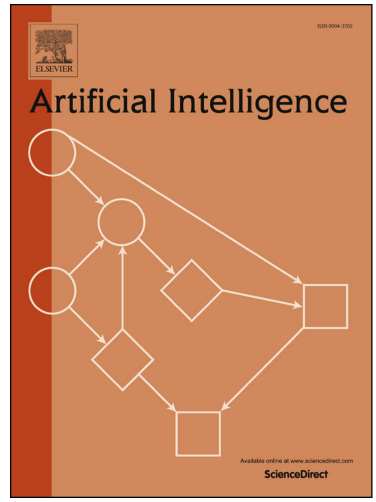
Accepted Manuscript



Belief revision and projection in the epistemic situation calculus

Christoph Schwering, Gerhard Lakemeyer, Maurice Pagnucco

PII: S0004-3702(17)30085-1
DOI: http://dx.doi.org/10.1016/j.artint.2017.07.004
Reference: ARTINT 3024

To appear in: *Artificial Intelligence*

Received date: 7 March 2016
Revised date: 7 July 2017
Accepted date: 19 July 2017

Please cite this article in press as: C. Schwering et al., Belief revision and projection in the epistemic situation calculus, *Artif. Intell.* (2017), http://dx.doi.org/10.1016/j.artint.2017.07.004

Belief revision and projection in the epistemic situation calculus

Christoph Schwering[a,*], Gerhard Lakemeyer[b], Maurice Pagnucco[a]

[a] *School of Computer Science and Engineering, The University of New South Wales, NSW, 2052, Australia*
[b] *Department of Computer Science, RWTH Aachen University, 52056 Aachen, Germany*

Abstract

This article considers defeasible beliefs in dynamic settings. In particular, we examine the belief projection problem: what is believed after performing an action and/or receiving new information? The approach is based on an epistemic variant of Reiter's situation calculus, where actions not only have physical effects but may also provide new information to the agent. The preferential belief structure is initially determined using conditional statements. New information is then incorporated using two popular belief revision schemes, namely natural and lexicographic revision. The projection problem is solved twofold in this formalism: by goal regression and by knowledge base progression.

Keywords: Knowledge representation, Reasoning about actions, Belief revision

1. Introduction

Knowledge and actions have long been identified as two key aspects of an intelligent system: McCarthy's pioneering 1959 paper [1] envisions a computer program that chooses its actions based on knowledge about its current situation. Ensuing from McCarthy's original *situation calculus* [2], numerous logical languages for modeling such dynamic systems have been developed. One of the most successful approaches is Reiter's variant of the situation calculus [3, 4], whose popularity is due to its simple yet powerful solutions for the *frame problem* and the *projection problem*. Projection refers to determining whether a certain formula is true after a sequence of actions; it is the fundamental operation in reasoning about actions and plays an essential role in planning. The versatility of Reiter's framework has been proven by a wide range of extensions that accommodate concepts such as time, concurrency, complex actions, decision theory, and, of particular relevance to this paper, knowledge and sensing. An explicit notion of knowledge allows for modeling both knowledge and lack thereof within the object language. For instance, we could express that a gift box is known to contain an unknown gift.

Unequivocal knowledge however is rare in everyday situations. More often than not, intelligent agents merely have *beliefs* which may or may not hold true in actuality. In fact, agents often consider both cases possible, but regard one of the options to be more plausible than the other. For example, an agent might believe that the gift box presumably is empty, but that if it is not empty, then most likely it contains a gift (whatever that gift may be). The second belief here is called *conditional* because it is constrained by a hypothesis (namely the box not being empty). Such conditionals are an intuitive way of expressing beliefs about different contingencies and, implicitly, their plausibility.

In a dynamic setting, beliefs are subject to *change*. Change comes in two types: *physical* change reflects what actually happens in the environment; *epistemic* change occurs when the agent receives new information about its environment. In our scenario, dropping the box could have the physical effect of breaking the objects inside the box. But it might be only after the following clinking noise that agent realizes the box was not empty and something actually broke inside it. Possible inconsistencies among beliefs and such new information can be resolved by *belief revision*, which aims to give up just enough old beliefs in order to accommodate the new information [5].

*Corresponding author.
Email addresses: c.schwering@unsw.edu.au (Christoph Schwering), gerhard@kbsg.rwth-aachen.de (Gerhard Lakemeyer), m.pagnucco@unsw.edu.au (Maurice Pagnucco)