Checkpoint Presentation: Integration of CBCT and a Skull Base Drilling Robot

Team member: Hao Dang, Zihan Chen
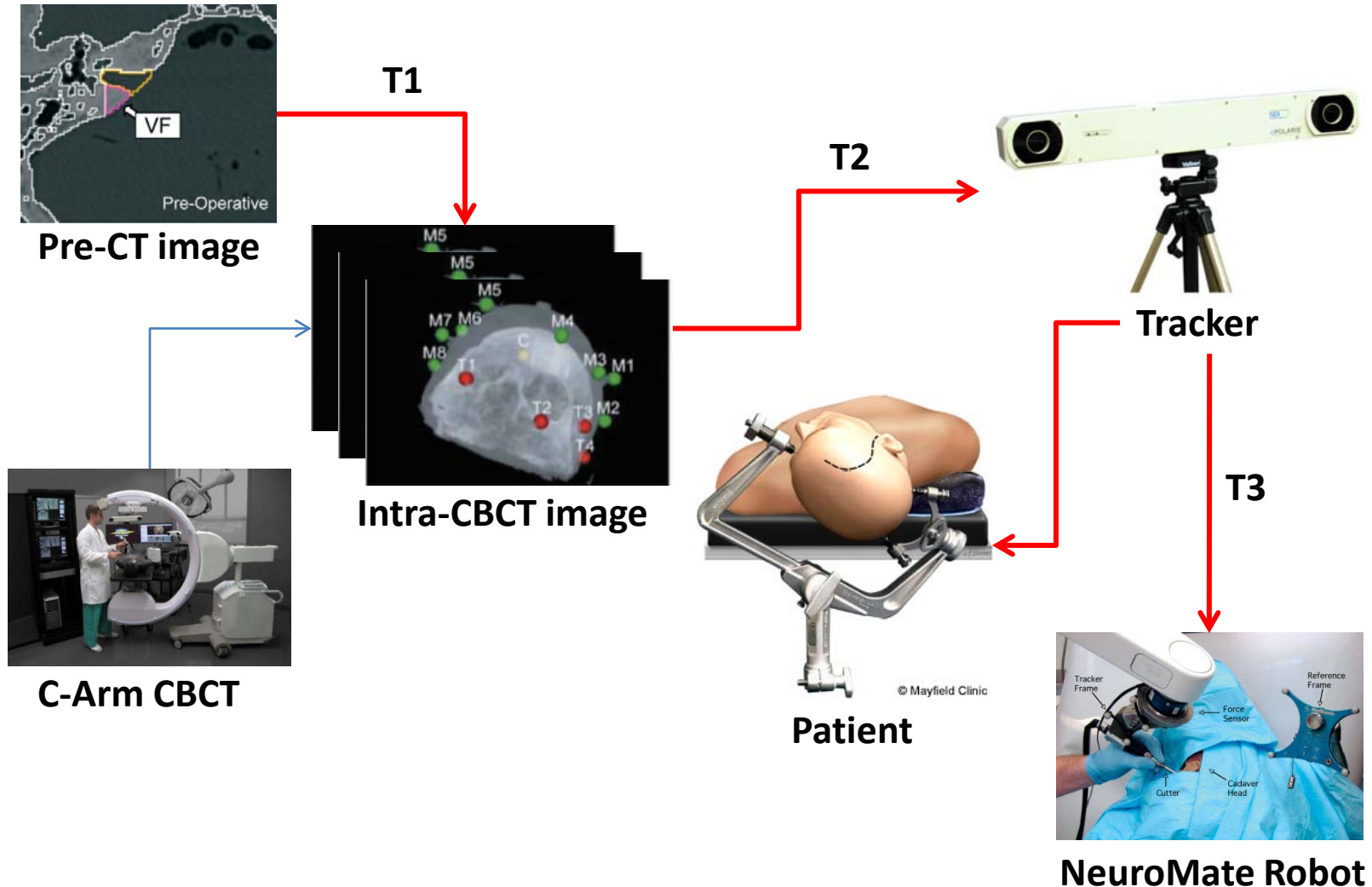
Mentors: Jeff Siewerdsen, Peter Kazanzides

Course mentor: Russ Taylor

April 7, 2011

Background & Motivation

Goal: Integrate C-arm CBCT into robotic system

Pre-CT image

T1

T2

Tracker

C-Arm CBCT

Intra-CBCT image

**Patient**

T3

NeuroMate Robot

Milestones & Progress

- Milestone 1: CT-Tracker registration
  - ~~Planned Date: Feb. 28~~ done!

- Milestone 2: CT-CBCT registration
  - ~~Planned Date: Mar. 12~~ done!

- Milestone 3: Robot-Tracker registration
 - ~~Planned Date: Mar. 31~~ done!

CT-Tracker registration

- Hardware platform: **NDI Polaris**
- Software platform: **TREK**-- Imaging and surgical navigation platform of the I-STAR Lab
- System Setup
  - Checked out/compiled latest version
  - Calibrated offset of NDI pointer
  - Configure 'tracker' and 'Registration' module
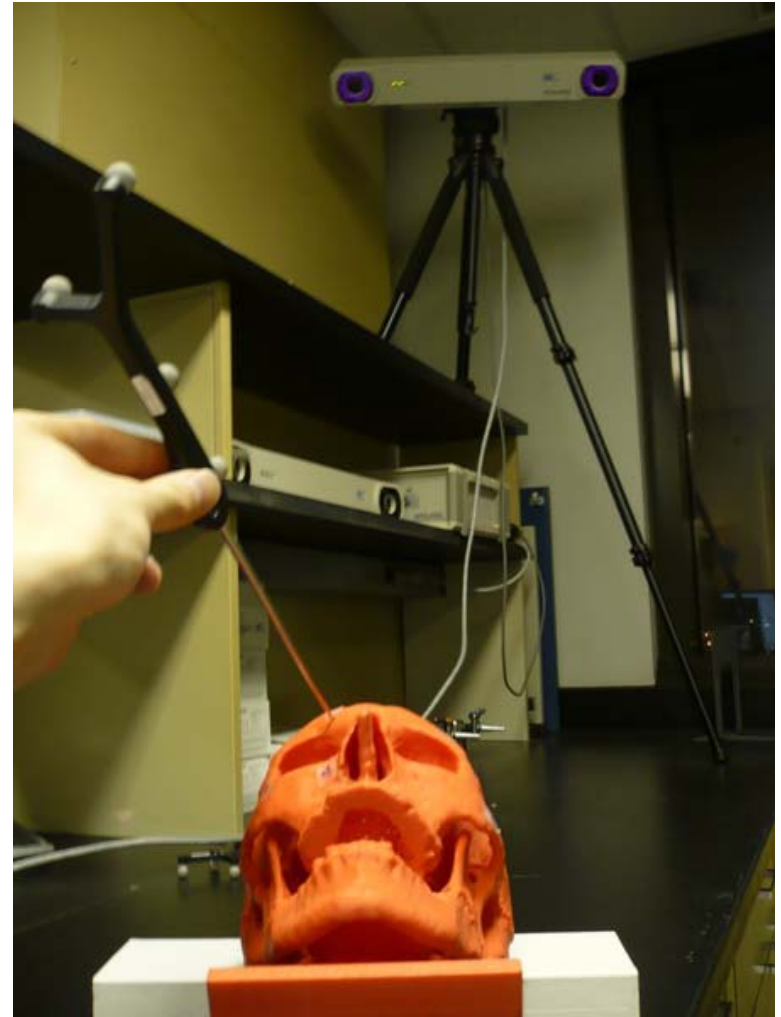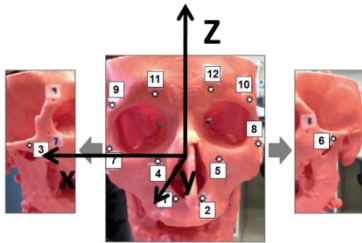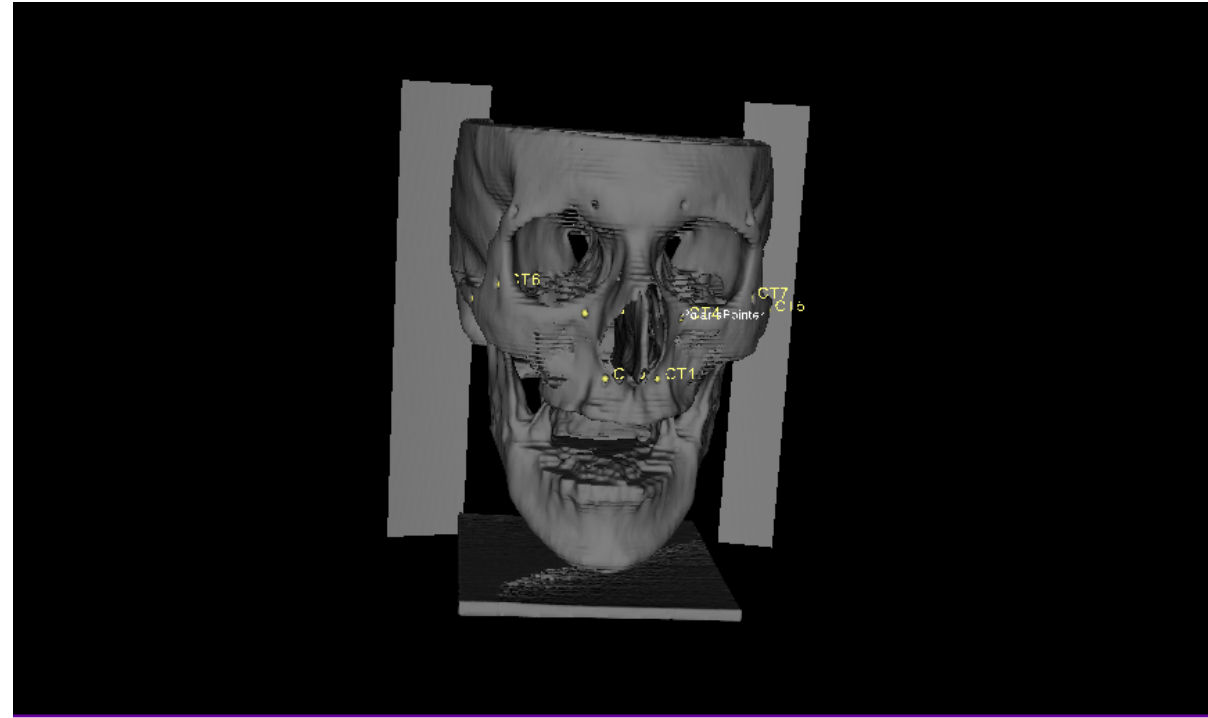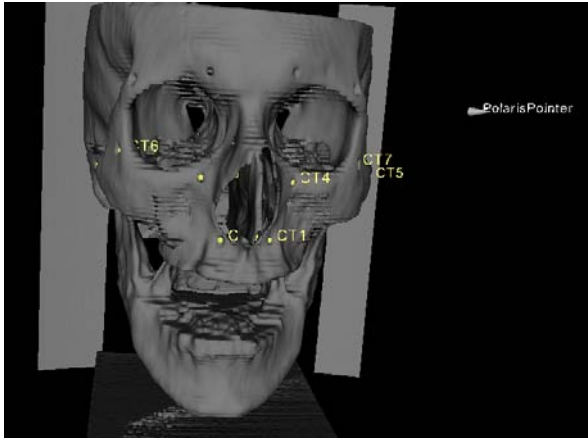
- Registration results
  - **Mean FRE: 0.5~0.8 mm**
  - **Mean TRE: <1mm**
- Data for this demo
  - 5 fiducials, 3 targets
  - Mean FRE: 0.85 (0.71, 0.55, 0.20, 1.83, 0.98)
  - Mean TRE: 0.92 (0.43, 0.71, 1.62)
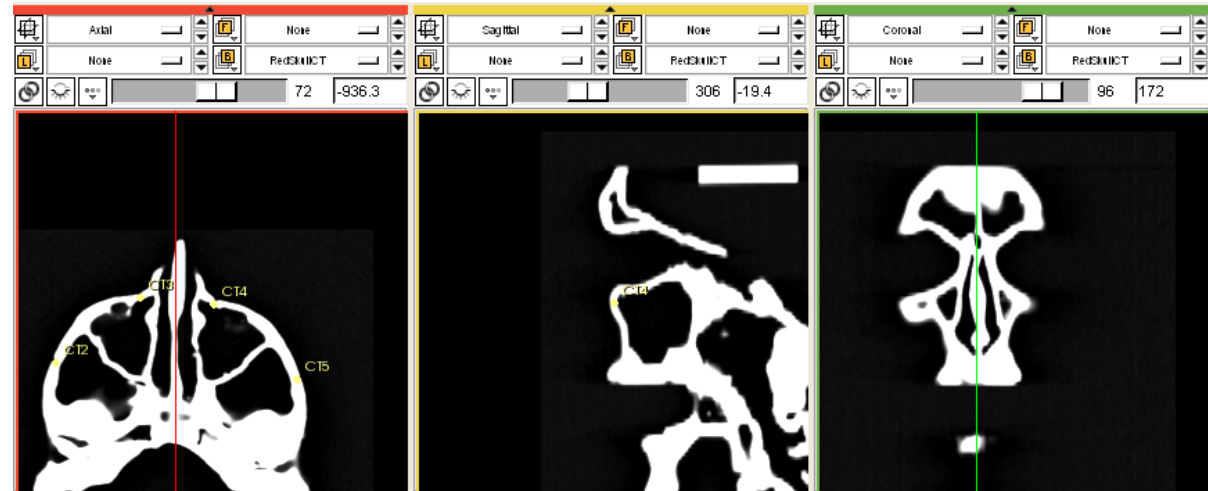
CT-CBCT registration

- Goal: register two 3D volumes
  - Fiducial based registration (Min and Expected)
  - Image based deformable registration (Max)
- Software Platform: TREK
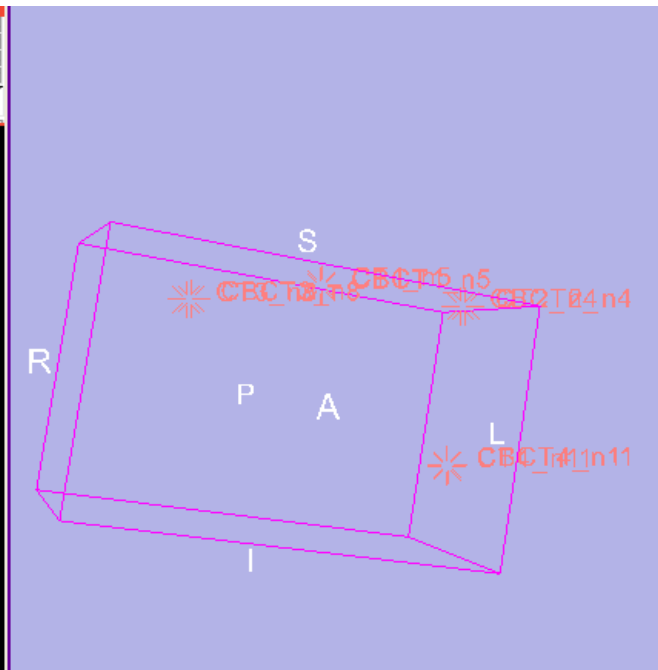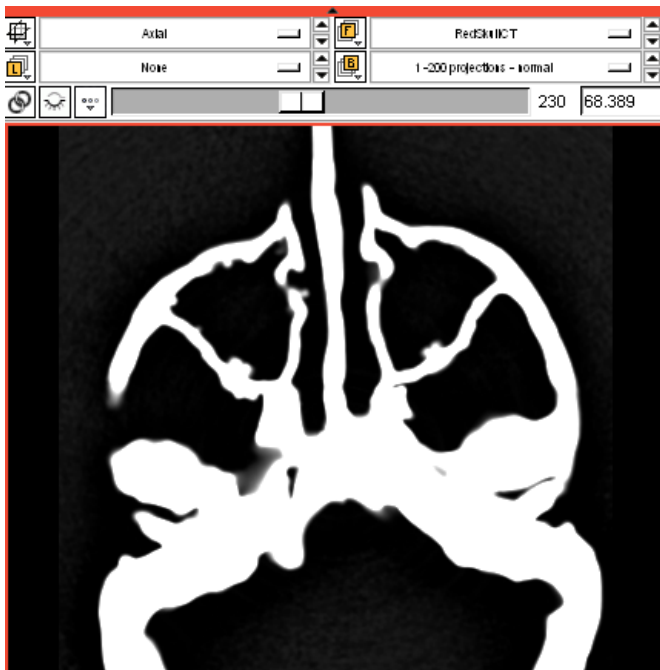- Result

  (1) Fiducial based
  - **Mean FRE: ~0.8 mm (<1mm)**
  - **Mean TRE: ~1mm**

  Data for demo on next slide
  - 4 fiducials, 2 targets
  - Mean FRE: 0.86   (0.75, 1.20, 0.55, 0.93)
  - Mean TRE: 0.84   (0.85, 0.83)

  (2) Image based rigid: did not work well.

  The difference in intensity pattern seems to require advanced processing like intensity matching. Directly turn to deformable registration later (optional)

Two pairs of fiducials are overlaid.
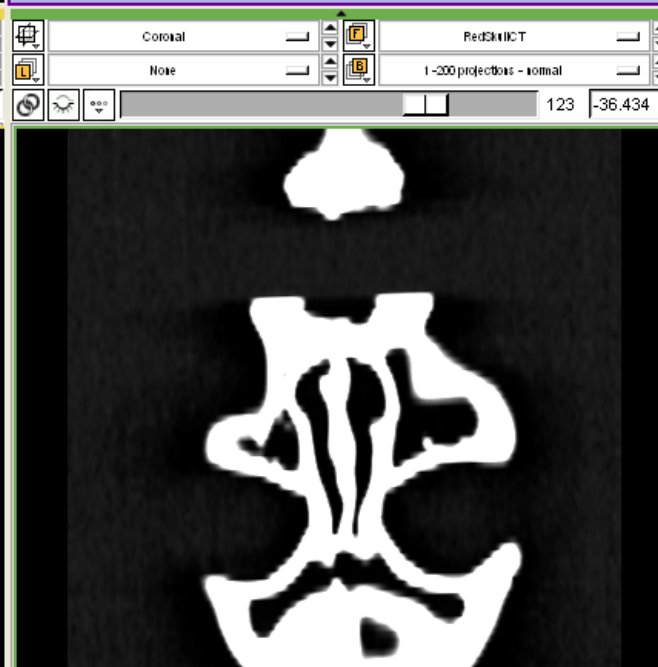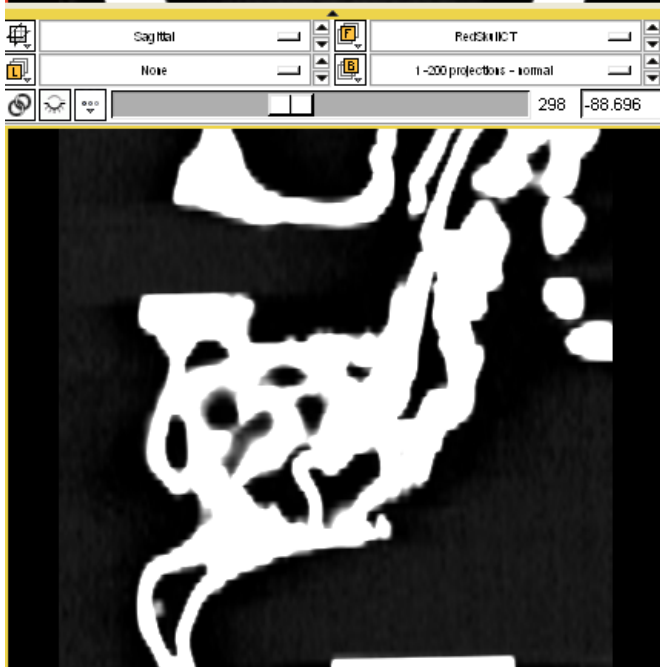
CT images only
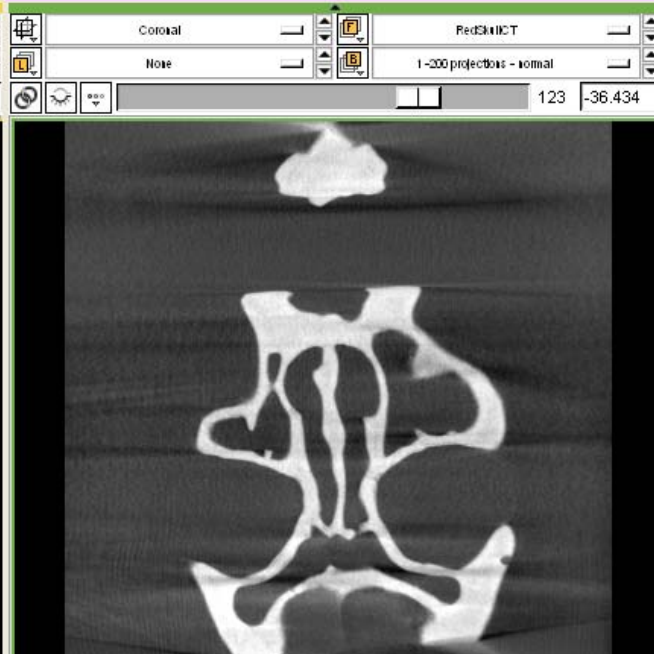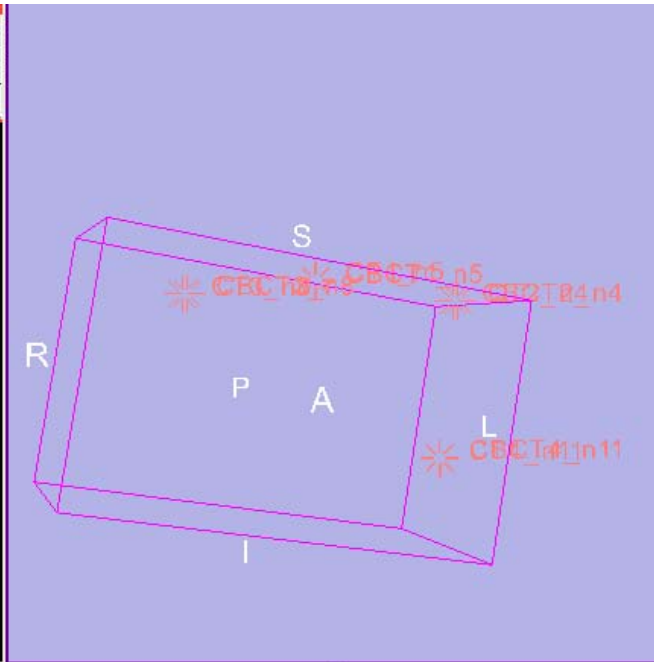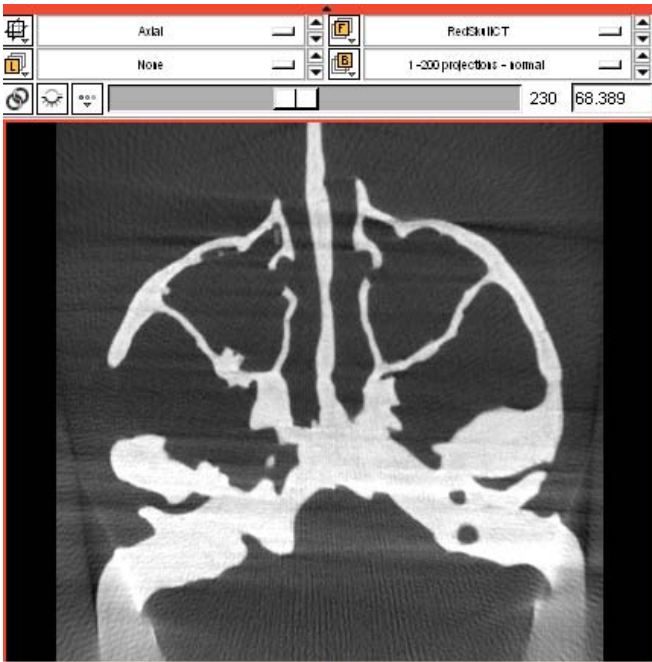
CBCT images only
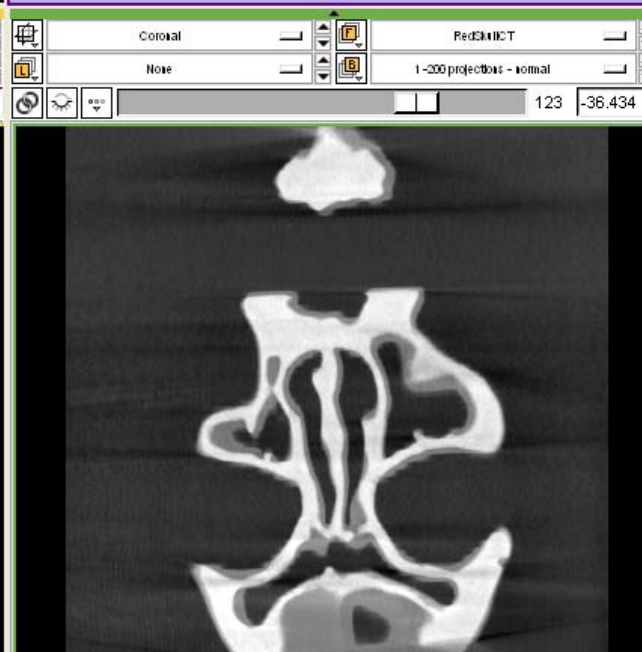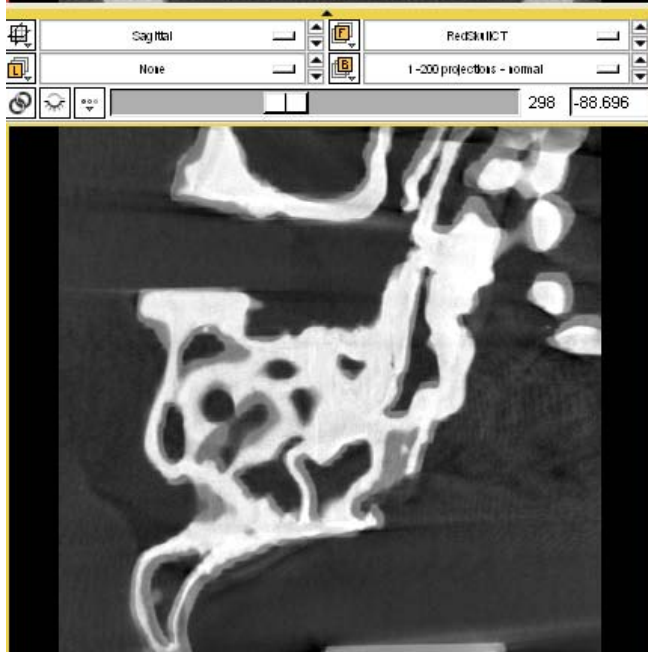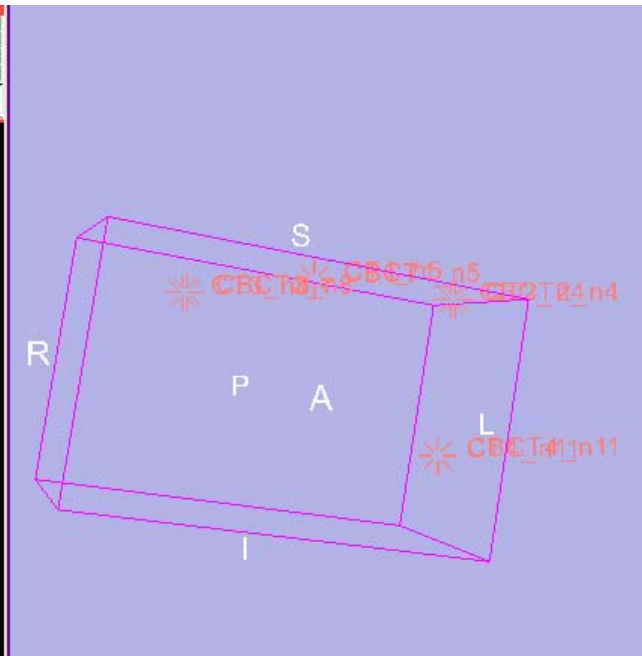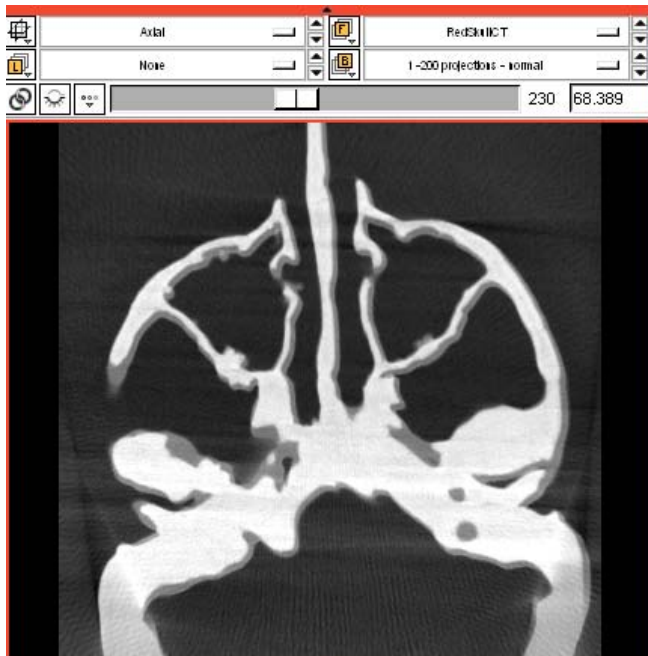
Overlay CT and CBCT images

Robot-Tracker registration

Robot-Tracker registration
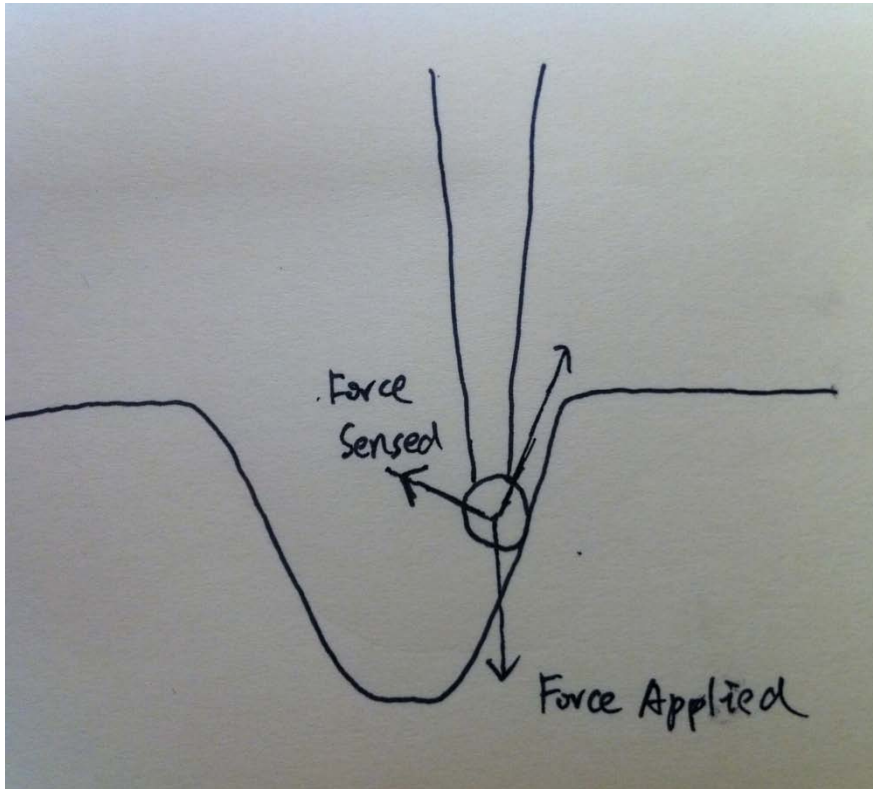
- Robot Pivot calibration
- 6 position
- Ball in Cone Search Method
- Data collection

Robot-Tracker registration

- devNDIserial component
- Pivot Calibration
- Tooltip position
- Data collection & Analysis

Robot-CBCT/CT registration

- Guide the robot to fiducials on the Red Skull

- Registration

Review deliverables

- Minimum

  - Fusion of intro-opera CBCT and pre-opera CT images by fiducial-based rigid registration (achieved)

  - Complete transformation flow including robot, skull, CBCT images along with navigation system (achieved)

  - Target-pointing experiment on phantom using CBCT-Guided skull base drilling robot system(CBR system) with navigation

- Expected

  - Foam-drilling experiment on phantom using CGR system with navigation

  - Transformation flow including robot, skull, CBCT images without navigation (achieved)

  - Parallel phantom experiments using two CGR systems and previous non-CBCT system. Compare results.

Review dependencies

No.	Dependencies	State	Date		
1	Access to NeuroMate® Robot	100%	N/A	Got access to mock room	✓
2	Move robot to Med Sch	20%	03/20/2011	Further discussion needed	✓
3	Access to CBCT and MISTC	100%	N/A	N/A	✓
4	Radiation traingin & badge	50%	02/24/2011	Hao OK, Zihan working on it	✓
5	Phantom	100%	N/A	Red Skull in Jeff's lab	✓
6	Cadaver & Neurosurgeo	20%	TBD	Need assess after phase 2. Got support from Jeff	
7	Bio hazard training	20%	TBD	Online training	

One step towards a more elegant system: Interaction via ICE

ICE

Neurosurgery Robot

Click to Start

Documentation

The following are well documented:

- Hardware setup
  - NDI Tracking system
  - NeuroMate Robot
- Software setup on Linux and Windows
  - CISST compiled with Qt
  - TREK
- Our codes on SkullBase Robot (SVN)
- Results and analysis for each registration
- Weekly meet notes and slides

Future milestones

- Milestone 4: Target-pointing experiments on Red Skull Phantom (Mock Room)

- Milestone 5: Move Robot to Medical Campus

- Milestone 6: Drilling experiments on another phantom (Medical Campus)

- Maximum: Cadaver studies

Changes in timeline

Project Timeline: Integration of CBCT and a Skull Base Drilling Robot — Hao Dang, Zihan Chen

Tasks	February				March				April				May			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Background Reading	▭															
Project Proposal & Presentation	▭															
Phase 1: Registration and Robot Control																
CBCT to Navigation Regstration			▨	▨												
CBCT/CT to Robot Direct Registration			▨	▨												
CT to CBCT Registration				▨	▨											
Robot to Naviagtion Regsitration				▨	▨	▨										
Virtual Fixture and Control						▨	▨									
Phase 2: Programming and System Integration																
devNIDserial Programming									▩							
TREK & Robot communication										▩						
Integration											▩					
Phase 3: Experiment																
System without Navigation												▨				
Phantom Pointing												▨				
Phantom Drilling)											▨					
Phase 4: Analysis and Final Report																
Further Analysis														▭		
Final Report															▭	
Documentation	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
Cadaver (Optional)																
Image Based Registration (Optional)																

Legend:
- Proposal
- Phase 1
- Phase 2
- Phase 3
- Phase 4
- Documentation

Key Dates	
02/22/2011	Presentation
03/27/2011	Finish Phase 1
04/21/2011	Finish Phase 2
05/07/2011	Phantom Drilling
05/19/2011	Final Poster

Future challenges

- Robot movement
- Larger registration error after integrating each part into a system
- Performance of current virtual fixture implementation

Thank you!
Questions?