Individual Lab Report
Weekly Progress

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

ILR10
April 4th, 2014

1. Individual Progress

My main responsibility for this progress review was to integrate my magnetic foot prototype into the robot chassis. This involved preparing two models, one for the end segments and another for the center segment. I designed and developed the end segment foot (See Figure 1) using a stub model provided by Nathaniel that was correctly sized for integration with the rest of the chassis. Due to volume limitations and the presence of another servo for actuating the entire segment, I couldn't simply join my existing prototype design, and had to use the lessons learned there to implement the same mechanism in a restricted design space.

The center segment foot (See Figure 2) was much more straightforward. The design of the center joint includes a screw passing through two pieces that allows them to rotate relative to each other. I was thus able to easily produce a center foot by combining the original foot prototype and a model of the screw itself into a single structure, allowing the segments on either side of the center joint to rotate independently of the foot. A remaining improvement I'd like to attempt is to add a wire pathway through the center screw, as the wire instead currently wraps around the outside of the robot where it may become subject to tangling or being pinched.

Finally, I was also involved with the final integration push to prepare for the progress review. This involved assembling the robot complete with its new feet, organizing the overall wiring, as well as preparing and installing the IMU with a custom cable, which was my first experience crimping and building a connector cable.

2. Challenges/Issues

The first designs for the end segment feet were particularly compact, having two servo motors inside, one to rotate the segment and another to operate the detachment mechanism. As a result, immediate challenges were fitting these motors within the segment and maintaining a plausible assembly process. I had to take care to ensure that the motors could be maneuvered into their mounts, that there were sufficient pathways for a screwdriver to secure the motors and detachment peg, and finally that wires had a path to the center segments that would be free of twisting or tension.

Integration revealed several serious issues, in particular the failure of the feet to hold the robot's weight as it moved. I had tested the prototypes for the amount of force they could sustain before sliding, but I realize now that this approach failed to take into account the dynamic forces created by the robot's motion, as well as configurations during which when the robot acts as a cantilever, such as when it's oriented sideways with an end segment detached. Generally, the robot tended to slide down the vertical surface, but on occasion detached entirely, so both the magnetic force as well as the friction of the foot surface must be increased.

Another issue related to integration is the variation in properties of the different surfaces the robot may attach to. The foot prototypes were tested on the relatively smooth metal surfaces of our lab bench, but our tests of the integrated robot took place on the large metal doors of the lab. These doors were considerably thicker than the lab bench, and so magnetic strength was slightly stronger, but they also have a more porous texture, making the robot much more prone to sliding. Tests using whiteboards showed very weak magnetic attachment. Our current best option for this variety of conditions is to aim to adhere to the weakest surface, and in cases where the magnets may overpower the detachment servo we apply additional layers of tape to the footpad to decrease their pulling force. Another strategy I plan to explore is to use partial extension of the detachment peg to accomplish this spacing, although that will require software calibration of the robot prior to tests.

3. Team Work

Nathaniel continued writing the new path planner which will replace the old GUI and provide a more user-friendly interface. He also prepared the end foot segment stub that would allow it to connect to the rest of the chassis, and we worked together before the progress review to get as much integration done as possible. He also made some improvements in the way we work with ROS, implementing both launch files and a parameter server to better streamline our development and the operation of the robot.

Songjie and Dipta continued work on the vision-based localization using AR tags, IMU data, and various data transformations and interpretations between them in ROS. These features will ultimately allow the robot to estimate its location in the world frame as well as its own pose. Combined with the vision system and image comparison, this will eventually allow the building of a sensor map from which defects can be detected and brought to the operator's attention.

4. Future Work

The attachment mechanism I developed will require further adjustment before our robot can walk on vertical surfaces. The current design fails to support the robot's weight except when completely static, and so I'll need to change the design to either reduce weight, increase friction, increase magnetic pull, or incorporate a combination of all of these approaches.

Given Nathaniel's discovery that the lever force of the end segments' motion is enough to detach the foot, we may be able to reduce weight by forgoing the detachment motors in those segments. Friction may be increased by replacing the electrical tape on the surface of the foot with a high-friction tape, such as those used for hockey sticks handles and drumsticks. Increasing the magnetic pull can easily be done by increasing the number of magnets in each foot, although this will make it more difficult to detach the feet. For the center foot, we can use one of our high-torque motors to overcome this increased magnetic pull. For the end segments, if their motion is insufficient to overcome a more powerful magnetic pull, then it may be possible to retain the detaching motors for a greater combined force.

Additionally, I'll also need to add a camera mount to the forward segment so the vision system can be fully integrated into the robot. Finally, since this is the final push for our dry run, I'll have to make myself available to assist with all aspects of the robot and its complete integration, so I plan to finish the optimizing of the attachment mechanism so I'm free to work on any other issues that arise.

5. Figures

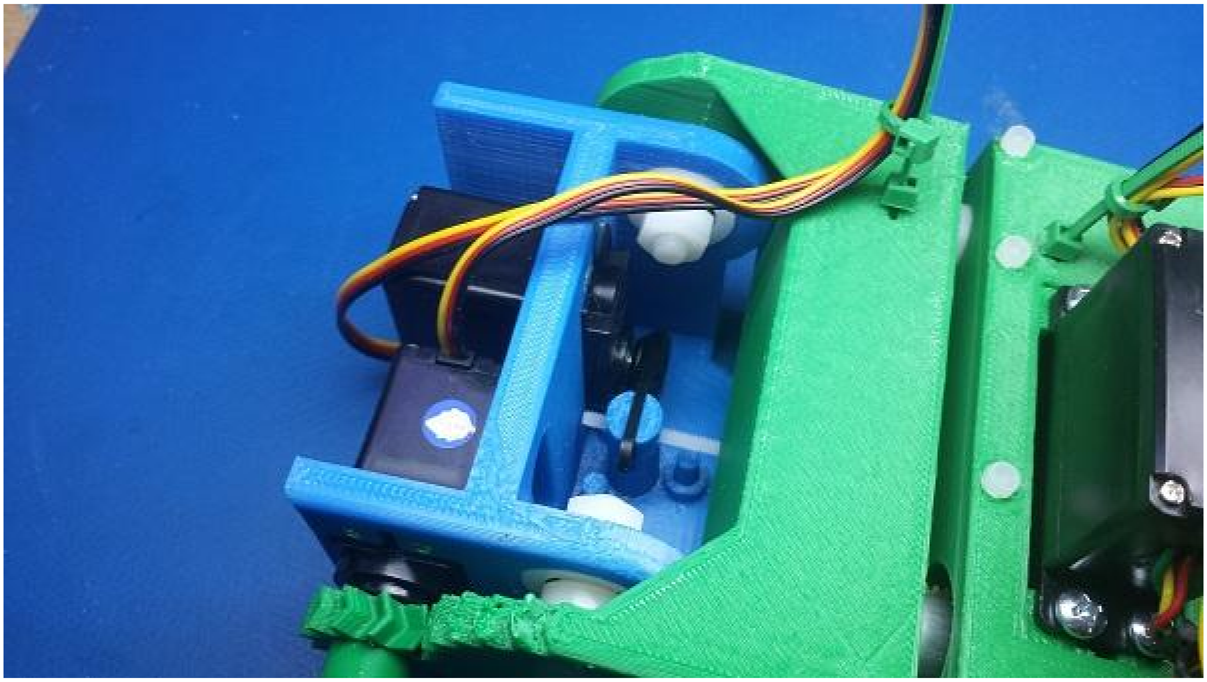

Figure 1: End Segment with integrated magnetic foot

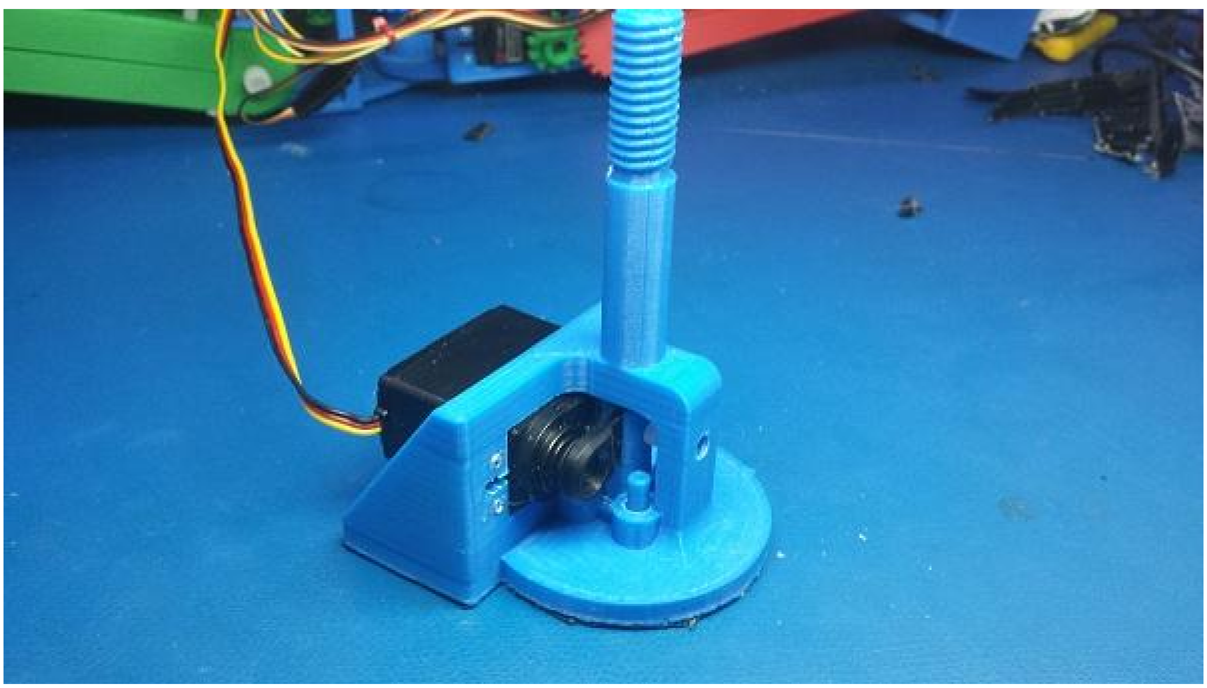

Figure 2: Center joint magnetic foot