of claims using rules and supported by sets of assumptions, and attacks are directed at the assumptions in the support of arguments.

Informally:

An argument for (*the claim*) $c \in \mathcal{L}$ *supported by* $S \subseteq \mathcal{A}$, *denoted* $S \vdash c$, *is a tree with nodes labelled by sentences in* $\mathcal{L}$ *or by* τ, *the root labelled by* c, *leaves either* τ *or assumptions in* S, *and non-leaves* s *have as children the elements of the body of some rule with head* s;

an argument $S_1 \vdash c_1$ *attacks an argument* $S_2 \vdash c_2$ *iff* c_1 *is the contrary of one of the assumptions* in S_2.

Assumption-Based Argumentation (ABA)

Attacks between (sets of) arguments correspond in ABA to attacks between sets of assumptions:

A set of assumptions A attacks a set of assumptions B iff an argument supported by a subset of A attacks an argument supported by a subset of B.

With argument and attack defined, it is possible to apply standard argumentation semantics in ABA.

For the admissibility semantics:

- *a set of assumptions is admissible iff it does not attack itself and it attacks all sets of assumptions that attack it;*
- *an argument $S \vdash s$ belongs to an admissible extension supported by $\Delta \subseteq \mathcal{A}$ iff $\mathrm{S} \subseteq \Delta$ and Δ is admissible.*

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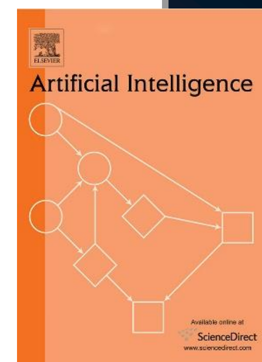

Argumentation in artificial intelligence

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Abstract

Over the last ten years, argumentation has come to be increasingly central as a core study within Artificial Intelligence (AI). The articles forming this volume reflect a variety of important trends, developments, and applications covering a range of current topics relating to the theory and applications of argumentation. Our aims in this introduction are, firstly, to place these contributions in the context of the historical foundations of argumentation in AI and, subsequently, to discuss a number of themes that have emerged in recent years resulting in a significant broadening of the areas in which argumentation based methods are used. We begin by presenting a brief overview of the issues of interest within the classical study of argumentation: in particular, its relationship—in terms of both similarities and important differences—to traditional concepts of logical reasoning and mathematical proof. We continue by outlining how a number of foundational contributions provided the basis for the formulation of argumentation models and their promotion in AI related settings and then consider a number of new themes that have emerged in recent years, many of which provide the principal topics of the research presented in this volume.

Keywords: Argumentation models; Dialogue processes; Argument diagrams and schemes; Agent-based negotiation; Practical reasoning

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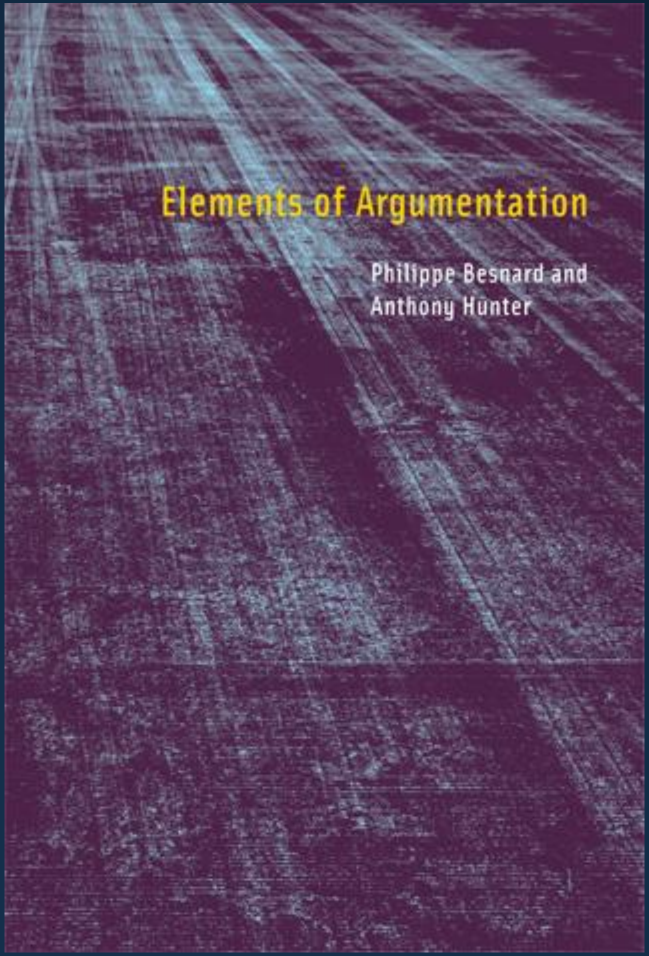

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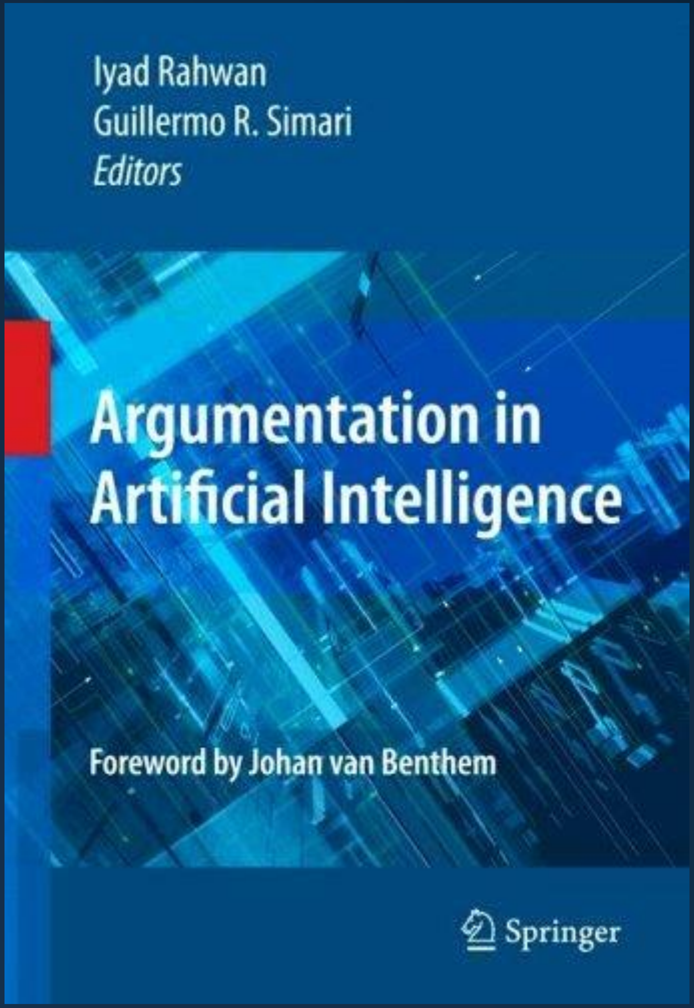

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Iyad Rahwan and Guillermo R. Simari
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Towards Artificial Argumentation

Katie Atkinson[1], Pietro Baroni[2], Massimiliano Giacomin[2], Anthony Hunter[3], Henry Prakken[4,5], Chris Reed[6], Guillermo Simari[7], Matthias Thimm[8], and Serena Villata[9]

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AI Magazine - Vol 38 No 3: Fall 2017, pp. 25-36.

Abstract

The field of computational models of argument is emerging as an important aspect of artificial intelligence research. The reason for this is based on the recognition that if we are to develop robust intelligent systems, then it is imperative that they can handle incomplete and inconsistent information in a way that somehow emulates the way humans tackle such a complex task. And one of the key ways that humans do this is to use argumentation — either internally, by evaluating arguments and counterarguments — or externally, by for instance entering into a discussion or debate where arguments are exchanged. As we report in this review, recent developments in the field are leading to technology for artificial argumentation, in the legal, medical, and e-government domains, and interesting tools for argument mining, for debating technologies, and for argumentation solvers are emerging.

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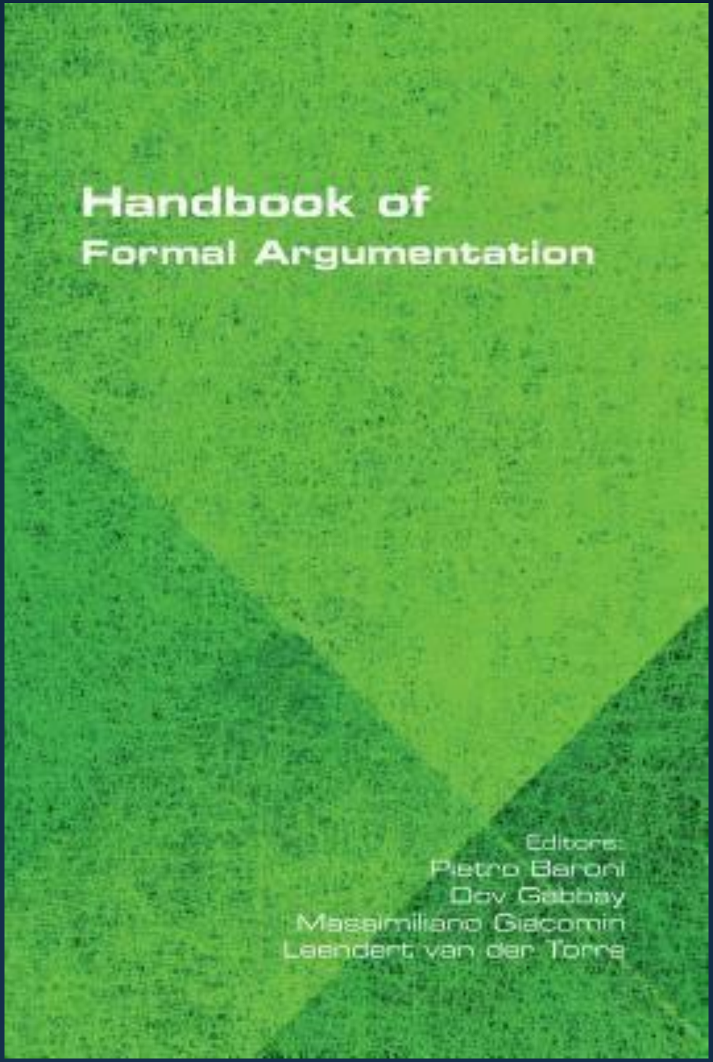

Handbook of Formal Argumentation
Pietro Baroni, Dov Gabbay, Massimilino Giacomin
Volume 1, College Publications, Feb 28, 2018.

Also Volume 2 (forthcoming August 2021).

Several more volumes planned.

Thank you!

Questions?