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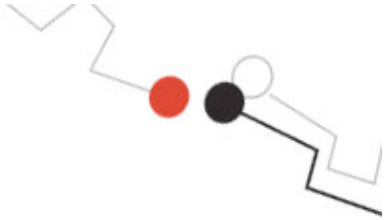

From Toronto to Amsterdam

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Since Moore [1980], the reasoning about actions community has been interested in epistemic actions and knowledge. Frameworks for reason with incomplete information, where agents are able to perform both physical (ontic) and epistemic actions have been proposed by, e.g., Shapiro et al. [1998], Scherl and Levesque [2003] and Baral and Zhang [2005]. These approaches are based on the solution to the frame problem, in terms of reduction axioms, proposed by Reiter [1991]. This was further extended by Scherl and Levesque [1993] to handle epistemic actions, leading to a reduction method to S5 logic. Combined with S5 theorem proving, it provides a decision procedure for the so-called plan verification problem. In the general case however, the reduced formula is exponentially larger than the original one and, up to now, no efficient reasoning about actions method were known. Here, we present a general framework which is a sum of S5 logic for modelling knowledge, star-free propositional dynamic logic (PDL) for modelling actions together with a perfect recall axiom. Moreover, we define two new operators: public observations and public assignments. Not surprisingly, we show that these two operators correspond to the public announcement from public announcement logic (PAL), firstly proposed by Plaza [1989], and the public assignment proposed by van Ditmarsch et al. [2005]. As showed by Herzig and De Lima [2006], in such formalism every deterministic public action can be decomposed in a sequence of two actions. The first one is a purely epistemic action (i.e., an epistemic actions that does not change the physical state of the world) and the second one is a purely ontic action (i.e., an ontic action that does not increase the knowledge of the agent). We then argue that public purely epistemic actions can be simulated by compound public announcements while public purely ontic actions can be simulated by compound public assignments. Therefore, since there is no need of PDL abstract actions, we restrict our actions to announcements and assignments only. We call the resultant logic epistemic dynamic logic (EDL). We then show a polynomial satisfiability reduction from EDL to S5 based on the polynomial reduction proposed by Lutz [2006]. It follows that validity, and in particular the plan verification problem, for EDL is in coNP for single-agent and in PSPACE for multi-agent environments.

References:

C. Baral and Y. Zhang. Knowledge updates: semantics and complexity issues. Artificial Intelligence, 164(1-2):209–243, 2005.
A. Herzig and T. De Lima. Epistemic actions and ontic actions: A unified logical framework. In J.S. Sichman et al., editors, IBERAMIA-SBIA 2006, LNAI 4140, pages 409–418. Springer-Verlag, 2006. to appear.
C. Lutz. Complexity and succintness of public announcement logic. In P. Stone and G. Weiss, editors, Proceedings of the Fifth AAMAS, pages 137–144, 2006.
R. Moore. Reasoning about knowledge and action. Technical Note 191, SRI International, 1980.
J. Plaza. Logics of public communications. In M. L. Emrich, Pfeifer M. S,
M. Hadzikadic, and Z. W. Ras, editors, Proceedings of the Fourth ISMIS, pages 201–216, 1989.
R. Reiter. The frame problem in the situation calculus: A simple solution (sometimes) and a completeness result for goal regression. In V. Lifschitz, editor, Papers in Honor of John McCarthy, pages 359–380. Academic Press Professional Inc., 1991.
R. Scherl and H. Levesque. The frame problem and knowledge-producing actions. In Proceedings of the Eleventh AAAI, pages 689–695. The AAAI Press, 1993.

R. Scherl and H. Levesque. Knowledge, action and the frame problem. Artificial Intelligence, 144(1–2):1–39, 2003.
S. Shapiro, Y. Lesp´erance, and H. Levesque. Specifying communicative multiagent systems. In Agents and Multi-Agent Systems - Formalisms, Methodologies, and Applications, volume 1441 of LNAI, pages 1–14. Springer-Verlag, 1998.
H. van Ditmarsch, W. van der Hoek, and B. Kooi. Dynamic epistemic logic with assignment. In F. Dignum, V. Dignum, S. Koenig, S. Kraus, M. Singh, and M. Wooldridge, editors, Proceedings of the Fourth AAMAS, pages 141–148. ACM, 2005.