Preface

The Web is a huge information resource depository all around the world and the huge amount of information on the Web is getting larger and larger every day. Nowadays, the Web is the most important means for people to acquire and publish information. Under this context, it is becoming very crucial for computer programs to deal with information on the Web automatically and intelligently. But most of today's Web content is suitable for human consumption. The Semantic Web has emerged as an extension of the current Web, in which Web resources are given computer-understandable semantics, enabling computers and people to better work in cooperation. The central idea of the Semantic Web is to make the Web more understandable to computer programs so that people can make more use of this gigantic asset.

The development of the Semantic Web proceeds in several steps, each step building a layer on top of another. The first layer is Uniform Resource Identifier (URI) and Unicode. The second layer is Extensible Markup Language (XML) and the third layer is the data representation format for Semantic Web, i.e., Resource Description Framework (RDF). The core layer is the ontology layer, in which RDF Schema (RDFS) and Web Ontology Language (OWL) represent the ontologies. Description Logics (DLs) are essentially the theoretical counterpart of OWL. Moreover, rule languages (e.g., RIF) are being standardized for the Semantic Web as well. In addition, to query RDF data as well as RDFS and OWL ontologies, Simple Protocol, and RDF Query Language (SPARQL) are proposed. On top of the ontology layer is the logic layer, which is the logical foundation of the Semantic Web. The rest of the Semantic Web layers are the Proof and Trust layers. On top of these layers, application with user interface can be built. From the layers of the Semantic Web, one of the important and declared goals of the Semantic Web is to reason about knowledge and data which are pervaded on the Web. So knowledge representation and reasoning have become very important research topics of the Semantic Web.

As it may be known, in the real world, human knowledge and natural language have a great deal of imprecision and vagueness. Fuzzy logic has been applied in a large number and a wide variety of applications, with real-world impact across a wide array of domains with human-like behavior and reasoning. Fuzzy logic has been a crucial means of implementing machine intelligence. So, in order to bridge the gap between human-understandable soft logic and machine-readable hard

logic, fuzzy logic cannot be ignored. None of the usual logical requirements can be guaranteed: there is no centrally defined format for data, no guarantee of truth for assertions made, and no guarantee for consistency. It can be believed that fuzzy knowledge management can play an important and positive role in the development of the Semantic Web. It should be noted, however, that fuzzy logic may not be assumed to be the (only) basis for the Semantic Web, but its related concepts and techniques will certainly reinforce the systems classically developed within the W3C. Currently, the research of fuzzy logic in the area of the Semantic Web for fuzzy knowledge representation and reasoning are attracting increased attention.

This book goes to great depth concerning the fast-growing topic of technologies and approaches of fuzzy logic in the Semantic Web. The topics of this book include fuzzy description logics and fuzzy ontologies, queries of fuzzy description logics and fuzzy ontology knowledge bases, extraction of fuzzy description logics and ontologies from fuzzy data models, storage of fuzzy ontology knowledge bases in fuzzy databases, fuzzy Semantic Web ontology mapping, and fuzzy rules and their interchange in the Semantic Web. Concerning the fuzzy description logics, three kinds of fuzzy description logics are introduced, which are the tractable fuzzy description logics, the expressive fuzzy description logics, and the fuzzy description logics with fuzzy data types. The syntax, semantics, knowledge base, and reasoning for the fuzzy description logics are investigated, and a fuzzy description logic reasoner called FRESG supporting fuzzy data information with customized fuzzy data types G is introduced. Concerning the queries of fuzzy description logics and fuzzy ontology knowledge bases, conjunctive query answering for the tractable fuzzy description logics, expressive fuzzy description logics and fuzzy description logics with data type support is investigated, and a fuzzy SPARQL query language is proposed. Concerning the extraction of fuzzy description logics and ontologies from fuzzy data models, extracting fuzzy description logics and ontologies from the fuzzy conceptual data models (including fuzzy ER and UML data models) and the fuzzy database models (including fuzzy relational and fuzzy object-oriented databases) is discussed, respectively. Concerning the storage of fuzzy ontology knowledge bases in fuzzy databases, storing fuzzy knowledge base structure information, and instance information in the fuzzy relational databases are presented. Concerning the fuzzy Semantic Web ontology mapping, based on fuzzy ontology concept comparison and conceptual graph, mappings among multiple fuzzy ontologies are investigated. Concerning the fuzzy rules and their interchange in the Semantic Web, fuzzy rule languages are introduced and a fuzzy RIF framework f-RIA (fuzzy Rule Interchange Architecture) is proposed based on the fuzzy rule interchange format RIF-FRD (RIF Fuzzy Rule Dialect).

This book aims to provide a single record of current research in the fuzzy knowledge representation and reasoning for the Semantic Web. The objective of the book is to provide the state-of-the art information to researchers, practitioners, and graduate students of the Web intelligence and at the same time serve the knowledge and data engineering professional faced with nontraditional

applications that make the application of conventional approaches difficult or impossible. Researchers, graduate students, and information technology professionals interested in the Semantic Web and fuzzy knowledge representation and reasoning will find this book a starting point and a reference for their study, research, and development.

We would like to acknowledge all of the researchers in the area of the Semantic Web and fuzzy knowledge representation and reasoning. Based on both their publications and the many discussions with some of them, their influence on this book is profound. The materials in this book are the outgrowth of research conducted by the authors in recent years. The initial research work were supported by the *National Natural Science Foundation of China* (61073139, 61202260, 61370075, 60873010), and in part by the *Program for New Century Excellent Talents in University* (NCET-05-0288). We are grateful for the financial support from the *National Natural Science Foundation of China* and the *Ministry of Education of China* through research grant funds. Additionally, the assistances and facilities of Northeastern University, China, are deemed important and highly appreciated. Special thanks go to Janusz Kacprzyk, the series editor of *Studies in Fuzziness and Soft Computing*, and Thomas Ditzinger, the senior editor of Applied Sciences and Engineering of Springer-Verlag, for their advice and help to propose, prepare and publish this book. This book will not be completed without the support from them. Finally, we wish to express deep thanks to Dr. Hailong Wang, Dr. Xing Wang, and Dr. Lingyu Zhang for their excellent research work and their great contributions to the book.

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