Case Study

Medical

Revolutionizing Breast Imaging

Meeting the Performance Needs of a Revolutionary 3D Ultrasound CT Breast Imaging System

Medical Imaging

CP6011

CP6012

Computer-On Modules | Blades & Mezzanines | CPU Boards | Systems | Mobile Rugged | Custom Solutions

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Executive Summary

While the most common method for early detection of breast cancer is mammography, critics of the procedure believe it is not necessarily the most effective tool for detecting tumors and may not always provide the most accurate results. In a 10-year retrospective study of breast-cancer screening and diagnostic evaluations among women, a total of 9762 screening mammograms and 10,905 screening clinical breast examinations were performed, for a median of 4 mammograms and 5 clinical breast examinations per woman over the 10-year period. Of the women who were screened, 23.8 percent had at least one false positive mammogram, 13.4 percent had at least one false positive breast examination, and 31.7 percent had at least one false positive result for either test. These false positive tests led to 870 outpatient appointments, 539 diagnostic mammograms, 186 ultrasound examinations, 188 biopsies, and 1 hospitalization. Over 10 years, one third of women screened had an abnormal test result that required additional evaluation, even though no breast cancer was present. The study concluded that techniques are needed to decrease false positive results while maintaining high sensitivity.[1]

The medical industry is continually searching for ways to improve the accuracy of breast cancer screening procedures. Faster, more accurate diagnosis can also help keep ever-spiraling health costs down and improve overall patient care. And with more comfortable and less time-consuming procedures, a larger percentage of women may be more willing to undergo them.

Traditional ultrasound technology, which is often used to produce images of the internal anatomy, is one option to mammography. It uses sound waves that travel through water and bounce off of tissues, organs, bones, and other anatomic substances to create a mirror image. However, 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. In addition, traditional ultrasound only identifies a possible mass, without necessarily being able to distinguish the type of mass. These limitations are similar to the problems encountered with mammography.

One company which is seeking to make an impact on breast cancer detection is TechniScan Medical Systems. The company is a privately held medical device company engaged in the development and commercialization of a revolutionary ultrasound imaging system, known as the UltraSound CT™, which has developed a new kind of ultrasound technology that uses both speed of sound and attenuation measurements to develop a 3D type image. The goal is to develop a scanning system to differentially characterize amongst normal, benign, and malignant tissue.

By characterizing the ultrasound properties of normal, benign and malignant tissues, the UltraSound CT™ has the potential to help physicians develop an appropriate diagnosis, perhaps without the need for invasive follow-up procedures. This kind of information about tissue properties is simply not available through traditional scanning methods and can often only be obtained through biopsy.

Revolutionizing Breast Imaging

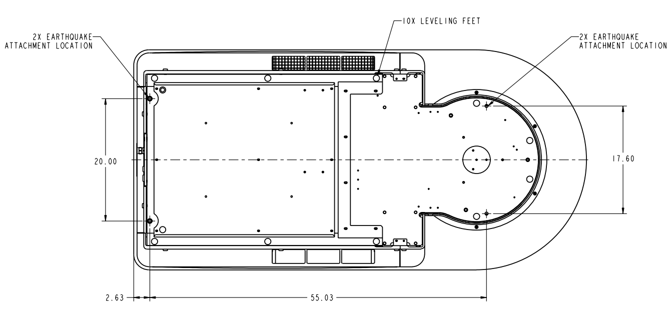
By David Pursley
Applications Engineer

The Application – 3D Ultrasound CT™ Imaging System

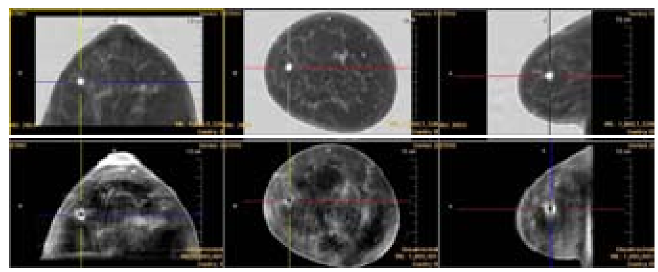
TechniScan's UltraSound CT system is designed to provide physicians with a new, non-invasive, diagnostic imaging tool that may provide detailed information about the anatomy (i.e. physical structures within the breast) and pathology (i.e. bulk tissue properties) of the breast.

Unlike conventional breast ultrasound which measures the echo of sound waves as they reflect off tissue to produce images, UltraSound CT uses transmission ultrasound to produce two unique sets of images of the breast; one based on the speed of sound and one based on the attenuation of sound. The images from these two different measurements can be displayed in many orientations for review by a radiologist.

Ultrasound transducers (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 transducers are connected via cable to a data acquisition system that uses one of the nodes in a seven-node Linux cluster to stream the raw ultrasound 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 unique inverse scattering algorithms allow the UltraSound CT to produce 3D images that accurately represent the physical structures and their spatial relationship to each other within the breast. Additionally, inverse scattering provides new information about the speed and attenuation of sound values of tissues registered in all three spatial directions. This fully digital technology provides information about tissue properties not previously available to physicians and radiologists which may improve diagnostic confidence. For instance, the system is capable of distinguishing unique tissue properties – enough to detect a water-filled cyst from a solid mass.



Another key benefit of the UltraSound CT system is its ability to scan the whole breast, allowing the radiologist to more easily localize and characterize areas of interest that have been identified by clinical exam or by mammography.

These benefits combine to provide additional information which may result in greater diagnostic confidence for radiologists and a safe and comfortable breast exam for women. As a result, TechniScan hopes to reduce the need for invasive, painful biopsies.

Technology Challenges

This application requires an immense amount of computational power to process the huge amount of data quickly. A typical scan of each breast can generate about 30 gigabytes (GB) of raw data – or 60GB total per patient. Transforming that data into an image requires a very compute-intensive algorithm. The final 3D image is only about 16 MB, but it requires a great deal of computing effort to create that image.

The early development of the Ultrasound CT™ Breast Imaging System focused on producing the highest quality images to obtain the most accurate data. However after improving the image quality and ensuring the accuracy of its results, TechniScan had some very serious performance hurdles to overcome. The very first scans required nearly 20 minutes per 2 mm breast layer, a process that TechniScan eventually culled down to only about 12 seconds per layer or 10 minutes per breast through the use of a redesigned data acquisition system that captured data 100 times faster than the previous design.

Although TechniScan's own optimization efforts enabled them to reduce the time needed for the patient to lie still for the scan (less than 10 minutes), they were unable to reduce the amount of time needed to compute and produce the 3D images needed for diagnosis. The current system incorporates a 7-node Linux cluster built with seven Kontron CP6011 single board computers that feature a 1.8 GHz Intel® Pentium® M processor with 2GB of memory, and connected by a fibre channel host adapter to a 2 terabyte RAID data storage system. The image processing time on this system was about five hours per breast. Obviously the system was too slow, so Techniscan asked Kontron and Intel to work together to help reduce the time to create an image.

TechniScan employed Intel's compilers and optimization tools to obtain the best possible scan-to-image conversion time using this platform: about 2 and 1/2 hours. Even with a 7-node distributed architecture and optimized software, the imaging was still too slow. It was determined that the system was limited by the computing capabilities of the system processors.

In order to be successfully commercialized, the performance of the system needed to satisfy the needs of its health care provider customers. Industry 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 initial goal is to produce complete images in less than 60 minutes.

Achieving Increased Performance with Multi-Core Architecture

To substantially decrease their image processing performance time, TechniScan engineers began working on changes to their algorithm that would further speed calculations. They also turned to Intel software tools to help reduce the calculation time. Once they reached the limits of those tools, TechniScan looked to Kontron and Intel to find a more powerful processing platform to achieve their goal.

After analyzing the design challenges, a multi-core platform was selected to deliver the performance needed. Intel's 65nm process technology makes it possible to integrate two cores in one physical package. Intel's platform approach to development combines a multi-core architecture and complementary system-enhancing technologies to deliver scalable, energy-efficient processing. The Intel Core Duo processor delivers nearly twice the performance as the previous Intel Pentium M 756, while consuming the same amount of power.

According to Kontron benchmark data using a single-threaded software application, the Kontron boards using the new Intel dual core processors show an increase in floating point performance of over 96.5 percent, higher integer performance of over 89.3 percent, and double the 3D mark.

To meet the requirement of the TechniScan UltraSound CT application, Kontron built the CP6012 single board computer using a single Intel Core Duo processor T2500 at 2GHz with 2GB of system memory. This increased the number of total processing cores from seven to 14 providing the necessary boost in performance that TechniScan was seeking. The initial results are encouraging and show that with Kontron's T7400 based CP6012, Techniscan should be able to achieve their initial goal of delivering images in less than 60 minutes.

Kontron CP6012 Overview

Kontron's CP6012, a 6U CompactPCI® CPU board with Intel® Core™ Duo processor T2500 (2 GHz), is a powerful, very flexible and high density CPU engine designed for applications calling for distributed high processing capabilities and tremendous I/O throughput. With its E7520 and 6300ESB chipset, it handles data throughput like a server.

Since Kontron develops boards in conjunction with the Intel processor roadmap, the CP6012 board was delivered within weeks of receiving the sample chips. Its membership in the Intel® Communications Alliance enables Kontron to get advanced engineering specifications and design information before the new chips reach production. This means the company can engineer its next-generation products based on the roadmap, and then deliver the real thing within days of getting the final chip. As a result, Kontron is able to deliver its customers with boards at the same time Intel releases final silicon, which can translate to saving months off the time it takes them to deliver products to market. Delivering a stable product based on Intel's embedded product line; Kontron ensures that its CP6012 offers long-term availability. This eliminates the risks associated with unplanned design changes and unexpected application modification.

The Kontron CP6012 offers more features and expandability than other CompactPCI boards in its class. The boards supports a configurable 64-bit, 66MHz, hot swap CompactPCI interface. In the System Master slot the interface is enabled, and if installed in a peripheral slot, the CP6012 is isolated from the CompactPCI bus.

A further feature of the CP6012 is its support of PICMG CompactPCI Packet Switching Backplane Specification 2.16. When installed in a backplane which supports packet switching, the CP6012 can communicate via two Gigabit Ethernet interfaces with other peripherals. With hot-swap and IPMI (Intelligent Platform Management Interface) support, the CP6012 meets the highest demands for the management of high-availability applications.

Kontron's CP6012 also offers a high degree of integration and the latest interface technologies such as PCI Express, up to 4 GB/400 MHz DDR2 SODIMM RAM (6.4 GB/sec throughput) and a fast Serial-ATA interface including hard drive or Compact Flash slot on board. Four Gigabit Ethernet interfaces via PCI Express(two to the backplane / two front-side), 4x USB 2.0, 1xCOM, VGA, and rear I/O support round out the feature set. There is room for customer-specific expansions on an XMC or alternative PMC slot for mezzanine cards. The ATI ES1000 provides sufficient graphics performance (VGA/CRT 1600 x 1200 pixels at 85Hz).

The CP6012 is designed for stability and packaged in a rugged format, which fits into applications situated in industrial environments, making it an ideal core technology for long-life applications.

Due to the robust construction of the system, it is ideal for image processing systems in medical applications, such as the TechniScan UltraSound CT imaging system.

Advantages of Standards-Based Blade Solutions

Blade server computing is fast transforming the server industry with a host of advantages in terms of design, functionality and total cost of ownership. According to IDC, market momentum in the blade market continued in the quarter with blade volumes up 50 percent year over year. Blade shipments increased more than 60 percent year over year in 2005 as IT managers began to adopt blades as a standard building block in their virtual IT infrastructures.

By separating CPU and memory from other components such as cabling, power supply, network connectivity and cooling systems, blade servers can significantly reduce massive enterprise server architectures into highly compact and dense form factor. Consequently, a number of blade servers can be combined into a single, powerful computing resource. Unlike their traditional rack counterparts, blade servers allow administrators to reduce power, cooling and space requirements and provide a real advantage due to the ease and speed at which they can be deployed.

Blade servers offer huge scalability in a small space and flexibility in the type of blades that can be used within a single chassis -- from low-cost uniprocessor blades to high-performance multi-processor blades as the cluster used in TechniScan's UltraSound CT system.

Standardization is among the top issues that blade suppliers must address. Many companies are reluctant to install proprietary architectures into their corporate systems because they fear limited choices for add-ons and technological dead-ends. This was a key consideration for the TechniScan UltraSound CT application, since the company was concerned about investing in many different form factors or getting locked into a proprietary architecture with a single source.

Standards-based architecture like PICMG 2.16 eases the process of product integration and maximizes a company's competitive advantage to meet their time-to-market window. PICMG 2.16, or CompactPCI Packet Switching Backplane, is one of the newer specifications issued by the PCI Industrial Computer Manufacturers Group (PICMG). PICMG 2.16 is an extension of the PICMG 2.x family of specifications that implements a packet-based switching architecture (based on Ethernet) on top of CompactPCI. This enables elements in a chassis to be considered "network elements" as opposed to the master/slave structure in the traditional, bus-based CompactPCI architecture.

PICMG 2.16 was developed to extend the life of existing CompactPCI systems by combining the inherent robustness and reliability of CompactPCI with packet-switched Ethernet fabrics. The PICMG 2.16 platform evolved from the confluence of new IP-based communication applications, the growing popularity of CompactPCI and the fact that IP Ethernet switching has become the dominant LAN topology in the enterprise marketplace. Its necessity, however, was driven by the ever-present need for bandwidth and time-to-market pressures - both inherent limitations of the PCI bus.

Although PICMG 2.16 has been designed to conquer the limitations of the PCI bus, this new architecture is designed to complement existing CompactPCI systems, not replace them -- thereby extending the life of the rugged and familiar CompactPCI architecture.

System architects developing around PICMG 2.16 can design high-bandwidth, exceptionally scalable and distributed systems capable of offering high availability and fault-tolerant features not possible with existing bus-based architectures.

Kontron is a leader in providing key building blocks for standards-based solutions. The CP6012 boards used in the TechniScan UltraSound CT application are fully PICMG 2.16 compliant. As a result, the boards are compatible with a wide range of modular off-the-shelf embedded components and provide support for major operating systems and real-time software.

Kontron is one of the few CompactPCI manufacturers that provide in-house support for most of the industry-proven, real-time operating systems that are currently available. Due to its close relationship with the software manufacturers, Kontron is able to produce and support BSPs and drivers for the latest operating system revisions in order to quickly take advantage of the changes in technology. Since Kontron boards are based on industry-standard components, they support most third party clustering software which allows any developer, like TechniScan, to add their own software to run the most compute-intensive applications. The configuration is highly scalable and can be easily modified to add nodes without doing anything except recompiling the software.

TechniScan, Intel and Kontron Collaborative Efforts

One of the key values that technology vendors can provide is to create a flexible technology solution that can react to changes in demands. TechniScan turned to Kontron not only to provide a solution that offered maximum computing power, but that was compatible with the other required components yet flexible enough to be adapted to meet evolving market needs and sustainable over time.

Kontron looks at market segments horizontally in the development phase, selecting the best advances in the technology that will give its customers the most benefits. Once these are identified, Kontron looks at the market segments vertically to provide solutions that are adapted for each market segment. In order for this application to be successful, Kontron was involved in the early stages and throughout the design process. Kontron not only leveraged its own knowledge and expertise in embedded computing technologies, but it utilized its close working relationship with Intel, to ensure TechniScan was able to get the maximum processing power available utilizing the most efficient COTS (Common off the Shelf), CompactPCI®-compliant products.

By utilizing the latest advanced technologies based on open standards and working in close collaboration, Kontron and Intel were able to help TechniScan deliver an application that could revolutionize breast cancer detection.

TechniScan UltraSound CT Breast Imaging System in the Real World

TechniScan is still working 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 continuing to work with them to ensure that the performance will stand up to the rigors of the daily environment it will be used.

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 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 employs more than 2,300 people worldwide and has manufacturing facilities in Europe, North America, and Asia-Pacific. The company is listed on the German TecDAX 30 stock exchange under the symbol "KBC". Kontron is a Premier member in the Intel® Communications Alliance which means earliest access to leading-edge Intel technologies and privileged engineering support. For additional information on Kontron, please visit www.kontron.com.

Refererences

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AUTHOR'S BIO

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