

# Computer Graphics in Medicine

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**M**edical images hold us captive. X-rays of your daughter's broken leg or a magnetic resonance scan of your father's brain tumor emit a tractor-beam that grabs your attention. With those images, we see clearly what is otherwise hidden from us and potentially lethal to a loved one.

Computer graphics is integral to the imaging systems that deliver this information. Our fixation on this miracle of discovery and our fascination with our own physiology compel us to push the technology further. Together, computer graphics and medicine have generated entirely new views of anatomy. So much new image information is available about the anatomic structure and pathology of disease that clinicians have been warned to expect more diseases to be detectable by imaging in the future. Yet technology races ahead, leaving clinical medicine to sort through the discoveries. What is useful? What can help health care now? As in other disciplines, the medical community needs to catch up with technology.

Matching new information with the appropriate clinical response is the challenge confronting us. This process always takes time. Early applications of computer graphics in medicine captured the imagination of the radiology community. For example, dramatic 3D views of bone and soft tissue were a necessity at any radiology conference in the late 1970s. Yet this technology has only recently reached clinical practice and has not yet become routine. Medical applications of computer graphics will not succeed unless they replace or eliminate more expensive procedures. We need to justify the information we deliver now in the context of clinical problems needing solutions. We also need to avoid the spiral where the diagnostic power of new imaging technologies accelerates our rush to respond with similarly high-tech (expensive) therapy.

## Cost versus clinical benefit

CT and MR scanners deliver inherently digital images. They include image processing and graphic computing power that is ideal for the application of computer graphics. All the pieces are there: 3D image data, high-resolution displays, large frame buffers, array processors, color displays, and hard-copy peripherals. Unfortunately, these imaging modalities that can most easily benefit from computer graphic applications are the most expensive. Due to their cost, widespread installation in the US, and controversial physician funding, CT and MR receive unprecedented public scrutiny. Likewise, computer graphic applications fall within this public focus.

With our physician colleagues, we return to the issue of clinical utility. What applications make sense? Given the current political climate, the medical imaging industry must make the connection between medical data rendering and subsequent therapy. It is not enough to make a pretty picture—we must look beyond to a broader view that includes genuine clinical benefit.

The US population expects high-tech medicine to be readily available, and the US generally surpasses other countries in the level of medical technology accessible to consumers—those with the ability to pay. Our national health care has become ex-

clusive. It doesn't need to be that way. For example, Japan has 13.6 MR systems per million people versus 12.3 in the US. This diffusion of high-tech medicine is only possible in Japan by freezing reimbursements at a low rate. Typically, in Japan you would pay \$200 per MR scan versus \$800 in the US.

There is tremendous pressure to reduce CT and MR product costs. Like CT, MR and ultrasound costs have crested during the past few years. At the same time, capability has dramatically improved. This process is natural for any technology as it matures, yet the process has accelerated recently as if steroid-induced.

## Reducing the costs

Articles in this special issue illustrate progress toward reducing the high cost of health care. They demonstrate how computer graphics can help speed surgery and simplify diagnosis. Cover and colleagues advance model deformation to an interactive session for simulating the surgical environment. Though demonstrated for hip prostheses, this technique is equally applicable to any orthopedic or cranio-facial disorder. Caponetti and Fanelli emphasize a different aspect of surgery, integrating advances in solids modeling with surgical simulation.

Ultrasound has proven to be one of the most cost-effective medical imaging devices for visualizing soft tissues. The equipment is relatively low cost, and the clinical benefits are manifest. Ultrasound images are typically 2D, making the article by Nelson and Elvins here on 3D visualization particularly interesting.

Shell rendering by Udupa and Odhner uses medical data to best demonstrate a new data structure that speeds visualization of volume data. They show how fuzzily defined structures, common in medical data, can be rendered at interactive rates.

The article by Yoshida and coworkers describes a surgical simulation system usable by clinicians and surgery students. This effort illustrates a remarkable integration of computer graphics, 3D rendering, and practical surgical instrumentation. □

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