Forgetting agent awareness: a partial semantics approach

Line van den Berg

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Univ. Grenoble Alpes & Inria, France
line.van-den-berg@inria.fr

Abstract

Partial Dynamic Epistemic Logic allows agents to have different knowledge representations about the world through agent awareness. Agents use their own vocabularies to reason and talk about the world and raise their awareness when confronted with new vocabulary. Through raising awareness the vocabularies of agents are extended, suggesting there is a dual, inverse operator for forgetting awareness that decreases vocabularies. In this paper, we discuss such an operator. Unlike raising awareness, this operator may induce an abstraction on models that removes evidence while preserving conclusions. This is useful to better understand how agents with different knowledge representations communicate with each other, as they may forget the justifications that led them to their conclusions.

1 Introduction

Agents use different ways to represent their knowledge about the world. This causes problems when they try to communicate: how do the agents translate their knowledge, expressed in their vocabulary, to the knowledge of other agents, which could be expressed in different vocabularies? When we require that agents are fully aware of each other's vocabularies, we can model their interactions with Dynamic Epistemic Logic (DEL). This has been achieved in the context of ontologies (a formal knowledge representation) and alignments (translations between different ontologies) in [8]. However, full awareness is not desirable nor realistic for *open* multi-agent systems where agents are continuously required to adapt their knowledge representations.

The problem with the modeling in DEL is that, on DEL, agents can only revise their knowledge and beliefs via dynamic upgrades such as announcements (changing knowledge), conservative and radical upgrades (changing beliefs). These eliminate or reorganize (some) worlds of the model. However, this also means that whatever may be learned in the future and whatever vocabulary may be acquired, should already be available in the present situation. This prevents agents to expand their vocabularies as is required in an open, dynamic setting.

To loosen this requirement, agent unawareness has been modeled for Dynamic Epistemic Logic using partial valuations [9]. This provides us with a richer framework because partial valuations allow propositions to be true, false or *undefined* and, when a proposition is undefined, agents are *unaware* of it. Whenever agents are confronted with new vocabulary, they raise their awareness via an "awareness raising" operator $+p$ [9].

Once provided with such an awareness raising operator it is natural to think of a dual, inverse operator for forgetting awareness. In this paper, we discuss such an operator. In particular, unlike raising awareness, forgetting awareness requires to understand what to do with consequences obtained from removed evidence. They may be forgotten as well or preserved. In the latter case, forgetting awareness induces an abstraction on models that may delete justifications while preserving their conclusions.

Besides its theoretical interest, this operator allows us to better understand how agents with different knowledge representations communicate and improve their alignments. Indeed, simple agents may forget the examples that led them to induce or discard more abstract conclusions [1, 2]. Hence, a full logical model of these agents [8] could take advantage of such a forgetting operator.

2 Related Work

Partial semantics have been introduced before for modal logic [6, 5, 10, 4], yet the connection with agent awareness was never explored. Instead, awareness and unawareness of agents have been studied from an epistemic logic perspective by adding an awareness operator to the language $A\phi$ [3]. A complete dynamic awareness logic with dynamics for increasing and decreasing awareness was developed in [13, 11, 7, 12].

However, in awareness logic, raising awareness of a proposition p comes equipped with disclosing the truth value of p. This is because all the propositions an agent may become aware of in the future are already specified in the initial setting and only awareness is considered as a partial function. We consider these two as different acts: becoming aware of a proposition and learning its truth value. In this way, unlike in awareness logic, models are truly open to evolve.

3 Forgetting

To raise awareness of a proposition p, $+p$, the valuation function is extended: p is added to the worlds of the model in which it was initially undefined [9]. Formally, this means that, in the model, all the worlds (globally), or all the accessible worlds for an agent (locally), in which p was initially undefined are duplicated and p is defined as true in one world and false in the other, while accessibility to and from duplicated worlds is preserved. This means that agents unaware of p become uncertain about p after raising awareness of p.

Similarly, to forget awareness of p, $-p$, we may delete the valuations of p from all the worlds in the model (globally), or from all the accessible worlds for an agent (locally). Worlds that are similar up to bisimilarity may be merged. This forces models on which awareness of p is raised and subsequently forgotten to be bisimilar to the original situation, see Figure 1.

However, this also raises a question what happens if awareness of p is raised, then p is used to learn something about another proposition q, and finally p is forgotten again. Consider, for example, the upgrade $+p; +q; !p; !(p \to q); -p$ as illustrated in Figure 2. When we apply $-p$ and remove the valuations of p from the worlds in the model, the truth value of q remains untouched: q will still be true even though its justification, p (because $p \to q$ was announced, linking the truth value of q to that of p), is removed. This means that this type of forgetting awareness induces an abstraction on models: removing evidence while preserving conclusions.

The question is then: is this feature of the forgetting awareness operator desirable? Should agents remember the conclusions drawn from forgotten evidence? Indeed, simple agents may forget the examples that led them to induce or discard more abstract conclusions [1, 2] because the conclusions enable them to successfully communicate without referring to the examples.

4 Conclusion

We have discussed a forgetting awareness operator for partial dynamic epistemic logic that removes valuations of the proposition that is to be forgotten from the worlds of the model. We have then shown that this type of forgetting awareness induces an abstraction on models that removes evidence while preserving conclusions.

Forgetting awareness is useful to better understand how agents with different knowledge representations communicate with each other and improve their alignments because simple agents may forget the justification for their drawn conclusions, without effecting the communication to take place successfully [1, 2]. Therefore, this could benefit a full logical model of such agents [8].

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Appendix: Figures

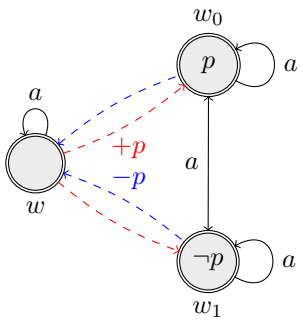

Figure 1: Raising awareness of p, $+p$, (left to right, the red dashed lines indicate how the worlds are mapped from the model on the left to the model on the right) and $-p$ (right to left, the blue dashed lines indicate how the worlds are mapped from the model on the right to the model on the left), where the worlds are merged up to bisimilarity. We have that $\mathcal{M}^{+p;-p}$ and $\mathcal{M}$ are bisimilar.

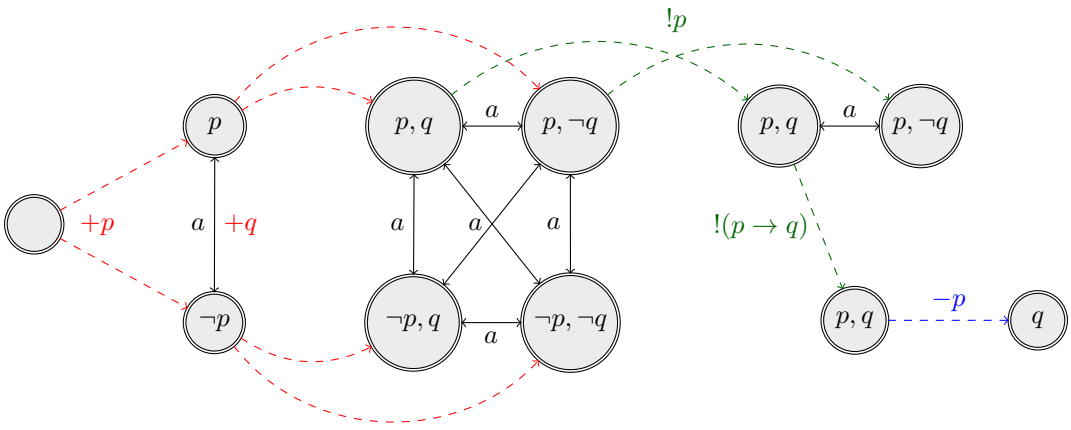

Figure 2: The figure illustrates the steps of the complex upgrade $+p; +q; !p; !(p \to q); -p$ applied to the "empty model" (where no propositions are defined), from left to right. For simplicity, the reflexive arrows are omitted and the dashed lines indicate how the worlds are mapped from the initial model (on the left) to the resulting model (on the right) where red stands for an awareness raise upgrade, green for an announcement and blue for a forgetting awareness upgrade. In the resulting model, on the right, q is known, but not justified anymore.

References

[1] Jérôme Euzenat. First experiments in cultural alignment repair (extended version). In *The Semantic Web: ESWC 2014 Satellite Events - ESWC 2014 Satellite Events, Anissaras, Crete, Greece, May 25-29, 2014, Revised Selected Papers*, pages 115–130, 2014.

[2] Jérôme Euzenat. Interaction-based ontology alignment repair with expansion and relaxation. In *Proceedings of the Twenty-Sixth International Joint Conference on Artificial Intelligence, IJCAI 2017, Melbourne, Australia, August 19-25, 2017*, pages 185–191, 2017.

[3] Ronald Fagin and Joseph Y Halpern. Belief, awareness, and limited reasoning. *Artificial intelligence*, 34(1):39–76, 1987.

[4] Jens Ulrik Hansen. Modeling truly dynamic epistemic scenarios in a partial version of del. *The Logica Yearbook 2013*, pages 63–75, 2014.

[5] Jan Jaspars and Elias Thijsse. Fundamentals of partial modal logic. *Studies in Logic Language and Information*, 1996.

[6] Elias Thijsse. Partial logic and knowledge representation. 1994.

[7] Johan Van Benthem and Fernando R Velázquez-Quesada. The dynamics of awareness. *Synthese*, 177(1):5–27, 2010.

[8] Line van den Berg, Manuel Atencia, and Jérôme Euzenat. Agent ontology alignment repair through dynamic epistemic logic. In *Proceedings of the 19th International Conference on Autonomous Agents and MultiAgent Systems*, page to appear. International Foundation for Autonomous Agents and Multiagent Systems, 2020.

[9] Line van den Berg, Manuel Atencia, and Jérôme Euzenat. Unawareness in multi-agent systems with partial valuations. In *Workshop on Logical Aspects of Multi-Agent Systems (LAMAS 2020)*, 2020.

[10] Wiebe Van der Hoek, Jan Jaspars, and Elias Thijsse. Honesty in partial logic. *Studia Logica*, 56(3):323–360, 1996.

[11] Hans Van Ditmarsch and Tim French. Awareness and forgetting of facts and agents. In *2009 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology*, volume 3, pages 478–483. IEEE, 2009.

[12] Hans Van Ditmarsch and Tim French. Becoming aware of propositional variables. In *Indian Conference on Logic and Its Applications*, pages 204–218. Springer, 2011.

[13] Hans Van Ditmarsch, Andreas Herzig, Jérôme Lang, and Pierre Marquis. Introspective forgetting. *Synthese*, 169(2):405–423, 2009.