Plugfest 2009: An Experiment in Global Telersurgical Interoperability

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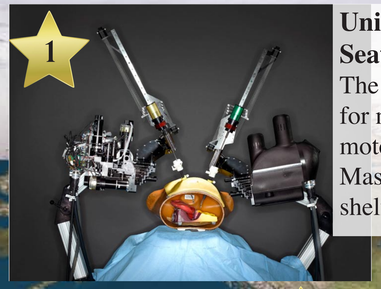
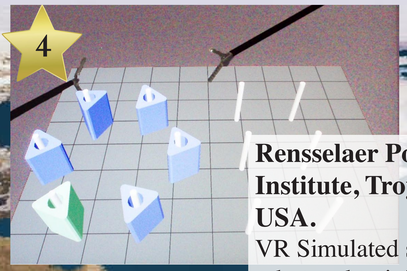


University of Washington, Seattle, WA, USA.
The Raven Surgical Robot for minimally invasive, remote telesurgery.
Master system used off-the-shelf hardware.

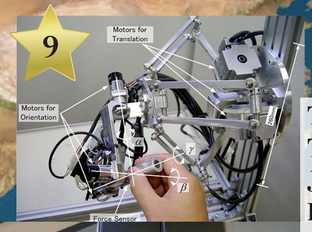


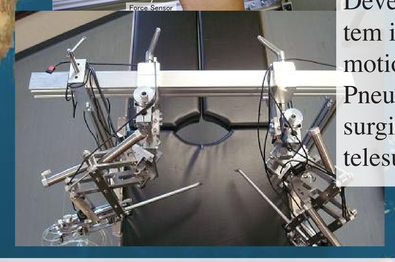
Rensselaer Polytechnic Institute, Troy, NY, USA.
VR Simulated surgical robot and training task.
Master system used off the shelf components and software from the UW.

Imperial College London, London, UK.
Surgical robotics researchers at connected using off-the-shelf components and software from the University of Washington.

Korea University of Technology and Education, Cheonan, South Korea
Used commercially available hardware with custom software.

LSR, Technische Universität München, Munich, Germany.
General purpose teleoperation master and slave systems for human-scale manipulation.

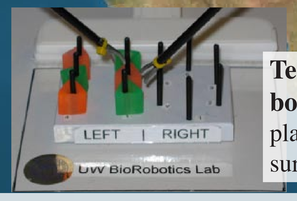




Tokyo Institute of Technology, Tokyo, Japan.
Developed master system is based on a delta motion platform.
Pneumatically driven surgical slave for MIS telesurgery.

SRI International, Menlo Park, CA, USA.
M7 Surgical Robot designed for remotely operated, open and battlefiled surgery.

Johns Hopkins University, Baltimore, MD, USA.
JHU Custom daVinci master and slave system. This is a research version of the state-of-the-art daVinci robot by Intuitive Surgical daVinci.



Telerobotic FLS Pegboard task. A pick-and-place task for evaluating surgical proficiency.

University of California at Santa Cruz, Santa Cruz, CA, USA.
Powered upper-limb exoskeleton. This presents a new model, using a full body immersive surgeon's console for telesurgical user interfaces.

- Introduction -

In the same way Internet standards have connected heterogeneous computing systems, we predict robot communication standards will speed development and adoption of teleoperated robots. The goal of the current work is to advance the state-of-the-art in telerobotic interoperability, focusing on the telesurgery domain. A **common data specification** is used by nine, globally dispersed telerobotics groups, and in one 24 hour period interoperability among 14 robotic telemedical systems is tested.

In the long run, this will benefit surgeons and care providers who can access patients and colleagues around the world using their chosen equipment, patients who will access a wider range of specialists, and robotics engineers who can develop new, innovative systems that will work with current teleoperation systems.

- Methods -

Each telerobotic system was configured to use a data specification, the **Interoperable Telesurgical Protocol (ITP)**. ITP specifies key teleoperation conventions like shared reference frame, representation of orientation, and clutching/indexing parameters. ITP data was exchanged over the Internet in low-latency UDP packets. Skype video was the only operator feedback.

Thirty two master-slave connections were attempted, and each robot was tested in at least four connections. Experimenters performed the **Telerobotic FLS task** with all surgical robots, a larger-scale pick-and-place task with the general purpose teleoperator.

Success/failure of the connections were noted, results of the block-transfer were recorded and users were asked to qualitatively evaluate the systems.

```
#pragma pack
#define SURGEON_DISENGAGED 0
#define SURGEON_ENGAGED 1
struct M2S_data {
   unsigned int sequence;
   unsigned int pactyp;
   unsigned int version;
   int delx[2];
   int dely[2];
   int delz[2];
   int delyaw[2];
   int delpitch[2];
   int delroll[2];
   int buttonstate[2];
   int grasp[2];
   int surgeon_mode;
   int checksum;
};
```

- Results -

Twenty-eight successes were recorded out of thirty attempted connections. The **table** shows the (ping time) and test results for each connection. Test result is the number of TFLS blocks transferred, or the transfer time of the large bimanual task.

One problem was with slow packet rates. Most systems used 100+ Hz, while one system used ~10Hz. The slow packet rate caused problems with velocity estimation in one robot. In another case, the orientation mapping between master and slave was too confusing, and the user did not complete the task.

Master Systems \ Slave Systems	UW	JHU	RPI	SRI	TOK	TUM**
UW			(*)12	(34) 14	(133) 15	
ICL		(112) 11	(*)6		(288) 5	(183) 7
JHU	(73) 9		(*)7	X		X
KUT	(180) 6		(*)6	(175) 4	(224) 6	(305) 13
RPI	(*) 8	(*) 13		(*) 2		
TOK	(135) 16			(*) 12		(302) 4.5
TUM		(115) 1	(*)4		(295) 2	
UCSC†	(21) 13	(83) 4	(*)5	(22) 9	(155) 30	

Furthermore, this experiment examined new techniques in human interfaces, and networking paradigms for telemedicine.