Individual Lab Report
Weekly Progress

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Team B: Team Space Jockey
Teammates: Nathaniel Chapman, Ardya Dipta Nandaviri, Songjie Zhong

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1. Individual Progress

My main individual accomplishment over this period was the development of a magnetic foot prototype. I first conducted a test on the sticky foot prototype we developed for the prior review, and found it woefully inadequate at holding a weight of even 1kg. Our target for holding strength has been 2kg per foot, and the prototype foot's surface area was approximately 9 square inches, so it was clear that we would have to switch to the magnetic option.

I first developed a small test rig to test the strength of stacked magnets (See Figure 1). I found that three stacked magnets were able to withstand a tension normal to the surface of at least 1kg before either the magnets or the glue holding them gave way. This was very encouraging, so I developed a prototype foot (See Figure 2) that spread four groups of magnets around a center hole. By pushing a peg through that hole, the foot could be pushed off the surface. For the next prototype, this peg's motion will be actuated by a servo motor.

In addition to magnetic foot work, I assisted Nathaniel both in the fabrication of the new chassis (See Figure 3) and the newly fabricated power distribution boards (See Figure 4). I managed to assemble and solder the entire spare board myself with Nathaniel just double-checking my work to be sure I had all the components in the right place and oriented to the correct polarity. For the chassis, some of the techniques I explored over the past weeks were very successful, particularly the placing of "raft extender" discs near the corners of each piece to prevent peeling.

I also conducted weight tests of both, and found the new chassis to be only 20% of the weight of the old one, excluding hardware. The new PDB was 50% of the weight of the old one. Overall, our attempts at weight reduction are proving to be remarkably successful, and I'm far more confident in the future of the project as a result.

2. Challenges/Issues

In printing the chassis the usual challenges with 3D printing were present. An especially time-consuming troubleshooting process occurred with the printer which ultimately led me to believe one of the spools of ABS was defective and discarding it. After that, fabrication went much more smoothly.

Assembling the spare PDB was challenging mainly because I had never soldered surface-mount parts before. No particular difficulties held back progress, it was just slow-going as a result of the care I took to do things right the first time for such an intricate process.

One unexpected issue in the development of a magnetic foot was the possibility that the magnets would be stronger than the glue used to bind them to the foot. This occurred in all of the early attempts, though least of all with epoxy. Printing the insets in the foot for magnets with the tightest tolerance possible helped greatly, as did the addition of a small lip to hold the magnet, although this latter development came at the cost of slightly reduced magnetic pull.

Another issue which is outstanding is deciding which configuration of magnets will best fit this application. The options include stacking multiple magnets, spreading them out in an array, or some combination of stacks and arrays. Tradeoff factors include surface area of contact and the increasing moment caused by stacking magnets away from the surface. The current configuration is made up of 4 stacks of 2 magnets spread radially around the peg.

3. Team Work

Nathaniel led the redesign of the chassis as well as the assembly of the new PCB. Now that he had moved on to other chassis segments, I was able to act further down the pipeline to fabricate the chassis as he completed pieces. He also showed me the basics of soldering surface-mount parts, and we completed both the robot PDB and spare in parallel. Nathaniel also contributed heavily to the brainstorming of magnetic foot designs that I later implemented and fabricated.

Dipta and Songjie worked together to connect MIT's April Tag code to ROS talkers and listeners. For both of them, this was their first exposure to ROS and so progress was understandably slow as they familiarized themselves. I was able to assist them in understanding ROS on a conceptual level, but my own experience had only been in python nodes, while they were choosing to interface with the April Tag code output in C++. As a result, ,my capacity to help them along was limited, because ROS's methods of compiling python and C++ nodes are very different from one another. Dipta and Songjie also took lead on compiling our risk register and lessons learned spreadsheets.

4. Future Work

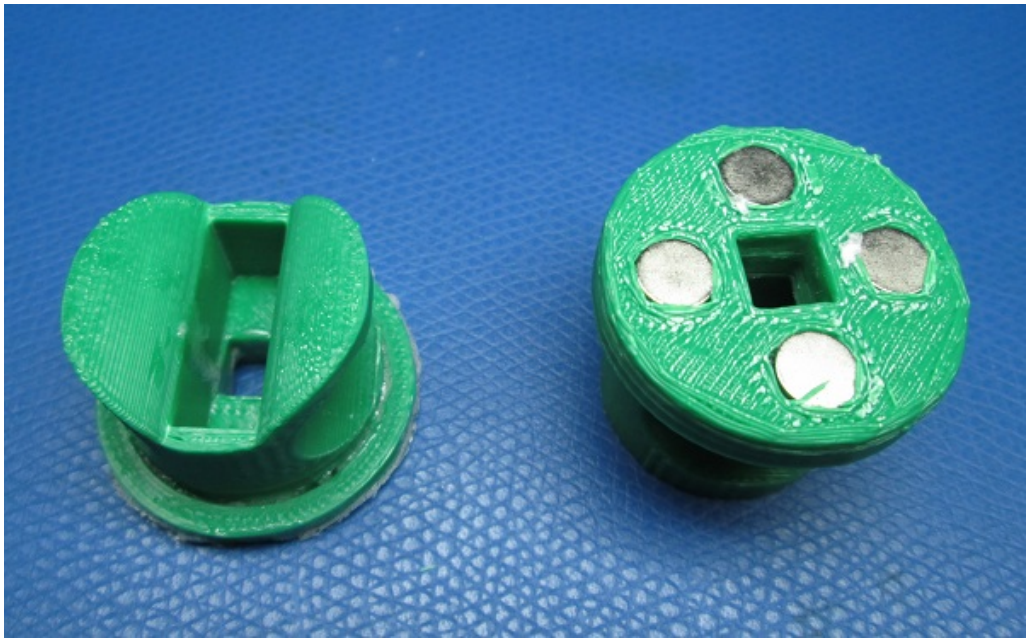
For the next progress review, I plan to continue fabricating pieces of the chassis and aiding assembly so we can again have a fully functional, completely integrated robot. I will also continue developing a magnetic foot until I have one that can hold the desired weight by itself. Once that is developed, I'll work with Nathaniel to integrate it directly into the structure of the chassis. This chassis will be used to test our existing software to perform a horizontal walk like the one demonstrated at the end of the Fall semester. After that is validated, we'll print a new chassis with magnetic feet built-in, for vertical walking.

Additionally, for the the next progress review we plan to have our first prototype of a path planning system. For now, our goal is a basic 2D view from above the robot which will allow the user to select waypoints. The robot will then move toward the waypoint using some of the encapsulated motions developed by the gait generator. I'll be working closely with Nathaniel on that and will be a good opportunity for me to resume the coding of new

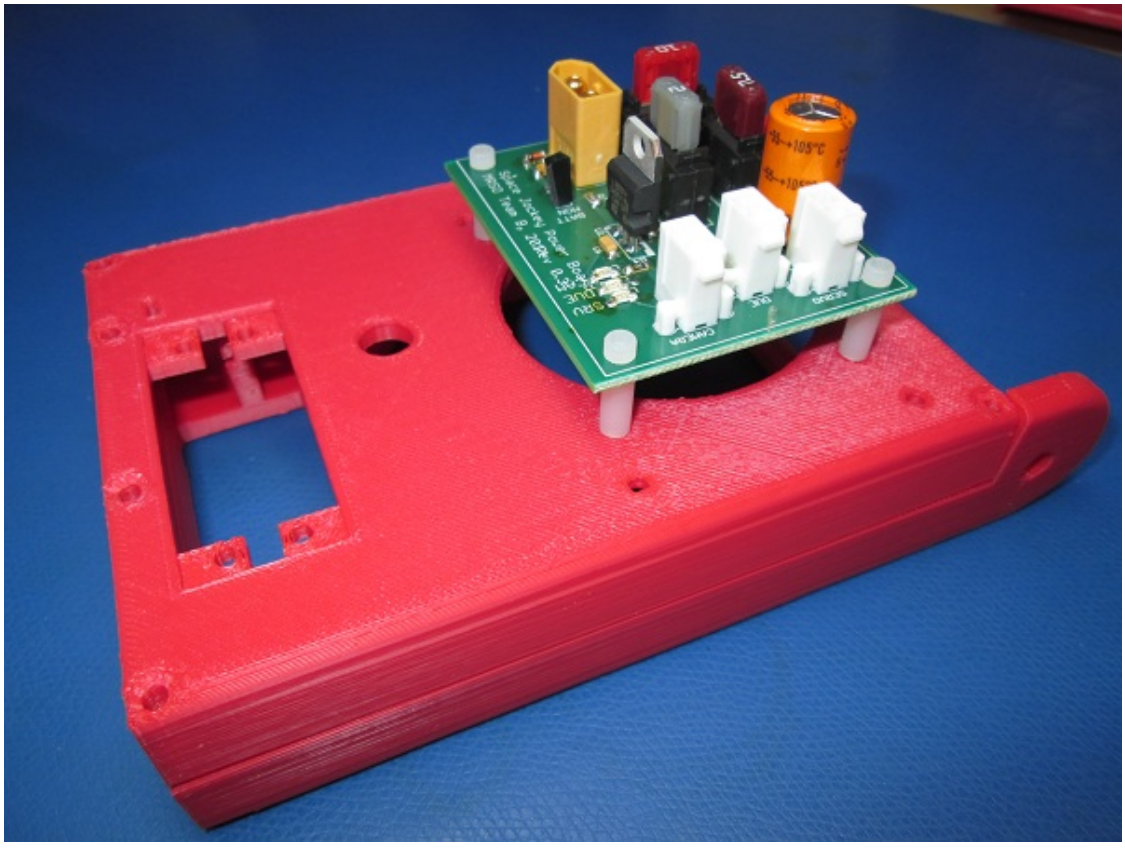
software. Dipta and Songjie will be working on localization using their April Tag software, which will ultimately combine with the path planner to give the robot a degree of autonomy. Depending on the progress made by both efforts there may be some degree of convergence by the next review, in such case I'll be working closely with the two of them as well.

5. Figures

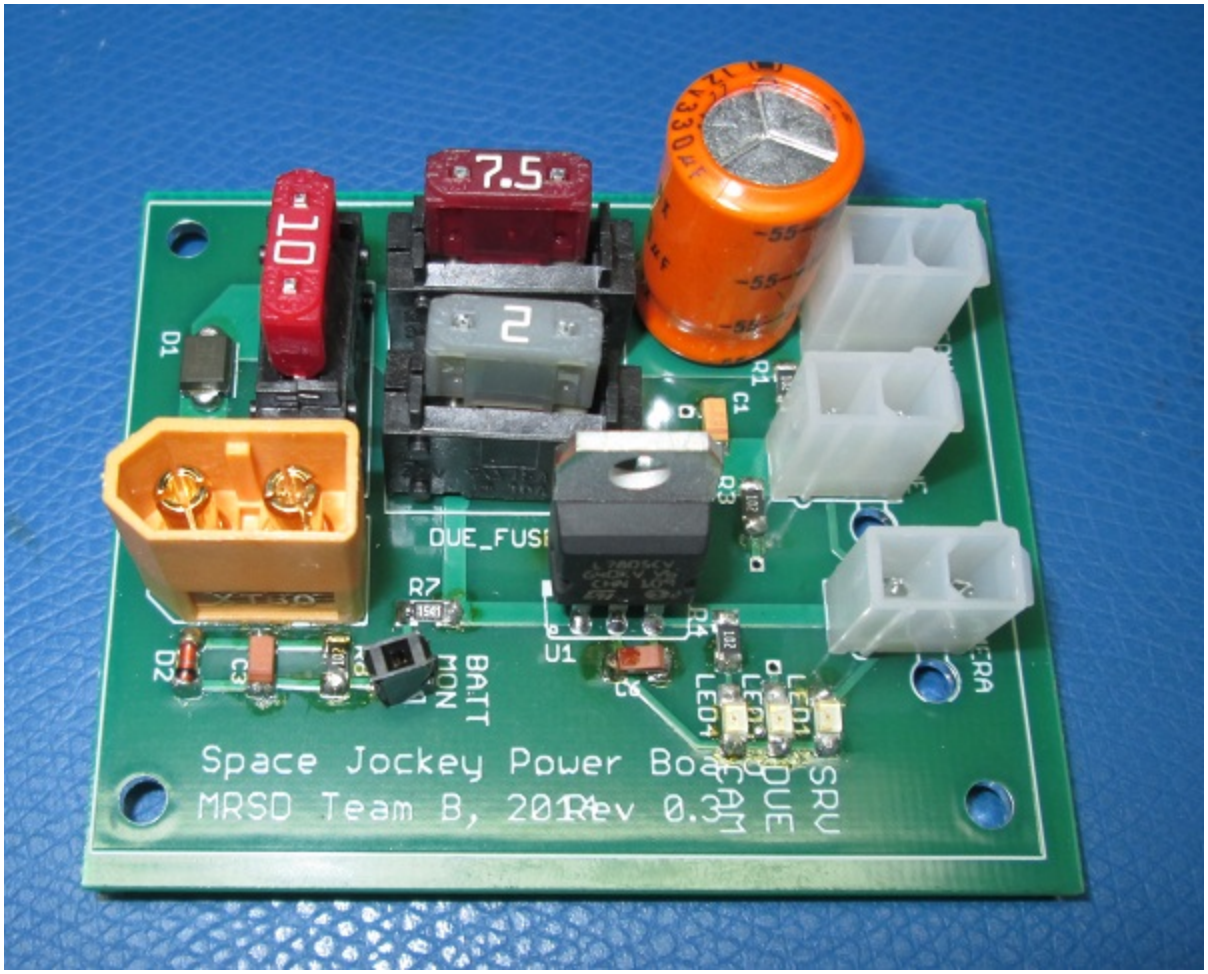
(Figure 1: Test rig with tension scale)



(Figure 2: Prototype Magnetic Foot)



(Figure 3: Newly fabricated chassis)



(Figure 4: Spare Power Distribution Board)