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Book reviews

Nonmonotonic reasoning: logical foundations of commonsense by Gerhard Brewka, Cambridge University Press, Cambridge, 1992, £19.50.

Since the time of Aristotle, logic has developed as a formalism for modelling the correct construction of arguments which demonstrate that a conclusion *necessarily* follows from a set of premises. Traditionally, there would be no uncertainty or doubt associated with these arguments. The arguments were used to establish facts; they were deductive proofs.

Nonmonotonic logics can be viewed as ways of augmenting the conclusions which can be drawn from classical logic in a given context. Aristotle, for example, is often attributed the statement that all men are mortal. We may express this fact as a sentence in first order logic: $\forall x.\ man(x) \supset mortal(x)$. If we know Aristotle is a man, then we may, indeed should, conclude that he is mortal. Nothing can make us retract this conclusion. If we are given more information about Aristotle, we may be enabled to conclude more facts about him. But nothing we subsequently learn about him will change our opinion about his mortality if we reason solely using classical logic.

However, there are many occasions in every day life when we may "jump" to a conclusion which is typically reasonable, but which may subsequently turn out to be invalid. A good example of this involved the first Red Panda to be brought into captivity last century. Anatomically, Red Pandas have many characteristics in common with Raccoons. Zoologists placed them in the Raccoon family, which in turn are members of the order *Carnivora.* In particular, Red Pandas have the characteristic dental features of carnivores. Carnivores usually eat meat; hence the name. So when the Red Panda arrived at London Zoo, its keeper tried to feed it on a diet of meat. The little Panda did not seem happy, and for reasons the keeper could not fathom it would take very little of its food. By a happy stroke of luck, the desperate keeper let the rather weakly Panda walk free in the grounds one day. It made a bee-line for the ornamental flower beds and started to eat the plants.

Carnivores typically eat meat. Red Pandas are carnivores, but Red Pandas eat herbs.

In any theory about carnivores we would certainly wish to conclude that Red Pandas were carnivores, and that they consequently had most of the properties of the carnivores. It would also be useful to be able to conclude, unless specific information was available to the contrary, that a typical carnivore ate meat. But in the case of Red Pandas, and Giant Pandas, we would want to be able to override that rule.

Classical logic has a limited range of quantifiers. We can either say a property is true "for all" entities of some kind, or that "there exists" an entity satisfying a certain property. What is required for the above scenario is to be able to draw a conclusion which is "typically" true in a given context, but which may need to be retracted if exceptional circumstances can be identified. In the general case, in developing theories of commonsense reasoning we want to model an ability to jump to (contingent) conclusions when it is consistent to do so. The important distinction with classical logic is that some of these contingent conclusions, or beliefs, may have to be retracted as additional information is acquired. Hence the epithet nonmonotonic; the number of conclusions which can be drawn may decrease as more information is obtained.

Various formalisms for nonmonotonic inference have been proposed over the last ten or twenty years. Amongst the earliest was the nonmonotonic logic NML of McDermott and Doyle. NML

proved to be somewhat counterintuitive in its behaviour, and Moore's later Autoepistemic Logic (AEL) has really superseded it. Default Logic and Circumscription are currently two of the most expressive formalisms; each having an abundance of variants. All these formalisms have distinct underlying philosophies, and the technical apparatus used to describe the inferences which may be performed using them is distinct in each case. However, a comparison of their behaviours rather suggests that in some deep sense they may all be just different ways of expressing the same thing. Establishing the precise relationships between the various formalisms is an active current research topic (see, e.g., Przymusinski, 1991).

Interest in nonmonotonic logics has expanded steadily with a wide ranging and daunting amount of literature now extant. Consequently, there is a great need to try and accumulate some of the emerging knowledge into book form in order to ease the apprenticeship for new practitioners of the art, and to present some of the ideas to a wider audience. Nonmonotonic logic is still a rapidly evolving field, but there is sufficient consensus on many of the issues that a book produced now should not be too ephemeral in its appeal. In fact, Philippe Besnard (1989) produced a worthy introduction to Default Logic a couple of years ago. Whilst focusing on default logic, it did include a chapter on circumscription and also some discussion of a number of alternative formalisms. However, the publication of Brewka's *Nonmonotonic Reasoning* is a valuable addition to the literature and complements Besnard's book in a number of ways.

After an introductory chapter, this book includes chapters on nonmonotonic modal logics (NML and AEL), default logic, circumscription, the preferred subtheories approach of Poole and Delgrande's conditional approach. These are all fairly terse presentations; the description of circumscription, for example, is not really much easier to follow than that in most of the research papers (but it *is* notoriously difficult to put across the idea behind it clearly). Not surprisingly, a great deal of the default logic chapter is focused on cumulative default logic; this is Brewka's personal research topic after all. But there is very little discussion of Lukaszewicz' modification of default logic. This contrasts (probably quite usefully) with Besnard's book, which does include quite a lot on Lukaszewicz work and little on Brewka's work (because little had been published on the latter at the time of writing). And, of course, this just goes to show that nonmonotonic logic is still an evolving field, with Brewka unable to reference Przymusinski's (1991) latest results on developing a unifying semantics for nonmonotonic logics because they had not been published when his book was written.

More practical aspects of nonmonotonic logics are covered with chapters on theorem proving, inheritance systems and nonmonotonic rule-based systems. The practical aspects are now becoming increasingly important. There is much debate in this book, and even more in the literature, about the relative merits and expressiveness of the various formalisms. But they will never be resolved until we have a body of experience with solving realistic, large scale, problems using one or other formalism. I suspect that the likelihood will be that different problems may well require the selection of a nonmonotonic logic with properties appropriate to the problem at hand. Further practical experience may well put requirements for logics with new properties. We have a great deal of work being put into the development of designer logics, all of which are elegant in their own way, and all of which are mathematically coherent. But the question is, can they solve real world problems, or are they just specific fragments of a more flexible "grand unified theory of commonsense reasoning" which has yet to be invented? Brewka's final chapter, "Where do we stand?" really concludes with a similar sentiment. This perhaps epitomises one main difference between this book and Besnard's. There is a strong feeling that Brewka's interest is in using mathematical formalisms to engineer applications which behave in a well understood way. I may be misrepresenting both, but Brewka's book seems to me to have the flavour of being written by a mathematically literate computer scientist, whereas Besnard's is more like it is written by a computer literate mathematical logician. It is mainly in this respect that the two books are complementary, although there is plenty of material not covered in the one that is covered in the other. But if you wish to choose (you *can* buy both), your choice between the two books may well

depend on how you perceive yourself. Then again, there is always the book by Lukaszewicz, which is altogether a more substantial tome . . .

References

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