Hintikka's World: scalable higher-order knowledge

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Abstract

Hintikka's World is a tool that shows how artificial agents can reason about higher-order knowledge (agent a knows that agent b knows that...). In this demonstration paper, we present symbolic models that enables to implement in *Hintikka's World* large examples such as real card games.

1 Introduction

The current trend is to construct programs that play games with imperfect information, for instance Hanabi [Bard *et al.*, 2019], but also video games such as Starcraft 2 [Hu *et al.*, 2018] An important ingredient is to reason about higher-order knowledge (an agent knows that another agents knows that...). That is why we claim that epistemic logic and its dynamic extension, Dynamic epistemic logic ([Baltag *et al.*, 1998], [van Ditmarsch *et al.*, 2008]), may offer a formal tool to provide explanation in such AI programs. needs to be understood is relevant in AI, especially in strategic reasoning [Aumann, 1999].

The only tool we are aware of that enables to see and explore mental states of agents is *Hintikka's world* and was presented at ECAI-IJCAI 2018 [Schwarzentruber, 2018]. *Hintikka's world* is a proof of concept of a graphical user interface that represent Kripke models by comic strips, as shown in Figure 1. The tool is available at the following address: http://hintikkasworld.irisa.fr/.

Kripke models are graphs and they were represented explicitly in memory in the first version of the tool. Explicit models are useful to learn how dynamic epistemic logic works by means of toy examples: muddy children, Sally and Anne [Wimmer and Perner, 1983], etc. However, in real card games, such as Hanabi, there are .... possible configurations of cards. Thus, it is impossible to represent the full graph in memory: the first version of Hintikka's world does not *scale*.

That is why, we proposed to represent Kripke models symbolically by means of Binary Decision Diagrams as it was done in the tool DEMO[1] [van Benthem *et al.*, 2015].

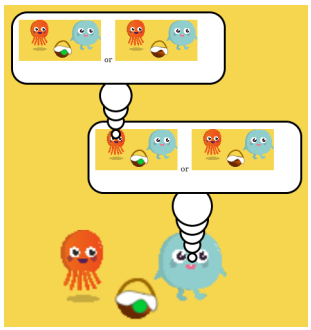

Figure 1: Graphical user interface of *Hintikka's world*

2 Symbolic models

3 Demonstration Outline

TODO expliquer Hanabi et comment on peut y jouer

4 System Description

TODO Expliquer comment c'est FAIT

4.1 Class Architecture

Figure 2 shows the main part of the architecture of *Hintikka's world*. The interesting part is the fact that the graphical user interface (GUI) is independent from the current example that is running (muddy children, Sally and Anne, etc.). In particular, adding a new example only requires to add a new class that inherits from `World` and to implement the method for drawing the scene from data (valuations, numbers, etc.) that are members of the class.

4.2 Model Checking

The tool highly rely on model checking. Indeed, for instance, performing the public announcement of ϕ requires to compute the subset of worlds in which ϕ holds and to prune the current Kripke model. We chose to write the model checking procedure in Javascript. Since model checking is in PTIME – thus is an easy task – and is used intensively, it suitable to run run it on the client-side for performance reasons.

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[1]The current implementation does not rely on DEMO since their work is not well-suited for a web application.

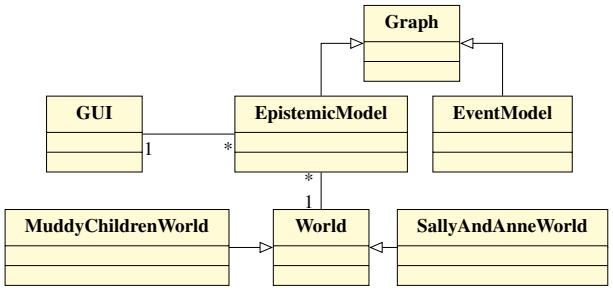

Figure 2: Architecture for the symbolic approach in *Hintikka's world*

4.3 Satisfiability Problem

5 Future Work

TODO implémzenter d'autres exemples etc.
TODO d'autres façons de "scaler"

References

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