The Robotic ENT Microsurgery System (REMS): Calibration and IRB Study

CIS II Spring 2015: Brian Gu, Barbara Kim, Kurt Lee
1. Introduction
   - People
   - Background Discussion
2. Project Overview
3. Project Plan
   - Deliverables
   - Member Responsibilities
   - Timeline and Milestones
   - Dependencies
   - Management Plan
   - Reading list

😊 = done
Team Members and Mentors

• Members:
  Brian Gu, Junior BME
  Barbara Kim, Junior BME
  Kurt Lee, Senior AMS

• Mentors:
  Kevin Olds
  Professor Russell Taylor
  Dr. Masaru Ishii, JHMI
Background - Sinus Surgery

- Traditionally performed "open" - entering through facial incision. Often associated with scarring and other complications.
- Endoscopic sinus surgery is minimally invasive, in favor.
Background - Sinus Surgery

• Challenges:
  - Many critical structures are in the surgical area (brain, eye orbit, carotid artery). These are closely intertwined with the sinuses.
  - Need to repeatedly remove operative instruments (cleaning, check CT position as tracking is poor)
  - Sinus tissue easily damaged, sensitive in general. Can occlude endoscopic view.
So optimizing the surgical procedure is important!! Thankfully, we have robots (though none established currently for OHNS).
REMS - Robotic ENT Microsurgery System

• Robotic system designed with the goal of addressing surgical challenges - specifically those encountered in OHNS (of which sinus surgery is a subset)

• Assists in manipulation - eliminates unwanted movement from surgeon (ie hand tremor)

• Assists in navigation - combines positional tracking information with registered pre-operative images to avoid sensitive anatomy ("barrier zones")
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Subproject 1: REMS Sinus Validation Study

• Primary goal is to determine if robotic surgical assistance with REMS improves surgical skill compared to conventional surgery.

• Protocol:
  • 20 students randomly separated into two groups
  • 10 will "learn sinus surgery" with the REMS
  • 10 with current learning protocol
  • compare accuracy of two groups

• An expert group will perform the task to gather data on how REMS affects professionals.
Subproject 2: Additional Calibration

- Tool holder not perfectly stiff
- Leads to minor deflection of the tool when used admittance style
- Error currently not accounted for in robot's kinematics
  - has a force sensor however!
- Use computer vision approach to track tool tip
- compare position from computer vision system to position/force in the REMS
- Calibrate using AX=XB method
- Do this for many different poses and forces
- Fit polynomial to account for error
Subproject 3: Modified Tool Holder

• Current tool holder allows for free rotation of tool
• Does not track this rotation
  • Not a problem for straight tools
  • Cannot accurately track tip of burred/angled tool tips
• Two options: Motorized holder or free rotation with tracking
  • Must be accurate to a few degrees
  • Must leave small footprint (does not interfere with hand movements of doctor)
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## Deliverables

<table>
<thead>
<tr>
<th>Minimum</th>
<th>Expected</th>
<th>Maximum</th>
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</thead>
<tbody>
<tr>
<td>Completion of one of the three</td>
<td>Completion of two of the three</td>
<td>Completion of all three sub-projects*</td>
</tr>
<tr>
<td>sub-projects</td>
<td>sub-projects</td>
<td></td>
</tr>
<tr>
<td>Either IRB study</td>
<td>IRB study</td>
<td>*presentable prototype</td>
</tr>
<tr>
<td>OR calibration</td>
<td>AND calibration</td>
<td>of the tool holder</td>
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</table>
Management Plan

• Each member will be "task manager" for a specific project, they are in charge of everything to do with that project (milestones, work assignment etc.)

• Weekly meetings between Kurt, Barbara, and Brian
  • distribute workload, update on progress, work on presentations
  • if a member feels like they are falling behind on their responsibilities, they will inform the group and work together to immediately discuss and address the issue through instant messaging (texts, FB)

• Meetings with Dr. Taylor, Kevin Olds, and Dr. Ishii on a need to basis
  • guidance, verification, brainstorming
Team Member Responsibilities

• Each subproject has "Task Manager"
  • Task Manager is in charge of their specific subproject - they will be the ones responsible for outward correspondence, milestones/progress tracking, and assignment of work, all for their "own" project
  • Work distributed based on skills and experience

• Brian Gu
  • Tool Holder Task Manager
  • Cad specialist
  • Computer vision development

• Barbara Kim
  • IRB Study Task Manager
  • Computer vision development

• Kurt Lee
  • Rems Calibration Task Manager
  • Overall management/organization
  • Data analysis
## Timeline

<table>
<thead>
<tr>
<th>Task</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
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</thead>
<tbody>
<tr>
<td><strong>Additional calibration of the REMS</strong></td>
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<tr>
<td>learn computer vision toolbox in MATLAB</td>
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<tr>
<td>build and test computer vision implementation</td>
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<tr>
<td>gather deflection data from REMS</td>
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<tr>
<td>analyze data and fit polynomial to the data (interpolation)</td>
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<tr>
<td><strong>IRB study using the REMS</strong></td>
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<tr>
<td>get proper certification and review protocol with Dr. Ishii</td>
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<tr>
<td>find undergraduate subjects for study and schedule</td>
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<tr>
<td>conduct study</td>
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<tr>
<td>analyze data gathered from the study</td>
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<tr>
<td><strong>Development of tool holder</strong></td>
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<tr>
<td>brainstorm design ideas</td>
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<td>create CADs of best designs</td>
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<td>3D print a preliminary prototype</td>
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# Milestones

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Expected Completion</th>
<th>Status</th>
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<tbody>
<tr>
<td>Project Plan Presentation</td>
<td>February 26th</td>
<td>In progress!</td>
</tr>
<tr>
<td>Meet Dr. Ishii</td>
<td>March 6th</td>
<td>Scheduled</td>
</tr>
<tr>
<td>Working Computer Vision System</td>
<td>March 20th</td>
<td>In training</td>
</tr>
<tr>
<td>Gather 10 undergraduates for study</td>
<td>March 28th</td>
<td>Not done</td>
</tr>
<tr>
<td>Checkpoint Presentation</td>
<td>April 9th</td>
<td>Not done</td>
</tr>
<tr>
<td>Have at least one CAD design</td>
<td>April 10th</td>
<td>Not done</td>
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<tr>
<td>Force Data and Position Data gathered</td>
<td>April 15th</td>
<td>Not done</td>
</tr>
<tr>
<td>Calibration data fit to polynomial</td>
<td>April 30th</td>
<td>Not done</td>
</tr>
<tr>
<td>Complete testing on undergraduates</td>
<td>April 30th</td>
<td>Not done</td>
</tr>
<tr>
<td>Poster Presentation</td>
<td>May 8th</td>
<td>Not done</td>
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</tbody>
</table>
Dependencies

• Meetings with Dr. Ishii, full correspondence
  • critical for IRB study
• 20 undergraduates with proper training for study
• Resources for prototyping and computer vision setup
  • beg (on knees) to Dr. Taylor
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Reading List


• Kevin Old's Thesis Draft

• CIS I material

• MATLAB Documentation regarding Computer Vision toolbox
Reading List (Contd.)

