Individual Lab Report - 1

Autonomous Reaming for Total Hip Replacement

HIPSTER | ARTHuR

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Team C:

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Contents

1 Individual Progress

1.1 Marker Pose Detection - Preliminary Tasks

Marker pose detection is the primary task to be performed by the camera. In the previous sprint, camera/ROS integration was achieved. The objective of this task is to further develop on the previously created `camera_node` by adding the functionality to load geometry files. This is a prerequisite to marker pose detection. A considerable amount of time was also spent on understanding the fiducial point/marker pose detection via the Windows GUI of the Atracsys SDK.

- ***Understanding Fiducial Point Detection*** The Atracsys SDK contains functionality to detect reflective fiducial points. Below is what a fiducial point looks like. In this case, it is a simple disc-shaped reflective material. A predefined geometry of fiducial points forms a marker. This geometry can be formed by placing the fiducial points on a registration probe that will be used to collect a point cloud of landmark points by the surgeon.

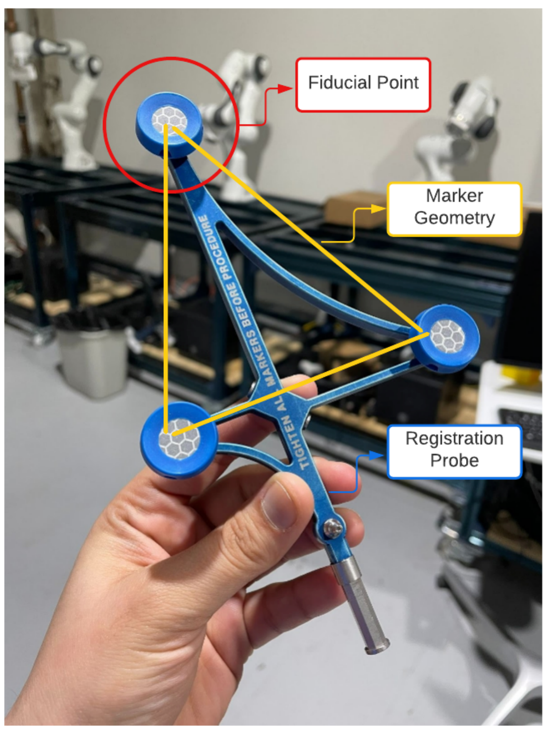

Figure 1: A Fiducial Point and Marker Geometry on the Registration Probe

The Atracsys Windows GUI is a helpful tool to understand the detection of fiducials and markers. It was also extremely helpful in visualizing raw and processed measurements from the camera. A screenshot is attached below.

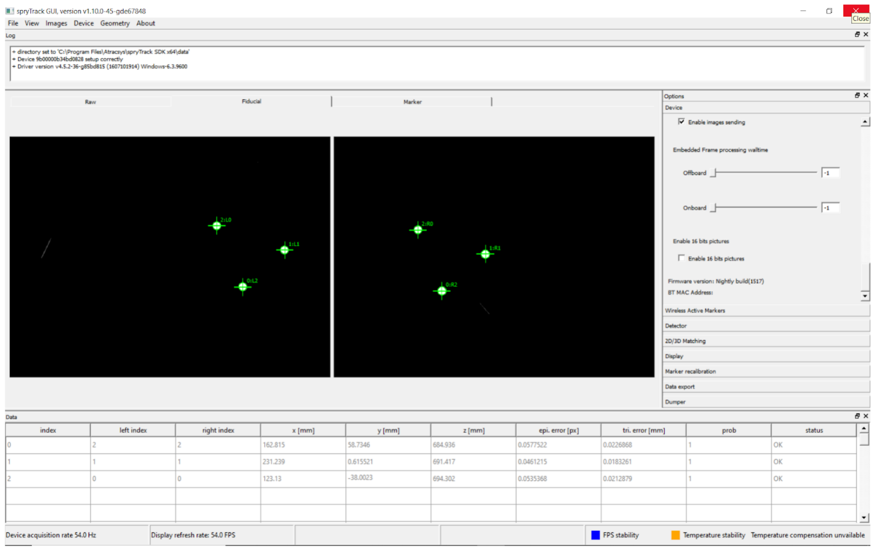

Figure 2: Atracsys Windows GUI showing detected fiducials.

- ***Loading Geometry Files*** The camera node should be able to load the geometry file to begin detecting the pose of the marker. Geometry files are `.ini` files. The `camera_node` matches the geometry of the detected fiducial points with the geometry file to calculate the 6DOF pose of the marker. The image below shows a sample geometry file and it being successfully loaded via `camera_node`.

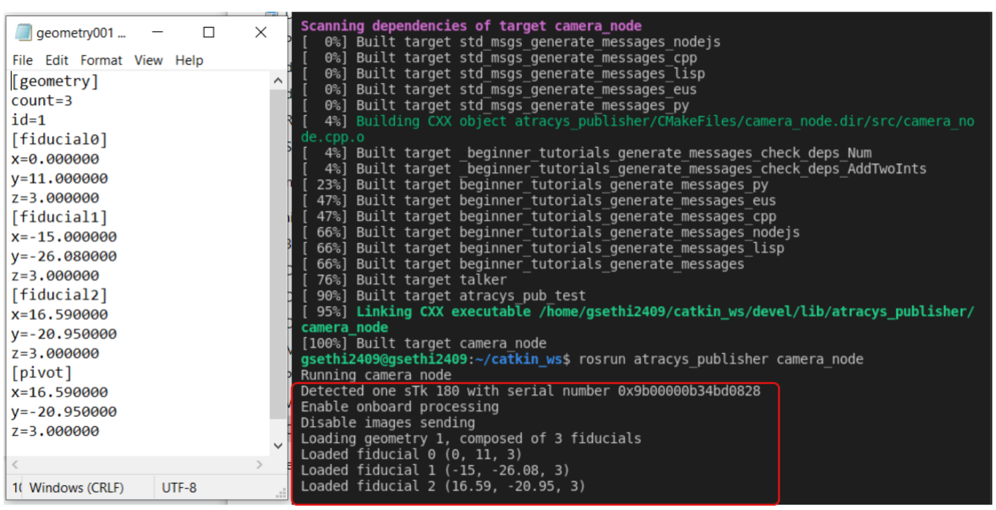

Figure 3: (Left) Sample Geometry File; (Right) Camera Node Loads Geometry File

1.2 Progress Review 1 Presentation

Considerable time was spent in preparing a collated presentation of all the progress in each subsystem so far. The presentation can be viewed here. For the presentation itself, time was spent speaking with each subsystem lead to understand their work and collate a summary of tasks to present on the presentation day. Various photos on the current camera progress were collected to showcase. Further, the presentation was rehearsed with the team and any feedback was incorporated.

2 Challenges

Some of the major challenges were to understand how the Atracsys SDK converts raw measurements to fiducial points and finally, using the geometry files to a 6DOF marker pose. Understanding this pipeline was crucial since it is at the core of the Perception subsystem. To navigate this, the SDK documentation was thoroughly referred to. After this, the SDK Windows GUI was used to load various geometry files and observe the results. These learnings will also be applied in future work on the Perception subsystem. In addition, loading the geometry files via the ROS node gave a few errors in directory path resolution and permissions. These errors and any conflicting permissions were resolved by referring to prior error logs. Challenges with code reliability are currently being tackled by testing for various edge cases and noting results.

3 Team Work

Following are the tasks accomplished by the team members since the previous ILR.

- ***Kaushik Balasundar*** worked on the registration problem. He researched various types of registration algorithms, integrated Open3D with ROS, wrote a script for converting a mesh file to a point cloud, implemented a preliminary ICP registration algorithm with Open3D for local and global registration, and tested ICP with some toy examples to verify its functionality.
- ***Parker Hill*** picked up the reamer handle, elicited motor requirements for the reaming assembly, and created a rough SolidWorks CAD model of it for use in the preliminary design and of an end-effector adapter. He also worked on all aspects of the Power Distribution Board PCB assignment (schematic, board layout, CAD/drawing, and analysis).
- ***Anthony Kyu*** worked on the high-level controls architecture, designing the block diagram, defining constraints for the controls system, and creating the linear dynamics for the model predictive control. When designing this, he collaborated and brainstormed extensively with Sundaram. Further, he collaborated with Parker on the PCB, sanity checking his circuit and pointing out some key issues that may have led to shorts. He also brainstormed a few ideas for mechanical design with Parker to mount the reamer to the end-effector. It should be noted, however, that Parker took lead on both the PCB and mechanical design tasks.
- ***Sundaram Seivur*** collaborated with Anthony in conceptualizing the optimal control problem for the system. In addition, he went through a significant amount of literature to decide

between model-predictive control and hybrid force position control. In addition, he was the primary point of contact in facilitating a new arm for the project.

- ***Gunjan Sethi*** worked on further developing the ROS package for the Atracsys camera- adding loading of geometry files, marker pose detection, ensuring code reliability and robustness. She prepared for Progress Review 1 by collating all the progress so far into a presentation and presenting it.

4 Plans

For future work, the following (individual) tasks have been planned for the MRSD project.

- ***Power Distribution System PCB*** Collaborate with the team to complete Task 11.
- ***Publish Marker Poses*** Further develop `camera_node` to acquire marker poses, typecast the poses to standard ROS message type, and publish them onto a topic. Further, test the node for reliability and robustness.