Individual Lab Report - 6

Autonomous Reaming for Total Hip Replacement

IPSTER | ARTHuR

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Team C:

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Contents

1 Individual Progress

1.1 Workspace Setup and System Re-Familiarization

This week's major portion was spent bringing the system back to its Spring Validation Demo state. For this, the team scheduled a pick-up time with the sponsors to procure the camera and robot arm. Meanwhile, the lab was cleaned and reorganized. The robot table was de-cluttered. Once the equipment arrived, the system was reconnected. Kaushik Balasundar ran the system execution commands and the team monitored the system to note any discrepancies with the Spring Validation demo.

1.2 Project Management Review

I led the project management review meeting. The following tasks were accomplished during this meeting.

- The team revisited the importance and use of JIRA as a task management tool during the Spring semester. In retrospect, the team felt that JIRA was rarely updated on high-stress days as the team members resorted to simple To-Do lists as a way to organize short-term goals. A collective decision was made to eliminate the use of JIRA as the primary task management tool and instead, use a simple whiteboard with sticky notes as shown in Figure 1 below.

  However, the team will still continue to use JIRA Roadmaps to organize long-term internal and external milestones.
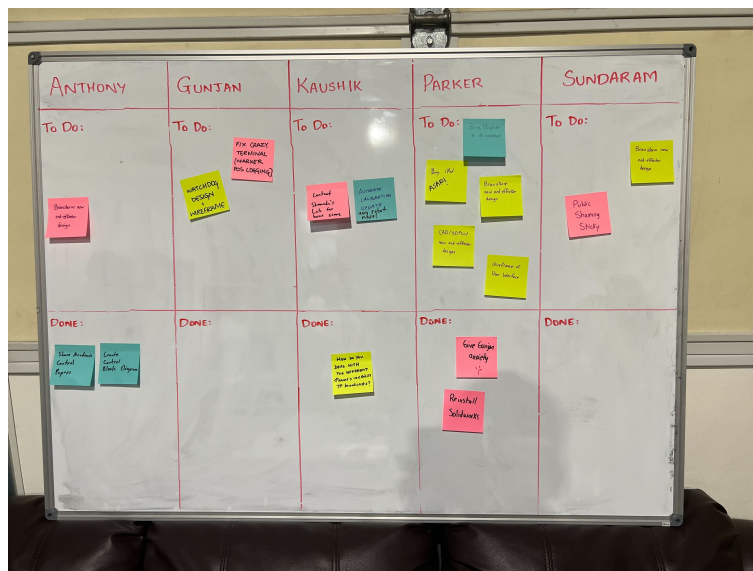

Figure 1: To-Do Board

- The current functional requirements were discussed. The team concluded that a re-vamped list of functional requirements must be drafted. Anthony Kyu communicated with the sponsors to meet and discuss the same.

- Internal milestones and sub-system level tasks, along with respective tentative deadlines, were determined. Owners for these tasks were assigned. These have been updated to the JIRA Roadmap.

- The team also reassessed risks and noted corresponding likelihoods and consequences.

1.3 Watchdog Module Brainstorm

Sundaram and I brainstormed the initial ideas of the functions that the watchdog module will perform. Since our system is a time and safety-critical one, it is essential to have a watchdog module that can log and handle exceptions without breaking the system. Right now, we have a rough idea of the functions of the watchdog and how it interacts with each subsystem. Figure 2, 3 and 4 show tables of our initial brainstorming. The watchdog module will eventually evolve into a full-fledged UI that will show important messages and health of the system.

Inputs<> WatchDog

Value	Type of Logging	Description	Owner
Acetabular Cup Pose	Terminal and Filesystem	every time new endpoint is calculated	Sundaram
Pelvis Marker, Registration Probe	Terminal	at camera FPS, throw warning when marker obstructor	Sundaram
Pelvis 3D Model	Terminal	Check path exists and log successful loading	Sundaram
Robot Arm Pose	Terminal	Log if robot pose received	Gunjan
URDF	Terminal	URDF Parser, necessary	Gunjan
Camera Health	Terminal	"Device Not Found" - grep	ps	kill any other processes using camera, restart node	Gunjan

Figure 2: WatchDog Module Integrates with Inputs

Perception <> WatchDog

Value	Type of Logging	Description
Pointloud Collection Hyperparams + Points	Filesystem	Log the number of points, FPS/delay, points logged
Correspondance Matching	Filesystem	Log corresponding points
ICP Hyperparameters+Results	Filesystem	Number of correspondences, etc, Error metric, latency
Reaming Point Selection	Filesystem	Same as input Acetabular Cup Pose

Dynamic Compensation <> WatchDog

Value	Type of Logging	Description
Pelvis Pose Error Calculation	Terminal (just a message maybe?)	Error < threshold
Trigger DC	Filesystem (log pose + timestamp!)	Error > threshold
Arm realignment	Terminal, Filesystem (with timestamp, latency)	Has the arm realigned successfully?

Figure 3: WatchDog Module Integrates with Perception and Dynamic Compensation

Control <> WatchDog

Value	Type of Logging	Description
Singularity Check	Terminal - Error	Log if joints are close to or at singularity
Reaming Progress	Terminal	depth of reaming completed
Reamer ON/OFF	Terminal	
ESTOP	Terminal	Button to kill all processes
Actuator Health	Terminal (maybe a plot?)	Motor speed, force values etc (?)
PCB Health	Terminal	Current

Figure 4: WatchDog Module Integrates with Controls

2 Challenges

Currently, the functional requirements need to be reassessed to reflect better the expectations from the sponsor. Further, the new end-effector design and ideas on refining the dynamic compensation of the system require more discussions with the stakeholders. Although we ideally hoped we would solidify these issues prior to our first progress review, we were unable to find a time this week that works best for both us and the sponsors. However, we have scheduled a meeting with them on the morning of PR1.

3 Team Work

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

- *Kaushik Balasundar* helped restore the system to the same working condition as demonstrated during the SVD encore. He then brainstormed ideas for the online camera to robot arm extrinsic calibration. He was involved in the team discussions regarding overall system enhancements, potential upgrades to the controls sub-system, reevaluating requirements, and the roadmap for the fall semester. He updated and started tracking the project's ongoing risks and updated the cyber-physical architecture.

- *Parker Hill* helped with re-evaluating the requirements, risks, and roadmap of the system and took helped to setup our new project management method. He also relocated his 3D printer to the lab and began brainstorming ideas for a new linearly actuated reaming end-effector with Sundaram and Anthony.

- *Anthony Kyu* worked with the team to re-familiarize and rebuild the workspace. He also contributed to updating the requirements, risks, and roadmap for the system. In addition,

he has been working with Sundaram and Parker to brainstorm ideas for the end-effector and source components to use in the design. And lastly, he has been compiling algorithms into one document for a new controller architecture for a Kinematic Task Prioritization Controller for the team to read through and understand for implementation.

- *Sundaram Seivur* worked on reassembling the workspace and revisiting previous implementation with the team. He also assisted Parker and Anthony in brainstorming ideas for the new end-effector design. He contributed in setting up the new project management methodology and re-evaluating the system requirements, risks and project roadmap. He spent time with Gunjan to ideate the Watchdog module's functionalities.

- *Gunjan Sethi* worked on assisting in bringing up the system for re-familiarization and conducting the project management review. Gunjan and Sundaram also brainstormed the watchdog module.

4   Plans

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

4.1   Prototype WatchDog Module

In the upcoming weeks, I will be working on developing the WatchDog v1 which will be a simple terminal logger. It will basically act as a first prototype based on the current architecture plan. I will also test and debug the first prototype to ensure it integrates well with all subsystems. I will also explore custom logging so we can log errors according to their sub-system of origin and criticality.