Evaluating an In-Vivo Surgical Training Demonstration over Broadband Internet

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ABSTRACT
This paper evaluates a demonstration of in-vivo (live) surgery over a broadband Internet connection between the USA and Australia. Two specific targets of the evaluation are the use of remote 3D video display of the laparoscopic surgery and the structure of the demonstration to replicate actual surgical training in the operating room. The evaluation materials include preliminary design and preparation records, recordings of the two-way video data and of the surgical video, exit questionnaires, debriefing discussion notes and follow-up interviews with the participants. Prior work in this area is surveyed and the demonstration is positioned with respect to this work. Conclusions are drawn about the effectiveness of the two key aspects of the demonstration and about possibilities for future work.

Author Keywords
Evaluation, Telehealth, Surgical Training, 3D Video

ACM Classification Keywords
H5.1. Multimedia Information Systems

INTRODUCTION
Aim of this Paper
The aim of this paper is to evaluate a demonstration of in-vivo surgical training presented over broadband Internet between Stanford (USA) and Sydney (Australia). The evaluation focuses on two aspects of the demonstration:

- Remote 3D video display of in-vivo laparoscopic surgery in a relevant application context
- The structure of the demonstration as a realistic surgical teaching scenario with mentoring by a senior surgeon at both operating room and remote sites to support dialogue between the surgical team and the observers.

The remote 3D video display showed the laparoscopic anatomy at the surgical site, the surgical instruments and the actions of the surgeon. Of interest was the acceptability of the 3D video display to the surgeons, in the context of a procedure with which they were familiar.

Would it aid their view of the surgical site and their spatial understanding of the surgical anatomy and were there ergonomic issues with prolonged viewing of this type of 3D video? The application context was important in answering this question. The surgeons were in a position to tell whether the information that they were seeing was suitable for their needs and in a form that they could watch over the time period of a typical operation.

The demonstration was structured to replicate the experience of surgeons learning by observing surgery directly. The concept of having a senior surgeon act as mentor, or “master of ceremonies”, at each site had been proposed as a way of focusing and managing the flow of information and discussion. It was also proposed as a way of supporting the surgeon by managing some of the attention load created by the remote audience. We were interested in how the audience responded to this structure and whether this structure was effective in supporting the remote teaching scenario.

One purpose of the demonstration was to act as a pilot for the idea of establishing a longer-term relationship between surgeons at Stanford and surgeons at a major hospital in Sydney (Nepean Hospital). This evaluation will also consider the results of the demonstration in that context.

Surgeons involved in the Demonstration
At Stanford Dr Camran Nezhat was the lead surgeon, Prof. LeRoy Heinrichs acted as the local mentor and Dr Linda Lewis provided the surgical case summary and assisted in the surgery. Four of Dr Nezhat’s surgical fellows observed the procedure in the operating room but did not take an active part in the demonstration. The Stanford work was supported by the Stanford University Medical Media and Information Technologies group.

In Sydney, Dr Pat Cregan acted as the local mentor and he and four of his surgical team from Nepean Hospital were the audience, ranging in expertise from Consultant to Intern. The Sydney audience was hosted by the CSIRO ICT Centre at its Marsfield Laboratory.

Description of the Surgical Presentation
The surgical presentation consisted of a preliminary discussion (outside the operating room) between the two sites which included introductions, a presentation by the surgeon on “The Role of New Technology in Surgery” and a review of each group’s surgical interests. The surgical fellow assisting the surgeon gave a clinical
description of the case, the participants waited until the patient was ready and then the camera followed the surgeons into the operating room. During surgery the surgeon described the key points of the surgery and the mentors at both sites gave additional commentary. At places during the surgery the surgeon asked questions and initiated discussions with the audience.

The main surgical procedure was removal of the patient’s appendix, performed in the context of a gynaecological procedure so it was both familiar to the audience of General Surgeons but offered something new in its context. The surgeon used a new laparoscopic system which contains a 3D camera (in place of the traditional 2D camera) and displays the 3D view to the surgeon on a head-mounted display.

The communication paths between the two sites consisted of multiple video and audio links, shown in Diagram 1.

Diagram 1: Video/audio links between the two sites.

The two-way video/audio link into the operating room supported dialogue between the surgical team and the audience in Sydney. Image 1 shows the camera view of the operating room. The mentor can be seen in the foreground holding a small microphone. Image 2 shows what the audience in Sydney could see and Image 3 shows the surgeon’s view of the remote audience.

A pair of video cables carried the left- and right-eye views from the surgical laparoscopic system out of the operating room to a computer with video capture cards. During the operation the 3D video from the laparoscope was displayed in Sydney on a large projection screen using two data projectors and polarising filters (Image 2). The audience watched the 3D video stream with plastic polarised glasses (Image 3). Both the mentor and surgeon wore or carried wireless microphones and these audio streams were combined with the video from the operating room camera and transmitted to Sydney.

In Sydney a video camera at the front of the meeting room sent a continuous video and audio stream of the audience to a computer monitor mounted on a mobile table which followed the camera into the operating room.

The video data was sent over the Internet using DVTS software (DVTS Consortium, 2004) which uses 30Megabits/second for each video stream, giving a high-quality low-latency output. The 3D video data used a modified version of the DVTS software developed by the CSIRO ICT Centre.

Evaluating the Demonstration

The approach to evaluating this event is strongly influenced by the works of Friedman & Wyatt (2004) and Pawson & Tilley (1997). Friedman and Wyatt discuss...
two basic approaches to evaluation in medical informatics (Friedman & Wyatt, 2004, Chapter 2). Their “objectivist” approach typically deals with a known situation, comparing a new “information resource” with existing ways of handling the same situation or comparing a deployed “information resource” with its design objectives. Their “subjectivist” approach seeks to understand the overall impact of a new “information resource” and the underlying reasons for its impact from multiple users’ points of view. The former approach is characterised by a fixed evaluation plan, controlled variables, prior measurement studies and carefully chosen independent and dependent variables. The latter approach is more enquiry-based, seeking to discover rather than necessarily compare. It adapts its methods and questions during the investigation as new evidence emerges.

Our work follows the “subjectivist” approach. We gathered data during the preparation for the event and prepared evaluation materials (questionnaire, debrief discussion points) based on our prior experience and on reports in the literature. We analysed the responses and reviewed the videotapes of the event and then conducted follow-up interviews based on what we had learnt.

Pawson & Tilley describe their approach to evaluation with the triad of Context, Mechanism and Outcome and a focus on basing an evaluation study on prior theories about underlying causes. In our case the Context contains the style of surgery (laparoscopic), the single audience connected to the surgeon by high-quality video/audio links, the preparatory discussions and the relevance of the surgical procedure. The Mechanism includes the 3D video projection of the surgical site, the use of surgical mentors and the explicit teaching mode of presentation by the surgeon. The Outcome is the response of the participants to the event.

Pawson & Tilley emphasise the role of underlying theories in their approach. In this case we had two theories which were based on our own prior experience of broadband telehealth applications and on our reading of the literature:

- We proposed that a 3D video display of the surgical site would enhance the audience’s understanding of the surgical anatomy of the particular patient and of the surgical procedure being performed
- We proposed that the viewing context (replicating a single group of people standing in the operating room, and to whom the surgeon was speaking directly) would support remotely the same sort of interaction and learning that the audience was familiar with in an operating room.

**MOTIVATION AND PRIOR WORK**

Within the telehealth community there is an emerging interest in using broadband Internet to present live (in-vivo) surgical procedures to remote audiences. The attraction for teaching is that the surgeon can present his or her work to an audience that cannot, for whatever reason, travel to the hospital or to an audience that is too numerous to fit in the operating room. The audience gets to observe the procedure unedited and in real time as the surgical choreography evolves.

Video and audio quality are important considerations in presenting live surgery. There must be sufficient bandwidth to support clear images and smooth movement within the video and the audio quality needs to be high enough to pick up subtle nuances in the voices and background sounds. Additionally, where dialogue between the surgeon and audience is supported the latency of the system needs to be low enough to support natural turn-taking in the conversation.

**In-vivo Surgical Presentations**

Dev et al. (2004) reported on an event conducted in October 2002 under the umbrella of the California Orthopaedic Research Network. In-vivo open surgery of the hand at the UCLA Medical Centre was shown to three remote sites: attendees at the Internet2 Fall Meeting in Los Angeles and observers on the UCLA and Stanford University campuses. The presentation was a choreographed surgical lesson, interleaving live surgery with explanations supported by high-quality 3D anatomical images. The audience interacted with questions and comments during the event. The authors evaluated the event both in terms of the opportunities for surgical learning that it created and also in terms of the organisational effort involved in staging it.

Shimizu et al. (2006) report on a bidirectional broadband teleconferencing system that they developed and applied to surgical teleconferencing. A series of 16 surgical teleconferences were conducted between February 2003 and January 2005 between hospitals in Korea and Japan, of which six involved in-vivo endoscopic surgery. They used DVTS to carry their video data and claim to be the “first to apply DVTS to clinical medicine”. They state that “high quality moving images are mandatory for surgical training and consultation” as their justification for using this form of video transmission.

In May 2005 the Networked Media Laboratory, Gwangju Inst. Of Science and Technology, Korea, supported a four-way presentation of laparoscopic surgery from Bundang Hospital at Seoul National University. The remote audience included two hospitals (Korea and Japan) and the 31st Korea Medical Association Conference in Seoul. The complex data paths included high-definition stereo video of the operating room, single-channel DV-quality video and an Access Grid link to support discussions between the sites. This event is described in a presentation by Dr JongWon Kim available from the GIST website (GIST, 2005). Their stated motivation is to share “recent medical knowledge about laparoscopic operation” but the published material focuses strongly on the technical aspects of broadband transmission of high-quality video data.

The Singapore National Eye Centre reported the presentation of in-vivo eye surgery from Japan in February 2006 to Singapore as the first stage in a series of experiments (SNEC, 2006). The view from the binocular operating microscope was sent in a 3D-High Definition...
format with the specific aim of showing the audience the “precise surgical manoeuvres and techniques” of the surgeon. An evaluation involving 25 surgeons is foreshadowed, and attributes to be studied include image quality, sense of depth, stability of transmission and the effect of varying the data rates (Megabits per second).

The Medical Research Information Center (Korea) and Stanford University are working towards in-vivo demonstrations of surgery over a gigabit/second network. Technical testing of their capability to send video from Korea to Stanford was conducted in late 2005 and video recordings of some of this work are available on the Stanford website (SUMMIT, 2005). The in-vivo display of surgery is intended as a precursor to experiments in remote surgical manipulation. (Paul Kim, Personal Communication).

An event with a related level of bandwidth and organisational complexity was described by Gunn et al. (2004). A simulated surgical presentation from Stanford University and a simulated remote intervention in an anaesthetic emergency during surgery were presented over a broadband Internet connection to a conference in Canberra, Australia. While this event did not involve in-vivo surgery it demonstrated the concepts of using broadband technology for remote teaching and demonstration of clinical skills and it used a 3D video display to the audience. The authors evaluated the audience’s perception of the 3D video and of the value and effectiveness of the presentations as teaching activities.

Common threads emerge from this prior work. Several of them were multi-site events and included a medical conference venue. They required extensive scripting and rehearsal of the events. They also required major infrastructure work to connect the venues with video, audio and control communications, especially where the conference site had limited connectivity and availability prior to the event. Often the audiences included generalists and non-medical attendees. Dev et al. (2004) describe these problems and the level of resources required to address them in detail.

By comparison the work described here focused on a single remote audience. Considerable effort was placed on the pre-operative meeting where formal introductions, descriptions of surgical backgrounds and discussion of contrasting surgical approaches went some way towards matching the situation of face-to-face teaching.

By comparison also, the surgical case study was highly relevant to the remote audience. The surgeon specialises in laparoscopic surgery to treat endometriosis which involves special cases of procedures familiar to the audience of General Surgeons.

Much of the prior work showcases capabilities related to presenting live video material remotely over broadband. This demonstration also showcases a capability – presenting high-quality 3D laparoscopic video data remotely. A difference is that reports of prior work tend not to contain in-depth evaluations of the capability.

**Other in-vivo Clinical work**
Li et al. (2006) report on the design and implementation of a system for remote management of emergency room triage and critical care incidents. Although this is an application rather than a teaching system its relevance to our work includes the need for the remote site (in this case the remote critical care specialist) to have high-quality visual and auditory access to the patient and to have high-quality two-way communication with the local clinicians. They observe that “… the use of near-broadcast quality audio and video streams … appears to be an important factor in the system’s rapid acceptance by users”. Alem et al. (2006) present a Human Factors evaluation of this system.

**RESULTS**

**3D Video**
The surgical audience’s response to the 3D display of the laparoscopic surgical site had two components – their response to the relatively static display of 3D anatomy (static because the patient’s internal organs were not moving and the laparoscopic camera was held steady) and their response to the display of the fast-moving surgical instruments in the field of view.

At three places during the surgery the surgeon commented on the quality of the 3D display in his virtual reality headset and asked about the quality as seen remotely. Each time the remote response was that the 3D picture was good. At one point the surgeon slowly released a droplet of water from the irrigator to show the 3D effect. One surgeon replied “Yes, you can see that difference [between 2D and 3D] quite clearly”. Image 4 shows a monocular view of this scene.

**Image 4: Irrigation tool showing a single drop of water.**

The response to observing the moving surgical instruments was quite different, and highlighted an effect that was later found to be caused by a software error in the PC receiving the 3D video. The visual effect was that movement of objects with clearly defined edges (surgical instruments) appeared jerky, as if there were a low and intermittent frame rate. One surgeon noticed this effect within one minute of 3D video display starting “It looks
When surgical trainees observe him in the operating room, when it was used.

The main focus of the debriefing discussion at the end of the session was on this issue. One senior surgeon in the audience commented "I couldn’t imagine being happy with that view”. When asked to rate the added benefit that the 3D view might give, over the traditional 2D display, another surgeon replied “I would say 80% better [than the 2D view] but for the jerkeness” and continued “Jerkeness over a long time, say a 2-hour operation, would give eye fatigue”.

In the exit questionnaire the surgeons ratings on the usability of the 3D video images on a 1 to 5 scale were widely spread (one ‘difficult to use(2)’, two ‘moderately usable(3)’, one ‘reasonably usable(4)’ and one ‘highly usable(5)’.

The ratings on the usefulness of the 3D video display, on a 1-5 scale, were two ‘medium(3)’, one ‘(4)’ and two ‘high(5)’.

When asked to rate the usefulness of the 3D display as compared to the normal 2D display on a 1-5 scale three of them rated it ‘greater(4)’, one rated it ‘similar(3)’ and one rated it between ‘much less(1)’ and ‘less(2)’.

In a follow-up interview the surgeon who gave a low rating for the usefulness of the 3D display described his inability to use artificial binocular displays for depth cues. He noted that perhaps 10% of people do not use binocular vision to perceive depth (they use other cues such as lighting, shading, specular reflection, occlusion, parallax and relative motion) and that novel technologies like this 3D video could disadvantage these people. When asked if a quality 3D display of the surgical site for laparoscopic surgery would be of value he replied that it would be “a remarkable advance” in that it would address two major problems for the laparoscopic surgeon: limited 3D view of the surgical site and spatial disorientation.

Audio
The audio equipment was configured differently at each of the two sites. In Sydney there were a number of table-top microphones placed on the long conference table (see Image 3) facing outwards and connected to an echo cancelling system. In Stanford two wireless microphones were used, one for the surgeon and one for the mentor, and the receivers fed into an audio mixer. These microphones were very sensitive to direction and distance from the speaker’s mouth. There was no support for echo cancellation at Stanford.

The quality of the audio streams can be observed in the video recordings of the event. The audio stream from Stanford to Sydney was primarily spoken commentary from the surgeon and the mentor. This required initial, then occasional, adjustment but for large time periods the audio was good. Contrary to our expectations the background sounds from the operating room did not cause any problems. One surgical instrument (an electrocauterising tool) emitted a clearly audible warning sound when it was used.

The audio from Sydney to Stanford was also spoken commentary and questions, primarily from the mentor who was sitting facing one of the microphones. The other surgeons sat across the table from him but facing to the screens at the end of the room and they needed to turn to the microphones when they spoke. The Australian accent and casual speaking style caused some misunderstandings until the audience adopted a “presentation style” of voice (Prof Heinrich’s description). The primary problem, at the Sydney site, was an echo from Stanford, which can be heard on the video recording every time someone in Sydney spoke.

In a follow-up interview the surgeon at Stanford was asked about the quality of the audio and video and he replied “Very good, just as if they were next door”. In the exit questionnaire the surgeons rated the usability of the audio, on a 1-5 scale. Two rated it ‘reasonably usable(4)’ and three rated it ‘highly usable(5)’.

Dialogue during the Pre-operative Discussions
The discussion before the operation lasted 30 minutes and was primarily led by the surgeon at Stanford. He presented his ideas on the technology that was central to this demonstration, then at three places asked for information about the audience by addressing the mentor in Sydney: “Patrick, will you tell us about the experience of your surgeons?” “How about your issues; do you use [a particular surgical technology]?” “Patrick, are you using simulators?” The mentor in Sydney answered initially then directed the questions to another senior surgeon. Another 30 minutes were spent waiting for the patient to be ready for surgery and this was filled with a discussion on surgical simulation for training between the two mentors. The previous senior surgeon spoke three times and a more junior surgeon spoke once.

Dialogue during the Demonstration
During the 45 minutes of presented surgery the primary communications were from the surgeon and from the mentor at Stanford. Occasionally the surgeon would ask a question or make a comment about what was happening and the mentor in Sydney would reply. The mentor in Sydney also made local comments about the visible anatomy and surgical actions.

Dialogue occurred twice between the two sites. In the first case the surgeon had isolated the appendix and was ready to choose a technique for sealing where it attached to the intestines before removing it. As an active teaching point he asked “Patrick, what do your residential fellows want us to demonstrate?” referring to the choice of technique. After a brief local discussion a request was made. The surgeon’s reply was “Good choice.”

The second section of dialogue occurred at the end when the mentor in Stanford asked for closing questions and for an assessment of the value of the 3D video. Two of the surgeons in Sydney took part in a short discussion on this point.

In a follow-up interview, the surgeon in Stanford said that when surgical trainees observe him in the operating room
the junior ones usually ask questions of the senior trainees rather than asking him, and that the senior trainees (fellows) don’t usually ask questions. In a follow-up interview with a senior surgeon in Sydney he rated the level of interaction at this event to be greater than he normally experiences in the operating room.

Role of the Mentors
Analysis of the video record of the demonstration shows that the two mentors played a very active role. In Stanford, the mentor filled the continuity role of a “master of ceremonies” as well as providing expert commentary on the progress of the surgery. In Sydney the mentor managed the questions and answers and provided additional local commentary.

In the exit questionnaire the audience rated the usefulness of the information from the two mentors at 4 or 5 on a Low(1) to High(5) scale.

In the follow-up interview the surgeon at Stanford spoke at length about the value of having the mentor in the operating room. He has extensive experience in presenting his surgical work on video. In those there was always someone to handle the audio-visual issues but this was the first time he had someone to handle the medical issues of the presentation, leaving him to concentrate on the surgery. He valued this aspect highly.

Ethical Considerations
Two important ethical considerations relating to in-vivo demonstrations of surgery are raised by Millat et al. (2006); concern for the proper care of the patient and concern for the correctness of the surgical information received by the audience. They raise these issues in the context of demonstrations at medical conferences and public events but it is just as important to consider them in the very specific context that was designed for this demonstration.

When asked in the follow-up interview about the level of intrusion into his surgery posed by the presence of the cameras and the video displays back from Sydney the surgeon made several points. Having a mentor in the operating room to manage the medical information freed him to focus his attention on the patient, and he cited one instance where he was able to focus so closely on the patient that he was unaware of the mentor’s presence. In terms of distraction for the others he specifically commented that the anaesthetic team and nursing team were very excited about presenting the surgery to an audience so far away and that they were specially focussed on their tasks to make the presentation a success. He also commented on the logistics of the event: “[This event] had less hassles and ran much more smoothly than other [similar events].” He said that “usually something goes wrong that I have to deal with but this time I could concentrate on the surgery.”

Both before and during surgery the surgeon went to a considerable effort to reference and explain what he was doing. His presentation early in the session gave the broad background to his work, with many specific references. He established the relevance of the surgical procedure to the remote audience and during the surgery he explained what he was doing.

Overall assessment of the demonstration
The video recording of the event shows that the audience paid close attention to both the pre-operative discussions and to the 3D video display from the laparoscope during surgery, as indicated by their gaze direction, attentive body posture and lack of distraction movements.

In the exit questionnaire the surgeons were asked how likely they would be to attend such an event in the future if it were conveniently located and on a topic in their surgical area of interest. On a 1-5 scale one replied ‘not sure(3)’, two replied ‘Very likely(4)’ and two replied ‘Definitely would(5)’.

During a follow-up interview one senior surgeon described the event as “excellent as a pilot exercise” and said that he would be keen to attend another and would encourage his surgical colleagues to also attend. He noted that demonstrations like this increase the cross-fertilisation of ideas and that surgeons benefit from this but that after completing their training surgeons rarely observe their colleagues’ work.

During the follow-up interview with the surgeon in Stanford he said that it “was a rewarding teaching experience”.

During the debrief discussion the surgeons discussed what form of surgical presentation they might offer to Stanford. Their practice includes open surgery of parts of the body that are difficult to access and where an audience in the operating room has difficulty seeing what is happening, and they discussed using a close-up 3D camera such as the laparoscope used in this event but held outside the patient to observe the surgical site. They suggested that such a presentation would illustrate their own expertise and be of interest to both Nepean Hospital and Stanford surgeons.

DISCUSSION
3D Video
The surgical audience distinguished strongly between the 3D view of the surgical site and the view of the motion of the instruments at the site. They rated the 3D view of the surgical site highly in their spoken comments during the event but were very critical of the displayed motion of the surgical instruments. The event organisers had not anticipated this distinction so the exit questionnaire did not cater for it. The audience responded by annotating their 1-5 ratings with specific comments about the problems with the motion display.

This demonstration was the first time that the system had been used to show real 3D surgical video to surgeons, and it highlights the importance of feedback from the application users. There had been no prior access to 3D video of live surgery and no facility at Stanford for pre-recording 3D video so much simpler laboratory test data was used, generated by moving small objects in the short depth-of-field range of the laparoscopic camera. The actual software development was done in Canberra,
300km from Sydney, and a surgical audience was not available to offer its opinion on the quality of the test data. This demonstration, in the role of a pilot presentation, was, however, the appropriate place for issues such as this to be discovered.

An issue which was raised in the debrief discussions confounds a simple assessment of the 3D video display. The surgical audience has been trained to do laparoscopic surgery using a monocular 2D display from the laparoscopic camera, because this is the prevailing technology in Australia. They have, therefore, learnt to construct a 3D model of the surgical site in their mind using all the other visible depth and structural cues (light, shading, specular reflection, occlusion, relative movement) and they use this ability in their daily work. In viewing a single demonstration of 3D video they might find it difficult to identify the additional value of the artificial binocular view of the site, even if the motion of the surgical instruments was presented smoothly. This is an issue that will require a more controlled experimental environment to answer.

Audio
The evidence on the audio quality is apparently contradictory. The audience in Sydney rated the audio quality as either reasonably usable or highly usable in their answers to the exit questionnaire, and the surgeon in Stanford rated the audio [and video] quality as “very good”. The evidence from the video recordings, however, shows that the voice link from Sydney to Stanford was hampered by a strong echo, that the audio levels from Stanford to Sydney rose and fell significantly due to the variable placement of the microphones, and the audio quality from Sydney to Stanford required the speakers in Sydney to turn towards, and focus their voice to, the microphones. This occurred even though the audio technician in Sydney was constantly adjusting the audio levels of the various components to minimise the problems.

An explanation for this is found in the conversation analysis. Key information components of the conversation (the surgeon’s lecture and explanations before surgery, the surgeon’s and the mentor’s comments during surgery) originated from Stanford and were delivered in units of speech whereas the microphone placements were stable. The mentor in Sydney did most of the talking from there and he made a strong effort to talk over the top of the echo from Stanford. Both audiences were unaware of the constant adjustments to the audio levels. From the audience’s point of view the bulk of the audio exchanges was, indeed, reasonably-to-highly usable. What this demonstration did highlight were the remaining deficiencies in the audio links and these should be addressed in any future events.

Structure of the Demonstration
The structure of the demonstration presented a realistic surgical teaching scenario. The surgeon was able to present his broad ideas at the time and place of the surgery, and during surgery he was able to explain and demonstrate to the audience what he was doing. The single location for the remote audience and the relatively small size meant that he was able to relate to them directly, though a more deliberate use of zoom and pan would have given him closer awareness of individuals when they spoke.

The role of ‘mentor’ at each site was important. The surgeon worked with the mentor during direct discussions between the sites, and was able to leave the medical communications to the mentor when he was focusing on surgery. In Sydney the mentor, who had been closely involved in setting up this demonstration, managed the flow of conversation and questions.

A description of the intent of the demonstration, included in the material handed out at the start, was that it hoped to “create a learning environment at the remote site that is closely connected to the ongoing surgery and at the same time has the freedom of a classroom, to interact with an instructor, have side discussions and consult textbooks and other learning materials.” As it happened, the intended surgical case, which would have led to discussions around previously circulated medical documents, was postponed and the replacement surgery was much simpler. This aspect of the demonstration was intended to replicate the situation described by Dev et al. (2004) but it remains untested for this audience.

The nature of the interaction between Stanford and Sydney was focused around the surgeon, and this appears to be what happens when junior surgeons or surgical fellows observe surgery in person. The surgeon and the two mentors initiated almost all the commentary and conversation and when the surgeon asked if there were questions there were very few replies though this may be because the actual operation was relatively straightforward. The patterns of interaction do not show an even spread of the dialogue amongst the participants and this might lead the organisers of future events to fine-tune the communications links differently.

Overall Assessment of the Demonstration
The surgeons in both Stanford and Sydney gave a positive overall assessment of the demonstration and in particular its role as a pilot for possible future events. By presenting the demonstration to surgeons in a focused surgical training context the organisers managed to uncover several important issues which should be addressed before any subsequent event is held.

The surgeons in Sydney gave a strongly positive response to the question about whether they would attend a similar event in the future, and this is consistent with their actual discussions at the end of their event where they were already considering what form a return demonstration would take.

CONCLUSIONS
We have used a subjectivist approach to evaluating this demonstration and have focused on two main aspects, the 3D video display and the structure of the demonstration. The remote 3D video display of in-vivo surgery showed the potential to enhance an audience’s understanding of
the surgical anatomy of a laparoscopic procedure, but the jerky nature of the display of the moving surgical instruments impaired this display and caused eye strain and discomfort during the 45 minute surgical presentation. A further demonstration with the software fault that caused the jerkiness corrected is required before any broader conclusion can be made in this surgical context about the 3D video display.

The structure of the demonstration supported the surgeon’s presentation of his work and enabled the audience to interact appropriately with the surgeon. The role of the two ‘mentors’ was important, both in allowing the surgeon to focus on his patient and in channelling the communications in a way that matched the audience’s expectations.

The overall assessment of the demonstration is that it piloted the broad concept of remote in-vivo presentation of laparoscopic surgery and, in doing so, it identified several issues that will need to be addressed for future events.

**FUTURE WORK**

This demonstration was presented in a very specific surgical context and between two specific institutions. The immediate future work is to explore a reciprocal demonstration from Nepean Hospital to Stanford and then to consider whether a succession of such events should take place.

On a broader scale this demonstration serves as a case study for using broadband communications links to teach and share clinical skills. Other situations might follow the patterns shown by this demonstration but would tailor them to their own data, visualisation and communications needs.

**ACKNOWLEDGMENTS**

This work was supported in Australia by the Australian Government through the Advanced Networks Program (ANP) of the Department of Communications, Information Technology and the Arts and by the CSIRO ICT Centre. In the USA it was conducted as part of the HAVNet project at Stanford University, partly supported by the National Library of Medicine contract number N01-LM-3-3512.

The author acknowledges the support of his colleagues at CSIRO (Chris Gunn, Matthew Hutchins, Alex Krumm-Heller, Keith Bengston, Bob Shields, Rosemary Hollowell, Craig Russell, Jocelyn Smith) and at Stanford (Robert Cheng, Margaret Krebs, Pat Youngblood, Parvati Dev, LeRoy Heinrichs), Dr Camran Nezhat and his colleagues at Stanford Hospital and Dr Pat Cregan and his colleagues at Nepean Hospital. The author also acknowledges the support of staff at AARNet who provided access to high-capacity bandwidth between Australia and the USA.

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