

Preface

This is the third volume on Uncertainty Reasoning for the Semantic Web, containing revised and significantly extended versions of selected workshop papers presented at three workshops on Uncertainty Reasoning for the Semantic Web (URSW), collocated with the International Semantic Web Conferences (ISWC) in 2011, 2012, and 2013. The first volume contained the proceedings of the first three workshops on URSW at ISWC in 2005, 2006, and 2007, while the second volume included revised versions of papers presented at the 2008, 2009, and 2010 editions of URSW or at the First International Workshop on Uncertainty in Description Logics (UniDL), held in 2010.

These three volumes together represent a comprehensive compilation of state-of-the-art research approaches to uncertainty reasoning in the context of the Semantic Web, capturing different models of uncertainty and approaches to deductive as well as inductive reasoning with uncertain formal knowledge.

The World Wide Web community envisions effortless interaction between humans and computers, seamless interoperability and information exchange among Web applications, and rapid and accurate identification and invocation of appropriate Web services. As work with semantics and services grows more ambitious, there is increasing appreciation of the need for principled approaches to the formal representation of and reasoning under uncertainty. The term *uncertainty* is intended here to encompass a variety of forms of incomplete knowledge, including incompleteness, inconclusiveness, vagueness, ambiguity, and others. The term *uncertainty reasoning* is meant to denote the full range of methods designed for representing and reasoning with knowledge when Boolean truth values are unknown, unknowable, or inapplicable. Commonly applied approaches to uncertainty reasoning include probability theory, Dempster-Shafer theory, fuzzy logic and possibility theory, and numerous other methodologies.

A few Web-relevant challenges that are addressed by reasoning under uncertainty include:

Uncertainty of available information: Much information on the World Wide Web is uncertain. Examples include weather forecasts or gambling odds. Canonical methods for representing and integrating such information are necessary for communicating it in a seamless fashion.

Information incompleteness: Information extracted from large information networks such as the World Wide Web is typically incomplete. The ability to exploit partial information is very useful for identifying sources of service or information. For example, that an online service deals with greeting cards may be evidence that it also sells stationery. It is clear that search effectiveness could be improved by appropriate use of technologies for handling uncertainty.

Information incorrectness: Web information is also often incorrect or only partially correct, raising issues related to trust or credibility. Uncertainty representation and reasoning helps to resolve tension among information sources having different

confidence and trust levels, and can facilitate the merging of controversial information obtained from multiple sources.

Uncertain ontology mappings: The Semantic Web vision implies that numerous distinct but conceptually overlapping ontologies will coexist and interoperate. It is likely that in such scenarios, ontology mapping will benefit from the ability to represent degrees of membership and/or likelihoods of membership in categories of a target ontology, given information about class membership in the source ontologies.

Indefinite information about Web services: Dynamic composability of Web services will require runtime identification of processing and data resources and resolution of policy objectives. Uncertainty reasoning techniques may be necessary to resolve situations in which existing information is not definitive.

Uncertainty is thus an intrinsic feature of many important tasks on the Web and the Semantic Web, and a full realization of the World Wide Web as a source of processable data and services demands formalisms capable of representing and reasoning under uncertainty. Unfortunately, none of these needs can be addressed in a principled way by current Web standards. Although it is to some degree possible to use semantic markup languages such as OWL or RDF(S) to represent qualitative and quantitative information about uncertainty, there is no established foundation for doing so, and feasible approaches are severely limited. Furthermore, there are ancillary issues such as how to balance representational power versus simplicity of uncertainty representations, which uncertainty representation techniques address uses such as the examples listed above, how to ensure the consistency of representational formalisms and ontologies, etc.

In response to these pressing demands, in recent years, several promising approaches to uncertainty reasoning on the Semantic Web have been proposed. The present volume covers a representative cross section of these approaches, from extensions to existing Web-related logics for the representation of uncertainty to approaches to inductive reasoning under uncertainty on the Web.

In order to reflect the diversity of the presented approaches and to relate them to their underlying models of uncertainty, the contributions to this volume are grouped as follows:

Probabilistic and Dempster-Shafer Models

Probability theory provides a mathematically sound representation language and formal calculus for rational degrees of belief, which gives different agents the freedom to have different beliefs about a given hypothesis. As this provides a compelling framework for representing uncertain, imperfect knowledge that can come from diverse agents, there are many distinct approaches using probability in the context of the Semantic Web. Classes of probabilistic models covered with the present volume are Bayesian networks, probabilistic extensions to description and first-order logics, and models based on the Dempster-Shafer theory (a generalization of the classical Bayesian approach).

Fuzzy and Possibilistic Models

Fuzzy formalisms allow for representing and processing degrees of truth about vague (or imprecise) pieces of information. In fuzzy description logics and ontology languages, concept assertions, role assertions, concept inclusions, and role inclusions have a degree of truth rather than a binary truth value. The present volume presents various approaches that exploit fuzzy logic and possibility theory in the context of the Semantic Web.

Inductive Reasoning and Machine Learning

Machine learning is supposed to play an increasingly important role in the context of the Semantic Web by providing various tasks, such as the learning of ontologies from incomplete data or the (semi-)automatic annotation of data on the Web. Results obtained by machine learning approaches are typically uncertain. As a logic-based approach to machine learning, inductive reasoning provides means for inducing general propositions from observations (example facts). Papers in this volume exploit the power of inductive reasoning for the purpose of ontology learning, and project future directions for the use of machine learning on the Semantic Web.

Hybrid Approaches

This volume segment contains papers that either combine approaches from two or more of the previous segments, or that do not rely on any specific classical approach to uncertainty reasoning.

Acknowledgments. We would like to express our gratitude to the authors of this volume for their contributions and to the workshop participants for inspiring discussions, as well as to the members of the workshop Program Committees and the additional reviewers for their reviews and for their overall support.

October 2014

Fernando Bobillo
Rommel N. Carvalho
Paulo C.G. Costa
Claudia d'Amato
Nicola Fanizzi
Kathryn B. Laskey
Kenneth J. Laskey
Thomas Lukasiewicz
Matthias Nickles
Michael Pool

Uncertainty Reasoning for the Semantic Web III
ISWC International Workshops, URSW 2011-2013,
Revised Selected Papers

Bobillo, F.; Carvalho, R.N.; Costa, P.C.G.; d'Amato, C.;
Fanizzi, N.; Laskey, K.B.; Laskey, K.J.; Lukasiewicz, Th.;
Nickles, M.; Pool, M. (Eds.)

2014, XVIII, 329 p. 56 illus., Softcover

ISBN: 978-3-319-13412-3