Bimanual teleoperation of Steady Hand Eye Robot with dVRK

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CIS 2 Presentation
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• Mentors:
Dr. Niravkumar Patel, Dr. Mahya Shahbazi
Dr. Russ Taylor, Dr. Iulian Iordachita
Background – Retinal Surgery

• In retinal microsurgery, surgeons are required to perform micron scale maneuvers
  • Vein cannulation: 60 micron needles in 100 micron veins
  • Surgeons need to feel force 7.5 mN in magnitude [2]

• Surgical performance is further challenged by [1]
  • thin and long surgical tools
  • physiological hand tremor
  • fatigue from prolonged operations

Illustration of retinal surgery
http://www.vrmagic.com/fileadmin/featuresite/eyesi30/ilm_peeling.jpg
Background – Steady-hand Eye Robot

• Technical Specifications
  • 5 DOF
  • admittance control
  • 0.25 mN resolution
  • repeatability of 3 µm, resolution of 1 µm
  • repeatability of 0.0001°, resolution of 0.0005°

• Disadvantages of SHER:
  • Inverted hand-eye coordination due to incision points
  • One-to-one motion scale
  • Non-transparent motion
Background – da Vinci Research Kit

• An “open-source mechatronics” system, based on the first-generation da Vinci system.
  • 7 DOF
  • Master-slave teleoperation
  • Stereo display
  • Surgeon console to improve ergonomics
  • Two controllers
Background – Teleoperated Retinal Surgery

• First reported system design for teleoperated eye surgery [3]
• Other teleoperated eye surgeries have been reported [4][5]
• However, no bimanual teleoperation has been reported
Bimanual Teleoperated Retinal Surgery

• Advantages:
  • Improved ergonomics
  • Arbitrary motion scale
  • Surgeon can reorient the workspace as needed
  • Less disturbance to the delicate movement due to surgeon-patient separation

• Challenges of teleoperation:
  • two tools to manipulate eye ball
  • sensory feedback
Project Goal

• Implement a bimanually teleoperated system for retinal surgeries with dVRK, which improves the safety, precision and ergonomics of surgical procedures.
Deliverable

• Minimum:
  • Framework to bimanually teleoperate two SHERs with dVRK with stationary eye ball

• Expected:
  • Framework to bimanually teleoperate two SHERs with dVRK with complex motions allowed such as rotating and tilting eye ball motion

• Maximum:
  • User study result of comparison of bimanually teleoperated, hand-over-hand and manual operation modes with complex motions allowed such as rotating and tilting eye ball motion
Design Approach

• Create ROS interfaces for the robots
• Prototype teleoperation logic, master/slave mid-level controller
• Implement other necessary components, including visual, audio feedback
• Test within the team and evaluate
• Iterate and improve
• Test with different users, potentially surgeons
System Design (Preliminary Concept)

- Surgical mode
  - Control point at tip
  - RCM constraint at insertion

- Maneuver mode
  - Control point at insertion
  - Sphere constraint
System Design (Preliminary Concept)

- SHER-SHER registration

- Eye-SHER registration
System Design (Preliminary Concept)

- **Teleop:**
  - Control mode: surgical/maneuver
  - Collision detection

- **Virtual Fixture**
  - Haptic Feedback

- **Desired Position**

- **Cartesian Position**

- **Master**

- **SHER**
  - Cartesian Position
  - Force Sensor

- **Surgeon**

- **Microscope**

- **Patient**
Management Plan

• Biweekly meetings with mentors
  • Time still needs to be worked out
• Meeting with Dr. Taylor and Dr. Iordachita as and when required
• Team meeting 1-2 times a week
  • Wednesday 6:30 pm onward
  • Saturday 5 pm if required
Responsibility distribution

• Since most of the project relies on coding, both team members can work together on different parts. But based on expertise and preference, the tasks were divided as follows.

• Max
  • ROS packages and dependencies for SHER robot, ensure compatibility with dVRK
  • Vision implementation
  • Sensor feedback

• Anurag
  • ROS packages for dVRK where needed, ensure compatibility with SHER robot.
  • Teleoperation logic
  • User study protocol
# Timeline

<table>
<thead>
<tr>
<th>Activity</th>
<th>Feburary</th>
<th>March</th>
<th>April</th>
<th>May</th>
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<tbody>
<tr>
<td>Preliminary Research</td>
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<td>Paper reading, mentor discussion</td>
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<td>Write project proposal, presentation</td>
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<tr>
<td>Design and Prototyping</td>
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<td>ROS interface for SHER 2.1</td>
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<td>Vision feedback</td>
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<tr>
<td>Teleoperation logic, surgical mode</td>
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<tr>
<td>Teleoperation logic, maneuver mode</td>
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<tr>
<td>Revise and improve</td>
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<tr>
<td>Final Evaluation</td>
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<td>Final Report and Presentation</td>
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<tr>
<td>Accomplishment</td>
<td>Estimated Date</td>
<td>Status</td>
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<tr>
<td>Presentation</td>
<td>Feb 7th</td>
<td>We are presenting now!</td>
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<td>Proposal</td>
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<td>Bimanual teleoperation logic, surgery mode</td>
<td>March 13th</td>
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<tr>
<td>Bimanual teleoperation logic, maneuver mode</td>
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<td>Final Presentation</td>
<td>May</td>
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## Dependencies

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<tr>
<th>Dependency</th>
<th>Plan to resolve</th>
<th>Estimated resolution date</th>
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<tbody>
<tr>
<td>Access to SHER 2.1</td>
<td>Schedule with Dr. Patel</td>
<td>Resolved</td>
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<tr>
<td>Access to dVRK</td>
<td>Coordinate with dVRK users</td>
<td>Resolved</td>
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<td>Shadowing an eye surgery</td>
<td>Coordinate with Dr. Patel</td>
<td>Feb</td>
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<td>IRB protocol (potentially)</td>
<td>Coordinate with Dr. Taylor</td>
<td>March</td>
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<td>Availability of students for evaluation</td>
<td>Coordinate with Dr. Patel and students in LCSR</td>
<td>April</td>
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References


