A modal adaptive logic for abduction

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Abstract

Purpose The aim of this presentation is to present a new adaptive logic, called $\mathbf{MLA^s}$, that enables to model abductive reasoning processes. The goal of these processes is to derive possible explanatory hypotheses (*explanantia*) for puzzling (empirical) phenomena (*explananda*). Therefore, this logic contains, in addition to deductive inference steps, defeasible reasoning steps based on an argumentation schema known as *Affirming the Consequent*:

$$(\forall\alpha)(A(\alpha) \supset B(\alpha)), B(\beta)/A(\beta) \tag{1}$$

It is important to mention that by using this schema I restrict the field of application of this logic in two ways. Firstly, I only consider abduction in a *strict* sense, by which I mean that the implication is given as a premise. Consequently, I do not consider any sort of *creative abduction* in which one has no relevant implication(s) at hand. Secondly, I limit myself to a predicative logic. Since I use a material implication, it would allow me, if I had used a propositional logic, to derive anything as a hypothesis (because $B \vdash A \supset B$). In the predicative case some sense of relevance is kept by the use of the universal quantifier.

The problem of multiple explanatory hypotheses This is not the first attempt to explicate abductive reasoning by means of the adaptive logics program[1]. Still, previous attempts have not completely dealt with the problem of multiple explanatory hypotheses.

To explain this problem, consider the following example. Suppose we have to explain the puzzling fact Pa while our background knowledge contains both $(\forall x)(Qx \supset Px)$ and $(\forall x)(Rx \supset Px)$. There are two roads that can be taken. Firstly, one can construct a logic in which one can only derive the disjunction $(Qa \vee Ra)$ and not the individual hypotheses Qa and Ra. This road, called

[1] for a systematic overview of adaptive logics, see [1]

practical abduction[2] and adequately modelled by the logics $\mathbf{LA^r}$ and $\mathbf{LA^r_s}$ [3], is suitable to model situations in which one has to act on the basis of the conclusions. For instance, in medical diagnoses, a physician who finds out that two possible diseases can be the cause for the examined symptoms, needs to take appropriate steps based on the fact that both diseases might be the cause.

Secondly, someone with a theoretical perspective (for instance, a scientist or a detective) is interested in finding out which of the hypotheses is the actual cause. Therefore it is important that he can *abduce* the individual hypotheses Qa and Ra in order to test them further one by one. Although there have been constructed adaptive logics that model this *theoretical* kind of abduction[4], these previous logics contain a quite complex proof dynamics. This is because, on the one hand, one has to be able to derive Qa and Ra separately, but on the other hand, one has to prevent the derivation of their conjunction $(Qa \wedge Ra)$. This is not only because there isn't any reason to take the conjunction as a hypothesis. Also, if the two hypotheses are incompatible, it would actually lead to explosion.

Advantages of the modal approach used in $\mathbf{MLA^s}$ There is actually a more elegant and natural way out of this problem by adding modalities to our language and deriving the hypotheses $\Diamond Qa$ and $\Diamond Ra$. In this way, the theoretical abductionist can work further on the individual hypotheses without having to prevent the conjunction, because the derivation of $(\Diamond Qa \wedge \Diamond Ra)$ does not imply $\Diamond(Qa \wedge Ra)$ in any standard modal logic. This approach also nicely coincides with the common idea that hypotheses are possibilities. Finally the logic $\mathbf{MLA^s}$ makes use of the *simple strategy* for adaptive logics[5]. So, the need to check for complex *Dab*-formulas is removed, which enhances greatly the computability.

Still, this logic is an adaptive logic in standard form with all according metatheoretical properties. The main advantages of an adaptive logic are threefold. Firstly, it allows for direct implementation of defeasible reasoning steps (in casu *Affirming the Consequent*). Secondly, it specifies exactly which condition would falsify the reasoning step. So, if this condition is derived later on in the proof, it defeats in a formal way all steps derived on the assumption of the falsehood of this condition. Thirdly, adaptive logics make it possible to nicely integrate defeasible (ampliative in this case) inferences with deductive inferences and display in this way the same internal and external dynamics that is found in actual human reasoning processes.

Applications All these features make this logic $\mathbf{MLA^s}$ very suitable for the modelling of actual abductive reasoning processes, which I will illustrate with two examples out of contexts that are regularly linked to abduction: a historical scientific discovery process and the reasoning process of a detective solving a murder case in a 'Sherlockian' way.

[2]according to the definition suggested in [6] (p224-225) and used in [2]
[3]see [6], [4], [5]
[4]see for instance [2] and [3]
[5]see [1], chapter 6

References

[1] Diderik Batens. *Adaptive Logics and Dynamic Proofs.* forthcoming, 2010.

[2] Hans Lycke. The adaptive logics approach to abduction. In Erik Weber, Thierry Libert, Pierre Marage, and Geert Vanpaemel, editors, *Logic, Philosophy and History of Science in Belgium. Proceedings of the Young Researchers Days 2008*, pages 35–41, Brussels, 2009. KVAB.

[3] Hans Lycke. Lunchtalk: an adaptive logic for theoretical abduction based on CL, october 2010.

[4] Joke Meheus. Adaptive logics for abduction and the explication of explanation-seeking processes. In Olga Pombo and Alexander Gerne, editors, *Abduction and the Process of Scientific Discovery*, pages 97–119. Centro de Filosofia das Cincias da U. de Lisboa, Lisboa, 2007.

[5] Joke Meheus. A formal logic for the abductions of singular hypotheses. *forthcoming*, 2010.

[6] Joke Meheus and Diderik Batens. A formal logic for abductive reasoning. *Logic Journal of the IGPL*, 14:221–236, 2006.