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Modality, Of Course! Modal Logic, Si!

Heinrich Wansing
University of Leipzig

1 Modality and Modal Logic

Modality as ways in which objects may stand in suitable relations with each other is a basic phenomenon. Prepositions may be necessarily true or false, rational agents may see to it that or believe or doubt that something is the case, each verification of a certain proposition may be provably transformable into a verification of some other proposition, etc.

Does modal logic, broadly conceived, offer adequate formal representations of modality? John McCarthy (1997) questions the usefulness of modal logic for the representation of modality in artificial intelligence (AI) and knowledge representation (KR). McCarthy requires for instance that "[i]ntroducing new modalities should involve no more fuss than introduce a new predicate". One may wonder why we should use modal logics at all, especially view of first-order KR formalisms like the situation calculus. Who would not like to avoid fuss?

I disagree with McCarthy, and I would like to argue in favour of modal logic. I think that it would be a bad move to avoid modal logic, in particular because modal logic is alive and thriving, perhaps more so than ever. It has become a mature field that can be of great benefit to many areas - including AI and KR.

First, abandoning modal logic does not solve McCarthy's problem quoted above. Introducing new predicates instead of modal operators may require including intensions, actions, events, and other entities into the domain of discourse, and we would also have to axiomatize these predicates. Of coursse, also newly introduced modal operators call for an axiomatization. However, using new predicates instead of modal operators deprives us of the appealing and insightful interpretation of modal formulas relative to possibly compound states with an interesting relational structure.

[1]Ref: http://www.wkap.nl/

Second, there is a general point to be made here. Although established and useful modal logics like **S4** and **S5** may be viewed as fragments of first-order logic, faithful embeddings and 'reductions' are in the first place *instrumental*. Normally, the reducing theory is not really meant to *replace* the reduced theory. The interest in reductions derives from the fact that they

1. may illuminate the reduced theory in some interesting and revealing way thathelps to obtain a better or a new understanding of the reduced theory; or

2. may prove to be technically useful due to a transfer of known properties from the reducing theory to the reduced one.

A well-known example is the Gödel translation of intuitionistic propositional logic **IPL** into **S4**, which is both conceptually illuminating and technically useful. This embedding reveals that intuitionistic implication can be viewed as strict material implication, and it allows one, for instance, to infer the decidability of **IPL** from the decidability of **S4**. But *never* has it been proposed to replace in any sense **IPL** by **S4**.

An interesting example in KR is provided by description logics, which are restricted first-order formalisms. Although the concept language ALC is only a syntactic variant of the smallest normal polymodal logic, it nevertheless has been suggested to *further extend* ALC by modal epistemic operators (see Gräber et al., 1995; Wolter and Zakharyaschev, 1998).

Another instructive example of the use of modal logic can be found in the logic of agency. The seeing-to-it-that theory of agency due to Belnap, Perloff, and Xu (see, for instance, Horty and Belnap (1995) and references therein) is an extended modal formalism, in which structured reference indices (namely moment-history pairs) are combined with a choice function partitioning for every agent α and moment m, the histories passing through m into sets of histories that are choice-equivalent for α at m. Modal logic broadly conceived is thus a much richer and more versatile research paradigm than just, say, interpreting normal modal operators as philosophically or otherwise interesting modalities.

2 From the Ancien Régime to Novel Power

The third reason why I think McCarthy is mistaken in dismissing modal logic is the fact that the field has never been more active and interesting than now, and ignoring this would be a misstake. Let me explain why.

Although the early Quinean reservations against modal logic inspired by the supposed opaque interaction of modal operators and quantifiers turned out to have no lasting impact, in his acknowledgment to *A Manual of Intensional Logic*, written in 1984, the distinguished modal logician Johan van Benthem describes himself as "an exponent (and product) of the "ancien régime" in intensional logic." This description is alluding to the development of situation theory (Barwise and Perry, 1983) and the fascination it had created. Indeed, in the early 1980s it seemed that modal logic had somehow lost its internal dynamics and external attraction. Since then, however, modal logic both in a narrow and in a wider sense has regained power. This recent rise of modal logic is due to various developments.

- The recognition and use of modal and temporal logic in computer science, for example in reasoning about programs. See, for instance, Kozen and Tiuryn (1990), Manna and Pnueli (1992).
- The use of modal logic in AI and its interface with philosophy, as witnessed by the TARK and DEON conferences and their proceedings volumes and, for instance, Fagin et al. (1995), Laux and Wansing (1995), Meyer and van der Hoek (1995), and Belnap et al. (1996).
- The use of modal and temporal logic in the syntax and semantics of natural language. See, for instance, Kracht (1989), van Benthem (1996), and Blackburn and Meyer-Viol (1997).
- Advances in the mathematics of modal logic, as witnessed by various works that have appeared recently or are about to apear. See, for example, Blackburn et al. (1998), Chagrov and Zakharyaschev (1997), Copeland (1996), Gabbay et al. (1994), Kracht (1996), Marx and Venema (1996), Ponse et al. (1995), de Rijke (1997), and Zakharyaschev et al. (1998).
- A growing interest in modal proof theory and generations of Gentzen's sequent calculus appliece to modal logics. See, for instance, Wansing (1996, 1998) and some of the papers in the present issue.

A further sign of the area's maturity is provided by the *Advances in Modal Logic* initiative with its bi-annual workshops and proceedings volumes devoted entirely to advanced research on all aspect of modal logic (see, Kracht et al., 1998).

And last, but certainly not as a research program that, although there was no prior intention of a *Journal of Logic, Language and Information* thematic issue on modal logic, it just happened that a collection of accepted papers emerged all of which are contributions to modal logic either in the sense of dealing with alethic, temporal, or epistemic modal operators or in the sense of dealing with "referential multiplicity" and semantic structures for modalities. The papers of the present issue reflect the recent interest in modal proof theory, the application of temporal and epistemic logics in AI, ant the mathematical sophistication achieved in modal model theory.

Maybe a "deeper" reason for the remarkable stability of modal logic and its present flourishing is the ubiquity of modal notions and the fact that so many phenomena lend themselves to the kind of restricted descriptions provided by modal formalisms. Various concepts of great philosophical or computational importance are modal, like for instance

- it is necessary that,
- always in the future it will be true that,
- agent α knows that,
- agent α sees to it that,
- agent α obligates agent β to see to it that,
- after every terminating execution of the program π it will be the case that.

These and further notions may be adjoined to all kinds of non-classical non-modal proposional or first higher-order base logics. And in contrast to the Quinean view and to McCarthy's dictum, I am inclined to predict that modal propositional and predicate logics will play a durable central role not only in philosophical analysis but also in formal representations in other disciplines like AI and computational linguistics.

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