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

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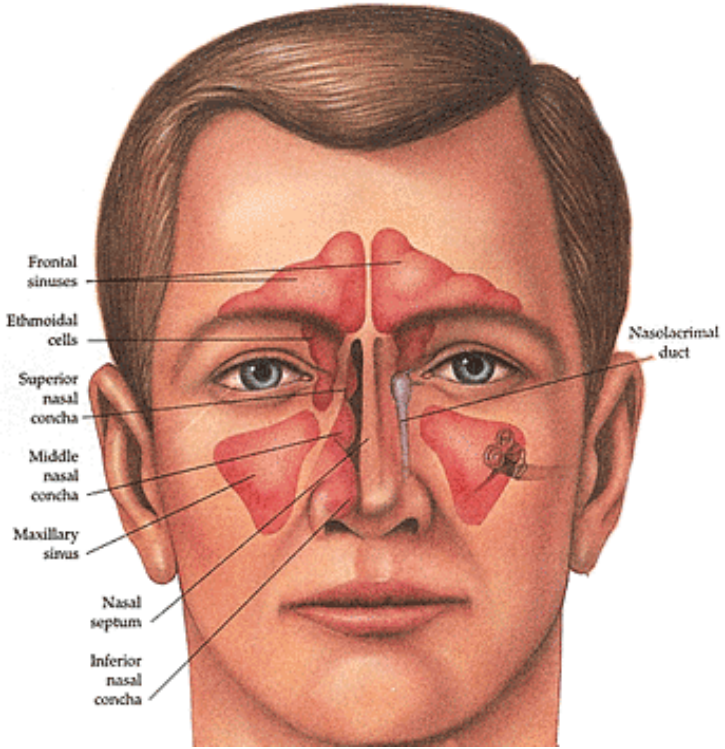
Team Members and Mentors

- Members:
  Brian Gu, Junior BME
  Barbara Kim, Junior BME
  Kurt Lee, Senior AMS
- Mentors:
  Kevin Olds
  Professor Russell Taylor
  Dr. Masaru Ishii, JHMI

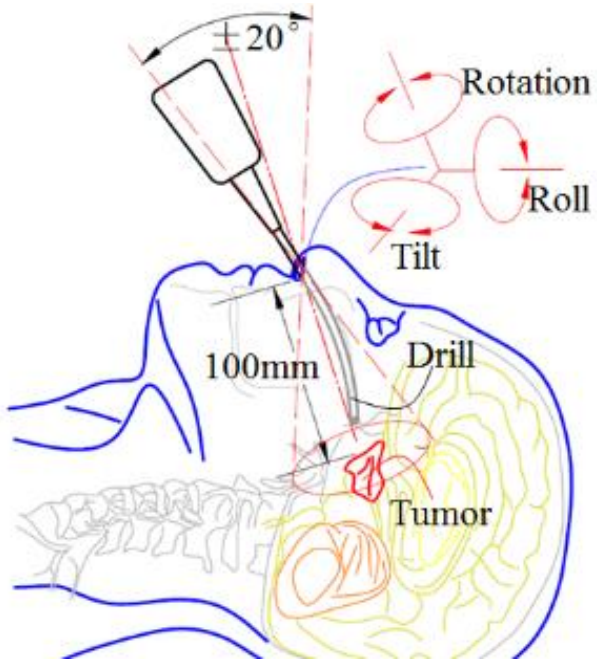
Background - Sinus Surgery

- 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

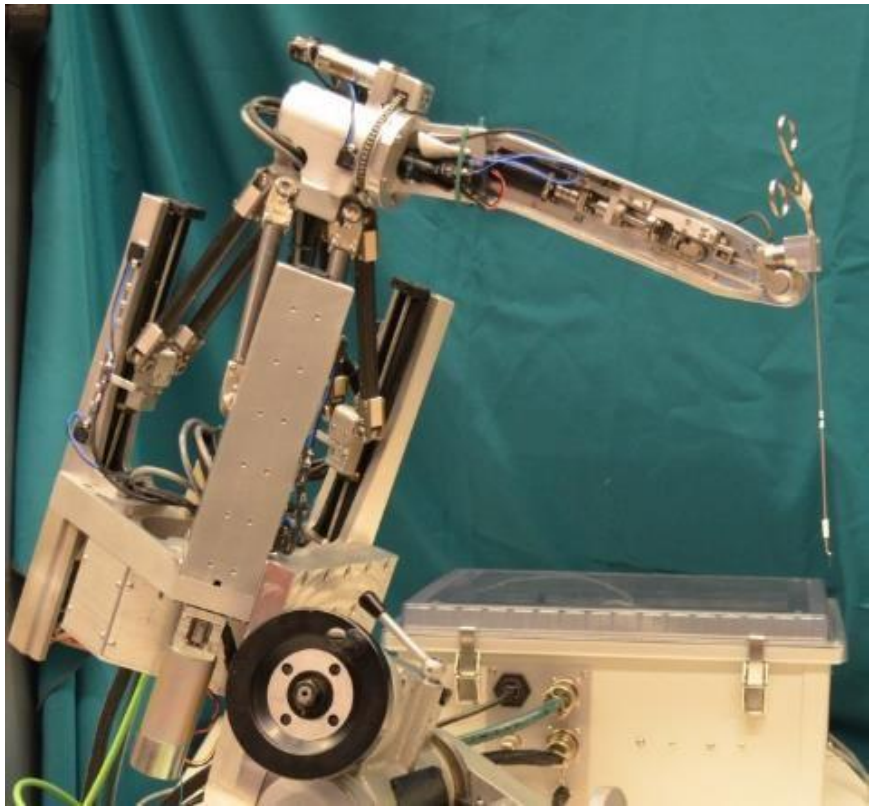
- Challenges:
  -Many critical structures are in the surgical area (brain, eye orbit, carotid artery). These are closely intertwined with the sinuses.
  -Need to repeatedly remove operative instruments (cleaning, check CT position as tracking is poor)
  -Sinus tissue easily damaged, sensitive in general. Can occlude endoscopic view.

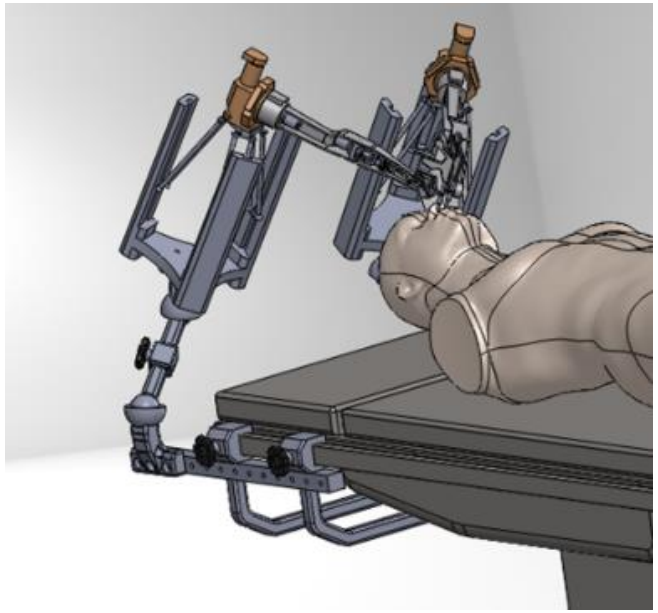

±20°
Rotation
Roll
Tilt
100mm
Drill
Tumor

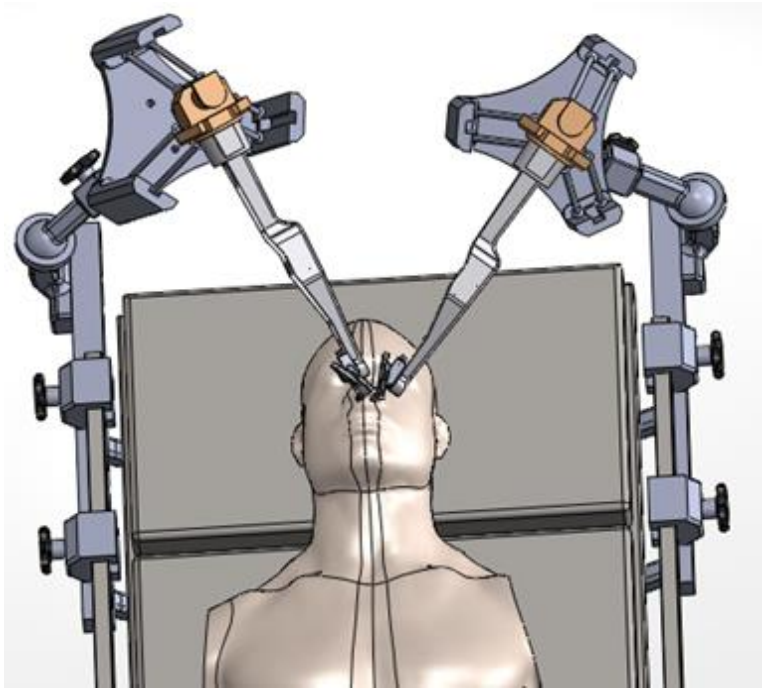
So optimizing the surgical procedure is important!! Thankfully, we have robots (though none established currently for OHNS).

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

Minimum	**Expected**	**Maximum**
Completion of one of the three sub-projects	Completion of two of the three sub-projects	Completion of all three sub-projects*
Either IRB study OR calibration	IRB study AND calibration	*presentable prototype of the tool holder

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

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

Milestones

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

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

- *N. Ahmidi, G. Hager, L. Ishii, G. Gallia and M. Ishii, "Robotic Path Planning for Surgeon Skill Evaluation in Minimally-Invasive Sinus Surgery," in Medical Image Computing and Computer Assisted Intervention (MICCAI)*, Berlin, Germany, 2012.
- Kevin Old's Thesis Draft
- CIS I material
- MATLAB Documentation regarding Computer Vision toolbox

Reading List (Contd.)

- *Reilink, R, Stramigioli S, Misra S. "Image-based flexible endoscope steering," in IEEE/RSJ Intenational Conference on Intelligent Robotics and Systems*, Taipei, Taiwan, 2010.
- Olds K, Chalasani P, Pacheco-Lopez P, Iordachita I, Akst L, Taylor R. “Preliminary Evaluation of a New Microsurgical Robotic System for Head and Neck Surgery”, IEEE/RSJ International Conference on Intelligent Robots and Systems, 2014.
- *Setliff RC 3rd. Minimally invasive sinus surgery: the rationale and the technique. Otolaryngol Clin North Am 1996;* 29(1):115-24.