Final Checkpoint Presentation

Team 2: Can Kocabalkanli and Nico Lamaison

Project Overview - Team 2

Title: Kinematic Simulation, Calibration, and Accuracy Assessment for the Galen Robot

Team Members: Can Kocabalkanli, Nicolas Lamaison

Mentors: Dr. Taylor, Dr. Munawar, Max Li, Henry Phalen

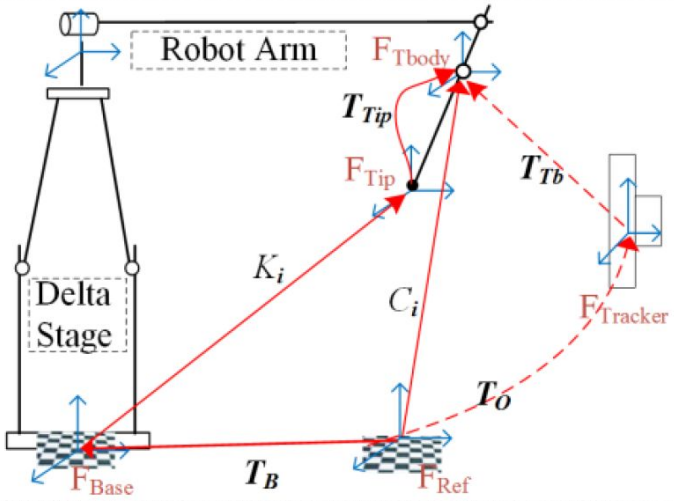
Goals:

- ➔ 1. Successfully model the kinematics and dynamics of the Galen in a simulation environment
- ➔ 2. Calibrate the Galen to improve end effector tool tracking accuracy

[1]: Taylor, "*The Galen Microsurgery System*", 3/21/2019, LCSR Industry Day, Baltimore

Calibration Pipeline Tested with Synthetic Data

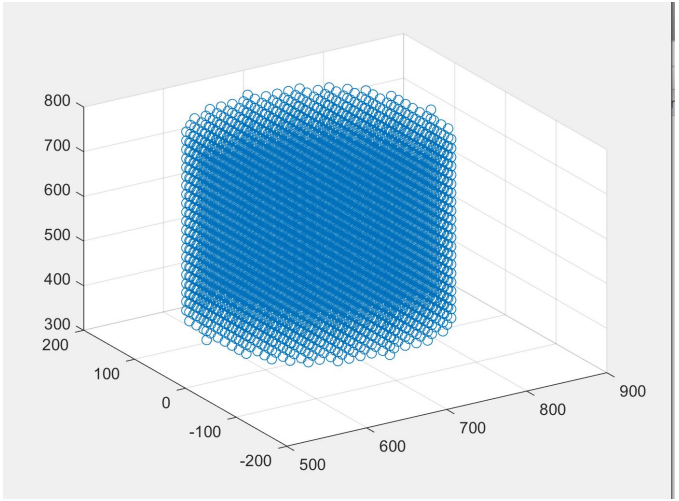
1. Generated known K_{Pre} T_b and T_{tip}
2. Used slightly distorted parameters to generate K_{dist}
3. Calculated C from these transformations
4. Calculate K_{HE} by performing Hand-Eye calibration using C and K_{dist}
5. Compare K_{HE} and K_{Pre}
6. Fit correction polynomial
7. Compare corrected K_{new} with K_{HE}

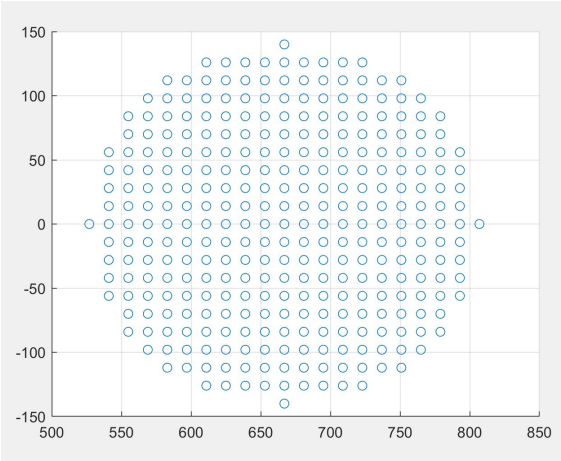


- Synthetic data with +/- 1.25 mm delta leg length and +/- 0.01 rad wrist distortion,
- Correction results in 0.015 mm average and 0.027 mm maximum positioning error

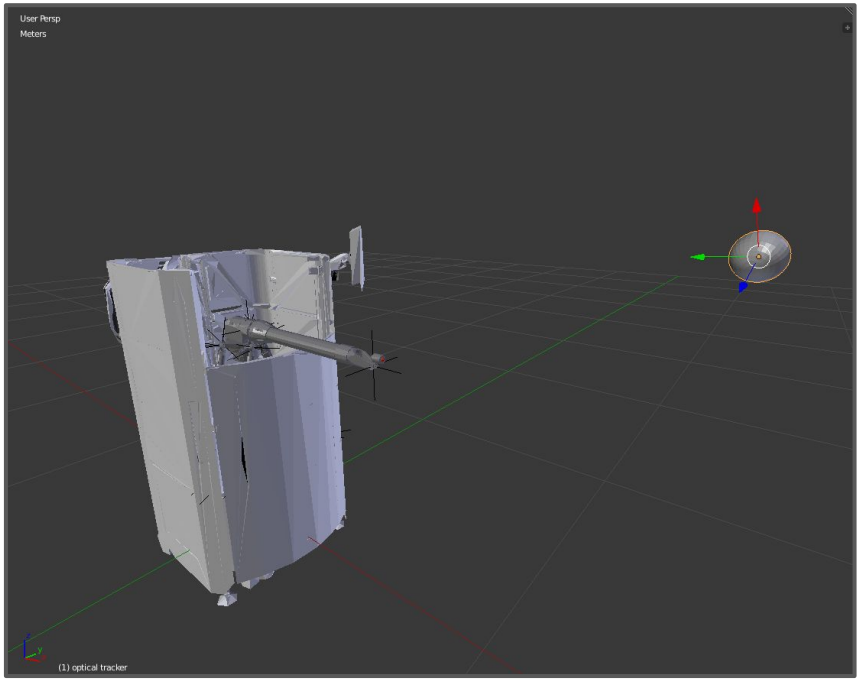
Designed Trajectories to be Executed

- Designed trajectory to be followed in the calibration exercise
- Trajectory spans the Galen workspace as a grid Simulated robot end effector will be brought to each one of these points (about 6600 points)





Galen Mk. 2 Kinematic Model



Calibration testing environment for Galen Mk.2. Here, the robot is shown with a sphere that resembles the optical tracker.

Progress since last time…

- ➔ Finished model of Galen robot's kinematic chain (delta + wrist)
- ➔ Added optical tracker to model

To-dos:

- ➔ Add tool to model for hand-eye calibration

Calibration Exercise

Sample trajectory for Galen Mk. 2. Instead of using direct position commands, desired positions are achieved using joint controllers.

Progress since last time…

➔ Simulated robot dynamics with PID controller and empirically-defined gains

To-dos:

➔ Debug calibration script

➔ Additional gain tuning

➔ Test calibration pipeline with experimental data

Task List

Task Start Date	Task End Date	Tasks	Dependency & Prerequisites	Status	Milestone Deadline	Milestone	Contacts for Help
02/13	03/14	A. Modeling robot in Blender	Galen STL & kinematic parameters	Complete	04/04	1.Galen model working in AMBF	Dr. Munawar
03/02	04/04	B. Run simulation script to move Galen	Task A	Complete			Dr. Munawar
03/16	04/04	C. Complete calibration scripts (virtual & real)	-	Complete	04/04	2. Having a complete calibration script to be tested	Max Li, Henry Phalen
03/18	04/04	D. Develop experimental procedure and evaluation metric	Task C, Atraxsys User Manual	Complete	04/04	3. Having an experimental procedure and instructions document	Anna Goodridge, Max, Henry, Kevin Gilboy
03/28	04/07	E. Complete virtual calibration pipeline test script	Task C	Complete	04/07	4. Script to log transformations and data from simulation ready	Dr. Munawar, Max, Henry
04/05	04/16	F. Test and debug calibration pipeline with robot simulation	Task B, C, E	In Progress	05/04	5. Calibration pipeline is ready to be used with data from the real experiment	Dr. Taylor, Max Li, Henry Phalen
04/24	05/01	*G. Galen robot simulation tutorials (if time allows)*	Task C,D,F	In Progress	05/09	6.Tutorials online on AMBF Wiki	Dr. Munawar
04/24	05/01	H. Prepare virtual/simulation demo	Task A,B	In Progress	05/05	7. Simulation Demo and Video	Dr. Munawar, Max, Henry