An Empirical Comparison of Argumentation Formalisms

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Abstract
One of the aims of argumentation formalisms is to bridge the gap between human reasoning and computer-based reasoning. Several argumentation formalisms have recently been proposed for this purpose, including ABA, ASPIC$^+$ and ASPIC$^-$, and different designed decisions have been implemented in different systems. In the current paper we focus on one particular design decision (that of *restricted rebut* versus *unrestricted rebut*). We present empirical results on which of these principles are most likely to be accepted by human users.

1. Introduction

Formal argumentation theory can be applied to bridge the gap between human reasoning and computer based reasoning [12,13,14].

Landmark paper has been Dung 95[4]. However, for many purposes this is too abstract. As it abstracts ways from rules, reasons and argumentation schemes.

To take these aspects into account, several formalisms for instantiated argumentation has been formalized. Such as ABA [9,10,11], ASPIC$^+$ [7,8], and ASPIC$^-$ [1].

These systems essentially work in 3 steps [3]: (1) based on a knowledge-base, arguments are constructed and the attacks relation is defined; (2) on the resulting graph (the argumentation framework), an argumentation semantics is applied, selecting different *Extensions* or *Labelings* of arguments; (3) based on the extensions of arguments, extensions of conclusions are defined.

One of the key design decisions, to be made by instantiated argumentation formalisms, is when precisely one argument attacks another argument. Here we can distinguish two key lines of thought, restricted rebut and unrestricted rebut [2]. With restricted rebut, one can attack an argument on a conclusion that has to be the direct consequence of a defeasible rule, whereas with unrestricted rebut, one can attack an argument on a conclusion that has been derived by at least one defeasible rule (be at last one or any previous one). An example of argumentation formalism that implements restricted rebut is ASPIC$^+$, an example of argumentation formalism that implements unrestricted rebut is ASPIC$^-$.

Given the different argumentation formalisms implementing different design decisions, it become worthwhile to examine which of these design principles has the best support among human users. The current paper therefor presents an empirical study on which of these principles (*restricted rebut* and *unrestricted rebut*) is most likely to be accepted by human users. For this we have carried out a survey among a

hundred students of Zhejiang University. We hope that our results can guide argumentation researchers designing formalisms that are most in line with human intuitions.

2. Research setup

In what follows we define an special case of [8]'s ASPIC$^+$ framework. Argument in [8] are constructed from strict and defeasible rules, and ordinary and axiom premises, of which only the former can be attacked. Besides, our special case introduces transposition of strict rule as a new set of rule, and models ordinary premises as antecedent free defeasible inference rules, and axiom premises as antecedent free strict inference rule. Consequently, the undermining attack can be regarded as a special type of rebutting attack. In order to compare two kinds of rebutting attack, we define them separately.

Definition1. An argumentation system is a tuple AS=($\mathcal{L}$, $\mathcal{R}$,n), where:

- $\mathcal{L}$is a logical language closed under negation ($\neg$).
- $\mathcal{R}$=$\mathcal{R}_s\cup\mathcal{R}_d$ is a set of strict ($\mathcal{R}_s$) and defeasible ($\mathcal{R}_d$) inference rules of the form$\varphi_1, \cdots, \varphi_n\rightarrow\varphi$ and $\varphi_1, \cdots, \varphi_n\Rightarrow\varphi$ respectively (where φ_i and φ are meta-variables ranging over wff in $\mathcal{L}$), and $\mathcal{R}_s\cap\mathcal{R}_d=\emptyset$.
- n is a partial function such that n: $\mathcal{R}_d \rightarrow\mathcal{L}$

We write $\psi = {}^{-}\varphi$ just in case $\psi =\neg\varphi$ or $\varphi=\neg\psi$(we will sometimes informally say that formulas φ and ${}^{-}\varphi$ are each other's negation).

Furthermore, we define the set of the transposition of strict rules $\mathcal{R}_{st}$as:

if$\varphi_1, \cdots, \varphi_n\rightarrow\psi\in\mathcal{R}_s$,

thenfor any i=1…n, we have $\varphi_1, \cdots,\varphi_{i-1},\neg\psi,\varphi_{i+1},\cdots, \varphi_n\rightarrow\neg\varphi_i\in\mathcal{R}_{st}$.

Definition2. An argument$A$ on the basis of an argumentation system ($\mathcal{L}$, $\mathcal{R}$,n) is defined as:

1. $A_1,\cdots,A_n\rightarrow\psi$ if $A_1,\cdots,A_n$(n$\geqslant$1) are arguments and there exists a rule Conc(A_1),…, Conc(A_n) $\rightarrow\psi$ in $\mathcal{R}_s\cup\mathcal{R}_{st}$, then we have
   Prem(A)= Prem (A_1)$\cup\cdots\cup$Prem (A_n)
   Conc(A)= ψ
   Sub(A)= Sub (A_1) $\cup\cdots\cup$Sub(A_n)$\cup\{A\}$
   DefRules(A)= DefRules(A_1)$\cup\cdots\cup$DefRules(A_n)
   TopRule(A)= Conc(A_1)$\cup\cdots\cup$Conc(A_n)$\rightarrow\psi$
2. $A_1,\cdots,A_n\Rightarrow\psi$ if $A_1,\cdots,A_n$ (n$\geqslant$1) are arguments and there exists a rule Conc(A_1),…, Conc(A_n) $\Rightarrow\psi$ in $\mathcal{R}_d$, then we have
   Prem(A)= Prem (A_1)$\cup\cdots\cup$Prem (A_n)
   Conc(A)= ψ
   Sub(A)= Sub (A_1) $\cup\cdots\cup$Sub(A_n)$\cup\{A\}$
   DefRules(A)= DefRules(A_1)$\cup\cdots\cup$DefRules(A_n)
   TopRule(A)= Conc(A_1)$\cup\cdots\cup$Conc(A_n)$\Rightarrow\psi$

Definition3. An argument$A$ attacks argument$B$iff$A$(unrestrictedor restricted) rebuts B or Aundercuts B, where:

- Aunrestricted rebuts B on B'iffConc(A)=${}^{-}$Conc(B') for some $B'\in$ Sub(B)
- A restricted rebuts B on B'iffConc(A)=${}^{-}$Conc(B') for some $B'\in$ Sub(B) and

TopRule(B')$\in\mathcal{R}_d$

- Aundercuts B on B'iffConc(A)=$-n(r)$ for some $B'\in$ Sub(B)s.t.TopRule(B') =r where$r\in\mathcal{R}_d$

The following is an example showed in [1].

John: *"Bob will attend conferences A and I this year, as he has papers accepted at both."*
Mary: *"That won't be possible, as his budget of £1000 only allows for one foreign trip."*

Observe that as Mary's argument attacks John's argument, only when applying unrestricted rebut, like with ASPIC$^-$, but not under ASPIC$^+$, not under restricted rebut.

As there seems to be disagreements among argumentation researches whether to apply restricted rebut (ASPIC$^+$) or unrestricted rebut (ASPIC$^-$). We thought therefor it was worthwhile to examine whether the human intuitions are more in lined with restricted rebut or unrestricted rebut.

Our research is carried out by providing the users with couples of example of an argument and a counter-argument being uttered during a discussion. The counter-argument attacks the first argument under unrestricted rebut but not under restricted rebut. We asked the users whether they feel that the counter-argument is a legitimate response to the first argument or not. If they answer yes, it is a legitimate response, then their intuitions are more in line with unrestricted rebut (as an implement to ASPIC$^-$), if they answer no, it is not a legitimate response, then their intuitions are more in line with restricted rebut (as an implement to ASPIC$^+$).

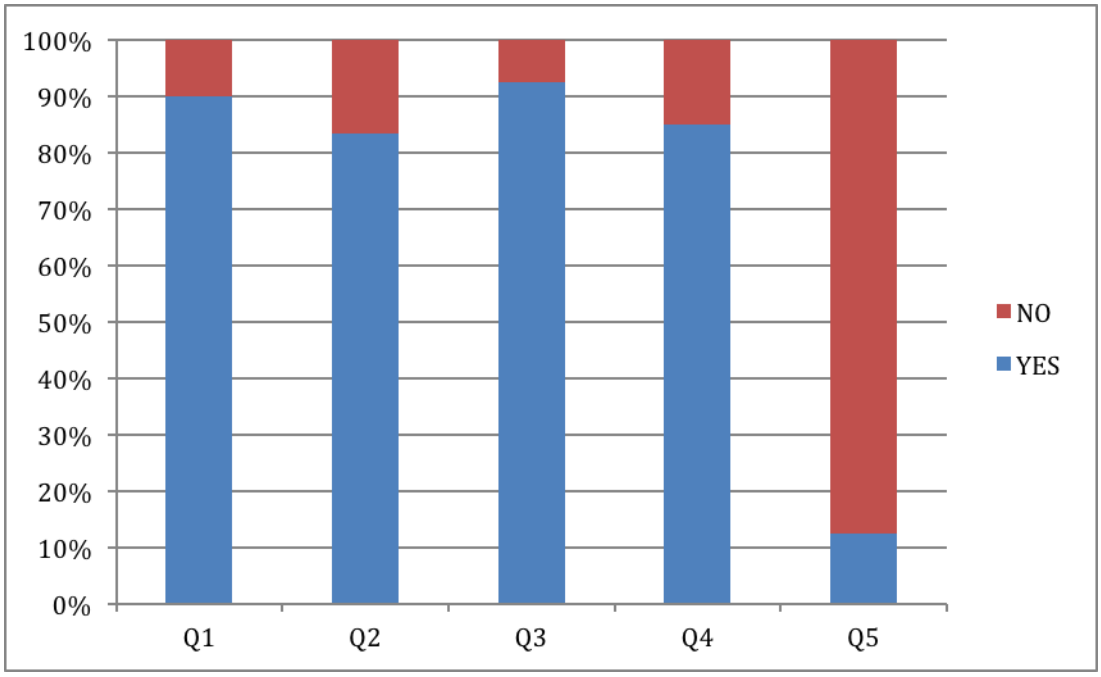
In order not to rely so much on a single question, we have formulated different questions for different scenarios. In some of these questions the counter-argument attacks the first argument under unrestricted rebut but not under restricted rebut. In some other questions they attack under both restricted rebut and unrestricted rebut. In the rest question they attack under neither restricted nor unrestricted rebut, because the arguments are entirely strict.

Then so we have five examples. To the first one, there is an attack under both restricted and unrestricted rebut. To the last one, there is no attack under restricted or unrestricted rebut. The middle one is 2, 3 and 4, there are attacks under unrestricted rebut but not under restricted rebut. 2, 3 and 4 are where we want to make sure the differences whether people agree with were restricted and unrestricted. 1 and 5 include to check whether the users' intuitions are in line with restricted and unrestricted rebut.

We attach the questionnaire in the Appendix.

3. Results

Our results are showed in the following table:



For question 1, 90% agrees that B is a legitimate counter reaction.

For question 2, 3 and 4, there are respectively 75%, 92.5% and 85% people agree that B is a legitimate counter reaction.

For the last question, only 12.5% agrees that B is a legitimate reaction, which means that people's intuitions are in line with that we cannot attack a strict argument.

From these results we can see that most of our subjects agrees that in question 2, 3 and 4, the argument of B attacks argument of A, which reveals people's intuitions are more in line with unrestricted rebut.

Further analysis will be given in the extended version of the current paper.

4. Discussion and Conclusions

Our results confirmed that unrestricted rebut is more natural than restricted rebut. These results are especially relevant when argumentation has dialectical aspects, like when there is discussion going on. Although unrestricted rebut is far more intuitive than restricted rebut, it comes with a price. It has been showed to yield inconsistent conclusions under preferred semantics [3].

Then we find that it seems to be a dilemma. In order to have a formalism that in lined with human intuitions, one should give up preferred semantics, which has been use for credulous reasoning. Whether there is any way to reconcile unrestricted rebut and credulous reasoning, is a topic for further research.

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Appendix

Since the survey was conducted among Chinese students, the questionnaire was designed in Chinese. The following is a translation of the questionnaire:

In the following five cases, you will see two arguments, which are arguments(A) and counter-arguments(B), would you consider that B is a legitimate response to A?

1. A: “We found Steven’s DNA at the scene of the crime, and we also confirmed that he has a similar previous convictions, so Steven is probably the murderer.”
   B: “Steven is not the murderer, because eyewitness Branden testified that Steven was not at the scene when the murder happened.”

2. A: “Jessica is a stan of two popular Korean bands, EXO and Bigbang. Both of them will hold concert series separately at nearby cities in next few weeks. So Jessica will attend at least two concerts recently.”
   B: “That won’t be possible. She has been assigned too much work rencently, so she can’t afford time to attend two concerts.”

3. A: “Lee is not only tall and handsome, but also rich, if you ever seen the luxury car he drives. So Lee maybe the Mcdreammy for girls in real life.”
   B: “No, he is not. He is only a chauffeur for the car owner.”

4. A: “Lying leads to crime. Crimes should be banned. So lying should be forbidden.”
   B: “Sometimes telling white lies may help others, there is no reason to forbid lying.”

5. A: “Every human is mortal. Lu Xun (a great writer from China) is a human. Lu Xun is mortal.”
   B: “Lu Xun left a rich spiritual legacies, which will be passed down from one generation to another. In this sense, his ideas isimmortal. ”