Creating a Clearer Image

The "toys" that OU engineers build for their medical colleagues and their patients could result in countless lives saved.

By Debra Levy Martinelli

Robert Taylor

In 2007, the most recent year for which the American Cancer Society has comprehensive data, an estimated 240,000 American women were diagnosed with breast cancer; 40,000 died from the disease. That year, another 2,000 cases occurred in men, and 450 lost their lives as a result.

Regardless of gender, the key to survival is early detection and treatment.

Mammograms are the most effective screening and diagnostic method, since they can identify cancer several years before physical symptoms develop. High-resolution digital mammography, approved by the Federal Drug Administration in 2000, gave physicians a valuable new tool for more specific diagnosis. Unlike traditional film mammography, the digital technology allows for manipulation of the images by magnifying and changing contrast.

Even with this amazing advance, digital mammography does not find every breast cancer. That is just not good enough for Hong Liu.

Liu is an internationally recognized leader in X-ray mammography and other medical imaging systems that are expected to lead to more timely detection, diagnosis and treatment of breast and other forms of cancer. In 2000 he came from Johns Hopkins University to the University of Oklahoma, where he is the Charles and Jean Smith Chair in Biomedical Engineering and professor of electrical and computer engineering and adjunct professor of medicine.

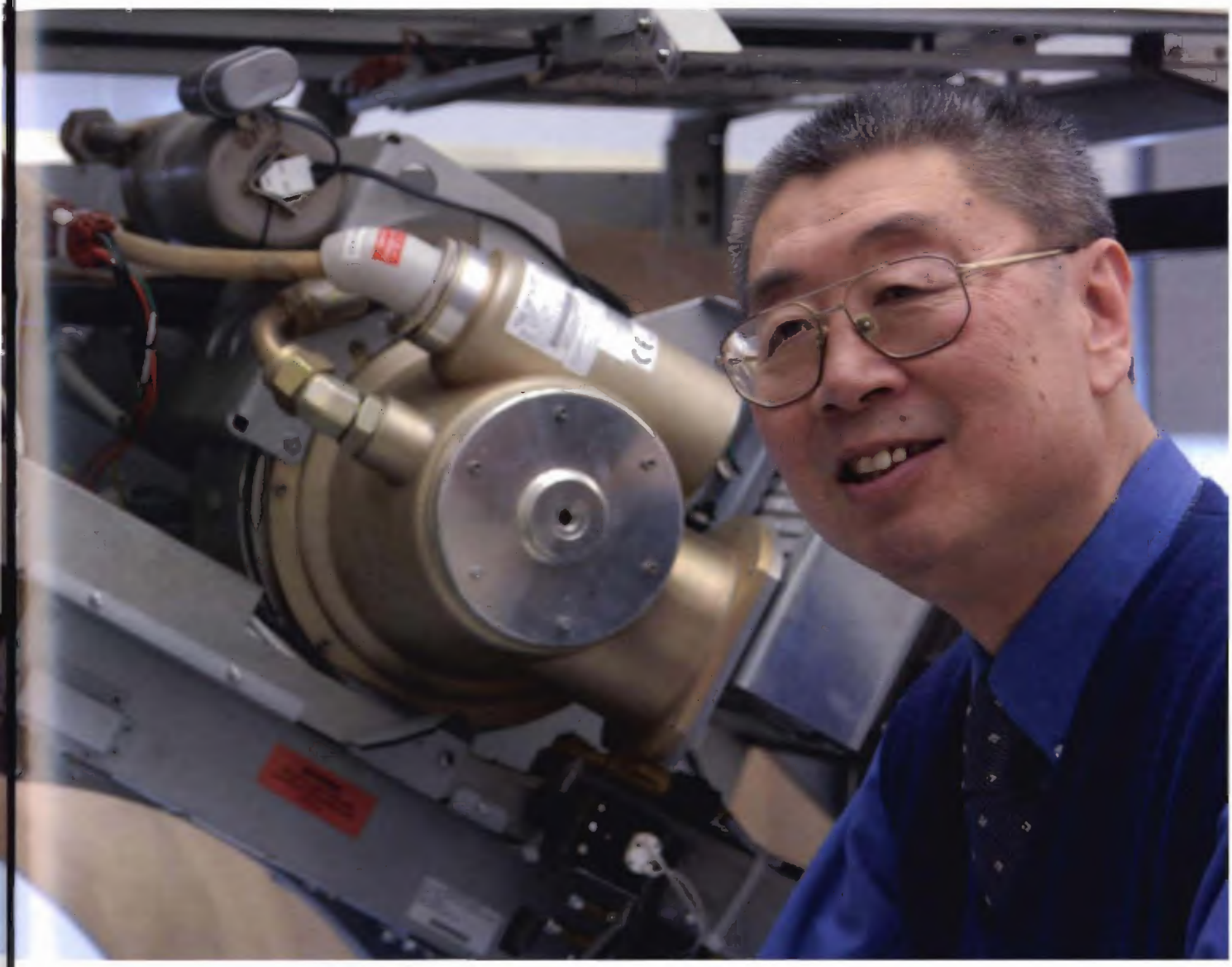
Since the discovery of X-ray more than 110 years ago, clinical radiography technologies have improved significantly, Liu explains. However, the basic principle of X-ray image—attenuation contrast—remains the same. Simply put, attenuation contrast refers to the differences in photographic density in an X-ray image, which correspond to the amounts of X-ray absorbed by different structures within the object.

The X-ray beam provides additional information, called phase, which can be utilized to improve the contrast in the image. The phase-contrast X-ray imaging and phase-retrieval techniques currently being developed by Liu and his team are still in the early research stage, but already show great promise.

"These methods demonstrate the potential to significantly improve the accuracy of clinical diagnosis as compared with the current analog and digital attenuation-based radiographic techniques," he says. "They have potential applications in therapeutics, also to monitor the effect of treatment or quantitatively evaluate prognosis."

If successful, Liu says, this research can revolutionize the theory and practice of clinical X-ray imaging, offering better screening and diagnostic accuracy at lower patient radiation.

The office of Lee Williams, vice president for Research and dean of the Graduate College on OU's Norman campus, oversees operations at the Stephenson Research and Technology Center on the University Research Campus, where Liu's laboratory is located. "Dr. Liu is both an excellent researcher and an excellent individual," Williams says. "His research is absolutely among the finest and most extensive at the University, which places tremendous demands on his time and energies.



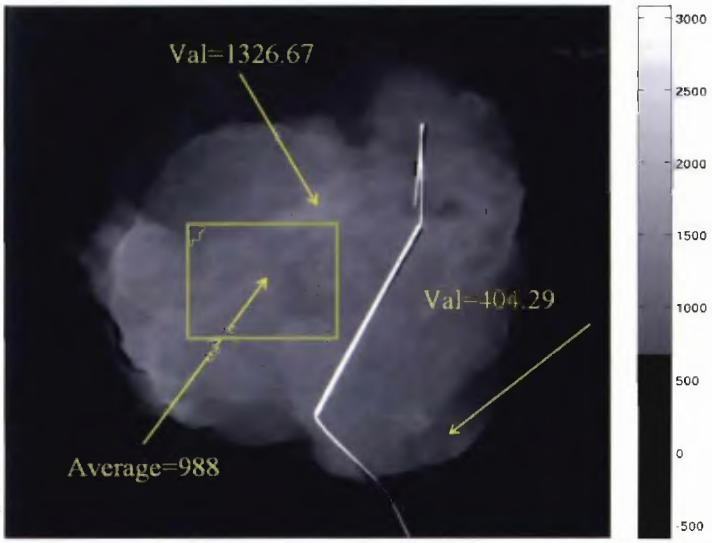


Image provided

"He is unfailingly courteous and considerate to everyone and is one of the most respected faculty among my staff. He also is an excellent supervisor and mentor to his graduate students and epitomizes the ideals of a scholar-teacher."

Tom Landers, dean of the OU College of Engineering, makes a point of visiting Liu's laboratory as often as possible. "The medical imaging work being conducted by Dr. Liu and his research team is so exciting because of the potential to improve both longevity and quality of life for cancer patients," Landers relates. "He is a superb scientist whose research is consistently supported under the most prestigious funding programs and published by

ABOVE: Dr. Hong Liu has a lot to smile about as he and colleagues continue to discover new X-ray technologies that may help save lives. LEFT: This X-ray phase image was acquired by an innovative prototype created by Dr. Liu that has the potential to improve the accuracy of cancer diagnosis in the future.

the premier journals. And OU has recognized his contributions with its highest award for research, the George Lynn Cross Professorship."

For all of Liu's accomplishments, honors and accolades—he is editor in chief of the *Journal of X-ray Science and Technology;* a Fellow of the American Institute of Medical and Biological Engineering and a Fellow of SPIE, the International Society for Optical Engineering; author of more than 160 scientific articles, numerous book chapters and several patents; and recipient of major research grants from the National Institutes of Health—he is disarmingly modest. His achievements, he maintains, are entirely attributable to the interdisciplinary and collaborative nature of the work.

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Ph.D. student Molly Wong learns as she contributes to a project aimed at developing and characterizing X-ray imaging techniques for cancer screening and diagnosis.

"My team and I are engineers working on medical applications. Our job is to investigate new concepts and characterize new modalities to provide better quality images for physicians so they can detect cancer earlier with higher sensitivity and specificity," Liu says. His group usually numbers 10 graduate and undergraduate students, post-doctoral researchers and visiting professors.

"We have to be outstanding in our own field, but we also have to understand the language and the needs of physicians, who are our end-users," he explains. "I always tell my students that we must listen to the physicians and always keep patients in our minds. We can apply for funding and build a huge toy, but we must make the toy a valuable tool."

These "toys" are complex prototypes made of electronic and mechanical components built into a framework of metal, wood and glass. The prototypes, which can take months or even years to construct, then are tested under clinical conditions at institutions across the country, including the University of Alabama-Birmingham, University of Iowa and the OU Health Sciences Center.

Doctoral student Molly Wong had a key role in the recent evaluation of one phase-contrast imaging prototype.

A second-year master's student at the time, Wong and doctoral candidate Da Zhang, disassembled and packed the entire structure—valued in the hundreds of thousands of dollars—and reassembled it on its arrival at a busy mammography clinic at the University of Iowa. During that week, Wong says she gained a new appreciation for the cooperative and balanced nature of the research process.

"Every day was precious. Da and I got to learn about what the physicians were doing, and they wanted to learn more about what we were doing," she recalls. "It was a tremendous help to collaborate with doctors to know more about what they need and what we can do to help them.

"The tests showed improved image quality with sharper, more defined structure edges. The doctors were really impressed and gave us great feedback. It was really rewarding to see the application and know we were headed in the right direction to help them better interpret X-rays in their clinical practice."

Being a part of Liu's team requires keen intellect and insatiable curiosity. The hours are long, but the rewards are many.

"Dr. Liu always looks at the big picture but breaks it down into projects with specific goals in mind," Wong relates. "We can complete a project in a matter of months and then write a scientific paper on it."

In 2008, Liu's team published 10 articles in authoritative journals. Students are the first named authors on the majority of them. Wong, for example, is the first author on one already published and another being readied for submission; she also is second author on at least two more.

"It is very important to share the results of our work with our colleagues to benefit the advancement of science and medicine. That is a measure of our success when applying for grant funding," Liu says. "But it is also very important for our students for their future careers."

The careers launched from Liu's laboratory are impressive. One Ph.D. student who worked on a collaborative project with the OU Medical Center is now a research associate there. A current doctoral student recently was wooed with a tempting job offer. "I encouraged him to pursue it but to finish his degree first," Liu says with a laugh.

These success stories are representative of just how sought-after Liu's students are. "If they make themselves competitive by working hard, learning the science and the ethics that go with it, and embracing teamwork and interdisciplinary collaboration, they will find good jobs, even in the current global economy," he declares. "The best people still find jobs. And these students are among the best."

Wong returns the compliment. "Dr. Liu is a visionary. Working with him is fascinating, rewarding and fun. I hope I will get my opportunity to pass along what I've learned to others."

Every day, little by little, with Wong and the rest of his team, Liu moves closer to his goal. "If we can develop an engineering solution to help physicians better screen, diagnose and treat breast cancer patients, we have done our job," he says.

A job, he hopes, that will help save lives.

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