

IEEE Signal Processing

Volume 34 | Number 2 | March 2017

MAGAZINE

SMART VEHICLE TECHNOLOGIES: PART 2

Signal Processing on the Move

Perfecting Protection
for Interactive Multimedia

Computational Neuromodulation
for Deep Brain Stimulation

New Fellows and
SPS Award Winners

Contents

Volume 34 | Number 2 | March 2017

SPECIAL SECTION

SIGNAL PROCESSING FOR SMART VEHICLE TECHNOLOGIES: PART 2

18 FROM THE GUEST EDITORS

John H.L. Hansen, Kazuya Takeda, Sanjeev M. Naik, Mohan M. Trivedi, Gerhard U. Schmidt, Yingying (Jennifer) Chen, and Wade Trappe

22 AUTOMOTIVE RADARS

Sujeet Patole, Murat Torlak, Dan Wang, and Murtaza Ali

36 ADVANCES IN AUTOMOTIVE RADAR

Florian Engels, Philipp Heidenreich, Abdelhak M. Zoubir, Friedrich K. Jondral, and Markus Wintermantel

47 SIGNAL PROCESSING CHALLENGES IN CELLULAR-ASSISTED VEHICULAR COMMUNICATIONS

Stefan Schwarz, Tal Philosofo, and Markus Rupp



IMAGE LICENSED BY GRAPHIC STOCK



ON THE COVER

Part 2 of the special section on signal processing for smart vehicle technologies provides an additional six articles, complementing those in Part 1, which was published in the November 2016 issue of *IEEE Signal Processing Magazine*.

COVER IMAGE: ©ISTOCKPHOTO.COM/NADIA

60 THE FUTURE OF AUTOMOTIVE LOCALIZATION ALGORITHMS

Rickard Karlsson and Fredrik Gustafsson

70 DSP APPLICATIONS IN ENGINE CONTROL AND ONBOARD DIAGNOSTICS

Zhijian James Wu and Sanjeev M. Naik

82 INTELLIGENT INTERACTIVE DISPLAYS IN VEHICLES WITH INTENT PREDICTION

Bashar I. Ahmad, James K. Murphy, Simon J. Goddard, Patrick M. Langdon, and Robert W. Hardy

FEATURE

95 PERFECTING PROTECTION FOR INTERACTIVE MULTIMEDIA

Ahmed Badr, Ashish Khisti, Wai-Tian Tan, and John Apostolopoulos

COLUMNS

7 Society News

SPS Fellows and Award Winners Recognized

12 Reader's Choice

Top Downloads in *IEEE Xplore*

14 Special Reports

Stepping Up Security with Signal Processing
John Edwards

114 Life Sciences

Computational Neuromodulation: Future Challenges for Deep Brain Stimulation
Konstantinos P. Michmizos, Blerita Lindqvist, Stephen Wong, Eric L. Hargreaves, Konstantinos Psychas, Georgios D. Mitsis, Shabbar F. Danish, and Konstantina S. Nikita

124 In the Spotlight

No Need for Speed: More Signal Processing Innovation Is Required Before Adopting Automated Vehicles
Wade Trappe



PG. 14

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 copying, reprint, or republication permission,** write to IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854 USA. Copyright © 2017 by the Institute of Electrical and Electronics Engineers, Inc. All rights reserved. Periodicals postage paid at New York, NY, and at 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.**

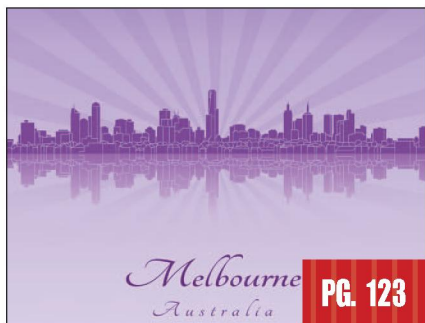
Digital Object Identifier 10.1109/MSP.2016.2642406

3 From the Editor

A Conversation About Signal Processing at Elementary School
Min Wu

5 President's Message

Introducing the IEEE Signal Processing Society Executive Committee
Rabab Ward

123 Dates Ahead

The IEEE International Symposium on Biomedical Imaging will be held 18–21 April in Melbourne, Australia.

EDITOR-IN-CHIEF

Min Wu—University of Maryland, College Park
U.S.A.

AREA EDITORS**Feature Articles**

Shuguang Robert Cui—Texas A&M University,
U.S.A.

Special Issues

Douglas O'Shaughnessy—INRS, Canada

Columns and Forum

Kenneth Lam—Hong Kong Polytechnic University,
Hong Kong SAR of China

e-Newsletter

Christian Debes—TU Darmstadt and
AGT International, Germany

Social Media and Outreach

Andres Kwasinski—Rochester Institute
of Technology, U.S.A.

EDITORIAL BOARD

Mrityunjoy Chakraborty—Indian Institute of
Technology, Kharagpur, India

George Chrisikos—Qualcomm, Inc.,
U.S.A.

Alfonso Farina—Selex ES, Italy

Mounir Ghogho—University of Leeds,
U. K.

Lina Karam—Arizona State University, U.S.A.

C.-C. Jay Kuo—University of Southern California,
U.S.A.

Sven Lončarić—University of Zagreb, Croatia

Brian Lovell—University of Queensland, Australia

Jian Lu—Qihoo 360, China

Henrique (Rico) Malvar—Microsoft Research,
U.S.A.

Yi Ma—ShanghaiTech University, China

Stephen McLaughlin—Heriot-Watt University,
Scotland

Athina Petropulu—Rutgers University,
U.S.A.

Peter Ramadge—Princeton University,
U.S.A.

Shigeki Sagayama—Meiji University, Japan

Erchin Serpedin—Texas A&M University,
U.S.A.

Shihab Shamma—University of Maryland,
U.S.A.

Vahid Tarokh—Harvard University, U.S.A.

Wade Trappe—Rutgers University, U.S.A.

Gregory Wornell—Massachusetts Institute
of Technology, U.S.A.

Dapeng Wu—University of Florida, U.S.A.

ASSOCIATE EDITORS—COLUMNS AND FORUM

Ivan Bajic—Simon Fraser University, Canada

Rodrigo Capobianco Guido—
São Paulo State University, Brazil

Ching-Te Chiu—National Tsing Hua University,
Taiwan

Xiaodong He—Microsoft Research

Danilo Mandic—Imperial College, U.K.

Aleksandra Mojsilovic—

IBM T.J. Watson Research Center

Fatih Porikli—MERL

Shantanu Rane—PARC, U.S.A.

Saeid Sanei—University of Surrey, U.K.

Roberto Togneri—The University of
Western Australia

Alessandro Vinciarelli—IDIAP-EPFL

Azadeh Vosoughi—University of Central Florida

Stefan Winkler—UIUC/ADSC, Singapore

Changshui Zhang—Tsinghua University, China

ASSOCIATE EDITORS—e-NEWSLETTER

Csaba Benedek—Hungarian Academy
of Sciences, Hungary

Paolo Braca—NATO Science and Technology
Organization, Italy

Quan Ding—University of California,
San Francisco, U.S.A.

Pierluigi Failla—Compass Inc, New York,
U.S.A.

Marco Guerriero—General Electric Research,
U.S.A.

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

Rabab Ward—President

Ali Sayed—President-Elect

Carlo S. Regazzoni—Vice President,
Conferences

Nikos D. Sidiropoulos—Vice President,
Membership

Thrasyloulos (Thrasos) N. Pappas—
Vice President, Publications

Walter Kellerman—Vice President,
Technical Directions

IEEE SIGNAL PROCESSING SOCIETY STAFF

Rebecca Wollman—Publications Administrator

IEEE PERIODICALS MAGAZINES DEPARTMENT

Jessica Barragué, *Managing Editor*

Geraldine Krolin-Taylor,
Senior Managing Editor

Mark David, *Director, Business Development -
Media & Advertising*

Felicia Spagnoli, *Advertising Production Manager*

Janet Dudar, *Senior Art Director*

Gail A. Schnitzer, Mark Morrissey,
Associate Art Directors

Theresa L. Smith, *Production Coordinator*

Dawn M. Melley, *Editorial Director*

Peter M. Tuohy, *Production Director*

Fran Zappulla, *Staff Director,
Publishing Operations*

Digital Object Identifier 10.1109/MSP.2017.2650178

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.



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