

*Medical Imaging 2014:*

---

# ***PACS and Imaging Informatics: Next Generation and Innovations***

**Maria Y. Law  
Tessa S. Cook**  
*Editors*

**18–20 February 2014  
San Diego, California, United States**

*Sponsored by*  
SPIE

*Cosponsored by*  
Modus Medical Devices Inc. (Canada)  
XIFIN, Inc.  
Ventana Medical Systems Inc.  
Intrace Medical (Switzerland)

*Cooperating Organizations*  
AAPM—American Association of Physicists in Medicine (United States) • APS—American Physiological Society • CARS—Computer Assisted Radiology and Surgery (Germany) • The DICOM Standards Committee • Medical Image Perception Society (United States) • Radiological Society of North America (United States) • Society for Imaging Informatics in Medicine (United States) • World Molecular Imaging Society

*Published by*  
SPIE

**Volume 9039**

Proceedings of SPIE, 1605-7422, V. 9039

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Medical Imaging 2014: PACS and Imaging Informatics: Next Generation and Innovations,  
edited by Maria Y. Law, Tessa S. Cook, Proc. of SPIE Vol. 9039, 903901 • © 2014 SPIE  
CCC code: 1605-7422/14/\$18 • doi: 10.1117/12.2064442

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 *Medical Imaging 2014: PACS and Imaging Informatics: Next Generation and Innovations*, edited by Maria Y. Law, Tessa S. Cook, Proceedings of SPIE Vol. 9039 (SPIE, Bellingham, WA, 2014) Article CID Number.

ISSN: 1605-7422

ISBN: 9780819498328

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2014, 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 [copyright.com](http://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 1605-7422/14/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



[SPIDigitalLibrary.org](http://SPIDigitalLibrary.org)

---

**Paper Numbering:** 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 as 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. Numbers in the index correspond to the last two digits of the six-digit CID Number.

# Contents

- vii *Conference Committee*
- ix *Awards*
- xi *Re-Thinking CAD for the next generation (Keynote Summary) [9039-1]*  
*Siegel, E, Univ. of Maryland School of Medicine (United States) and Veterans Affairs*  
*Maryland Health Care System (United States)*

---

## BEYOND PACS: ADVANCED RADIOLOGY WORKFLOW

---

- 9039 03 **Development of a web-based DICOM-SR viewer for CAD data of multiple sclerosis lesions in an imaging informatics-based efolder [9039-2]**  
K. Ma, J. Wong, M. Zhong, J. Zhang, B. Liu, The Univ. of Southern California (United States)
- 9039 04 **Remote volume rendering pipeline for mHealth applications [9039-3]**  
I. Gutenko, K. Petkov, C. Papadopoulos, X. Zhao, J. H. Park, A. Kaufman, Stony Brook Univ. (United States); R. Cha, Samsung Research America (United States)
- 9039 05 **Separation of metadata and bulkdata to speed DICOM tag morphing [9039-4]**  
M. Ismail, Y. Ning, J. Philbin, Johns Hopkins Univ. (United States)
- 9039 06 **The oncology medical image database (OMI-DB) [9039-5]**  
M. D. Halling-Brown, P. T. Looney, M. N. Patel, The Royal Surrey County Hospital NHS Trust (United Kingdom); L. M. Warren, A. Mackenzie, K. C. Young, The Royal Surrey County Hospital NHS Trust (United Kingdom) and Univ. of Surrey (United Kingdom)
- 9039 07 **A concept of a generalized electronic patient record for personalized medicine [9039-6]**  
J. Meier, Univ. Leipzig (Germany); R. Deshpande, B. J. Liu, The Univ. of Southern California (United States); T. Neumuth, Univ. Leipzig (Germany)
- 9039 08 **Biomedical image representation and classification using an entropy weighted probabilistic concept feature space [9039-7]**  
M. M. Rahman, S. K. Antani, D. Demner-Fushman, G. R. Thoma, National Library of Medicine (United States)

---

## MEDICAL IMAGE SHARING AND EXCHANGE

---

- 9039 09 **OC ToGo: bed site image integration into OpenClinica with mobile devices [9039-8]**  
D. Haak, J. Gehlen, S. Jonas, T. M. Deserno, Uniklinik RWTH Aachen (Germany)
- 9039 0B **Medical imaging document sharing solutions for various kinds of healthcare services based on IHE XDS/XDS-I profiles [9039-10]**  
J. Zhang, Y. Yang, K. Zhang, J. Sun, T. Ling, T. Wang, M. Wang, Shanghai Institute of Technical Physics (China); P. Bak, McMaster Univ. (Canada)

- 9039 0C **Automated collection of medical images for research from heterogeneous systems: trials and tribulations** [9039-28]  
M. N. Patel, P. Looney, K. Young, M. D. Halling-Brown, The Royal Surrey County Hospital NHS Trust (United Kingdom)
- 9039 0D **OsiriX plugin for integrated cardiac imaging research** [9039-12]  
M. Hüllebrand, A. Hennemuth, Fraunhofer MEVIS (Germany); D. Messroghli, T. Kühne, Deutsches Herzzentrum Berlin (Germany)

---

#### DIAGNOSTICS AND THERAPEUTIC APPLICATIONS OF IMAGING INFORMATICS

---

- 9039 0E **A web-based neurological pain classifier tool utilizing Bayesian decision theory for pain classification in spinal cord injury patients** [9039-13]  
S. K. Verma, The Univ. of Southern California (United States); S. Chun, VA Long Beach Healthcare System (United States); B. J. Liu, The Univ. of Southern California (United States)
- 9039 0F **Wearable technology as a booster of clinical care** [9039-14]  
S. Jonas, A. Hannig, C. Spreckelsen, T. M. Deserno, Uniklinik RWTH Aachen (Germany)
- 9039 0G **Development of a user customizable imaging informatics-based intelligent workflow engine system to enhance rehabilitation clinical trials** [9039-15]  
X. Wang, C. Martinez, J. Wang, Y. Liu, B. Liu, The Univ. of Southern California (United States)
- 9039 0H **Mapping of ApoE4 related white matter damage using diffusion MRI** [9039-16]  
S. Tsao, Univ. of Washington (United States); N. Gajawelli, The Univ. of Southern California (United States) and Children's Hospital Los Angeles (United States); D. H. Hwang, The Univ. of Southern California (United States); S. Kriger, San Francisco V. A. Medical Ctr. (United States); M. Law, H. Chui, The Univ. of Southern California (United States); M. Weiner, San Francisco V. A. Medical Ctr. (United States); N. Lepore, The Univ. of Southern California (United States) and Children's Hospital Los Angeles (United States)
- 9039 0I **The power of hybrid / fusion imaging metrics in future PACS systems: a case study into the white matter hyperintensity penumbra using FLAIR and diffusion MR** [9039-17]  
S. Tsao, S. J. Ma, P. A. Michels, N. Gajawelli, The Univ. of Southern California (United States) and Children's Hospital Los Angeles (United States); M. Law, H. Chui, The Univ. of Southern California (United States); N. Lepore, The Univ. of Southern California (United States) and Children's Hospital Los Angeles (United States)
- 9039 0J **Local image descriptor-based searching framework of usable similar cases in a radiation treatment planning database for stereotactic body radiotherapy** [9039-18]  
A. Nonaka, H. Arimura, K. Nakamura, Kyushu Univ. (Japan); Y. Shioyama, Saga Heavy Ion Medical Accelerator (Japan); M. Soufi, Kyushu Univ. (Japan); T. Magome, The Univ. of Tokyo Hospital (Japan) and Japan Society for the Promotion of Science (Japan); H. Honda, H. Hirata, Kyushu Univ. (Japan)

---

## KNOWLEDGE, SEARCH, AND DATA MINING

---

- 9039 OK **A collaborative framework for contributing DICOM RT PHI (Protected Health Information) to augment data mining in clinical decision support** [9039-19]  
R. Deshpande, W. Thuptimdang, The Univ. of Southern California (United States);  
J. DeMarco, Univ. of California, Los Angeles (United States); B. J. Liu, The Univ. of Southern California (United States)
- 9039 OL **Classification of visual signs in abdominal CT image figures in biomedical literature** [9039-20]  
Z. Xue, D. You, S. Antani, L. R. Long, D. Demner-Fushman, G. R. Thoma, National Library of Medicine (United States)
- 9039 OM **Incorporating intelligence into structured radiology reports** [9039-21]  
C. E. Kahn Jr., Medical College of Wisconsin (United States)
- 9039 ON **PearlTrees web-based interface for teaching informatics in the radiology residency** [9039-22]  
M. Y. Licurse, T. S. Cook, Hospital of the Univ. of Pennsylvania (United States)
- 9039 OO **Pattern search in multi-structure data: a framework for the next-generation evidence-based medicine** [9039-23]  
S. R. Sukumar, K. C. Ainsworth, Oak Ridge National Lab. (United States)

---

## POSTER SESSION

---

- 9039 OQ **A service protocol for post-processing of medical images on the mobile device** [9039-25]  
L. He, X. Ming, L. Xu, Q. Liu, Huazhong Univ. of Science and Technology (China)
- 9039 OR **Teleradiology mobile internet system with a new information security solution** [9039-26]  
H. Satoh, Tokyo Health Care Univ. (Japan); N. Niki, Univ. of Tokushima (Japan); K. Eguchi, Teikyou Univ. School of Medicine (Japan); H. Ohmatsu, M. Kusumoto, National Cancer Ctr. Hospital East (Japan); M. Kaneko, N. Moriyama, Tokyo Midtown Medical Ctr. (Japan)
- 9039 OS **Imaging informatics based on method of MR temperature measurement in high-intensity focused ultrasound** [9039-27]  
X. Chen, J. Zhang, Shanghai Institute of Technical Physics (China)
- 9039 OT **The conversion of synchrotron radiation biomedical and medical images into DICOM images** [9039-29]  
Y. Wang, J. Sun, Shanghai Institute of Technical Physics (China); J. Sun, Shanghai Jiao Tong Univ. (China); J. Zhang, Shanghai Institute of Technical Physics (China)
- 9039 OU **Analysis of scalability of high-performance 3D image processing platform for virtual colonoscopy** [9039-30]  
H. Yoshida, Y. Wu, W. Cai, Massachusetts General Hospital and Harvard Medical School (United States)

- 9039 0V **Analysis of grid performance using an optical flow algorithm for medical image processing**  
[9039-31]  
R. A. Moreno, R. C. P. Cunha, M. A. Gutierrez, Instituto do Coração da Univ. de São Paulo  
(Brazil)
- 9039 0W **An imaging informatics-based system utilizing DICOM objects for treating pain in spinal  
cord injury patients utilizing proton beam radiotherapy (Cum Laude Poster Award)**  
[9039-32]  
S. K. Verma, B. J. Liu, The Univ. of Southern California (United States); S. Chun, VA Long  
Beach Healthcare System (United States); D. S. Gridley, Loma Linda Univ. (United States)

*Author Index*

# Conference Committee

## *Symposium Chairs*

**Ehsan Samei**, Duke University (United States)  
**David Manning**, Lancaster University (United Kingdom)

## *Conference Chairs*

**Maria Y. Law**, Hong Kong Sanatorium and Hospital (Hong Kong, China)  
**Tessa S. Cook**, The University of Pennsylvania Health System (United States)

## *Conference Program Committee*

**William W. Boonn**, The University of Pennsylvania Health System (United States)  
**Thomas M. Deserno**, RWTH Aachen (Germany)  
**Steven C. Horii**, The University of Pennsylvania Health System (United States)  
**Heinz U. Lemke**, Computer Assisted Radiology and Surgery (Germany)  
**Brent J. Liu**, The University of Southern California (United States)  
**Eliot L. Siegel**, University of Maryland Medical Center (United States)  
**Jianguo Zhang**, Shanghai Institute of Technical Physics (China)

## *Session Chairs*

- 1 Keynote: Joint Session with Conferences 9035 and 9039  
**Heinz U. Lemke**, Computer Assisted Radiology and Surgery (Germany)
- 2 Beyond PACS: Advanced Radiology Workflow  
**Brent J. Liu**, The University of Southern California (United States)
- 3 Medical Image Sharing and Exchange  
**Jianguo Zhang**, Shanghai Institute of Technical Physics (China)
- 4 Diagnostics and Therapeutic Applications of Imaging Informatics  
**Thomas M. Deserno**, RWTH Aachen (Germany)

- 5 Knowledge, Search, and Data Mining  
**William W. Boonn**, The University of Pennsylvania Health System  
(United States)
- 6 Radiology for the Non-Radiologists  
**Maria Y. Law**, Hong Kong Sanatorium and Hospital (Hong Kong,  
China)



## Awards



### Robert F. Wagner Award

Robert F. Wagner was an active scientist in the SPIE Medical Imaging meeting, starting with the first meeting in 1972 and continuing throughout his career. He ensured that the BRH, and subsequently the CDRH, was a sponsor for the early and subsequent Medical Imaging meetings, helping to launch and ensure the historical success of the meeting. The Robert F. Wagner All-Conference Best Student Paper Award (established 2014) is acknowledgment of his many important contributions to the Medical Imaging meeting and his many important advances to the field of medical imaging.

Sponsored by:



The Medical Image Perception Society

**SPIE**<sup>®</sup>

2014 Recipients:

First Place: **MRI signal and texture features for the prediction of MCI to Alzheimer's disease progression** (9035-78)

A. Martínez-Torteya, J. A. Rodríguez-Rojas, J. M. Celaya-Padilla, J. I. Galván-Tejada, V. M. Treviño-Alvarado, Sr., J. G. Tamez-Peña, Tecnológico de Monterrey (Mexico)

Second Place: **Distinguishing benign confounding treatment changes from residual prostate cancer on MRI following laser ablation** (9036-49)

G. Litjens, H. Huisman, Radboud Univ. Nijmegen Medical Ctr. (Netherlands); R. Elliot, Case Western Reserve Univ. (United States); N. Shih, M. Feldman, Univ. of Pennsylvania (United States); S. Viswnath, Case Western Reserve Univ. (United States); J. Futterer, J. Bomers, Radboud Univ. Nijmegen Medical Ctr. (Netherlands); A. Madabhushi, Case Western Reserve Univ. (United States)

## Re-Thinking CAD for the Next Generation

**Eliot Siegel, M.D., FACR, FSIIM,  
Professor and Vice Chairman Research Informatics University of Maryland School  
of Medicine Department of Diagnostic Radiology and Nuclear Medicine, Chief  
Imaging VA Maryland Healthcare System**

The re-emergence of "artificial intelligence that has, in part, been inspired by the prowess of the IBM Watson Jeopardy! Challenge and the inclusion of Siri in the 4S and later versions of the iPhone, has resulted in a re-evaluation of the potential for this technology in medical diagnosis and treatment. The intelligent electronic medical record will be associated with many algorithms written to optimize patient care and many will require information related to medical images. However, ironically, despite the early transition to digital records in diagnostic imaging in the early 1990s at facilities such as the Baltimore VA Medical Center, radiology images and reports are relatively difficult to mine in comparison with structured data such as laboratory and genomic data, ICD 9 medical codes, and practitioner specific performance data. One of the dangers facing diagnostic imaging today is the potential for this lack of machine intelligibility of our data to result in marginalization of radiology and nuclear medicine in the current era of big data and personalized medicine.

One of the most important components of the Watson deep Q/A software is the ability to interactively delve deeper into evidence. Unfortunately, this is currently not available for commercially released CAD (computed aided detection CADe and computer aided diagnostic CADx) software which just provides a CAD mark or no mark depending on criteria which is not typically transparent to the reader, resulting in a "black box" with regard to the source of the data.

This current approach to CAD does not allow the user to determine the reason that CAD software identified a lesion. For example, with CAD markings on a thoracic CT for lung nodules was the marking made due to lesion size, or morphology, or density, or location, or connectedness or a combination of these? What was the weighting and the relative certainty of the software for each of these factors? This level of confidence would be very helpful clinically as would the nature and number of cases in the database(s) used as a reference and training set for the software.

With regard to sources of data for CAD algorithms, there has recently been a major increase in the urgency of recommendations for sharing of databases associated with clinical trials and other sources of high quality imaging data. One example of this has been the Editorial in the New England Journal of Medicine by Dr. Jeffrey Drazen. The Institute of Medicine has recently tackled this issue and has created a "Committee on Strategies for Responsible Sharing of Clinical Trial Data" with a

statement of task that is currently available for public comment. Additionally, Francis Collins, Director of the NIH recently acknowledged the current “unhealthy” state of affairs with the NIH grant and review process and emphasized the value of sharing and reusing data funded by NIH. Despite all of the advances in computer technology, we are still arguably at the paper stage in our clinical trial data with regard to our ability to discover and combine research data associated with clinical trials and other sources of imaging and related metadata. Research data including those associated with major medical journals and clinical trials are typically created for a single purpose and beyond one or two manuscripts, remain largely locked up or have major challenges with accessibility. Even when the data are made accessible, they are typically associated with limited access through a proprietary Internet portal or even require requests using a hard drive and conventional mail. Often there is a requirement for submission of a “research plan” and data and then a considerable wait for permission to use the data, which is not always granted. This is far too unwieldy and impractical for data that is required for clinical decision support. One such example is the data associated with the Alzheimer’s Disease Neuroimaging Initiative which is an excellent example of a high quality study with exemplary images and metadata. However this database does not have an API or other means of access to the data and requires that users access data via the ADNI portal and submit a request to the publications committee to the ADNI Data Sharing and Publications Committee. A similar situation exists for the NCI funded CTEP program which requests that investigators provide a description of the “research project”, “list of investigators involved with the project”, and a copy of the “investigator’s” CV. This model may work acceptably well in an environment in which users are interested in writing papers but is completely unusable in a decision support environment.

Mammography is the most utilized application of Computer Assisted Detection in current clinical use. A 2013 SPIE session that focused on challenges in CAD commercialization underscored the fact that despite the large corpus of previous and active research on CAD, incorporation of this technology into clinical practice has been “disappointingly slow”. That session also raised the question about CAD use in mammography. A recent study conducted at the University of Maryland utilized the web site of the Society of Breast Imaging and that of the imaging online news magazine, Diagnostic Imaging to obtain information for a study evaluating opinions regarding CAD use and its underlying legal issues. The vast majority of mammographers (89%) indicated that they always use CAD when reading screening mammograms but only 2% indicated that they always rely on CAD to provide an accurate diagnosis and approximately half indicated that they rarely or never rely on CAD. While 36% of mammographers indicated that they sometimes change interpretation based on CAD, 62% indicated that they rarely or never change their interpretation based on CAD. This paradoxical universal use and lack of reliance on CAD is undoubtedly related to the reimbursement received by CMS and other payors. Also, only 23% of clinicians routinely archive the results of the CAD markings while 72% rarely or never do. This raises the medico-legal question of spoliation of CAD markings used in the process of diagnosis for

mammography which could be risky from an evidentiary point of view in court. Most lawyers suggest that anything used to make a diagnosis should be saved and available for presentation in court should there be a question of the quality of the diagnostic interpretation.

The mismatch between the state of the art in artificial applications in evaluation of the electronic medical record and the lack of ready access to imaging databases and the "black box" nature of the current state of mammography coupled with a relative lack of confidence in the value of CAD for applications such as mammography suggests that there are many opportunities for improvement for next generation CAD systems.

Potential improvements in next generation CAD include features, which maintain accuracy while improving efficiency and productivity. These solutions must be affordable and result in increased confidence. This improvement in confidence could be better achieved if the CAD systems provided information about their "reasoning" and the evidence used to suggest a positive or negative finding and allow radiologists and clinicians to "drill" down into the rationale used and the quantitative levels of certainty of various findings. Next generation CAD systems could also be utilized to routinely measure parameters that are currently not measured such as pulmonary texture in a patient with suspected COPD, liver texture in a patient with suspected cirrhosis or bone mineral density of the vertebrae in a patient at risk for osteoporosis. These parameters could serve as the imaging equivalent to a general physical exam and could be saved as metadata without necessarily being part of the routine diagnostic imaging report provided to the requesting clinicians. Next generation CAD systems could also be utilized to provide personalized analysis such as a personalized version of the Fleischner criteria for lung nodule follow up adjusted for morphology of the nodule, patient age, geographic location and other parameters. These patient specific data could also be utilized to inform CAD markings and CAD criteria for detection and diagnosis of disease.

Specific recommendations for improvement for next generation CAD systems includes much better training for users to optimize the use of CAD including the pitfalls of the software, color coding of markings related to probability/confidence of disease and the evaluation of the potential to utilize DICOM working group 23's proposed API and the resulting ability to run multiple algorithms from different providers (commercial and research) on a single host workstation.