Imprecise probability in statistical inference and decision making

This special issue of the International Journal of Approximate Reasoning (IJAR) grew out of the 6th International Symposium on Imprecise Probability: Theories and Applications (ISIPTA ‘09), organized by The Society for Imprecise Probability: Theories and Applications (SIPTA) at Durham University (UK) in July 2009 (http://www.sipta.org/isipta09). The biennial ISIPTA meetings have been well established among the leading international conferences on generalized methods for uncertainty quantification. The first ISIPTA took place in Gent, followed by meetings at Cornell, Lugano, Carnegie Mellon and Prague. Collingwood College in Durham provided an excellent location for the 2009 meeting, and in addition to the conference programme it offered excellent opportunities for collaborations and informal discussions, within walking distance of the UNESCO World Heritage site of Durham Cathedral and Castle.

Following a selective refereeing process, 47 papers were presented at ISIPTA ‘09, all in a short plenary introduction and overview followed by a poster presentation enabling detailed discussions. In addition there were 21 contributions as poster-only presentations, a new initiative for the ISIPTA conferences which enabled a wider variety of topics to be presented, for example research ideas that were still being developed and presentations of software. Furthermore, four tutorials on key topics in imprecise probability were presented by Cassio de Campos, Robert Hable, Erik Quaeghebeur and Lev Utkin. Kurt Weichselberger presented a substantial introduction to the symmetric theory of probability. Two special sessions were held in memory of colleagues who contributed significantly to the field of imprecise probability and had passed away since the previous ISIPTA meeting, namely Henry Kyburg and Pauline Coolen-Schrijner. Isaac Levi kindly introduced the session in honour of Henry Kyburg, which was organized by Teddy Seidenfeld, and he discussed the many contributions of Henry to imprecise probability theory and beyond. In the session in honour of Pauline Coolen-Schrijner papers were presented by three of her Ph.D. students.

At the meeting also the IJAR Young Researcher Award, generously provided by Elsevier, was awarded. Impressed by the many very strong applications received from excellent young researchers with various specialisations and at different stages of their career, the Selection Committee decided to divide the award among several candidates. The Prize in Gold was awarded to Sebastien Destercke (Montpellier, Ph.D.: Toulouse) and to Erik Quaeghebeur (CMU, Ph.D.: Ghent), honouring their various outstanding contributions that already have had a considerable impact on work by other researchers. The Prize in Silver was awarded to: Allessio Benavoli (Manno, Ph.D.: Firenze), Karina Delgado (Sao Paulo), Martin Fuchs (Toulouse; Ph.D.: Vienna), Nathan Huntley (Durham), Kevin Loquin (Toulouse, Ph.D.: Montpellier) and Tahani Maturi (Durham).

ISIPTA ‘09, like previous ISIPTA meetings, benefited greatly from the excellent support for the conference organisation and the editorial process by Serafin Moral. To thank Serafin for this tireless work over many years, he was presented with a copy of Keynes’ ‘A Treatise on Probability’, signed by his grateful friends from the imprecise probabilities community.

The papers in this special issue of the International Journal of Approximate Reasoning are closely related to papers presented at ISIPTA ‘09. The guest editors selected 10 conference papers from the many excellent contributions, which reflect well the wide range of topics at the conference and which fit well with the focus of the journal. Authors of the conference papers were invited to submit a related full-length paper, all invited authors kindly accepted this invitation. Subsequently, each paper was carefully reviewed again by two external referees and by the guest editors.

The paper by Benavoli and Antonucci considers aggregation of multiple sources of information containing knowledge about a common domain, where the information is modelled by coherent lower previsions, also allowing for conflicting information. After the general derivation, detailed results are given for the case of linear-vacuous mixtures. The results achieved are applied to sensor networks, and Zadeh’s paradox is discussed.

De Cooman, Hermans, Antonucci and Zaffalon show that certain credal nets remain computationally tractable when strong (conditional) independence is replaced by the often more appropriate notion of epistemic irrelevance. For directed trees the authors manage to derive an exact message-passing algorithm for belief updating that is entirely formulated in

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doi:10.1016/j.ijar.2010.08.001
terms of coherent lower previsions and that is linear in the number of nodes. An application of the algorithm to on-line character recognition is presented.

Corani and de Campos propose a new imprecise classifier, called the ‘tree augmented naive credal classifier’. It uses the Extreme Imprecise Dirichlet Model in a global way which produces narrower intervals than the general Imprecise Dirichlet Model and has computational advantages. Experimental evaluation shows that in the naive credal classifier the results provided by both models are about the same and that the tree augmented naive credal classifier is more reliable than the Bayesian tree augmented naive classifier.

Cozman uses connections between martingale theory and concepts of epistemic and regular irrelevance to derive new concentration inequalities and laws of large numbers under weak assumptions of irrelevance that are expressed using lower and upper expectations. This work adds to the study of laws of large numbers, generalizing applicability by further weakening the conditions, yet keeping proofs close to well-known results in probability theory. It also raises interesting questions regarding the relationship between martingales and regular and epistemic irrelevance.

Crossman and Skulj study imprecise Markov chains with an absorbing state. In their approach the imprecise transition matrix is constant over time, but in each time the transition to the next one can be obtained with a different precise transition matrix. In this setting they show that under some general regularity conditions, when conditioning on non-absorption there is convergence to a set of probabilities which is independent of the initial state.

Farrow and Goldstein present methods for analysing decision problems based on multi-attribute utility hierarchies, structured by mutual utility independence, which are not precisely specified due to unwillingness or inability of an individual or group to agree on precise values for the trade-offs between the various attributes. They illustrate their approach through an example involving decisions with regard to introduction of a new course at a university.

Hable’s paper addresses parameter estimation in an imprecise probability model which consists of coherent upper previsions. A minimum distance estimator is defined and studied, and important aspects of applications are discussed including computation. The estimator is illustrated by an application to a linear regression model using data on individuals’ heights and weights, and is implementable even for large-scale problems.

Loquin, Strauss and Crouzet propose a novel approach for noise quantification at each location of a signal. Instead of the conventional kernel-based approach, commonly used in signal processing, they apply possibility distributions which lead to interval-valued results. Applications show that the length of the obtained interval and the local noise level are highly correlated. The propagation of the noise in the involved signal processing method is direct and does not require any additional computation.

Pelessoni, Vicig and Zaffalon investigate the pari-mutuel model (PMM), an intuitive method to assign imprecise probabilities starting from a precise probability model. They study the natural extension of the initial assessment to general gambles and relationships of the PMM with risk measurement, introducing a new imprecise risk measure. They also discuss dilation and imprecision increase when conditioning in the PMM.

Schmelter’s paper considers ordinary stochastic differential equations whose coefficients depend on parameters, using random compact sets to model the parameter uncertainty. This leads to continuous set-valued stochastic processes, the properties are investigated and a simple example from mechanics is used to illustrate the theoretical concepts.

The papers in this special issue provide ample evidence of the success of ISIPTA ‘09 and of the progress of research and applications involving imprecise probabilities, previsions and utilities, particularly in statistical inference and decision making with important breakthroughs for implementation including powerful computational algorithms. We hope that they also motivate readers to participate in the 7th International Symposium on Imprecise Probability: Theories and Applications (ISIPTA ’11), to be held in Innsbruck, Austria, in July 2011 (http://www.isipta.org/isipta11).

Acknowledgements

We are grateful to Thierry Denoeux for the opportunity to publish this special issue of IJAR containing papers related to research presented at ISIPTA ‘09, and to Marco Zaffalon for his support and advice throughout this process. On behalf of ISIPTA, we thank Elsevier and Thierry Denoeux for establishing the IJAR Prizes, and Teddy Seidenfeld and Damjan Skulj for, together with Thomas Augustin, evaluating the applications as members of the IJAR Prizes’ Selection Committee. We thank the referees of the papers, their contributions were very helpful to us and to the authors and have led to substantial improvements of the papers. Finally, we thank the authors for presenting their exciting research results at ISIPTA’09 and for accepting our invitation to submit extended papers for this special issue.

Thomas Augustin  
University of Munich, Germany  
E-mail address: thomas@stat.uni-muenchen.de

Frank Coolen  
University of Durham, UK  
E-mail address: frank.coolen@durham.ac.uk
Serafin Moral  
Universidad de Granada, Spain  
E-mail address: smc@decsai.ugr.es

Matthias Troffaes  
University of Durham, UK  
E-mail address: matthias.troffaes@durham.ac.uk