Telemanipulation and Telestration of the Steady Hand Eye Robot

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Computational
Sensing + Robotics
THE JOHNS HOPKINS UNIVERSITY

Performance of Robotic Augmentation in Microsurgery – Scale Motions

- Rajesh Kumar[1], Tushar M. Goradia[3], Aaron C. Barnes[2], Patrick Jensen[5], Lois L. Whitcomb[2], Dan Stoianovici[2,4], Ludwig M. Auer[6], Russell H. Taylor[1]
- 1999

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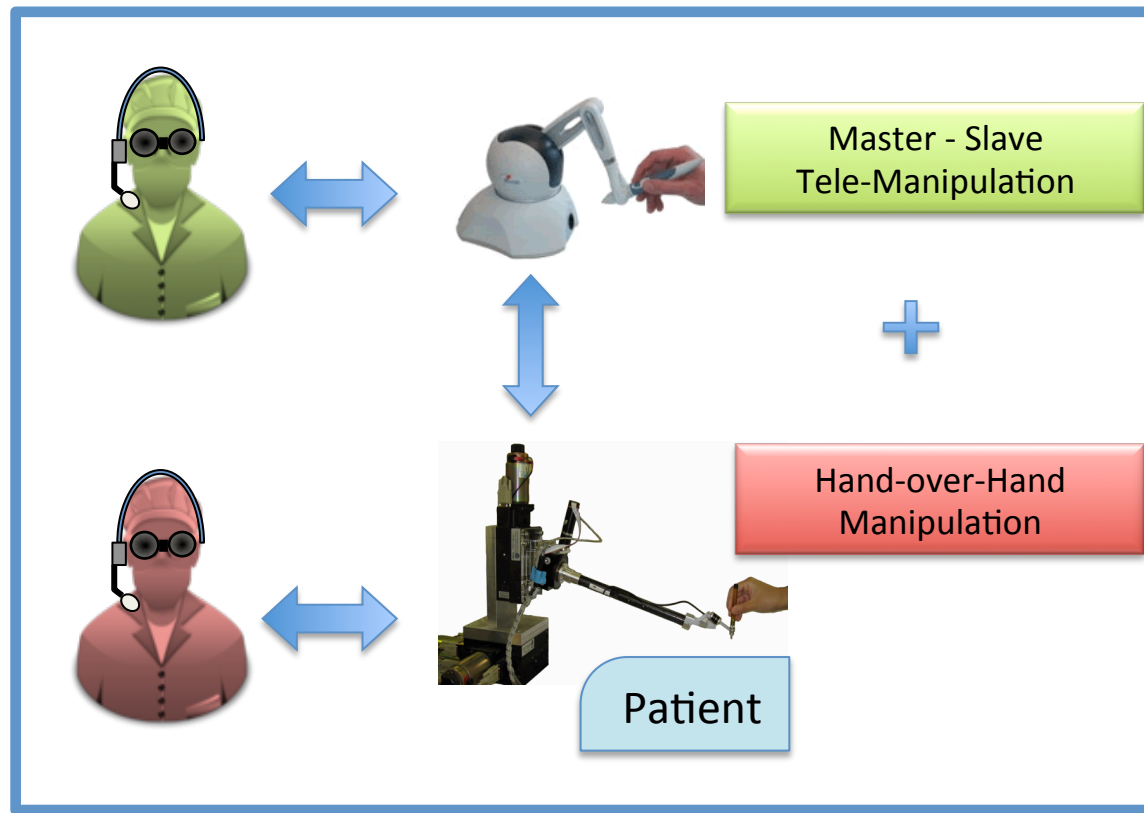
Johns Hopkins University, Baltimore, Maryland, USA
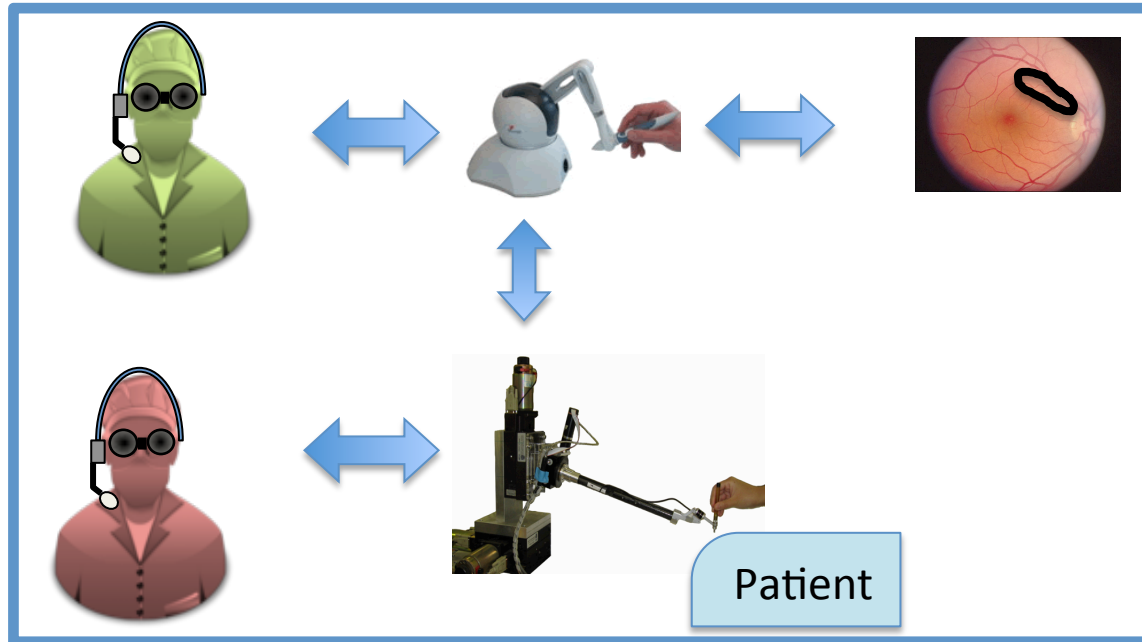
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Project Overview

Project Overview Cont.

Telestration

Paper Overview

Performance of Robotic Augmentation in Microsurgery

- <u>Goal</u>: to evaluate microsurgical cooperative assistants in their ability to augment fine surgical motions

- <u>How</u>: experiments performed using the Steady Hand Robot and the LARS Robot

- <u>Evaluation</u>: results compared with traditional microsurgery technique

Background

- Anastamosis
  - Joining two blood vessels as a bypass
  - A needle guides a suture material in and out of the vessel wall as the ends of the vessels are conjoined
  - Requires fine control

- Steady Hand Robot
  - Fine control, 5 DOF, force sensor
  - Tremor cancellation
  - Positional accuracy on the order of 10s of microns

- LARS
  - Fine control, 7 DOF, force sensor
 - Positional accuracy on the order of 100s of microns
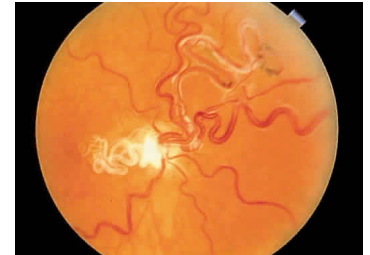
Fraser et. al.

Introduction

- Cooperative control system
  - Integrates safety and information into the procedure without taking away control from the human surgeon
  - Allows the surgeon's superior intelligence/experience to be used with greater precision

- But how can we evaluate the usefulness?

Experimental Setup
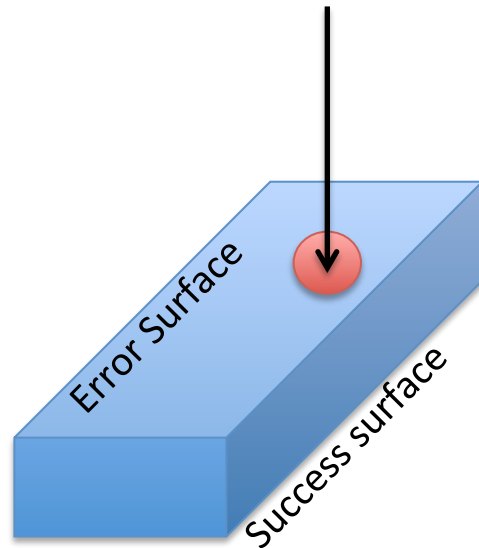
- Sandwich of two metallic plates
- Insulator in between
- Microsurgical needle
- Holes on the top surface (250, 200, and 150 microns)
- Lower sheet is success, top sheet is error
- Both surfaces connected to Robot; closed circuit is recorded

Three Versions

- Three different experiments for both robots:

1. <u>Unassisted Series</u> - the surgeon used only the conventional techniques to perform the pick-and-place operations

2. <u>Hand Held Series</u> - the needle holder was attached rigidly to the force sensor at the end-effector of the robot. The robot complied to user applied forces

3. <u>Autonomous Series</u> - the robot is registered to the plates (using 8 corner holes) and performs the task autonomously.

Results

Success Rate

Size of Holes	Unassisted	LARS Robot		Steady Hand Robot	
		Hand-held	Autonomous	Hand-held	Autonomous
250um	48.8%	56.0%	53.0%	77.8%	98.4%
200um	46.3%	50.8%	50.0%	76.7%	97.7%
150um	43.0%	46.0%	48.0%	79.0%	96.5%

Errors in a fixed time

Size of Holes	Unassisted	LARS Robot		Steady Hand Robot	
		Hand-held	Autonomous	Hand-held	Autonomous
250um	120.5	65.0	58.0	29.6	5.0
200um	110.0	76.8	62.0	27.0	7.0
150um	107.0	66.8	65.0	25.0	11.0

Conclusions

- Robots can extend human capabilities
- Steady hand eye robot significantly increases the accuracy without affecting operator perception (users reported equivalent ease of use)

Applying to our Project…

- Adapt ideas for telemanipulation validation
  - Spatial experiment
  - Experiment 1: Unassisted
  - Experiment 2: Eye Robot - hand held
  - Experiment 3: Omni
  - Question: using scaling, does Experiment 3 give better accuracy rates than Experiment 2?

Thoughts

- Positive
  - Simple and clear result
  - Experimental set up in the form of "correct" or "incorrect" constitutes easy analysis
  - Clear difference between LARS and SHR

- Room for improvement
  - More details about the experiment (e.g. how many tries did each subject have?)
  - Illustration of the metallic plate sandwich
  - Missing the purpose and details of the autonomous series
  - "Several other factors such as mistakes made in positioning the needle, spacing between sutures, etc…"

Future Work

- Further experiments to evaluate parameters that may have had an effect on this experiment
    - Ex. Training

- Recruit surgeons to perform the same experiment, rather than 6 grad students

Questions?