SIGNAL PROCESSING Volume 35 | Number 2 | March 2018



SUBSURFACE EXPLORATION

Recent Advances in Geo-Signal Processing, Interpretation, and Learning

Signal Processing Supports a New Wave of Audio Research

Traffic Signs in the Wild: Highlights from the 2017 IEEE VIP Cup Reconstruction of a Signal from the Real Part of Its DFT

Real-Time Ultrasound Thermography and Thermometry





Contents

Volume 35 | Number 2 | March 2018

SPECIAL SECTION

SUBSURFACE EXPLORATION: RECENT ADVANCES IN GEO-SIGNAL PROCESSING, INTERPRETATION, AND LEARNING

16 FROM THE GUEST EDITORS
Ghassan AlRegib, Sergey Fomel,
and Renato Lopes

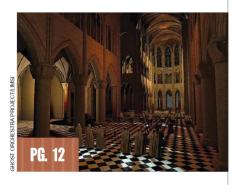
MACHINE LEARNING FOR
VOLCANO-SEISMIC SIGNALS
Marielle Malfante, Mauro Dalla Mura,
Jean-Philippe Métaxian, Jérôme I. Mars,
Orlando Macedo, and Adolfo Inza

31 A SEISMIC SHIFT IN SCALABLE ACQUISITION DEMANDS NEW PROCESSING

Eileen R. Martin, Fantine Huot, Yinbin Ma, Robert Cieplicki, Steve Cole, Martin Karrenbach, and Biondo L. Biondi

41 IMPROVING SPARSE MULTICHANNEL BLIND DECONVOLUTION WITH CORRELATED SEISMIC DATA

Kenji Nose-Filho, André Kazuo Takahata, Renato Lopes, and João Marcos Travassos Romano





ON THE COVER

This special issue of *IEEE Signal Processing Magazine* provides an introduction to the role of signal processing in areas where automation and learning are being deployed in Earth exploration. Articles are diverse in their coverage and discuss a wide range of problems in geophysics. Some of these problems range from near-surface monitoring to well-log data estimation and from compression of seismic data to the interpretation of seismic volumes using machine learning.

COVER IMAGE: SOIL: @ISTOCKPHOTO.COM/PRAPANN, GROUND PHOTO: @ISTOCKPHOTO.COM/ DOTTEDHIPPO

51 ADVANCES IN SEISMIC DATA COMPRESSION VIA LEARNING FROM DATA

Ali Payani, Afshin Abdi, Xin Tian, Faramarz Fekri, and Mohamed Mohandes

AN APPROXIMATE REPRESENTATION
OF THE FOURIER SPECTRA
OF IRREGULARLY SAMPLED
MULTIDIMENSIONAL FUNCTIONS
Adelson Santos de Oliveira

70 WELL LOC AND SEISMIC DAT

72 WELL-LOG AND SEISMIC DATA INTEGRATION FOR RESERVOIR CHARACTERIZATION

Soumi Chaki, Aurobinda Routray, and William K. Mohanty

82 SUBSURFACE STRUCTURE ANALYSIS USING COMPUTATIONAL INTERPRETATION AND LEARNING

Ghassan AlRegib, Mohamed Deriche, Zhiling Long, Haibin Di, Zhen Wang, Yazeed Alaudah, Muhammad Amir Shafiq, and Motaz Alfarraj

99 ARRAY PROCESSING IN MICROSEISMIC MONITORING

James. H. McClellan, Leo Eisner, Entao Liu, Naveed Iqbal, Abdullatif A. Al-Shuhail, and Sanlinn I. Kaka

112 WIRELESS DIGITAL COMMUNICATION TECHNOLOGIES FOR DRILLING

Arnaud Jarrot, Andriy Gelman, and Julius Kusuma

121 DIGITAL ROCK PHYSICS

Hasan Al-Marzouqi

132 RETRIEVING LOW WAVENUMBER INFORMATION IN FWI

Wenyi Hu, Jiefu Chen, Jianguo Liu, and Aria Abubakar

142 COMPLEX AUTOREGRESSIVE TIME-FREQUENCY ANALYSIS

Marcus C.B. Andrade, Milton J. Porsani, and Bjorn Ursin



IEEE SIGNAL PROCESSING MAGAZINE (ISSN 1053-5888) (ISPREG) is published bimonthly by the Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, 17th Floor, New York, NY 10016-5997 USA (+1 212 419 7900). Responsibility for the contents rests upon the authors and not the IEEE, the Society, or its members. Annual member subscriptions included in Society fee. Nonmember subscriptions available upon request. Individual copies: IEEE Members US\$20.00 (first copy only), nonmembers US\$241.00 per copy. Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. Copyright Law for private use of patrons: 1) those post-1977 articles that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA; 2) pre-1978 articles without fee. Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. For all other copyring, reprint, or republication permission, write to IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 USA. Copyright © 2018 by the Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Periodicals postage paid at New York, NY, and a additional mailing offices.

Postmaster: Send address changes to IEEE Signal Processing Magazine, IEEE, 445 Hoes Lane, Piscataway, NJ 08854 USA. Canadian GST #125634188

Printed in the U.S.A.

COLUMNS

7 Society News

SPS Fellows and Award Winners Recognized

12 Special Reports

Signal Processing Supports a New Wave of Audio Research John Edwards

154 SP Competitions

Traffic Signs in the Wild Dogancan Temel and Ghassan AlRegib

162 Tips & Tricks

Reconstruction of a Signal from the Real Part of Its Discrete Fourier Transform Stephen So and Kuldip K. Paliwal

166 Life Sciences

Real-Time Ultrasound Thermography and Thermometry Emad S. Ebbini, Claudio Simon, and Dalong Liu

DEPARTMENTS

4 From the Editor

Research Gems Found Digging with Industry Robert W. Heath, Jr.

5 President's Message Big Ideas or Big Data?

Ali H. Sayed

176 Dates Ahead



The 43rd IEEE International Conference on Acoustics, Speech, and Signal Processing will be held 15–20 April in Calgary, Alberta, Canada.



IEEE prohibits discrimination, harassment, and bullying. For more information, visit http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html.

IEEE Signal Processing Magazine

EDITOR-IN-CHIEF

Robert W. Heath, Jr.—The University of Texas at Austin, U.S.A.

AREA EDITORS

Feature Articles

Matthew McKay—Hong Kong University of Science and Technology, Hong Kong SAR of China

Special Issues

Namrata Vaswani — Iowa State University, U.S.A.

Columns and Forum

Roberto Togneri—The University of Western Australia

e-Newsletter

Ervin Sejdic—University of Pittsburgh, U.S.A.

Social Media and Outreach

Tiago Henrique Falk—INRS, Canada

EDITORIAL BOARD

Mrityunjoy Chakraborty—Indian Institute of Technology, Kharagpur, India George Chrisikos—Qualcomm, Inc., U.S.A.

Alfonso Farina — Leonardo S.p.A., Italy
Clem Karl — Boston University, U.S.A.
C.-C. Jay Kuo — University of Southern California,
U.S.A.

Erik Larsson—Linköping University, Sweden Jian Lu—Qihoo 360, China

Helen Meng—City University of Hong Kong, Hong Kong SAR of China

Douglas O'Shaughnessy—INRS Universite de Recherche, Canada

Osvaldo Simione—Kings College London, U.K. Vahid Tarokh—Duke University, U.S.A. Wade Trappe—Rutgers University, U.S.A.

ASSOCIATE EDITORS—COLUMNS AND FORUM

Ivan Bajic—Simon Fraser University, Canada Ching-Te Chiu—National Tsing Hua University, Tajwan

Panayiotis (Panos) Georgiou—University of Southern California, U.S.A.

Hana Godrich—Rutgers University, U.S.A. Xiaodong He—Microsoft Research

Danilo Mandic—Imperial College, U.K. Vishal Patel—Rutgers University, U.S.A.

Fatih Porikli—Australian National University

Shantanu Rane—PARC, U.S.A. Saeid Sanei—University of Surrey, U.K.

Changshui Zhang—Tsinghua University, China

ASSOCIATE EDITORS—e-NEWSLETTER

Csaba Benedek—Hungarian Academy of Sciences, Hungary

Yang Li—Harbin Institute of Technology, China Yuhong Liu—Penn State University at Altoona, U.S.A.

Andreas Merentitis—University of Athens, Greece

Michael Muma—TU Darmstadt, Germany Xiaorong Zhang—San Francisco State University, U.S.A.

ASSOCIATE EDITOR—SOCIAL MEDIA/OUTREACH

Guijin Wang-Tsinghua University, China

IEEE SIGNAL PROCESSING SOCIETY

Ali Sayed—President

Ahmed Tewfik-President-Elect

Fernando Pereira—Vice President, Conferences

Nikos D. Sidiropoulos—Vice President, Membership

Sergio Theodoridis—Vice President, Publications
Walter Kellerman—Vice President,
Technical Directions

IEEE SIGNAL PROCESSING SOCIETY STAFF

William Colacchio—Senior Manager, Publications and Education Strategy and Services Rebecca Wollman—Publications Administrator

IEEE PERIODICALS MAGAZINES DEPARTMENT

Jessica Welsh, *Managing Editor* Geraldine Krolin-Taylor,

Geraldine Krolin-laylor, Senior Managing Editor

Janet Dudar, Senior Art Director

Gail A. Schnitzer, Associate Art Director

Theresa L. Smith, Production Coordinator

Mark David, Director, Business Development -Media & Advertising

Felicia Spagnoli, Advertising Production Manager Peter M. Tuohy, Production Director

Kevin Lisankie, Editorial Director Dawn M. Melley, Staff Director, Publishing Operations

Digital Object Identifier 10.1109/MSP.2017.2781920

SCOPE: IEEE Signal Processing Magazine publishes tutorial-style articles on signal processing research and applications as well as columns and forums on issues of interest. Its coverage ranges from fundamental principles to practical implementation, reflecting the multidimensional facets of interests and concerns of the community. Its mission is to bring up-to-date, emerging and active technical developments, issues, and events to the research, educational, and professional communities. It is also the main Society communication platform addressing important issues concerning all members.