Testing the Benefits of Structured Argumentation in Multi-Agent Deliberation Dialogues

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Abstract
Work on argumentation-based dialogue systems often assumes that the adoption of argumentation leads to improved efficiency and effectiveness. Several studies have taken an experimental approach to prove these alleged benefits, but none has so far supported the expressiveness of a logic for structured argumentation. This paper shows how the use of argumentation in deliberation dialogues can be tested while supporting goal-based agents that use the ASPIRE framework for structured argumentation.

Example dialogue
agent utterance logical form
a I suggest we go to the pizzeria. propose(0)
why-propose
b Why should we go there? why-propose(0)
If not yet proposed, propose if
a I would go to the pizzeria, we could drink wine and that means we will enjoy our food. argue(0, α = |p₁, p₂| → ϕ₂)
If not yet proposed, propose if
b There is also a bistro. propose(α)
If not yet proposed, propose if
a I don't want to go there. reject(0)
If not yet proposed, propose if
b The pizzeria does serve tasty pizzas and having those means we will enjoy the food. argue(0, α = |p₁, p₂| → ϕ₂)
If not yet proposed, propose if
a We can not drink wine, though. argue(¬p₁ → ¬ϕ₁)
If not yet proposed, propose if
b And drinking wine does not mean we will enjoy the food. argue(¬ϕ₁ → ¬p₂)
If not yet proposed, propose if

Deliberation model

Scenario generation
Rule chains
Given some length ℓ, an option α, a goal g and set of beliefs \{p₁, ..., pₙ\}
\[ C_{g, α} = \{ α \mathrel{⇒} p₁, ..., α \mathrel{⇒} pₙ \mathrel{⇒} g \} \]
Conflict generation
A set of possible conflicts \( C_{g, α} \) contains for every rule \( p \mathrel{⇒} q \in C_{g, α} \)
- a fact \( ¬q \) (an undercutter)
- a fact \( ¬p \) (an underminer)
- a fact \( ¬q \) (a rebuttal)

Strategies
Internal reasoning
- Every goal has a utility \( U^{g}_{α} \)
For an option, sum the utilities of goals it promotes
- Possible to construct an argument \( A \mathrel{⇒} g \) for \( o \) such that \( o \in A \)?
- Option heuristic \( H^{g}_{α} \)
  - build iff the sum of utilities > 0
  - destroy otherwise

Arguing agent
If not yet proposed, propose if build
For existing proposals
- build and currently out?
  - destroy and currently in
  - Find argument to play or question a move

Non-arguing agent
If not yet proposed, propose if build
For existing proposals
- Reject if destroy

Conclusion
- First experiments with structured argumentation
- Arguing outperforms non-arguing effectiveness
- Partly confirms Karunatilake et al. 2009, Pasquier et al. 2010, Black 2011

Experiment
An Java implementation of the dialogue model, scenario generation model and agent strategies was made. 1000 dialogues were generated and two metrics were applied.

Arguing vs. non-arguing efficiency (number of moves)

Arguing vs. non-arguing effectiveness (combined utility for the outcome)