Production of a Multisource, Real-time, Interactive Lesson in Anatomy and Surgery: CORN Demonstration

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ABSTRACT

During Internet2's 2002 Fall Member Meeting in Los Angeles, the California Orthopaedic Research Network (CORN) demonstrated a unique distributed learning environment that sought to enrich medical student understanding of hand anatomy and surgery. Live, streaming video of an orthopedic surgical procedure at UCLA Medical Center was combined with related stereoscopic, 'virtual hand' images from Stanford, to teach participants at a third location. Medical students, anatomists and surgeons at these remote but connected sites valued the simultaneous real-time interactions among the different venues. A number of technical issues were resolved during this exercise. This paper describes the process of arranging such a demonstration and summarizes the lessons learned from our experience so that this innovative pedagogical approach can be successfully adopted on a broader scale.

Keywords: Medical Education, Internet2, Distributed Learning, Anatomy, Surgery

Introduction and Educational Objective

The California Orthopaedic Research Network (CORN) was formed to explore the medical potential of high-performance network capabilities and to facilitate health applications whose development has been hampered by inadequate bandwidth or lack of Quality of Service (QoS) guarantees. On October 29, 2002, some of the key capabilities of CORN were demonstrated to an Internet2 audience at the Wilshire Grand Hotel in Los Angeles, CA. The core of this interactive demonstration centered on a real-time streaming video of an orthopedic surgical procedure ("four-corner fusion of the wrist"), combined with anatomic learning and real-time interactions between students, anatomists and surgeons, all at separate but connected sites.

Integrated teaching of basic and clinical sciences is synergistic and mutually beneficial. The correlation between anatomy of a region with pathology and appropriate surgery on that same region in a single learning experience greatly increases students' understanding of that topic. Often, when medical students observe surgery, there is limited or no opportunity for such comprehensive teaching. Real-time interactivity in the form of impromptu questions is vital to this learning experience. In this demonstration, we used innovative technology and created such a learning experience for students by bringing together expertise and resources from remote sites in real-time and high fidelity.

Network Infrastructure and Participants

The following sites were networked during the wrist surgery:

1. UCLA School of Medicine (Operating Room). Neil F. Jones, MD led the surgical team and Randolph H. Steadman, MD provided commentary and fielded questions from viewers at remote sites.

2. UCLA Visualization Portal (Mathematics Department). LuAnn Wilkerson, EdD facilitated a group of 15-20 medical students who viewed the surgery as well as activity at other participating sites. Students had the opportunity to query participants at any site about issues related to the surgery procedure and anatomy.

3. Stanford University School of Medicine (SUMMIT). Sakti Srivastava, MD displayed anatomical images that were related to the ongoing surgery, and correlated aspects of the anatomy to the surgery. Images were selected from both the Bassett Collection and from a customized dataset – "the interactive virtual hand".

4. University of Wisconsin. Dr. Steven Senger's laboratory was a back-up server site for the anatomy images and also hosted the Information Channels web page, which is the main entry point to access some of the services and applications developed at SUMMIT.

Internet2's Fall Member Meeting (Wilshire Grand Hotel). A panel moderated the sequence of events and interactions visible to an audience of about 200 and to participants at all venues. Panel members also gave short presentations. The panel consisted of Parvati Dev, PhD (SUMMIT), W. Edward Johansen, MSEE, JD (Internet2

Health Science Leadership Team), Anju Relan, MD (UCLA), Chadwick F. Smith, MD (USC), and Wayne H. Akeson, MD (UCSD).

A schematic representation of the network infrastructure is summarized in Figure 1. Polycom videoconferencing units connected all venues; in addition, high-resolution high-bandwidth video was sent from the UCLA operating room to SUMMIT, the UCLA Visualization Portal and the Wilshire Grand Hotel to view the surgical procedure in finer detail. Anatomical images of the hand were served from SUMMIT to client PC's at each venue. Two screens at the Wilshire Grand provided real-time views of the demonstration. The screens provided combinations of a quad view of all four videoconferenced venues (Figure 2), PowerPoint presentations by the panel members, radiographic or anatomical images of the hand, or a close-up view of the surgery (Figure 3). A stereoscopic effect could be obtained with goggles available to the students in the Visualization Portal.

Pre-Event Planning and Rehearsals

Preparations for this demonstration began several months in advance and can be divided into four phases. Phase 1 consisted of creating an outline for the teaching exercise and identifying appropriate personnel, hardware, software and network availability. Phase 2 involved testing each system independently and knowing its capabilities and limitations. Phase 3 was to develop a detailed lesson script to choreograph each component. Phase 4 involved testing each part over the network and consisted of several rehearsals.

Demonstration Sequence

An on-site Producer at the auditorium of the Wilshire Grand Hotel coordinated inputs from all remote sites and choreographed the ultimate demonstration to members in the audience. Each remote participant had access to the multiplexed Polycom images and audio to enable tele-videoconferencing. The core of the real-time demonstration was hand surgery at the UCLA operating room (Drs. Jones, surgeon, and Steadman), complemented by simultaneous stereoscopic media and commentary from SUMMIT (Dr. Srivastava; anatomist and surgeon). Members at UCLA Visualization Portal (Dr. Wilkerson and students) and the Wilshire Grand Hotel (panel and audience) had the ability to participate with questions and commentary throughout the demonstration.

The surgical procedure being performed was a "four-corner fusion" of four of the wrist bones and the related wrist anatomy was being demonstrated. As the UCLA Surgical team explained the purpose of the surgery in stabilizing the wrist, Dr. Srivastava provided views of a virtual hand that showed bones of the wrist in several different orientations and axes (e.g., radial, ulnar, and transverse). Similarly, as the surgical team performed the initial steps of the surgery in approaching the wrist bones, Dr Srivastava provided detailed anatomical images of the tissues encountered and explanations for their role in the surgery. Thus, during the surgical procedure the students and audience had concurrent access not only to the surgeon's visual perspective but also a virtual window into the detailed anatomical relationship of the structures in question.

A final demonstration, unrelated to the surgery, allowed viewers at the UCLA Visualization Portal and at the Wilshire Grand Hotel to use a haptic (force feedback) device remotely to generate coordinated, synchronized movements.

Discussion

The successful demonstration generated positive feedback from most participants. Students at the UCLA Visualization Portal valued simultaneous access to surgery and anatomical images, and the opportunity to query surgeons at various points during the procedure. This combined use of video, static images and audio appears to have great educational value.

However, the technical problems in implementing this demonstration were not trivial and are worthy of analysis when considering future multi-site demonstrations of this type. The anatomists and surgeons were not accustomed to complex computing. An on-site "producer" is essential to choreograph and implement the wishes of the various participants as the demonstration unfolds, e.g., switching between different video streams and deciding what to make available for display at each venue. Towards this end, it is essential to have individuals at each site that understand the high-performance system needs and nuances (3). In addition, despite three months of preparation, there were several logistical problems that were unanticipated. Although the system components were individually tested for a month before the event, the full system configuration was not testable until 24 hours prior to the event.

The Multicast technology provides a good example of unanticipated difficulties. The day before the event Multicast was working well at the Wilshire Grand Hotel, but not at the UCLA Visualization Portal. However, the day of the event itself, apparently due to some network routers or switch reconfiguration, Multicast stopped working at the Wilshire Grand, but started working at the UCLA Visualization Portal. These last-minute changes altered the script of the event. It is important, then, not only that all network equipment remains active during the course of the demonstration, but also that system administrators at the venues remain aware of the role of their site within the demonstration infrastructure. In this way, the system administrators are aware of what can be done and what shouldn't be done for the demo. For example, no software upgrades or rebooting procedures should be done after the final tests before the demo.

A service that would have been very useful to have for the CORN demo is a background phone conference for all remote technical people involved to facilitate solving technical issues off-line, without interfering with the event itself. In later demos that SUMMIT has done, this communications channel has proved to be very convenient.

From an educational perspective, some of these technical difficulties did lead to interference in the 'flow' of teaching and interactions. For example, at one point in the demonstration sequence, because of loss of the multicast capability, the 3D cursor for pointing to anatomical structures was not simultaneously visible on all screens leading to confusion by some of the audiences. Also, lack of a background telephone channel between the venues and the Producer occasionally led to misunderstanding about what image was actually visible at each site. Consequently, delays occurred whenever a confirmation consensus had to be reached.

In conclusion, potential applications for CORN and other organizations wishing to exploit the potential of Internet2 are broad and include (a) accessing large image databases (such as the Visible Human and the Bassett anatomy collection); (b) the use of haptic technology in telesurgery; (c) education; and (d) research (4). In preparing interactive demonstrations such as CORN, that take advantage of the high bandwidth of Internet2, it is important to recognize the 'exponential' complexity involved. Factors contributing to this complexity include (a) multisite videoconferencing and multiple data paths; (b) the requirement for the movement and setup of many pieces of equipment; (c) the use of high-resolution video systems; (d) viewing of stereo images; (e) the use of several communications protocols (TCP, UDP, and Multicast). In summary, the CORN demonstration was a valuable educational experience and the participants expect to move forward to develop this multisite real-time demonstration and commentary as a new educational tool.

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FIGURE LEGENDS

FIGURE 1. Data streams between participating venues at the I2 CORN Demonstration. Arrows denote direction of data flow. **Wilshire**=Wilshire Grand Hotel; **VisPort**=UCLA Visualization Portal; **WISC**=Senger Lab, University of Wisconsin, LaCrosse; **Stanford**=SUMMIT at Stanford; **OR**=UCLA Operating Room.

FIGURE 2. Multiplexed real time video displayed at venues. Clockwise from ULH: Wilshire I2 Panel; Visualization Portal (Dr. Wilkerson and students); Stanford (Dr. Srisvastava); and ULCA Operating Room (Dr. Steadman and OR Team).

FIGURE 3. Example of simultaneously correlated images of relevant wrist anatomy (left) and surgery (right) made available side-by-side to medical students over the high-bandwidth network. The anatomical image (from Stanford) shows a coronal section of the wrist displaying the carpal bones, while the surgical image (from UCLA OR) shows the same carpal bones as seen through the incision during surgery.

Internet2-CORN

DATA STREAMS

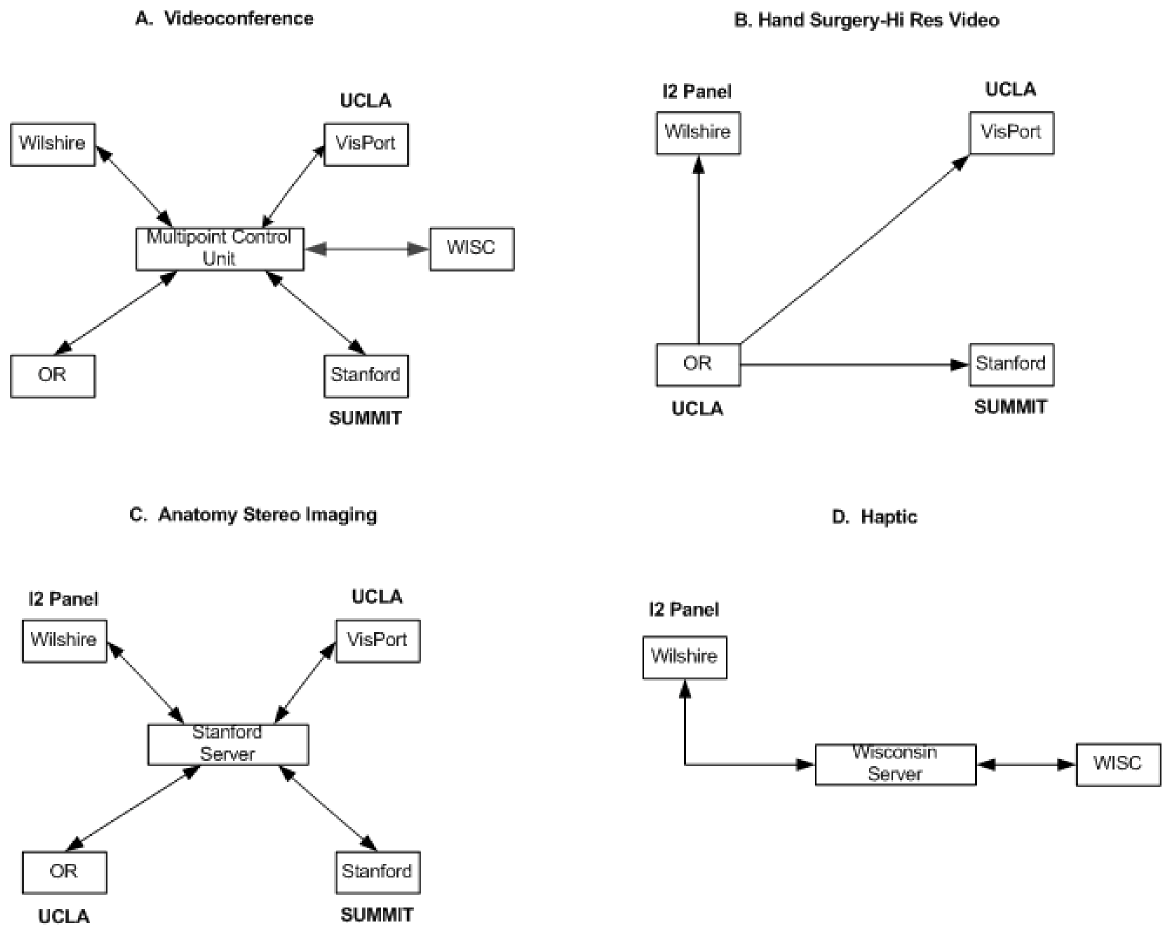

Figure 1


INTERNET2
Los Angeles, CA
UCLA Visualization Portal
UCLA Operating Room
Stanford University
Remote
Stereo
Viewer

Figure 2

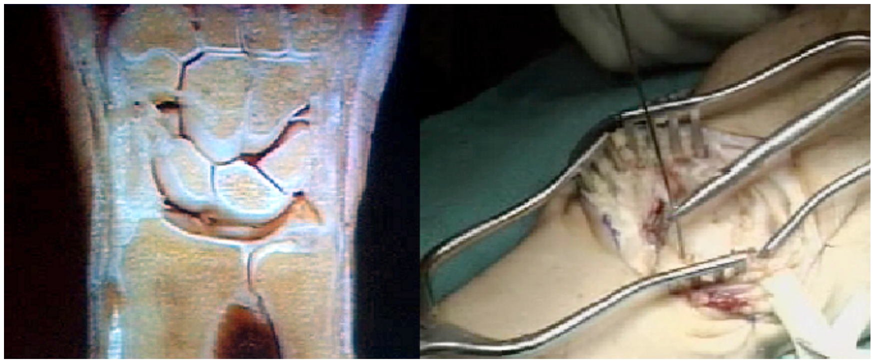

Figure 3