Belief Functions: Theory and Applications (BELIEF 2014)

This special issue of the International Journal of Approximate Reasoning (IJAR) collects a number of significant papers published at the 3rd International Conference on Belief Functions (BELIEF 2014).

The series of biennial BELIEF conferences, organized by the Belief Functions and Applications Society (BFAS), is dedicated to the confrontation of ideas, the reporting of recent achievements, and the presentation of the wide range of applications of this theory. The series started in Brest, France, in 2010, while the second edition was held in Compiègne, France, in May 2012. The upcoming BELIEF 2016 will take place in Prague in September 2016.

The Third International Conference on Belief Functions, BELIEF 2014, was held on September 26–28 at St. Hugh's College, Oxford, UK. The aim of the conference was to provide opportunities to exchange ideas and present new results on the theory of belief functions and related areas such as random sets, imprecise probability, and possibility theory. Original contributions were solicited on theoretical aspects (including mathematical foundations, decision making, combination rules, continuous belief functions, independence and graphical models, statistical estimation, etc.), as well as on applications to all areas of computer science, business, and engineering.

The organisers paid significant attention to ensuring the highest quality of the reviewing process. We received 56 submissions, of which 47 were accepted (83%). Volume 8764 of the Lecture Notes of Computer Science (http://www.springer.com/gb/book/9783319111902) collects all accepted contributions to BELIEF 2014. The Program Committee (PC) consisted of 45 academics with diverse research interests and expertise, ranging from experts in the theory and application of belief functions to scientists active in imprecise probabilities and random sets, mainstream statisticians, computer scientists, and engineers. Papers were reviewed in blind mode, with each paper assigned to at least three reviewers, sometimes four or five. While 35 papers were directly accepted after the first round of reviews (62%), 14 others underwent a rebuttal stage in which authors were asked to revise their paper in accordance to the reviews, and prepare an extensive response addressing the reviewers' concerns. The final decision was made by the program chair, sometimes with the assistance of the reviewers. As a result, 12 additional papers were accepted for publication in the proceedings, and the quality of the manuscripts witnessed a significant improvement. The rebuttal stage, introduced for the first time in this edition of BELIEF, was a clear success and we recommend its adoption for the future editions of the conference as well.

Two invited talks were presented by major researchers in Artificial Intelligence. Nando de Freitas, Professor of Computer Science at Oxford University, gave a talk on the challenges facing the wider field of AI in the near future. Thomas Lukasiewicz, also Professor of Computer Science at Oxford University, spoke about "Uncertainty in the Semantic Web," outlining how uncertainty is dealt with in semantic web applications, and illustrating in more detail some of his most recent published work.

For the first time we introduced a best paper and a best student paper award, to provide recognition for authors of substantial contributions to the theory of belief functions. We hope this will be a long-standing practice. The Best Paper Award, sponsored by Elsevier and the International Journal of Approximate Reasoning (IJAR) went to the paper "Evidential Object Recognition based on

Information Gain Maximization" by two new members of our community, Thomas Reineking and Kerstin Schill from the University of Bremen, Germany. The paper, which proposes an active object recognition framework based on belief function inference and information gain maximisation, was signalled by the Board as an example of novelty and significant methodological contribution likely to spur further research. The Best Student Paper Award, sponsored by the International Society for Information Fusion (ISIF), was assigned to the paper "Evidential Logistic Regression for SVM Classifier Calibration" by Ph.D. student Philippe Xu and his advisors Franck Davoine and Thierry Denoeux, from the Université de Technologie de Compiègne, France. We held a discussion panel on the status and future of the theory of belief functions, which we believe helped to bring our community together and set clear targets for its future development and further growth.

In conclusion, BELIEF 2014 was a successful conference, which consolidated the results of the series of conferences on Belief Functions and their Applications initiated four years ago, and stimulated a profound discussion on the current state of the field.

The papers presented in this special issue of the International Journal of Approximate Reasoning are extended version of selected papers presented at BELIEF 2014. The organisers selected five conference papers from the many excellent contributions, which reflect the wide range of topics at the conference and adheres to the standard of the journal in terms of significance and quality. Authors of these 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 three or more external referees and by ourselves.
As a result, this special issue collects the following contributions:

- 'Proposition and learning of some belief function contextual correction mechanisms' by Frédéric Pichon, David Mercier, Eric Lefèvre and François Delmotte attempts to enlarge the set of tools available in belief function theory to deal with contextual knowledge about source quality. This aim is achieved by providing an interpretation to each one of two contextual correction mechanisms introduced initially from purely formal considerations, and deriving extensions of two interesting and non-contextual correction mechanisms. A sound, easy to interpret and computationally simple method is also provided to learn from the available data the contextual knowledge associated with the correction mechanisms studied in this paper.

- 'Active Classification using Belief Functions and Information Gain Maximization' by Thomas Reineking studies the problem of obtaining reliable estimates of the parameters of a probabilistic classification model under lack of sufficient training data. The author presents a classification approach based on belief functions that makes the uncertainty resulting from limited amounts of training data explicit and thereby improves classification performance. In addition, the paper represents classification as an active information acquisition task in which features are sequentially selected by maximizing the expected information gain with respect to the current belief distribution. The author considers different measures of uncertainty for belief functions and provides efficient algorithms for computing them.

- 'Evidential calibration of binary SVM classifiers' by Philippe Xu, Franck Davoine, Hongbin Zha and Thierry Denoeux deals with the issue of classifier combination in machine learning, from the point of view of belief theory. In order to combine distinct sources of information, it is necessary to represent the outputs of classifiers in a common space via a transformation called calibration

- this is traditionally done using class membership probabilities. However, using a single probability measure may be insufficient to model the uncertainty induced by the calibration step, especially in the case of limited training data. In this paper, the authors extend therefore classical probabilistic calibration methods to the evidential framework.

- 'Prediction of future observations using belief functions: a likelihood-based approach' by Orakanya Kanjanatarakul, Thierry Denoeux and Songsak Sriboonchitta proposes instead a new approach to statistical prediction in the Dempster-Shafer framework. Given a parametric model, the random variable to be predicted is expressed as a function of the parameter and a pivotal random variable. A consonant belief function in the parameter space is constructed from the likelihood function, and combined with the pivotal distribution to yield a predictive belief function quantifying the uncertainty about future data. The asymptotic consistency of the method is established in the iid case, under reasonable assumptions.

- Last but not least, 'Compositional Models in Valuation-Based Systems with Examples in Specific Theories' by Radim Jiroušek and Prakash P Shenoy shows that Pearl's causal networks can be described using Causal Compositional Models (CCMs) in the Valuation-Based Systems (VBS) framework. The latter is a generalization of several uncertainty theories, and conditioning and intervention can be easily described there in an elegant and unifying algebraic way without having to implement any graphical manipulations of the causal network. In particular, the authors describe how such operations can be computed for a simple example with a hidden (unobservable) variable.

discounted rates in a difficult area like Oxford's, and Anne-Laure Jousselme for her assistance with building a mailing list of authors of belief functions papers.

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The Guest Editor

Fabio Cuzzolin

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