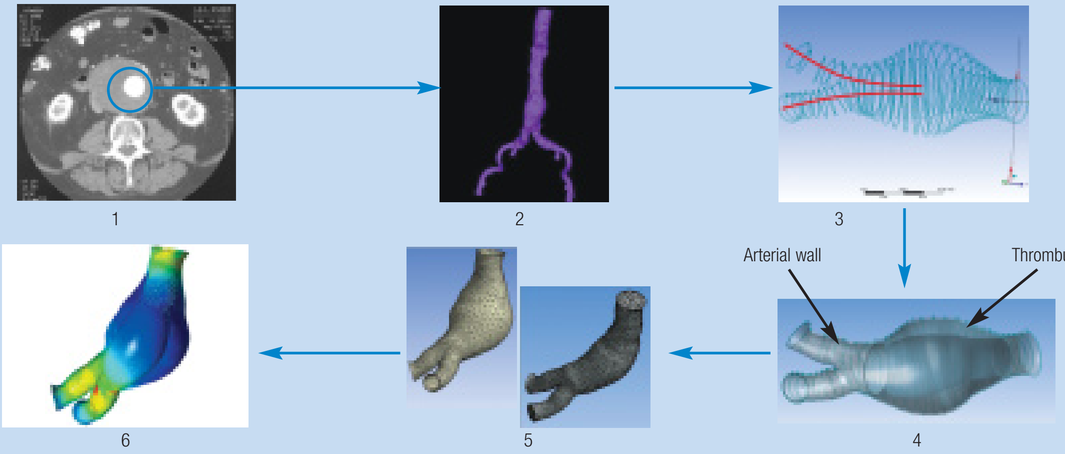
Simulation Driven Product Development: Making Life Longer and Better

The biomedical industry is emerging as a strategic user of engineering simulation.

By Thierry Marchal and Kumar Dhanasekharan, ANSYS, Inc.

Recent analyses show that leading biomedical companies around the world are continuously growing their investment into research and development (R&D), with an increase of 12.5 percent in 2006 that reached total R&D expenses exceeding $9 billion [1]. This is no surprise, given the need for advanced medical treatments and care due to a large and growing population of aging individuals, the need to find minimally invasive treatments for conditions such as diabetes and heart disease, and the increasing demand for artificial organs. As medical product innovation continues to become more complex, there is a strong emerging need for Simulation Driven Product Development, which has been seen and is broadly accepted in the semiconductor, aerospace and automotive industries.

Simulation is becoming an integral part of the product design cycle in biomedical applications ranging from prosthetics and artificial organs to endovascular techniques to surgical devices, medical equipment and diagnostic products. There are a number of reasons for such simulation to continue its entrenchment in biomedical product development. First, the advancement in technologies such as high-performance computing (HPC) is able to meet the demands of biomedical product development, allowing healthcare institutions, life science researchers and the industry to conduct large-scale simulation studies. The increasing ability to import computed tomography (CT) scans and magnetic resonance imaging (MRI) into simulation software — a process now becoming routine — makes it feasible to address in vivo device design needs (such as with respiratory drug delivery and endovascular devices), essentially enabling virtual prototyping. In addition, the integration of simulation techniques across multiphysics, from structural analysis to flow modeling to thermal analysis, is enhancing the virtual prototyping needs of the biomedical industry. For example, in studying aneurysms, ANSYS simulation tools have been used to import CT scans into the simulation



Simulation Driven Product Development is being applied regularly in the biomedical industry. This aneurysm study was performed within an integrated environment to analyze coupled fluid flow and structural simulation. The steps are: 1) CT scan; 2) segmentation from scans to extract branches; 3) cuts are written in form of splines; 4) creation of solid geometry composed of arterial wall/thrombus and automatic creation of fluid volume from the solid geometry; 5) independent mesh for each simulation technique (flow modeling and structural modeling); and 6) coupled fluid and structural model with model setup, analysis and post-processing in a single environment.

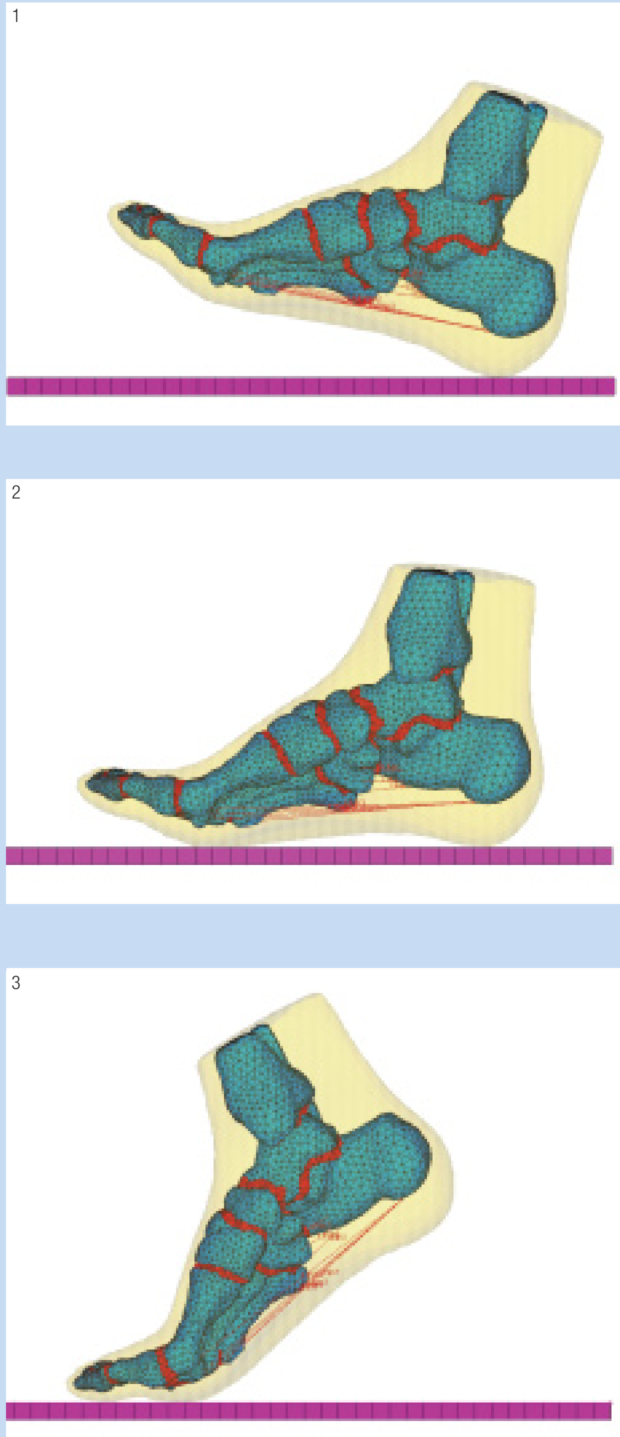
environment, allowing researchers to study a structural analysis of the weakened arteries along with the flow patterns in a single virtual environment, truly creating a virtual prototype model with multiphysics, all in an integrated manner.

Another growing area is drug delivery, particularly with medicines that are released into the bloodstream or respiratory system. There is a need to better understand the process and how adjustments can be made to accelerate drug delivery to the point of highest efficacy, which then will allow healthcare companies to design better devices that administer appropriate dosages.

Similarly, orthopedic departments are paying more attention to the virtual prototyping approach brought by computed-aided engineering (CAE). Bones are critical pieces of the body, having complex, specific geometries; they are made of different materials exhibiting strongly nonlinear behavior. Until now, scientists have lacked proper, robust models that can be used to bring together, into a single simulation, characteristics as complex as poro-elasticity, nonlinear viscoelasticity and linear elasticity, which are needed for an accurate description of an intervertebral disc (ID), for example. The improved robustness of existing models together with the availability of reliable material properties now provides evidence that these numerical results can bring new, invaluable information to doctors. As a result, healthcare institutions now are studying how a hip prosthesis will perform related to a comfortable walk over a long period of time as well as investigating — prior to planning spinal surgery or even designing an ID implant — whether the remodeling procedure leading to the unification of the pedicle screw and the vertebra is likely to progress smoothly. [See Standing Up Right on page s10.]

To illustrate recent concrete progress in addressing real-life problems and pain relief via CAE, this biomedical spotlight describes applications in which simulation technology has made a major difference. Both fluid flows and solid mechanics, or the combination of the two, appear in surprising applications. Some are critical to patient life or function, such as lung air flow and spine implant; others simply make life more comfortable through better ear implants and insole design.

For the future, imagine the impact of simulation to drive the development of patient-specific medicine and medical care. For example, tomorrow's surgeons may be able to take CT scans of patient physiology and use simulation to conduct virtual surgery as well as study the procedure's effectiveness as part of the overall process. This is enabled through automation of simulation along with rapid design comparisons through automated parametric studies — and it is rapidly becoming reality. The era of simulation in the biomedical world is rising. ■



Proper design of a medical insole required to develop an accurate modeling of the foot at different stance phases during required ambulation: 1) the initial contact state; 2) the mid-stance state; and 3) the toe-off state. The resulting data was used to calculate the pressure and stress induced on the plantar surface as well as inside deep tissues.

References

[1] *The R&D Scoreboard 2006*, Volume 2, Department of Trade and Industry (DTI), U.K.