Gregor Rozinaj
Radoslav Vargic (Eds.)

Communications in Computer and Information Science 1527

Systems, Signals and Image Processing

28th International Conference, IWSSIP 2021
Bratislava, Slovakia, June 2–4, 2021
Revised Selected Papers

Springer

IWSSIP 2021
BRATISLAVA, SLOVAKIA

Communications in Computer and Information Science 1527

More information about this series at https://link.springer.com/bookseries/7899

Gregor Rozinaj · Radoslav Vargic (Eds.)

Systems, Signals and Image Processing

28th International Conference, IWSSIP 2021
Bratislava, Slovakia, June 2–4, 2021
Revised Selected Papers

Springer

Editors
Gregor Rozinaj
Slovak University of Technology in Bratislava
Bratislava, Slovakia

Radoslav Vargic
Slovak University of Technology in Bratislava
Bratislava, Slovakia

ISSN 1865-0929 ISSN 1865-0937 (electronic)
Communications in Computer and Information Science
ISBN 978-3-030-96877-9 ISBN 978-3-030-96878-6 (eBook)
https://doi.org/10.1007/978-3-030-96878-6

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

Preface

Signal processing is a phenomenon which is a principal tool for all applications based on computer technologies for an interaction with the real world. Data/signal retrieval, processing, and visualization comprise the general methodology in most scientific areas. From filter design, Fourier and other transforms, feature extraction, etc. through machine learning and system adaptation to user-oriented products like 5G networks, IoT, virtual teleportation, or tele-surgery operations, this is a very brief resume of the power of signal processing. Advanced signal processing is therefore a very complex topic with deeply structuralized content.

The International Conference for Systems, Signal and Image Processing (IWSSIP) is a well-established event with traditional participation of people from all continents. In 2021, the 28th IWSSIP conference was organized by the Slovak University of Technology, Bratislava, Slovakia, following the previous successful IWSSIP 2020 event in Rio de Janeiro, Brazil, and past conferences in various countries.

We are proud of having outstanding invited speakers who significantly increased the scientific quality of this event. Touradj Ebrahimi from École Polytechnique Fédérale de Lausanne, Switzerland, presented the state of the art in image compression standards based on artificial intelligence. Gabriel Miro-Muntean from Dublin City University, Ireland, gave a deep introduction to "Delivering High Quality Rich Media Content in Current Network Environment: Challenges and Solutions". Abir Hussain from Liverpool John Moores University, UK spoke about the "Detection and Localization of Objects Within Images Using Computer Vision and Machine Learning". We are deeply thankful to all three speakers for their valuable time and invited lectures.

Due to special COVID-19 pandemic regulations the presentations of all three keynote speakers, as well as the whole conference, was organized in a strictly online format with the stress on full interaction among IWSSIP participants. The whole conference was powered by underline.io and we would like to express our gratitude for their professional help with organizing the online event.

Despite the fact that one of the main goals of scientific conferences is to gather researchers working in similar areas in one place, there was still huge interest in the online IWSSIP 2021 event. We received 76 paper proposals from authors in 17 countries. The best 20 papers were accepted and selected for this publication. These papers are closely related to advances in signal processing. The orientation of presented papers shows the huge diversity and complexity of advanced signal processing.

We would like to thank all participants of IWSSIP 2021, as well as everyone who helped to make this conference successful.

June 2021

Gregor Rozinaj
Radoslav Vargic

Organization

Honorary Chairs

Branka Zovko-Cihlar	University of Zagreb, Croatia
Pavol Podhradský	Slovak University of Technology, Slovakia

General Chair

Gregor Rozinaj	Slovak University of Technology, Slovakia

Program Committee Chair

Radoslav Vargic	Slovak University of Technology, Slovakia

Steering Committee

Aura Conci	Universidade Federal Fluminense, Brazil
Mislav Grgić	University of Zagreb, Croatia
Sonja Grgić	University of Zagreb, Croatia
Fabiana Leta	Universidade Federal Fluminense, Brazil
Panos Liatsis	Khalifa University of Science and Technology, United Arab Emirates
Pavol Podhradsky	Slovak University of Technology, Slovakia
Snjezana Rimac-Drlje	University of Osijek, Croatia
Gregor Rozinaj	Slovak University of Technology, Slovakia
Markus Rupp	Technische Universität Wien, Austria
Radoslav Vargic	Slovak University of Technology, Slovakia
Branka Zovko-Cihlar	University of Zagreb, Croatia

Program Committee

Narcis Behlilovic	University of Sarajevo, Bosnia and Hercegovina
Ángel Sánchez Calle	Universidad Rey Juan Carlos de Madrid, Spain
Aura Conci	Universidade Federal Fluminense, Brazil
Jan Cornelis	Vrije Universiteit Brussel, Belgium
Žarko Čučej	University of Maribor, Slovenia
Marek Domański	Poznań University of Technology, Poland
Touradj Ebrahimi	EPFL, Switzerland

Irena Galic	University of Osijek, Croatia
Dušan Gleich	University of Maribor, Slovenia
Mislav Grgić	University of Zagreb, Croatia
Sonja Grgić	University of Zagreb, Croatia
Yo-Sung Ho	Gwangju Institute of Science and Technology, South Korea
Ebroul Izquierdo	Queen Mary University of London, UK
Dimitrios Karras	National and Kapodistrian University of Athens, Greece
Erich Leitgeb	Graz University of Technology, Austria
Fabiana Leta	Universidade Federal Fluminense, Brazil
Panos Liatsis	Khalifa University of Science and Technology, United Arab Emirates
Rastislav Lukac	Intel Corporation, Canada
Galia Marinova	Technical University of Sofia, Bulgaria
Marta Mrak	Queen Mary University of London, UK
Peter Planinšič	University of Maribor, Slovenia
Pavol Podhradsky	Slovak University of Technology, Slovakia
Snježana Rimac-Drlje	University of Osijek, Croatia
Gregor Rozinaj	Slovak University of Technology, Slovakia
Markus Rupp	Technische Universität Wien, Austria
Ryszard Stasiński	Poznan University of Technology, Poland
Boris Šimak	Czech Technical University in Prague, Czech Republic
Rodica Tuduce	University Politehnica of Bucharest, Romania
Ján Turán	Technical University of Košice, Slovakia
Radoslav Vargic	Slovak University of Technology, Slovakia
Stamatis Voliotis	Technological Educational Institute of Chalkida, Greece
Krzysztof Wajda	AGH University of Science and Technology, Poland
Drago Zagar	University of Osijek, Croatia
Theodore Zahariadis	National and Kapodistrian University of Athens, Greece
Branka Zovko-Cihlar	University of Zagreb, Croatia

Additional Reviewers

Abreu, Raphael	Bergo, Felipe
Aguilera, Cristhian A.	Bezerra, Eduardo
Araújo, José Denes	Bozek, Jelena
Aung, Zeyar	Bravenec, Tomas
Bergamasco, Leila	Bujok, Petr

Burget, Radim
Casaca, Wallace
Ciarelli, Patrick Marques
Copetti, Alessandro
Costa, Tales Fernandes
Čepko, Jozef
Davídková Antošová, Marcela
Devamane, Shridhar
Gonçalves, Vagner Mendonça
Habijan, Marija
Haddad, Diego Barreto
Henriques, Felipe
Hocenski, Zeljko
Hrad, Jaromír
Jakóbczak, Dariusz Jacek
Juhár, Jozef
Kačur, Juraj
Karwowski, Damian
Kominkova Oplatkova, Zuzana
Körting, Thales Sehn
Kos, Marko
Kultan, Matej
Laguna, Juana Martinez
Latkoski, Pero
Lima, Alan
Londák, Juraj
Lopes, Bruno
Lopes, Guilherme Wachs
Lourenço, Vítor
Malajner, Marko
Mandic, Lidija
Marana, Aparecido Nilceu
Marchevský, Stanislav
Markovska, Marija
Matos, Caio
Medvecký, Martin
Minárik, Ivan
Mocanu, Stefan
Mustra, Mario
Nyarko, Emmanuel Karlo
Paiva, Anselmo
Papa, Joao Paulo
Polak, Ladislav
Prinosil, Jiri
Rakús, Martin
Rodriguez, Denis Delisle
Rybárová, Renata
Silva, Aristófanes
Silvestre, Santiago
Slanina, Martin
Sousa De Almeida, Joao Dallyson
Sousa, Azael Melo E.
Tcheou, Michel
Toledo, Yanexis Pupo
Trúchly, Peter
Veras, Rodrigo
Vitas, Dijana
Vlaj, Damjan
Vukovic, Josip
Zamuda, Ales
Zeman, Tomas

Organizing Committee

Zuzana Brunclíková, Slovakia
Lucia Hlinková, Slovakia
Juraj Kačur, Slovakia
Juraj Londák, Slovakia
Ivan Minárik, Slovakia
Pavol Podhradský, Slovakia
Šimon Tibenský, Slovakia
Marek Vančo, Slovakia
Radoslav Vargic, Slovakia

Contents