

Using Gaming Technology to Save Lives, with Medical Imaging

by Stuart G. Hall

Imaging's need for higher processing speeds

It's taken for granted that progress in increasing the power of the computers and reducing their cost has played a fundamental role in speeding up the implementation of medical imaging technology. So maintaining the pace of advancement in imaging modalities, plus synergetic developments from multi-slice CT to molecular imaging, goes hand in glove with improvements in computational power. One way medical images are being improved is by using visual images from more than one source - magnetic resonance imaging (MRI) and computerized tomography (CT) scans for example. The generation of computer-enhanced images from multiple sources must begin with accurate alignment of the visual data.



When three dimensions and millions of pixels are involved, the task becomes exponentially complex. Within this scope, the need for higher processing speeds is essential. And this is precisely where the cost-effective benefits of gaming industry technology are starting to make an impact. Already nimble players in the marketplace are using gaming GPUs to dramatically increase processing speed. Now with the use of the Cell Broadband Engine (Cell BE) processor (the first implementation of the Cell Broadband Engine Architecture) used in Sony PlayStation 3 (PS3), with its highly parallel architecture and its high memory bandwidth the possibility is for medical imaging to take an exponential step forward in performance, with real gains to be had in improving services to the patient.

Early to see these crossover benefits with a gaming industry background, Dutch-based 3mensio, founded in August 2003, focuses on exploiting the capabilities offered by so-called Graphics Processing Units (GPUs) on graphics boards that are quickly becoming commodity components of PCs. Their tremendous speed and programmability, enhancing quickly as a result of the fierce competition in the multi-billion dollar computer games industry, to provide the path towards a new level of functionality and price/performance for advanced 3D medical imaging. Another company using games-derived GPU technology to speed up radically processing is Canadian company Acceleware. The company is currently examining the possibility of creating hardware (GPU) accelerated reconstruction algorithms.

Their expertise lies in their ability to harness the parallelizable properties of the GPU, making it an exceptional tool for processing certain algorithms. The business model is to integrate with existing companies, providing seamless integration of their two hardware and software products creating a faster and better end user experience. "We believe that we will be able to accelerate the CT-reconstruction

algorithm by a significant factor. One of our major goals would be to bring the reconstruction to near real-time, thereby reducing the time spent waiting for image reconstruction," said Acceleware's Alice Ford-Hutchinson. They're joined by another Canadian company, Calgary Scientific Medical Group, which has also exploited the advanced gaming graphic capabilities to manipulate and display large data sets using the computing power of both standard Mac and Microsoft operating systems.

These 'early movers' innovative approach in marrying gaming technology to medical imaging has not got unnoticed in the multi-billion dollar market place. Obviously business is going to notice when any commoditized technology is a good deal cheaper than specialized solutions, and when applied to the growing needs of medical imaging and the need to improve speed and quality of service to the patient you can start to see why gaming-originated solutions are really starting to make significant inroads. In the last few months a newcomer on the scene has started making waves, thanks to the need for exponentially greater computer power for the PlayStation platform. Jointly developed by a Sony, Toshiba, and IBM, in an alliance known as 'STI'. The architectural design and first implementation were carried out at the STI Design Center over four years, on a budget reported to be approximately US\$400 million.

What's doubly significant about the PS3 is the purpose built GPU it runs on. The PS3's GPU (called the RSX), when combined with the cell processor, is designed to provide two teraflops of floating point horsepower. "A measure of the extraordinary processing power of RSX compared to current-generation game consoles is the numbers of transistors it will contain: 300 million. This is more than the total number of transistors in both the central processing units and the graphics processing units of the three leading current-generation systems, combined," claimed the RSX's graphics-card manufacturer Nvidia in a pre-launch statement.

Mercury rising

Early proof of the power of the PS3 Cell processor in medical imaging came just a few months ago Mercury Computer Systems announced a cooperation with the Institute of Medical Physics (IMP) of Erlangen, Germany, which is focused on the joint development and commercialization of medical imaging technology deployed on the processor.

Under the terms of the agreement, Mercury is working together with the IMP on designing and implementing ambitious reconstruction and visualization algorithms with real-time performance on the processor, to deliver orders-of-magnitude performance increases while also reducing the complexity and costs of medical image processing systems. Together with IMP technology, Mercury will integrate the algorithms into high-performance Cell-based systems designed to significantly accelerate the reconstruction and visualization of medical imaging data for medical OEMs.

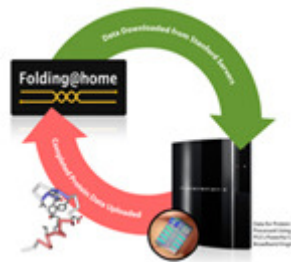
As example of the joint work, Mercury and the IMP have developed a processor-based solution capable of performing modern CT reconstruction more than 100 times faster than conventional microprocessors. The level of parallelism along with the vast I/O capabilities permits the processor to efficiently implement complex CT reconstruction algorithms with close to real-time performance. The processor enables system design in which the radiologist can view images obtained from better algorithms, with higher quality, much sooner than ever before.

"With the Cell processor, advanced approaches thought to be too demanding in terms of processing can now enter daily routine," says Marc Kachelriess, Professor of Medical Imaging at the IMP. "The tremendous

processing power of the Cell BE processor enables the use of iterative reconstruction algorithms designed for the reduction of beam hardening and metal artifacts. Analytical and statistical CT reconstruction algorithms that allow for enhanced image quality, while keeping the X-ray exposure of the patient as low as possible, can also be implemented on a Cell BE processor-based platform."

Want a cost-effective medical imaging supercomputer? Just ask friendly PS3 gamers

The supercomputing story begins last month when Sony announced that PlayStation computer entertainment systems will have the capability to connect to Stanford University's Folding@Home program, a distributed computing project aimed at understanding protein folding, misfolding and related diseases. Folding@Home is leveraging PS3's powerful chip – and what will be an even more powerful distributed supercomputing network of PS3 systems – to help study the causes of diseases



The beneficial relationship between Folding@Home and PS3.

With the addition of PS3 donors, Folding@Home is the most powerful distributed computing resource on the planet, and for the calculations Stanford run (parallel independent molecular dynamics trajectories), the most powerful supercomputer of any type (distributed or otherwise). And the latest news is that the Stanford team are just shy of making the one petaflop mark, with the key help of the PS3 donors. (As of 2006, the fastest supercomputer's performance tops out at one petaflops.) In addition computing capacity more than doubled last month, thanks to the addition of hundreds of thousands of PS3 consoles. Sony are reportedly looking seriously at the possibility of providing such a super-computer to commercial ventures, though this would require some kind of incentive to users to get access to their PS3 capacity.

"We're thrilled to have Sony be part of the Folding@Home project," says Vijay Pande, Associate Professor of Chemistry at Stanford University and Folding@Home project lead. "With PS3 now part of our network, we will be able to address questions previously considered impossible to tackle computationally, with the goal of finding cures to some of the world's most life-threatening diseases."

Blades of glory?

Collaborators from Mayo Clinic and IBM have also exploited parallel computer architecture and memory bandwidth to dramatically speed up the processing of 3-D medical images. The advance significantly aids image registration - the computer-enhanced alignment of two medical images obtained at different dates or

by using different imaging devices, in three-dimensional space. With the images properly aligned over one another, a radiologist can more easily detect structural changes such as the growth or shrinkage of tumors.

"This alignment of images both improves the accuracy of interpretation and improves radiologist efficiency, particularly for diseases like cancer," says Mayo radiology researcher Bradley Erickson, M.D., Ph.D who initially contacted IBM to discuss Mayo's computing needs. Through porting and optimization of Mayo Clinic's Image Registration Application on the IBM BladeCenter QS20, the application produced image results 50 times faster than the application running on a traditional processor configuration.



Pictured Mayo radiology researcher Bradley Erickson, M.D., Ph.D

For this imaging project, Mayo Clinic and IBM used 98 sets of images and ran the optimized registration application on the QS20, in comparison with running the original application on a typical processor configuration. The application running on a typical processor configuration completed the registration of all 98 sets of images in approximately seven hours. The team adapted a 'mutual-information-based' 3-D linear registration algorithm application optimized for Cell/B.E. and completed the registration for all 98 sets of images in just 516 seconds, with no registration taking more than 20 seconds. "Alignment is computationally expensive so making it a lot faster is good for both the radiologist who has to run the process a couple of times and better for the patient who doesn't have to wait as long for the result. We've turned hours into seconds," says IBM's Shahrokh Daijavad.

The 3-D linear algorithm finds the best spatial positioning to maximize the amount of information gathered from the two images, thereby optimizing sampling quality while reducing sampling time. Greater efficiencies were achieved by caching data in cuboids or 'bricks' so image sampling did not 'waste' pixels. When sampling ratio was comparatively low, the team packed the sampled moving pixel images in a contiguous fashion (in an 'image stripe') to speed retrieval when needed.

By running the application faster, a physician will be able to make a quicker diagnosis and promptly begin appropriate treatments for patients. "Currently this is still in testing with Mayo in Bradley Erickson's lab, it's not yet ready to roll out for clinical use," confirms Shahrokh. "However we are currently in negotiations to do just that – there's a good possibility it will happen." Shahrokh adds that for IBM this was the start of a potentially much broader involvement in the medical imaging business, "working in partnership with the major OEMs to become a player".

Virtual reality, samba style



In a different kind of games-related spin-off IBM has teamed up with game specialists Brazilian-based Hoplon Infotainment, this time integrating IBM's better-known mainframe expertise with the PS3 Cell. The

aim is to create a super-fast virtual environment platform, which has the potential to handle complex simulations. "As online environments increasingly incorporate aspects of virtual reality - including 3D graphics and lifelike, real-time interaction among many simultaneous users - companies of all types will need a computing platform that can handle a broad spectrum of demanding performance and security requirements," says Jim Stallings, general manager, IBM System z. "To serve this market, the Cell/B.E. processor is the perfect complement to the mainframe, the only server designed to handle millions of simultaneous users."

To achieve this goal, the workload will be divided between the mainframe and the Cell processor. The Cell will handle the complex simulation associated with operating in virtual worlds, says Jon Erickson, editorial director of the software development portal Dr Dobb's Portal. "Well, it isn't exactly PlayStation 3 meets the mainframe - but it's close," says Erickson. "The potential for a combination of Z-series and Cell for existing medical imaging applications is immediate. The potential for the concept of virtual world on top of that platform, for the domain of medical applications, is a little further away in time," cautions IBM's Shahrokh Daijavad. The potential applications for 3D medical imaging are obvious, if commercially unproven at this juncture, but watch this space as we intend to keep a close eye on developments on Medicexchange.com.

Next stop Washington

Next stop for the PS3 chip is the forthcoming late July 'Workshop on Solving Computational Challenges in Medical Imaging,' where IBM and the University of Washington will show how next-generation technology currently featured in computer entertainment and video-processing platforms is helping drive advancements in medical imaging.

This high-level two-day workshop will bring leaders in academia and industry together "to discuss the current status, unmet clinical needs, challenges, and opportunities in medical imaging from computational perspectives". It promises to be an interesting two days, according to Professor of Bioengineering at UW's Image Computing Systems Laboratory, Yongmin Kim who with over 25 years experience is excited about the benefits of the new PS3 chip for clinicians.



Professor of Bioengineering at UW's Image Computing Systems Laboratory, Yongmin Kim

In fact Seattle is well known for its expertise in ultrasound and Professor Kim is himself working currently with a company on developing a new ultrasound machine using the PS3 Cell, with preliminary results to be presented at the Washington meeting. "The Cell's higher power means you can essentially do more for less, less cost for greater speed," he says.

"The impact of the Cell chip means a ten to 20 times improvement using the multi-core processor, allowing the use of algorithms which we didn't previously have the computer power for. This is a leap forward for medical imaging technology, for example digital radiography, x-ray CT, MRI and ultrasound."