Belief revision in the propositional closure of an attribute-constraint pair formalism

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Spring 2016

Scientific context. The issue of belief revision can be presented as follows. Let \( \psi \) be the set of beliefs of an agent about the world at a given time. This agent is confronted to a new set of beliefs \( \mu \), that is supposed to take precedence over \( \psi \). The revision of \( \psi \) by \( \mu \)—denoted by \( \psi + \mu \)—is the set of beliefs of the agent after having taken into account \( \mu \). If the conjunction of \( \psi \) and \( \mu \)—\( \psi \land \mu \)—is consistent, then the revision amounts to this conjunction. In the other case, according to the minimal change theory [1], \( \psi + \mu \) is obtained by minimally modifying \( \psi \) into \( \psi' \) so that \( \psi' \land \mu \) is consistent (and, it this case, \( \psi + \mu \equiv \psi' \land \mu \)). This result is dependent from the chosen revision operator, which determines the way the modification is evaluated. For example, if \( \psi \) represents the assertions “Every bird flies and has feathers. Ostriches are birds.” and \( \mu \) represents the belief “Marcel is an ostrich that does not fly.”, a potential revision of \( \psi \) by \( \mu \) consists in giving up the fact that every bird flies; another one consists in giving up the fact that ostriches are birds. In [1], some postulates (known as the AGM postulates) are proposed that a revision operator should satisfy.

Belief revision has been studied in the Orpailleur team for its application to case-based reasoning, which is a reasoning paradigm based on the adaptation of past problem-solving episodes (see [2] for a synthesis). Several inference engines for revision have been implemented in various formalisms and are gathered on the Web page http://revisor.loria.fr: REVISOR/PL and REVISOR/PLAK in propositional logic [3] (\( \mathcal{L}_{pl} \)), REVISOR/CLC in the formalism of conjunctions of linear constraints [4] (\( \mathcal{L}_{clc} \)), REVISOR/QA in qualitative algebras [5] (including Allen algebra and RCC8), and REVISOR/PCQA in the propositional closure of a qualitative algebra [6]. Belief revision in the propositional closure of \( \mathcal{L}_{clc} \) has been studied [7], but remains to be implemented.

The semantics in these formalisms can be given by means of the notion of interpretation: a set \( \Omega \) of interpretations is given and a knowledge base \( \varphi \) represents a subset \( \mathcal{M}(\varphi) \) of \( \Omega \). Then, the deductive inference is defined by \( \varphi_1 \models \varphi_2 \) if \( \mathcal{M}(\varphi_1) \subseteq \mathcal{M}(\varphi_2) \). If a distance function \( d \) can be defined on \( \Omega \), then a revision operator \( +_d \) can be defined by:

\[
\mathcal{M}(\psi +_d \mu) = \{ J \in \mathcal{M}(\mu) \mid d(\mathcal{M}(\psi), J) = d(\mathcal{M}(\psi), \mathcal{M}(\mu)) \}
\]

i.e., the models of \( \psi +_d \mu \) are the models \( J \) of \( \mu \) that are the closest ones to models \( I \) of \( \psi \) according to \( d \); \( d(I, J) \) measures the modification from \( I \) to \( J \).

Some of the REVISOR engines have been used in Taaable, an application of CBR in the cooking domain [8].

The revision operators implemented in the REVISOR family match this definition (with some slight differences for some of them, though). Now, the idea is to study belief revision in a formalism extending the attribute-value formalism frequently used in CBR applications.

Goal of the internship. This internship aims at studying the formalism \( \mathcal{L}_{pcac} \), an attribute-constraint formalism and belief revision in \( \mathcal{L}_{pcac} \). In order to illustrate this formalism, here is an example of formula of \( \mathcal{L}_{pcac} \):

\[ \neg a \lor ((x_1 + 2x_2 > 3) \land (m - n > 5) \land \neg (C = \text{blue})) \]

where \( a \) is a Boolean variable, \( x \) and \( y \) are real variables, \( m \) and \( n \) are integer-value variables, and \( C \) is a variable of the enumerated type \{red, yellow, blue, . . . \}.

This internship may follow some of the following steps (more or less in chronological order):

- Literature review (on belief revision, CBR and relevant knowledge representation formalisms);
- Precise definition of \( \mathcal{L}_{pcac} \) (syntax, semantics, deductive inferences);
- Characterization of a belief revision operator on \( \mathcal{L}_{pcac} \);
• Study of the complexity of such operators;
• Study of the subclass of distance-based revision operators;
• Definition of an algorithm for such operators (this will probably be based on the algorithm of [7]);
• Study of its algorithmic complexity and optimization;
• Implementation and test of a prototype;
• Integration of adaptation rules in the revision algorithm (that affects the distance function by giving some "shortcuts" in the metric space);
• Extension to a more expressive language, e.g., a language similar to an object-based representation formalism or a structural description logic, where values can themselves have attributes;
• Etc. (some other steps are likely to emerge during the work).

For further information do not hesitate to contact me (by e-mail, and then by, e.g., phone).

References


