Radar Sensor Technology XX

Kenneth I. Ranney
Armin Doerry
Editors

18–21 April 2016
Baltimore, Maryland, United States

Sponsored and Published by
SPIE

Volume 9829
Contents

vii Authors
ix Conference Committee

SESSION 1 ALGORITHMS AND PROCESSING I

9829 02 Automatic polar ice thickness estimation from SAR imagery [9829-1]
9829 03 Exploiting synthetic aperture radar imagery for retrieving vibration signatures of concealed machinery [9829-2]
9829 04 Multistatic passive coherent location using multilateration techniques [9829-4]
9829 05 Frequency notching effects on GPR imagery while operating in crowded spectrum scenarios [9829-5]

SESSION 2 PROGRAMS AND SYSTEMS

9829 06 Context-sensitive design and human interaction principles for usable, useful, and adoptable radars [9829-6]
9829 07 Second generation of AVTIS FMCW millimeter wave radars for mapping volcanic terrain [9829-7]
9829 08 94 GHz pulsed coherent radar for high power amplifier evaluation [9829-8]
9829 09 Eye safe single aperture laser radar scanners for 3D acquisition [9829-9]
9829 0A FlexSAR, a high quality, flexible, cost effective, prototype SAR system [9829-10]

SESSION 3 APPLICATIONS AND EXPLOITATION

9829 0B Polarization differences in airborne ground penetrating radar performance for landmine detection [9829-11]
9829 0D Segmenting and extracting terrain surface signatures from fully polarimetric multifocus SAR-C data [9829-13]
9829 0E A millimeter-wave reflectometer for whole-body hydration sensing [9829-14]
9829 0F Microwave reconstruction method using a circular antenna array cooperating with an internal transmitter [9829-15]
### SESSION 4  NOISE AND LPI RADAR

| 9829 0G | Fractal characteristics for binary noise radar waveform [9829-16] |
| 9829 0H | High frequency oscillators for chaotic radar [9829-17] |
| 9829 0I | Investigation of correlation characteristics for random array collaborative beamforming using noise signals [9829-18] |
| 9829 0J | Investigation of target and ground clutter reflections on the correlation between transmitted and received noise signals [9829-19] |

### SESSION 5  ALGORITHMS AND PROCESSING II

| 9829 0K | Efficient sidelobe ASK based dual-function radar-communications [9829-21] |
| 9829 0L | Computationally efficient beampattern synthesis for dual-function radar-communications [9829-22] |

### SESSION 6  NONLINEAR AND COGNITIVE RADAR

| 9829 0O | Phase responses of harmonics reflected from radio-frequency electronics [9829-25] |
| 9829 0P | Derivation and validation of the nonlinear radar range equation [9829-26] |
| 9829 0Q | Waveform design for cognitive radar: target detection in heavy clutter [9829-27] |
| 9829 0R | A dynamic spectrum analysis solution for the characterization of the UHF spectrum [9829-28] |

### SESSION 7  INVITED SESSION ON PROFILES IN RESEARCH AND DEVELOPMENT

| 9829 0T | Pathfinder radar development at Sandia National Laboratories (Invited Paper) [9829-30] |
| 9829 0U | Trends in radar: a U.S. Army Research Laboratory perspective (Invited Paper) [9829-31] |
| 9829 0V | Three-dimensional radar imaging techniques and systems for near-field applications (Invited Paper) [9829-32] |

### SESSION 8  INDOOR/URBAN TARGET DETECTION, LOCALIZATION, AND TRACKING

| 9829 0Y | Feature analysis for indoor radar target classification [9829-35] |
| 9829 0Z | MIMO radar for through-wall target identification in single and two wall scenarios [9829-36] |
### SESSION 9  ALGORITHMS AND PROCESSING III

<table>
<thead>
<tr>
<th>9829 10</th>
<th>Synthetic aperture radar speckle reduction for circle mode SAR images [9829-37]</th>
</tr>
</thead>
<tbody>
<tr>
<td>9829 11</td>
<td>A novel photonic beam-space receiver for multi-function radar [9829-38]</td>
</tr>
<tr>
<td>9829 12</td>
<td>Matched filter based iterative adaptive approach [9829-39]</td>
</tr>
<tr>
<td>9829 13</td>
<td>An Implementation of real-time phased array radar fundamental functions on DSP-focused, high performance embedded computing platform [9829-40]</td>
</tr>
<tr>
<td>9829 14</td>
<td>Real-time radar signal processing using GPGPU (general-purpose graphic processing unit) [9829-41]</td>
</tr>
<tr>
<td>9829 15</td>
<td>Circuit models for Salisbury screens made from unidirectional carbon fiber composite sandwich structures [9829-42]</td>
</tr>
</tbody>
</table>

### SESSION 10  RADAR MICRODOPPLER

<table>
<thead>
<tr>
<th>9829 16</th>
<th>Some applications of the characteristics non-uniform Doppler to radar [9829-43]</th>
</tr>
</thead>
<tbody>
<tr>
<td>9829 17</td>
<td>Classification of human activity on water through micro-Dopplers using deep convolutional neural networks [9829-44]</td>
</tr>
<tr>
<td>9829 18</td>
<td>Radar fall detectors: a comparison [9829-45]</td>
</tr>
<tr>
<td>9829 19</td>
<td>Radar fall detection using principal component analysis [9829-46]</td>
</tr>
<tr>
<td>9829 1B</td>
<td>Radar micro-Doppler based human activity classification for indoor and outdoor environments [9829-48]</td>
</tr>
</tbody>
</table>

### SESSION 11  QUANTUM RADAR

<table>
<thead>
<tr>
<th>9829 1C</th>
<th>The generalized ambiguity function: a bridgework between classical and quantum radar [9829-49]</th>
</tr>
</thead>
<tbody>
<tr>
<td>9829 1D</td>
<td>Improving quantum sensing efficiency with virtual modes [9829-50]</td>
</tr>
<tr>
<td>9829 1E</td>
<td>Clutter attenuation using the Doppler effect in standoff electromagnetic quantum sensing [9829-51]</td>
</tr>
<tr>
<td>9829 1F</td>
<td>A quantum radar detection protocol for fringe visibility enhancement [9829-52]</td>
</tr>
<tr>
<td>9829 1G</td>
<td>Quantum seismography [9829-53]</td>
</tr>
<tr>
<td>9829 1H</td>
<td>Analytical formulation of the quantum electromagnetic cross section [9829-54]</td>
</tr>
<tr>
<td>9829 1I</td>
<td>Quantum computation of the electromagnetic cross section of dielectric targets [9829-55]</td>
</tr>
</tbody>
</table>
### SESSION 12  CS FOR RADAR: JOINT SESSION WITH CONFERENCES 9829 AND 9857

<table>
<thead>
<tr>
<th>9829 1J</th>
<th>A new two-step algorithm for spotlight synthetic aperture radar imaging [9829-56]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POSTER SESSION</strong></td>
<td></td>
</tr>
<tr>
<td>9829 1K</td>
<td>Antenna phase center locations in tapered aperture subarrays [9829-57]</td>
</tr>
<tr>
<td>9829 1L</td>
<td>Representing SAR complex image pixels [9829-58]</td>
</tr>
<tr>
<td>9829 1M</td>
<td>Comments on airborne ISR radar utilization [9829-59]</td>
</tr>
<tr>
<td>9829 1N</td>
<td>Index for surface coherence (ISC): a method for calculating change susceptibility [9829-60]</td>
</tr>
<tr>
<td>9829 1P</td>
<td>Instantaneous stepped-frequency, non-linear radar part 2: experimental confirmation [9829-65]</td>
</tr>
<tr>
<td>9829 1Q</td>
<td>Urban-area extraction from polarimetric SAR image using combination of target decomposition and orientation angle [9829-66]</td>
</tr>
<tr>
<td>9829 1R</td>
<td>Fully polarimetric data from the ARL RailSAR [9829-67]</td>
</tr>
<tr>
<td>9829 1S</td>
<td>Distributed transmit beamforming on mobile platforms using high-accuracy microwave wireless positioning [9829-68]</td>
</tr>
</tbody>
</table>
Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Adler, Eric D., 0U
Ahmad, Fauzia, 0K, 18, 19
Alexander, David B., 0I
Allebach, Joshua M., 0J
Amin, Moeness G., 0K, 0L, 18, 19
Atwood, Thomas, 03
Balasingham, Ilangko, 0F
Beal, A. N., 0H
Bickel, D. L., 1K
Blake, William, 12
Blakely, J. N., 0H
Boashash, Boualem, 18, 19
Brandsema, Matthew J., 1H
Breaux, Nancy A., 16
Broderick, Sean P., 0Z
Brown, E. R., 0E
Bufler, Travis D., 0Y
Cai, Jingxiao, 14
Campbell, Justin B., 03
Capron, Barbara, 1F
Cassidy, Scott L., 07
Castillo, Steven, 0T
Christianson, Andrew J., 04
Comberiate, Thomas M., 1S
Corron, N. J., 0H
Dean, R. N., 0H
Deroba, Joseph C., 11
Dietlein, Charles, 0U
Doery, Armin, 03, 1K, 1L, 1M
Dogaru, Traian, 0B, 0U
Dunkel, Ralf, 03
Erol, Baris, 18
Finegan, T. M., 09
Fox, Geoffrey C., 02
Gallacher, Thomas F., 08
Gallagher, Kyle A., 00, 0P, 0R, 0U, 1P
Geaga, Jorge V., 0D
Gebhardt, Evan T., 0Z
Gerstle, Walter H., 03
Govoni, Mark A., 0U
Gray, John E., 16, 1C
Hall, Thomas E., 0V
Hansen, Jeremiah J., 16
Haslem, Brent, 0A
Hassanien, Aboulhasr, OK, 0L
Hayat, Majeed M., 03
Hedden, Abigail, 0U
Himed, Braham, 0I, 0J
Hodkin, Jason E., 1S
Hu, Mengqi, 1J
Hunter, Robert L., 08
Jaramillo, Monica, 03
Jensen, Mark, 0A
Jitrik, Oliverio, 1D, 1E, 1G, 1I
Jokanovic, Branka, 19
Jones, A. Mark, 0V
Kaiser, Sean A., 04
Kim, Youngwook, 17
Kirk, Benjamin H., 0Q
Kirose, Getachew, 1R
Klein, Laura M., 06
Knight, Chad, 0A
Koltenbah, Benjamin, 1F
Kong, Fanxing, 14
Lanzagorta, Marco, 1D, 1E, 1G, 1H, 1I
Le, Calvin, 0B
Le, Truc, 1D
Lenzing, Erik H., 15
Li, Bing C., 0G
Li, Zhengzheng, 12
Lu, Da, 1Q
Macfarlane, David G., 07
Martone, Anthony F., 00, 0P, 0Q, 0R, 0U, 1P
Mazzaro, Gregory J., 00, 0P, 1P
McCormick, K., 09
McGowan, Sean F., 00
McMakin, Douglas L., 0V
McNamara, Laura A., 06
Mitchell, Gregory, 0U
Moon, Taesup, 17
Musgrove, Cameron, 10
Nanzer, Jeffrey A., 1S
Narayanan, Ram M., 04, 05, 0F, 0I, 0J, 0O, 0P, 0Q, 0R, 0Y, 0Z, 15, 1B, 1H, 1P
Nepal, Ramesh, 12
Nolan, P., 09
Palmer, Robert D., 14
Parazzoli, Claudia, 1F
Parks, Allen D., 1C
Patel, Ankit, 13
Pérez, Francisco, 03
Phelan, Brian R., 05, 1R
Pooler, Richard K., 0R
Prather, Dennis, 11
Qiao, Zhijun G., 1J, 1Q
Rahnemooonfar, Maryam, 02
Ranney, Kenneth I., 05, 0U, 1P, 1R
Ressler, Marc A., 05
Riley, Elliot J., 15
Robertson, Duncan A., 07, 08
Santhanam, Balu, 03
Schuetz, Chris, 11
Sheen, David M., 0V
Sherbondy, Kelly D., 05, 0O, 0P, 0Q, 0R, 1P, 1R
Shi, Shouyuan, 11
Smith, Gregory D., 05
Starodubov, D., 09
Sun, Ligang, 1J
Tedeschi, Jonathan R., 0V
Tran, Jonathan, 1N
Uhlmann, Jeffrey, 1D, 1E, 1G, 1I
Venegas-Andraca, Salvador E., 1D, 1E, 1G, 1I
Volfson, L., 09
Wang, Guanyong, 1J
Weber, Mark, 13
Wiesman, Seth, 11
Wu, Zhilu, 1Q
Yari, Masoud, 02
Yu, Xining, 13
Zaghloul, Amir, 0U
Zahrai, Allen, 13
Zenaldin, Matthew, 1B
Zhang, Lei, 1J
Zhang, W.-D., 0E
Zhang, Yan Rockee, 12, 13, 14
Zhang, Yimin D., 0K, 0L
Zhou, Huiyuan, 0F
Zilevu, Kojo S., 1S
Zou, Bin, 1Q
Conference Committee

Symposium Chair
David A. Logan, BAE Systems (United States)

Symposium Co-chair
Donald A. Reago Jr., U.S. Army Night Vision & Electronic Sensors Directorate (United States)

Conference Chairs
Kenneth I. Ranney, U.S. Army Research Laboratory (United States)
Armin Doerry, Sandia National Laboratories (United States)

Conference Program Committee
Fauzia Ahmad, Villanova University (United States)
Moeness G. Amin, Villanova University (United States)
Joseph C. Deroba, U.S. Army CERDEC Intelligence and Information Warfare Directorate (United States)
Mark Govoni, U.S. Army CERDEC Intelligence and Information Warfare Directorate (United States)
John E. Gray, Naval Surface Warfare Center Dahlgren Division (United States)
Majeed Hayat, The University of New Mexico (United States)
Chandra Kambhamettu, University of Delaware (United States)
Seong-Hwoon Kim, Raytheon Space & Airborne Systems (United States)
James L. Kurtz, University of Florida (United States)
Marco O. Lanzagorta, U.S. Naval Research Laboratory (United States)
Changzhi Li, Texas Tech University (United States)
Jenshan Lin, University of Florida (United States)
Hao Ling, The University of Texas at Austin (United States)
David G. Long, Brigham Young University (United States)
Jia-Jih Lu, General Atomics Aeronautical Systems, Inc. (United States)
Neeraj Magotra, Western New England University (United States)
Anthony F. Marfone, U.S. Army Research Laboratory (United States)
Gregory J. Mazzaro, The Citadel (United States)
George J. Moussally, Mirage Systems (United States)
Ram M. Narayanan, The Pennsylvania State University (United States)
Lam H. Nguyen, U.S. Army Research Laboratory (United States)
Hector A. Ochoa, The University of Texas at Tyler (United States)
Zhijun G. Qiao, The University of Texas-Pan American (United States)
Ann Marie Raynal, Sandia National Laboratories (United States)
Jerry Silvious, U.S. Army Research Laboratory (United States)
Brian Smith, U.S. Army Armament Research, Development and Engineering Center (United States)
Helmut Suess, Deutsches Zentrum für Luft- und Raumfahrt e.V. (Germany)
David Tahmoush, U.S. Army Research Laboratory (United States)
Russell Vela, Air Force Research Laboratory (United States)
Berenice Verdin, The University of Texas at El Paso (United States)
Frank Yakos, SELEX Galileo, Inc. (United States)
Yan Rockee Zhang, The University of Oklahoma (United States)

Session Chairs

Opening Remarks
Armin W. Doerry, Sandia National Laboratories (United States)
Kenneth I. Ranney, U.S. Army Research Laboratory (United States)

1 Algorithms and Processing I
Jerry L. Silvious, U.S. Army Research Laboratory (United States)

2 Programs and Systems
Gregory J. Mazzaro, The Citadel (United States)

3 Applications and Exploitation
Joseph C. Deroba, U.S. Army CERDEC Intelligence and Information Warfare Directorate (United States)

4 Noise and LPI Radar
Yan Rockee Zhang, The University of Oklahoma (United States)

5 Algorithms and Processing II
Lam H. Nguyen, U.S. Army Research Laboratory (United States)

6 Nonlinear and Cognitive Radar
Anthony F. Martone, U.S. Army Research Laboratory (United States)

7 Invited Session on Profiles in Research and Development
Armin W. Doerry, Sandia National Laboratories (United States)
Kenneth I. Ranney, U.S. Army Research Laboratory (United States)

8 Indoor/Urban Target Detection, Localization, and Tracking
Ram M. Narayanan, The Pennsylvania State University (United States)

9 Algorithms and Processing III
Ann Marie Raynal, Sandia National Laboratories (United States)
10 Radar MicroDoppler
Ram M. Narayanan, The Pennsylvania State University (United States)

11 Quantum Radar
Marco O. Lanzagorta, U.S. Naval Research Laboratory (United States)
Salvador Elias Venegas-Andraca, Tecnológico de Monterrey (Mexico)

12 CS for Radar: Joint Session with Conferences 9829 and 9857
Ram M. Narayanan, The Pennsylvania State University (United States)