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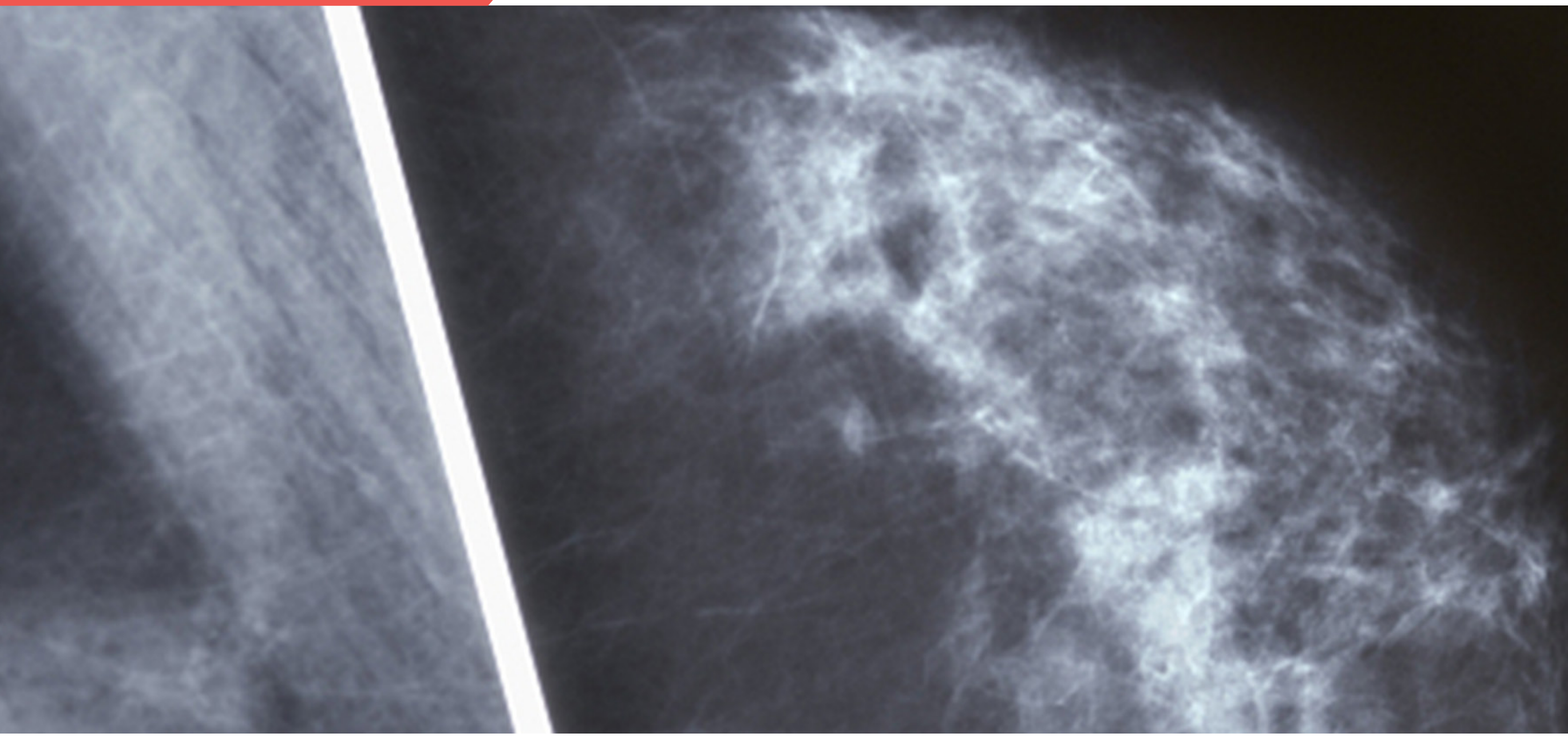


Artificial Intelligence for Imaging Breast Cancer

ABSTRACT

The incidence of breast cancer in women is high and has been increasing over the years. However, the mortality rate is decreasing as a result of improved early detection and treatment. These findings have driven worldwide efforts to increase breast cancer awareness and to deliver early cancer detection with improved treatment possibilities.

The achievements obtained for early detection would not have been possible without the massive strides in development of information technology and computational power. Where only 2D analogue images were available 20 years ago, today we consistently work with 3D imaging. These technologies however have resulted in an exponential increase in data volume that consistently challenges radiologists' capabilities.

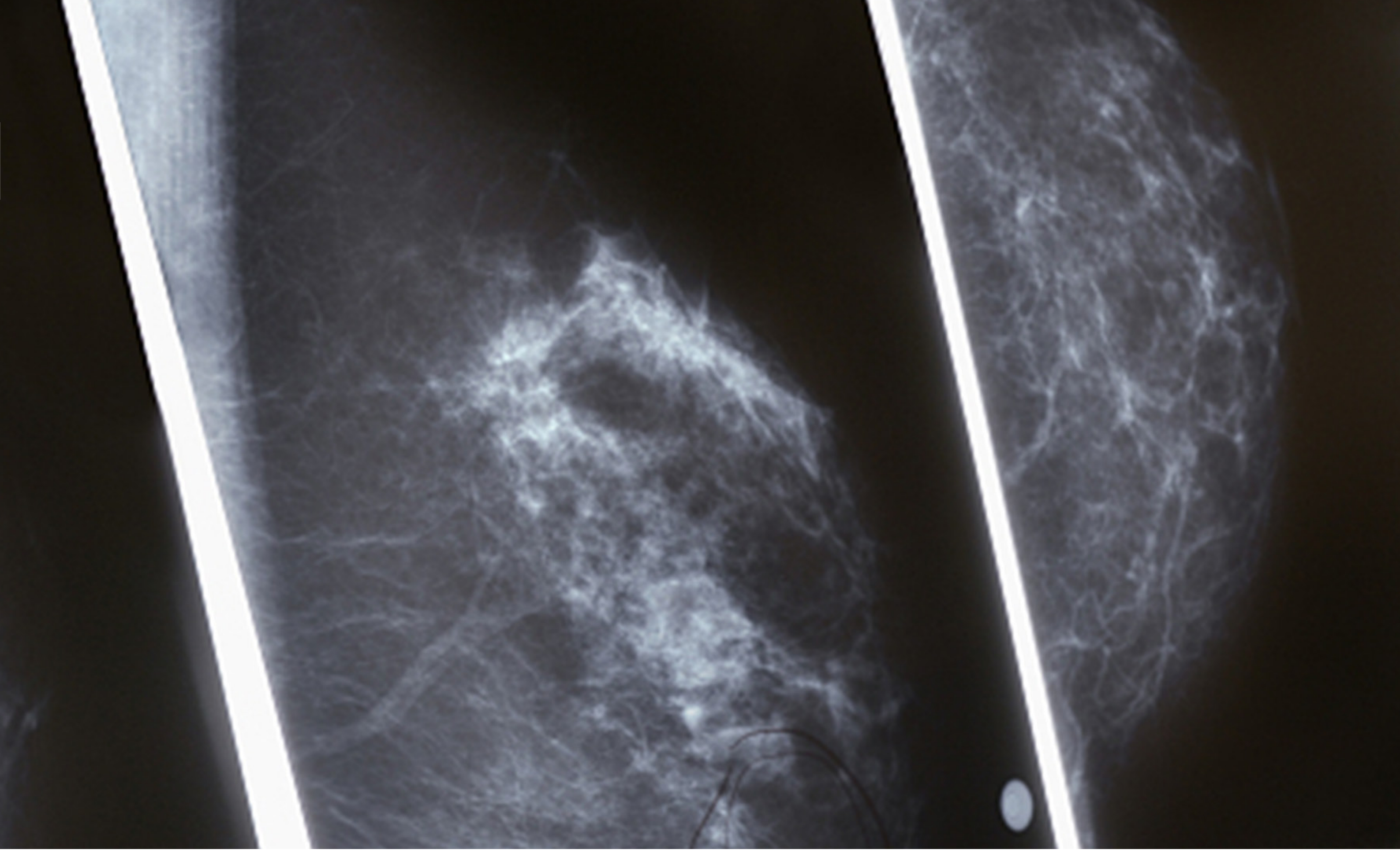
Artificial Intelligence promises to be a potential solution for the current imbalance between the demand on radiologists' time and the increasing volume of imaging data generated that needs to be reviewed.

Artificial Intelligence has further potentials for improving future practice workflows. Ongoing studies are working towards creating patient-specific screening and diagnostic workups, improving patient scheduling and protocol selection, radiation dose reduction, automated acquisition, improved image reconstruction to increase lesion visibility, a prioritised reading list (putting highly suspicious cases first and non-suspicious cases last), decreasing reading time, and prediction of breast cancer risk.

Recent studies have shown that artificial Intelligence can improve radiologists' cancer detection rates, reduce recall rates, and reduce reading times of high data volume exams such as 3D mammograms.

BACKGROUND

The overall risk of a woman developing breast cancer is 1 in 8. Breast cancer is also the second leading cause of death from cancer in women. The chance that a woman will die from breast cancer is 1 in 39 (2.5%). However, breast cancer death rates have decreased steadily since 1989,



with an overall decline of 43% by 2020. This decline has been attributed to earlier detection and treatment of breast cancer through increased awareness, regular breast cancer screening and better treatment possibilities.[1]

The positive impact of breast cancer screening on decreasing mortality has led numerous technological developments aimed at improving early detection. These include improved technologies related to ultrasound (US) (improved image quality, 3D US and US elastography), mammography (3D mammography aka Digital Breast Tomosynthesis DBT and contrast enhanced mammography) and magnetic resonance imaging (MRI). Mammography is currently the mainstay for breast cancer screening, with 3D mammography clearly taking over from 2D Mammograms particularly for patients with dense breasts.[2,3] Currently over 80% of mammography machines in the United States are 3D units compared to only 30% in 2016.

Most of the challenges related to developing and perfecting the above technologies are now overcome. However, these technologies have resulted in an exponential increase in volume of images that need to be reviewed by the radiologist.[3] For example, for mammography, which is the mainstay for breast cancer screening, moving to 3D from 2D mammography means having to read 200-300 images instead of just 4. Comparison with past mammograms can detect subtle changes that may be the earliest signs of a developing breast cancer, but it also increases the number of images that need to be seen by 2 to 3-fold. This massively impacts the demand on the experienced breast radiologist's reading time.

ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) consists of a set of deep-learning enabled tools that could assist radiologists to achieve faster turnaround times and possibly to deliver more accurate results by prioritising cases and highlighting areas of concern (such as asymmetry, calcifications, architectural distortions and masses).[4] AI also has the potential to diminish radiologist fatigue, possibly mitigating radiologist shortages, by supporting the interpretation of large image datasets generated by 3D mammography. AI algorithms may also help reduce radiation dose and improve cancer visibility (conspicuity).[3]

DENSE BREASTS HAVE 2.2X INCREASED RISK OF DEVELOPING CANCER COMPARED WITH AVERAGE DENSITY BREASTS

Currently available AI solutions integrate with 2D mammography. They can detect asymmetries, masses, calcifications, and distortions within the breast. Abnormal areas can be depicted based on the level of suspicion using heat maps (red – high suspicion to blue – low suspicion) (Fig 1). Any abnormalities detected are also scored based on the likelihood of malignant disease (100% - highly suspicious and 0% - not suspicious) (Fig 2).

3D mammography-capable AI packages are currently in an advanced stage of development.[5] They work on the same principles of those based on 2D mammography but will be of greater benefit for screening the larger image volumes. When a 3D mammogram is performed, a synthetic 2D mammogram is generated from the data obtained; these can be used with currently available AI technologies. AI is also being implemented to generate an enhanced synthetic 2D mammogram which delivers better lesion conspicuity thereby reducing the likelihood of missed cancers.

Numerous research articles are reporting the use of AI in assessment of breast density. Dense breasts have 2.2x increased risk of developing cancer compared with average density breasts. However, inter-, and intra-observer variability in the interpretation of breast density is high. AI-assessed breast density can be standardised to eliminate observer bias.

The general consensus is that the best results are obtained when combining the experienced radiologist with AI. Clinical judgement is important in interpreting mammographic findings (Fig 3). Future AI interpretation algorithms will need to integrate electronic health records and prior mammograms done by the patient to improve specificity.

CONCLUSION

At each step of the breast imaging process, from the decision to perform screening and image acquisition to the reporting of imaging findings and follow-up recommendations, there are multiple potential opportunities for AI to augment the benefits of 3D mammography. These will lead to improved practice efficiency and ultimately improved patient health outcomes of breast cancer screening and diagnostic evaluation.

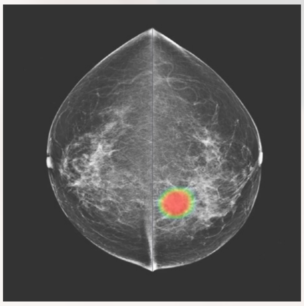


Figure 1: Deep learning technology can accurately analyse mammography images to detect lesions that could indicate breast cancer and provides location information for any detected lesions in the form of outlines and heatmaps (red - high, green - intermediate and blue - low level of suspicion for breast cancer). (Source: https://grand-challenge.org/aiforradiology/product/lunit-insight-mmg/).

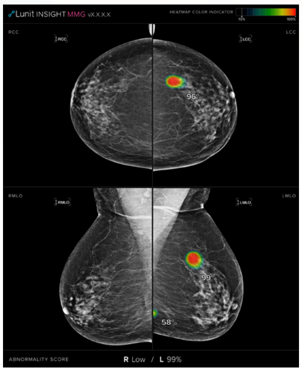
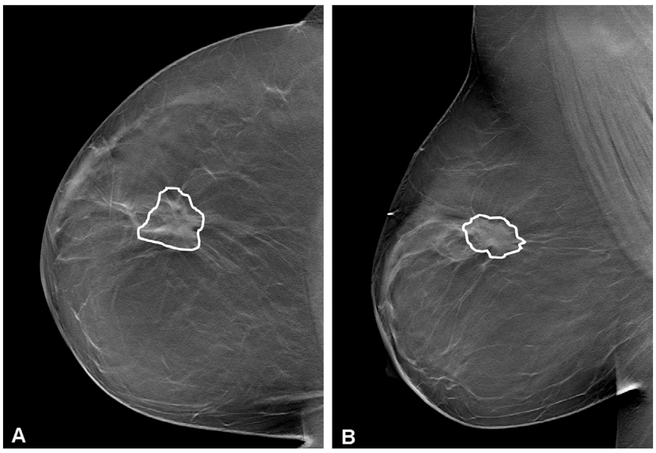


Figure 2: Same technology as in figure 1 showing percentage likelihood of malignancy (100% highly suspicious, 0% not suspicious). (Source: https://grand-challenge.org/aiforradiology/product/lunit-insight-mmg/).

Figure 3: Screening mammography in a 57-year-old woman with a history of excision of an area of atypical ductal hyperplasia with associated microcalcifications 10 months before. Craniocaudal (A) and mediolateral oblique (B) right breast screening DBT mammograms show a white outline around a suspicious architectural distortion. Using clinical judgment, these findings were deemed benign postsurgical changes. (Images obtained from NYU Langone Health internal cases.)[3]



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