Surgical Skill Evaluation in Endoscopic Sinus Surgery

Group 4

Vishwa Parekh

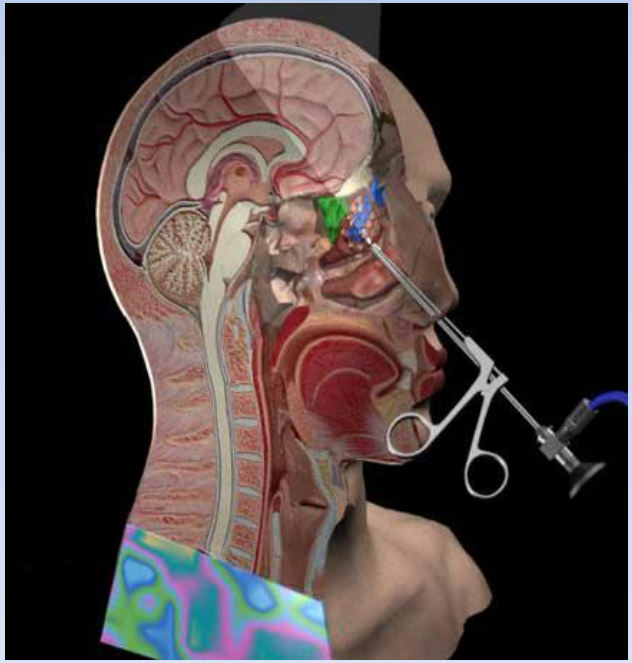
Mentors: Dr. Gregory Hager, Daniel Mirota, Narges Ahmidi

PROJECT GOAL

Develop a mathematical model for surgical skill evaluation in endoscopic sinus surgery.

Input: Series of Surgical movements

Output: Surgical Skill Level

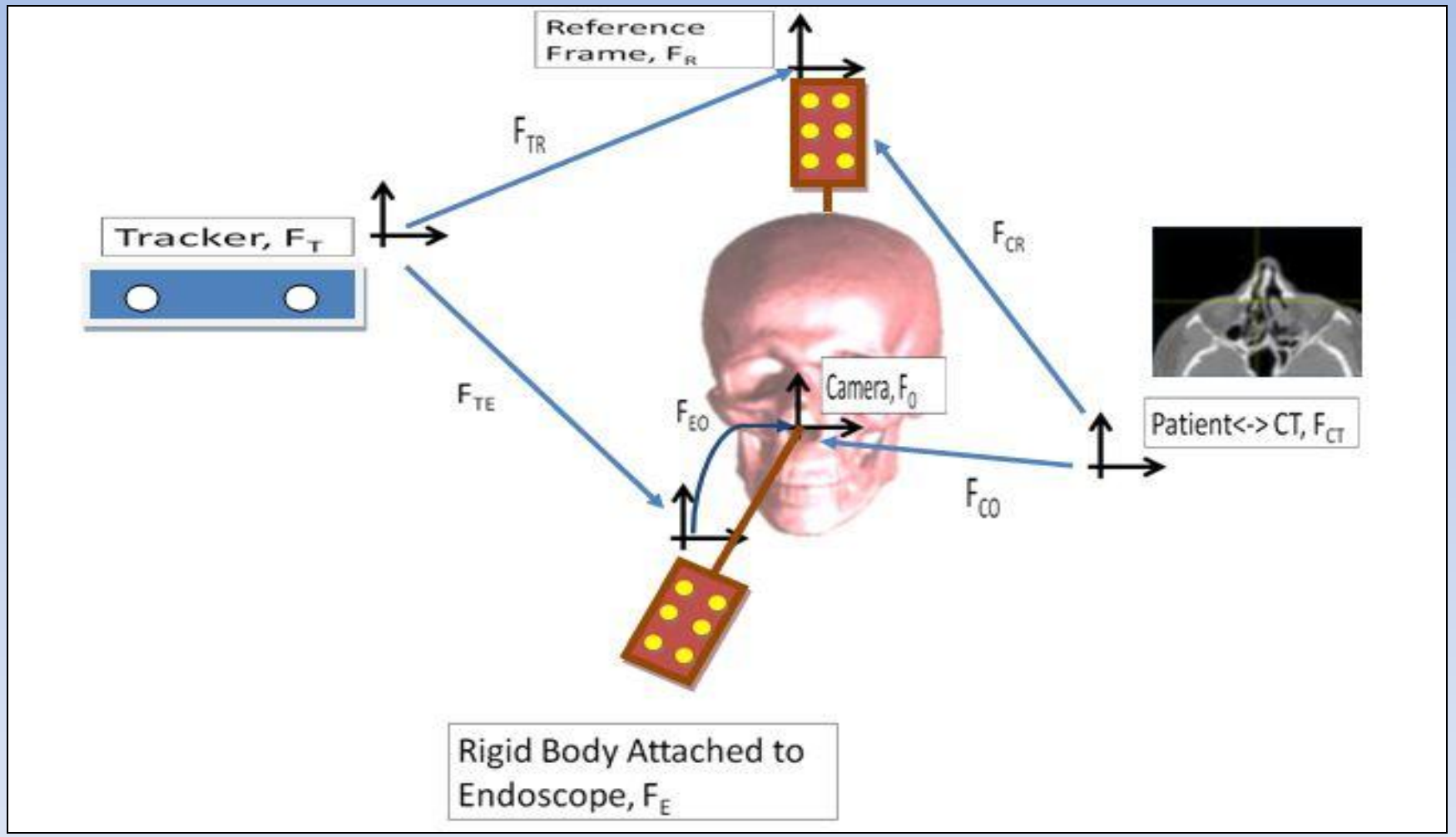


CIS1 Lecture slides on registration

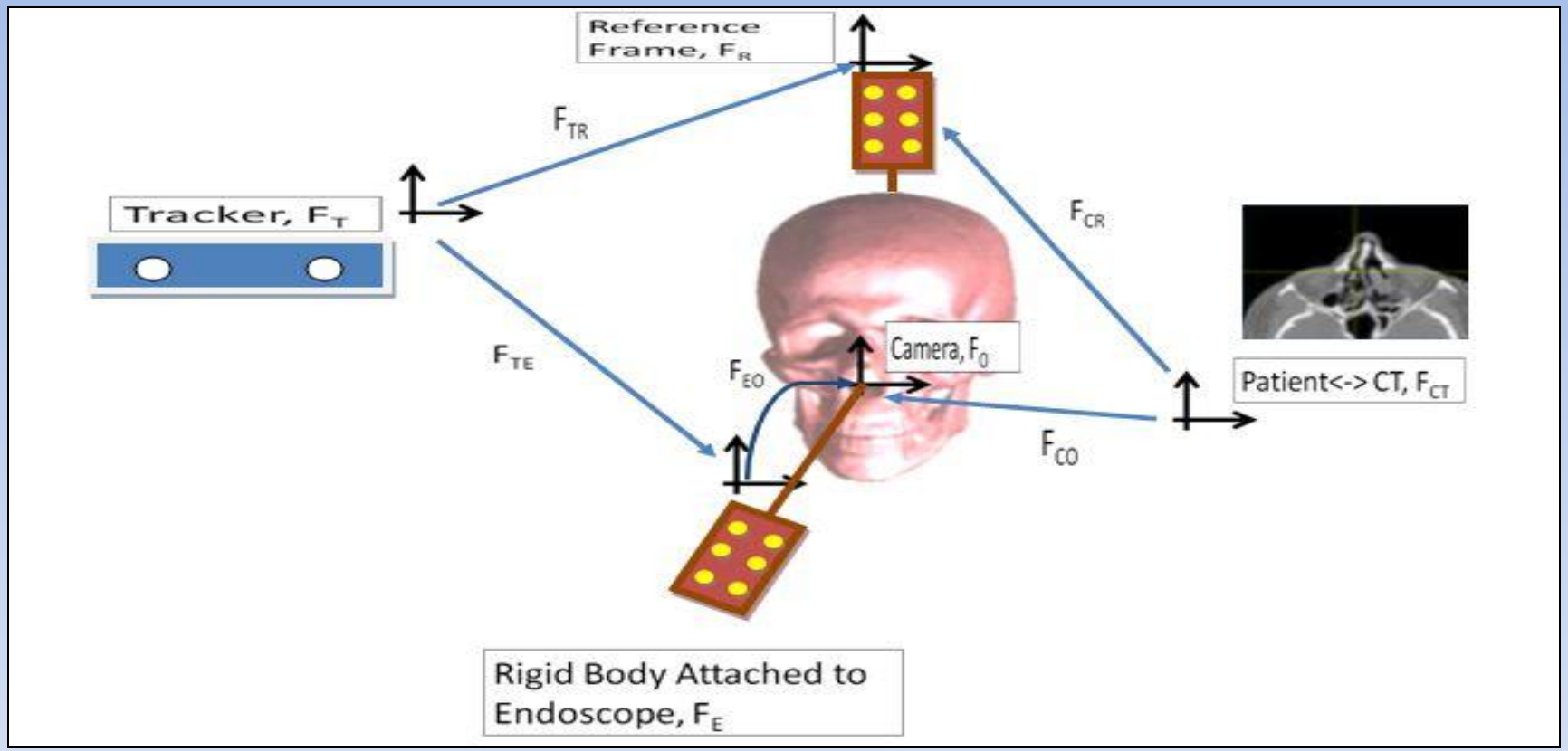
Milestones and Progress

Milestone	Status	Planned Date	Date Accomplished
Recording Software	Completed	February 25	February 25
Registration Pre Processing Software	Completed	March 3	March 7
Test the Recording Software in the lab	Completed	March 19	March 26
Record Data from OR	-	March 24	-
Registration Software	2D-3D Registration Completed, Currently working on segmenting region of CT corresponding to the image.	March 31	-
Optimization Software	Completed	April 14	March 19
Surgical Skill Modeling for 1 surgeon	-	April 25	-
Surgical Skill Modeling for multiple surgeons	-	May 10	-

Diagrammatic representation of the system currently employed in the operating room



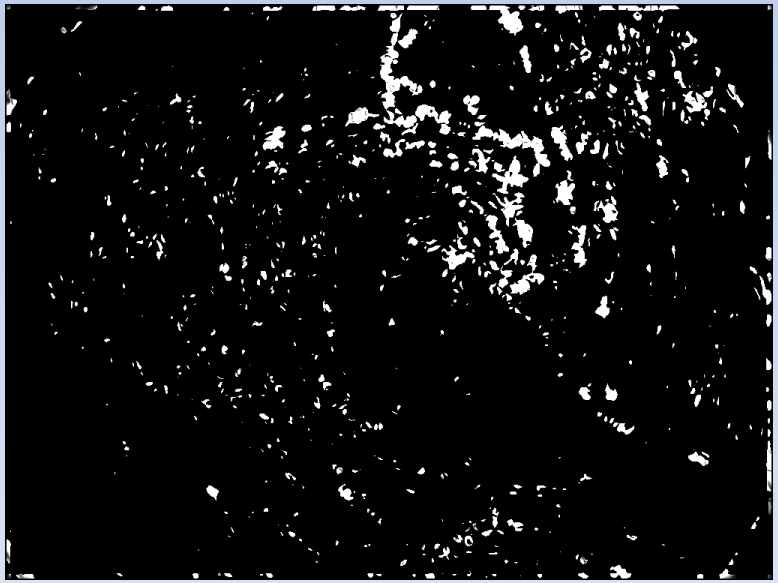
Recording Software



- Used cisstStereoVision and sawMedtronicStealthlink and the libraries these were dependent on

Synchronization Software

- Remove the phase difference between tracker data and video data
- Optical Flow
- Lucas Kanade Approach

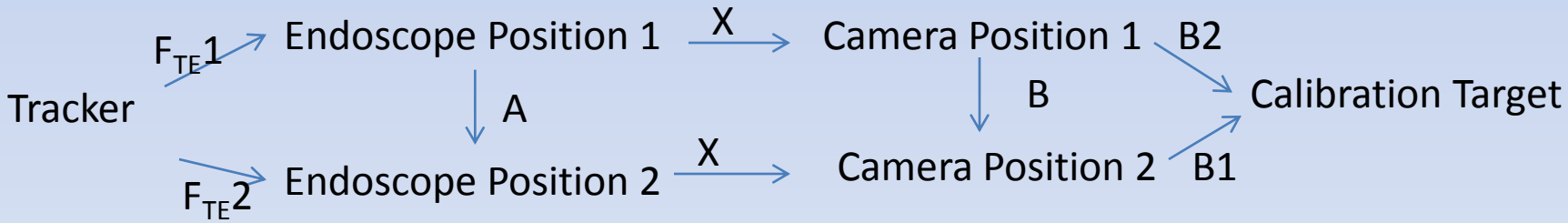


Images from dataset of previously recorded surgery

Camera Calibration + Hand Eye Coordination

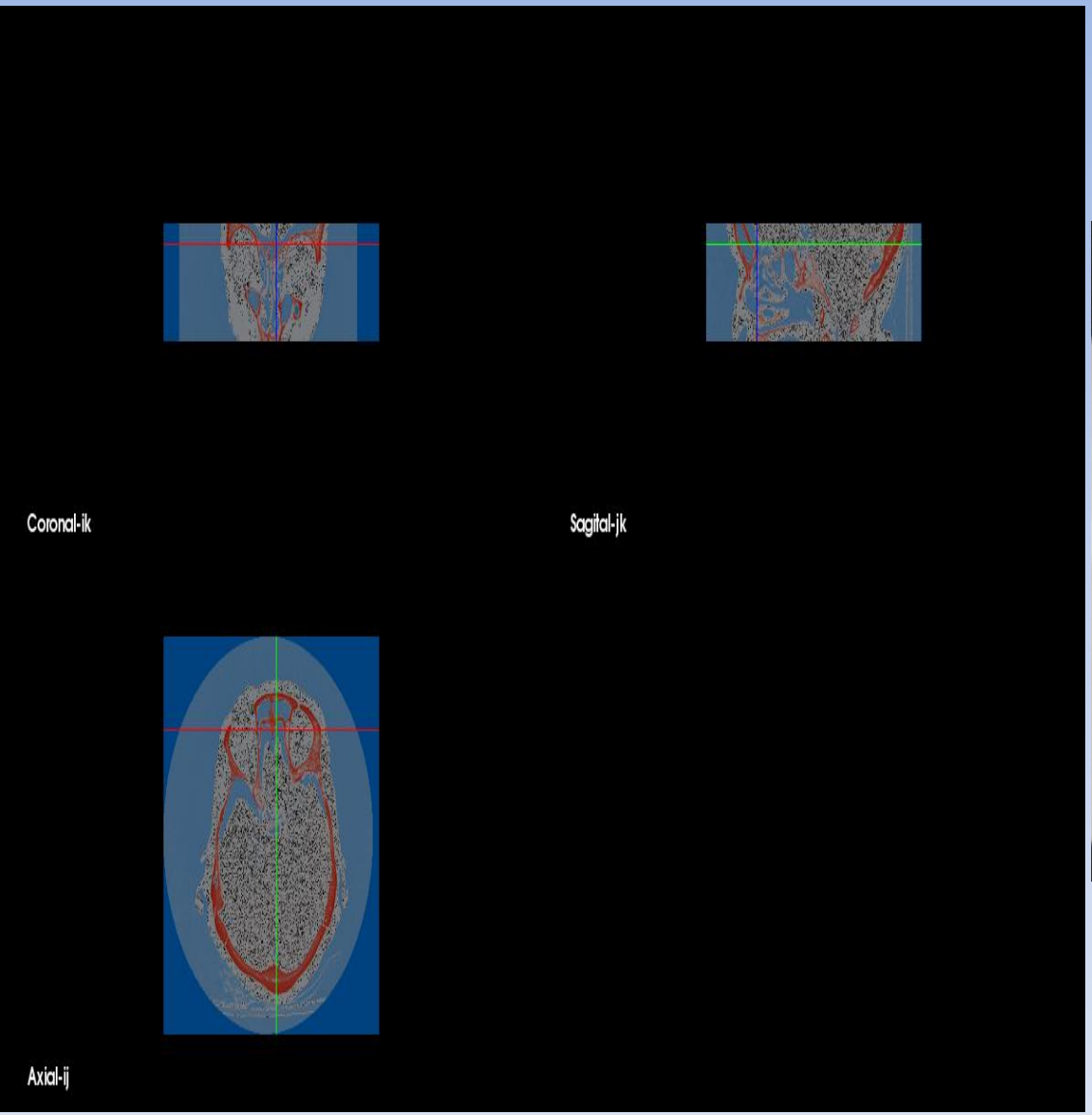
- Intrinsic Camera Parameters (focal length, principle point and lens distortion) and Extrinsic Camera Parameters (camera pose estimation) are found out using multiplanar calibration.

- Solving for F_{EO}:: AX =XB method from CIS1



2D-3D Registration

- Intrinsic Camera Parameters already known
- Goal: To estimate pose of the camera (R,t) and then camera position in CT co ordinates.
- Given non collinear 2D points, p (landmarks marked on the image) and corresponding 3D points, P; estimate a transformation $p = FP$
- F: 3 x 4 transformation matrix for the 3d points to image
- $p \times FP = 0$



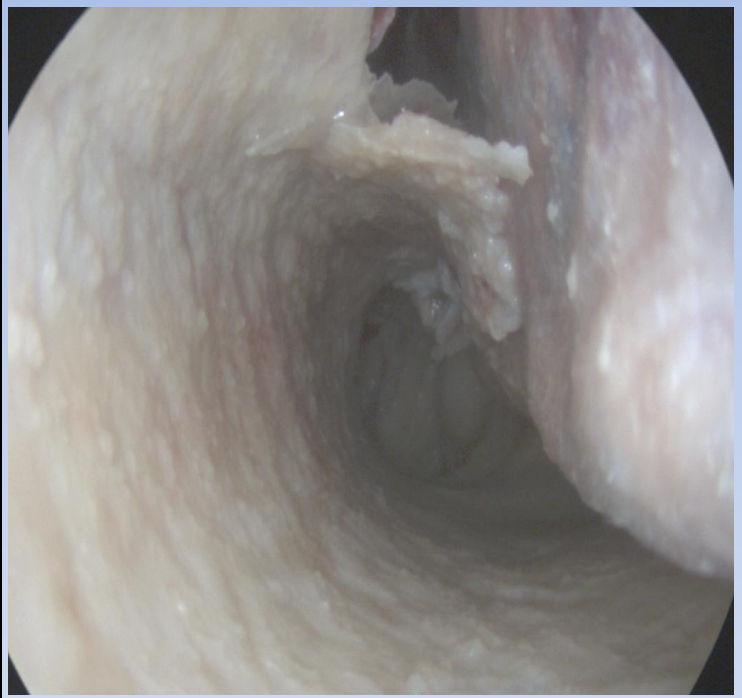
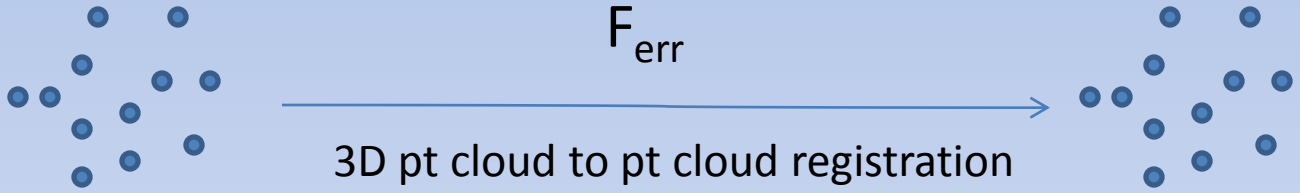


Image and CT scan from dataset of previously recorded surgery

Registration Optimization



Measured Values
using tracker
$q = Fp$

3D pt cloud to pt cloud registration
using method by K. Arun et al
IEEE PAMI, Vol 9, no
5, pp 698-700, Sept 1987

Ground Truth, Result from
Video-CT Registration
$q = F^{*}p$ where $F^{*} = F * F_{err}$

Difficulties encountered so far

- Problems with OpenCV
  - Finding features to track does not work properly with version 2.2 of OpenCV (gives erroneous points), downgraded to OpenCV 2.1
- Stealthlink libraries available only for VS2005
- Debug and Release modes in Visual Studio
  - Spent a lot of time trying to debug certain errors in debug mode of Visual Studio while the program was able to run with no problems in Release Mode.

STATUS of DELIVERABLES

Minimum:

- ✓ Develop software to Record Data from the surgery
- ✓ Develop software to compute the various transformations using the tracker data
- ❑ Develop a software to compute Registration between camera motion and CT data using Tracker based as well as Video based registration

Expected:

- ❑ Minimum Deliverables
- ✓ Develop an algorithm to optimize registration over all frames and use it to optimize registration obtained using tracker based and video based registration.
- ❑ Model the different surgical movements for one surgeon.

Maximum:

- ❑ Expected Deliverables.
- ❑ Model the different surgical movements for multiple surgeons.
- ❑ Develop a model to classify a surgical movement into expert and novice category for different movements.

DEPENDENCIES

Dependency	Status	Plan for resolving
CISST Library	Resolved	-
Medtronic Stealthlink libraries	Resolved	-
System with capture card to record data from OR	Resolved	-
Training for Access to OR	Resolved	Complete the training required for access to OR.
Required system (Stealthlink Tracker, endoscope, Foot pedal) in the OR	Resolved	Mentors are working on to get this system into the OR
Camera Calibration Toolbox	Resolved	Part of CISST library.
Software for Surgical Modeling	Pending	Available in the lab. Talk to mentors for access.

References

1. *D. J. Mirota, H. Wang, R. H. Taylor, M. Ishii, G. L. Gallia, and G. D. Hager, "A system for video-based navigation for endoscopic endonasal skull base surgery," medical imaging, IEEE transactions on, ISS. 99, 2011.*
2. *Chien-ping Lu, Gregory D. Hager and Eric Mjolsness, 'fast and globally convergent pose estimation from video images', IEEE transactions on pattern analysis and machine intelligence, 2000*
3. *Carol E. Reiley and Gregory D. Hager, 'Decomposition of Robotic Surgical Tasks: An analysis of Subtasks and Their Correlation to Skill.*
4. D. J. Mirota, A. Uneri, S. Schafer, S. Nithiananthan, D. D. Reh, G. L. Gallia, R. H. Taylor, G. D. Hager, and J. H. Siewerdsen, "High-accuracy 3D image-based registration of endoscopic video to C-arm cone-beam CT for image-guided skull base surgery," in *Medical Imaging 2011: Visualization, Image-Guided Procedures, and Modeling*, 2011, p. 79640j-1.
5. R.Y. Tsai, *An Efficient and Accurate Camera Calibration Technique for 3D Machine Vision.* Proceedings of IEEE Conference on Computer Vision and Pattern Recognition, Miami Beach, FL, pp. 364-374, 1986

Thank you…