

Introduction to Belief Change

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1 Presenter

Maurice Pagnucco joined Macquarie University as a lecturer in Computing in 1998. Prior to that he held postdoctoral positions at the University of Sydney and at the University of New South Wales. He completed his doctoral studies in Computer Science at the University of Sydney in early 1996 on the role of abductive reasoning within the process of belief revision. He also undertook his undergraduate studies at the University of Sydney culminating in an Honours degree in Computer Science and including one year at the Department of Computer Science at the University of Milan, Italy. His research interests lie in logic-based approaches to artificial intelligence; in particular, belief revision, logics of action, abductive reasoning, nonmonotonic inference, and knowledge representation.

2 Lecture Summary

Belief change concerns itself with modelling the way in which entities (or agents) maintain beliefs about their environment and how they modify their stock of beliefs upon receipt of new information. There are many ways in which this can be done while using some form of logic as a basis: preferential structures, probability theory, possibility theory, etc. In this series of lectures we aim to give an introduction to the field of belief change. We focus on the popular AGM approach throughout most of the lectures but will indicate links with other areas such as nonmonotonic reasoning and give an indication of advanced topics and current research. Under this approach, the main idea is to delineate a class of functions corresponding to “rational” belief change.

Some important morals to be drawn include the way in which one can adopt an underlying classical logic and modify the way in which that logic is used to derive more complex (nonmonotonic) behaviour. Also, links with areas such as nonmonotonic reasoning, logics for conditionals, choice theory, possibility theory, etc. indicate the utility of this approach.

2.1 Lecture 1: Belief Change — Motivation and Introduction

In the first lecture we introduce the idea of belief change and attempt to motivate the central ideas leading to its development. This will be done through a series of examples. An important idea is that of ‘rational’ belief change — we wish to concentrate on those ways of modifying our stock of beliefs which conform to certain principles of rational behaviour.

We shall essentially follow the well known AGM approach. It is one of the most cited belief change approaches in the literature. We begin by introducing some of the common belief change operations under this approach. More details follow in the subsequent lectures.

In particular, we shall examine the following topics:

- What is belief change?
- Rationality criteria
- AGM approach
- Belief Expansion
- Belief Contraction

2.2 Lecture 2: Belief Change — Introduction to AGM Approach

The AGM approach to belief change is one of the most commonly cited frameworks and is appealing due to its simple but elegant development. Many of the results have elegant and insightful proofs. Although we do not have the time to consider these proofs in any detail we shall present the main results that underly this approach.

The basic idea behind the AGM approach is to focus on three operators — expansion, contraction and revision — and to characterise the class of rational expansion/contraction/revision functions via a series of rationality postulates. These are commonly referred to as the AGM postulates. We examine each set of postulates and look at some of their consequences.

While these postulates are guided by rationality criteria and do provide some insight, the AGM approach also provides a number of methods for “constructing” such functions. Such constructions provide further insight into the nature of the belief change being captured and are also important from a pragmatic or implementational point of view.

Topics include:

- Belief contraction
- First construction — maximal nonimplying subsets
- Maxichoice contraction
- Full meet contraction
- Partial meet contraction
- Selection functions
- Recovery
- Withdrawals
- Saturatable Sets
- Belief revision

2.3 Lecture 3: Belief Change via Preference

In the third lecture we examine two of the most important constructions for AGM belief change functions: systems of spheres and epistemic entrenchment. Both are based on the idea of placing a preference ordering over

certain objects — ‘worlds’ (propositional models) in the case of spheres and sentences in the case of entrenchment — which are subsequently used to determine which beliefs to maintain and which to reject in the course of a change in belief.

Topics include:

- Epistemic entrenchment
- Belief change via entrenchment
- Systems of spheres
- Belief change via systems of spheres
- Alternative forms of belief change

2.4 Lecture 4: Belief Change and Nonmonotonic Reasoning

Nonmonotonic reasoning has become a popular research area in the field of artificial intelligence. One way of viewing such reasoning is to see it as making inferences by default or based on ‘what is usually the case’. In this lecture we briefly look at the KLM approach to nonmonotonic reasoning and show that certain properties of nonmonotonic reasoning identified by KLM correspond quite closely to the AGM postulates for belief revision. We give a method for intertranslating belief revision operators into nonmonotonic consequence relations. We also indicate other ways in which belief change and nonmonotonic reasoning are related.

Topics include:

- Nonmonotonic reasoning
- Nonmonotonic consequence relations
- KLM approach to nonmonotonic consequence
- Belief change and nonmonotonic consequence
- Ramsey test
- Conditionals
- Gärdenfors triviality result

2.5 Lecture 5: Current Research and Advanced Topics

In the last lecture we briefly survey more advanced topics in belief change and indicate areas of current active research. Some possible topics include the following although participants are encouraged to suggest areas of their own interest which may be related to belief change and can be discussed during the course of this lecture.

- Belief bases vs. belief sets and computational approaches
- Belief update
- Coherence
- Contraction proposals
- Iterated revision
- Relationships between belief change, nonmonotonic reasoning, conditionals, rational choice, ...
- Non-prioritised belief change
- Abductive belief change
- Reasoning about action and belief change
- Dealing with uncertainty
- Morals to be drawn

The following references will be referred to during the course of the lectures and provide a good starting point for further study. Some are quite difficult to understand and an attempt has been made to indicate where this is so.

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