Guest Editorial
Foreword to the Special Issue on Subsurface Sensing Using Ground-Penetrating Radar (GPR)

GROUND-PENETRATING radars (GPRs) have been utilized for subsurface sensing for more than 40 years; the wide range of applications includes geology, glaciology, sedimentology, hydrology, mining/tunneling, concrete/pavement evaluation, archaeology, and many others. The major advantage of GPR with respect to other nondestructive techniques is the combination of fine downrange resolution (which can be of the order of a few centimeters) with large penetration depth (ranging from less than a meter to over 3 km depending on material properties and operational frequency.) In addition to traditional surface-based GPRs, systems are now frequently operated on airborne or in subsurface platforms (also known as borehole radars). Several companies worldwide manufacture commercial GPR equipment, thousands of companies offer GPR services, and many institutions perform research in the field. GPR clearly is an important technology for geoscience and remote sensing applications.

The diversity of GPR applications has resulted in the evolution of a variety of radar systems, with all requiring coupling of radiation through an interface into the subsurface and almost all using ultrawide operational bandwidths (i.e., fractional bandwidths greater than 20%). GPR technologies and systems continue to evolve as the range of applications increases. Recent interests in mapping the underground infrastructure of urban areas, antipersonnel landmine detection, and archaeology demand not only 3-D imaging but also detection and classification of observed inhomogeneities. Responding to these demands, scientists and engineers from many areas (geophysics, hydrology, radar and antenna engineering, electromagnetic field theory, signal and image processing, inverse scattering, etc.) have continued to perform research in ultrawideband technologies, imaging/inversion methods, and scientific data interpretation. As a result, substantial advances have occurred in recent years.

This special issue of the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING (TGRS) serves to record the current state of the art and to report recent results to the wider geoscience and remote sensing community. Contributions for the special issue were solicited from papers presented at the biennial international scientific conference on GPR (held in Columbus, OH, in 2006 and Delft, The Netherlands, in 2004), as well as from the general geoscience and remote sensing community through announcements in TGRS. The special issue includes 17 papers selected through a thorough external review process. These papers describe new approaches to subsurface sensing, including developments in electromagnetic wave propagation, imaging/inversion of GPR data, and antenna/radar technologies. Associated applications range from glaciology to pavement evaluation to landmine detection. We are pleased to submit this special issue to the TGRS community and hope that it accomplishes the goal of capturing the current state of the art of GPR for remote sensing applications.

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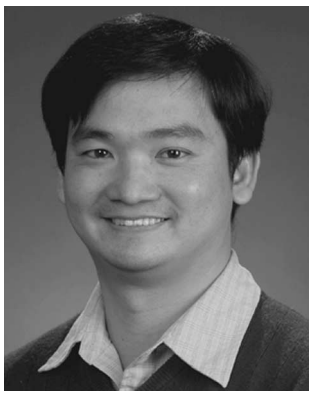


Chi-Chih Chen (S'92–M'97) received the M.S. and Ph.D. degrees from The Ohio State University (OSU), Columbus, in 1993 and 1997, respectively.

He has been with the ElectroScience Laboratory, OSU, since 1993 as a Postdoctoral Researcher (1997–1999), Senior Research Associate (1999–2003), and Research Scientist (2004–present). He is also an Adjunct Assistant Professor with the Department of Electrical and Computer Engineering, OSU. His research interests include ground-penetrating radar technology, novel radar systems (vehicle obstacle detection, insect tracking, RFID, etc.), buried target detection/classification, UWB antenna designs, UWB dual-polarization feed/probe antenna designs for antenna and RCS ranges, and miniature antenna designs for communication and navigation systems. He has published journal papers and book chapters in these areas and has given short courses on miniature antennas and ground-penetrating radar antennas.

Dr. Chen is a member of the American Physical Society, the IEEE Geoscience and Remote Sensing Society, the Society of Exploration Geophysicists, the Association for Machine Translation in the Americas, Sigma Xi, and Phi Kappa Phi. He has served as Treasurer, Vice Chairman, and Chairman of the Joint IEEE AP/MTT Columbus Chapter (2000–2002) and as Technical Chair for the 2006 International Conference on Ground Penetrating Radar (GPR). He is on the International Advisory/Science Committee of the International Conference on GPR. He was the recipient of the OSU Lumley Engineering Research Award in 2004 for his research contributions.

Joel T. Johnson (S'88–M'96–SM'03) received his bachelor's degree in electrical engineering from the Georgia Institute of Technology, Atlanta, in 1991 and the S.M. and Ph.D. degrees from the Massachusetts Institute of Technology, Cambridge, in 1993 and 1996, respectively.

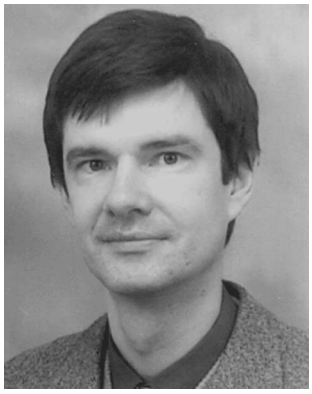
He is currently a Professor with the ElectroScience Laboratory, Department of Electrical and Computer Engineering, The Ohio State University, Columbus. His research interests are in the areas of microwave remote sensing, propagation, and electromagnetic wave theory.

Dr. Johnson is a member of Commissions B and F of the International Union of Radio Science (URSI) and a member of Tau Beta Pi, Eta Kappa Nu, and Phi Kappa Phi. He has been serving as an Associate Editor of the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING since 2001. He was the recipient of the Best Paper Award from the IEEE Geoscience and Remote Sensing Society in 1993, the Office of Naval Research Young Investigator Award, the National Science Foundation CAREER Award, and the Presidential Early Career Award for Scientists and Engineers. He was recognized by the U.S. National Committee of URSI as a Booker Fellow in 2002.

Motoyuki Sato (S'79–M'80–SM'02) received the B.E., M.E., and Dr. Eng. degrees from Tohoku University, Sendai, Japan, in 1980, 1982, and 1985, respectively, all in information engineering.

He is currently a Professor with the Center for Northeast Asian Studies, Tohoku University. From 1988 to 1989, he was a Visiting Researcher with the Federal German Institute for Geoscience and Natural Resources (BGR), Hannover, Germany. He has organized international research projects such as polarimetric borehole radar applications to hydrogeology within the U.S. and Korea, and various groundwater and permafrost surveys by GPR in collaboration with research centers in Mongolia, China, and Russia. Recently, he has been engaged in the development of GPR for humanitarian demining, and conducted field evaluation tests in Afghanistan, Egypt, Croatia, and Cambodia with local demining organizations. He has been a Visiting Professor with Jilin University (Changchun, China), the Delft University of Technology (Delft, The Netherlands), and the Mongolian University of Science and Technology (Inner Mongolia, China). His current interests include transient electromagnetics and antennas, radar polarimetry, GPR, borehole radar, electromagnetic induction sensing, and interferometric and polarimetric SAR.

Dr. Sato is a member of the Administrative Committee of the IEEE Geoscience and Remote Sensing Society (GRSS) (2006–2007), where he is responsible for specialty symposia and Asian issues. He currently serves as the Chair of the IEEE GRSS Japan Chapter (2006–present). He has organized GPR conferences in Japan biannually since 1989. He served as the Technical Chairman of the Sixth International Conference on Ground Penetrating Radar (GPR'96), Sendai, Japan, and was an Organization Committee Member of symposia, including the International Conference on Ground Penetrating Radar (since 1996 biannually). He is an Associate Editor of the IEEE GEOSCIENCE AND REMOTE SENSING LETTERS.



Alexander G. Yarovoy (M'96–SM'04) received the Diploma (with honors) in radiophysics and electronics and the Cand. Phys. & Math. Sci. and Dr. Phys. & Math. Sci. degrees in radiophysics from Kharkov State University, Kharkov, Ukraine, in 1984, 1987, and 1994, respectively.

In 1987, he joined the Department of Radiophysics, Kharkov State University, as a Researcher and then became a Full Professor in 1997. From September 1994 to 1996, he was with the Technical University of Ilmenau, Ilmenau, Germany, as a Visiting Researcher. Since 1999, he has been with the International Research Centre for Telecommunications-Transmission and Radar, Delft University of Technology, Delft, The Netherlands, where he coordinates all UWB-related projects. His main research interests are in UWB technology and its applications (in particular, GPR radars) and applied electromagnetics (in particular, UWB antennas).

Prof. Yarovoy served as the Co-Chairman and the Technical Program Committee Chair of the Tenth International Conference on Ground Penetrating Radar (GPR2004), Delft, and the Secretary of the First European Radar Conference (EuRAD'04), Amsterdam, The Netherlands. He was the recipient of the 1996 International Union of Radio Science (URSI) "Young Scientists Award" and the European Microwave Week Radar Award in 2001 for the paper that best advances the state-of-the-art in radar technology (together with L. P. Ligthart and P. van Genderen).