# Studies in Computational Intelligence

Volume 794

**Series editor**

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

The series "Studies in Computational Intelligence" (SCI) publishes new developments and advances in the various areas of computational intelligence—quickly and with a high quality. The intent is to cover the theory, applications, and design methods of computational intelligence, as embedded in the fields of engineering, computer science, physics and life sciences, as well as the methodologies behind them. The series contains monographs, lecture notes and edited volumes in computational intelligence spanning the areas of neural networks, connectionist systems, genetic algorithms, evolutionary computation, artificial intelligence, cellular automata, self-organizing systems, soft computing, fuzzy systems, and hybrid intelligent systems. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output.

More information about this series at http://www.springer.com/series/7092

László T. Kóczy · Jesús Medina-Moreno
Eloísa Ramírez-Poussa
Editors

# Interactions Between Computational Intelligence and Mathematics Part 2

Springer

*Editors*
László T. Kóczy
Department of Information Technology
Széchenyi István University
Győr, Hungary

and

Budapest University of Technology
and Economics
Budapest, Hungary

Jesús Medina-Moreno
Department of Mathematics,
Faculty of Science
University of Cádiz
Cádiz, Spain

Eloísa Ramírez-Poussa
Department of Mathematics,
Faculty of Economic and
Business Sciences
University of Cádiz
Cádiz, Spain

ISSN 1860-949X ISSN 1860-9503 (electronic)
Studies in Computational Intelligence
ISBN 978-3-030-01631-9 ISBN 978-3-030-01632-6 (eBook)
https://doi.org/10.1007/978-3-030-01632-6

Library of Congress Control Number: 2018930367

© Springer Nature Switzerland AG 2019
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

The latest technological advances in handling very complex problems make necessary the combination of mathematical techniques with computational intelligence tools in order to solve these various problems emerging in many different areas. Indeed, important funding programs are devoted to the development of new instruments to deal with the challenges that we face in the current technological age. Without doubt, research topics associated with the interaction between computational intelligence and mathematics play a key role at presence. In this special issue, engineers, scientists, and mathematicians provide appealing contributions focused on the solution of meaningful and realistic problems, which connect those two research areas. This contributed volume presents a series of novel solutions for such problems.

Chapter "On the Incorporation of Interval-Valued Fuzzy Sets into the Bousi-Prolog System: Declarative Semantics, Implementation and Applications" by Clemente Rubio-Manzano and Martín Pereira-Fariña is focused on the design and the implementation of an interval-valued fuzzy (IVF) logic language and its incorporation into the Bousi-Prolog system. First of all, a detailed study on the syntax and the semantics corresponding to the IVF logic language is presented. The formalization of the notion of least IVF Herbrand model for IVF programs plays a key role in this research. From the implementation point of view, the main challenge is now to add an IVFSs' arithmetic to the Warren Abstract Machine based on similarity. By means of potential applications, the authors show that the IVF logic programming language thus developed is very useful in modeling the uncertainty and imprecision of the knowledge related to lexical resources.

Chapter "The Existence of Generalized Inverses of Fuzzy Matrices" by Miroslav Ćirić and Jelena Ignjatović provides a novel approach for testing the existence of different generalized inverses of fuzzy matrices whose entries belong to a complete residuated lattice. An iterative method to compute these greatest generalized inverses is also proposed. In particular, this iteration ends in a finite number of steps when the considered fuzzy matrices have their entries in a Heyting algebra. Moreover, the problem of representing generalized inverses as a solution for linear equation systems is discussed.

Chapter "Gender Detection of Twitter Users Based on Multiple Information Sources" by Marco Vicente, Fernando Batista, and Joao P. Carvalho presents a mechanism based on the combination of four different classifiers for the gender detection of Twitter users. Each of these classifiers has been trained, under a supervised approach, in order to analyze the most influential features in the gender detection problem: user name, screen name, user description, content of the tweets, and the profile picture. A final classifier, combining the results obtained from the previous classifiers, gives a prediction about the user gender. The experiments carried out in this paper have considered two different datasets in regard to the nationality. According to the high percentage of accuracy, the authors conclude that the proposed mechanism for gender detection works efficiently.

Chapter "On the *n*-ary Generalization of Dual Bonds" by Ondrej Krídlo and Manuel Ojeda-Aciego deals with the problem of obtaining logical consequences from the underlying information given as a set of tables. Specifically, this problem is transferred to the extraction of logical consequences from a set of formal contexts. The bonds and the Chu correspondences are two important constructions that allow relating two formal contexts. In this contribution, the authors introduce the notion of *n*-ary dual bond as a generalization of the bond between two formal contexts to the case of *n* formal contexts. Furthermore, some properties of these new type bonds are presented, together with a process for generating *n*-ary bonds.

Chapter "Brouwer's Ideas and Intuitionistic Fuzziness" by Krassimir Atanassov presents an interesting discussion about Luitzen Egbertus Jan Brouwer's ideas, one of the most relevant mathematicians of the twentieth century, from the intuitionistic fuzzy point of view. Intuitionistic fuzzy sets are one of the most interesting extensions of fuzzy sets given by Atanassov in 1983. In this study, the author shows that intuitionistic fuzziness corresponds to Brouwer's idea that the law of excluded middle is not valid. In addition, the paper presents the application of Brouwer's fixed-point theorem for the intuitionistic fuzzy quantifiers and operators from modal and level types.

Chapter "Nature Inspired Clustering – Use Cases of Krill Herd Algorithm and Flower Pollination Algorithm" by Piotr A. Kowalski, Szymon Łukasik, Małgorzata Charytanowicz, and Piotr Kulczycki studies the resolution of the data clustering problem applying two different metaheuristic techniques such as the Krill Herd Algorithm (KHA) and the Flower Pollination Algorithm (FPA). The investigation is formalized by means of an optimization task with a set of cluster centers representing a single solution. Considering datasets extracted from the UCI Machine Learning Repository, computational experiments are carried out in order to analyze the effectiveness of the proposed algorithms. Finally, the authors evaluate and compare the quality of the obtained results by using the Rand index value. As the result of this wide investigation, they conclude that both KHA and FPA can be considered suitable tools to carry out clustering.

Chapter "On the Lower Limit for Possibilistic Correlation Coefficient with Identical Marginal Possibility Distributions" by István Á. Harmati and Robert Fullér studies the possibilistic correlation *coefficient* within possibility theory. The authors have considered the works given by Fullér et al. in which two

questions, about a new measure on interactivity between fuzzy numbers, called the "weighted possibilistic correlation coefficient," were left unanswered. This paper proves that when the marginal possibility distributions have equal, strictly increasing or strictly decreasing membership functions, the lower limit of the possibilistic correlation coefficient is −1. In addition, they also present an extension of these results to the general case for fuzzy and quasi-fuzzy numbers. It is important to highlight that the results presented in this work can be very useful in time-series models and fuzzy statistics.

Chapter "A Generalized Net Model for the Coordination and Synchronization of Human and Computer-Based Expert Type Decision Support Activities" by Evdokia Sotirova, Janusz Kacprzyk, Krassimir Atanassov, and Eulalia Szmidt is framed in the area of decision making. In this work, the authors introduce a new approach for modeling and supporting a special class of multi-agent decision making. The generalized net model of a decision-making process involves the human agents (experts), some decision-making tools, and techniques exemplified by algorithms, procedures, decision support systems, and expert systems. Therefore, they prove that the use of the tools and techniques of the generalized nets can organize, coordinate, and synchronize both the work of experts and decision-making tools in order to obtain results in the most adequate, effective, and efficient way.

Chapter "Wavelet Analysis and Structural Entropy Based Intelligent Classification Method for Combustion Engine Cylinder Surfaces" by Szilvia Nagy and Levente Solecki develops an intelligent fuzzy classification method, based on *structural entropy* and *wavelet analysis*, for characterizing combustion engine cylinder surfaces. From scanned images of the surfaces, the proposed method is capable of identifying whether a surface is either worn or new and if such surface can be helpful to establish the grade of wear. Specifically, structural entropies are used to determine the general slope of the shape of the surface. Concerning the wavelet analysis, this technique is employed to separate the scale behavior patterns of the surfaces. The authors conclude that the developed method can distinguish, with a good accuracy, both a worn surface scanned by a contact stylus and a new surface scanned by an optical scanner on a silicone replica.

We wish to thank the authors for their excellent and inspiring contributions and anonymous peer reviewers whose insight and suggestions have helped a lot to improve the contributions. And last but not least, we wish to thank Dr. Tom Ditzinger, Dr. Leontina di Cecco, and Mr. Holger Schaepe for their dedication and help to implement and finish this large and ambitious publication project.

Győr/Budapest, Hungary — László T. Kóczy
Cádiz, Spain — Jesús Medina-Moreno
Cádiz, Spain — Eloísa Ramírez-Poussa

# Contents

**On the Incorporation of Interval-Valued Fuzzy Sets into the Bousi-Prolog System: Declarative Semantics, Implementation and Applications** . . . . . 1
Clemente Rubio-Manzano and Martín Pereira-Fariña

**The Existence of Generalized Inverses of Fuzzy Matrices** . . . . . 19
Miroslav Ćirić and Jelena Ignjatović

**Gender Detection of Twitter Users Based on Multiple Information Sources** . . . . . 39
Marco Vicente, Fernando Batista and Joao P. Carvalho

**On the *n*-ary Generalization of Dual Bonds** . . . . . 55
Ondrej Krídlo and Manuel Ojeda-Aciego

**Brouwer's Ideas and Intuitionistic Fuzziness** . . . . . 65
Krassimir Atanassov

**Nature Inspired Clustering – Use Cases of Krill Herd Algorithm and Flower Pollination Algorithm** . . . . . 83
Piotr A. Kowalski, Szymon Łukasik, Małgorzata Charytanowicz and Piotr Kulczycki

**On the Lower Limit for Possibilistic Correlation Coefficient with Identical Marginal Possibility Distributions** . . . . . 99
István Á. Harmati and Robert Fullér

**A Generalized Net Model for the Coordination and Synchronization of Human and Computer-Based Expert Type Decision Support Activities** . . . . . 115
Evdokia Sotirova, Janusz Kacprzyk, Krassimir Atanassov and Eulalia Szmidt

**Wavelet Analysis and Structural Entropy Based Intelligent Classification Method for Combustion Engine Cylinder Surfaces** . . . . . 127
Szilvia Nagy and Levente Solecki