# Objective Assessment of Telesurgical Robot Systems: Telerobotic FLS

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**Abstract:** The Society of American Gastrointestinal Endoscopic Surgeons (SAGES) Fundamentals of Laparoscopic Surgery (FLS) program contains curriculum that includes both a cognative and psychomotor skills. In this research the use of FLS Block Transfer task is used to evaluate the performance of surgeons' teleoperating the University of Washington Surgical robot. The use of the FLS Trainer Box and accessories kit provides a well-defined series of tasks that can be repeated by any researchers working in the field of surgical robotics so that systems can be evaluated using a common method.

**Keywords:** Telesurgery, Fundamentals of Laparoscopic Surgery, Robotic Surgery

## 1. Introduction

As early as 1985, robotics entered the operating room; a PUMA560 was used to assist in orienting a needle for biopsy of the brain in a 52-year-old male patient [1]. In the late 1990's the Laparoscopic Workstation from University of California, Berkeley [2] and Black Falcon from MIT [3] made notable contributions to the field. Currently groups in France [8], Japan [9], Hawaii [10] and Washington [7] are developing surgical robotic systems. The BioRobotics Lab at the University of Washington has developed the RAVEN over the last five years. Just as each surgical robot system is different, each group uses a different means by which to evaluate their system.

In the late 1990's the Society of American Gastrointestinal Endoscopic Surgeons (SAGES) created a committee to develop curriculum for teaching the Fundamentals of Laparoscopic Surgery (FLS). The outcome of this has been a curriculum that includes both cognitive as well as psychomotor skills. The FLS skills tasks have been validated to show significant correlation between score and postgraduate year [4]. These tasks have been used to quantitatively assess the skill of thousands of surgeons ranging from novice to expert and are considered by many the "gold standard" in surgical skill assessment.

A surgical robot is a tool that provides the surgeon with capabilities not possible with traditional tools. The SAGES FLS skills tasks provide a structured and repeatable means by which to evaluate surgeons on a particular system. The use of the FLS skills tasks in the field of surgical robotics will allow researchers from different groups to have a common basis for objective evaluation and comparison of their systems.

## 2. Methods

The University of Washington's RAVEN Surgical Robot is a telesurgical system consisting of three major components: the patient site, the surgeon site and a network between them. The network allows for connection through a local network within the lab, a wireless network or commercial Internet [5]. The RAVEN supports the ability to perform three of the five FLS skills tasks: block transfer, intracorporeal knot tying and pattern cutting. For this initial investigation, block transfer and intracorpreal knot tying were performed. The RAVEN was tested in both local (surgeon and patient sites in the same room) as well as teleoperation modes. For comparison an ISI da Vinci was used to perform the same two sets of tasks in a local operation mode.

NASA's Extreme Environment Mission Operations (NEEMO) program provided a unique opportunity for surgical teleoperation experiments. NEEMO is a NASA training analog that takes place at the National Undersea Research Center (NURC) in Key Largo, FL [6]. As part of the 12-day NEEMO XII mission, two non-engineer Aquanauts set up the RAVEN for two days of teleoperation experiments in the habitat. Once the RAVEN returned to shore it was set up at the NURC base for further teleoperation experiments. Table 1 summarizes the sets of experiments in this study.

Table 1 Initial Telerobotic FLS experiments. Local experiments were performed with the entire system in Seattle, WA before deployment to Florida. NURC operates the Aquarius undersea habitat located at a depth of 65 feet, 3.5 miles offshore from the Keys. A surgical expert who uses the ISI da Vinci clinically also performed the same tasks performed with the RAVEN with an ISI da Vinci.

| System | Surgeon Site | Patient Site |
|---|---|---|
| da Vinci | Seattle | Seattle |
| RAVEN | Seattle | Seattle |
| RAVEN | Seattle | Aquarius |
| RAVEN | Seattle | NURC Base |

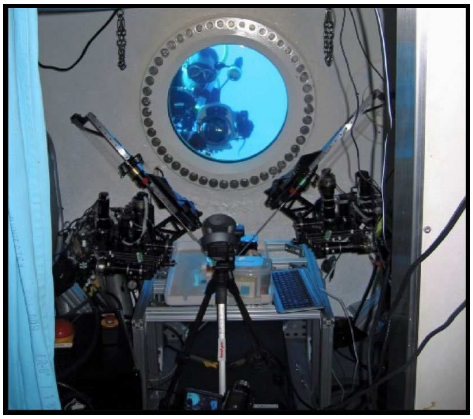

Figure 1 The RAVEN Surgical Robot deployed in Aquarius.

## 3. Results

Two expert surgeons and one resident participated in the evaluation using the RAVEN in both local and teleoperation modes. None of the subjects had any errors during the block transfer, thus "score" is reported as completion time. One expert surgeon with clinical experience on the da Vinci used it to perform the FLS skills tasks for comparison. Completion times for the block transfer task under teleoperation conditions were notably longer than with the local experiments (Figure 2).

## 4. Discussion and Future Work

The SAGES FLS program provides a well-defined series of skills tasks that any research group can perform. The use of FLS tasks for telesurgical robotic system

evaluation will allow researchers across the world to share common results. This initial investigation has shown that teleoperation increases task completion times. Further investigation will study with greater depth the effects of time delay on task performance. It will include more subjects performing multiple replicates of each different time delay condition.

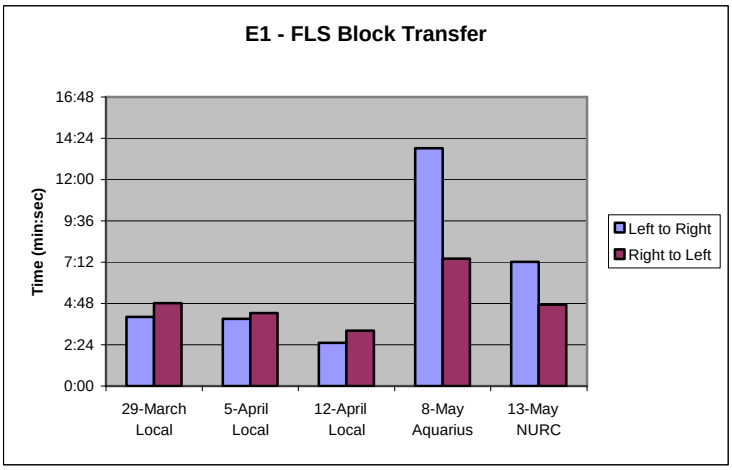


Figure 2. Average Block Transfer completion times for surgeon E1. For the local experiments a total of 9 trials were performed on three separate days a week apart. Time constraints during the NEEMO XII only allowed surgeon E1 to perform a single trial teleoperating between Seattle, WA and Aquarius and a single trial between Seattle and NURC base. By comparison, surgeon E1 performed three block transfer trials on a da Vinci with an average time of 1:00 left-to-right and 0:55 right-to-left.

## 5. Acknowledgements

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