Carnegie Mellon University

16-682

MRSD Project II

Task 14 Progress Review 7
Team C - COBORG

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September 16, 2021

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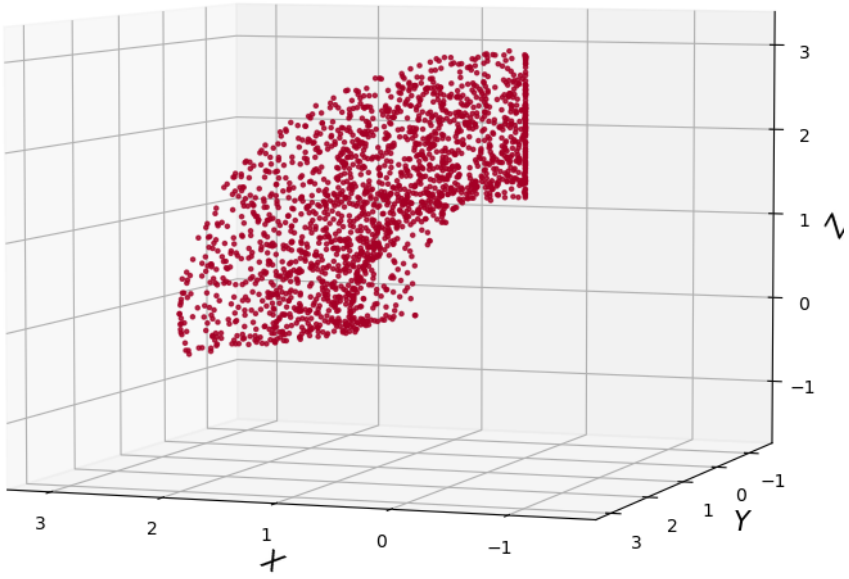
1. Individual Progress

My primary tasks for this progress review were centered on creating requirements for our system's task space. In the spring our project group had a general idea of how our system would operate and in the kinds of situations people would use it. However, we never went into detail about these situations. Now that our team has a functional system and we have both the time and project understanding, it is important to revisit our system's uses in more detail because we have the ability to adapt it to meet all of the needs of our customer. To this end I wrote a series of requirements specifying the task space of the robot, i.e. where we believe the robot should be required to be functional and, subsequently, where we will test the robot against in our final validation. This list of requirements defined not only the primary areas in which targets should be identifiable, but also the amount of motion allowed by a user while the system is stabilizing (relevant to the mechanical system), an estimated margin of error, and expectations about the spread of the user's hands (relevant to the vision system). These requirements were accompanied by some light research regarding the length of human arms and recorded assumptions and reasonings to support the validity of the requirements. As it stands, our project seeks to cover the vast majority of potential users and comfortable arm positions, but the intricacy of the system itself may necessitate scaling back some of these requirements to be easier to achieve. For this case I'm thinking primarily of the minimum distance at which someone can hold a part. Currently the minimum is listed as 1.5 feet, but considering that our system involves a robotic arm moving into this small space between a part and the human's chest, it may be necessary for safety reasons if this minimum distance were increased. All of that is to say that we currently have requirements written, and with sound reasoning behind them, but that I would not be surprised if they were to change as we test the system more thoroughly in person and get an understanding of how these requirements translate into the real world.

These requirements were also the basis of my second task for this progress review. I began creating a program that will allow our team to test the robot's capability in the task space. In order to make sure we can meet our task space requirements, the robot's workspace must entirely overlap the task space (and then some), as well as the previous considerations listed, such as stabilization space, etc. To this end my program chooses a large series of points within these spaces and projects them onto a plot, as seen in Figure 1 below. Although it is not currently functional, the program will run path planning on each of these points and color the end targets in the graph based on the path planner's success. Analyzing these plots will help us understand where our system falls short; additionally we can quickly tweak the URDF with different configurations to vet which mechanical system(s) *would* feasibly meet our requirements.

Figure 1 - Task Space Check



This figure shows the monte-carlo task space checker for the mechanical system. Once it is connected to functional path planning we will demonstrate the other plots as well as our systems' different successes and failures. This will also come with a decision about the path forward for the mechanical system.

In addition to my primary tasks described above, I also created the initial draft of the WBS schedule for the team and laid out the initial PowerPoint for our project management review. Having a plan set out helped everyone consider the future of the project for this semester, even as most of the members were in the weeds of transferring the project to the Jetson Xavier.

Finally, I also discussed various changes and improvements that will have to be made to our actuated manipulation system in order to make it fully functional, as well as capable. I intend for following through on those changes to be a significant portion of my upcoming Progress Review #8 tasks.

2. Challenges

The primary problem that we encountered in this cycle was that a reasonable task space may be well outside the current capacity of both our vision and mechanical systems. Up until this point we have been working with a minimal system, 3 degrees of freedom and 1 RGB-D camera; this was fine for testing but we'll likely need to make significant changes to provide a robust system useful to customers. However, these changes could quickly scale out of hand. Based on our current defined task space it may be necessary to have up to four cameras to cover the entire volume accurately. This is probably prohibitively expensive, either financially or computationally. That is why, once we can better understand the overlap of our task space and work space, we will have to make some difficult decisions about what the system can or should do and how we will accomplish that.

3. Teamwork

Jason's work during this previous cycle was primarily moving the current project over to the Jetson Xavier. He was able to get our full demonstration running which is an excellent jumping off point for our current semester. Additionally, Jason created a series of alternative URDF models that represent various upgrades we could make to our mechanical system. To better understand the capability of these arms, Jason made working models out of cardboard.

Gerry's work during this previous cycle included applying finishing touches to the voice subsystem by adding new features and creating README files for organization. Additionally Gerry helped set up the Jetson Xavier and analyzed whether our current PCB board would be sufficient for a mechanical system with increased degrees of freedom and power requirements.

Yuqing's work during this previous cycle included transferring the current project over to the Jetson Xavier and integrating the subsystem components to create a successful demonstration of our full system that we showed last spring. Yuqing also cleaned up the vision nodes and improved our visual pipeline.

Husam's work during this previous cycle primarily included creating a CAD design for updating our mechanical aesthetic and structural system. He also began procuring parts to build the system. Additionally Husam created the project management kanban board.

4. Plans

Before the next progress review I will finalize the mechanical work space program and develop a plan with Jason to update our mechanical system so that it can cover all of the scenarios that we deem necessary. Additionally I'll work with Yuqing to similarly check the vision system's work space and hopefully this will also lead to future plans for the vision system, though these may not be cemented by Progress Review #8.

Beyond this I will be evaluating a number of improvements to our smart manipulation system recommended by Julian Whitman (our sponsor) and Gerry. Finally I will begin debugging the smart manipulation node and updating it with some of the suggested improvements where appropriate.