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Group 7 : Gesture Controls for Raven Robot
26 March 2013
Seminar Paper Summary

This paper is a review and discussion of two papers, *M.J.H. Lum, J. Rosen, T.S. Lendvay, M.N. Sinanan, B. Hannaford, 'Effect of Time Delay on TeleSurgical Performance,' IEEE International Conference on Robotics and Automation (ICRA), 2009* and *M.J.H Lum, J. Rosen, H. King, D.C.W. Friedman, G. Donlin, G. Sankaranarayanan, B. Harnett, L. Huffnam, C. Doarn, T. Broderick, B. Hannaford, 'Telesurgery Via Unmanned Aerial Vehicle (UAV) with a Field Deployable Surgical Robot,' Proceedings, Medicine Meets Virtual Reality (MMVR), Long Beach, CA, 2007.* For disambiguation, as the primary authors are the same, the papers will be referred to by the first word of their title. Both papers were chosen for their relevance to the project, as they discuss or involve networking, and their use of the Raven surgical robot.

The paper *Effect of Time Delay on TeleSurgical Performance*, by Lum et al., discusses two groups of experiments regarding surgical performance vis-à-vis network latency. One group of experiments was a laboratory test where the operator's data packets were given a set time delay. The second group was various field tests where operators used the Raven over a variety of connections. Both experiments aimed to show and quantify the erosion in performance caused by network latency. The laboratory experiment used a Raven connected to its controls via LAN, with a time delay of zero, 250, or 500 milliseconds. The operators, both surgeon and non-surgeon, performed the FLS "Block Transfer" task, which simulates handling and manipulating tissue. This gave the results that, with a 250 ms delay, the task took 1.45x the length of the 0ms control group. At 500 ms, the task took 2.04x as long. Controls were moved 1.28x for 250ms delay and 1.53x for 500 ms delay with respect to the control. These results were statistically significant with alpha < 0.02.

The field experiments confirmed this trend, although there was no mention of statistical significance. The same task was performed in a variety of environments, one in the desert with an unmanned aerial vehicle acting as a relay[1], two in NASA's Extreme Environments Mission Operations lab (NEEMO), and two over commercial internet. A control setup over LAN was also used. These showed a similar pattern to the lab experiments, although a quantitative analysis was not provided.

The author's conclusion notes that audiovisual information is the limiting factor in network latency. As this will be present in all networked surgical robots, the authors suggest that semi-autonomy be implemented in future systems to avoid controller overshot.

This paper's strong points are its relevance to the project, and its understandability. It is relevant as the demonstration our group is performing is currently spread between multiple computers. The paper is also easily understandable and explains its technical terms well.

The paper's weak points are that it is very short, and its results do not seem very strong. The laboratory tests had extreme latencies, which were much larger than the field latencies, and did not attempt to make a trendline of latencies.

The second paper, *Telesurgery via UAV*, presents a demonstration that acts more as a potential proof of concept rather than a quantitative analysis. This paper was relevant because it shows a real-world demonstration of a Raven teleoperated by networked controls. This is again similar to our group's goal. The researchers performed an unmentioned procedure at a distance of 100 meters. They encountered significantly worse network conditions than over a conventional network. Their network encountered significant data loss at 2 Mbps, which required scaling back to 800 kbps. This was not lossless either, but was found to be workable. Although the results were not numeric, save for the network transmission rate, the team did have some important findings. Their major finding was that, under minimal or low visual feedback and with a

[1] Not the same experiment as the second paper

time delay, surgeons are able to perform surgical tasks. The surgeons had noted pixelation in the video feed, but did not feel that it affected their performance. This makes the demonstration of teleoperated robotic surgery a success in that surgeons were comfortable using current equipment in admittedly suboptimal conditions. This paper helps reinforce the claims of feasibility surrounding teleoperated surgery.

The paper's strong points are its clarity and the strength of its conclusion relative to its aims. The paper was very clear, which is very much a function of it being less technical than the first paper. Its points and supporting figures were sufficient and easy to understand. The conclusion was very strong for a qualitative analysis; the finding is valuable and encouraging. Furthermore, it gives perspective to the quantitative analysis of the first paper. While the first paper discusses the quantitative impacts of network latency, this paper discusses the qualitative impacts of data availability, which is directly impacted by latency. It puts further perspective on the performance in the field experiments of the first paper. While the field experiments of the first were significantly slower than control, overall performance irrespective of time may not be degraded.