PROCEEDINGS OF SPIE

12th International Symposium on Medical Information Processing and Analysis

Eduardo Romero
Natasha Lepore
Jorge Brieva
Ignacio Larrabide
Editors

5–7 December 2016
Tandil, Argentina

Organized by
SIPAIM Foundation (International Society) • Universidad Nacional del Centro de la Provincia de Buenos Aires - UNICEN (Argentina) • Universidad Nacional de Colombia • Universidad Panamericana (Mexico)

Sponsored by
SIPAIM Foundation (International Society) • Ministerio de Ciencia, Tecnología e Innovación Productiva - MinCyT (Argentina) • Universidad Nacional del Centro de la Provincia de Buenos Aires - UNICEN (Argentina) • Universidad Nacional de Colombia (Colombia) • Universidad Panamericana (Mexico) • Comisión de Investigaciones Científicas - Provincia de Buenos Aires - CIC (Argentina) • Consejo Nacional de Investigaciones Científicas y Técnicas de Argentina (Argentina)

Published by
SPIE

Volume 10160

Proceedings of SPIE 0277-786X, V. 10160

12th International Symposium on Medical Information Processing and Analysis, edited by Eduardo Romero, Natasha Lepore, Jorge Brieva, Ignacio Larrabide, Proc. of SPIE Vol. 10160, 1016001
© 2017 SPIE · CCC code: 0277-786X/17/$18 · doi: 10.1117/12.2271156

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:
Author(s), "Title of Paper," in *12th International Symposium on Medical Information Processing and Analysis*, edited by Eduardo Romero, Natasha Lepore, Jorge Brieva, Ignacio Larrabide, Proceedings of SPIE Vol. 10160 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-786X (electronic)

ISBN: 9781510607781
ISBN: 9781510607798 (electronic)

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE. DIGITAL LIBRARY
SPIEDigitalLibrary.org

Paper Numbering: *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

DATA SIMULATION AND MODELLING

BRAIN - SIGNAL PROCESSING

ADDITIONAL PAPER

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Conference Committees

Conference Chairs

Eduardo Romero, University Nacional de Colombia (Colombia)
Natasha Lepore, Children's Hospital Los Angeles (United States)
Jorge Brieva, Universidad Panamericana (Mexico)
Ignacio Larrabide, Instituto PLADEMA, CONICET, UNICEN (Argentina)

Organizing Committee

Eduardo Romero, Universidad Nacional de Colombia (Colombia)
Natasha Lepore, The University of Southern California (United States)
Ignacio Larrabide, UNICEN (Argentina)
Juan D'Amato, UNICEN (Argentina)
Juan David García, Universidad Nacional de Colombia (Colombia)
Angel Cruz Roa, Universidad de los Llanos (Colombia)
Pablo Rinaldi, UNICEN (Argentina)
Gustavo Boroni, UNICEN (Argentina)
Virginia Cifuentes, UNICEN (Argentina)

Program Committee

Eduardo Romero, Universidad Nacional de Colombia (Colombia)
Ignacio Larrabide, Instituto PLADEMA, CONICET, UNICEN (Argentina)
Juan D'Amato, UNICEN (Argentina)
Lucas Daniel Lo Vercio, UNICEN (Argentina)

Reviewers

Eduardo Romero, Universidad Nacional de Colombia (Colombia)
Jorge Brieva, Universidad Panamericana (Mexico)
Ignacio Larrabide, Instituto PLADEMA, CONICET, UNICEN (Argentina)
Juan D'Amato, UNICEN (Argentina)
Juan David García, Universidad Nacional de Colombia (Colombia)
Andrea Rueda, Pontificia Universidad Javeriana (Colombia)
Olivier Lézoray, Université de Caen Basse-Normandie (France)
Sara Wong, Universidad Simón Bolívar (Venezuela)
Fabio Martínez, Universidad Industrial de Santander (Colombia)
Felíx Martínez, Universidad Panamericana (Mexico)
Javier Adur, Universidad Nacional de Entre Ríos (Argentina)
Daniel Racoceanu, Pontificia Universidad Católica del Perú (Peru)
Ricardo Gutiérrez, Universidad EAFIT (Colombia)
Katya Rodríguez, IIMAS, Universidad Nacional Autónoma de México (Mexico)

Emanuele Schiavi, Universidad Rey Juan Carlos (Spain)
Ernesto Moya-Albor, Universidad Panamericana (Mexico)
Nidiyare Hevia-Montiel, Universidad Nacional Autónoma de Mexico (Mexico)
Diego Gómez, Universidad Antonio Nariño (Colombia)
Gloria Díaz, Instituto Tecnológico Metropolitano (Colombia)
Alexander Cerquera, Universidad Antonio Nariño (Colombia)
Olivier Salvado, Commonwealth Scientific and Industrial Research Organisation (Australia)
Maria Zuluaga, University College London (United Kingdom)
Antoine Manzanera, ENSTA-ParisTech (France)
Leonardo Valencia, Pontificia Universidad Javeriana (Colombia)
Juan Jiménez, Universidad Autónoma Metropolitana (Mexico)
Quentin Noirhomme, Maastricht University (Netherlands)
Alfredo Hernandez, INSERM (France)
Germán Castellanos Domínguez, Universidad Nacional de Colombia (Colombia)
Alexandra La Cruz, Universidad Simón Bolívar (Venezuela)
Francisco Gómez, Universidad Nacional de Colombia (Colombia)
Norberto Malpica, Universidad Rey Juan Carlos (Spain)
Gianfranco Passariello, Universidad Simón Bolívar (Venezuela)
Crescencio Garcia, Universidad Nacional Autónoma de México (Mexico)
Raul Ramos, Universidad Industrial de Santander (Colombia)
Javier Pascau, Universidad Carlos III de Madrid (Spain)
Luis Rodríguez, Escuela Colombiana de Ingeniería Julio Garavito (Colombia)
Fabio González, Universidad Nacional de Colombia (Colombia)
Fernando Arámbula Cosío, Universidad Nacional Autónoma de México (Mexico)
Maira García, Universidad EAN (Colombia)
Antonio José Bravo, Universidad Nacional Experimental del Táchira (Venezuela)
Jhimli Mitra, Case Western Reserve University (United States)
Angel Cruz, Universidad de los Llanos (Colombia)
Soumya Ghose, Case Western Reserve University (United States)
Alfredo Mantilla, Tecnológico de Monterrey (Mexico)
Cristina Santa Marta, Universidad Nacional de Educación a Distancia (Spain)
Oscar David Robles, Universidad Rey Juan Carlos (Spain)
Pablo Javier Blanco, Universidad Rey Juan Carlos (Spain)
Javier Dottori, UNICEN (Argentina)
Hrvoje Bogunović, Medical University of Vienna (Austria)
Rosana Barbuzza, UNICEN (Argentina)
Constantyn Butakoff, Universitat Pompeu Fabra (Spain)
Mariana del Fresno, UNICEN (Argentina)
Enzo Ferrante, Imperial College London (United Kingdom)

Rosa M. Figueras i Ventura, Hospital Clínic de Barcelona (Spain) and Galgo Medical (Spain)
Alfredo Higueras Esteban, Hospital Clínic de Barcelona (Spain) and Galgo Medical (Spain)
Gustavo Meschino, Universidad Nacional de Mar del Plata (Argentina)
Fernando Yepes-Calderon, Children's Hospital Los Angeles (United States)

Session Chairs

1 Biosignal
Petia Radeva, Universitat de Barcelona (Spain)

2 Ultrasound
Jose M. Massa, UNICEN (Argentina)

3 Brain - Structure
Olivier Coulon, CNRS (France)

4 Man Machine Interface
Cristian García Bauza, UNICEN (Argentina)

5 Methods
Pablo Rinaldi, UNICEN (Argentina)

6 Digital Pathology
Anant Madabhushi, Case Western Reserve University (United States)

7 E-Health, Diabetes and Glaucoma
Mariana del Fresno, UNICEN (Argentina)

8 Brain - Behavioral Disorders
Natasha Lepore, The University of Southern California (United States)

9 Cardiovascular Imaging
Ignacio Larrabide, Instituto PLADEMA, CONICET, UNICEN (Argentina)

10 Large Scale Data Interactions
Marius Linguraru, George Washington University (United States)

11 Brain Connectomics
Eduardo Romero, Universidad Nacional de Colombia (Colombia)

12 Data Simulation & Modelling
Jorge Brieva, Universidad Panamericana (Mexico)

13 Brain - Signal Processing
Juan D'Amato, UNICEN (Argentina)

Introduction

Welcome to conference proceedings from the 12th International Symposium on Medical Information Processing and Analysis - SIPAIM 2016!

SIPAIM 2016 was held, for the first time, in Tandil, Argentina. The symposium was organized by the Universidad Nacional del Centro de la Provincia de Buenos Aires (UNICEN). The organization had the support of the Comisión de Investigaciones Científicas y Tecnológicas de la Provincia de Buenos Aires (CICPBA), the Ministerio de Ciencia y Tecnología (MINCYT), Universidad Nacional del Centro de la Provincia de Buenos Aires (UNICEN), Comisión Nacional de Investigaciones Científicas y Tecnológicas (CONICET) and Pladema Institute (Universidad Nacional del Centro de la Provincia de Buenos Aires), Universidad Nacional de Colombia (UNAL), Universidad Panamericana (Mexico) and SIPAIM foundation.

Over the last couple of years, SIPAIM has evolved from a small meeting to an international symposium with participation of researchers from several countries across Latin America, North America, Europe and Asia. The collaboration with SPIE has brought growing attention to the event and has improved the quality and visibility of the proceedings. SIPAIM is mainly focused on gathering Latin American community on medical image analysis and information processing where researchers can participate in discussions about recent results, ongoing research and future projects in the areas and topics of the symposium. The symposium is also a great opportunity for networking among the members of this community. SIPAIM is addressed to researchers, students and professionals in a wide range of disciplines including Engineering, Physics, Mathematics, Computer Science, Biology and Health Sciences, and includes keynote lectures by recognized experts on issues related to acquisition, digitization, visualization, processing, analysis and interpretation of medical information. There are also several tutorials aimed at the complementary education of students concerning the topics of the conference.

We received 74 submissions, and after a very strict revision process, 56 papers were accepted for presentation. The conference included the participation of eight internationally recognized keynote and workshop speakers. The symposium included the following tracks: Medical and Biomedical Imaging, eHealth, Digital Pathology, Gait Analysis and Biosignals, Representation Based Biosignal Analysis, and Analysis of Medical Procedures through Imaging.

SIPAIM's venue was in the quiet and friendly city of Tandil, Argentina. Tandil is recognized as a strong technology development city in Argentina with the University as the city's beating heart. This young city (founded in 1823), is surrounded by hills and has a relaxed way of life treasured by tourists from the whole country and abroad. SIPAIM organizers hope that each and every one of this year's SIPAIM attendees had the chance to see this in Tandil, and that they had a nice and interesting time with its technical program. See you next year!

Eduardo Romero
Natasha Lepore
Jorge Brieva
Ignacio Larrabide