

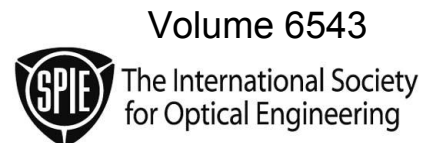
PROCEEDINGS OF SPIE

Infrared Imaging Systems: Design, Analysis, Modeling, and Testing XVIII

Gerald C. Holst
Editor

11–13 April 2007
Orlando, Florida, USA

Sponsored and Published by
SPIE—The International Society for Optical Engineering



Proceedings of SPIE—The International Society for Optical Engineering, 9780819466655, v. 6543

SPIE is an international technical society dedicated to advancing engineering and scientific applications of optical, photonic, imaging, electronic, and optoelectronic technologies.

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Infrared Imaging Systems: Design, Analysis, Modeling, and Testing XVIII*, edited by Gerald C. Holst, Proceedings of SPIE Vol. 6543 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819466655

Published by
SPIE—The International Society for Optical Engineering
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone 1 360/676-3290 (Pacific Time) • Fax 1 360/647-1445
<http://www.spie.org>

Copyright © 2007, The Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at <http://www.copyright.com>. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/07/\$18.00.

Printed in the United States of America.

Contents

ix *Conference Committee*

SESSION 1 TARGET, BACKGROUNDS, AND ATMOSPHERICS I

- 654302 **Simulation of active and passive infrared images using the SE-WORKBENCH (Keynote Paper)** [6543-01]
J. Latger, T. Cathala, N. Douchin, OKTAL Synthetic Environment (France); A. Le Goff, DGA/DET/CELAR (France)
- 654303 **Modelling and analysis of ship surface BRDF** [6543-02]
D. A. Vaitekunas, W. R. Davis Engineering, Ltd. (Canada)
- 654304 **Modelling reflections from exact surfaces in CameoSim** [6543-03]
A. A. Mitchell, J. M. Brewster, A. W. Haynes, P. A. Richardson, Defence Science and Technology Lab. (United Kingdom)
- 654305 **CUBI: a test body for thermal object model validation** [6543-04]
A. Malaplate, P. Grossmann, F. Schwenger, Research Institute for Optronics & Pattern Recognition (FGAN-FOM) (Germany)

SESSION 2 TARGET, BACKGROUNDS, AND ATMOSPHERICS II

- 654307 **Computer-aided camouflage assessment in real time** [6543-06]
T. Müller, M. Müller, Fraunhofer Institute IITB (Germany)
- 654308 **A new instrument for measuring optical transmission in the atmosphere** [6543-07]
T. A. Kaurila, Defence Forces Technical Research Centre (Finland)

Pagination: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication.

SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

SESSION 3 MODELING I

- 65430A **An engineer's approach to system performance (Invited Paper)** [6543-09]
G. C. Holst, JCD Publishing Co. (USA)
- 65430B **Range performance benefit of contrast enhancement** [6543-10]
R. Vollmerhausen, EO Consultant (USA); V. Hodgkin, Night Vision and Electronic Sensors Directorate, RDECOM (USA)
- 65430C **NVThermIP vs TOD: matching the target acquisition range criteria** [6543-11]
P. Bijl, M. A. Hogervorst, TNO Defense Security and Safety, Human Factors (Netherlands)
- 65430D **Cell balancing for vehicle identification perception experiments and correcting for cell imbalance in test results** [6543-12]
R. K. Moore, E. L. Jacobs, C. E. Halford, Univ. of Memphis (USA)
- 65430E **Super-resolution reconstruction and local area processing** [6543-13]
G. C. Holst, JCD Publishing (USA); E. Cloud, H. Lee, T. Pace, D. Manville, J. Puritz, DRS Technologies (USA)

SESSION 4 MODELING II

- 65430F **Direct view optics model for facial identification** [6543-14]
R. G. Driggers, S. Moyer, U.S. Army Night Vision and Electronic Sensors Directorate (USA); K. Krapels, Office of Naval Research (USA); L. Larsen, J. Fanning, J. G. Hixson, U.S. Army Night Vision and Electronic Sensors Directorate (USA); R. H. Vollmerhausen, EO Consultant (USA)
- 65430G **Effects of band-limited noise on human observer performance** [6543-15]
S. Salem, E. Jacobs, R. Moore, Univ. of Memphis (USA); M. Hogervorst, P. Bijl, TNO Human Factors (Netherlands); C. Halford, Univ. of Memphis (USA)
- 65430H **Temporal/spatial tracking requirements for tracking humans** [6543-16]
A. L. Robinson, The Univ. of Memphis (USA); B. Miller, S. Moyer, C. Ra, U.S. Army Night Vision and Electronic Sensors Directorate (USA)
- 65430I **An image sharpness metric for image processing applications using feedback** [6543-17]
E. P. Lam, Thales Raytheon Systems (USA) and Raytheon Space and Airborne Systems (USA); C. A. Leddy, S. R. Nash, Raytheon Space and Airborne Systems (USA)
- 65430J **Sine wave contrast target for direct view optics field performance measurements** [6543-18]
K. Krapels, P. Larson, Office of Naval Research/Naval Research Laboratory Reserves (USA); R. G. Driggers, L. Larsen, J. Fanning, U.S. Army Night Vision and Electronic Sensors Directorate (USA)
- 65430K **Third-generation FLIR simulation at NVESD** [6543-55]
P. Richardson, B. Miller, U.S. Army Night Vision and Electronic Sensors Directorate (USA)

WORKSHOP ON V50, E-ZOOM, AND BOOST MODELING APPROACHES

- 65430L **Guidance on methods and parameters for Army target acquisition models** [6543-56]
B. P. Teaney, J. P. Reynolds, J. O'Connor, U.S. Army Night Vision and Electronic Sensors Directorate (USA)

SESSION 5 MODELING III

- 65430M **Electronic zoom functionality in under-sampled imaging systems** [6543-19]
S. D. Burks, J. P. Reynolds, J. Hixson, B. Teaney, U.S. Army Night Vision and Electronic Sensors Directorate (USA); R. Vollmerhausen, Consultant (USA)
- 65430N **Finding a fusion metric that best reflects human observer preference** [6543-20]
R. K. Moore, C. E. Halford, C. L. Howell, The Univ. of Memphis (USA)
- 65430O **Impact of path radiance on MWIR and LWIR imaging** [6543-21]
V. A. Hodgkin, T. Maurer, U.S. Army Night Vision and Electronic Sensors Directorate (USA); C. Halford, Univ. of Memphis (USA); R. Vollmerhausen, Consultant (USA)
- 65430P **A new optical flow estimation method in joint EO/IR video surveillance** [6543-22]
H. Man, Stevens Institute of Technology (USA); R. J. Holt, City Univ. of New York (USA); J. Wang, R. Martini, R. Netravali, I. Mukherjee, Stevens Institute of Technology (USA)

SESSION 6 MODELING IV

- 65430Q **Correlation between the number of spatial, thermal, and total cues in LWIR imagery and probability of identification** [6543-24]
M. Brickell, Univ. of Memphis (USA); T. Edwards, Redstone Technical Test Ctr. (USA); C. Halford, Univ. of Memphis (USA); K. Dennen, ERC, Inc. (USA)
- 65430R **Silhouette and background information analysis** [6543-25]
M. N. Moore, J. D. O'Connor, U.S. Army Night Vision and Electronic Sensors Directorate (USA)
- 65430S **Quantitative analysis of infrared contrast enhancement algorithms** [6543-26]
S. Weith-Glushko, C. Salvaggio, Rochester Institute of Technology (USA)
- 65430T **Active imaging system performance model for target acquisition** [6543-27]
R. L. Espinola, B. Teaney, Q. Nguyen, U.S. Army Night Vision and Electronic Sensors Directorate (USA); E. L. Jacobs, C. E. Halford, The Univ. of Memphis (USA); D. H. Tofsted, U.S. Army Research Lab. (USA)

SESSION 7 MODELING V

- 65430U **Modeling the blur associated with vibration and motion** [6543-28]
R. Vollmerhausen, Consultant (USA); M. H. Friedman, J. Reynolds, S. Burks, U.S. Army Night Vision and Electronic Sensors Directorate (USA)

- 65430V **An evaluation of fusion algorithms using image fusion metrics and human identification performance** [6543-29]
C. Howell, R. Moore, Univ. of Memphis (USA); S. Burks, U.S. Army Night Vision and Electronic Sensors Directorate (USA); C. Halford, Univ. of Memphis (USA)
- 65430W **EO/IR sensor model for evaluating multispectral imaging system performance** [6543-30]
R. Richwine, Millenium Engineering and Integration Co. (USA); A. K. Sood, Magnolia Optical Technologies (USA); R. S. Balcerak, Defense Advanced Research Projects Agency (USA); K. Freyvogel, Pennsylvania State Electro-Optics Center (USA)
- 65430X **Modeling the effects of high contrast and saturated images on target acquisition performance** [6543-31]
B. P. Teaney, J. G. Hixson, B. Blecha, U.S. Army Night Vision and Electronic Sensors Directorate (USA)
- 65430Y **Designing an error metric for super-resolution enhanced IR passive ranging** [6543-32]
J. H. Cha, U.S. Army Night Vision and Electronic Sensors Directorate (USA); A. L. Abbott, Virginia Polytechnic Institute and State Univ. (USA)
- 65430Z **IR system field performance with superresolution** [6543-33]
J. Fanning, J. Miller, U.S. Army Night Vision and Electronic Sensors Directorate (USA); J. Park, G. Tener, Lockheed Martin Missiles and Fire Control (USA); J. Reynolds, U.S. Army Night Vision and Electronic Sensors Directorate (USA); P. O'Shea, U.S. Army Redstone Technical Test Center (USA); C. Halford, Univ. of Memphis (USA); R. Driggers, U.S. Army Night Vision and Electronic Sensors Directorate (USA)

SESSION 8 SYSTEMS AND TESTING I

- 654310 **Real-time image processing and fusion for a new high-speed dual-band infrared camera** [6543-34]
M. Müller, Fraunhofer Institut für Informations-und Datenverarbeitung (Germany); O. Schreer, M. López Sáenz, IRCAM GmbH (Germany)
- 654311 **Broad-band optical test bench (OPTISHOP) to measure MTF and transmittance of visible and IR optical components** [6543-35]
D. Cabib, A. Rahav, T. Barak, CI Systems Ltd. (Israel)
- 654312 **Detector spatial response testing of LWIR FPAs** [6543-36]
K. A. Lindahl, W. Burmester, K. L. Whiteaker, R. Banks, E. E. Penniman, P. B. Johnson, Ball Aerospace & Technologies Corp. (USA)
- 654313 **Automated testing of ultraviolet, visible, and infrared sensors using shared optics** [6543-37]
J. A. Mazzetta, S. D. Scopatz, Electro Optical Industries, Inc. (USA)

SESSION 9 SYSTEMS AND TESTING II

- 654314 **Advances in infrared lens characterization: measurement of MTF using common undersampled IR systems** [6543-39]
C. Nichols, StingRay Optics (USA); P. Bryant, Left Coast Consulting (USA); C. Alexay, StingRay Optics (USA)

- 654317 **Characterization of a C-QWIP LWIR camera** [6543-44]
D. P. Forrai, M. Sempstrott, R. Fischer, L-3 Communications Cincinnati Electronics, Inc. (USA); K.-K. Choi, U.S. Army Research Lab. (USA); J. W. Devitt, L-3 Communications Cincinnati Electronics, Inc. (USA)
- 654318 **Near infrared testbed sensor** [6543-45]
R. B. Sanderson, J. F. McCalmont, Air Force Research Lab. (USA); J. B. Montgomery, M&M Aviation (USA); R. S. Johnson, MacAulay-Brown, Inc. (USA); D. J. McDermott, Air Force Research Lab. (USA)
- 65431A **Signal processing for distributed sensor concept: DISCO** [6543-47]
M. K. Rafailov, Richer, Inc (USA)
- 65431B **Laser dazzling of focal plane array cameras** [6543-48]
R. (H.) M. A. Schleijsen, J. C. van den Heuvel, A. L. Mieremet, TNO Defense, Security and Safety (Netherlands); B. Mellier, CELAR (France); F. J. M. van Putten, TNO Defense, Security and Safety (Netherlands)

POSTER SESSION

- 65431D **Multimodal human verification using stereo-based 3D information, IR, and speech**
[6543-53]
C. Park, Samsung Thales Co., Ltd. (South Korea)

Supplement to Workshop: Question-and-Answer Transcript, Guidance on methods and parameters for Army target acquisition models [6543-56]

Author Index

Conference Committee

Symposium Chair

John C. Carrano, Luminex Corporation (USA)

Symposium Cochair

Larry B. Stotts, Defense Advanced Research Projects Agency (USA)

Program Track Chair

Gabor F. Fulop, Maxtech International, Inc. (USA)

Conference Chair

Gerald C. Holst, JCD Publishing Co. (USA)

Program Committee

Piet Bijl, TNO Defense, Security and Safety: Human Factors (Netherlands)

Frank R. Carlen, U.S. Army Aberdeen Test Center (USA)

Dieter Clement, Forschungsfesellschaft für Angewandte
Naturwissenschaften e.V. (Germany)

Ronald G. Driggers, U.S. Army Night Vision and Electronic Sensors
Directorate (USA)

David P. Forrai, L-3 Communications Cincinnati Electronics, Inc. (USA)

Thomas Holland, Naval Surface Warfare Center (USA)

Keith A. Krapels, Office of Naval Research (USA)

Terrence S. Lomheim, The Aerospace Corporation (USA)

Stephen W. McHugh, Santa Barbara Infrared, Inc. (USA)

Luanne P. Obert, U.S. Army Night Vision and Electronic Sensors Directorate
(USA)

Hector M. Reyes, Raytheon Co. (USA)

Michael A. Soel, FLIR Systems, Inc. (USA)

John J. Szymanski, Los Alamos National Laboratory (USA)

Curtis M. Webb, Northrop Grumman Corporation (USA)

Session Chairs

- 1 Target, Backgrounds, and Atmospherics I
Frank R. Carlen, U.S. Army Aberdeen Test Center (USA)
Dieter Clement, Forschungsfesellschaft für Angewandte
Naturwissenschaften e.V. (Germany)

- 2 Target, Backgrounds, and Atmospherics II
Frank R. Carlen, U.S. Army Aberdeen Test Center (USA)
Dieter Clement, Forschungsfesellschaft für Angewandte
Naturwissenschaften e.V. (Germany)
- 3 Modeling I
Piet Bijl, TNO Defense, Security and Safety: Human Factors (Netherlands)
Michael A. Soel, FLIR Systems, Inc. (USA)
Hector M. Reyes, Raytheon Company (USA)
- 4 Modeling II
Piet Bijl, TNO Defense, Security and Safety: Human Factors (Netherlands)
Michael A. Soel, FLIR Systems, Inc. (USA)
Hector M. Reyes, Raytheon Company (USA)
- 5 Modeling III
Keith A. Krapels, Office of Naval Research (USA)
Ronald G. Driggers, U.S. Army Night Vision and Electronic Sensors
Directorate (USA)
- 6 Modeling IV
Joseph P. Reynolds, U.S. Army Night Vision and Electronic Sensors
Directorate (USA)
Terrence S. Lomheim, The Aerospace Corporation (USA)
- 7 Modeling V
Joseph P. Reynolds, U.S. Army Night Vision and Electronic Sensors
Directorate (USA)
Terrence S. Lomheim, The Aerospace Corporation (USA)
- 8 Systems and Testing I
David P. Forrai, L-3 Communications Cincinnati Electronics, Inc. (USA)
John J. Szymanski, Los Alamos National Laboratory (USA)
- 9 Systems and Testing II
Jay James, Santa Barbara Infrared, Inc. (USA)
Curtis M. Webb, Northrop Grumman Corporation (USA)