Proceedings of the Sixteenth International Conference on
Principles of Knowledge Representation and Reasoning (KR 2018)

Argumentation for Reasoning with Conflicting Clinical Guidelines and Preferences

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Abstract

We propose to use two structured argumentation formalisms, assumption-driven ABA$^+$ and goal-driven ASPIC-G, to enable automated patient-centric medical reasoning with interacting clinical guideline recommendations, patient-specific conditions and preferences over recommendations and goals.

1 Introduction

Medical decision making involves careful deliberation about the condition of a patient, their preferences and the treatments that should lead to a desired state. Clinical guidelines provide best practice recommendations for achieving patient well-being given a single disease. When managing multiple health conditions (multimorbidities), guidelines need to be merged, whence various interactions influencing the evolution of the patient arise (Fraccaro et al. 2015).

Transition-based Medical Recommendation model (TMR) (Zamborlini et al. 2017) is a state of the art development in representation of clinical guideline recommendations. TMR identifies components and relations typically present in multimorbidity situations, such as clinical care actions, their effects on various physical properties and measures of the quality of the evidence. It also allows for modelling guideline interactions, such as conflicting or overlapping actions, when merging multiple guidelines. TMR thus offers a comprehensive template for representing generic guideline recommendations and capturing interactions among them, therefore providing crucial steps in facilitating medical decision making.

However, TMR lacks mechanisms for *reasoning* with guideline recommendations and their interactions. In particular, TMR does not accommodate patient-specific conditions, preferences over actions or goals, which are crucial for making patient-centric decisions (Peleg 2013; Vermunt et al. 2017). We propose to address these issues by applying two *argumentation*-based methods for reasoning with clinical guidelines, patient information and preferences.

Generally speaking, argumentation allows to reason with conflicting information in a way that aims to emulate human reasoning. In medical reasoning particularly, "argumentation is appealing as it allows for important conflicts to be highlighted and analysed and unimportant conflicts to be suppressed." (Atkinson et al. 2017) We thus propose to use structured argumentation formalisms *Assumption-Based Argumentation with Preferences* (*ABA*$^+$) (Bondarenko et al. 1997; Čyras and Toni 2016) and *ASPIC*$^+$ *with Goals* (*ASPIC-G*) (Modgil and Prakken 2014; Oliveira et al. 2018) for automating patient-centric reasoning with conflicting guideline recommendations and preferences.

Both ABA$^+$ and ASPIC-G use TMR to represent recommendations and interactions via rules and arguable elements from which arguments are constructed. Both formalisms augment this representation with patient-specific information and preferences. However, they emphasise different perspectives: specifically, reasoning in ABA$^+$ is driven by assumptions representing applicability of recommendations and preferences over the actions recommended; instead, reasoning in ASPIC-G is driven by goals concerning desirable patient outcomes and preferences over those goals.

2 Proposal

Roughly, a guideline recommendation in TMR is represented via the associated *action* with its *effects* on *properties* (patient conditions) and their *contributions* (positive or negative). In the multimorbidity setting, where multiple guidelines need to be merged and their recommendations considered in tandem, one can use TMR to identify *interactions* among recommendations. Intuitively, interactions record the relationships between different recommendations, for instance, *contradiction* relationship in case one recommendation urges to avoid the action suggested by another recommendation. Several types of interactions, such as contradiction, repetition, alternative, can be identified.

TMR thus encompasses a patient-agnostic representation, whereas the reasoning with recommendations happens using patient-specific information and various preferences. On the one hand, certain recommendations may be deemed inapplicable if the actions suggested negatively contribute to particular goals, or generally patient well-being, by affecting their existing conditions. On the other hand, recommendations may be in conflict simply because different conditions may require opposite treatment methods. In such a case, preferences often come into play. For instance: the patient may prefer one course of action over another; the clinician may prioritise goals to be achieved.

The TMR model can be easily mapped to structured argumentation. In general terms, the knowledge representation components of ABA$^+$ and ASPIC-G amount to rules and arguable elements (assumptions in ABA$^+$, defeasible rules in ASPIC-G). In particular, we model recommendations as arguable elements, and relate their associated actions, properties and effects via rules. We use the interactions along with the contributions to relate conflicting recommendations via rules. These also take into account the possible patient specific-conditions, existence of which we specify for any given patient. We likewise set goals and preferences (over recommendations or goals) for a given patient.

Reasoning in argumentation amounts to constructing arguments and counterarguments and finding the 'best' arguments (formally defined via argumentation semantics) conclusions of which can be accepted. Preferences over argument components can also be integrated and they influence the reasoning outcomes. Specifically, given patient-specific recommendations, goals and preferences in ABA$^+$ or ASPIC-G, we construct arguments based on recommendations, for actions, leading to various goals, and use argumentation semantics to resolve conflicts among recommendations. This yields compatible recommendations to follow for a specific patient while respecting preferences.

3 Related Work

Argumentation has been successfully applied in healthcare (see e.g. (Longo 2016; Atkinson et al. 2017) for recent overviews): in (Hunter and Williams 2012) superiority among treatments is determined based on the evidence from clinical trials (as summarised in clinical guidelines); in (Tolchinsky et al. 2006) multi-agent deliberation is facilitated by helping experts to construct and evaluate arguments concerning viability of organ transplantation; in (Grando, Glasspool, and Boxwala 2012) arguments are instantiated with guideline statements to find argument achieving a specified goal; in (Qassas et al. 2016) clinicians' discussions are mapped to argumentation for determining the best claims; in (Fox et al. 2006) agents are enabled to exchange clinical arguments too. We plan to study connections of our work to these works in the future.

In (Wilk et al. 2017), instead of argumentation, model finding and theorem proving in first-order logic (generally undecidable) are used to reason with interacting guidelines, taking into account patient conditions and preferences. Their guideline representation components are quite different from ours, but we leave formal comparison of their and our works for the future.

Acknowledgements Kristijonas Čyras was funded by the EPSRC project **EP/P029558/1** ROAD2H: Resource Optimisation, Argumentation, Decision Support and Knowledge Transfer to Create Value via Learning Health Systems.
The work of Tiago Oliveira was supported by JSPS KAKENHI Grant Number **JP18K18115**.

References

Atkinson, K.; Baroni, P.; Giacomin, M.; Hunter, A.; Prakken, H.; Reed, C.; Simari, G. R.; Thimm, M.; and Villata, S. 2017. Towards Artificial Argumentation. *AI Magazine* 38(3):25–36.

Bondarenko, A.; Dung, P. M.; Kowalski, R.; and Toni, F. 1997. An Abstract, Argumentation-Theoretic Approach to Default Reasoning. *Artificial Intelligence* 93(97):63–101.

Čyras, K., and Toni, F. 2016. ABA+: Assumption-Based Argumentation with Preferences. In Baral, C.; Delgrande, J. P.; and Wolter, F., eds., *Principles of Knowledge Representation and Reasoning, 15th International Conference*, 553–556. Cape Town: AAAI Press.

Fox, J.; Black, L.; Glasspool, D.; Modgil, S.; Oettinger, A.; Patkar, V.; and Williams, M. 2006. Towards a general model for argumentation services. In *Argumentation for Consumers of Healthcare, Papers from the 2006 AAAI Spring Symposium*, 52–57. Stanford: AAAI.

Fraccaro, P.; Arguello Casteleiro, M.; Ainsworth, J.; and Buchan, I. 2015. Adoption of Clinical Decision Support in Multimorbidity: A Systematic Review. *JMIR Medical Informatics* 3(1):e4.

Grando, M. A.; Glasspool, D.; and Boxwala, A. A. 2012. Argumentation logic for the flexible enactment of goal-based medical guidelines. *Journal of Biomedical Informatics* 45(5):938–949.

Hunter, A., and Williams, M. 2012. Aggregating evidence about the positive and negative effects of treatments. *Artificial Intelligence in Medicine* 56(3):173–190.

Longo, L. 2016. Argumentation for Knowledge Representation, Conflict Resolution, Defeasible Inference and Its Integration with Machine Learning. In Holzinger, A., ed., *Machine Learning for Health Informatics - State-of-the-Art and Future Challenges*, volume 9605. Springer. 183–208.

Modgil, S., and Prakken, H. 2014. The ASPIC + framework for structured argumentation: A tutorial. *Argument and Computation* 5(1):31–62.

Oliveira, T.; Dauphin, J.; Satoh, K.; Tsumoto, S.; and Novais, P. 2018. Argumentation with Goals for Clinical Decision Support in Multimorbidity. In *17th International Conference on Autonomous Agents and Multiagent Systems*. Stockholm: IFAAMAS.

Peleg, M. 2013. Computer-interpretable clinical guidelines: A methodological review. *Journal of Biomedical Informatics* 46(4):744–763.

Qassas, M. A.; Fogli, D.; Giacomin, M.; and Guida, G. 2016. ArgMed: A Support System for Medical Decision Making Based on the Analysis of Clinical Discussions. In Papathanasiou, J.; Ploskas, N.; and Linden, I., eds., *Real-World Decision Support Systems: Case Studies*. Springer. 15–41.

Tolchinsky, P.; Cortés, U.; Modgil, S.; Caballero, F.; and López-Navidad, A. 2006. Increasing Human-Organ Transplant Availability: Argumentation-Based Agent Deliberation. *IEEE Intelligent Systems* 21(6):30–37.

Vermunt, N. P. C. A.; Harmsen, M.; Westert, G. P.; Olde Rikkert, M. G. M.; and Faber, M. J. 2017. Collaborative goal setting with elderly patients with chronic disease or multimorbidity: a systematic review. *BMC Geriatrics* 17(1):167.

Wilk, S.; Michalowski, M.; Michalowski, W.; Rosu, D.; Carrier, M.; and Kezadri-Hamiaz, M. 2017. Comprehensive mitigation framework for concurrent application of multiple clinical practice guidelines. *Journal of Biomedical Informatics* 66:52–71.

Zamborlini, V.; da Silveira, M.; Pruski, C.; ten Teije, A.; Geleijn, E.; van der Leeden, M.; Stuiver, M.; and van Harmelen, F. 2017. Analyzing interactions on combining multiple clinical guidelines. *Artificial Intelligence in Medicine* 81:78–93.