Imprecise probability models and their applications

This special issue of the International Journal of Approximate Reasoning (IJAR) grew out of the 5th International Symposium on Imprecise Probabilities and Their Applications (ISIPTA’07), held in the beautiful city of Prague, Czech Republic, in July 2007 (http://www.sipta.org/isipta07). The symposium was organized by Gert de Cooman, Jirina Vejnarova, and Marco Zaffalon.

The term imprecise probabilities is used to refer to a number of approaches that allow for a more general and flexible modeling of uncertainty or chance by giving up the restriction to sharp and additive numerical probabilities. These approaches may be characterised from many different philosophical standpoints and many different types of mathematical calculus. ISIPTA meetings are a primary forum for presenting and discussing new advances in imprecise probabilities. Previous meetings were held in Ghent (Belgium) in 1999, in Cornell (USA) in 2001, in Lugano (Switzerland) in 2003, and in Pittsburgh (USA) in 2005. Here, we continue the good tradition of basing a special issue of the International Journal of Approximate Reasoning on the ISIPTA meetings.

The meeting in Prague started with a series of tutorials devoted to different aspects of imprecise probabilities, that were presented by Scott Ferson, George Klir, Enrique Miranda and Teddy Seidenfeld. It also benefited from invited talks by Terrence Fine and Glenn Shafer.

After a rather selective reviewing process, 48 papers were included in the proceedings of the conference, and we had the pleasure, and the burden, to select eight of them for this special issue. In our selection we have tried to encompass the variety mentioned above, both from the theoretical and from the applied point of view; there are nonetheless many other papers that would have also deserved to be included in this special issue.

We begin with three papers concerned with results in the context of generalised Bayesian learning. The first of these, authored by Kriegler, presents a so-to-say open version of Bayes’ rule, dropping the implicit closed world assumption that one of the considered models has to be the true model producing the data. Technically this is achieved by extending the parameter space to the space of all models and then contracting it again. The methodology is illustrated in the context of auto-regressive processes.

The paper by Piatti, Zaffalon, Trojani and Hutter investigates the problem of learning about a categorical random variable. It is well known that, in this context, an initial state of prior ignorance is not compatible with learning. The authors consider then an alternative approach, called near ignorance, which resembles ignorance in many respects but seems at the same time to allow for learning. To which extent this is really the case is established in this paper.

The paper by Pelessoni and Vicig is concerned with a structure-free version of Williams’ notion of coherence of a number of conditional lower previsions. The authors study this notion and compare it with other approaches to consistency in the literature, such as Walley’s notion of coherence or the notion of centered convexity. All these approaches arise in the extension of the subjective probability approach of de Finetti to take into account imprecision.

Next, the paper by Fierens contributes to the frequentist branch of imprecise probability, initiated by T.L. Fine and colleagues, where sets of measures are interpreted from the frequentist point of view, leading to so-called chaotic models. By introducing real-valued test functions, Fierens extends the concept of chaotic models to real-valued variables, investigates their properties and illustrates the basic ideas with data on exchange rates in Argentina.

The third part of the issue is devoted to the problem of decision making with imprecise probabilities. We have two papers on this. The one by Hable is concerned with decision making under imprecise sample (and prior) information. He derives a necessary and sufficient condition for the existence of a least favorable model, which allows to reduce the complex decision problem to an easier solvable classical decision problem.

Next, Troffaes investigates the approximation of loss functions and credal sets by finitary ones, and bounds the effects of such an approximation. He considers a decision problem where the available information is modeled by an arbitrary (not necessarily convex nor closed) set of probabilities and a state-independent utility function.

We conclude the issue with two different applications of imprecise probability models of general methodological interest. The paper by Antonucci, Bruhlmann, Piatti and Zaffalon presents a credal network for risk evaluation in case of intrusion of
civil aircrafts into restricted flight area. The authors show the capabilities of the proposed model by means of some preliminary tests referred to simulated scenarios. This application can be considered not only as a useful tool for decision support in this field, but also as a quite general imprecise-probability paradigm for information fusion.

Finally, the paper by Oberguggenberger, King and Schmelzer presents a case study in the context of aerospace engineering. They compare several precise and imprecise probability methods for performing a sensitivity analysis, namely sensitivity indices based on direct simulation, recently proposed interval spreads based on simulations with the Cauchy distribution, random sets and also fuzzy sets.

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