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Symbolic and Quantitative Approaches to Reasoning with Uncertainty

14th European Conference, ECSQARU 2017
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Proceedings

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Preface

The biennial ECSQARU conference is a major forum for advances in the theory and practice of reasoning under uncertainty. Contributions are provided by researchers in advancing the state of the art and practitioners using uncertainty techniques in applications. The scope of the conference includes, but is not limited to, fundamental and representation issues, reasoning, and decision-making in both qualitative and quantitative paradigms.

Previous ECSQARU conferences were held in Compiègne (2015), Utrecht (2013), Belfast (2011), Verona (2009), Hammamet (2007), Barcelona (2005), Aalborg (2003), Toulouse (2001), London (1999), Bonn (1997), Fribourg (1995), Granada (1993), and Marseille (1991).

The 14th European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU 2017) was held in Lugano, Switzerland, during July 10–14, 2017. The event was co-located with the 10th International Symposium on Imprecise Probability: Theories and Applications (ISIPTA 2017).

A young researcher award granted by Springer for excellent research in the area of symbolic and quantitative approaches to reasoning with uncertainty was assigned to Nico Potyka.

The papers in this volume were selected from 63 submissions, after a strict single-blind review process by the members of the Program Committee. In addition, the volume contains the abstracts of five invited talks by outstanding researchers in the field: Leila Amgoud, Alessio Benavoli, Jim Berger, Didier Dubois, and Eyke Hüllermeier.

We would like to thank all the members of the Program Committee and the additional reviewers for their timely and valuable reviews. We also thank the members of the Organizing Committee for their work and contribution to the success of the conference.

We gratefully acknowledge operational support from IDSIA (Istituto Dalle Molle di Studi sull'Intelligenza Artificiale), USI (Università della Svizzera Italiana), and SUPSI (Scuola Universitaria Professionale della Svizzera Italiana) as well as financial support from ONERA.

July 2017

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Invited Talks

Evaluation Methods of Arguments: Current Trends and Challenges

Leila Amgoud

IRIT – CNRS, Toulouse, France

Argumentation is a reasoning process based on the justification of conclusions by arguments. Due to its explanatory power, it has become a hot topic in Artificial Intelligence. It is used for making decisions under uncertainty, learning rules, modeling different types of dialogs, and more importantly for reasoning about inconsistent information. Hence, an argument's conclusion may have different natures: a statement that is true or false, an action to do, a goal to pursue, etc. Furthermore, it has generally an *intrinsic strength*, which may represent different issues (the certainty degree of its reason, the importance of the value it promotes if any, the reliability of its source, ...). Whatever its intrinsic strength (strong or weak), an argument may be weakened by other arguments (called *attackers*), and may be strengthened by others (called *supporters*). The overall acceptability of arguments needs then to be evaluated. Several evaluation methods, called semantics, were proposed for that purpose. In this talk, we show that they can be partitioned into three classes (extension semantics, gradual semantics, ranking semantics), which answer respectively to following questions:

1. What are the coalitions of arguments?
2. What is the overall strength of an argument?
3. How arguments can be rank-ordered from the most to the least acceptable ones?

We analyze the three classes against a set of rationality principles, and show that extension semantics are fundamentally different from the two other classes. This means that in concrete applications, they lead to different results. Namely, in case of reasoning with inconsistent information, extension semantics follow the same line of research as well-known syntactic approaches for handling inconsistency, while the two other classes lead to novel and powerful ranking logics. We argue that there is no universal evaluation method. The choice of a suitable method depends on the application at hand. Finally, we point out some challenges ahead.

Bayes + Hilbert = Quantum Mechanics

Alessio Benavoli

IDSIA, Lugano, Switzerland

Quantum mechanics (QM) is based on four main axioms, which were derived after a long process of trial and error. The motivations for the axioms are not always clear and even to experts the basic axioms of QM often appear counter-intuitive. In a recent paper, we have shown that:

- It is possible to derive quantum mechanics from a single principle of self-consistency or, in other words, that QM laws of Nature are logically consistent;
- QM is just the Bayesian theory generalised to the complex Hilbert space.

In particular, we have considered the problem of gambling on a quantum experiment and enforced rational behaviour by a few rules. These rules yield, in the classical case, the Bayesian theory of probability via duality theorems. In our quantum setting, they yield the Bayesian theory generalised to the space of Hermitian matrices. This very theory is QM: in fact, we have derived all its four postulates from the generalised Bayesian theory. This implies that QM is self-consistent. It also leads us to reinterpret the main operations in quantum mechanics as probability rules: Bayes' rule (measurement), marginalisation (partial tracing), independence (tensor product). To say it with a slogan, we have obtained that quantum mechanics is the Bayesian theory in the complex numbers.

Encounters with Imprecise Probabilities

Jim Berger

Duke University, Durham, USA

Although I have not formally done research in imprecise probability over the last twenty years, imprecise probability was central to much of my research in other areas. This talk will review some of these encounters with imprecise probability, taking examples from four areas:

- Using probabilities of a “higher type” (I.J. Good’s phrase), with an application to genome-wide association studies.
- Robust Bayesian bounds, with an application to conversion of p-values to odds.
- Importance (and non-importance) of dependencies in imprecise probabilities.
- Imprecise probabilities arising from model bias, with examples from both statistical and physical modeling.

Symbolic and Quantitative Representations of Uncertainty: An Overview

Didier Dubois

IRIT, CNRS and University of Toulouse, Toulouse, France

The distinction between aleatory and epistemic uncertainty is more and more acknowledged to-date, and the idea that they should not be handled in the same way becomes more and more accepted. Aleatory uncertainty refers to a summarized description of natural phenomena by means of frequencies of occurrence, which justifies a numerical approach based on probability theory. In contrast, epistemic uncertainty stems from a lack of information, and describes the state of knowledge of an agent. It seems to be basically qualitative, and is captured by sets of possible worlds of states of nature, one of which is the actual one. In other words, beliefs induced by aleatory uncertainty are naturally quantitative, while this is less obvious for beliefs stemming from epistemic uncertainty for which there are various approaches ranging from qualitative ones like three-valued logics and modal logics to quantitative ones like subjective probabilities. The qualitative approaches can be refined by considering degrees of beliefs on finite value scales or yet by means of confidence relations. Moreover aleatory and epistemic uncertainty may come together, and leads to the use of upper and lower probabilities.

In this talk, we review the various approaches to the representations of uncertainty, by showing similarities between quantitative and qualitative approaches. We give a general definition of an epistemic state or an information item, as defining a set of possible values, a set of plausible ones, a plausibility ordering on events. Moreover, epistemic states must be compared in terms of informativeness.

The basic mathematical tool for representing uncertainty is the monotonic set-function, called capacity of fuzzy measure. In the quantitative case, the most general model is based on convex probability sets, that is, capacities that stand for lower probabilities. In the qualitative case, the simplest non-Boolean approach is based on possibility and necessity measures. It is shown that possibility theory plays in the qualitative setting a role similar to the one of probability theory in the quantitative setting. Just as a numerical capacity can, under some conditions, encode a family of probability distributions, a qualitative capacity always encodes a family of possibility distributions. For decision purposes, Sugeno integral is similar to Choquet integral.

Logical reasoning under incomplete information can be achieved by means of a simplified version of epistemic logic whose semantics is in terms of possibility theory, in contrast with probabilistic reasoning. It can be extended to reasoning with degrees of beliefs using generalised possibilistic logic. Various ways of defining logics of uncertainty are outlined, absolute, comparative, or fuzzy.

Finally we discuss the issue of uncertainty due to conflicting items of information. In the numerical setting this is naturally captured by the theory of evidence, that essentially models unreliable testimonies and their fusion. A general approach to the fusion of information items is outlined, proposing merging axioms that apply to quantitative and qualitative items of information. Finally, we show that using Boolean valued capacities, we can faithfully represent conflicting information coming from several sources. In this setting, necessity functions represent incomplete information while possibility measures represent precise but conflicting pieces of information.

This talk owes much to works performed with M. Banerjee, D. Ciucci, L. Godo, W. Liu and J. Ma, H. Prade, A. Rico, S. Schockaert, among others.

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Learning from Imprecise Data

Eyke Hüllermeier

Paderborn University, Paderborn, Germany

This talk addresses the problem of learning from imprecise data. Although it has been studied in statistics and various other fields for quite a while, this problem received renewed interest in the realm of machine learning more recently. In particular, the framework of superset learning will be discussed, a generalization of standard supervised learning in which training instances are labeled with a superset of the actual outcomes. Thus, superset learning can be seen as a specific type of weakly supervised learning, in which training examples are imprecise or ambiguous. We introduce a generic approach to superset learning, which is motivated by the idea of performing model identification and “data disambiguation” simultaneously. This idea is realized by means of a generalized risk minimization approach, using an extended loss function that compares precise predictions with set-valued observations. Building on this approach, we furthermore elaborate on the idea of “data imprecisation”: By deliberately turning precise training data into imprecise data, it becomes possible to modulate the influence of individual examples on the process of model induction. In other words, data imprecisation offers an alternative way of instance weighting. Interestingly, several existing machine learning methods, such as support vector regression or semi-supervised support vector classification, are recovered as special cases of this approach. Besides, promising new methods can be derived in a natural way, and examples of such methods will be shown for problems such as classification, regression, and label ranking.

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