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Advances in Breast Imaging

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Breast cancer is the most common cancer in women, irrespective of race or ethnicity. It is the most common cause of cancer related deaths among Hispanic women in the United States and second most common for white, Black, Asian/Pacific Islander and American Indian/Alaska Native women.[1] Similar statistics are observed worldwide.[2]

The *International Workshop on Breast Imaging* (IWBI), held July 8–11, 2018, in Atlanta, Georgia, was the 14th in a series of workshops/conferences originally named the *International Workshop on Digital Mammography* (IWDM until 2016), targeting novel breast imaging methods. Until 2012, there was a strong focus on digital techniques in mammography. At that time, digital breast tomosynthesis (DBT) was taking center stage, hence the conference name was changed to the *International Workshop on Breast Imaging* (IWBI). Today the meeting incorporates an even broader scope reflecting the significant advances being made in breast imaging including instrumentation approaches (e.g., MRI, ultrasound, molecular breast imaging with single photon and PET), computer algorithmic approaches (e.g., modeling, simulation, artificial intelligence, deep learning), and biomarker based technologies (e.g., molecular probes, software based methods). Increasingly, combinations of these approaches cross disciplinary borders just as radiology, pathology, oncology and surgery to diagnose and treat patients in a more holistic manner. The special nature of IWBI is the gathering of disciplines that usually do not meet at the same time – medicine, psychology, physics, and engineering – meeting to address advancing imaging technologies in breast cancer detection and treatment. Researchers in these disciplines do not typically gather at larger imaging conferences. IWBI is the major forum for achieving interdisciplinary interaction. There are other breast cancer focused meetings, but IWBI is the only long-standing meeting completely dedicated to bringing together a diverse group of researchers, clinicians, and industry representatives jointly committed to developing, validating, and translating technology (e.g., imaging hardware, image analysis tools, computer-aided decision support systems) for early detection and subsequent patient management of breast cancer.

IWBI 2018 covered a wide spectrum of traditional and "hot" emerging topic areas related to breast cancer, ranging from technology development and basic science applications, to translational and clinical implementation assessments and patient outcomes. In addition to three keynote speakers and two highly interactive poster sessions, there were nine presentation sessions: Screening & Clinical Interpretation, Deep Learning: Lesion Detection & Classification, Breast Density, Intersection of Clinical Imaging Sources, Image Quality: Dose & Motion, Novel Imaging Technology, Imaging Phantoms, Image Analysis & Computer-Aided Techniques, and Simulation & Virtual Clinical Trials. Presenters at the meeting were invited to submit their work to this *Journal of Medical Imaging special section* and nine papers were accepted spanning a variety of important and interesting topics.

Brombal et al. report on their first *in vivo* synchrotron radiation (SR) breast computed tomography (BCT) development program that capitalizes on the high spatial coherence of SR and phase-contrast (PhC) imaging. The program is in its early stages and this paper reports on high-resolution BCT acquisitions of breast specimens, and shows that by applying the phase-retrieval algorithm a five-time CNR increase can be obtained with a minor loss in spatial resolution across soft tissue interfaces. Also on the more technical side, Scarparo et al. provide a method for denoising DBT to adhere better to the "as low as reasonably achievable" (ALARA) principle for minimizing radiation dose. They propose and evaluate a double denoising approach that filters in both projection (pre-reconstruction) and image (post-reconstruction) domains, showing that double filtering is not superior to filtering in the projection domain only. They suggest that the noise model in the DBT image domain may be better modeled by a Burr distribution than a Gaussian distribution. Also related to DBT and improving quality is the paper by Rose et al. in which they investigate fiber-like features and how image reconstruction can affect their appearance. They considered the impact of reconstruction algorithm and regularization strength on the conspicuity of fiber-like signals of various orientations in a simulation. They found that at low regularization setting, there was significant variation in conspicuity as a function of orientation in the viewing plane, with the conspicuity of fibers nearly aligned with the plane of the x-ray source trajectory being decreased relative to more obliquely oriented fibers. Additionally, increasing regularization strength mitigates this orientation dependence at the cost of increasing depth blur of these structures.

Deep learning, as at many conferences today, was also a very hot topic at IWBI. In this issue we have three deep learning related papers. Ionescu et al. built a convolutional neural network (CNN) to predict visual analog scale (VAS) density scores from full-field digital mammograms (FFDM). They used contralateral mammograms of screen detected cancers and prior images of women with cancers detected subsequently, matched to controls on age, menopausal status, parity, HRT and BMI to evaluate performance on breast cancer prediction. There was no significant difference between reader VAS and predicted VAS for the prior test set, indicating that their fully automated method shows promising results for cancer risk prediction comparable to human performance. Automatic mass detection was the focus of CNN method used by Agarwal et al. They used a patch-based CNN method and also investigated the use of transfer learning. They evaluated three CNNs and found that *InceptionV3* performed best for classifying the mass and non-mass breast regions. They also showed the benefit of domain adaptation between the CBIS-DDSM (digitized) and INbreast (digital) datasets using the *InceptionV3* CNN. In a slightly different vein, Whitney et al. looked at the effect of biopsy on MRI radiomics for diagnosis and prognosis of breast cancer, noting that a challenge is the fact that the appearance of lesions on images may be affected by biopsy. The distributions for most non-size features for each lesion type, however, failed to show significant differences between biopsy conditions. Fourteen features outperformed random guessing in classification.

The remaining papers cover a variety of important topics, but all touched upon image quality and observer performance to some extent. Salkowski et al. compared technical recalls between DBT and FFDM looking at imaging modality (FFDM, DBT + FFDM, DBT + synthesized mammography (SynM)), images requested, and indications. Only 0.57% of cases in the study were recalled for indications or repeated views. DBT had significantly less recalls compared to FFDM, with: 27.2% for motion, 53.3% for positioning, and 19.4% for technique/artifacts. There were significant differences prior to and after implementing DBT + SynM. Technical recalls declined significantly with the inclusion of DBT (SynM/FFDM) compared to FFDM alone. Recalls for motion demonstrated the greatest decrease. Positioning was a dominant factor overall regardless of modality. They contend that continued technologist education in positioning could decrease technical recalls. Fieselmann et al. assessed a commercial software application for fast onsite quantification of volumetric breast density using breast tissue equivalent phantom experiments resulting in a mean absolute error of 3.84%. Reproducibility of measurement resulted in Pearson correlation coefficients higher than 0.90 for a variety of comparisons. Agreement between breast density categories computed by the software with those determined by 32 radiologists was good with 69.5% for FFDM and 64.6% for DBT. Finally, Huang et al. compared contrast-enhanced digital mammography (CEDM) and contrast-enhanced DBT (CEDBT) for lesion assessment. Two radiologists assessed CEDM and CEDBT patient images (BIRADS 4 or 5) side-by-side and compared contrast enhancement of lesions and lesion margins. CEDBT provided better lesion margins than CEDM with limited reduction in contrast enhancement with less radiation dose than CEDM + DBT.

We hope that the papers compiled here from the 2018 IWBI meeting provide readers with an overview of some of the exciting and important areas of research being investigated by researchers around the world to improve the detection, diagnosis, and treatment of breast cancer patients, to improve outcomes and quality of life. We also hope to spark more interest in multi-disciplinary, team-science-based breast cancer imaging research that will lead to new technologies and techniques to help eradicate this deadly disease.

References

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