Advocating qualitative methods in artificial intelligence

A personal account after 40 years of research

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For about twenty years now, the advanced treatment of information, or artificial intelligence if we prefer, has been dominated by quantitative approaches such as statistical methods, Bayesian nets, or neural nets, in contrast with the previous period, which was logically oriented. The point is certainly not to dispute the interest and merits of quantitative methods, which have their roots in a very long history. The purpose of the talk is rather to show that there exists a complementary panoply of qualitative tools, which have appeared much more recently, and which may be useful in the long range for a variety of tasks. The main benefits of qualitative modeling are to remain close to the way humans handle information, by being close to logic, and thus to be more explanation-oriented. The talk will focus on a large part of the research area to which the lecturer has been contributing for about forty years now, namely possibility theory and its numerous developments, briefly summarized below. The talk will not deal with technical details, but will rather try to convey ideas, and to be accessible for any researcher working on the handling of information.

Possibility theory is the simplest setting for handling epistemic uncertainty, since thanks to a pair of dual possibility and necessity measures, one may capture situations of ignorance where some event may be fully possible as well as the opposite event, while the two events have no certainty at all. Possibilistic logic handles classical logical formulas layered according to their level of certainty, where any set of formulas above a given level is logically closed under conjunction. Possibilistic logic remains close to classical logic, while handling certainty levels associated with formulas. It can encode nonmonotonic reasoning, belief revision, and even desire revision (thanks to a variant). Possibilistic functional dependencies go well with the idea that if we do not take into account the information that is below some confidence level, more functional dependencies may hold that are thus less certain. Besides, a possibilistic logic base can be equivalently represented by a Bayesian-like possibilistic network. Generalized possibilistic logic can handle not only conjunctions of possibilistic logic formulas, but also disjunctions and negations thereof. Its high representation power is to be related with the fact that any monotonically increasing set function can be represented by a disjunction of necessity measures in a finite setting. Possibility theory is also of interest for modeling qualitative criteria for decision under uncertainty, or for modeling preferences by taking advantage of possibilistic networks for providing a graphical representation, or thanks to its capabilities for modeling bipolarity between what is more or less strongly rejected and what is guaranteed to be satisfactory to various extent. Generally speaking, possibilistic modeling makes uses of weighted minimum and weighted maximum when quantitative approaches extensively use weighted sums. Sugeno integrals (which have a logical counterpart in terms of thresholded if-then rules) generalize weighted minimum and maximum, just as Choquet integrals generalize weighted sum. But possibility theory is not an isolated representation framework. Indeed it has been shown that almost all, qualitative or quantitative representation settings used en AI, ranging from classical, or modal logic to abstract argumentation and
rough sets, from formal concept analysis to possibility theory and belief functions theory, from Sugeno integrals to Choquet integrals, as well as (ana)logical proportions, were sharing the same basic structure, called the cube of opposition, an extension of the square of opposition inherited from Aristotle. This enables fruitful parallels or hybridization between theories.

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