Elements of Argumentation

Philippe Besnard (IRIT, Toulouse, France)

and

Anthony Hunter (Department of Computer Science, UCL, London, UK)

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Motivation for logical formalisations of practical argumentation

An argument: A claim with some justification

- All squares have fours corners. That is a square, and so it has four corners.
- If I had a sister, I would know about it. As I don't know about it, I don't have a sister.
- If the patient has angina, then prescribe daily asprin. Mr Jones has angina, therefore prescribe him daily asprin.
- This film should have won an Oscar because it was a good movie with an edge.

Argumentation as a cognitive process

Argumentation is a key way humans deal with conflicting information:

- Argumentation involves identifying arguments and counterarguments relevant to an issue (e.g. What are the pros and cons for the safety of mobile phones for children?).

- Argumentation involves weighing, comparing, or evaluating arguments. (e.g. What sense can we make of the arguments concerning mobile phones for children?).

- Argumentation may involve drawing conclusions (e.g. A parent answering the question "Are mobile phones safe for my children?").

- Argumentation may involve convincing an audience (e.g. A politician making the case that mobile phones should be banned for children because the risk of radiation damage is too great)

Argumentation involves one or more agents

- **Monological argumentation**
  - e.g. A newspaper article by a journalist
  - e.g. A political speech by a politician
  - e.g. A review article by a group of scientists
  - e.g. A problem analysis by someone prior to making a decision
- **Dialogical argumentation**
  - e.g. Lawyers arguing in a court
  - e.g. Traders negotiating in a marketplace
  - e.g. Politician debating about new legislation

Background to monological argumentation

- Monological argumentation involves collating information (certain and uncertain).
  - Objective info (e.g. externally measured or verifiable, trusted 3rd party sources, etc)
  - Subjective info (e.g. beliefs, opinions, personal preferences, etc)
  - Hypothetical info (e.g. info used for the sake of argumentation)
- Monological argumentation involves analysing that information without recourse to other agents.
- Monological argumentation can be viewed as an internal process with perhaps a tangible output (e.g. an article or a speech or a decision).
- Dialogical argumentation can be viewed as incorporating monological argumentation.

Formalising monological argumentation

- **Abstract argumentation:** Graph-based approaches (each node is an argument and each arc is an attack relationship)

  e.g. Dung, Bench-Capon, Dunne, Cayrol et al, Coste-Marquis et al, etc.

- **Defeasible argumentation:** Defeasible logic-based approaches (propositional kb & literal queries) that use a non-classical notion of implication.

  e.g. Nute, Simari et al, Cayrol et al, Caminada+Amgoud, Prakken, Krause et al, Toni et al, etc.

- **Coherence argumentation:** Classical logic-based approaches (propositional/first-order kb & queries) that base each argument on a consistent subset of the information available.

  e.g. Pollock, Benferhat et al, Elvang et al, Amgoud+Cayrol, Besnard+Hunter, etc.

Presenting arguments + counterarguments

Arguments

Let Δ be set of formulas in classical logic

An **argument** is a pair $\langle \Phi, \alpha \rangle$ such that

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

Φ is the **support** and α is the **claim** of the argument

Example: Let $\Delta = \{\alpha, \alpha \rightarrow \beta, \gamma \rightarrow \neg\beta, \gamma, \delta, \delta \rightarrow \beta, \neg\alpha, \neg\gamma\}$

Some arguments are:

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

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

Arguments: A first-order example

$$f_1 \quad \forall \mathtt{x}.(\mathtt{validDrugTrial}(\mathtt{trial78}) \rightarrow (\mathtt{healthy}(\mathtt{x}) \wedge \mathtt{under75}(\mathtt{x}) \wedge \mathtt{treatment}(\mathtt{x}, \mathtt{p237}, \mathtt{50mg}, \mathtt{daily}) \rightarrow \mathtt{decreaseBloodCholesterol}(\mathtt{x})))$$

$$f_2 \quad \forall \mathtt{x}, \mathtt{y}.((\mathtt{numberOfPatients}(\mathtt{x}, \mathtt{y}) \wedge \mathtt{y} > \mathtt{1000} \wedge \mathtt{trialAtGoodHospital}(\mathtt{x})) \rightarrow \mathtt{validDrugTrial}(\mathtt{x}))$$

$$f_3 \quad \mathtt{numberOfPatients}(\mathtt{trial78}, \mathtt{2479}) \wedge \mathtt{2479} > \mathtt{1000} \wedge \mathtt{trialAtGoodHospital}(\mathtt{trial78})$$

$$f_4 \quad \forall \mathtt{x}.(\mathtt{healthy}(\mathtt{x}) \wedge \mathtt{under75}(\mathtt{x}) \wedge \mathtt{treatment}(\mathtt{x}, \mathtt{p237}, \mathtt{50mg}, \mathtt{daily}) \rightarrow \mathtt{decreaseBloodCholesterol}(\mathtt{x}))$$

This can be summarized by the following argument, where $\{f_1, f_2, f_3\}$ is the support for the argument, and f_4 is the consequent.

$$\langle \{f_1, f_2, f_3\}, f_4 \rangle$$

Counterarguments

A **rebuttal** for $\langle \Phi, \alpha \rangle$ is an argument $\langle \Psi, \beta \rangle$
where $\beta \vdash \neg\alpha$

An **undercut** for $\langle \Phi, \alpha \rangle$ is an argument $\langle \Psi, \neg(\phi_1 \wedge \ldots \wedge \phi_n) \rangle$
where $\{\phi_1, \ldots, \phi_n\} \subseteq \Phi$

Example: Let $\Delta = \{\alpha, \alpha \rightarrow \beta, \gamma, \gamma \rightarrow \neg\alpha\}$

- $\langle \{\gamma, \gamma \rightarrow \neg\alpha\}, \neg\alpha \rangle$ is an undercut for $\langle \{\alpha, \alpha \rightarrow \beta\}, \beta \rangle$
- $\langle \{\gamma, \gamma \rightarrow \neg\alpha\}, \neg(\alpha \wedge (\alpha \rightarrow \beta)) \rangle$ is a more conservative undercut

Canonical undercut

A **canonical undercut** for an argument $\langle \Phi, \alpha \rangle$, where $\Phi = \{\phi_1, .., \phi_n\}$, is an argument of the following form

$$\langle \Psi, \neg(\phi_1 \wedge ... \wedge \phi_n) \rangle$$

Example

$\langle \{\neg\alpha \vee \neg\beta\}, \neg(\alpha \wedge \beta) \rangle$ is a canonical undercut for $\langle \{\alpha, \beta\}, \alpha \wedge \beta \rangle$

- A canonical undercut is a “maximally conservative” undercut in the sense that the support and claim are the weakest possible for an undercut.
- Because they are maximally conservative, they subsume many other undercuts, thereby removing much redundancy.

Example of an argument tree

- α = Simon Jones is a Member of Parliament
- β = We can publicise details about the private life of Simon Jones.
- γ = Simon Jones just resigned from the House of Commons.

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

Another example of an argument tree

$$\langle\{\forall x.Q(x), \forall x.Q(x) \rightarrow \exists y,z.S(y,z)\}, \exists y,z.S(y,z)\rangle$$

$$\uparrow$$

$$\langle\{Pa, \forall x.(P(x) \rightarrow \neg Q(x) \vee R(x)), \neg\exists x.R(x)\}, \diamond\rangle$$

$$\nearrow \qquad\qquad \nwarrow$$

$$\langle\{\exists x.\neg(P(x) \rightarrow \neg Q(x) \vee R(x))\}, \diamond\rangle \qquad \langle\{\forall x.\neg(P(x) \wedge \neg R(x))\}, \diamond\rangle$$

A negative example

Let $\Delta = \{\alpha, \alpha \rightarrow \beta, \gamma \rightarrow \neg\alpha, \gamma\}$

$$\begin{array}{c} \langle\{\alpha, \alpha \rightarrow \beta\}, \alpha \wedge \beta\rangle \\ \uparrow \\ \langle\{\gamma, \gamma \rightarrow \neg\alpha\}, \ldots\rangle \\ \uparrow \\ \langle\{\alpha, \gamma \rightarrow \neg\alpha\}, \ldots\rangle \end{array}$$

This is not an argument tree because the undercut to the undercut is actually making exactly the same point (α and γ are incompatible) as the undercut itself does, just by using modus tollens instead of modus ponens

Another negative example

Let $\Delta = \{\alpha, \beta, \alpha \rightarrow \gamma, \beta \rightarrow \delta, \neg\alpha \vee \neg\beta\}$

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

$$\nearrow \qquad\qquad \nwarrow$$

$$\langle\{\alpha, \neg\alpha \vee \neg\beta\}, \neg\beta\rangle \qquad\qquad \langle\{\beta, \neg\alpha \vee \neg\beta\}, \neg\alpha\rangle$$

This is not an argument tree because the two children nodes are not canonical undercuts.

Argument trees

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 $\langle \Phi, \beta \rangle$ with ancestor nodes $\langle \Phi_1, \beta_1 \rangle, \ldots, \langle \Phi_n, \beta_n \rangle$ is Φ a subset of $\Phi_1 \cup \cdots \cup \Phi_n$
3. The children nodes of a node N consist of canonical undercuts for N that obey 2.

A **complete argument tree** is an argument tree where children nodes of a node N consist of all canonical undercuts for N that obey 2.

Need for argumentation with first-order logic

Argumentation systems based on defeasible logic are restricted to propositional rules of the form (where α_1,..., α_i, β are ground literals), and claims are restricted to being literals.

$$\alpha_1 \wedge \ldots \wedge \alpha_i \rightarrow \beta$$

Yet any applications for argumentation require knowledgebases and queries with

- Disjunction
- Arbitrary nesting of connectives
- Existential and universal quantification
- Equality

Judging arguments + counterarguments

Example of judgement

Blue arguments are undefeated

Red arguments are defeated

Mr Jones has to have surgery to remove the heart tumour

$\uparrow$

This is not a good plan: If we do it, there is a 50% chance he will die in the theatre

$\uparrow$

But if we do nothing, then there is a 100% chance he will die within one month

Judgement of arguments

- There are various ways we can judge individual trees to ascertain whether the root argument is “warranted”.
- A common definition (e.g. Garcia+Simari) is “recursive defeat”
  - For any leaf node A_i, $mark(A_i) =$ undefeated
  - For any non-leaf node A_i, $mark(A_i) =$ defeated
    iff there is a child A_j, s.t. $mark(A_j) =$ undefeated
  - For any non-leaf node A_i, $mark(A_i) =$ undefeated
    iff for all children A_j, $mark(A_j) =$ defeated
  - The root argument A_r is warranted
    iff $mark(A_r) =$ undefeated

Example of judgement

Blue arguments are undefeated

Red arguments are defeated

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

$$\uparrow$$

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

$$\nearrow \qquad \nwarrow$$

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

$$\nearrow \qquad \nwarrow$$

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

Taking degree of undercut into account

Are all undercuts equal? Can they all defeat their parent?

$$\begin{array}{cc} \langle\{\forall x.P(x)\}, \forall x.P(x)\rangle & \langle\{\forall x.P(x)\}, \forall x.P(x)\rangle \\ \uparrow \quad 1/n & \uparrow \quad n/n \\ \langle\{\neg P(a)\}, \Diamond\rangle & \langle\{\forall x.\neg P(x)\}, \Diamond\rangle \end{array}$$

Here n is a parameterization of the size of the domain
(e.g cardinality of the Herbrand universe).

Taking degree of undercut into account

For the predicates

$$H(x) = \text{x uses a homeopathic treatment}$$
$$L(x) = \text{x uses a treatment that has a long history}$$
$$E(x) = \text{x uses a treatment that is effective}$$

we can construct

$$\langle\{H(p_0), \forall x.(H(x) \rightarrow L(x)), \forall x.(L(x) \rightarrow E(x)\}, E(p_0)\rangle$$
$$\uparrow \qquad m/n$$
$$\langle\{H(p_1) \wedge \neg E(p_1) \wedge ...... \wedge H(p_m) \wedge \neg E(p_m)\}, \diamond\rangle$$

So as the number of patients m increases who have taken a homeopathic treatment and found that it is not effective, the greater the degree of undercut.

Since no treatment is perfect, and every treatment would have some degree of undercut.

An abstraction of a labelled argument tree

Provided $A_0, A_1, A_2, ..., A_5$ as well as k, m, n (where $k < n$ and $m < n$) conform with our definitions, here is a labelled argument tree in abstract form:

$$
\begin{array}{ccccc}
 & & A_0 & & \\
 & 1/n \nearrow & & \nwarrow m/n & \\
 & A_1 & & A_2 & \\
1/n \nearrow & & \nwarrow 1/n & \uparrow k/n & \\
A_3 & & A_4 & A_5 &
\end{array}
$$

Judgement involves semantic issues

In addition to judging the structure, we also need to judge the meaning of arguments (whether atomic or logical).

Buy an original Ming vase for 100 Euro because it is cheap

$\uparrow$

Don't buy a vase if there is a small chip in it

Buy an Ikea vase for 5 Euro because it is cheap

$\uparrow$

Don't buy a vase if there is a small chip in it

Judgement involves semantic issues

Is the root defeated in this first tree when the undercut does not seem believable?

Go to Bermuda because there are nice beaches

$\uparrow$

Don't go to Bermuda because it is dangerous flying through the triangle

Go to Bermuda because there are nice beaches

$\uparrow$

Don't go to Bermuda because flying there causes too much environmental damage

One approach is to consider believability of arguments from the perspective of the audience.

Motivation for taking the audience into account

There is always an audience for practical argumentation

- A newspaper article by a journalist
- A political speech by a politician
- A review article by a scientist
- Auto-argumentation where it is important for agents(s) to identify key arguments/counterargument for their own use, such as for problem analysis prior to making a decision.
  - An oncology management plan for clinician + patient
  - Annotated notes made when looking for a house to buy

Judging arguments w.r.t. the audience

- Taking the audience into account is a way for argumentation systems to interact intelligently and more meaningful with users.
- There appear to be a number of dimensions to consider including
  - Values (Bench-Capon JLC 2003, Atkinson et al AAAI'07)
  - Impact (Hunter AAAI'04)
  - Believability (Hunter AAAI'04)
  - Relevance to decision (Amgoud+Prade AAMAS'05)
  - Relevance to topics of interest (Hunter draft)
- These dimensional are part of a shift from a syntactic approach to a semantic approach, or even a semiotic approach, to judging.

There is also a need to be aposite for an audience

- Consider an article in a current affairs magazine: Only a small subset of all possible arguments, that either the writer or the reader could construct from their own knowledgebases, are used.
- A journalist regards some arguments as having higher impact and/or more believable for the intended audience and/or ... than others, and so makes a selection.
- This need for apositeness is reflected in law, medicine, science, politics, advertising, management, ..., and just ordinary every-day life.

More believable argumentation

Motivation for more believable arguments

- Arguments are tailored to the likely beliefs of the audience.
- So good arguments are believable arguments.
- Consider a politician who is giving a speech on a plan by the government to charge car drivers to be able to drive into the city, and the audience might be one of the following:
  - a group of residents who live in the city
  - a group of representatives for small businesses in the city
- The need to tailor arguments according to the beliefs of the audience is reflected in many professional domains (e.g. medicine, law, journalism, science, commerce, etc).

Motivation for more believable arguments

N = It will be a nice weekend for a BBQ party

B = We should have a BBQ party

R = The weather forecast is for rain at the weekend

S = The astrological forecast says it will not be a good weekend for a party

$$\begin{array}{cc} \langle\{N, N \rightarrow B\}, B\rangle & \langle\{N, N \rightarrow B\}, B\rangle \\ \uparrow & \uparrow \\ \langle\{R, R \rightarrow \neg N\}, \diamond\rangle & \langle\{S, S \rightarrow \neg N\}, \diamond\rangle \end{array}$$

Empathy and antipathy for arguments

- Model the beliefs of the intended audience by a set of propositional formulae Γ.
- Evaluate the empathy/antipathy the audience would have for each argument $\langle\Phi, \alpha\rangle$ in an argument tree based on their beliefs.
  - Empathy is the degree to which Γ entails Φ (e.g. the proportion of models of Γ that are models of Φ).
  - Antipathy is the degree to which Γ conflicts Φ (e.g. the minimum Dalal distance between the models of Γ and the models of Φ).

Pairwise theory comparison

Let $M(X, Y)$ be the set of interpretations of X delineated by atoms in Y.

$$M(X, Y) = \{w \models \wedge X \mid w \in I(Y)\}$$

Let $X = \{\alpha\}$ and $Y = \{\beta \wedge \gamma\}$.

$$M(X, X \cup Y) = \{\{\alpha, \beta, \gamma\}, \{\alpha, \beta\}, \{\alpha, \gamma\}, \{\alpha\}\}$$
$$M(Y, X \cup Y) = \{\{\alpha, \beta, \gamma\}, \{\beta, \gamma\}\}$$

Degree of entailment

Let X and Y be sets of classical propositional formulae each of which is consistent (i.e. $X \nvdash \bot$ and $Y \nvdash \bot$). The **degree of entailment** of X for Y, denoted $E(X, Y)$, is defined as follows:

$$E(X,Y) = \frac{|M(X, X \cup Y) \cap M(Y, X \cup Y)|}{|M(X, X \cup Y)|}$$

$E(\alpha, \alpha \wedge \beta) = 1/2$ $\quad$ $E(\alpha, \alpha \wedge \beta \wedge \gamma) = 1/4$

$E(\alpha, \alpha \wedge \beta \wedge \gamma \wedge \delta) = 1/8$ $\quad$ $E(\alpha \wedge \beta, \alpha \vee \beta) = 1$

$E(\alpha \wedge \beta, \alpha \wedge \epsilon) = 1/2$ $\quad$ $E(\alpha \wedge \beta \wedge \gamma, \alpha \wedge \epsilon) = 1/2$

$E(\alpha \wedge \beta \wedge \gamma \wedge \delta, \alpha \wedge \epsilon) = 1/2$ $\quad$ $E(\alpha \wedge \beta, \alpha \wedge \neg\beta) = 0$

Degree of conflict

For X and Y, sets of classical propositional formulae each of which is consistent, the **degree of conflict** is defined as follows:

$$C(X,Y) = \frac{\mathsf{Min}(\mathsf{Distances}(X,Y))}{\log_2(|I(X \cup Y)|)}$$

$$C(\alpha \wedge \beta, \alpha \wedge \neg\beta) = 1/2$$

$$C(\alpha \wedge \beta, \neg\alpha \vee \neg\beta) = 1/2$$

$$C(\alpha \wedge \beta, \neg\alpha \wedge \neg\beta) = 1$$

$$C(\alpha \wedge \beta, \neg\alpha \wedge \beta) = 1/2$$

Believability of argument trees

Let $\langle \Phi, \alpha \rangle$ be an argument and let Γ be a beliefbase.

- The **empathy** for $\langle \Phi, \alpha \rangle$ is $E(\Gamma, \Phi)$.
- The **antipathy** for $\langle \Phi, \alpha \rangle$ is $C(\Gamma, \Phi)$.

Let $\Delta = \{\alpha \vee \beta, \alpha \rightarrow \gamma, \neg\gamma, \neg\beta, \delta \leftrightarrow \beta\}$ and let $\Gamma = \{\alpha, \neg\beta\}$.

$$\langle \{\alpha \vee \beta, \neg\beta\}, \alpha \vee \neg\delta \rangle$$
$$\uparrow$$
$$\langle \{\alpha \rightarrow \gamma, \neg\gamma\}, \Diamond \rangle$$

So $E(\Gamma, \{\alpha \vee \beta, \neg\beta\}) = 1$ and $C(\Gamma, \{\alpha \rightarrow \gamma, \neg\gamma\}) = 1/3$.

An example

Consider the following beliefs of a group of pensioners

$B =$ Better treatments for serious diseases are available

$C =$ More money needs to be spent on better treatments

$\neg L =$ There is not a lack of cheap entertainment facilities for teenagers to relax and unwind

$\neg M =$ Current teenagers do not have more worries and pressures than any previous generation

$\neg N =$ The government should not provide cheap entertainment facilities for teenagers

For

$T =$ Tax increase is necessary

we have

$$A_1 = \langle \{B, B \rightarrow C, C \rightarrow T\}, T \rangle$$
$$A_2 = \langle \{L, M, L \wedge M \rightarrow N, N \rightarrow T\}, T \rangle$$

So empathy by the pensioners for A_1 is 1/2, and antipathy by the pensioners for A_2 is 1/2.

Selecting a more believable subtree

For a beliefbase $\{\delta, \neg\gamma\}$,

$$\langle\{\beta \rightarrow \alpha, \beta\}, \alpha\rangle \quad \text{Antipathy = Empathy = 0}$$

$$\nearrow \qquad\qquad \nwarrow$$

$$\text{Antipathy = 1/3} \quad \langle\{\gamma \wedge \neg\beta\}, \diamond\rangle \qquad \langle\{\delta, \alpha \leftrightarrow \neg\delta\}, \diamond\rangle \quad \text{Empathy = 1/2}$$

$$\uparrow \qquad\qquad \uparrow$$

$$\text{Empathy = 1} \quad \langle\{\neg\gamma\}, \diamond\rangle \qquad \langle\{\neg\delta\}, \diamond\rangle \quad \text{Antipathy = 1}$$

Conclusions on taking the audience into account

- Numerous formal theories of argumentation evaluate arguments on grounds of certainty and preference as viewed from the presenter's perspective, but the audience's perspective is increasingly of interest.
- Taking audience into account means that
  - the "more appropriate" arguments can be presented.
  - the arguments can be better judged.
- Number of dimensions to consider
  - Values (Moral/ethical criteria)
  - Impact (Effect on desiderata)
  - Believability (Empathy/Antipathy)
  - Relevance to decision (Effect on goals)
  - Relevance to topics of interest (What an argument is about)

Computational issues

Implementing logic-based argumentation

There are prototype implementations for argumentation systems based on defeasible logic.

- Defeasible Logic Programming Interpreter (www.cs.uns.edu.ar/ grs/)
- ASPIC Components (www.argumentation.org)
- CaSAPI System for Argumentation (www.doc.ic.ac.uk/ ft/)

There is an ongoing development of an implementation for an argumentation system based on classical logic.

Constructing argument trees is expensive

Building an argument tree involves many calls to an automated theorem prover (an ATP). Each call, denoted $\Psi?\beta$, returns either $\Psi \vdash \beta$ or $\Psi \nvdash \beta$.

If we want to know if $\langle \Phi, \alpha \rangle$ is an argument, then we have a series of calls where $\Phi = \{\phi_1, .., \phi_k\}$.

$$(\Phi?\alpha), (\Phi?\bot), (\Phi \setminus \{\phi_1\}?\alpha), ..., (\Phi \setminus \{\phi_k\}?\alpha)$$

In the worst case, to find all arguments in Δ for α, we require 2^{n+1} calls to the ATP (where $|\Delta| = n$).

Tackling problems of computational viability

- Complexity analyses
- Theoretical proposals
  - Compilation of a knowledgebase (Besnard+Hunter KR’06)
  - Contouring (Hunter ECAI’06)
  - Approximate arguments (Hunter NMR’06)
- Empirical studies
  - EPSRC “Argumentation Factory” Project (Started Jan 2007)

Conclusions for the talk

In this talk, we have considered some elements of practical argumentation that can be conceptualized in a logic-based framework.

- Presenting arguments + counterarguments
- Judging arguments + counterarguments
- Intrinsic analyses (e.g. degree of undercut, degree of inconsistency, degree of information, etc.)
- Extrinsic analyses (e.g. value, impact, believability, relevance, etc.)
- Rationalizing arguments + counterarguments (e.g. pruning arguments, merging equivalent or similar arguments, etc.)
- Computational issues (e.g. complexity, algorithms, etc)

More information

Papers at

www.cs.ucl.ac.uk/staff/a.hunter

Book to be published early in 2008

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