

Studies in Computational Intelligence

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Computational Intelligence Methodologies Applied to Sustainable Development Goals

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*This book is dedicated to all those colleagues
who wanted to contribute to it but were
unable to do so because of COVID-19.*

Preface

A few years ago, as one more stage in the close collaboration between the Group of Intelligent Computing of the University of La Laguna (Spain) and the Models of Decision and Optimization (MODO) Research Group of the University of Granada (Spain), both the teams agreed to constitute the Decision, Optimization and Sustainable Intelligent Systems (DOSIS) Working Group. Among the members of DOSIS are some of the authors in this book as well as all its three editors and, as it may be quite obvious, one of its main research lines is that one relative to the interface area between artificial intelligence (AI) and sustainable development goals (SDGs). The high interest for researching in that interface area is evident. There is no doubt that two of the leading issues that concern all of humanity today are those related to sustainable development and intelligent systems.

Every day new sectors appear in which the methodologies and techniques of AI are applied successfully, hoping that in the short term, they will affect the productive sector as a whole, equality and inclusion, environmental responsibility and many other areas. There are already studies that report the specific impacts produced by the application of AI in sustainable development. These impacts are generally positive, but there are also negative ones in some cases. However, to the best of our knowledge, there is no international referenced study that rigorously reports the extent to which AI could affect all aspects of sustainable development.

Thus arises a field of research and study, as pertinent as it is timely and critical, which focuses on analyzing how AI can influence the ability to comply in a timely manner with all the SDGs.

SDGs are a call for action by all countries to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, social protection and job opportunities, while tackling climate change and environmental protection. More important than ever, the goals provide a critical framework for COVID-19 recovery. As a whole, the SDGs are vital for a recovery that leads to a greener, more inclusive economies and more robust and resilient societies (<https://www.un.org/sustainabledevelopment/>).

On the other hand, although AI is umbrella for large variety of methodologies and techniques, it is patent that some of the current most successful AI systems are based on computational intelligence (CI). CI is the theory, design, application and development of biologically and linguistically motivated computational paradigms. Traditionally, the three main pillars of CI have been neural networks, fuzzy systems and evolutionary computation. However, in time, many nature-inspired computing paradigms have evolved. Thus, CI is an evolving field, and at present in addition to the three main constituents, it encompasses computing paradigms like ambient intelligence, artificial life, cultural learning, artificial endocrine networks, social reasoning and artificial hormone networks. CI plays a major role in developing successful intelligent systems, including games and cognitive developmental systems (<https://cis.ieee.org/about/what-is-ci>).

Encouraged by knowing potential applications of CI in the achievement of the 17 objectives and 169 goals recognized in the 2030 Agenda for Sustainable Development, in this book, we collect 18 contributions that are adjusted to that end. These are classified into four parts (a first cross-sectional and three more oriented to specific areas) that focus models on: CI and SDGs, health control, emissions control and transportation and distribution. As a whole, the 18 contributions approach problems from the three main areas of sustainable development: society, economy and environment, and they are authored by recognized scholars from 13 countries: Algeria, Brazil, Chile, Colombia, Cuba, Czechia, India, Iran, Mexico, Morocco, Poland, Spain and USA.

The first part opens with a paper by O. Castillo and P. Melin (from Mexico): “[A Review on the Role of Computational Intelligence on Sustainability Development](#),” in which an overview of the existing publications using CI techniques in applications to sustainability development is presented. Authors provide the up-to-date relevant statistics and analysis of the existing work in this area. In addition, they outline future possible trends for research on applying intelligent systems to problems in sustainability development. Then J. Kacprzyk, J. W. Owsinski, E. Szmidi and S. Zadrozny (from Poland) present the work entitled “[Fuzzy Linguistic Summaries for Human Centric Analyses of Sustainable Development Goals \(SDG\) Related to Technological Innovations](#).” Authors propose to use fuzzy logic-based linguistic data summaries for the assessment and evaluation of both the essence of SDGs and their fulfillment, as such a form is very human consistent because it uses natural language that is the only fully natural means of articulation and communication for the humans. The third contribution in this section is “[Impact of Human-Computer Interaction in the Global Sustainable Development Goals](#)” by J. Muñoz-Arteaga, H. Luna-García, C. Collazos and A. Granollers (from Colombia and Spain). The paper shows as the research area of human–computer interaction (HCI) plays a key role into the design and development of software applications and practices aimed to achieve the SDGs.

The second part is dedicated to the health control models and includes five chapters. In the first, “[Investigating the Key Parameters Affecting Sustainable IoT-based Marketing](#),” S. E. Najafi, H. Nozari and S. A. Edalatpanah (from Iran) show as perceived usefulness, ease of use, trust, social acceptance, enjoyment of use and

controllability have been identified as effective variables on the use of Internet of things (IoT) in sustainable smart marketing. Then these key indicators are reviewed and prioritized, and a framework for expressing the positions of the impact of the IoT on sustainable marketing is presented. In the following chapter, R. Bello, M. M. García, Y. Caballero, A. Rosete and Y. Rodríguez (from Cuba), titled “[Applications of Computational Intelligence in the Studies of COVID-19](#),” analyze how CI techniques have allowed developing different studies about COVID-19, creating several prediction models and formulating new knowledge about it. In “[Quantification of African Swine Fever \(ASF\) Introduction Risk Using OWA Operators](#),” E. H. Cables, F. Moreno, M. T. Lamata and F. Gómez (from Colombia and Spain) introduce a novel methodology to quantify risk factors related to ASF introduction using expert knowledge. The methodology is based on operator weight average, in which weights are determined by using linguistic labels and a consensus mechanism.

The fourth chapter in this second part, by J. C. Figueroa–García, C. Franco and R. Neruda (from Colombia and Czechia), is entitled “[An Optimization Model for Location-Allocation of Health Services Under Uncertainty](#),” and it considers the existence of fuzzy uncertainty in an optimization model for allocation of healthcare facilities to serve patients with different needs. The last chapter in this part is “[Computational Intelligence and Tikhonov Regularization with Reduced Dimension Model: Applications in Health, Renewable Energy and Climate Heat Transfer Inverse Problems](#)” by L. Correia da Silva Jardim, D. Campos Knupp, T. M. de Souza Monteiro de Barros, L. A. da Silva Abreu, C. Cruz-Corona and A. J. Silva Neto (from Brazil). Authors present a method to predict the optimal value of the Tikhonov’s regularization parameter by solving simplified versions of the inverse problems considered. The results obtained demonstrate the feasibility of the technique in three problems with potential practical applications in bioengineering, renewable energy and climate.

The third part, which deals with emissions control models, includes five chapters. Along the first one, “[Intelligent Collaborative Freight Distribution to Reduce Greenhouse Gas Emissions: A Review](#),” C. Expósito-Izquierdo, A. Expósito-Márquez, B. Melián-Batista, J. A. Moreno-Pérez and J. M. Moreno-Vega (from Spain) review optimization models for horizontal collaborative freight transport that include environmental and economic criteria. Specifically, they consider models for planning delivery routes and for cross-docking. The next chapter, “[Pressure Sensor Placement for Leak Location in Zones of a Water Distribution Network](#),” is authored by M. J. Ares-Milián, M. Quiñones-Grueiro, C. Verde, and O. Llanes-Santiago (from Cuba). Authors present a novel sensor placement approach for leak location in large-scale water distribution networks (WDN), and the satisfactory performance of the proposal is demonstrated under uncertain conditions and measurement noise even when the sensitivity of the sensors is limited. The third contribution in this part, by M. L. S. Araujo, Y. K. L. Kitagawa, D. M. Moreira and E. G. Sperandio Nascimento (from Brazil), is entitled “[Forecasting Tropospheric Ozone Using Neural Networks and Wavelets: Case Study of a Tropical Coastal-Urban Area](#).” Authors present a study realized by using data from a tropical coast-urban site in Southeast Brazil, highly influenced by intense convective weather with complex terrain, and short-term forecasting of hourly ground-level ozone is performed using long short-term

memory, a type of recurrent neural network, with the discrete wavelet transform. R. Coelho (from Brazil) authored the fourth work “[Power Curve Estimation of Wind Farms with Imprecise Data by Fuzzy Quadratic Programming](#)” where a parametric approach that solves quadratic programming problems under different kind of uncertainties in its data is shown. In order to demonstrate the efficiency of the approach, a fuzzy regression analysis problem is used. To close the part, the effect of the growth of carbon emissions in the function of GDP per capita, in countries of America and Europe, its behavior and the results they generate with regards to the SDG 8 and 13 are analyzed by A. Quintero, M. Gaitán-Angulo, M. I. Gómez-Caicedo, A. L. Mercado Suárez and R. E. Reyes-Gil (from Colombia) in “[Effect of the Growth of Carbon Emissions as a Function of GDP per Capita and Its Relationship with the SDG in American and European Countries: An Application of Neural Networks.](#)”

Finally, the fourth part collects five papers on transportation and distribution models. In the first chapter, “[A Fuzzy Approach for Organizational Transportation Aligned with the Sustainable Development Goals: Health Promotion, Inequality Reduction, and Responsible Consumption,](#)” E. Sánchez-Ansola, A. C. Pérez-Pérez and A. Rosete (from Cuba) introduce a new model for the School Bus Routing Problem (SBRP) that have a direct impact on three of the 3rd, 10th and 12th SDGs. The proposed model focuses on fuzzy modeling of maximum students’ walking distance and bus capacity restrictions. The following chapter, by J. Ruiz-Meza, J. Brito and J. R. Montoya-Torres (from Spain and Colombia), is titled “[A VND to Solve the Bi-objective Tourist Trip Design Problem, Including Reducing CO₂ with Fuzzy Constraints.](#)” Authors propose solving a bi-objective problem of planning tourist routes for multiple days, selecting the transport mode and multiple fuzzy constraints. To find the optimal planning they use two criteria: obtaining the most excellent satisfaction or benefit for the tourist and reducing CO₂ emissions. The third contribution in the section, “[Time Variant Multi-objective Multi-item Solid Transportation Problem in Sustainable Development in Terms of Interval Valued Fuzzy Numbers,](#)” by T. Sifaoui and M. Aïder (from Algeria) presents a new procedure for converting the problem in the title to a deterministic form, and then, a hybrid method expressed with different membership function is used to solve the converted transport problem. H. El Raoui, D. Pelta, A. Rufián-Lizana, M. Oudani and A. El Hilali Alaoui (from Morocco and Spain) are the authors of “[On the Generation of Alternative Solutions for a Perishable Food Distribution Problem.](#)” The work outlines the application of a modelling to generate alternatives approach that can generate a set of near optimal solutions, but maximally different from the best one, which is applied to solve a perishable food distribution problem by using as intermediate a general variable neighborhood search algorithm. Finally, the contribution by G. Maity and S. Kumar-Roy (from India) entitled “[Solving Two-Stage Multi-objective Transportation Problem Using Goal Programming and Its Application to Sustainable Development](#)” closes the last part to finish the book. Authors focus on a two-stage Multi-Objective Transportation Problem (MOTP) and solve it through goal programming. Considering goals corresponding to the objective functions of both stages, they solve two-stage MOTP and then derive Pareto optimal solution. Finally, a numerical

example based on real scenario is presented to show the effectiveness of the study in sustainable development.

The variety and diversity of contributions collected in this book give a very good idea of the potential that CI has to contribute to the solution of the SDGs. But it is very important to emphasize that due to the inter and multi-disciplinary nature of the scientific, technological and social fields covered by the 2030 Agenda for Sustainable Development, this volume, and that is the main aim of the editors, want to be a sample, surely very limited, of the enormous work that lies ahead.

To finish, the editors want to state that there have been several authors who for different reasons but in all cases related to the COVID-19 have not finally been able to send their contributions to this book on time. We want to express our gratitude to all of them because we know the efforts they have made to participate in this editorial project. Finally, we also want to express that we are indebted to Prof. Janusz Kacprzyk, who since we presented our editorial idea to him has not stopped encouraging us to carry it out. To conclude, editors acknowledge the financial support provided by the projects PID2020-112754 GB-I00 (Spanish Ministry of Economy and Competitiveness and FEDER funds from the European Union) and B-TIC-640-UGR20 (Regional Govern of Andalusia).

Granada, Spain
Granada, Spain
San Cristóbal de La Laguna, Spain

José Luis Verdegay
Carlos Cruz
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