

## Mission Critical Motion Control

# 3D Ultrasound Exam

*Precise, non-invasive, diagnostic breast exams using motion and imaging may reduce need for biopsies*

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To ease the stress of breast cancer exams, increase accuracy, and reduce the number of biopsies being performed, TechniScan Medical Systems ([www.techniscanmedicalsyste.ms.com](http://www.techniscanmedicalsyste.ms.com)) has developed a painless, non-invasive UltraSound CT imaging system.

According to Barry Hanover, chief operating officer at TechniScan, the system "is a combination of highly synchronized motion control, data acquisition, and a high-speed computational architecture." The system produces two unique 3D images which show the speed of sound and attenuation of sound for various tissues and structures of up to 1 mm within a breast.

"Most ultrasound systems send out a pulse and look for the first reflections back and stop sampling the data," says Hanover. "Our algorithms sample data after it has passed through the breast. Approximately 15 Gbytes of data per breast is acquired through dedicated data acquisition and multiplexing boards and is stored on a two-terabyte RAID system. A Linux cluster computer simultaneously acquires data, manages the RAID, and calculates the image algorithms."

The resulting 3D images augment traditional mammography exams by pro-

viding physicians with detailed information about the physical structures within the breast, as well as their bulk tissue properties. This information may enable physicians to better differentiate normal or benign from malignant tissue and to more confidently determine when a biopsy is required.

### How the System Works

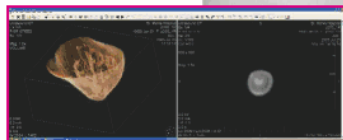
The new USCT scanning process has the patient lying face down on an examination table that has an opening which allows the breast to be suspended in a comfortable, temperature-controlled, water bath reservoir. During the approximate ten-minute exam, opposing transmitting and receiving transducer arrays rotate around the breast in two-degree increments, producing ultrasonic sound transmission data for the breast at each rotational position.

The collected ultrasound data and the exact positioning of the arrays are stored in computer memory for 180 views for each 2-mm slice of the breast (approximately 30 slices/breast). Utilizing proprietary algorithms based on inverse scattering mathematics, data is transformed into images of the speed of sound and attenuation of sound of the breast tissue with approximately 1-mm resolution.

To view a video presentation of the system, visit the TechniScan Medical Systems' website at [www.techniscanmedicalsyste.ms.com/technology.php](http://www.techniscanmedicalsyste.ms.com/technology.php)

### Technology-Enabled Process

All the precise movements and I/O required during this critical process is handled by motion control technology developed by Galil Motion Control ([www.galilmc.com](http://www.galilmc.com)). The system includes a 4-axis, card-level Ethernet controller, a stepper module for driving two stepper motors in microstepping mode and an I/O daughter

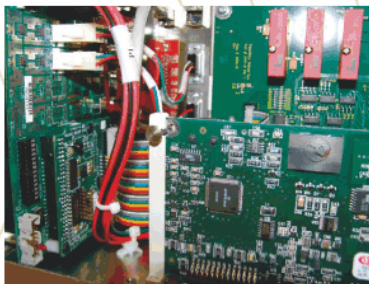


TechniScan imaging system produces unique 3D images which show the speed of sound and attenuation of sound for various tissues and structures within the breast approximately 1 mm in size.

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## Mission Critical Motion Control



**Integration of motion controller, I/O, and drives into a compact package separate from the data acquisition system and host processor provides noise isolation and interface integrity.**

board which adds 40 additional digital I/O and eight analog inputs to the controller.

"From a motion control standpoint, our biggest issue is precision," says Martin Kammeyer, a systems engineer at TechniScan. "We are measuring within a wave field at sub-millimeter resolution. If the motion control is not exactly correct all the time, and not exactly calibrated all the time, it causes a huge problem for us. Image quality, resolution, specificity, and predictive value are all impacted by the motion."

The system currently utilizes three axes of motion, leaving one axis available for adding capabilities in the future. One rotational axis is used to capture views in two degree increments, while a vertical axis captures slices that are correlated computationally to provide the 3D images. A third axis controls a breast retention rod which is under control by the operator, and is used to dock with the breast and insure that it's held perfectly still. Safety features include settings for low stall torque and controlled acceleration and deceleration of the retention rod.

In addition to meeting the application's precise motion requirements, Kammeyer says the system communicates commands and status from the host processor to the motion controller using the Ethernet interface. "This provides an industry standard interface with maximum isolation between the data acquisition system where the host processor resides and the general I/O and motion control services provided by the controller. This is important from the point of view of noise isolation as well as interface integrity."

Kammeyer adds that the Galil DMC-2143

controller enables them to perform all low-level functions related to I/O and motion control in firmware running on the controller. "This isolates the host processor from I/O details such as bit manipulation, event timing, and error detection," he adds. "Additionally, the status is available at any time to the host via a memory array on the controller."

All signals from the ultrasound receiver are amplified, filtered, and converted to a 14-bit digital value by the data acquisition and MUX system. The digital value is then stored in a computer memory for eventual storage on the RAID subsystem, which includes a series of disks that store data at high speeds. Once the data is stored on the RAID subsystem, the image and rendering algorithms convert the stored data into a set of images that can be viewed, archived, or transmitted electronically.

According to TechniScan, there are several factors that make USCT ultrasonic images so effective in aiding physicians with their diagnoses. Unlike mammograms, the USCT images provide physicians with information on the physical characteristics of different breast tissues. The reason is that the ultrasound waves of the USCT pass from the transmitter to the receiver, going through the breast tissue while allowing both speed and attenuation to be measured. Because most cancerous tissue has different attenuation characteristics than normal and benign tissue, the USCT is able to provide radiologists with new information about tissue properties that may help them improve their diagnostic confidence.

Conversely, there are two primary problems with current mammography screening methods. First, cancer is missed in about 15 percent of patients who actually have it. These are referred to as "false negatives." Second, mammography generates a high rate of "false positives" where a biopsy is performed and the pathologist determines that the tissue was benign. Current statistics show as many as four out of every five biopsies has a negative result.

An additional advantage of USCT images is that they are automatically computed with the resolution not dependent upon the skill of the operator. Plus, the unique inverse scattering algorithms allow the USCT to produce true 3D images that accurately show the physical structures within the breast.

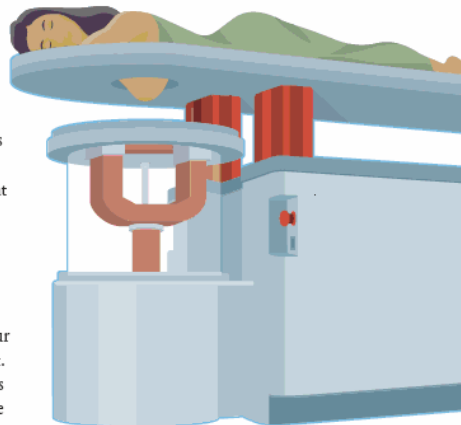
"The motion controller plays an important

role in this process," Kammeyer explains.

"That's because measurement accuracy and repeatability is crucial as repeated scans are taken on multiple breast levels and all the images must line up to produce an accurate 3D image. We also found it important that the controller provide dual loop compensation, which allows feedback from both the encoder on the actual scan shaft and the encoder on the motor. The dual feedback sensors and dual loop compensation eliminated the backlash errors from the gearbox on the motor."

Kammeyer also says that the level of integration in the motion control subsystem simplified application development. "Since the stepper drives and I/O integrated right onto the controller, it significantly shortened our development time and reduced the complexity of the design," he says.

According to Kammeyer, the application turned out to be just about a perfect mix of processing power and resources. "The Galil Motion Controller enabled us to achieve precise motion control, while keeping scanning time to a minimum, while still efficiently performing other critical functions such as temperature and water flow control in the background."



**One rotational axis captures views in two-degree increments, while a vertical axis captures slices that are correlated computationally to provide the 3D images. A third axis controls a breast retention rod which is under control by the operator.**