

Founding Editors

Gerhard Goos

Karlsruhe Institute of Technology, Karlsruhe, Germany

Juris Hartmanis

Cornell University, Ithaca, NY, USA

Editorial Board Members

Elisa Bertino

Purdue University, West Lafayette, IN, USA

Wen Gao

Peking University, Beijing, China

Bernhard Steffen 

TU Dortmund University, Dortmund, Germany

Gerhard Woeginger 

RWTH Aachen, Aachen, Germany

Moti Yung

Columbia University, New York, NY, USA

More information about this subseries at <http://www.springer.com/series/7412>

Yanio Hernández Heredia ·
Vladimir Milián Núñez ·
José Ruiz Shulcloper (Eds.)

Progress in Artificial Intelligence and Pattern Recognition

7th International Workshop
on Artificial Intelligence and Pattern Recognition, IWAIPR 2021
Havana, Cuba, October 5–7, 2021
Proceedings

Editors

Yanio Hernández Heredia 
Universidad de las Ciencias Informáticas
La Habana, Cuba

Vladimir Milián Núñez 
Universidad de las Ciencias Informáticas
La Habana, Cuba

José Ruiz Shulcloper
Universidad de las Ciencias Informáticas
La Habana, Cuba

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-030-89690-4 ISBN 978-3-030-89691-1 (eBook)
<https://doi.org/10.1007/978-3-030-89691-1>

LNCS Sublibrary: SL6 – Image Processing, Computer Vision, Pattern Recognition, and Graphics

© Springer Nature Switzerland AG 2021

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, expressed 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 7th International Workshop on Artificial Intelligence and Pattern Recognition (IWAIPR 2021) was the latest edition in a series of biennial conferences aimed at serving the scientific community active in these fields in Cuba and other countries. Due to the COVID-19 pandemic it was necessary to postpone the conference for a year and in this edition, for the same reason, the Organizing Committee decided on a virtual modality.

As has been the case for previous editions of the conference, IWAIPR 2021 hosted worldwide participants with the aim of promoting and disseminating ongoing research on mathematical methods and computing techniques for Artificial Intelligence and Pattern Recognition, and in particular for bioinformatics, cognitive and humanoid vision, computer vision, image analysis and intelligent data analysis, as well as their application in a number of diverse areas such as industry, health, robotics, data mining, opinion mining and sentiment analysis, telecommunications, document analysis, and natural language processing and recognition. Moreover, IWAIPR 2021 was a forum for the scientific community to exchange research experience, to share new knowledge, and to increase the cooperation among research groups working in artificial intelligence, pattern recognition and related areas.

IWAIPR 2021 received 73 contributions from authors in (15) countries. After a rigorous double-blind reviewing process, where three highly qualified reviewers reviewed each submission, 42 papers authored by 147 authors from (11) countries were accepted. The scientific quality of the accepted papers was above the overall mean rating.

Like the most recent editions of the conference, IWAIPR 2021 was a single-track conference in which all papers were presented in oral sessions. IWAIPR 2021 presentations were grouped into four sessions: Artificial Intelligence, Data Mining and Applications; Pattern Recognition and Applications; Biometrics, Image, and Video Analysis; and Signals Analysis and Processing.

We would like to point out that the reputation of the IWAIPR conferences is growing and therefore the proceedings are published, as in the case of IWAIPR 2018, in the series Lecture Notes in Computer Science by Springer.

Besides the 42 accepted submissions, the scientific program of IWAIPR 2021 also included the conference “End-to-end Document Analysis: From Unreadable Data to Operable Information” of an outstanding invited speaker, Professor Apostolos Antonacopoulos (University of Salford, UK), who is the Past President of the International Association for Pattern Recognition.

IWAIPR 2021 was endorsed by the International Association for Pattern Recognition (IAPR) and therefore the conference conferred the IAPR-IWAIPR Best Paper Award. The aim of this award is to acknowledge and encourage excellence, originality, and innovation in new models, methods, and techniques with an outstanding theoretical

contribution and practical application to the field of artificial intelligence, pattern recognition, and/or data mining.

The selection of the winners is based on the wish of the author to be considered for the prize, the evaluation and recommendations from members of the Program Committee, and the evaluation of the Award Committee. This committee, carefully chosen to avoid conflicts of interest, evaluate each nominated paper for the Best Paper.

We want to express our gratitude to the prestigious experts Heydi Mendez-Vazquez, Research Director from the CENATAV, DATYS, Cuba; Walter Kropatsch from the Vienna University of Technology, Austria, and Gregory Randall, from the Institute of Electrical Engineering, University of the Republic of Uruguay.

IWAIPR 2021 was organized by Universidad de las Ciencias Informáticas, Cuba (UCI) and the Cuban Association for Pattern Recognition (ACRP) with the sponsorship of the Cuban Society for Mathematics and Computer Sciences (SCMC). We acknowledge and appreciate their valuable contribution to the success of IWAIPR 2021.

We gratefully acknowledge the help of all members of the Organizing Committee and of the Program Committee for their support and for the rigorous work in the reviewing process.

We also wish to thank the members of the local committee for their unflagging work in the organization of IWAIPR 2021 that helped create an excellent conference and proceedings.

We are especially grateful to Alfred Hofmann (Vice President Publishing, Computer Science, Springer), Anna Kramer (Assistant Editor, Computer Science, Springer), and Volha Shaparava (Springer Nature OCS Support) for their support and advice during the preparation of this LNCS volume.

Special thanks are due to all authors who submitted their work to IWAIPR 2021, including those of papers that could not be accepted.

Finally, we invite the artificial intelligence and pattern recognition communities to attend IWAIPR 2023 in Havana, Cuba.

October 2021

Yanio Hernández Heredia
Vladimir Milián Núñez
Jose Ruiz Shulcloper

Organization

Program Chairs

Yanio Hernández Heredia	Universidad de las Ciencias Informáticas, Cuba
Vladimir Milián Núñez	Universidad de las Ciencias Informáticas, Cuba
Jose Ruiz Shulcloper	Universidad de las Ciencias Informáticas, Cuba

Local Organizing Committee

Nadiela Milan Cristo	Universidad de las Ciencias Informáticas, Cuba
Beatriz Aragón Fernández	Universidad de las Ciencias Informáticas, Cuba
José Eladio Medina Pagola	Universidad de las Ciencias Informáticas, Cuba
Héctor Raúl González Díez	Universidad de las Ciencias Informáticas, Cuba

IAPR-IWAIPR Best Paper Award Committee

Heydi Mendez-Vazquez	CENATAV, Cuba
Walter Kropatsch	Vienna University of Technology, Austria
Gregory Randall	University of the Republic, Uruguay

Program Committee

Sergey Ablameyko	Belarusian State University, Belarus
Yudivián Almeida	Universidad de La Habana, Cuba
Rene Alquezar	UPC, Spain
Leopoldo Altamirano	INAOE, Mexico
Mauricio Araya	UTFSM, Chile
G. Arroyo-Figueroa	Instituto Nacional de Electricidad y Energías Limpias, Mexico
Rafael Berlanga	Universitat Jaume I, Spain
Ana Bernardos	Universidad Politécnica de Madrid, Spain
Ramon Brena	Tecnologico de Monterrey, Mexico
Maria Elena Buemi	Universidad de Buenos Aires, Argentina
Lázaro Bustio-Martínez	Universidad Iberoamericana, Mexico
Hiram Calvo	Instituto Politécnico Nacional, Mexico
José Ramón Calvo de Lara	CENATAV, Cuba
Sergio Daniel Cano-Ortiz	Universidad de Oriente, Cuba
Jesús Ariel Carrasco-Ochoa	INAOE, Mexico
César Castellanos	Universidad Nacional de Colombia, Colombia
Eduardo R. Concepcion-Morales	Universidad de Cienfuegos, Cuba
Raúl Cruz-Barbosa	Universidad Tecnológica de la Mixteca, Mexico

Claudio De Stefano	Università degli Studi di Cassino e del Lazio Meridionale, Italy
Shridhar Devamane	KLE Institute of Technology, India
Alfonso Estudillo-Romero	Université de Rennes 1, France
Jacques Facon	Universidade Federal do Espírito Santo, Brazil
Gustavo Fernandez Dominguez	AIT Austrian Institute of Technology, Austria
Carlos Ferrer	Universidad Central “Marta Abreu” de Las Villas, Cuba
Yaima Filiberto	Universidad de Camagüey, Cuba
Giorgio Fumera	University of Cagliari, Italy
Edel Garcia Reyes	CENATAV, Cuba
Milton García-Borroto	Universidad Tecnológica de La Habana, Cuba
Eduardo Garea Llano	Centro de Neurociencias de Cuba, Cuba
Alexander Gelbukh	Instituto Politécnico Nacional, Mexico
Luis Gomez Deniz	CTIM, Spain
Hector Raul Gonzalez Diez	Universidad de las Ciencias Informáticas, Cuba
Rocio Gonzalez-Diaz	University of Seville, Spain
Antoni Grau	Technical University of Catalonia, Spain
Laurent Heutte	Université de Rouen, France
Yanio Hernandez	Universidad de las Ciencias Informáticas, Cuba
Javier Hernandez-Ortega	Universidad Autonoma de Madrid, Spain
Xiaoyi Jiang	University of Münster, Germany
Vitaly Kober	CICESE, Mexico
Martin Kampel	Vienna University of Technology, Austria
Tomas Krajník	Czech Technical University, Czech Republic
Walter Kropatsch	TU Wien, Austria
Manuel S. Lazo-Cortés	TecNM/Instituto Tecnológico de Tlalnepantla, Mexico
Marcos Levano	Catholic University of Temuco, Chile
Aurelio Lopez-Lopez	INAOE, Mexico
Juan Valentín Lorenzo-Ginori	Universidad Central “Marta Abreu” de Las Villas, Cuba
Daniela López De Luise	CI2S Labs, Argentina
Julio Madera	University of Camagüey, Cuba
Francesco Marra	University Federico II of Naples, Italy
Cristian Martinez	UNSa, Argentina
Jose Francisco Martinez-Trinidad	Instituto Nacional de Astrofísica Óptica y Electrónica, Mexico
José Eladio Medina Pagola	Universidad de las Ciencias Informáticas, Cuba
Heydi Mendez-Vazquez	CENATAV, Cuba
Ana Maria Mendonça	University of Porto, Portugal
Marcelo Mendoza	Universidad Técnica Federico Santa María, Chile
Vladimir Milián Núñez	Universidad de las Ciencias Informáticas, Cuba
Miguel Moctezuma-Flores	UNAM, Mexico
Eduardo Morales	INAOE, Mexico
Carlos Morell	UCLV, Cuba

Alexandra Moutinho	Instituto Superior Tecnico, Portugal
Alfredo Muñoz-Briseño	CENATAV, Cuba
João Neves	IT - Instituto de Telecomunicações, Portugal
Lawrence O’Gorman	Bell Labs, USA
Martha R. Ortiz-Posadas	Universidad Autónoma Metropolitana Iztapalapa, Mexico
Kalman Palagyi	University of Szeged, Hungary
Joao Papa	São Paulo State University, Brazil
Glauco Vitor Pedrosa	University of Brasilia, Brazil
Billy Peralta	Universidad Andres Bello, Chile
Marieta Peña Abreu	Universidad de las Ciencias Informáticas, Cuba
Ignacio Ponzoni	Universidad Nacional del Sur, Argentina
Oswaldo Andrés Pérez García	CITMATEL, Cuba
Adrián Pérez-Suay	Universitat de València, Spain
Gregory Randall	Universidad de la República, Uruguay
Pedro Real	Univesity of Seville, Spain
Yunia Reyes González	Universidad de las Ciencias Informáticas, Cuba
Carlos A. Reyes-García	INAOE, Mexico
Dayana Ribas	University of Zaragoza, Spain
Edgar Roman-Rangel	ITAM, Mexico
Alejandro Rosete	CUJAE, Cuba
Jose Ruiz Shulcloper	Universidad de las Ciencias Informáticas, Cuba
Cesar San Martin	Universidad de La Frontera, Chile
Guillermo Sanchez-Diaz	Universidad Autónoma de San Luis Potosí, Mexico
Carlo Sansone	University of Naples Federico II, Italy
Alfredo Simón-Cuevas	Universidad Tecnológica de La Habana José Antonio Echeverría, Cuba
Juan Humberto Sossa Azuela	Instituto Politécnico Nacional, Mexico
Antonio-José Sánchez-Salmerón	Universitat Politècnica de València, Spain
Alberto Taboada-Crispi	UCLV, Cuba
Sergio A. Velastin	Queen Mary University of London, UK
Vera Yashina	Federal Research Center “Computer Science and Control” of the Russian Academy of Sciences, Russia

Additional Reviewers

Pablo Layana Castro	Universitat Politecnica de Valencia, Spain
Yanir Díaz	INAOE, Mexico
Antonio García Garvía	UPV, Spain
Leonardo Barboni	Universidad de la República, Uruguay

Contents

Artificial Intelligence, Data Mining and Applications

Layer-Wise Relevance Propagation in Multi-label Neural Networks to Identify COVID-19 Associated Coinfections.	3
<i>Marilyn Bello, Yaumara Aguilera, Gonzalo Nápoles, María M. García, Rafael Bello, and Koen Vanhoof</i>	
A Machine Learning Based Approach for Estimation of the Lung Affection Degree in CXR Images of COVID-19 Patients.	13
<i>Eduardo Gareca-Llano, Hector A. Castellanos-Loaces, Eduardo Martinez-Montes, and Evelio Gonzalez-Dalmau</i>	
Deep Neural Network to Detect Gender Violence on Mexican Tweets.	24
<i>Grisel Miranda, Roberto Alejo, Carlos Castorena, Eréndira Rendón, Javier Illescas, and Vicente García</i>	
Consumer Price Index Forecasting Based on Univariate Time Series and a Deep Neural Network.	33
<i>Reynaldo Rosado, Aldis Joan Abreu, José C. Arencibia, Hector Gonzalez, and Yanio Hernandez</i>	
Application of a Generalized Regression Neural Network to the Estimation of Average Gait Speed.	43
<i>Elías O. García Alvaredo, Gianna Arencibia Castellanos, Fidel E. Hernández Montero, and Tania Y. Aznielle Rodríguez</i>	
Gait Speed Estimation Based on Artificial Neural Network: Comparison with the Application of the Inverted Pendulum Model.	52
<i>Gianna Arencibia Castellanos, Fidel E. Hernández Montero, and Tania Y. Aznielle Rodríguez</i>	
Scalable Generalized Multitarget Linear Regression With Output Dependence Estimation.	60
<i>Julio Camejo Corona, Hector Gonzalez, and Carlos Morell</i>	
Covariance Matrix Adaptation Evolution Strategy for Convolutional Neural Network in Text Classification.	69
<i>Orlando Grabiél Toledano-López, Julio Madera, Héctor González, and Alfredo Simón Cuevas</i>	

A Novel Approach for Detection and Location of Cyber-Attacks in Water Distribution Networks	79
<i>Claudia Rodríguez Martínez, Marcos Quiñones-Grueiro, Cristina Verde, and Orestes Llanes-Santiago</i>	
Identification of Non-linear Chemical Systems with Neural Networks	91
<i>Reynold Alejandro Oramas Rodríguez, Ana Isabel González Santos, and Laura García González</i>	
Convolutional Neural Networks as Support Tools for Spinocerebellar Ataxia Detection from Magnetic Resonances	103
<i>Robin Cabeza-Ruiz, Luis Velázquez-Pérez, and Roberto Pérez-Rodríguez</i>	
A Hybrid Brain-Computer Interface using Extreme Learning Machines for Motor Intention Detection	115
<i>Ramón Osmany Ramírez Tasé, Denis Delisle Rodríguez, Oluwarotimi Williams Samuel, and Alberto López Delis</i>	
Peripheral Nerve Segmentation in Ultrasound Images Using Conditioned U-Net	124
<i>Harold Mauricio Díaz-Vargas, Cristian Alfonso Jimenez-Castaño, David Augusto Cárdenas-Peña, Oscar David Aguirre-Ospina, and Alvaro Angel Orozco-Gutierrez</i>	
Assessing the Relationship Between Binarization and OCR in the Context of Deep Learning-Based ID Document Analysis	134
<i>Rubén Sánchez-Rivero, Pavel Bezmaternykh, Annette Morales-González, Francisco José Silva-Mata, and Konstantin Bulatov</i>	
Pattern Recognition and Applications	
Pattern Recognition Strategies to Classify Traced Neurons	147
<i>José D. López-Cabrera, Leonardo A. Hernández-Pérez, and Juan V. Lorenzo-Ginori</i>	
Evaluation of Hepatic Fibrosis Stages Using the Logical Combinatorial Approach	158
<i>Nathalie Alemán-García and Martha R. Ortiz-Posadas</i>	
A Proposal of Condition Monitoring with Missing Data and Small-Magnitude Faults in Industrial Plants	167
<i>José M. Bernal-de-Lázaro, Carlos Cruz Corona, Marcelo Lisboa Rocha, Antônio J. Silva Neto, and Orestes Llanes-Santiago</i>	

A Proposal of Metric for Improving Remaining Useful Life Prediction in Industrial Systems	177
<i>Adriana Villalón-Falcón, Alberto Prieto-Moreno, Marcos Quiñones-Grueiro, and Orestes Llanes-Santiago</i>	
A Fuzzy Logic Proposal for Diagnosis Multiple Incipient Faults in a Power Transformer	187
<i>J. C. Fernández, L. B. Corrales, F. H. Hernández, I. F. Benítez, and J. R. Núñez</i>	
A Robust Fault Diagnosis Strategy in Mechanical Systems Using Pythagorean Fuzzy Sets	199
<i>Adrián Rodríguez Ramos, José Luís Verdegay Galdeano, and Orestes Llanes-Santiago</i>	
Prediction of Diabetes Mortality in Mexico City Applying Data Science	211
<i>Joaquín Pérez-Ortega, Andrea Vega-Villalobos, Nely Nely Almanza-Ortega, Rodolfo A. Pazos-Rangel, José Crispín Zavala-Díaz, José María Rodríguez-Lélis, and Yazmín Hernández</i>	
Balancing of Samples in Class Hierarchy	219
<i>Shuhei Aoki and Mineichi Kudo</i>	
Feature Selection with Class Hierarchy for Imbalance Problems	229
<i>Tomoya Horio and Mineichi Kudo</i>	
SVM Based EVM for Open Space Problems	239
<i>Yasuyuki Kaneko and Mineichi Kudo</i>	
Data Drive Fuzzy Cognitive Map for Classification Problems	249
<i>Jairo A. Lefebvre-Lobaina and María M. García</i>	
Extracting Composite Summaries from Qualitative Data.	260
<i>Carlos R. Rodríguez Rodríguez, Marieta Peña Abreu, and Denis Sergeevich Zuev</i>	
A Novel Initial Population Construction Heuristic for the DINOS Subgroup Discovery Algorithm	270
<i>Lisandra Bravo-Ilisástigui, Lenier Reyes-Morales, Diana Martín, and Milton García-Borroto</i>	
A Survey on the Methods to Determine the Sensitivity of Textual Documents: Solutions and Problems to Solve	280
<i>Saturnino Job Morales Escobar, José Ruiz Shulcloper, Cristina Juárez Landín, Osvaldo Andrés Pérez García, and José Sergio Ruiz Castilla</i>	

Automatic Classification of Diabetic Foot Ulcers Using Computer Vision Techniques.	290
<i>José Daniel López-Cabrera, Yusely Ruiz-Gonzalez, Roberto Díaz-Amador, and Alberto Taboada-Crispi</i>	

Biometrics, Image, and Video Analysis

Image Segmentation Applied to Line Separation and Determination of GPN2 Protein Overexpression for Its Detection in Polyacrylamide Gels . . .	303
<i>Jorge Juárez, María del Rayo Graciela Guevara-Villa, Anabel Sánchez-Sánchez, Raquel Díaz-Hernández, and Leopoldo Altamirano-Robles</i>	
Underwater Image Enhancement Using Adaptive Algorithms	316
<i>Shaneer Luchman and Serestina Viriri</i>	
Improving the Robustness of DCT-Based Handwritten Document Image Watermarking Against JPEG-Compression	327
<i>Ernesto Avila-Domenech and Alberto Taboada-Crispi</i>	
Automated System for the Detection of Lung Nodules.	337
<i>E. Martinez-Machado, M. Perez-Diaz, and R. Orozco-Morales</i>	
Video and Image Complexity in Human Action Recognition	349
<i>Andrea Burgos-Madrigal and Leopoldo Altamirano-Robles</i>	
A Wide 2D Median Filter for GPU Devices	360
<i>Maikel Salas Zaldivar</i>	
Medical Image Watermarking with Separable Moments	370
<i>Yenner J. Díaz Núñez, Anier Soria Lorente, and Stefan Berres</i>	

Signals Analysis and Processing

Intra-day Population Fluxes from Mobile Phone Data in Havana, Cuba	383
<i>Milton García-Borroto, Orlando Martínez-Durive, Eduardo Sánchez, Humberto Díaz, and Alejandro Lage-Castellanos</i>	
Semantic Segmentation of Radio-Astronomical Images	393
<i>Carmelo Pino, Renato Sortino, Eva Sciacca, Simone Riggi, and Concetto Spampinato</i>	
Content-Based Image Retrieval for Surface Defects of Hot Rolled Steel Strip Using Wavelet-Based LBP	404
<i>Fatma Zohra Boudani, Nafaa Nacereddine, and Nacera Laiche</i>	

Decision Rules for Radar Detection in the Moments Space with Arbitrary Correlation Degree and Constant False Alarm Rate	414
<i>Camilo Guillén and Nelson Chávez</i>	
Interpretable Diagnosis of ADHD Based on Wavelet Features and Logistic Regression	424
<i>Julián D. Pastrana-Cortes, Maria Camila Maya-Piedrahita, Paula Marcela Herrera-Gómez, David Cárdenas-Peña, and Alvaro A. Orozco-Gutierrez</i>	
Evaluation of GOI Detectors in EGG Signals Assuming Different Models for the Pulse Length Variability	434
<i>Carlos A. Ferrer Riesgo, Reinier Rodríguez-Guillén, and Elmar Nöth</i>	
Author Index	445