

Communications in Computer and Information Science

1239

Commenced Publication in 2007

Founding and Former Series Editors:

Simone Diniz Junqueira Barbosa, Phoebe Chen, Alfredo Cuzzocrea,
Xiaoyong Du, Orhun Kara, Ting Liu, Krishna M. Sivalingam,
Dominik Ślęzak, Takashi Washio, Xiaokang Yang, and Junsong Yuan

Editorial Board Members

Joaquim Filipe 


Polytechnic Institute of Setúbal, Setúbal, Portugal

Ashish Ghosh

Indian Statistical Institute, Kolkata, India

Igor Kotenko 

*St. Petersburg Institute for Informatics and Automation of the Russian
Academy of Sciences, St. Petersburg, Russia*

Raquel Oliveira Prates 

Federal University of Minas Gerais (UFMG), Belo Horizonte, Brazil

Lizhu Zhou

Tsinghua University, Beijing, China

More information about this series at <http://www.springer.com/series/7899>

Marie-Jeanne Lesot · Susana Vieira ·
Marek Z. Reformat · João Paulo Carvalho ·
Anna Wilbik · Bernadette Bouchon-Meunier ·
Ronald R. Yager (Eds.)

Information Processing and Management of Uncertainty in Knowledge-Based Systems

18th International Conference, IPMU 2020
Lisbon, Portugal, June 15–19, 2020
Proceedings, Part III

Editors

Marie-Jeanne Lesot
LIP6-Sorbonne University
Paris, France

Marek Z. Reformat
University of Alberta
Edmonton, AB, Canada

Anna Wilbik
Eindhoven University of Technology
Eindhoven, The Netherlands

Ronald R. Yager
Iona College
New Rochelle, NY, USA

Susana Vieira
IDMEC, IST, Universidade de Lisboa
Lisbon, Portugal

João Paulo Carvalho
INESC, IST, Universidade de Lisboa
Lisbon, Portugal

Bernadette Bouchon-Meunier
CNRS-Sorbonne University
Paris, France

ISSN 1865-0929 ISSN 1865-0937 (electronic)
Communications in Computer and Information Science
ISBN 978-3-030-50152-5 ISBN 978-3-030-50153-2 (eBook)
<https://doi.org/10.1007/978-3-030-50153-2>

© Springer Nature Switzerland AG 2020

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

We are very pleased to present you with the proceedings of the 18th International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems (IPMU 2020), held during June 15–19, 2020. The conference was scheduled to take place in Lisbon, Portugal, at the Instituto Superior Técnico, University of Lisbon, located in a vibrant renovated area 10 minutes from downtown. Unfortunately, due to the COVID-19 pandemic and international travel restrictions around the globe, the Organizing Committee made the decision to make IPMU 2020 a virtual conference taking place as scheduled.

The IPMU conference is organized every two years. Its aim is to bring together scientists working on methods for the management of uncertainty and aggregation of information in intelligent systems. Since 1986, the IPMU conference has been providing a forum for the exchange of ideas between theoreticians and practitioners working in these areas and related fields. In addition to many contributed scientific papers, the conference has attracted prominent plenary speakers, including the Nobel Prize winners Kenneth Arrow, Daniel Kahneman, and Ilya Prigogine.

A very important feature of the conference is the presentation of the *Kampé de Fériet Award* for outstanding contributions to the field of uncertainty and management of uncertainty. Past winners of this prestigious award are Lotfi A. Zadeh (1992), Ilya Prigogine (1994), Toshiro Terano (1996), Kenneth Arrow (1998), Richard Jeffrey (2000), Arthur Dempster (2002), Janos Aczel (2004), Daniel Kahneman (2006), Enric Trillas (2008), James Bezdek (2010), Michio Sugeno (2012), Vladimir N. Vapnik (2014), Joseph Y. Halpern (2016), and Glenn Shafer (2018). This year, the recipient of the *Kampé de Fériet Award* is Barbara Tversky. Congratulations!

The IPMU 2020 conference offers a versatile and comprehensive scientific program. There were four invited talks given by distinguished researchers: Barbara Tversky (Stanford University and Columbia University, USA), Luísa Coheur (Universidade de Lisboa, Instituto Superior Técnico, Portugal), Jim Keller (University of Missouri, USA), and Björn Schuller (Imperial College London, UK). A special tribute was organized to celebrate the life and achievements of Enrique Ruspini who passed away last year. He was one of the fuzzy-logic pioneers and researchers who contributed enormously to the fuzzy sets and systems body of knowledge. Two invited papers are dedicated to his memory. We would like to thank Rudolf Seising, Francesc Esteve, Lluís Godó, Ricardo Oscar Rodriguez, and Thomas Vetterlein for their involvement and contributions.

The IPMU 2020 program consisted of 22 special sessions and 173 papers authored by researchers from 34 different countries. All 213 submitted papers underwent the thorough review process and were judged by at least three reviewers. Many of them were reviewed by more – even up to five – referees. Furthermore, all papers were examined by the program chairs. The review process respected the usual

conflict-of-interest standards, so that all papers received multiple independent evaluations.

Organizing a conference is not possible without the assistance, dedication, and support of many people and institutions.

We are particularly thankful to the organizers of special sessions. Such sessions, dedicated to variety of topics and organized by experts, have always been a characteristic feature of IPMU conferences. We would like to pass our special thanks to Uzay Kaymak, who helped evaluate many special session proposals.

We would like to acknowledge all members of the IPMU 2020 Program Committee, as well as multiple reviewers who played an essential role in the reviewing process, ensuring a high-quality conference. Thank you very much for all your work and efforts.

We gratefully acknowledge the technical co-sponsorship of the IEEE Computational Intelligence Society and the European Society for Fuzzy Logic and Technology (EUSFLAT).

A huge thanks and appreciation to the personnel of Lisbon's Tourism Office 'Turismo de Lisboa' (www.visitlisboa.com) for their eagerness to help, as well as their enthusiastic support.

Our very special and greatest gratitude goes to the authors who have submitted results of their work and presented them at the conference. Without you this conference would not take place. Thank you!

We miss in-person meetings and discussions, yet we are privileged that despite these difficult and unusual times all of us had a chance to be involved in organizing the virtual IPMU conference. We hope that these proceedings provide the readers with multiple ideas leading to numerous research activities, significant publications, and intriguing presentations at future IPMU conferences.

April 2020

Marie-Jeanne Lesot
Marek Z. Reformat
Susana Vieira
Bernadette Bouchon-Meunier
João Paulo Carvalho
Anna Wilbik
Ronald R. Yager

Organization

General Chair

João Paulo Carvalho

INESC-ID, Instituto Superior Técnico,
Universidade de Lisboa, Portugal

Program Chairs

Marie-Jeanne Lesot
Marek Z. Reformat
Susana Vieira

LIP6, Sorbonne Université, France
University of Alberta, Canada
IDMEC, Instituto Superior Técnico,
Universidade de Lisboa, Portugal

Executive Directors

Bernadette
Bouchon-Meunier
Ronald R. Yager

LIP6, CNRS, France
Iona College, USA

Special Session Chair

Uzay Kaymak

Technische Universiteit Eindhoven, The Netherlands

Publication Chair

Anna Wilbik

Technische Universiteit Eindhoven, The Netherlands

Sponsor and Publicity Chair

João M. C. Sousa

IDMEC, Instituto Superior Técnico,
Universidade de Lisboa, Portugal

Web Chair

Fernando Batista

INESC-ID, Instituto Superior Técnico,
Universidade de Lisboa, Portugal

International Advisory Board

João Paulo Carvalho, Portugal
 Giulianella Coletti, Italy
 Miguel Delgado, Spain
 Mario Fedrizzi, Italy
 Laurent Foulloy, France
 Salvatore Greco, Italy
 Julio Gutierrez-Rios, Spain
 Eyke Hüllermeier, Germany
 Uzay Kaymak, The Netherlands
 Anne Laurent, France
 Marie-Jeanne Lesot, France
 Luis Magdalena, Spain

Christophe Marsala, France
 Benedetto Matarazzo, Italy
 Jesús Medina Moreno, Spain
 Manuel Ojeda-Aciego, Spain
 Maria Rifqi, France
 Lorenza Saitta, Italy
 Olivier Strauss, France
 Enric Trillas, Spain
 Llorenç Valverde, Spain
 José Luis Verdegay, Spain
 Maria-Amparo Vila, Spain

Program Committee

Giovanni Acampora
 Rui Jorge Almeida
 Derek Anderson
 Troels Andreasen
 Michał Baczynski
 Fernando Batista
 Radim Belohlavek
 Nahla Ben Amor
 Salem Benferhat
 James Bezdek
 Piero Bonissone
 Isabelle Bloch
 Ulrich Bodenhofer
 Gloria Bordogna
 Bernadette

University of Naples Federico II, Italy
 Maastricht University, The Netherlands
 University of Missouri, USA
 Roskilde University, Denmark
 University of Silesia, Poland
 INESC-ID, ISCTE-IUL, Portugal
 Palacky University, Czech Republic
 Institut Supérieur de Gestion de Tunis, Tunisia
 Université d'Artois, France
 University of Missouri, USA
 Piero P Bonissone Analytics, USA
 ENST, CNRS, UMR 5141, LTCI, France
 QUOMATIC.AI, Austria
 CNR, Italy
 LIP6, CNRS, Sorbonne Université, France

Bouchon-Meunier
 Humberto Bustince
 Christer Carlsson
 João Paulo Carvalho
 Oscar Castillo
 Martine Ceberio
 Ricardo Coelho
 Giulianella Coletti
 Didier Coquin
 Oscar Cordon
 Inés Couso

UPNA, Spain
 Åbo Akademi University, Finland
 Universidade de Lisboa, Portugal
 Tijuana Institute of Technology, Mexico
 University of Texas at El Paso, USA
 Federal University of Ceará, Brazil
 University of Perugia, Italy
 LISTIC, France
 University of Granada, Spain
 University of Oviedo, Spain

Keeley Crockett	Manchester Metropolitan University, UK
Giuseppe D’Aniello	University of Salerno, Italy
Bernard De Baets	Ghent University, Belgium
Martine De Cock	University of Washington, USA
Guy De Tré	Ghent University, Belgium
Sébastien Destercke	CNRS, UMR Heudiasyc, France
Antonio Di Nola	University of Salerno, Italy
Scott Dick	University of Alberta, Canada
Didier Dubois	IRIT, RPDMP, France
Fabrizio Durante	Free University of Bozen-Bolzano, Italy
Krzysztof Dyczkowski	Adam Mickiewicz University, Poland
Zied Elouedi	Institut Supérieur de Gestion de Tunis, Tunisia
Francesc Esteva	IIIA-CSIC, Spain
Dimitar Filev	Ford Motor Company, USA
Matteo Gaeta	University of Salerno, Italy
Sylvie Galichet	LISTIC, Université de Savoie, France
Jonathan M. Garibaldi	University of Nottingham, UK
Lluís Godó	IIIA-CSIC, Spain
Fernando Gomide	University of Campinas, Brazil
Gil González-Rodríguez	University of Oviedo, Spain
Przemysław Grzegorzewski	Systems Research Institute, Polish Academy of Sciences, Poland
Lawrence Hall	University of South Florida, USA
Istvan Harmati	Széchenyi István Egyetem, Hungary
Timothy Havens	Michigan Technological University, USA
Francisco Herrera	University of Granada, Spain
Enrique Herrera-Viedma	University of Granada, Spain
Ludmila Himmelspach	Heinrich Heine Universität Düsseldorf, Germany
Eyke Hüllermeier	Paderborn University, Germany
Michal Holčápek	University of Ostrava, Czech Republic
Janusz Kacprzyk	Systems Research Institute, Polish Academy of Sciences, Poland
Uzay Kaymak	Eindhoven University of Technology, The Netherlands
Jim Keller	University of Missouri, USA
Frank Klawonn	Ostfalia University of Applied Sciences, Germany
László T. Kóczy	Budapest University of Technology and Economics, Hungary
John Kornak	University of California, San Francisco, USA
Vladik Kreinovich	University of Texas at El Paso, USA
Ondrej Krídlo	University of P. J. Šafárik in Košice, Slovakia
Rudolf Kruse	University of Magdeburg, Germany
Christophe Labreuche	Thales R&T, France
Jérôme Lang	CNRS, LAMSADE, Université Paris-Dauphine, France
Anne Laurent	LIRMM, UM, France
Chang-Shing Lee	National University of Tainan, Taiwan

Henrik Legind Larsen	Legind Technologies, Denmark
Marie-Jeanne Lesot	LIP6, Sorbonne Université, France
Weldon Lodwick	University of Colorado, USA
Edwin Lughofer	Johannes Kepler University Linz, Austria
Luis Magdalena	Universidad Politécnica de Madrid, Spain
Christophe Marsala	LIP6, Sorbonne Université, France
Trevor Martin	University of Bristol, UK
Sebastià Massanet	University of the Balearic Islands, Spain
Marie-Hélène Masson	Université de Picardie Jules Verne (Heudiasyc), France
Jesús Medina	University of Cádiz, Spain
Patricia Melin	Tijuana Institute of Technology, Mexico
Jerry Mendel	University of Southern California, USA
Radko Mesiar	STU, Slovakia
Enrique Miranda	University of Oviedo, Spain
Javier Montero	Universidad Complutense de Madrid, Spain
Susana Montes	University of Oviedo, Spain
Jacky Montmain	École des Mines d'Alès, France
Juan Moreno Garcia	Universidad de Castilla-La Mancha, Spain
Petra Murinová	University of Ostrava IT4Innovations, Czech Republic
Yusuke Nojima	Osaka Prefecture University, Japan
Vilém Novák	University of Ostrava, Czech Republic
Hannu Nurmi	University of Turku, Finland
Manuel Ojeda-Aciego	University of Malaga, Spain
Nikhil Pal	ISI, India
Gabriella Pasi	University of Milano-Bicocca, Italy
David Pelta	University of Granada, Spain
Irina Perfilieva	University of Ostrava, Czech Republic
Fred Petry	Naval Research Lab, USA
Davide Petturiti	University of Perugia, Italy
Vincenzo Piuri	University of Milan, Italy
Olivier Pivert	IRISA, ENSSAT, France
Henri Prade	IRIT, CNRS, France
Raúl Pérez-Fernández	Universidad de Oviedo, Spain
Anca Ralescu	University of Cincinnati, USA
Dan Ralescu	University of Cincinnati, USA
Marek Z. Reformat	University of Alberta, Canada
Adrien Revault d'Allonnes	LIASD, France
Agnès Rico	LIRIS, Université Claude Bernard Lyon 1, France
M. Dolores Ruiz	University of Cádiz, Spain
Thomas A. Runkler	Siemens Corporate Technology, Germany
Mika Sato Illic	University of Tsukuba, Japan
Daniel Sanchez	University of Granada, Spain
Glen Shafer	Rutgers University, USA
Grégory Smits	IRISA, University of Rennes 1, France
João Sousa	TU Lisbon, IST, Portugal

Martin Štěpnička	IRAFM, University of Ostrava, Czech Republic
Umberto Straccia	ISTI-CNR, Italy
Olivier Strauss	LIRMM, France
Michio Sugeno	Tokyo Institute of Technology, Japan
Eulalia Szmidt	Systems Research Institute, Polish Academy of Sciences, Poland
Marco Tabacchi	Università degli Studi di Palermo, Italy
Vicenc Torra	Maynooth University, Ireland
Linda C. van der Gaag	Utrecht University, The Netherlands
Barbara Vantaggi	Sapienza University of Rome, Italy
José Luis Verdegay	University of Granada, Spain
Thomas Vetterlein	Johannes Kepler University Linz, Austria
Susana Vieira	Universidade de Lisboa, Portugal
Christian Wagner	University of Nottingham, UK
Anna Wilbik	Eindhoven University of Technology, The Netherlands
Sławomir Zadrozny	Systems Research Institute, Polish Academy of Sciences, Poland

Additional Members of the Reviewing Committee

Raoua Abdelkhalek	Yurilev Chalco-Cano
Julien Alexandre Dit Sandretto	Manuel Chica
Zahra Alijani	Panagiotis Chountas
Alessandro Antonucci	Davide Ciucci
Jean Baratgin	Frank Coolen
Laécio C. Barros	Maria Eugenia Cornejo Piñero
Leliane N. Barros	Cassio P. de Campos
Libor Behounek	Gert De Cooman
María José Benítez Caballero	Laura De Miguel
Kyle Bittner	Jean Dezert
Jan Boronski	J. Angel Diaz-Garcia
Reda Boukezzoula	Graçaliz Dimuro
Ross Boylan	Paweł Drygaś
Andrey Bronevich	Hassane Essafi
Petr Bujok	Javier Fernandez
Michal Burda	Carlos Fernandez-Basso
Rafael Cabañas de Paz	Juan Carlos Figueroa-García
Inma P. Cabrera	Marcelo Finger
Tomasa Calvo	Tommaso Flaminio
José Renato Campos	Robert Fullér
Andrea Capotorti	Marek Gagolewski
Diego Castaño	Angel Garcia Contreras
Anna Cena	Michel Grabisch
Mihir Chakraborty	Karel Gutierrez

Allel Hadjali
Olgierd Hryniewicz
Miroslav Hudec
Ignacio Huitzil
Seong Jae Hwang
Atsushi Inoue
Vladimir Janis
Balasubramaniam Jayaram
Richard Jensen
Luis Jimenez Linares
Katarzyna Kaczmarek
Martin Kalina
Hiroharu Kawanaka
Alireza Khastan
Martins Kokainis
Ryszard Kowalczyk
Maciej Krawczak
Jiri Kupka
Serafina Lapenta
Ulcilea Leal
Antonio Ledda
Eric Lefevre
Nguyen Linh
Nicolas Madrid
Arnaud Martin
Denis Maua
Gilles Mauris
Belen Melian
María Paula Menchón
David Mercier
Arnau Mir
Soheyila Mirshahi
Marina Mizukoshi
Jiří Močkoř
Miguel Molina-Solana
Ignacio Montes
Serafin Moral
Tommaso Moraschini
Andreia Mordido
Juan Antonio Morente-Molinera
Fred Mubang
Vu-Linh Nguyen
Radoslaw Niewiadomski

Carles Noguera
Pavels Orlovs
Daniel Ortiz-Arroyo
Jan W. Owsinski
Antonio Palacio
Manuel J. Parra Royón
Jan Paseka
Viktor Pavliska
Renato Pelessoni
Barbara Pękala
Benjamin Quost
Emmanuel Ramasso
Eloisa Ramírez Poussa
Luca Reggio
Juan Vicente Riera
Maria Rifqi
Luis Rodriguez-Benitez
Guillaume Romain
Maciej Romaniuk
Francisco P. Romero
Clemente Rubio-Manzano
Aleksandra Rutkowska
Juan Jesus Salamanca Jurado
Teddy Seidenfeld
Mikel Sesma-Sara
Babak Shiri
Amit Shukla
Anand Pratap Singh
Damjan Skulj
Sotir Sotirov
Michal Stronkowski
Andrea Stupnánová
Matthias Troffaes
Dana Tudorascu
Leobardo Valera
Arthur Van Camp
Paolo Vicig
Amanda Vidal Wandelmer
Joaquim Viegas
Jin Hee Yoon
Karl Young
Hua-Peng Zhang

Special Session Organizers

Javier Andreu	University of Essex, UK
Michał Baczyński	University of Silesia in Katowice, Poland
Isabelle Bloch	Télécom ParisTech, France
Bernadette Bouchon-Meunier	LIP6, CNRS, France
Reda Boukezzoula	Université de Savoie Mont-Blanc, France
Humberto Bustince	Public University of Navarra, Spain
Tomasa Calvo	University of Alcalá, Spain
Martine Ceberio	University of Texas at El Paso, USA
Yurilev Chalco-Cano	University of Tarapacá at Arica, Chile
Giulianella Coletti	Università di Perugia, Italy
Didier Coquin	Université de Savoie Mont-Blanc, France
M. Eugenia Cornejo	University of Cádiz, Spain
Bernard De Baets	Ghent University, Belgium
Guy De Tré	Ghent University, Belgium
Graçaliz Dimuro	Universidade Federal do Rio Grande, Brazil
Didier Dubois	IRIT, Université Paul Sabatier, France
Hassane Essafi	CEA, France
Carlos J. Fernández-Basso	University of Granada, Spain
Javier Fernández	Public University of Navarra, Spain
Tommaso Flaminio	Spanish National Research Council, Spain
Lluís Godó	Spanish National Research Council, Spain
Przemysław Grzegorzewski	Warsaw University of Technology, Poland
Rajarshi Guhaniyogi	University of California, Santa Cruz, USA
Karel Gutiérrez Batista	University of Granada, Spain
István Á. Harmati	Széchenyi István University, Hungary
Michal Holčápek	University of Ostrava, Czech Republic
Atsushi Inoue	Eastern Washington University, USA
Balasubramaniam Jayaram	Indian Institute of Technology Hyderabad, India
Janusz Kacprzyk	Systems Research Institute, Polish Academy of Sciences, Poland
Hiroharu Kawanaka	Mie University, Japan
László T. Kóczy	Budapest University of Technology and Economics, Hungary
John Kornak	University of California, San Francisco, USA
Vladik Kreinovich	University of Texas at El Paso, USA
Henrik Legind Larsen	Legind Technologies, Denmark
Weldon Lodwick	Federal University of São Paulo, Brazil
Maria Jose Martín-Bautista	University of Granada, Spain
Sebastia Massanet	University of the Balearic Islands, Spain
Jesús Medina	University of Cádiz, Spain
Belén Melián-Batista	University of La Laguna, Spain
Radko Mesiar	Slovak University of Technology, Slovakia
Enrique Miranda	University of Oviedo, Spain

Ignacio Montes	University of Oviedo, Spain
Juan Moreno-García	University of Castilla-La Mancha, Spain
Petra Murinová	University of Ostrava, Czech Republic
Vilem Novák	University of Ostrava, Czech Republic
David A. Pelta	University of Granada, Spain
Raúl Pérez-Fernández	University of Oviedo, Spain
Irina Perfilieva	University of Ostrava, Czech Republic
Henri Prade	IRIT, Université Paul Sabatier, France
Anca Ralescu	University of Cincinnati, USA
Eloísa Ramírez-Poussa	University of Cádiz, Spain
Luis Rodríguez-Benítez	University of Castilla-La Mancha, Spain
Antonio Rufian-Lizana	University of Sevilla, Spain
M. Dolores Ruiz	University of Granada, Spain
Andrea Stupnanova	Slovak University of Technology, Slovakia
Amanda Vidal	Czech Academy of Sciences, Czech Republic
Aaron Wolfe Scheffler	University of California, San Francisco, USA
Adnan Yazici	Nazarbayev University, Kazakhstan
Sławomir Zadrozny	Systems Research Institute Polish Academy of Sciences, Poland

List of Special Sessions

Fuzzy Interval Analysis

Antonio Rufian-Lizana	University of Sevilla, Spain
Weldon Lodwick	Federal University of São Paulo, Brazil
Yurilev Chalco-Cano	University of Tarapacá at Arica, Chile

Theoretical and Applied Aspects of Imprecise Probabilities

Enrique Miranda	University of Oviedo, Spain
Ignacio Montes	University of Oviedo, Spain

Similarities in Artificial Intelligence

Bernadette Bouchon-Meunier	LIP6, CNRS, France
Giulianella Coletti	Università di Perugia, Italy

Belief Function Theory and Its Applications

Didier Coquin	Université de Savoie Mont-Blanc, France
Reda Boukezzoula	Université de Savoie Mont-Blanc, France

Aggregation: Theory and Practice

Tomas Calvo	University of Alcalá, Spain
Radko Mesiar	Slovak University of Technology, Slovakia
Andrea Stupánová	Slovak University of Technology, Slovakia

Aggregation: Pre-aggregation Functions and Other Generalizations

Humberto Bustince	Public University of Navarra, Spain
Graçaliz Dimuro	Universidade Federal do Rio Grande, Brazil
Javier Fernández	Public University of Navarra, Spain

Aggregation: Aggregation of Different Data Structures

Bernard De Baets	Ghent University, Belgium
Raúl Pérez-Fernández	University of Oviedo, Spain

Fuzzy Methods in Data Mining and Knowledge Discovery

M. Dolores Ruiz	University of Granada, Spain
Karel Gutiérrez Batista	University of Granada, Spain
Carlos J. Fernández-Basso	University of Granada, Spain

Computational Intelligence for Logistics and Transportation Problems

David A. Pelta	University of Granada, Spain
Belén Melián-Batista	University of La Laguna, Spain

Fuzzy Implication Functions

Michał Baczyński	University of Silesia in Katowice, Poland
Balasubramaniam Jayaram	Indian Institute of Technology Hyderabad, India
Sebastià Massanet	University of the Balearic Islands, Spain

Soft Methods in Statistics and Data Analysis

Przemysław Grzegorzewski	Warsaw University of Technology, Poland
--------------------------	---

Image Understanding and Explainable AI

Isabelle Bloch	Télécom ParisTech, France
Atsushi Inoue	Eastern Washington University, USA
Hiroharu Kawanaka	Mie University, Japan
Anca Ralescu	University of Cincinnati, USA

Fuzzy and Generalized Quantifier Theory

Vilém Novák	University of Ostrava, Czech Republic
Petra Murinová	University of Ostrava, Czech Republic

Mathematical Methods Towards Dealing with Uncertainty in Applied Sciences

Irina Perfilieva	University of Ostrava, Czech Republic
Michal Holčápek	University of Ostrava, Czech Republic

Statistical Image Processing and Analysis, with Applications in Neuroimaging

John Kornak	University of California, San Francisco, USA
Rajarshi Guhaniyogi	University of California, Santa Cruz, USA
Aaron Wolfe Scheffler	University of California, San Francisco, USA

Interval Uncertainty

Martine Ceberio	University of Texas at El Paso, USA
Vladik Kreinovich	University of Texas at El Paso, USA

Discrete Models and Computational Intelligence

László T. Kóczy	Budapest University of Technology and Economics, Hungary
István Á. Harmati	Széchenyi István University, Hungary

Current Techniques to Model, Process and Describe Time Series

Juan Moreno-Garcia	University of Castilla-La Mancha, Spain
Luis Rodriguez-Benitez	University of Castilla-La Mancha, Spain

Mathematical Fuzzy Logic and Graded Reasoning Models

Tommaso Flaminio	Spanish National Research Council, Spain
Lluís Godo	Spanish National Research Council, Spain
Vilem Novák	University of Ostrava, Czech Republic
Amanda Vidal	Czech Academy of Sciences, Czech Republic

Formal Concept Analysis, Rough Sets, General Operators and Related Topics

M. Eugenia Cornejo	University of Cádiz, Spain
Didier Dubois	IRIT, Université Paul Sabatier, France
Jesús Medina	University of Cádiz, Spain
Henri Prade	IRIT, Université Paul Sabatier, France
Eloísa Ramírez-Poussa	University of Cádiz, Spain

Computational Intelligence Methods in Information Modelling, Representation and Processing

Guy De Tré	Ghent University, Belgium
Janusz Kacprzyk	Systems Research Institute, Polish Academy of Sciences, Poland
Adnan Yazici	Nazarbayev University, Kazakhstan
Sławomir Zadrozny	Systems Research Institute Polish Academy of Sciences, Poland

Contents - Part III

Soft Methods in Statistics and Data Analysis

Imprecise Approaches to Analysis of Insurance Portfolio with Catastrophe Bond.	3
<i>Maciej Romaniuk</i>	
Random Steinhaus Distances for Robust Syntax-Based Classification of Partially Inconsistent Linguistic Data.	17
<i>Laura Franzoi, Andrea Sgarro, Anca Dinu, and Liviu P. Dinu</i>	
Possibilistic Bounds for Granular Counting	27
<i>Corrado Mencar</i>	
A Fuzzy Model for Interval-Valued Time Series Modeling and Application in Exchange Rate Forecasting.	41
<i>Leandro Maciel, Rosangela Ballini, and Fernando Gomide</i>	
A Method to Generate Soft Reference Data for Topic Identification	54
<i>Daniel Vélez, Guillermo Villarino, J. Tinguaro Rodríguez, and Daniel Gómez</i>	
SK-MOEFS: A Library in Python for Designing Accurate and Explainable Fuzzy Models.	68
<i>Gionatan Gallo, Vincenzo Ferrari, Francesco Marcelloni, and Pietro Ducange</i>	
Two-Sample Dispersion Problem for Fuzzy Data	82
<i>Przemysław Grzegorzewski</i>	

Image Understanding and Explainable AI

Transparency of Classification Systems for Clinical Decision Support	99
<i>Antoine Richard, Brice Mayag, François Talbot, Alexis Tsoukias, and Yves Meinard</i>	
Information Fusion-2-Text: Explainable Aggregation via Linguistic Protoforms	114
<i>Bryce J. Murray, Derek T. Anderson, Timothy C. Havens, Tim Wilkin, and Anna Wilbik</i>	

Fuzzy and Generalized Quantifier Theory

Graded Decagon of Opposition with Fuzzy Quantifier-Based Concept-Forming Operators	131
<i>Stefania Boffa, Petra Murinová, and Vilém Novák</i>	
Graded Cube of Opposition with Intermediate Quantifiers in Fuzzy Natural Logic	145
<i>Petra Murinová and Vilém Novák</i>	
On the Properties of Intermediate Quantifiers and the Quantifier “MORE-THAN”	159
<i>Vilém Novák, Petra Murinová, and Stefania Boffa</i>	
On Semantic Properties of Fuzzy Quantifiers over Fuzzy Universes: Restriction and Living on.	173
<i>Antonín Dvořák and Michal Holčápek</i>	

Mathematical Methods Towards Dealing with Uncertainty in Applied Sciences

On the Relationship Among Relational Categories of Fuzzy Topological Structures	189
<i>Jiří Močkoř</i>	
Interactive Fuzzy Fractional Differential Equation: Application on HIV Dynamics	198
<i>Vinicius Wasques, Beatriz Lariate, Francielle Santo Pedro, Estevão Esmi, and Laécio Carvalho de Barros</i>	
HIV Dynamics Under Antiretroviral Treatment with Interactivity	212
<i>Beatriz Lariate, Francielle Santo Pedro, Estevão Esmi, and Laécio Carvalho de Barros</i>	
On Categories of L -Fuzzifying Approximation Spaces, L -Fuzzifying Pretopological Spaces and L -Fuzzifying Closure Spaces.	226
<i>Anand Pratap Singh and Irina Perfilieva</i>	
Measure of Lattice-Valued Direct F -transforms and Its Topological Interpretations	240
<i>Anand Pratap Singh and Irina Perfilieva</i>	
Gold Price: Trend-Cycle Analysis Using Fuzzy Techniques	254
<i>Linh Nguyen, Vilém Novák, and Michal Holčápek</i>	
On PSO-Based Approximation of Zadeh’s Extension Principle	267
<i>Jiří Kupka and Nicole Škorupová</i>	

On Uncertain Discontinuous Functions and Quasi-equilibrium in Some Economic Models	281
<i>Inese Bula</i>	
Nonlocal Laplace Operator in a Space with the Fuzzy Partition.	295
<i>Hana Zámečníková and Irina Perfilieva</i>	
A Comparison of Explanatory Measures in Abductive Inference	304
<i>Jian-Dong Huang, David H. Glass, and Mark McCartney</i>	
On Integral Transforms for Residuated Lattice-Valued Functions.	318
<i>Michal Holčápek and Věc Bui</i>	
Optimal Control Under Fuzzy Conditions for Dynamical Systems Associated with the Second Order Linear Differential Equations	332
<i>Svetlana Asmuss and Natalja Budkina</i>	
Statistical Image Processing and Analysis, with Applications in Neuroimaging	
High Dimensional Bayesian Regularization in Regressions Involving Symmetric Tensors	347
<i>Rajarshi Guhaniyogi</i>	
A Publicly Available, High Resolution, Unbiased CT Brain Template	358
<i>John Muschelli</i>	
Statistical Methods for Processing Neuroimaging Data from Two Different Sites with a Down Syndrome Population Application	367
<i>Davneet S. Minhas, Zixi Yang, John Muschelli, Charles M. Laymon, Joseph M. Mettenburg, Matthew D. Zammit, Sterling Johnson, Chester A. Mathis, Ann D. Cohen, Benjamin L. Handen, William E. Klunk, Ciprian M. Crainiceanu, Bradley T. Christian, and Dana L. Tudorascu</i>	
Bayesian Image Analysis in Fourier Space Using Data-Driven Priors (DD-BIFS)	380
<i>John Kornak, Ross Boylan, Karl Young, Amy Wolf, Yann Cobigo, and Howard Rosen</i>	
Covariate-Adjusted Hybrid Principal Components Analysis	391
<i>Aaron Wolfe Scheffler, Abigail Dickinson, Charlotte DiStefano, Shafali Jeste, and Damla Şentürk</i>	

Interval Uncertainty

On Statistics, Probability, and Entropy of Interval-Valued Datasets	407
<i>Chenyi Hu and Zhihui H. Hu</i>	
A Computational Study on the Entropy of Interval-Valued Datasets from the Stock Market.	422
<i>Chenyi Hu and Zhihui H. Hu</i>	
Tolerance and Control Solutions of Two-Sided Interval Linear System and Their Applications.	436
<i>Worrawate Leela-apiradee, Phantipa Thipwiwatpotjana, and Artur Gorka</i>	
Dealing with Inconsistent Measurements in Inverse Problems: An Approach Based on Sets and Intervals	449
<i>Krushna Shinde, Pierre Feissel, and Sébastien Destercke</i>	
Enhancing the Efficiency of the Interval-Valued Fuzzy Rule-Based Classifier with Tuning and Rule Selection	463
<i>José Antonio Sanz, Tiago da Cruz Asmus, Borja de la Osa, and Humberto Bustince</i>	
Robust Predictive-Reactive Scheduling: An Information-Based Decision Tree Model	479
<i>Tom Portoleau, Christian Artigues, and Romain Guillaume</i>	
Orders Preserving Convexity Under Intersections for Interval-Valued Fuzzy Sets	493
<i>Pedro Huidobro, Pedro Alonso, Vladimir Janiš, and Susana Montes</i>	

Discrete Models and Computational Intelligence

Improvements on the Convergence and Stability of Fuzzy Grey Cognitive Maps	509
<i>István Á. Harmati and László T. Kóczy</i>	
Group Definition Based on Flow in Community Detection.	524
<i>Maria Barroso, Inmaculada Gutiérrez, Daniel Gómez, Javier Castro, and Rosa Espínola</i>	
Fuzzy Temporal Graphs and Sequence Modelling in Scheduling Problem . . .	539
<i>Margarita Knyazeva, Alexander Bozhenyuk, and Uzay Kaymak</i>	

Current Techniques to Model, Process and Describe Time Series

Predicting S&P500 Monthly Direction with Informed Machine Learning	553
<i>David Romain Djoumbissie and Philippe Langlais</i>	
A Fuzzy Approach for Similarity Measurement in Time Series, Case Study for Stocks	567
<i>Soheyla Mirshahi and Vilém Novák</i>	
Fuzzy k-NN Based Classifiers for Time Series with Soft Labels	578
<i>Nicolas Wagner, Violaine Antoine, Jonas Koko, and Romain Lardy</i>	

Mathematical Fuzzy Logic and Graded Reasoning Models

Converting Possibilistic Networks by Using Uncertain Gates	593
<i>Guillaume Petiot</i>	
Depth-Bounded Approximations of Probability	607
<i>Paolo Baldi, Marcello D'Agostino, and Hykel Hosni</i>	
Unification in Łukasiewicz Logic with a Finite Number of Variables.	622
<i>Marco Abbadini, Federica Di Stefano, and Luca Spada</i>	
Two Dualities for Weakly Pseudo-complemented quasi-Kleene Algebras	634
<i>Umberto Riveccio, Ramon Jansana, and Thiago Nascimento</i>	
On the Logic of Left-Continuous t-Norms and Right-Continuous t-Conorms	654
<i>Luís Godo, Martín Sócola-Ramos, and Francesc Esteve</i>	
Automorphism Groups of Finite BL-Algebras.	666
<i>Stefano Aguzzoli and Brunella Gerla</i>	
Fuzzy Neighborhood Semantics for Multi-agent Probabilistic Reasoning in Games	680
<i>Martina Daňková and Libor Běhounek</i>	

Formal Concept Analysis, Rough Sets, General Operators and Related Topics

Towards a Logic-Based View of Some Approaches to Classification Tasks	697
<i>Didier Dubois and Henri Prade</i>	
Fuzzy Relational Mathematical Morphology: Erosion and Dilation	712
<i>Alexander Šostak, Ingrida Uljane, and Patrik Eklund</i>	

Isotone \mathcal{L} -Fuzzy Formal Concept Analysis and \mathcal{L} -Valued Fuzzy Measures and Integrals.	726
<i>Ondrej Křidlo</i>	
Galois Connections Between Unbalanced Structures in a Fuzzy Framework.	736
<i>Inma P. Cabrera, Pablo Cordero, Emilio Muñoz-Velasco, and Manuel Ojeda-Aciego</i>	
Impact of Local Congruences in Attribute Reduction.	748
<i>Roberto G. Aragón, Jesús Medina, and Eloísa Ramírez-Poussa</i>	
Towards a Classification of Rough Set Bireducts	759
<i>M. José Benítez-Caballero, Jesús Medina, and Eloísa Ramírez-Poussa</i>	
Computational Intelligence Methods in Information Modelling, Representation and Processing	
Fast Convergence of Competitive Spiking Neural Networks with Sample-Based Weight Initialization	773
<i>Paolo Gabriel Cachi, Sebastián Ventura, and Krzysztof Jozef Cios</i>	
Intelligent Detection of Information Outliers Using Linguistic Summaries with Non-monotonic Quantifiers	787
<i>Agnieszka Duraj, Piotr S. Szczepaniak, and Łukasz Chomatek</i>	
Network of Fuzzy Comparators for Ovulation Window Prediction.	800
<i>Łukasz Sosnowski, Iwona Szymusik, and Tomasz Penza</i>	
Contextualizing Naive Bayes Predictions	814
<i>Marcelo Loor and Guy De Tré</i>	
Author Index	829