Journal of Medical Imaging

GUEST EDITORIAL

Introduction to the JMI Special Issue on Advances in Breast Imaging

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Breast imaging remains an active domain of research, with an unchanged ultimate aim to reduce breast cancer mortality. Thirty years of come-together-events, from a first meeting at the *SPIE Medical Imaging Conference* in 1993, the launch of the 2 yearly *International Workshops on Digital Mammography* (IWDM) and the expansion to the *International Workshop on Breast Imaging* (IWBI), have shown an amazing growth in approaches to better breast cancer detection and care. The May 2020 edition of the IWBI was remotely hosted in Leuven (Belgium) and was one of the first events switching to an online setting due to the Covid-19 pandemic. The May 2022 IWBI, on the other hand, was one of the first in-person meetings after the pandemic, hosted again in Leuven (Belgium). The proceedings of IWBI 2020 and 2022 are available in the SPIE Digital Library. This current JMI Special Issue on Advances in Breast Imaging, for which the call was launched at the IWBI 2022, reflects substantial developments in breast imaging. The special issue includes a series of papers that were presented at the IWBI and a few new submissions.

Today's solutions to fight breast cancer include (1) higher performance imaging devices, new imaging devices, and multimodality devices; (2) new artificial intelligence (AI)-based acquisition, processing and reconstruction, analysis, and decision support; (3) new (personalized) breast screening approaches; and (4) deep technical or clinically driven test methods, with anthropomorphic phantoms, model observer-based readings, and virtual imaging trial approaches. The types of populations being studied in the frame of research projects are numerous, from animal models, to screening dedicated population subgroups, or whole populations including all minorities, as well as virtual populations using anthropomorphic models. Ultimately, all results should be aggregated to offer the best technical solutions for all women, through the added value of breast imaging focused workshops and topical journals. The present collection of papers is an up-to-date sample of most of the current research tracks.

A first paper by Kolokotroni et al. (Athens, Greece) focuses on the visualization and quantification of the mammary gland of a mouse model to increase its potential use for comparative studies or preclinical pharmaceutical studies. Phosphotungstic acid-enhanced (PTA) staining in combination with micro-CT was validated in distinct development stages of the gland and upon short term treatment with synthetic progesterone. This new *ex-vivo* small animal imaging technique was shown to be a candidate for basic (imaging) research of the mammary gland. Pre-clinical work is often at the start of new cancer treatments and is therefore very important.

Other papers focus on technical developments and optimization of devices for use in women. Whether digital breast tomosynthesis (DBT) should be performed with wide angle rather than small angle is a technical optimization topic addressed by Huang et al. (Stonybrook, New York, USA). A cascaded linear system model was used to predict detectability of masses from breast structural noise. Patients were imaged with narrow angle and wide angle DBT. The wide angle DBT was shown to downgrade the false positive findings compared with narrow angle DBT, and could improve detection of masses and asymmetries in patients with dense breasts.

Contrast enhanced mammography is increasingly used in clinical routine. Several technical developments are still on going. The paper Schaeffer et al. (FDA, Maryland, USA) is a theoretical study to compare cadmium telluride (CdTe) and gallium arsenide (GaAs) photon counting detectors for contrast enhanced spectral mammography. The use of a simulation platform allows selective focus on different aspects of a technology in development, such as charge cloud size, electronic noise, photon spectrum, and number of energy bins. Output is provided in terms of iodine quantification, spectral performance, and dose to the patient. Breast imaging applications are different from other x-ray applications due to the use of low energy spectra.

Scatter radiation is deteriorating the quality in most x-ray imaging. This is also the case in contrast enhanced DBT, where most implementations don't use a grid. In addition, low energy and high energy acquisitions have different scatter-to-primary ratios. Duan et al. (Stonybrook, New York, USA) have trained a convolutional neural network to predict results that would be obtained using (time-consuming) Monte Carlo techniques.

Contrast enhanced spectral mammography optimization will benefit from use of a digital anthropomorphic breast phantom in virtual imaging trials. Li et al. (FDA, Maryland, USA) completed existing breast phantoms and different types of mass models with time-varying enhancement patterns. Applications include the investigation of optimal timing of contrast enhanced mammography, DBT and breast computed tomography along with other parameters that can be deduced from *in silico* trials.

New approaches to breast cancer screening were also explored. The paper by Dembrower et al. (Stockholm, Sweden) studies the added value of calibrating AI based detection algorithms to both stand-alone readers or the combined reader strategies, as generally implemented in European screening settings. Optimal sensitivity and abnormal interpretation rate were targeted. In order to make a stand-alone reader achieve a similar sensitivity and abnormal interpretation rate as two readers aided by the same AI algorithm, a double downstream workload would be the result, while only a modest increase would be needed for the combined reader + AI implementation.

An alternative or additional approach to improved breast cancer screening is personalization. In a paper by Dahlblom et al. (Malmö, Sweden), the selective addition of DBT through AI is investigated. They used the data of the Malmö Breast Tomosynthesis Trial, but here investigated what the results would have been if a 2D mammography risk predicting algorithm would have appointed the higher risk women to undergo DBT. In the present example, if a risk score of 9 on a scale of 1 – 10 would be referred for DBT, the cancer detection rate in the added DBT exams would have been 14/1000, and overall 26% more cancers would have been detected, with only 12% of the women having been imaged with DBT. The article features on the issue cover.

Finally, two papers addressed AI and radiomics in ultrasound. In the study worked out by Mullen et al. (Baltimore, Maryland, USA), upstream data fusion (UDF), machine learning, and automated registration are used to detect lesions that are present in both DBT of cranio-caudal and medio-lateral-oblique views and with ultrasound. Machine learning is used to detect all candidate lesions. The false positives are then reduced by UDF performing data association of detections of the same lesion in the different images of the patient. In this implementation, UDF generated fused detections of cancers and neglected other signals. This approach decreases the number of false alarm lesions while maintaining high sensitivity. Muhtadi et al. (Chapel Hill, North Carolina, USA) showed that texture quantified from ultrasound parametric images are diagnostically relevant and may be used to characterize breast lesions effectively. The research was based upon the known facts that texture patterns of US images, and in particular the Nakagami distribution model describing the tissue scattering statistics, can differentiate between benign and malignant breast tumors. The study investigates a series of issues, such as ROI size for analysis and the relevance of a large series of radiomics parameters in characterizing breast cancer lesions from ultrasound images.

We invite you to read through the scientific work compiled in this special issue, and to discover with us some of the advances in today's breast imaging.