Success Story

Robarts Research Institute

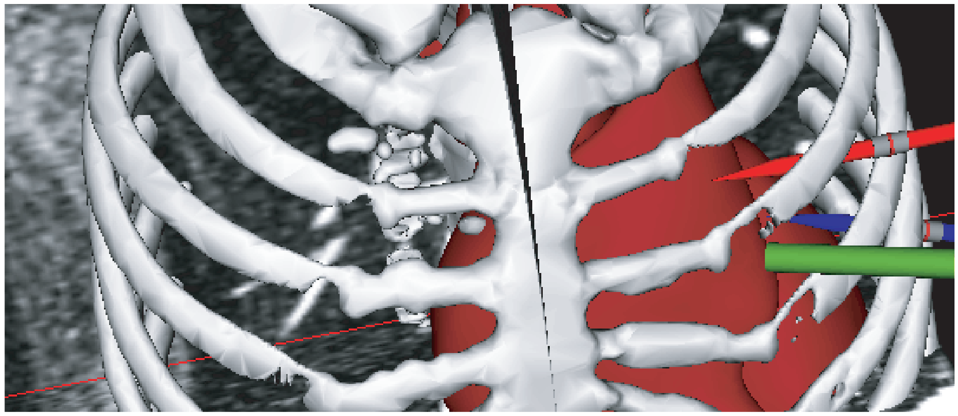


Image courtesy of Atamai Inc.

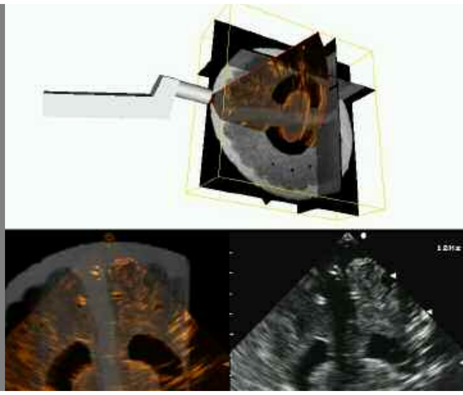
Silicon Graphics Prism™ System Enables Advanced Medical Simulation for Development of Minimally Invasive Surgery Techniques

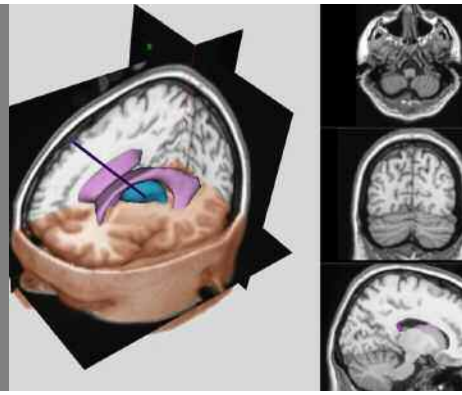
Robarts Research Institute is revolutionizing medical research by using advanced visualization technology to develop minimally-invasive surgery and therapy techniques that will decrease trauma to the patient. By creating a virtual surgical environment to model functioning human organs and simulate surgical procedures, researchers in Robarts' Virtual Augmentation and Simulation for Surgery and Therapy (VASST) Laboratory are advancing a broad range of medical procedures in areas such as neurosurgery, prostate cancer therapy, breast cancer biopsy, and cardiac intervention and surgery.

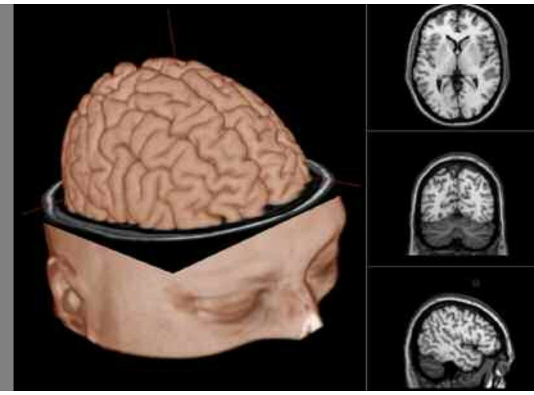
The virtual surgical environment will guide surgeons during minimally-invasive surgical procedures in the operating room (OR), and lead to enhanced tools that can be used for surgical planning and during surgery. Image-guided surgical tools will incorporate information from multiple sources and present it to the surgeon in a single virtual representation. A surgeon will be able to perform procedures, such as the treatment of arterial fibrillation, or the repair of heart valves, by introducing instruments into the cardiac chambers through the wall of the beating heart, thus avoiding the need to arrest the heart, open the chest and place the patient on a heart-lung machine. Advanced visualization techniques will closely track heart movements within the chest cavity to avoid damaging delicate tissue while incising and suturing.

Cardiac surgeon, Dr. Gerard Guiraudon, the clinical collaborator on Robarts' beating heart projects, explained, "Because in conventional surgery, surgical targets need to be viewed and accessed directly, unnecessary trauma is often inflicted upon the patient. Virtual reality visualization of the organ registered to the patient will allow target-specific access without the need for direct vision. Such visualization is the key to effective minimally-invasive surgery on the beating heart."

To meet the intense computing demands created by the VASST project, Robarts chose a complete compute, visualization and storage solution from SGI. Using a Silicon Graphics Prism™ visualization system, SGI storage technology and Visual Area Networking (VAN), researchers are now able to do interactive real-time volume rendering of their largest datasets in the laboratory, office or operating room. Additionally, the virtual surgical environment will accelerate medical research by eliminating time-consuming and costly trials involving animal or human subjects. In a parallel to the aerospace industry, where a pilot can use a simulation to evaluate the efficacy of various technical







approaches or maneuvers without risking expensive aircraft or life, surgical simulators will increasingly perform similar roles in the development of new surgical and therapeutic procedures. With Robarts' virtual environment, for the first time, researchers and surgeons will be able to plan, develop, practice and evaluate an entire minimally-invasive surgical procedure without the use of living creatures.

According to Dr. Terry Peters, scientist and principal investigator at Robarts, "Achieving these goals requires an ability to compute and present results to a surgeon in real-time. For instance, the visualization that results from Robarts' beating-heart model must be synchronized with ultrasound images and presented to the surgeon with no delay to be of benefit in the OR. Generating visual results in real-time requires exceptional hardware and software capabilities."

Silicon Graphics Prism Visualization System Delivers Industry-Leading Performance

For high quality, interactive volume rendering of entire datasets, Robarts has

deployed a Silicon Graphics Prism visualization system with twenty-four Intel® Itanium® 2 processors, four ATI® FireGL graphics processor units (GPUs), and 28GB of memory. Because the system has a high degree of scalability, as medical imaging devices increase in resolution to create even larger data sets, Robarts can grow their visualization capabilities by seamlessly and independently scaling compute, memory, graphics and I/O.

"We selected SGI because of proven leadership in medical imaging and benchmarked performance that beat the competition," says Peters. "Just as important, the Linux® operating system of the Silicon Graphics Prism platform integrates well with our existing Linux desktop environment. Code developed on desktop systems is easily portable to our SGI system, so we are able to use our existing code in the SGI environment without a big porting effort."

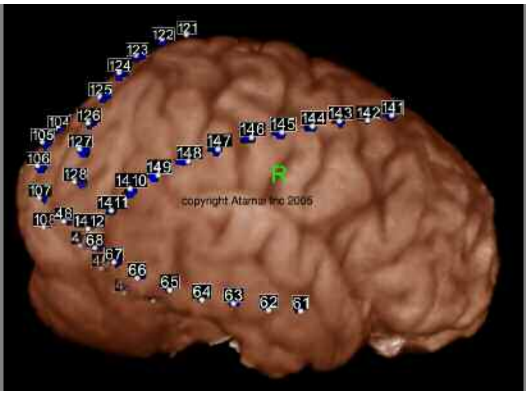
Silicon Graphics Prism visualization systems enable breakthrough insights by integrating SGI's advanced visualization capabilities with the computational power needed to process, segment, and analyze large volumes of medical data. Typical commodity graphics systems (clusters) must break large data sets into smaller chunks for graphics processing—a process that is time-consuming and imperfect. As a complete visualization system, Silicon Graphics Prism was designed to address terabyte-sized, highly complex data as a single contiguous data set in memory. Results of computation are immediately available to the system's GPUs for display, in contrast to clustered systems where computational results must be retrieved across comparatively slow cluster interconnects before display is possible.

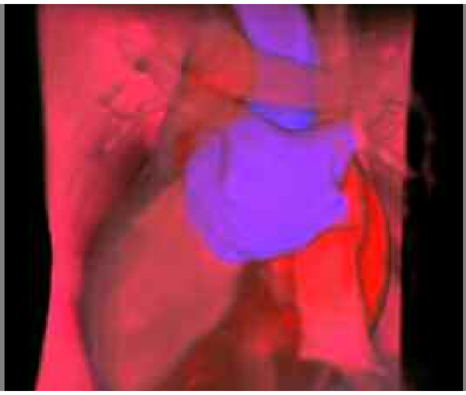
"The multiple GPUs on our Silicon Graphics Prism system will give us the dynamic volume rendering capability needed to visualize an entire complex data set such as our beating heart model both in the lab and in the OR," says Peters. "Surgeons can change views and interact with the model in real-time. Different GPUs can be assigned different tasks to increase graphics performance.

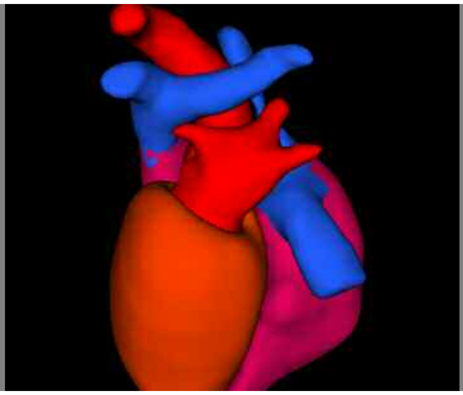
"For instance, one GPU might image the locations of surgical instruments and probes which can be composited with output from another GPU displaying the output of the beating heart model registered to ultrasound from the patient," Peters continues. "Because the graphics technology in the Silicon Graphics Prism system is similar to that in our Linux desktops, we are again able to immediately leverage highly-optimized graphics code that we've previously developed, so our code can offload intensive graphics operations to GPUs for even greater speedup."

Bringing Advanced Visualization To the Operating Room with VAN

Because it's not always possible to move advanced visualization systems where they are needed, Robarts also added SGI's Visual Area Networking (VAN) capability. VAN extends the benefits of the Silicon







Graphics Prism system across local and wide area networks, delivering high-resolution volume visualization of multiple imaging modalities to physicians' offices, diagnostic centers, and operating rooms. Additionally, geographically-dispersed experts in a broad range of fields can collaborate together by using VAN to run interactive volume visualization applications on their thin clients while the patient's data remains safe and secure. Highly scalable and flexible, VAN solutions can easily be deployed to provide analytical and visual capabilities that are 10 to 1,000 times more powerful than those available with traditional desktop solutions.

Using VAN technology, a surgeon or researcher developing a new technique with the help of Robarts' virtual environment can collaborate with other experts in different locations by sharing the same view of the model. "When we start testing our image-guided surgical tools, VAN will be used to transmit the output of applications running on the Silicon Graphics Prism system in the VASST computer laboratory to operating rooms and laboratories in the next building," adds Peters.

As part of the VAN solution, OpenGL Vizserver™ software enables the transfer of rich data between the Silicon Graphics Prism system and a thin client. To keep the files small, VAN technology transmits only the pixels of the rendered graphic, rather than the raw data itself, and supports a variety of compression mechanisms to facilitate visualization over slower transports. As a result, VAN technology can operate on virtually any type of client, bringing the power of interactive visualization and multi-site collaboration to individuals and teams throughout Robarts.

An Advanced Storage Infrastructure

Achieving real-time results also requires a state-of-the-art storage infrastructure. Storage bottlenecks can impede the flow of critical data and stall progress. To meet the growing storage needs of its busy research centers, Robarts chose an SGI InfiniteStorage solution capable of delivering data where and when it's needed while providing an economical and readily expandable storage pool.

The SGI InfiniteStorage Shared File System CXFS™ is deployed at Robarts to deliver shared data across many different computing platforms providing exceptional bandwidth over a fibre channel SGI® InfiniteStorage SAN Server. A separate SGI Altix 350 system is deployed as a metadata server for CXFS, coordinating data access between heterogeneous CXFS clients. CXFS clients read and write data directly across the SAN at the full bandwidth of 2Gb/second fibre channel.

Storage is provided using 2TB of fibre channel RAID storage coupled with 7TB of economical SATA disk storage. Data Lifecycle Management (DLM) software from SGI is used to manage migration between the two pools. The active data set is stored on fibre channel RAID for maximum performance. When data is no longer being used, it is automatically migrated to SATA storage by SGI InfiniteStorage Data Migration Facility (DMF) software based on rules defined by Robarts. Whenever a file stored in the SATA pool is accessed, it is automatically recalled to the active storage pool. The result is a large pool of online storage with the performance and capacity needed to meet the needs of the entire VASST effort, but at a fraction of the cost of fibre channel disk.

Atamai, Inc.: A Different Approach to Medical Software

Atamai, a collaborative venture with Robarts, the University of Western Ontario

Canada's only independent center for medical research, Robarts Research Institute, is developing advanced technology to improve surgical techniques and reduce invasiveness, and is a center of excellence for the development and use of medical imaging.

and the London Health Sciences Centre, provides custom medical visualization solutions to research groups worldwide. The company was formed over five years ago by graduate students from the VASST project. Since that time, Atamai has broadly applied its tremendous expertise in the programming required for medical visualization, while retaining a close association with researchers at Robarts.

Atamai is pioneering a new, cooperative approach to application development. Rather than developing restricted, proprietary software solutions, the company maintains a growing repository of software components that can be modified and assembled quickly into functioning applications. Much of this code base is available under a non-restrictive license, making it attractive for academic environments to use and contribute code. These institutions and their employees derive comfort from the fact that their access to the intellectual property is preserved.

“Under the terms of our ongoing relationship, Atamai is helping us to continue developing our interactive visualization platform and other critical initiatives such as our beating-heart model,” says Peters. ”The company knows our requirements inside and out, which enables them to support our ongoing development efforts like no other company in the medical software field.”

Partnerships Make the Difference

Robarts is working closely with both SGI and Atamai to overcome roadblocks and uncover the innovations that will lead to success. SGI Professional Services and Atamai are working together to ensure that Atamai software takes full advantage of the global shared memory and other features of the Silicon Graphics Prism architecture. This collaboration benefits not only Robarts, but all Atamai customers. The Atamai software now fully leverages advanced graphics APIs from SGI and incorporates advanced image processing and analysis techniques originally developed at Robarts.

"We're excited to collaborate with SGI Professional Services on this breakthrough system for Robarts," said Dr. Yves Starreveld, president, Atamai. "A project of this scope—where the stakes are so obviously high—requires enormous expertise in system integration and scientific computation. Fortunately, the Silicon Graphics Prism platform made porting as easy as possible by providing a familiar Linux shared-memory programming environment enhanced by Intel's powerful programming tools and SGI's sophisticated scientific computation libraries."

Both Atamai and SGI are committed to the success of the VASST project. With its existing system already fully subscribed, Robarts is planning upgrades that will more than double the capabilities of the existing system. “We feel confident that we’ve got the right people, the right infrastructure and the right partnerships in place to enable the VASST project to succeed,” concludes Peters.

Current VASST Research Initiatives:

- Enhanced visualization for surgical guidance to make it possible for a surgeon to accurately locate organs and perform surgery without making large incisions in the body surface.
- The ability to visualize and manipulate dynamic images in real-time to give a surgeon a complete and detailed view of an organ without the need to expose the organ for direct visual inspection.
- Image registration to align virtual models with patient images. This provides a surgeon with a level of detail not achievable from non-invasive imaging technologies (MRI, CT, ultrasound) alone.
- The development of robotic instruments that provide haptic (tactile) feedback to the surgeon to increase a surgeon’s sensitivity when performing robotically-assisted surgery through small openings.
- Tracking of surgical instruments and probes in a virtual environment.
- The integration of 2D and 3D ultrasound images with beating heart models.
- Mathematical models of tissue to ensure that computer models responds to incisions and other surgical procedures like a real patient.

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