Mercury Computer Systems, Inc.

Digital Breast Tomosynthesis (DBT)

A New Tool for Detecting Breast Cancer

Mercury expertise accelerates research techniques toward clinical use.

One in every eight women is diagnosed with breast cancer at some time in her life. Early detection using mammography can save many lives, so improving the accuracy and effectiveness of mammography is a vital goal of medical research. At the Massachusetts General Hospital (MGH), some of the world's leading researchers are pioneering a new approach to improve the speed of detection and accuracy of diagnosis, and to identify tumors even earlier than with traditional techniques.

Current 2D mammography

Today's mammography techniques rely on a pair of 2D X-ray images of the breast, taken from two different directions: top to bottom and side to side. The breast is pulled away from the body, compressed, and held between two glass plates, to ensure that the whole breast is viewed. Regular mammography records the pictures on film, and digital mammography records the pictures on the computer. The images are then read by a radiologist. Breast cancer, which is denser than most healthy nearby breast tissue, appears as irregular white areas—sometimes called shadows.

Interpreting a mammogram is difficult, and small growths may be obscure or undetectable. A mammogram shows the shadows of structures inside the breast, but on standard mammography the shadows from structures on one side of the breast are superimposed on those in the other side of the breast along with everything in between. A cancer can literally be hidden like a single tree in a forest.

In addition, the superimposed tissues may look like a cancerous tumor on a mammogram, causing false-positive call-backs, when the patient must return to the clinic for further diagnosis or even biopsy.

A clearer view

The MGH researchers have developed a 3D mammography technique that makes it possible to explore the interior of the breast without the superimposition of the other tissues. Digital breast tomosynthesis (DBT) is a new kind of test that is designed to overcome three critical issues: discomfort with compression, cancer hiding within overlapping tissue, and a limited number of views.

The technique takes multiple X-ray pictures of each breast from many angles. The breast is positioned the same way it is in a conventional mammogram, but only a little pressure is applied—just

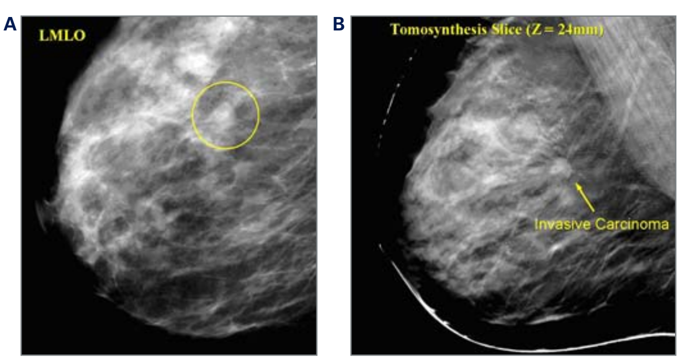

__Figure 1a.__ Standard 2D left Medio-Lateral Oblique (LMLO) view with obscure lesion. __b.__ Tomosynthesis Slice with patent lesion

Made possible by a grant from the United States Army and the engineering expertise of the General Electric Company, a Tomosynthesis scanner was built and installed at the MGH

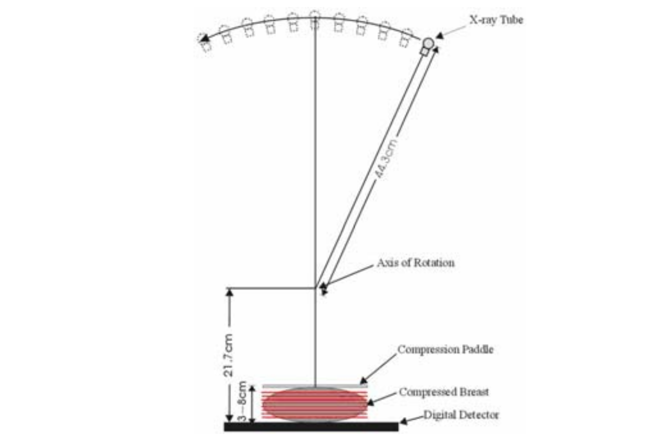

Figure 2. *Geometry of DBT acquisition*

enough to keep the breast in a stable position during the procedure. The X-ray tube moves in an arc around the breast while 11 images are taken during a seven-second examination. Then the information is sent to a computer, where it is assembled to produce clear, highly focused 3-dimensional images throughout the breast.

DBT combines the data from eleven low-dose 2D images to create a single 3D composite image, using no additional examination time or X-ray energy and fewer breast compressions. While not yet clinically available or FDA approved, DBT provides much greater detail and clarity, and allows physicians to identify tumors that are easy to miss with the 2D approach.

Computational problem and solution

The image reconstruction process in DBT is a complex mathematical technique that required up to five hours on a conventional computer—far too long for clinical application.

MGH researchers joined forces with Mercury engineers to develop the mathematical optimizations, design the accelerated software, and provide the best-fitting acceleration technology for the problem. The ensemble of theoretic results, software implementation, and acceleration hardware has yielded today's remarkable results. Instead of five hours, physicians can produce the composite 3D images in less than five minutes.

Acceleration

The DBT volumetric images are computed using a complex algorithm known as maximum-likelihood expectation maximization (MLEM). To speed up the computation for this algorithm sixty-fold, Mercury engineers ported it to graphics processing units (GPUs). These devices have a programmable rendering pipeline, in contrast to the fixed pipelines of previous graphics accelerators. Careful design of the software port was required to optimize the processing performance for the GPU architecture, and to overcome the natural GPU limitations of memory, I/O bandwidth, and instruction set.

Benefits

Early results with DBT are promising. Researchers believe that this new breast imaging technique will make breast cancers easier to see in dense breast tissue, and will make breast screening more comfortable.

Not only have the MGH researchers shown that they will be able to find more cancers earlier, but they will be able to reduce many of the false alarms that occur using conventional mammography due to the overlap of normal structures in the breast. DBT virtually eliminates these false-positive studies. This will save a great deal of anxiety for many women, and will reduce the overall cost of breast cancer screening while improving its accuracy.

This sixty-fold increase in performance means that DBT can now be brought out of the laboratory and into the clinic to provide much better care for women. Because of Mercury's contribution to this MGH project, more patients and their families may benefit from this breakthrough diagnostic technology.

The early results have shown that the technique is promising enough that broader clinical trials would be forthcoming. This would potentially lead to a broader recognition of the value of the technology and its eventual incorporation into a repertoire of tools in the battle against breast cancer.

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