

The IEEE SENSORS JOURNAL is published by the IEEE Sensors Council, which is sponsored by 26 IEEE societies (see the inside back cover). For membership and subscription information and pricing, please visit <https://www.ieee.org/membership-catalog>. *Member copies of Transactions/Journals are for personal use only.*

Editor-in-Chief (2024-present)

ZEYNEP CELIK
Electrical Engineering Department
University of Texas at Arlington
Arlington, TX 76019 USA

Past Editor-in-Chief (2018-2024)

SANDRO CARRARA
Biomedical Circuits & Systems
École Polytechnique Fédérale
de Lausanne (EPFL)
Lausanne, CH-1015 Switzerland

Past Editor-in-Chief (2011-2018)

KRIKOR B. OZANYAN
Photonic Sensors and Systems
Univ. of Manchester
Sch. Elect. & Electron. Eng.
Manchester, M13 9PL U.K.

Past Editor-in-Chief (2009-2011)

EVGENY KATZ
Colloid Science Chemistry
& Biomolecular Sci.
Clarkson Univ.
Potsdam, NY 13699 USA

Past Editor-in-Chief (2003-2009)

H. TROY NAGLE
Electrical & Computer Engineering
NC State Univ.
Raleigh, NC 27695-7115 USA

Founding Editor-in-Chief (2001-2003)

VLADIMIR LUMELSKY
Mechanical Engineering,
Computer Science
Univ. of Wisconsin
Madison, WI 53706 USA

2024 Editorial Board

Associate Editors-in-Chief

MARCO JOSE DA SILVA
Johannes Kepler University Linz
Austria
CARLOS RUIZ ZAMARREÑO
Public University of Navarra,
Spain

Radiation Sensors

Topical Editor
CHENG-TA CHIANG
National Chia-Yi University
Chiayi City, Taiwan

Sensor Systems Integration

Topical Editor
MEHMET YUCE
Monash Univ.
Victoria, Australia

Sensor Applications

Topical Editor
SUBHAS C. MUKHOPADHYAY
Macquarie University
Australia

Mechanical & Magnetic Sensors

Topical Editor
PAUL C.-P. CHAO
National Chiao Tung Univ.
Hsinchu, Taiwan

Chemical & Biosensors

Sensor Materials
Topical Editor
CAMILLA BARATTO
National Institute
of Optics (INO)
Brescia, Italy
Sensor Phenomena and Modelling
Topical Editor
TARIKUL ISLAM
Jamia Millia Islamia
New Delhi 110025, India

Fiber Optic Sensors/Integrated Optical Sensors

Topical Editor
MINGHONG YANG
Wuhan University of Technology, China
Sensor Data Processing
Topical Editors
PIERLUIGI SALVO ROSSI
Norwegian University of
Science and Technology, Norway
DONG WANG
Shanghai Jiao Tong University, China

Sensor Interface Electronics and System Networks

Topical Editor
CHANG-HEE WON
Temple University, USA
Topical Editor-at-Large
JOHN R. VIG
Consultant
33 Bucks Mill Rd.
Colts Neck, NJ 07722 USA
Intelligent Sensors
Topical Editor
AHISH PANDHARIPANDE
Signify
Eindhoven, AE, The Netherlands

QAMMER H. ABBASI
Univ. of Glasgow, U.K.
SHIVA ABBASZADEH
Univ. of Waterloo, Canada
BARBARA ADINOLFI
Inst. of Applied Physics, Italy
MOHAMMED JALAL AHAMED
Univ. of Windsor, Canada
MAHMOUD ALMASRI
Univ. of Missouri, USA
IBRAHEEM AL-NAIIB
King Fahd Univ. of Petroleum
and Minerals, Saudi Arabia
MICHAEL ANTONIOU
Univ. of Birmingham, U.K.
VANITA ARORA
SS Automation Solutions Private Limited,
India
MOHSEN ASADNIA
Macquarie Univ., Australia
MOHAMED ATEF
United Arab Emirates Univ., UAE
HUSSEIN ATTA
King Fahd Univ. of Petroleum
and Minerals, Saudi Arabia
VARUN BAJAJ
PDPM Indian Inst. of Information
Technology Design and
Manufacturing Jabalpur, India
GIUSEPPE BARILLARO
Univ. of Pisa, Italy
ARINDAM BASU
Nanyang Technological Univ.,
Singapore
SHARMISTHA BHADRA
McGill Univ., Canada
PARTHA BHATTACHARYYA
Indian Inst. of Engineering
Science and Technology, India
RAHUL BHATTACHARYYA
MIT Auto-ID Labs, USA
KARABI BISWAS
Indian Inst. of Technology Kharagpur, India
CHINMAY CHAKRABORTY
BIT Mesra, India
AMITAYA CHAKHERJEE
Jadavpur Univ., India
LIANG-BI CHEN
National Penghu Univ. of Science
and Technology, Taiwan
PAI-YEN CHEN
Wayne State Univ., USA
YUELIAN CHEN
Univ. of Manitoba, Canada
ZHENGHUA CHEN
Inst. for Infocomm Research (I2R),
A*STAR, Singapore
HUANYU (LARRY) CHENG
The Pennsylvania State Univ., USA
XU CHENG
Wuhan Inst. of Technology, China
XU CHENG
Tianjin Univ. of Technology, China
BHSKAR CHOUBEY
Universität Siegen
Naturwissenschaftlich-Technische
Fakultät, Germany
SHUBHAJIT ROY CHOWDHURY
Indian Inst. of Technology Mandi, India
TIEN-KAN CHIU
National Chiao Tung Univ.
JOÃO PAULO J. DA COSTA
Hamm-Lippstadt Univ. of Applied
Sciences, Germany
WALTENEUGS DARGIE
TU Dresden, Germany
FLORENC DEMIROZI
Univ. of Stavanger, Norway
SAAKSHI DHANEKAR
Indian Inst. of Technology Jodhpur, India
AMIR EBRAHIMI
RMIT Univ., Australia
WEILEUN FANG
National Tsing Hua Univ., Taiwan
TAI FEI
Univ. of Applied Sciences and
Art Dortmund, Germany
KE FENG
National Univ. of Singapore, Singapore
FRANCESCO FIORANELLI
Delft Univ. of Technology, The Netherlands
GIANCARLO FORTINO
Università della Calabria, Italy
BIN GAO
Univ. of Electronic Science
and Technology of China, China

ELENA GAURA
Cogent Computing Applied
Research Centre, U.K.
BOBY GEORGE
Indian Inst. of Technology
Madras, India
PANTELIS GEORGIU
Imperial College London, U.K.
SANKET GOEL
BITS-Pilani, India
VINAY CHAKRAVARTHI GOGINENI
NTNU-Trondheim, Norway
CHINTHAKA P. GOONERATNE
Indian Inst. of Technology, Madras, India
PROSANTA GOPE
The Univ. of Sheffield, U.K.
BENOIT GOSSELIN
Université Laval, Canada
FUQIANG GU
Chongqing Univ., China
PRASANTA KUMAR GUHA
Indian Inst. of Technology (IIT)
- Kharagpur, India
HAMIDA HALLIL
Univ. of Bordeaux, France
TE HAN
Beijing Inst. of Technology, China
DONGSOO HAR
KAIST, Korea
SHYQYRI HAXHA
Royal Holloway Univ.
of London, U.K.
CHAO HU
Univ. of Connecticut, USA
XUEHAO HU
University of Mons, Belgium
CHENG-SHENG HUANG
National Chiao Tung Univ., Taiwan
XINTAO HUAN
Beijing Inst. of Technology, China
SHIH-CHIA HUANG
National Taipei Univ.
of Technology, Taiwan
WEI-CHEN HUANG
National Yang Ming Chiao Tung
Univ., Taiwan
YULONG HUANG
Harbin Engineering Univ., China
CHUNG-CHIH (FRANK) HUNG
National Yang Ming Chiao Tung
Univ., Taiwan
AGOSTINO IADICICCO
Univ. of Naples Parthenope, Italy
BERNHARD JAKOB
Johannes Kepler Univ. Linz, Austria
MUHAMMAD ALI JAMSHED
Univ. of Glasgow, U.K.
MEHDI JAVANMARD
Rutgers Univ., USA
ABHISHEK KUMAR JHA
Gdańsk Univ. of Technology, Poland
RAJAN JHA
Indian Inst. of Technology (IIT)
Bhubaneswar, India
HAOJIAN JIN
Zhejiang Univ., China
GEETHU JOSEPH
Delft Univ. of Technology, The Netherlands
SUNGYONG JUNG
Univ. of Detroit State Univ., USA
BRAJESH KUMAR KAUSHIK
Indian Inst. of Technology
Roorkee, India
SHAKEB AHMAD KHAN
Jamia Millia Islamia (JMI), India
CHANG-SOO KIM
Missouri Univ. of Science and
Technology, USA
YOUNGWOOK KIM
Sogang Univ., South Korea
JURGEN KOSEL
King Abdullah Univ. of
Science and Technology,
Saudi Arabia
AJAY GIRI PRAKASH KOTTAPALLI
Univ. of Groningen, Netherlands
RICHARD F. KUZES
Pacific Northwest National
Laboratory, USA
GIJS KRUIJEN
Univ. of Twente, Netherlands
MAHESH K. KUZES
Indian Inst. of Technology, India
CHIMAN KWAN
Johns Hopkins Univ., USA
NAGESWARA LALAM
U.S. Department of Energy, USA
AIME LAY- EKUKILLE
Univ. of Salento, Italy

ANDRÉ EUGENIO LAZZARETTI
Universidade Tecnológica Federal
do Paraná, Brazil
ARNALDO G. LEAL JUNIOR
Universidade Federal do Espírito
Santo, Brazil
CHING-HUNG LEE
National Yang Ming Chiao Tung Univ.,
Taiwan
HSIN-YING LEE
National Cheng Kung Univ.,
Taiwan
HUANG CHEN LEE
National Chung Cheng Univ.,
Taiwan
JEONG BONG (JB) LEE
Baylor Univ., USA
SANG-SEOK LEE
Totomi Univ., Japan
SEONGWOOK LEE
Chung-Ang Univ., Republic of Korea
YUN-JU LEE
National Tsing Hua Univ., Taiwan
JUAN ANTONIO LEÑERO BARDALLO
Univ. of Seville, Spain
GUO LI
Chongqing Univ., China
NAN LI
Xidian Univ., China
QIILANG LI
George Mason Univ., USA
QING LI
Agricultural Univ., China
SHENG-SHAN LI
National Tsing Hua Univ.,
Taiwan
TAO LI, University of Cincinnati, USA
WEIHUA LI
South China Univ. of Technology,
China
XINGWANG LI
Henan Polytechnic Univ., China
YONGBO LI
Northwestern Polytechnical Univ., China
YONGJIA LI
Inftelcom Austria, Austria
YOU LI
Univ. of Calgary, Canada
ZENGE LI
China Univ. of Mining and
Technology, China
YU-TE LIAO
National Chiao Tung Univ.,
Taiwan
CHIH-TING LIN
National Taiwan Univ., Taiwan
YU-CHENG LIN
National Cheng Kung Univ.,
Taiwan
GUOZHEN LIU
Chinese Univ. of Hong Kong, China
LIANSHENG LIU,
Harbin Institute of
Technology, China
ZHILIANG LIU
Univ. of Electronic Science
and Technology of China, China
SILIANG LU
Anhui Univ., China
GUOMING MA
North China Electric Power Univ., China
JAIME LLORET MAURI
Universitat Politècnica de Valencia, Spain
YONGHAO MIAO
Beihang Univ., China
CHENG-YAO LO
National Tsing Hua Univ. (NTHU),
Taiwan
REZA MALEKIAN
Malmö Univ., Sweden
NIRUPAMA MANDAL
Indian Inst. of Technology (ISM)
Dhanbad, India
ENGIN MASAZADE
Marmara Univ., Turkey
RUI MIN
Beijing Normal Univ., China
SATYENDRA KUMAR MISHRA
SRM CCTC, Spain
ROSARIO MORELLO
Univ. Mediterranea of
Reggio Calabria, Italy

SHAIBAL MUKHERJEE
Indian Inst. of Technology
Indore, India
RAYIBABU MULAVEESALA
Indian Inst. of Technology Ropar, India
ANINDYA NAG
Technische Univ. Dresden, Germany
QING NI
Univ. of Technology Sydney, Australia
PEDRO OLIVEIRA CONCEIÇÃO JUNIOR
Univ. of São Paulo (USP), Brazil
DANILO ORLANDO
Univ. degli Studi di Pisa, Italy
OM JEE PAUNDE
IIT (BHU) Varanasi, India
SARBAJIT PAUL
ABB AG, Germany
LIANG PEI
Shanghai Jiao Tong Univ., China
MARC PETROVICH
Univ. of Southampton, U.K.
DAVID PLETS
imec-Ghent Univ., Belgium
R. N. PONNALAGU
BITS Pilani, India
OCTAVIAN POSTOLACHE
Instituto de Telecomunicações/IST,
Portugal
KHURAM KARIM QURESHI
King Fahd Univ. of Petroleum and Minerals,
Saudi Arabia
MUHAMMAD MAHBOOB UR RAHMAN
Information Technology Univ., Pakistan
IGNATIOS RAPTIS
NCSR Demokritos, Greece
PRIYADIP RAY
Lawrence Livermore Nat. Lab., USA
JEAN-MICHEL REDOUTÉ
Univ. of Liege, Belgium
VALÉRIE RENAUDIN
Gustave Eiffel Univ., France
FERRAN REVERTER
Universitat Politècnica de
Catalunya, Spain
CHIRASREE ROYCHAUDHURI
Indian Inst. of Engineering
Science and Technology, India
STEFAN RUPITSCH
Albert-Ludwigs-Universität Freiburg
Technische Fakultät, Germany
TAKUYA SAKAMOTO
Kyoto Univ., Japan
PIOTR SAMCZYŃSKI
Warsaw Univ. of Technology, Poland
FABRIZIO SANTI
Sapienza Univ. of Rome, Italy
AVIK SANTRA
Infineon Technologies, Germany
THILO SAUTER
Danube Univ. Krems, Austria
KAZUAKI SAWADA
Toyoashi Univ. of Technology, Japan
EDWARD SAZONOV
Univ. of Alabama, USA
EMILIANO SCIFENO
Univ. Campus Bio-Medico
di Roma, Italy
HAIDONG SHAO
Human Univ., China
ANUJ KUMAR SHARMA
National Inst. of Technology
Delhi, India
CHANGQING SHEN
Soochow Univ., China
JUANJUAN SHI
Soochow Univ., China
MARYAM SHOJAEI BAGHINI
Indian Institute of Technology
Bombay, India
JOSEPH SHOR
Bar-Ilan Univ., Israel
ANAND MOHAN SHRIVASTAV
SRM Inst. of Science and Technology, India
JITENDRA SINGH
CSIR-CEERI Pilani, India
GYMAMA SLAGHTER
Old Dominion Univ., USA
MARIOS SOPHOCLEOUS
eBOS Technologies Ltd, Cyprus
NAGENDER KUMAR SURYADEVARA
Univ. of Hyderabad, India
SHAWANA TABASSUM
UT Tyler, USA
LI-CHIA JERRY TAI
National Yang Ming Chiao Tung Univ.,
Taiwan
CHAO TAN
Tianjin Univ., China
ZHICHAO TAN
Zhejiang Univ., China

WEI TANG
New Mexico State Univ., USA
TAO TANG
Chinese Academy of Sciences, China
IRENE TURIN
KU Leuven Science Engineering and
Technology Group, Belgium
ANTREAS THEODOSIU
Lumocube LTD, Cyprus
GUI YUN TIAN
Univ. of Electronic Science
and Technology of China, China
MONIKA TOMAR
Univ. of Delhi, India
KAGAN TOPALLI
Astranis Space Technologies Corp., USA
MUSTAFA MERT TORUNBALCI
Broadcom Inc., USA
DANIELE TOSI
Nazarbayev Univ., Kazakhstan
TSUNG-HENG TSAI
National Yang Ming Chiao Tung Univ., Taiwan
MARKO VAHURKONEN
Univ. of Eastern Finland, Finland
JOHAN WAHLSTRÖM
University of Exeter, Sweden
BO WANG
Hamad Bin Khalifa Univ., Qatar
XIAO WANG
Soochow Univ., China
PENG WANG
Univ. of Kentucky, USA
LIN WANG
Queen Mary Univ. of London, U.K.
XIAO WANG
Anhui Univ., China
WEI WEI
Xi'an Univ. of Technology, China
FANGQING WEN
China Three Gorges Univ., China
THERAVUT WILAIPRASITORN
Vidyasirimedhi Inst. of Science
and Technology, Thailand
CHANG-HEE WON
Temple Univ., USA
KAI WU
Xaxia Tech Univ., USA
QIANG WU
Northumbria Univ., U.K.
YUEDONG XIE
Beihang University, China
YUYONG XIONG
Shanghai Jiao Tong Univ., China
CHEN YANG
Beihang Univ., China
MING YANG
Guizhou Univ., China
RUINHUI YANG
Anhui Medical Univ., China
YANG YANG
Chinese Academy of Sciences, China
HER-TERNG YAU
National Chung Cheng Univ., Taiwan
LEVENT YOBAS
Hong Kong Univ. of Science and Technology,
Hong Kong
RUI YUAN
Wuhan Univ. of Science and Technology,
China
XIAOFENG YUAN
Central South Univ., China
MINHEE YUN
Univ. of Pittsburgh, USA
MOHAMMAD HOSSEIN ZARIFI
Univ. of British Columbia, Canada
YING ZHANG
Georgia Inst. of Technology, USA
YU-DONG ZHANG
Univ. of Leicester, U.K.
CHUN ZHAO
Univ. of York, U.K.
HAOJIAN ZHAO
Southwest Jiaotong Univ., China
XIAOJIN ZHAO
Shenzhen Univ., China
YONGQIANG ZHAO
Northwestern Polytechnical
Univ., China
XIAOSHAN (SEAN) ZHU
Univ. of Nevada Reno, USA
BAODING ZHOU
Shenzhen University, China
NI ZHU
Univ. Gustave Eiffel, France
YONG ZHU
Griffith Univ., Australia

IEEE Publishing Operations

Senior Director, Publishing Operations: DAWN MELLEJ
Director, Editorial Services: KEVIN LISANKIE
Director, Production Services: PETER M. TUOHY
Associate Director, Digital Assets & Editorial Support: NEELAM KHINVASARA
Senior Manager, Journals Production: PATRICK KEMPP
Journals Production Manager: EILEEN MCGUINNESS

IEEE SENSORS JOURNAL (ISSN 1558-1748) is published semimonthly by The Institute of Electrical and Electronics Engineers, Inc. Responsibility for the contents rests upon the authors and not upon the IEEE, the Society/Council, or its members. **IEEE Corporate Office:** 3 Park Avenue, 17th Floor, New York, NY 10016. **IEEE Operations Center:** 445 Hoes Lane, Piscataway, NJ 08854. **NJ Telephone:** +1 732 981 0060. **Price/Publication Information:** Member and nonmember subscription prices available upon request. **Copyright and Reprint Permissions:** Abstracting is permitted with credit to the source. Libraries are permitted to photocopy for private use of patrons, provided the per-copy fee of \$31.00 is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For all other copying, reprint, or republication permission, write to Copyrights and Permissions Department, IEEE Publications Administration, 445 Hoes Lane, Piscataway, NJ 08854. Copyright © 2024 by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. IEEE prohibits discrimination, harassment and bullying. For more information visit <http://www.ieee.org/ nondiscrimination>.