A BETTER BREAST TEST

Bringing digital imaging to mammography

By KAREN F. SCHMIDT

One woman in every eight in the United States will develop breast cancer at some point during her lifetime. Fortunately, mammography has helped doctors diagnose more cases and at earlier stages of the disease, so that more women – at least among those over age 50 – are now surviving this often-lethal cancer. The American Cancer Society recommends that all women between the ages of 40 and 49 get a mammogram every two years and then every year thereafter.

Those guidelines threaten to overwhelm the nation's radiologists, who in the past viewed X-rays primarily of symptomatic patients. Now, in screening for breast cancer, they must hunt for subtle signs of disease in women who have no outward symptoms. Moreover, if every woman in the United States followed the American Cancer Society recommendations, radiologists would have to scrutinize 170 million new images each year.

As it stands, radiologists have so many mammograms to read each day that they must reach a verdict on the cancer status of a woman's breast tissue in just a few minutes, says Laurie Fajardo, a radiologist who specializes in mammography at the University of Arizona's Tucson Breast Center. Radiologists must rapidly judge the quality of the right and left film images and compare the two breasts for asymmetry. Then they look for puckers, skin thickening, and abnormal veins and milk ducts. Finally, they take out a magnifying glass to search the film for evidence of tiny lesions and lumps.

"A lot of radiologists are afraid to read mammograms," Fajardo says. "It's stressful and tedious."

In fact, it's not uncommon for these physicians to miss danger signs. Where Fajardo works, each radiologist must scan about 75 images per day, only a few of which will reveal abnormalities. She estimates that 5 to 10 percent of the time, radiologists fail to pick up the early warning signs of breast cancer when viewing mammograms. A variety of things can cause this, she says, including an error in judgment by the radiologist, obstruction of a cancer sign by dense tissue, and a poorly exposed and displayed film image. "Any number of things must be perfect in order to get a good mammogram reading," Fajardo says.

Engineers and computer scientists around the world are now seeking to make the radiologist's job easier and thus improve the odds that a mammogram will accurately detect cancer. Their strategy is to upgrade the quality of mammogram images.

"There's absolutely nothing logical about looking at a film on a light box. It presents a negative image, in which you're looking at an object's shadow that is lighter than its surroundings," says Clinton M. Logan, a mechanical engineer at Lawrence Livermore (Calif.) National Laboratory.

"Mammography is an area that is ready for computer assistance," he asserts.

Logan's research group and others aim to dispense with film and light boxes altogether by creating a digital mammography system. In the near future, they say, a radiologist will gaze at a computer monitor displaying a high-contrast breast image. And the computer will even help the radiologist by flagging the suspicious regions in the mammogram that require the most careful examination.

To develop a system of computer-assisted diagnosis of breast cancer, researchers must first convert film images to digital versions that a computer can analyze. They do this with a digitizer, a device that resembles a copy machine. They place an X-ray film from a mammogram on the machine, and a light beam scans the image. The digitizer's detectors measure how much light passes through millions of points on the image, and then the machine assigns numbers to them: low numbers for dark spots and high numbers for light areas.

Radiologists can then view this digitally translated image with the aid of a computer to obtain greater contrast than that on the original film. Some clinics are experimenting with software that enables radiologists to zoom in on hard-to-read areas, further enhancing the contrast there, says Kevin Bowyer, a computer scientist and engineer at the University of South Florida in Tampa.

"Lots of medical facilities are digitizing their films for their researchers to start looking at, but doctors, by and large, are not using digital images yet," says Bowyer, who organized the First International Workshop on Mammogram Image Analysis, held in February in San Jose, Calif.

That could quickly change. Several research groups already have developed advanced software that can interpret digitized mammograms. Philip Kegelmeyer, a computer-vision scientist at Sandia National Laboratories/California in Livermore, has trained a computer to analyze textures and recognize patterns that signify stellate lesions – difficult-to-find and virulent growths that result in breast cancer 95 percent of the time.

At the San Jose workshop, Kegelmeyer described how the software works. First, the computer scans the image, measuring the size and shape of tissue structures and looking for unusual patterns. The computer classifies its findings and determines whether a spot should be marked as a potential danger zone.

"It's like having five different experts in a room, each good at spotting different kinds of patterns," Kegelmeyer explains. "They all look at the image, have different opinions, fight among themselves, and then come up with a consensus."

Stellate lesions aren't the only harbingers of breast cancer. Other researchers have set out to design software that recognizes additional signs of the disease.

Logan first developed digital radiography techniques to detect flaws in parts used by the U.S. military. Then, several years ago, he realized that the same technology could help identify tissue abnormalities in the breast. Now, he and his co-workers are applying their imaging expertise to computer-assisted diagnosis, focusing on microcalcifications – tiny, calcium-rich mineral deposits. About half of the women in the United States diagnosed with breast cancer show microcalcifications as one sign of the disease, he notes.

At the Medical Imaging 1993 conference, held in February in Newport Beach, Calif., the Lawrence Livermore researchers presented their "mammographer's assistant," a computer algorithm for detecting microcalcifications. When fed a digitized mammogram, the computer searches for microcalcifications and, 10 minutes later, produces an image with suspicious areas circled.

Logan and his colleagues must still work out some bugs, though. They're aiming to give the computer a more discriminating eye by improving its ability to distinguish danger warnings from benign signs.

"The problem with our algorithm," says Logan, "is that in some images it finds lots of things we don't want it to find."

An even more difficult aspect of breast cancer diagnosis challenges two biophysicists at the University of Manchester in England. Sue Astley and Peter Miller want to develop software that detects architectural distortions of the breast – subtle signs of disease that are tough to recognize. They hope to train a computer to compare right and left breasts for symmetry. Astley and Miller described their work at the San Jose workshop.

"The technical problem is that there's a very high degree of normal asymmetry within a woman's breasts," Astley says. "Fat replaces glandular tissue as she ages, but not necessarily at the same rate in each breast."

She and Miller designed their computer program to divide each image into anatomical segments and then make a comparison between the analogous fatty and granular regions in the right and left breasts.

"At the moment, we can detect some abnormal asymmetries – something like 70 percent – but not nearly enough to be clinically useful," Astley says.

If scientists do find a way to train a computer to recognize all of the important signs of breast cancer, they may one day create an automated screening system. A computer could prescreen mammograms, and then radiologists would view only those images that contain suspicious signs.

Automated screening could potentially become vital to meeting future demands for reasonably priced health care, Bowyer suggests. But even if researchers overcome the technical obstacles of automated screening, legal obstacles might prevent its implementation, he adds. Who would take the blame – and pay any malpractice claims – for the small number of errors that a computer would inevitably make?

More likely, radiologists will first use computers to guide them quickly to the most suspicious areas in an image. Radiologists do catch more cancer signs with the aid of a computer, several studies indicate. Kegelmeyer recently reported that four radiologists, each given the same set of 85 mammograms to read, spotted 10 percent more cancer signs when cued by computer analyses of these images (SN: 1/9/93, p.28). "With the computer's help, third-year residents who had never looked at mammograms professionally were performing as well as 20-year veterans," Kegelmeyer says.

Fajardo and Astley both say they have observed similar improvements in the radiologists they've tested. However, they still can't use computer-assisted diagnosis with actual patients in clinical practice until larger studies prove its efficacy.

So far, researchers have had to convert film to digital images, but ultimately they hope to design a completely new mammography machine that will capture the breast view digitally from the start.

"Computer-aided diagnosis will do its best when it has the best quality of data to start with, and that means getting film out of that loop," says Logan, whose group is working with medical instrumentation companies to develop an all-digital system.

When a mammogram is created, a fluorescent material sensitive to X-ray energy converts the X-ray image to visible light. To make a film, this visible light must react with photochemicals. To make a digital image, the light passes instead to about a million light detectors that reside in a charge-coupled device, which operates like a television camera. The information recorded feeds into a computer that assigns a number to each tiny square area, or pixel. The entire digital image can then be displayed on a computer monitor or television screen, says Logan.

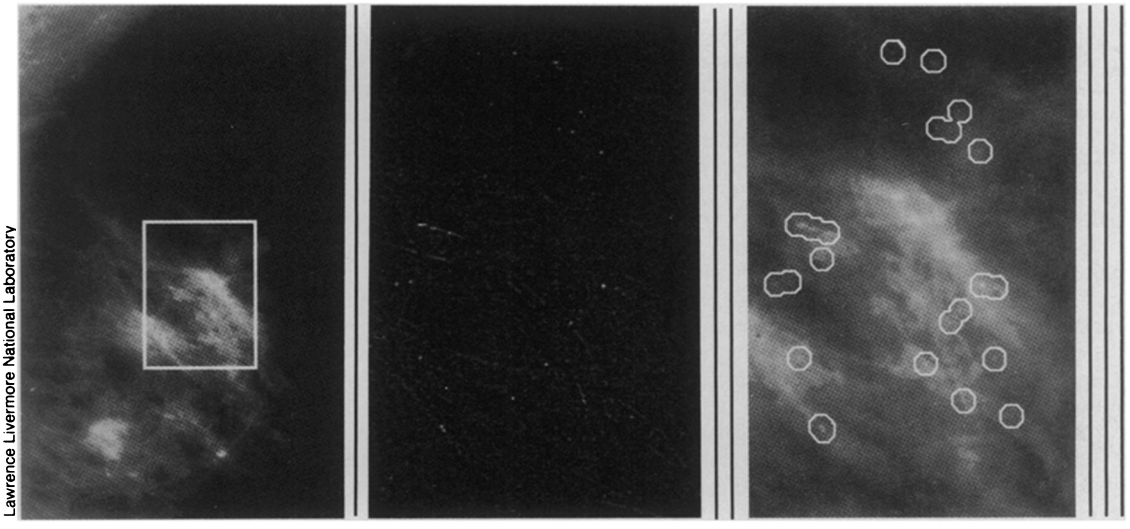
New devices that help doctors guide the insertion of needles during breast biopsies already record digital images, but these images cannot depict areas larger than 5 by 5 centimeters. A more advanced scanning camera for collecting digital data from the whole breast, as well as high-resolution monitors that can display such images, still need to be developed, Logan says.

Once scientists solve the problem of capturing and displaying the digital image, they'll be able to investigate lowering the X-ray dose needed, he notes. Unlike film-based mammography, a digital system does not require a threshold X-ray exposure in order to react with photochemicals that capture the darkened image. Thus, engineers could choose the optimal X-ray energy to minimize the radiation dose to the patient, Logan remarks.

Compared with film, digital mammograms should also be easier to store, copy, and transfer to other medical facilities, Logan notes. While fragile film must be warehoused in temperature-controlled environments, digital mammograms could be kept on sturdier computer disks. Moreover, he says, the disks could store all of the mammograms from one patient, making it easier for radiologists to trace a woman's history and to spot changes.

In the end, researchers hope that improved accuracy in breast cancer detection will lead to fewer false alarms and fewer repeat procedures. Thus, computer-assisted diagnosis should also reduce unnecessary stress in women who must endure this nerve-wracking experience.

Says Kegelmeyer, "Digital mammography is going to reduce the anxiety for women as well as improve the quality of breast cancer screening." □



Lawrence Livermore National Laboratory

With digital mammography, a radiologist could zoom in on a dense area of tissue (left) to search for tiny calcium-rich nodules (middle). Researchers are also developing software that interprets digital mammograms. The computer circles suspicious areas that radiologists should scrutinize (right).