

Towards a sound and complete dialogue system for handling enthymemes

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Statement

We confirm that the work this paper is based on has not been already presented to a KR audience in a major forum.

Abstract

A common assumption for argumentation-based dialogues is that any argument exchanged is complete, in the sense that its premises entail its claim. However, in real world dialogues agents commonly exchange enthymemes — arguments with incomplete logical structure. In the work summarised here (Xydis et al. 2021) we formalised the dialogical exchange of enthymemes that are missing some constituent elements, such that it is not possible to directly entail the claim of the intended argument from the premises of the enthymeme exchanged. We also proved that, under certain conditions, the status of moves made during a dialogue conforming to our system, corresponds with the status of arguments in the Dung argument framework instantiated by the contents of the moves made at that stage in the dialogue. Here, we discuss our contributions and the significance of our results.

1 Introduction

ASPIC⁺ (Modgil and Prakken 2013) is an established framework for formalising argumentation-based characterisations of well known *non-monotonic* (*nm*) inference relations over belief bases. ASPIC⁺ arguments are built from premises in the belief base and defeasible and/or deductive inference rules (where the former may be domain specific defaults and the latter the inference rules of a Tarskian logic; e.g., classical logic). The arguments and attack (counter-argument) relation amongst arguments instantiate a Dung *Argumentation Framework* (*AF*) (Dung 1995), and the claims of the ASPIC⁺ arguments evaluated as justified under Dung semantics identify the *nm* inferences from the underlying belief base. These argumentative characterisations can be generalised to dialogues that enable *distributed nm* reasoning; human and/or AI agents exchange arguments that aim to establish a dialogue’s ‘topic’ (a belief or decision option) as an *nm* inference from the knowledge pooled by the participating agents. These dialogical models can then be used to enhance the quality and scope of both human and AI reasoning, by supporting joint human-AI reasoning¹, as well as providing normative guidance for dialectical exchange and debate amongst humans (Modgil 2017a).

Existing dialogical formalisations of *nm* inference typically assume that arguments are complete, i.e. that *all* the premises and deductive/defeasible rules used to construct an argument in support of a claim, are conveyed in the communicated argument. However, in real-world dialogues, humans tend to communicate arguments that are not logically complete – *enthymemes* (Walton 1989) – omitting elements (inference rules and/or premises and/or the claim) because, for example, they assume the omitted elements can be reconstructed by their interlocutors (be they other humans or AI agents). As a result misunderstandings may occur, as the receiver of an enthymeme may either be incapable of correctly ‘filling in’ the missing information, or may do so incorrectly. These misunderstandings can then compromise the key desired correspondence – i.e., soundness and completeness (**SC**) – result for dialogical formalisms of distributed *nm* reasoning; that is, at any given stage of a dialogue *d*:

d establishes the topic α iff α is the claim of a justified argument in the *AF* instantiated by ASPIC⁺ arguments constructed from the pooled knowledge (i.e., the contents of declarative locutions thus far exchanged). (**SC**)

2 Discussion

Suppose agents Ag_1 and Ag_2 are participating in a dialogue to decide whether information about Bob’s affair should be published. Ag_1 can construct a complete ASPIC⁺ argument A claiming “the information should not be published” ($\neg pub$), where A consists of: the premise “Bob is no longer a public figure ($\neg pf$)”; the sub-argument A' concluding that “the information is not in the public interest” ($\neg pi$) given that “affairs do not concern the public” ($\neg ap$); the sub-argument A'' concluding that “the information is private” (pr) given that “romantic preferences are private” (rp). A , A' and A'' are shown in Fig. 1. However Ag_1 may not communicate (move) A , but instead moves the enthymeme $E_1 = “\neg pf, \neg pi, pr, hence \neg pub”$, holding back from communicating the supporting premises and defeasible rules that constitute the sub-arguments for the intermediate conclusions $\neg pi$ and pr . Ag_2 might then query $\neg pi$ and pr , eliciting Ag_1 ’s arguments A' and A'' respectively, which together ‘backward extend’ E_1 to yield the complete ‘intended’ argument A .

Although there are works focusing on construction and deconstruction of enthymemes (e.g. (Black and Hunter 2012)) as well as their understanding (e.g. (Hunter 2022)), these do not examine enthymemes employed in dialogues. The dialogues formalised in (Black and Hunter 2009), (Hosseini 2017) and (Prakken 2005), accommodate locutions that allow for querying the premises of enthymemes, and responding with arguments that backward extend enthymemes (as described above). However, these works do not support the use of enthymemes that require *forward extending* in order to yield the claim. This, we argue is a feature of real world dialogues that we address in our paper (Xydis et al. 2021). Consider that argument $B = “Bob is the UN envoy for the Middle East (*en*), hence Bob is a public figure (*pf*)” is the intended argument of Ag_2 , but Ag_2 attacks E_1 with the enthymeme $E_2 = en$ (“But Bob is the UN envoy for the Middle East”). It is not immediately clear why E_2 attacks E_1 (since *en* does not directly challenge any element of E_1). Our running example is used in (Modgil 2013) to illustrate that to avoid misunderstandings, and so ensure a fully rational exchange, a formal dialogue model should normatively prompt Ag_1 to seek clarification—“what is implied by *en* such that your intended argument attacks E_1 ?”—to which Ag_2 might reply that *en* implies *pf*, thus *forward extending* E_2 to yield B which negates a premise in E_1 .$

Notice that before Ag_1 seeks clarification, Ag_2 can be said to win the dialogue, given that E_2 is moved as a counter-argument (as indicated by the preposition “but”) to A . The dialogue thus fails to establish the topic $\neg pub$. However, suppose the *AF* instantiated by ASPIC⁺ arguments that are in turn constructed from the contents of A and E_2 , and where attacks amongst arguments are defined in the usual way (i.e., based on whether the conclusion of one argument negates an element in the attacked argument). Then E_2 does

¹E.g., state of the art approaches to value alignment (Russell 2019) will require joint human-AI deliberations (Modgil 2017a).

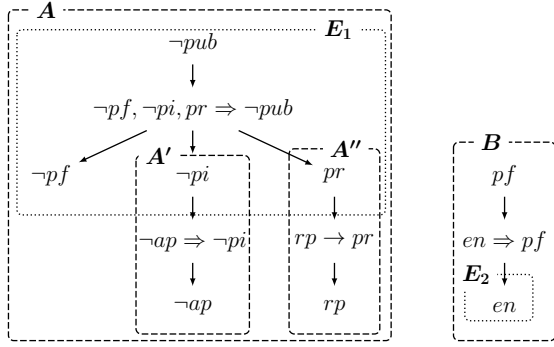


Figure 1: ASPIC⁺ arguments and enthymemes in Section 2’s running example. *A* and *B* (enclosed by a dashed line) in which defeasible and strict inference rule applications are respectively denoted by \Rightarrow and \rightarrow . The sub-arguments *A'* and *A''* of *A*, backward extend *A* on $\neg pi$ and *pr*, respectively, and are enclosed by a dashed line. The enthymemes E_1 of *A* and E_2 of *B* are enclosed by a dotted line; *B* forward extends E_2 .

not ‘formally’ (as opposed to pragmatically as in the case of the dialogue) attack *A* (since E_2 does not negate any element in *A*) and so Ag_1 ’s argument *A* is justified. Soundness and completeness (SC) thus fails to hold: the topic $\neg pub$ is the claim of a justified argument.

Observe that (de Saint-Cyr 2011) allows for both backward and forward extending of enthymemes, as does the dialogue system in (Xydis et al. 2020), which additionally enables resolution of misunderstandings arising due to use of enthymemes, but these and the above mentioned works do not show SC results. A notable exception is (Prakken 2005), but it only addresses backward extension of enthymemes.

The main contribution of our paper (Xydis et al. 2021) is a dialogue system in which agents can move enthymemes and seek clarification to elicit forward extension of enthymemes (using locutions not typically formalised in argumentation based dialogues). Indeed, as shown in (Xydis et al. 2020), the additional locutions included in our system to handle enthymemes, are by no means contrived, but are typical of real world dialogical exchanges. We show below a natural language dialogue in our dialogue system. In brackets we include the locutions introduced in (Xydis et al. 2021) and the formalisation of enthymemes and arguments exchanged in the dialogue. Note, *pub* is a complete argument, whereas the internal structure of the other arguments and enthymemes exchanged in the dialogue are shown in Fig. 1.

1. Ag_2 : Information about Bob’s affair should be published. (**assert** *pub*)
2. Ag_1 : Bob is no longer a public figure. Affairs do not concern the public, so Bob’s affair is not in the public interest. Romantic preferences are private, hence information about Bob’s affair is private. (**assert** $\neg pf; \neg ap; \neg ap \Rightarrow \neg pi; \neg pi; rp; rp \rightarrow pr; pr$)
3. Ag_2 : So what? (**and-so**)
4. Ag_1 : So, information about Bob’s affair should not be published. (**hence** $\neg pf; \neg pi; pr; \neg pf, \neg pi, pr \Rightarrow \neg pub; \neg pub$)

5. Ag_2 : Bob is UN envoy for the Middle East. (**assert** *en*)
6. Ag_1 : So what? (**and-so**)
7. Ag_2 : Bob is UN envoy for the Middle East. Therefore, Bob is a public figure. (**hence** *en*; $en \Rightarrow pf; pf$)

We show (Xydis et al. 2021) that for exhaustive dialogues with ‘honest and understanding’² participants, a dialogue establishes a topic (as determined by evaluation of the dialogical status of moves in what we call the *dialogue framework*) iff the topic is the claim of a justified ASPIC⁺ argument in the instantiated *AF* defined by the locutions’ contents. This SC result —not shown previously for dialogue systems that support forward extension of enthymemes—is significant since it demonstrates that when enthymemes are used in a dialogue, participants can still reach the same outcome as they would if they were restricted to moving only complete intended arguments. Thus, we show that the use of enthymemes in dialogues — a ubiquitous real-world feature of dialogues that supports efficient inter-agent communication — does not compromise the long term aim of comprehensive accounts of distributed *nm* reasoning.

Additionally, to the best of our knowledge, our work is the first to show SC results for ASPIC⁺ dialogues (since complete arguments are a special case of enthymemes).³ The significance for distributed formalisations of *nm* reasoning is apparent, given that ASPIC⁺ has been shown to capture other logic-based argumentation systems (e.g., (Amgoud and Cayrol 2002; Bondarenko et al. 1997; Gordon, Prakken, and Walton 2007)) and established *nm* logics (e.g., (Brewka 1989; Brewka 1994))

3 Conclusion

Our work paves the way for sound and complete formalisations of distributed non-monotonic reasoning that accommodate the use of any kind of enthymeme, by enabling the uncertainty that may arise from their use to be resolved through dialogical interactions. Our work thus contributes to the long term realisation of: 1) computational tools for inculcating rational dialectical skills amongst humans (e.g., in educational settings (Modgil 2017a)); and 2) dialogical scaffolding for human-AI communication and joint reasoning. The latter is an especially salient requirement given contemporary concerns about AI reasoning and making decisions independently of human input and preferences (Modgil 2017a; Russell 2019).

²When an *honest* participant *Ag* moves an enthymeme *E* against an enthymeme E' moved by their counterpart Ag' , then *E* is indeed part of a complete intended argument *X* which defeats what *Ag* assumes to be the complete intended argument *Y* of Ag' from which E' was constructed. It also means that if *Ag* forward extends their enthymeme *E* with an enthymeme E'' , then E'' indeed forward extends *E* where *E* and E'' together constitute *X*. An *understanding* participant is correct in their assumption of the intended complete argument of their counterpart (i.e., in this case *Ag* is correct to assume that *Y* is the intended complete argument from which E' was constructed).

³(Modgil 2017b) formalises ASPIC⁺ dialogues extended to accommodate reasoning about preferences; however SC results are not shown.

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