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PACS and Imaging Informatics: Next Generation and Innovations

Maria Y. Law
Tessa S. Cook
Editors

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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.

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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. Rodriguez-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, Radbound 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. Futterrer, 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% indicaterd 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.