Networks, Simulation, Robotics, and Orthopaedics

The California Orthopaedic Research Network

APPLICATIONS THAT TAKE ADVANTAGE OF ADVANCED network capabilities are essential to today's orthopaedic surgeons. "Orthopaedic knowledge compounds in a manner similar to money invested at 12 percent: it doubles every six years. The average orthopaedic surgeon who finishes residency training at the age of 30 and retires at 65 will be exposed to six doublings," according to Dr. Victor Frankel of New York University.

"How can they keep up? Digitized information, simulation, and remote access via advanced networks are the answer. Lifelong learning—so important to good patient care yet so hard to achieve—will be greatly facilitated by access to knowledge provided by Internet2 applications."

The California Orthopaedic Research Network (CORN) was formed to show the medical potential of advanced networks by demonstrating applications that illustrate real-time streaming of orthopaedic surgery. Its focus is to provide evidence that information technology enhances noninvasive surgical techniques and is key to the future of medical services. CORN members use advanced networks for education, research, and day-to-day interaction, including streaming video for viewing surgery in real time, access to large image collections such as the Visible Human, and the use of haptics (teleoperation) to sense remote actions.

Facilitating Orthopaedics

CORN's first area of emphasis comprises the facilitation and coordination of health applications whose development and deployment have been hampered or prevented by slower Internet technology.

University research projects have explored intensively high bandwidth and numerous possible service guarantees. CORN will demonstrate the utility of advanced network applications to a broad range of orthopaedic research, education, and clinical practice.

James Davis, Ph.D., associate vice chancellor of information technology at UCLA, said: "What is striking about CORN is the convergence of several next-generation network technologies, a sense of direction in a particular medical area, and a critical mass of capability and interest. Having been involved with streaming laparoscopic surgery video over Internet2 and the start-up of the megaconferences in the late 1990s, I'm excited to see CORN begin to explore the comprehensive application of several Internet technologies."

CORN's second area of emphasis lies in the facilitation and coordination of general application tools that take advantage of the advanced network services of the California Research and Education

The California Orthopaedic Research Network (CORN) was launched at the fall 2002 Internet2 meeting in Los Angeles. Initial CORN participants included the University of Southern California, Stanford University, UC Los Angeles, and UC San Diego. The launch event featured a multisite, interactive, real-time demonstration of high-performance network applications currently in use throughout the health sciences community. The organizers selected applications that demonstrated the use of high bandwidth for transmission of real-time video, as well as access to interactive images from large media collections.

(Photo, top right: Simulation servers provide interactive access to rich three-dimensional anatomical models.)

Network (CalREN) of the Corporation for Education Network Initiatives in California (CENIC) and Internet2's Abilene network infrastructures. These tools are most likely to arise in the process of developing specific applications across a range of application areas, but their ultimate value will be to seed the long-term distributed development of applications to support health care and the life sciences.

One tool resource that is being studied is the Visible Human Project. The project makes available high-resolution, cross-sectional images of the entire bodies of both male and female humans. These images are being used over the Internet for teaching anatomy, for research on visualization and modeling, and for further development of network tools to manage and access large data sets.

The Biomedical Informatics Research Network (BIRN) is a second tool resource, according to Michael Marron, director of the Division of Biomedical Technology of the National Center for Research Resources at the National Institutes of Health. BIRN, supported by the National Center for Research Resources, integrates biomedical research efforts across key research centers throughout the United States.

Prof. W. LeRoy Heinrichs of Stanford University uses haptically enabled laparoscopic tools to execute simulated surgical procedures across Internet2.

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>
> Parvati Dev, Stanford University

Video-conferencing

CORN members use videoconferencing over the CalREN and Abilene networks to support their research collaborations. At Stanford University, weekly research meetings are held with collaborators in Wisconsin and Sweden. Committee meetings with Internet2 and other organizations are now held online, thereby mitigating the need for travel. "The importance of seeing our collaborators instead of just hearing them over a phone conference is very significant," says Parvati Dev of Stanford University. "We rely on it for effective collaborations. If we lose network connectivity, as happened after a summer thunderstorm in Wisconsin, the quality of interaction is reduced greatly and the remote collaborator frequently gets left out of the research conversation."

While videoconferencing supports research interaction, multicast streaming video of lectures, surgical demonstrations, and virtual attendance at conferences are becoming applications of increasing importance. The Internet2 consortium has held megaconferences, with participants located at multiple remote sites joining participants in an online conference. The technology has worked very successfully and is ready for wider use. Utilizing these techniques, UCLA plans to stream a live surgical procedure from the operating room, over CalREN, to selected sessions of scientific meetings.

Multimedia Libraries

Large multimedia libraries offer a different challenge to orthopaedic surgeons. The speed of download of a large image is proportional to the available bandwidth; that is, access to greater bandwidth implies faster image downloads. Interactive access to an image library requires repeated and rapid download of large amounts of data. If requests can be predicted (as for radiology images), then preloading the images is possible, resulting in the smoothing of the bandwidth demand.

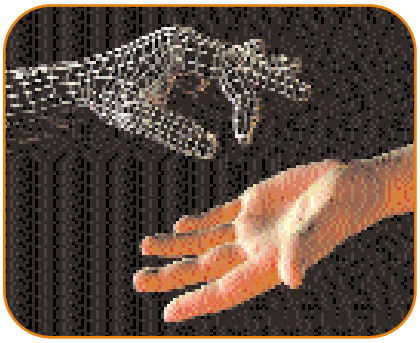
Stanford University, working with the University of Wisconsin–La Crosse, has developed an image server for a library of anatomical dissections to support anatomy and orthopaedic specialties. The library images are rotated views of a dissection taken at five degree intervals

of rotation. By moving the cursor left or right, the user rotates the image. An up/down movement changes the depth of dissection. For some datasets, other dimensions of movement are also available. Because the direction of the user request is unpredictable and because the images are large, only a limited amount of preloading and caching is possible. An additional feature of the server creates a stereo pair by using a pair of images five degrees apart, giving the user a 3-D view of the dissection. The image server supports multiple client sessions, and with a large enough number of client computers, the server transmits hundreds of megabits of data per second, making a visible blip on Internet2 traffic monitors.

"Applications such as the image server and library will support orthopaedic and other specialties. As more such servers come into use, we will see the increasing importance of advanced networks like CalREN and Abilene," said Dr. Amy L. Ladd, orthopaedic surgeon at Stanford University and participant in its image server project. "Access of images requiring high bandwidth will open the door for live interaction. Surgical demonstrations, stereo images, and surgical simulation will not only be retrievable; they may well be used for distance learning in a collaborative classroom or operating suite."

Robotics and Telecommunications Merge

Beyond image and data sharing, another area in which advanced applications play a role involves physical interaction over a large distance for education as well as clinical and surgical care. The combination of telecommunications links and robotics can provide such physical interaction over large distances. A demonstration in the fall of 2001 showed that high-bandwidth and high-quality dedicated telecommunication circuitry could enable surgical care to be provided over a distance of more than 4,000 miles. Dr. Moji Ghodoussi, director of telerobotics programs at Computer Motion, Inc., participated in the Internet2 demonstration session held during SICOT/SIROT 2002. "High bandwidth with quality-of-service guarantees is essential to efficacious surgical care administered over telecommunication links," said Dr. Ghodoussi. "It is imperative that quality-of-service characteristics get implemented for delivering surgical care. We need widespread adoption of these techniques, which will enable remote areas of the globe to have access to expert care. I can envision expert care, anywhere, anytime."



A symbolic joining of the virtual and the real.

The Value of CENIC and Internet2

CORN utilizes CENIC's CalREN. Every founding member of CORN is among the founders of CENIC. "CENIC, through its CalREN connection, is dedicated to bringing advanced network resources to every aspect of education and research. We are proud of the role we are playing in helping CORN realize its mission," said John Vaille, director of Digital California Project applications at CENIC.

The founding members of CORN are also among the founders of Internet2 and are working closely with the Internet2 Health Sciences Applications Initiative. The initiative has a scope that includes clinical practice, medical and related biological research, education, and health awareness in the public. Mary Kratz, manager of the Health Sciences Applications Initiative at Internet2, said: "CORN's applications that demonstrate real-time streaming of an ongoing orthopaedic surgery bring exciting new potential for the practice of medicine. Information technology that enhances noninvasive surgical techniques is a key to the future of medical services."

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Dr. Amy L. Ladd, orthopaedic surgeon at Stanford University and participant in its image server project

Expanding CORN

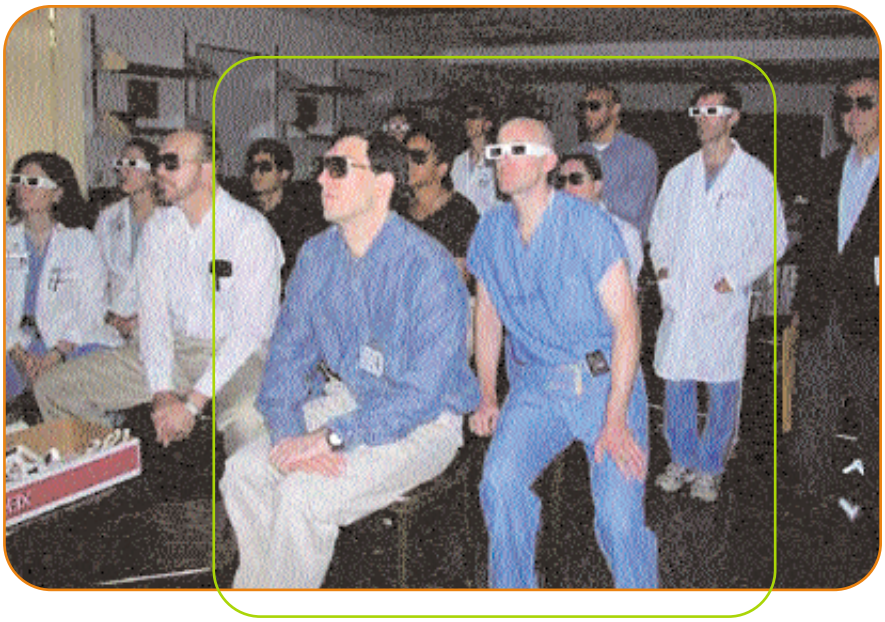
Under the auspices of the Internet2 Health Sciences Applications Initiative, the leadership team of the Health Sciences Initiative will collaborate with other professional associations in the health sciences and Internet community to develop guidelines for safe and effective use of the Internet. In orthopaedic surgery, members of the leadership team of the Health Sciences Applications Initiative have already interacted with the leadership of key orthopaedic societies—including SICOT, the world orthopaedic organization, and SIROT, SICOT's research branch—and plans to interact with the American Academy of Orthopaedic Surgeons, the Orthopaedic Research and Education Foundation, and the American Orthopaedic Association.

The CORN initiative provides a road map for expansion of advanced applications both in orthopaedic surgery and in other medical specialties. According to W. Edward Johansen, a patent attorney who acts as advisor to the Internet2 Health Science Applications Initiative, "The leadership team of the Internet2 Health Sciences Applications Initiative

will leverage and influence Internet2 resources to apply solutions to the medical domain, using the CORN initiative as a template for other specialties."

The specific mechanism of operation through the Internet2 Health Sciences Applications initiative will be through working groups. The leadership team has nominated Chadwick F. Smith from USC to chair the orthopaedic working group. Invited to join are Wayne H. Akeson of UCSD, Victor H. Frankel of NYU, Stuart Goodman of Stanford University, Barbara C. Zimmerman of the Center for Devices and Radiological Health at the U.S. Food and Drug Administration, and Amy L. Ladd of Stanford University. ●

Many thanks to CORN participants Parvati Dev and W. Edward Johansen for their invaluable contribution to this article.



Orthopedic surgeons view a dissection in real-time stereo video demonstrated by Dr. Amy L. Ladd and Cary A. Kornfeld.

Related Links

American Academy of Orthopaedic Surgeons *www.aaos.org*

Biomedical Informatics Research Network *www.nbirn.net/*

Internet2 Health and Life Sciences Applications Initiative *www.internet2.edu/health/*

Orthopaedic Research and Education Foundation *www.oref.org*

SICOT *www.sicot.org*

Visible Human Project *www.nlm.nih.gov/research/visible/visible_human.html*

Leading the Way to Tomorrow's Internet

InterAct is published annually by the Corporation for Education Network Initiatives in California (CENIC). CENIC is a not-for-profit corporation formed by California Institute of Technology, California State University, Stanford University, the University of California, and the University of Southern California to facilitate and coordinate the deployment, development, and operation of a set of seamless and robust advanced network services.

CalREN-2, CENIC's first project, is available for qualified public- and private-sector institutions for research and learning purposes. CalREN-2 is California's segment of the national Internet2 initiative and is partially funded by the National Science Foundation.

In the 2000–2001 fiscal year, the state of California provided funding for the Digital California Project, or DCP, which is CENIC's second project. The DCP creates cohesive and seamless advanced network services interconnecting K–12 schools and institutions of higher education in California. For additional information about CENIC, see ***www.cenic.org*** or contact Tom West, president of CENIC, at either ***twest@cenic.org*** or ***562-346-2280.***

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