

Multiparty Argumentation Game for Consensual Expansion Applied to Evidence Based Medicine

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Abstract. Evidence based medicine (EBM) requires many different sources of knowledge when dealing with complex patients. Such a discipline inherently involves the issue of conflicts arising amongst arguments coming from different sources, such as guidelines, trials and clinical studies. In this paper we consider a set of agents with their own medical argumentation which exchange medical arguments to enrich their own knowledge and suggest a set of treatments resulting from the argumentation process.

1 Introduction

Evidence Based Medicine (EBM) involves the application of the best practice towards a treatment as supported by the scientific method [1]. One way used by medical doctors to implement EBM is to use medical guidelines in their clinical practice. However, contradictions happen between the different guidelines and clinical trials. Multi-Agent Systems can help EBM by combining existing medical guidelines. In Argumentation Theory, the positions (arguments) and the oppositions (attacks) are first-class citizens. In this paper, we adopt a dialectical approach of argumentation where the argumentation is the outcome of a dispute process [2–4]. Agents play a game to decide the best treatment to be applied to a patient and highlight where the conflicts are. In [5] we focused on formalizing the argumentation game while the significance of this paper resides in its application for EBM. In particular, we evaluate our approach with a case study involving a patient affected by hypertension, dyslipidemia and cardiovascular complications.

2 Background

In order to represent evidence, here we adopt the abstract approach to argumentation proposed in [2]. Medical arguments are viewed as abstract entities supporting claims about treatments to be proposed for a patient. The fact that an argument is challenged by another captures the notion of conflict in the treatments.

Definition 1 (AF). *An Argumentation Framework is a couple $AF = \langle A, R \rangle$ where A is a finite set of arguments, $R \subseteq A \times A$ is a binary relation called attack relation.*

Contrary to [6], arguments are atomic entities representing the drugs to be used in a treatment for a patient, while attacks represent conflicts amongst the drugs related to the particular patient status. For example, for a dyslipidemic patient that has a history of myocardial infarction, n-3 fatty acids (N3FA) and statins are arguments and N3FA attack statins due to the patient's history.

An argumentation framework does not allow to model missing information. That is the reason why [7] introduce the *Partial Argumentation Framework (PAF)* representing the fact that an argument attacks (or not) a second argument can be ignored.

Definition 2 (PAF). A partial argumentation framework is a triplet $PAF = \langle A, R, I \rangle$ where: $\langle A, R \rangle$ is the underlying AF as defined in Def. 1, $I \subseteq A \times A$ is the ignorance relation which verifies that $R \cap I = \emptyset$. We call non-attack relation $N = (A \times A) \setminus (R \cup I)$.

To capture the heterogeneous viewpoints related to medical guidelines, trials and meta analysis, we consider a set of agents, each of them having its own arguments and conflicts. The agents aim at expanding their argumentation based on a consensus.

Formally, we consider here a profile of n argumentation frameworks $S = \langle AF_1, \dots, AF_n \rangle$. Our goal is to expand this vector in a profile of partial argumentation frameworks $P = \langle PAF_1, \dots, PAF_n \rangle$ where each PAF_i expands the corresponding AF_i with S by taking account the arguments, the attacks and the non-attacks from the other AFs in S . For this purpose, we focus on the consensual expansion proposed by [7]. In order to expand an AF_i on a PAF_i , we consider all the arguments and only the consensual attacks.

Definition 3 (Consensual expansion). Let $S = \langle AF_1, \dots, AF_n \rangle$ be a profile of n argumentation frameworks $AF_i = \langle A_i, R_i \rangle$ with $1 \leq i \leq n$. Let $conf(S) = (\bigcup_i R_i) \cap (\bigcup_i N_i)$ be the set of non-consensual attacks. The consensual expansion of AF_i with S is a partial argumentation framework $PAF_i = \langle A'_i, R'_i, I'_i \rangle$ where: $A'_i = \bigcup_j A_j$, $R'_i = R_i \cup ((\bigcup_{j \neq i} R_j) \setminus conf(S))$ and $I'_i = conf(S) \setminus (A_i \times A_i)$. Then, $N'_i = (A'_i \times A'_i) \setminus (R'_i \cup I'_i)$.

The arguments in the consensual expansion (A'_i) are all the arguments from the initial profile. A new attack is added (R'_i) if it is consensual, i.e. if all agents which initially consider these arguments agree on this conflict. An attack is ignored (I'_i) if it is not consensual ($conf(S)$) and if it was not considered *a priori* ($A_i \times A_i$).

3 Proposal

We adopt an individual-oriented approach where the consensual expansion emerges from the interactions between the agents. Our proposal consists of a multiparty argumentation game, where more than two agents play and observe moves on a gameboard. At the end of the game, each agent builds its *PAF* with the arguments and the conflicts recorded on the gameboard.

Definition 4 (gb). The gameboard is an objective representation of the game with a triplet $gb = \langle AM, RM, DM \rangle$ where: AM is the record list of argument moves, RM is the record list of attack moves and DM is the record list of denial moves.

Agents perceive the gameboard and can act on it by adding arguments, attacks and non-attacks. These moves are evaluated via an artifact which records the dialogue history. Each utterance of a move is interpreted by the artifact for updating the gameboard in order to build the common partial argumentation framework.

Definition 5 (AF_{gb}). We call common partial argumentation framework $PAF_{gb} = \langle A_{gb}, R_{gb}, D_{gb} \rangle$, the argumentation framework defined such that: A_{gb} is the set of arguments in the argument moves from AM, R_{gb} is the set attacks in the attack moves from RM and D_{gb} is the set of ignorances in the denial moves from DM.

We aim at defining the game such that the rational rules of utterances and the rules of the game leads to a common partial argumentation framework $PAF_{gb} = \langle A_{gb}, R_{gb}, D_{gb} \rangle$.

The game we propose is a n -players simultaneous game based on the gameboard. Our argumentation game is subdivided into two subgames. The first one, the **argument game**, aims at collecting the agents' arguments. The second game, the **attack game**, collects all the consensual and non-consensual attacks. The argument (resp. attack) game ends when all the players withdraw, i.e. when they have no more arguments (resp. attacks) to push forward. Agents communicate by playing moves. The content of the moves depends on the subgame.

Argument game. Agents can submit new arguments. A move is well-formed iff it contains an argument ($m = \langle i, \text{assert}(a) \rangle$) with $1 \leq i \leq n$ and $a \in \bigcup_i A_i$.

Attack game. Agents can add or retract attacks. A move is well-formed iff it contains an attack ($m = \langle i, \text{assert}(a, b) \rangle$) with $1 \leq i \leq n$ and $a, b \in A_{gb}$ or a non-attack ($m = \langle i, j, \text{deny}(a, b) \rangle$) with $1 \leq i, j \leq n$, $a, b \in A_{gb}$ and there is a move $m = \langle j, \text{assert}(a, b) \rangle$ in AM). Contrary to the attack moves, the non-attack moves are replying moves.

Rational rules Each player i can check the legality of moves and submit it if it is the case. During the argument game (resp. the attack game), an agent submits a move based on the rational rule (1) (resp. (2)):

$$ag_i \text{ utters } \begin{cases} m = \langle i, \text{assert}(a) \rangle \\ \text{if } \exists a \in A_i \wedge a \notin A_{gb} \\ m = \langle i, \text{withdraw} \rangle \text{ else} \end{cases} \quad (1) \quad ag_i \text{ utters } \begin{cases} m = \langle i, \text{assert}(a, b) \rangle \text{ if} \\ \exists (a, b) \in R_i \wedge (a, b) \notin D_{gb} \\ m = \langle i, j, \text{deny}(a, b) \rangle \text{ if} \\ \exists (a, b) \in N_i \wedge (a, b) \notin D_{gb} \\ m = \langle i, \text{withdraw} \rangle \text{ else} \end{cases} \quad (2)$$

The game is regulated by a scheduler which gives the token to agents in a fair way. Here we assume that agents are honest. At the end of the game, each player expands its argumentation framework with the arguments, the attacks and the denials reported in the common partial argumentation framework:

Definition 6 (Game expansion). Let $S = \langle AF_1, \dots, AF_n \rangle$ be a profile of n argumentation frameworks and $AF_i = \langle A_i, R_i \rangle$ be one of them. The expansion of AF_i with $PAF_{gb} = \langle A_{gb}, R_{gb}, D_{gb} \rangle$ is the partial argumentation framework $PAF_i = \langle A_i'', R_i'', I_i'' \rangle$ defined such that: $A_i'' = A_{gb}$, $R_i'' = R_i \cup R_{gb}$, $I_i'' = D_{gb} \setminus (A_i \times A_i)$.

Contrary to [7], agents do not need to know the arguments and the attacks of all the other agents but only the outcome of the game. As demonstrated in [5], the common partial argumentation framework allows to expand the individual argumentation frameworks in a consensual manner.

4 Usecase

We use our argumentation game to compare the results of different clinical trials, when a doctor is called to make a decision about a 55 years old patient who is affected by chronic hypertension, dyslipidemia and has coexistent cardiovascular complications. The problem for the medical doctor that has to decide about such a patient is to combine a set of drugs so that the probability of certain outcomes, such as myocardial infarction or kidney failure, are minimized.

We used the meta-analysis in [8–10], which compare different treatments for dyslipidemia, hypertension and cardiovascular complications: Statins, N3FA (n-3 fatty acid), Resins, Angiotensin-converting enzyme (ACE) and Diet. Fig. 1 compares the risk for the treatments. For instance, the risks due to cardiac mortality are less with N3FA rather than Resins (a_4). The other risks of mortality are equivalent for these two treatments (a_9). We consider five agents. Each of them is associated with an Argumentation Framework. The first evaluates cardiac mortality (AF_1), the second focuses on other mortality (AF_2), the third considers myocardial infarction (AF_3), the fourth focuses on stroke (AF_4) and the last one is interested in kidney outcome. The profile of the corresponding argumentation frameworks is in Fig. 1.

Treatments are represented by arguments: Statins (S), N3FA (N), Resins (R), ACE (A) and Diet (D). Each pairwise comparison is captured by an attack when there is an evidence for the benefit of one treatment over another one. The output of our argumentation game is represented in bottom of Fig. 1. Finally, our system allows to conclude that introducing N3FA, statins and ACE inhibitors is the treatment which has the lower risk. The clinical trials lead to the same conclusion. Resins, would be a good drug to deal with dyslipidemia, but the trials indicate that resins rise the probability of mortality for other causes, so, as a first choice, Statins are more indicated. In the case that the dyslipidemia worsens then the doctor will have to decide if the risk of cardiovascular complications justify the introduction of a combined therapy, but this case is outside the scope of this paper.

5 Conclusion

In this paper, we have considered a set of agents, each of them is equipped with its own argumentation framework. We have formalized a multiparty argumentation game, where more than two agents play and observe moves on a gameboard. In our individual-oriented approach, the building of the consensual expansions emerges from the interactions between the agents. Furthermore, our model is explanatory since it renders intelligible the conflicts between the agents which appear during the process, i.e. the contradiction in the medical guidelines.

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Id	Treatment	Comparison	Treatment	Indicator
a_1	Statins	>	Diet	card. mort.
a_2	Statins	<	Resins	card. mort.
a_3	Statins	<	N3FA	card. mort.
a_4	Resins	<	N3FA	card. mort.
a_5	Diet	<	N3FA	card. mort.
a_6	Diet	<	Resins	card. mort.
a_7	Statins	>	Diet	other mort.
a_8	Statins	>	Resins	other mort.
a_9	Statins	=	N3FA	other mort.
a_{10}	N3FA	>	Diet	other mort.
a_{11}	N3FA	>	Resins	other mort.
a_{12}	Statins	>	ACE	Myocardial
a_{13}	Statins	<	Diet	Myocardial
a_{14}	ACE	<	Diet	Myocardial
a_{15}	N3FA	>	Statins	Myocardial
a_{16}	N3FA	>	ACE	Myocardial
a_{17}	N3FA	<	Diet	Myocardial
a_{18}	Statins	>	ACE	Stroke
a_{19}	Statins	>	Diet	Stroke
a_{20}	ACE	<	Diet	Stroke
a_{21}	N3FA	<	Statins	Stroke
a_{22}	N3FA	>	Diet	Stroke
a_{23}	Statins	<	ACE	kidney out.
a_{24}	ACE	>	Diet	kidney out.

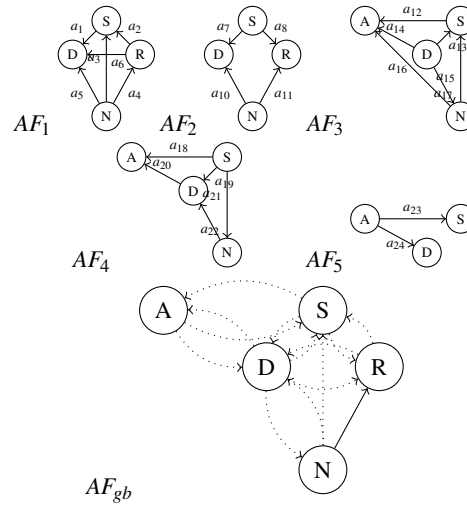


Fig. 1: Comparison of treatments (at left), the profile of argumentation frameworks (at top right) and the output (at bottom right).

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