Sensitive to the Touch

The Project: Create a realistic, virtual reality simulation with which doctors and students can practice a knee arthroscopy procedure.
The Solution: Use two off-the-shelf haptic devices instead of a computer mouse, and a haptics software development kit to touch-enable the procedure.

By David Chen, Ph.D.

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Virtual reality technology like that in the Nintendo Wii isn’t just for kids anymore. Haptic technology&#151providing virtual touch, or force feedback to computer users&#151is an increasingly common element in surgical simulation solutions. Product designers are building a sense of touch into a variety of simulators using off-the-shelf haptic devices and easy-to-use software development toolkits.

Medical simulation systems that use haptics change the paradigm for how surgeons and residents are trained. “See one, do one, teach one” is the current philosophy for medical students learning new procedures. Yet to gain real confidence, “practice makes perfect” is a better mantra. Rather than practicing on live patients, medical simulation gives students the ability to try new procedures in a highly realistic setting where they have “permission to fail”&#151much as pilots use flight simulators.
Touch of Life Technologies (ToLTech) recently launched a diagnostic knee arthroscopy simulator, ArthroSim, in which surgeons use two Phantom haptic devices from SensAble Technologies&#151one in each hand&#151to interact with their virtual patient. ToLTech’s co-founder and director of engineering, Dr. Karl Reinig, and his team used SensAble's OpenHaptics software development kit (SDK) to touch-enable the procedure.
Diagnostic knee arthroscopy requires skills that can only be acquired through repeating the procedure until surgeons learn the “feel” of it. The joint compartment is small, the view often blocked by thin waving structures resembling fan coral, and there are many nooks and crannies that hinder motion of the arthroscope and probe.
Recreating this environment presented many challenges for Reinig’s team. For the experience to resemble real diagnostic arthroscopy, the soft tissues must all deform in response to flexion and side-to-side forces applied by the surgeon. The cartilage of the femur and tibia must feel hard, smooth, and nearly incompressible, while

softer tissue structures&#151like the anterior cruciate ligament or the menisci&#151must deform significantly when probed and feel different as well.

The team began by milling away a cadaver’s knee, then creating images from the revealed cross-sections to produce 1/10th mm resolution data. From the cross sections, the team produced high-fidelity texture-mapped polygonal models. Engineers ran finite element analysis and applied the resulting data to animate the models so they respond to the user flexing the knee and putting force on it.

Using SensAble’s OpenHaptics SDK, Reinig’s team created a system that takes position and orientation information coming in from the haptic devices, and produces the desired forces to be delivered back out to the user’s hand. Because SensAble's OpenHaptics toolkit is patterned after the OpenGL API, it is familiar to most graphics programmers, which makes it easy to learn and use. Custom software developed by Reinig’s team produces the deformations of the tissues associated with contact with either the virtual arthroscope or probe.

“SensAble’s Desktop haptics have proven to be an economical, robust, and high-fidelity solution for tracking the virtual tools while displaying the diverse forces to the students,” Reinig said.

Haptics are being used in dozens of medical training applications ranging from epidural to arthroscopic simulation; from stroke rehabilitation to temporal bone drilling; from virtual suturing to simulated sonograms. As medicine meets the world of virtual reality, haptics likely will play an increasingly important role.

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