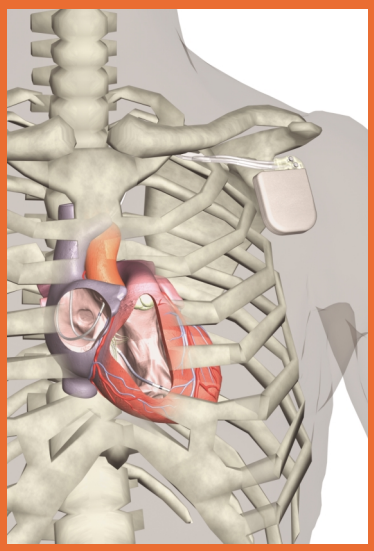
Success Story

Medtronic Uses SGI™ Technology for Innovations in Life-Saving Medical Devices



"Medtronic would not be achieving the high level of quality products that it is if it weren't for the visualization and simulation activities that are allowed by SGI technology."

—Tim Abraham, Surgical Simulator Development Coordinator, Cardiac Management Therapy Delivery Division, Medtronic

Medtronic is the world leader in medical technology, providing lifelong solutions for people with chronic disease. Specifically, the company is the world's leading designer and supplier of pacing systems for the treatment of heart conditions, heart failure, and various cardiovascular diseases.

A Medtronic pacing system consists of three essential components: the pacemaker, the pacing lead, and the programmer. The pacemaker works in conjunction with the pacing lead, a special insulated wire that carries tiny electrical pulses from the pacemaker to the heart and relays information about the heart's electrical activity back to the pacemaker. These two components are surgically implanted inside the body. The third component, the programmer, is a specialized computer that is kept at the hospital or clinic and used by a physician or nurse to monitor and adjust the settings of the pacemaker.

The first Medtronic nonimplantable pacemaker was developed in 1949. Medtronic's first implantable therapy appeared on the market in the late 1950s and was designed to normalize the too-slow heartbeat of bradycardia patients. Since 1985, significant improvements in pacemaker patients' quality of life have been achieved by adding the ability for the pacing system to adjust automatically to changing activity levels, such as when the patient is exercising. In the early 1990s Medtronic introduced a therapy for people who go into tachyarrhythmia or tachyarrest, a condition in which the heart is beating too rapidly. It was about this time that Medtronic began using RISC systems that were based on SGI workstations with MIPS® R4000® processors. Medtronic needed to develop a higher level of knowledge about its products, how they behave, and how they could be developed or modified more quickly. The SGI 3D visualization environment proved to be the perfect solution for facilitating new product-development practices.

Medtronic's newest therapy, cardiac resynchronization, addresses heart-failure conditions. At present, only 4% of would-be heart transplant recipients ever receive a new heart. The majority of patients on the waiting list continue to suffer from the condition of their deteriorating hearts and/or from directly related complications—poor circulation, diabetes, kidney failure, and brain malfunction. A newly released system called InSync® is emerging as a promising treatment for some of the more than 20 million people worldwide now in the throes of progressive heart failure. In the United States, hospitalization for chronic heart failure totals more than 6.8 million days a year. The total cost of treating the disease is more than $38 billion annually, and the cost is expected to mount as the population ages. With InSync, Medtronic seeks to reduce the number of hospital visits and improve the quality of life for many of these severely compromised patients.

Computer-Based Modeling and Simulation

SGI systems for computer modeling and simulation, such as Silicon Graphics® O2® and Silicon Graphics® Octane® workstations and SGI™ Origin™ family servers, are helping Medtronic to speed the design and development of new therapies.

Tim Abraham, surgical simulator development coordinator at Medtronic's Cardiac Management Therapy Delivery Division, explains, "The computer technology used is dramatically reducing design time and changes the way we think of the design process. We now are able to do more, faster, and have extreme confidence in the design decisions that we make. The simulation technology we have developed gives us critical traction required in this competitive marketplace."

The company uses a host of software products to explore new possibilities, such as I-DEAS®, Pro/ENGINEER®, ABAQUS®, Maya®, and customized tools written by Medtronic for use in conjunction with these applications.

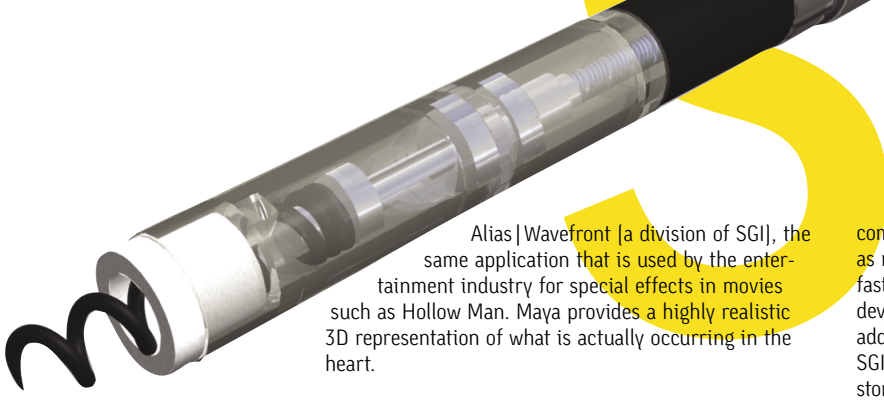
Modeling the Environment

In developing complex medical devices intended for implantation, modeling the device is only half the equation. Medtronic also models the environment in which the product is being placed, in this case the heart. A primary focus is to provide better, more reliable products for its patients. Medtronic pacing system research and development focuses on uncovering new innovations within its products. At present there is much study surrounding pacemaker lead materials, and Medtronic plans to meet the challenges of continuous innovation through use of simulation and modeling technologies.

According to Abraham, "New surgical simulators will need to be able to model complex anatomies as well as physiologic behavior and cardio physical properties. In addition to procedural simulator training, it is also hoped that the models will be able to predict design performance prior to production."

In the future the advancements in heart modeling will result in a rapid increase in model complexity. Conditional slider bars can then be used to quickly modify the condition of the model by enlarging the heart, enlarging the valve, increasing or restricting the blood flow, and then mapping the conditions to best represent the type of environment in which the lead should be placed. The models will be used for research and development of new products and for training purposes as well as in clinical studies for product comparison analyses.

ABAQUS, from HKS, is Medtronic's primary mechanical modeler. The company also uses Maya, from



Alias|Wavefront (a division of SGI), the same application that is used by the entertainment industry for special effects in movies such as Hollow Man. Maya provides a highly realistic 3D representation of what is actually occurring in the heart.

Trends in Performance and Model Complexity

Through the years, SGI hardware and software solutions have helped Medtronic minimize the time required to test models while maximizing product development speeds. Using SGI™ 2000 series systems, the complex jobs ran three weeks. With the introduction of a new SGI™ Origin™ 3000 series system with a 600 MHz processor, that time dropped to just one week. With further advancements in processor speed and computing systems architecture working in combination with optimized code and newly developed algorithms, courtesy of ABAQUS, Medtronic hopes to achieve overnight turnaround on highly complex jobs within the next few years.

Among the many benefits of these faster computers being used by the scientists are being able to solve more problems and the ability to add features to their models or increase the number of elements without worrying about bringing the computer to its knees. According to Abraham, "Electrophysiologic models increase the complexity by a factor of nearly 10. If end users drive the model to its end point, where I believe they want to, the complexity of the models we run today may well be just a fraction of those we are running within three years."

Compute and Storage Capacity

To ensure adequate compute capacity, SGI is working with Medtronic to divide the workload between their SGI 2000 series and SGI Origin 3000 series systems. SGI is also helping to implement a scheduling program and making sure CPU sets are in place to optimize utilization and performance. With the release of ABAQUS 6.2, scalability is now up from four CPU jobs to six to eight CPU jobs depending on the type of elements used in the job.

The SGI 2000 series system, with an InfiniteReality2™ graphics pipe, also serves as Medtronic's primary rendering machine for any type of data sets such as volume data or Maya 3D models. The SGI 2000 series system is complemented by the real-time volume rendering capacity of the Octane workstations. In addition to its rendering capabilities, the SGI 2000 series system is a great tool for animators because of the speed at which it rasterizes images.

Complex 3D models take up a lot more space than their contemporaries. And with regulatory mandates requiring companies to have an audit trail for the data generated as new products are created, data storage capacity is fast becoming a crucial component of pacing system development. To meet the requirement, Medtronic has added nearly 3TB of storage to its SGI 2000 series and SGI Origin 3000 series systems and bumped up disk storage capacity significantly on its SGI workstations.

Next Steps

SGI computer modeling and simulation are helping move Medtronic in other new and equally inspiring directions. The Medtronic surgical simulator project now under way strives to improve the quality of patient therapies by using 3D modeling to provide physicians with advanced levels of technical and training support. Medtronic envisions its virtual surgeries being distributed to physicians in hospitals and clinics via a central SGI server using the unique SGI visual serving technology.

A similar effort was undertaken in recent years when Medtronic created a surgical simulator on an OpenGL® API-based system to train physicians on the delivery of a heart failure lead. Current simulator drawbacks, however, include the ability to use only a limited number of polygons to represent the model as well as issues involving reliability. High-performance visualization servers from SGI will be able to deliver the millions of polygons needed to accurately simulate placement of a lead anywhere in the heart.

Intrinsic Value

Using SGI hardware and a range of advanced modeling and simulation technology, Medtronic has increased the insight and the understanding of very scientific data. Now, people who may not understand the complexities of a product design as described in a white paper, or decision makers who may not realize its value in the marketplace, can go to a computer and gain valuable product insight through visualization tools that communicate the ideas in three-dimensional clarity. According to Abraham, "The most successful people within the company are regularly utilizing these technologies."

In summing up what SGI brings to the research and development table, Abraham says, "The most significant contribution that SGI provides for Medtronic is value...the kind that stands behind the computer, even more so than what's in the computer. SGI delivers not only the physical technology of the computer, but backs it with an intellectual and scientific support system as well as a hardware support system that is second to none. It's about much more than just cycles in a computer, it's about the partnership."

For more information on Medtronic's products, therapies, and services, visit its Web site at www.medtronic.com.

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