Individual Lab Report - 6

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

In the first two weeks of this fall semester, my main responsibilities were to reassemble and re-familiarize the system. I contributed to assembling the arm back to the vention base and re-attaching the end effector to the Gen3 arm. Apart from this, I was responsible for developing the architecture for the Watchdog module for which I worked alongside Gunjan. I brainstormed the critical components of each subsystem that needs to be logged and can lead to the failure of the operation as can be seen in Fig. 1. I was also contributing to brainstorming ideas for the new end

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

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

Figure 1: Watchdog functionality

effector design as part of our new endeavor this semester. The new design includes a linear actuator to complete the reaming process while the Gen3 arm holds a position in the correct orientation. We brainstormed the ideal position for the end effector, the stroke length of the linear actuator required, an axial load cell, and bearings for constraining the motion. I sourced some components like a new angle vice for mimicking the motion of the pelvis closer to that during the actual surgery. I also actively worked on changing the project management methodology of our team. As extensive agile methods using Jira did not work for our team last semester, we decided to move to a simpler agile
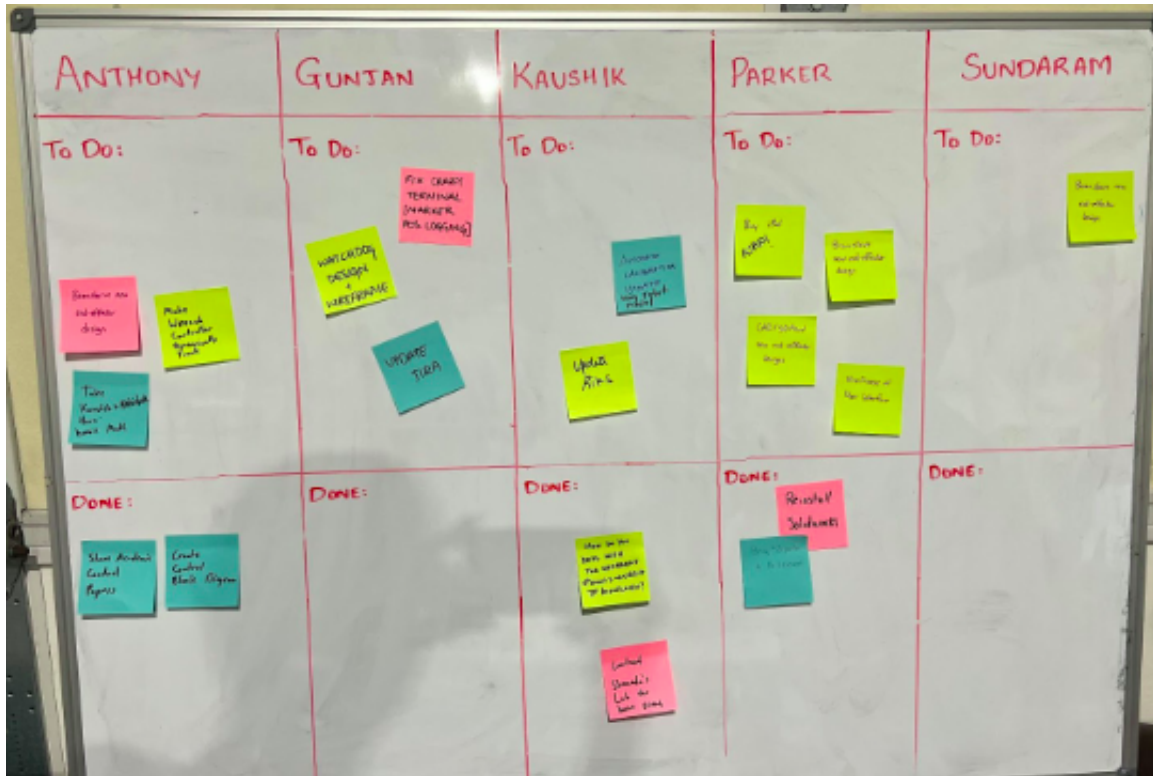
Figure 2: Team task board

method on a whiteboard with 'To Do' and 'Done' for all tasks as seen in Fig. 2. Instead of having constrained sprints, we decided to have higher level milestones as checkpoints. I also presented our team's progress this week.

2 Challenges

2.1 MRSD Project Challenges

The challenges this time were limited as our semester just began, however, we had some trouble redesigning some subsystems that would lead to changes in the functioning of the system as a whole. Since the watchdog module is entirely new in our system, I had to revisit and re-familiarize with each subsystem to understand the critical functionalities of each of them. Even though we have identified a direction to build the watchdog module, I believe we would have to make changes as we start developing the subsystem. We had to spend a lot of time re-evaluating the system requirements and our methods to validate them. For this, we also scheduled a meeting with our sponsors to validate the metrics in our performance requirements.

3 Team Work

3.1 Sundaram Seivur

Sundaram 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.

3.2 Anthony Kyu

Anthony 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.

3.3 Kaushik Balasundar

Kaushik 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.

3.4 Gunjan Sethi

Gunjan 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.

3.5 Parker Hill

Parker 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.

4 Future Plan

In the coming weeks I would work on developing the first version of the watchdog module. This would be a terminal logger that would read from all the subsystems, monitor their health, and save all the critical metrics in a text file. I would also think about how this would look on the system UI that we would start developing after the first iteration of the watchdog module. I will also spend time understanding the mathematics for implementing our new task-prioritization based velocity controller. This will involve reading literature on task-prioritization and singularity avoidance.