Individual Lab Report - 7

Autonomous Reaming for Total Hip Replacement

HIPSTER | ARTHuR

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Team C:

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1 Individual Progress

1.1 MRSD Project

For Progress Review 8, I worked on finalizing an architecture of the Watchdog subsystem and started developing its features for version 1 of the watchdog module. I discussed with the owner of each subsystem about possible reasons for failure that we might want to keep track of. During our meeting with the sponsors, I shared the architecture with our stakeholders and shared in detail the functionality of the watchdog. I made corrections in the architecture based on the feedback I received from them. The final watchdog architecture can be seen in Fig. 1 The items marked in

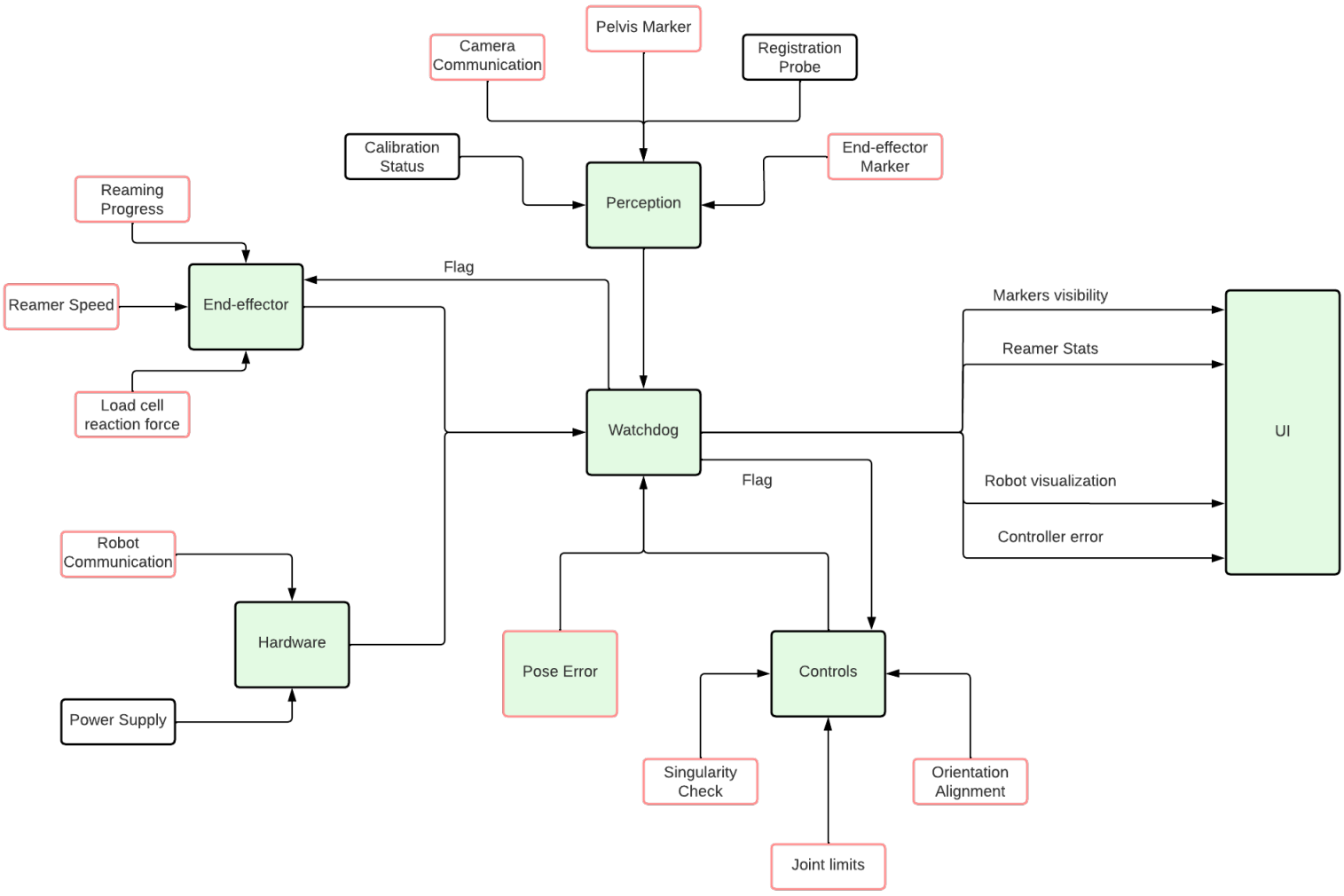

Figure 1: Watchdog Architecture

red in the architecture are items that we would keep track of at all times. The other items are used temporarily in the system and need not be kept track of at all times. The watchdog is also expected to act as a filter of information between the perception, controls and hardware subsystems. The watchdog will first read the perception system health and send a flag to the controls system if the

perception health is good. This will allow the controls system to take over and align the end-effector to the reaming end point orientation. Once this alignment is within the tolerance zone, the watchdog will send a flag to the hardware subsystem to start moving the linear actuator. Over

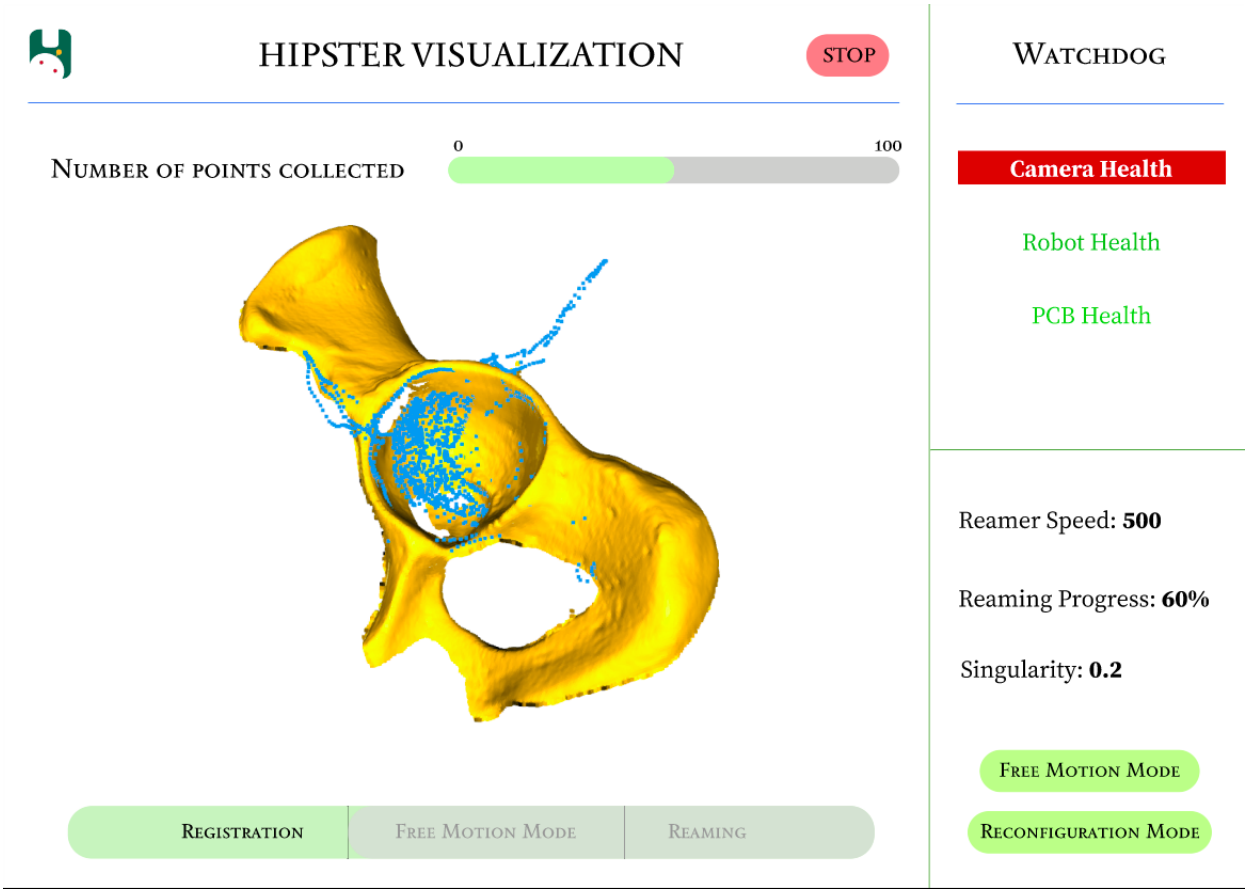

Figure 2: UI Wireframe

the last two weeks, I also worked on creating a basic wireframe for the User Interface(UI), as can be seen in Fig. **??**. The UI is expected to convey critical aspects of the system performance to the user/surgeon, which will help in ensuring that the procedure is proceeding as expected. The watchdog module will also display the health of the subsystems on the UI. I emphasized on keeping the design simple, easy to achieve and neat in displaying the contents effectively. I also received feedback from our sponsors on the UI and incorporated the changes suggested by them to match general medical UI standards.

Apart from this, I also spent some time with Parker to finalize the components for the end-effector and evaluated the performance of the 3D printed prototype.

2 Challenges

2.1 MRSD Project Challenges

My main challenge this time was time management between the various commitments I had. The planning course assignment was very time consuming and I had to delay the development of

the watchdog in the meantime. Basic on the feedback we received from our sponsors, I had to make changes to the watchdog and UI. While developing the watchdog module, I have to assume some aspects of the system functionality as our controls and hardware subsystem have major changes from last semester and are still under development. We are still evaluating the performance of the 3D printed end-effector. We currently have the end-effector at 45 degrees from the last joint of the Gen3 arm and are checking the stiffness of the arm at this configuration.

3 Team Work

3.1 Sundaram Seivur

Sundaram worked on finalizing the watchdog architecture and started implementing features for the watchdog. He made changes to the architecture based on the feedback provided by our sponsors. He worked on creating the wireframes for the User Interface and conceptualized the critical components that need to be visualized on the UI. He also assisted Parker in finalizing the design for the end-effector and helped evaluate the performance of the 3D printed assembly.

3.2 Anthony Kyu

Anthony worked with Kaushik to implement a basic joint velocity controller on both simulation and on the real arm, implementing inverse kinematics, singularity damping, and joint limit avoidance algorithms. He also worked with Kaushik to test the performance of this controller, testing how well it could track a pelvis marker and tuning the PID gains to do so. Furthermore, Anthony worked with Parker to help finalize the CAD design, sourcing key components such as the motor, load cells (and load cell electronics), and the linear motion mechanism. He also helped Parker calibrate his 3D printer. Lastly, Anthony also put together a knowledge sharing session with the team to explain the math and algorithms behind the Task Prioritization controller to be implemented.

3.3 Kaushik Balasundar

Kaushik set up a simulation environment to serve as a testbed to implement and validate the working of the velocity controller. He then worked closely with Anthony in implementing the new joint velocity controller in simulation with singularity damping and joint limit avoidance. He further helped validated the controller's performance and tune the gains for the real robot arm.

3.4 Gunjan Sethi

Gunjan developed the necessary script to convert STL-filetype pelvis scans to PCD format to facilitate usage in the current system pipeline. Further she worked on assessing the feasibility of using RQt and Open3D for the UI development. Gunjan also began development on the watchdog module.

3.5 Parker Hill

Parker worked with Sundaram and Anthony to finalize the CAD for the new linearly actuated end-effector design and sourced, printed out, and assembled all components for the first version

of the design. He also developed an outline and began sourcing parts for the electrical subsystem. Finally, he spent some time with Kaushik learning more about the software aspects of the project to be able to help more with the user interface in the future.

4 Future Plan

Before the next Progress Review I would finished developing the first version of the watchdog and would have validated its functionality. I have already finished implementing features to check the health of the perception system and shortly would start working on implementing tasks for the control subsystem. I will also closely work alongside Gunjan and Parker to develop the User Interface in the coming weeks. As a team, we would also periodically conduct tests to evaluate the progress and performance of the system as a whole, especially the control and the hardware subsystems. I would spend a majority of my time testing the watchdog module for expected failure cases and test for any funny edge cases that may occur.