Case Study

TechniScan Medical Systems, Inc. and Kontron AG

Intel® Core™2 Duo Processor T7400

Kontron CP6012 Single Board Computer

3D Ultrasound Breast Imaging

How Much Performance Do You Need for 3D Medical Imaging?

You'll find 7 Kontron single board computers using Intel® Core™2 Duo processors inside the new TechniScan® 3D Ultrasound* CT Breast Imaging System

Case Summary

TechniScan® Medical Systems' 3D UltraSound* CT Breast Imaging system produces images on par with MRI clarity, and can actually distinguish unique tissue properties—enough to detect a water-filled cyst from a solid tumor. If approved by the FDA, the TechniScan system has the potential to reduce the need for painful, invasive biopsies.

This breakthrough medical imaging solution is based on a custom-built data capturing platform and a seven-node processing system, which TechniScan uses to collect, transmit and convert 30 GB of raw mathematical data into 3D, MRI-quality images. The whole process occurs in less than 60 minutes.

TechniScan's earliest system designs didn't perform this well. Data capturing in the initial design happened too slowly, which meant the patient had to lie still for hours. The data then had to be converted into an image, a process that initially took five hours. Through software optimization, TechniScan refined the process to develop images in about 2-1/2 hours. But even that was too long for TechniScan and their health care provider customers.

This case study explains how the TechniScan 3D Ultrasound CT Breast Imaging System works, and how new Kontron CP6012 single board computers using the Intel® Core™2 Duo processors are helping to meet TechniScan's goal for images in less than 60 minutes.

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—Rudi Wieczorek
Kontron Chief Technology Officer

Looking for a Better Way to Diagnose Breast Cancer

Mammography is the gold standard when it comes to early detection of breast cancer. Coupled with self examination, mammography helps detect a lot of cancer while it's still treatable. Yet mammography doesn't catch everything, and suspicious findings are not always cancer. It is well documented that 70 to 80% of breast biopsies result in a benign outcome.

The medical industry is searching for ways to improve the accuracy of screening and diagnostic procedures so that patients are not unnecessarily subjected to painful, invasive tests. Faster, more accurate diagnosis can also help keep ever-spiraling health costs down and improve overall patient care. Moreover, women might be more willing to seek screening procedures if the whole process is more comfortable and less time consuming.

What About Ultrasound Technology?

Traditional ultrasound technology is one adjunctive technology to mammography. Often used to produce images of the internal anatomy, it uses sound waves that bounce off of tissues, organs, bones, and other anatomic substances to create an image.

The downside is that traditional ultrasound images can be quite fuzzy, which makes it difficult to detect small and subtle tissue variations—like some early forms of cancer. What's more, traditional ultrasound—while good at distinguishing between fluid-filled cysts and solid masses—is not necessarily able to discern the type of mass; such as those that are benign versus those that are cancer. These limitations are similar to the problems encountered with mammography.

TechniScan's solution is different. Using both speed-of-sound and sound attenuation measurements, the TechniScan 3D UltraSound CT Breast Imaging System develops a very high quality 3D-type image. The image offers detailed information about the anatomy of the breast, including both the physical structure within the breast and the bulk tissue properties of the breast. By characterizing the properties of normal, benign and malignant tissues, the TechniScan technology may be able to help physicians confidently develop an appropriate diagnosis without invasive biopsy.

How it Works

The TechniScan 3D UltraSound CT Breast Imaging System utilizes a computationally-intense imaging algorithm called inverse scattering to provide two independent images, one is a quantitative image of the speed of sound and the other image shows the attenuation of sound. These two independent images synergistically deliver a very clear 3D image of the breast.

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> —Frank Setinsek
> TechniScan System Architect

To gather the two kinds of measurements with the TechniScan system, the technician positions the patient face down on the scanning table with her breast suspended in a water bath. Ultrasound arrays (one is a transmitter the other is a receiver) on either side of the breast take pictures at 180 positions as they circle around the pendant breast. Each cycle creates an image "slice," and each breast requires about 30–50 slices to complete the full breast image.

The ultrasound arrays are hooked up to a data acquisition system that uses one of the nodes in the seven-node image processing system to stream the raw data onto a 2 terabyte RAID. As data from each slice is transferred to storage the remaining nodes in the cluster start computing the image from the raw data. This distributed architecture uses TechniScan proprietary and patented algorithms to create the 3D image of the breast.

The Performance Factor

Consider the kind of data we're talking about here. Scans of each breast generate about 30 gigabytes of raw data. Transforming that data into an image requires a very compute-intensive algorithm. The final images are only about 16 MB, but it takes a great deal of computing effort to create the images.

Initial design work on the Ultrasound CT Breast Imaging System focused on producing the highest quality images and obtaining the most accurate data. "This was paramount," says Frank Setinsek, System Architect at TechniScan. "Our whole aim is to improve the quality of women's health care and minimize the need for invasive, painful biopsies."

Once TechniScan had the quality and accuracy finely tuned, they turned their attention to performance of the system. "Our initial system design took an extraordinary amount of time to capture the data and process the images," Setinsek explained. "Even though we were able to generate very high quality, accurate images, our system was limited by the computing capabilities of the system processors."

Even with a seven-node distributed architecture, the original system design was painfully slow. The very first scans took nearly 40 minutes to capture one "slice" of data. TechniScan eventually culled this down to about 12 seconds per slice—or 10 minutes per breast—through the use of a redesigned data acquisition system that was 100 times faster than the old design.

Although TechniScan's own optimization efforts enabled them to reduce the time needed for the patient to lie still for the scan (about 10 minutes), they were unable to reduce the amount of time needed to compute and produce the 3D images

needed for diagnosis (about 5 hours). Each node in TechniScan's seven-node system was built with a Kontron CP6011 single board computer bearing a 1.8 GHz Intel® Pentium® M processor with 2 GB of memory on each board, and connected by a fibre channel host adapter to a 2 terabyte RAID data storage system. TechniScan employed Intel's compilers and optimization tools to obtain the best possible scan-to-image conversion time using this platform, cutting the image processing time from 5 hours to about 2-1/2 hours.

"That just wasn't good enough," says Setinsek. "The customer's [health care provider's] expectation is to be able to review images with the patient immediately after the exam. Because image processing begins at the start of the exam, the ultimate goal is to produce complete images in less than 30 minutes."

Success with Multi-Core Processing Technology

To bring their image processing performance time down, TechniScan engineers began working on changes to their algorithm that would speed calculations. They also turned to Intel software tools to help reduce the calculation time. Once they reached the limits of those tools, TechniScan asked Kontron and Intel to find a more powerful processing platform that would aid their efforts.

Although new multi-core processing technology is only beginning to reach the marketplace, Intel was able to provide samples of its most powerful dual-core chips for Kontron to test. Kontron then quickly built the Kontron CP6012 single board computer using the Intel® Core™ Duo processor T2500 at 2 GHz with 2 GB of memory on each board and (4) Gigabit Ethernet interfaces. Two of these boards are currently being evaluated by TechniScan.

TechniScan is anxiously awaiting the next version of Kontron's CP6012 board with the Intel® Core™2 Duo T7400 processor. Effectively increasing the number of total processing cores from seven to fourteen is expected to give TechniScan the performance boost they need—and then some. "We not only project that we will meet our current goal of delivering images in less than 60 minutes," says Setinsek. "We will have room on this platform to increase the size of the raw data files without affecting the time it takes to create an image."

Because Kontron develops boards in lock-step with the Intel processor roadmap, it was very quick and easy for them to deliver the new Kontron CP6012 board within a few weeks of getting the sample Intel chips. "Our Premier membership in the Intel Embedded and Communications Alliance allows us to get advanced engineering specifications and design information before the new chips reach production. This means we can engineer products based on the latest Intel roadmap, and then deliver the actual solution within days of getting the final chip," says Rudi Wieczorek, Kontron's CTO. "We can deliver boards at the same time Intel releases final silicon, which is a huge win for our customers, saving months off the time it might take them to deliver products to market."

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What's also important to understand is that the seven-node, Kontron CP6012 SBC-based TechniScan system is really just a generic embedded supercomputer. The clustering software used by TechniScan is fairly universal, although its use with the CompactPCI* interface and hot-plug cards is not all that common in an embedded application. But the bottom line is that any developer could add their own software, like TechniScan, to run the most compute-intensive applications. The configuration could be modified to add nodes without doing anything except recompiling the software.

It should be noted that TechniScan's custom-built data acquisition system also uses Intel components, including the Intel® IOP321 I/O processor. "We could not buy a system to capture the data fast enough, so we had to build our own," Setinsek claims. "But there was no need to design our own chip because the Intel® IOP321 I/O processor gave us the high throughput needed to capture and transfer the data almost in real time. We were able to get up to 120 Mbytes/sec using the Intel chip—over a hundred times faster than our first design."

Setinsek says Kontron and Intel have been extremely helpful throughout the design process. "We're a pretty small company, and it means a lot to have such an experienced design team helping us out." The mere fact that both companies work globally was also important. "We knew that any Intel or Kontron design would be sustainable over a long time and compatible with the other components we needed."

In the Hands of the FDA

TechniScan still has work to do to ensure that its 3D Ultrasound CT Breast Imaging System can perform in the real world as it does in the test environment. Kontron and Intel are working with them to ensure that it will.

For now, the final decision on the efficacy of this new diagnostic tool is being evaluated in clinical trials and will ultimately be reviewed for clearance by the FDA.

About the Intel® Communications Alliance

The Intel® Embedded and Communications Alliance is a community of communications and embedded developers and solutions providers who share a common vision on the convergence of computing technologies. The member companies within the Alliance are committed to the development of modular, standards-based building blocks, platforms, and solutions based on Intel technologies, processors, products, and services. The availability of these standards-based modular building blocks and solutions offer the market greater choice, faster time to profit, and the opportunity to innovate using modular building blocks from multiple levels of integration—silicon, software, boards and complete systems.

About Kontron

A global leader in embedded computer technology and mobile rugged solutions, Kontron supplies a diversified customer base of OEMs, system integrators, and application providers in the automation, test and measurement, communications, medical, gaming and entertainment, military, aerospace, transportation, and energy markets. The company helps its customers considerably reduce their time-to-market and gain a competitive advantage with products including: high-performance open computer platforms and systems, single board computers, human-machine interfaces, and mobile rugged computers and displays. Kontron is a Premier member of the Intel Communications Alliance and was selected as member of the year in 2006.

For more information:

www.kontron.com
www.techniscanmedicalsystems.com
www.intel.com/go/eca
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° Please note: TechniScan Medical Systems, Inc. has not yet received approval from the US Food and Drug Administration to market the UltraSound CT Breast Imaging System, so we do not make any claims about the unique product capabilities or engage in any marketing efforts. Current clinical studies are focused on demonstrating equivalence of the company's automated Ultrasound CT to traditional hand-held ultrasound. Future studies will examine the diagnostic benefits of the unique bulk tissue measures of sound speed and attenuation.

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