Individual Lab Report
Weekly Progress

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Team B: Team Space Jockey
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ILR09
March 21st, 2014

1. Individual Progress

For this progress report, the majority of my efforts went towards the development of a magnet-based attachment mechanism. I proved the viability of magnets for attachment in the prior progress review, and for this one I built a prototype foot that integrates a servo motor and linkage which produced a linear motion to push the foot off the surface.

Also during this period I assisted Nathaniel with the printing of the final chassis parts, and updated the robot's URDF representation to match the dimensions of the new chassis. Until now the URDF representation of the robot was primarily symbolic, and used for visualizing relative link positions and orientations while I was developing a basic gait. This new URDF model will allow us to leverage ROS's existing modules for forward and inverse kinematics for precise motion control.

2. Challenges/Issues

One issue in developing the magnetic foot was the tendency of the magnets to easily slide along the surface once any shear force was applied. This was remedied first with a layer of duct tape, which was thick enough to significantly reduce the magnetic force. Electrical tape was only marginally worse at resisting slip but was thin enough to have almost no noticeable effect on magnetic strength. By comparing the normal and shear forces necessary to move the foot, electrical tape seemed to offer the best tradeoff. Both tapes had the added benefit of aiding the glue in keeping the magnets secured in their insets.

A recurring difficulty was balancing magnetic strength with other aspects of the foot module. The first prototype because the ABS holding the motor in place gave way before the force of the magnets was overcome. A later iteration failed because the total magnetic force was too great for the motor to overcome. The final integration halved the number of magnets and was still too weak to push off, but the addition of two layers of electrical tape reduced the magnetic force by just enough to allow detachment. After all this, I now know that I can very finely tune the magnetic force by varying both the number of magnets and the layers of tape separating them from the surface. Three prototype feet are shown in figure 1.

Fabricating the foot prototypes also involved a variety of challenges. The most desirable and effective final product would have all magnets level and positioned at the surface of the foot, with few air bubbles between the tape and ABS to ensure maximum cohesion. To this end, I developed a fabrication method that accomplishes this nearly perfectly. I first glue the magnets into their respect insets using epoxy, then apply a layer of electrical tape over the entire foot. On top of this layer are a few stacked napkins, and then a plate of sheet metal, then the entire apparatus is tightly clamped overnight. The metal uniformly draws the magnets to the surface, while the compressed napkins push the tape tightly against the ABS surface. I was very satisfied with the results of this method, which is contrasted with a simpler clamping to a wood block in figure 2.

3. Team Work

Nathaniel nearly completed the new chassis by printing the center segments and assembling the prototype. He also coded a global path planner which can direct a virtual robot in a 2D plane to either move to a waypoint or position itself such that lifting the front segment will provide a useful camera view of it.

Songjie developed the precursors for a flaw detection routine. The program first warps a camera image to fit onto a reference map of the entire workspace. This is made possible by the April Tags which provide reference points for determining the camera position and orientation and thus the Homography to warp the image onto the map. Then, the program compares these this warped image to the reference map, and colors the major pixel differences in red.

Dipta successfully integrated the IMU orientation data into a ROS message format so it could be passed to other modules, and will ultimately assist localization and pose correction.

4. Future Work

The attachment mechanism that was developed this week will next need to be integrated into the middle and end segments of the robot, along with a camera in the front end segment. Because Nathaniel is most familiar with the chassis so far, he'll prepare template end and center segments for me to integrate my magnetic foot design into. Before I can do this, I'll have to perform some experiments with our planned demonstration surface to decide the best number of magnets to use. I'll also integrate limit switches into the underside of each foot so the gait controller can wait for a successful detachment before moving any segments.

Before the next progress review, I'll also shift back into software development in the final push towards our spring demonstration, working with the entire team to integrate all of the various modules together into a single ROS pipeline.

5. Figures

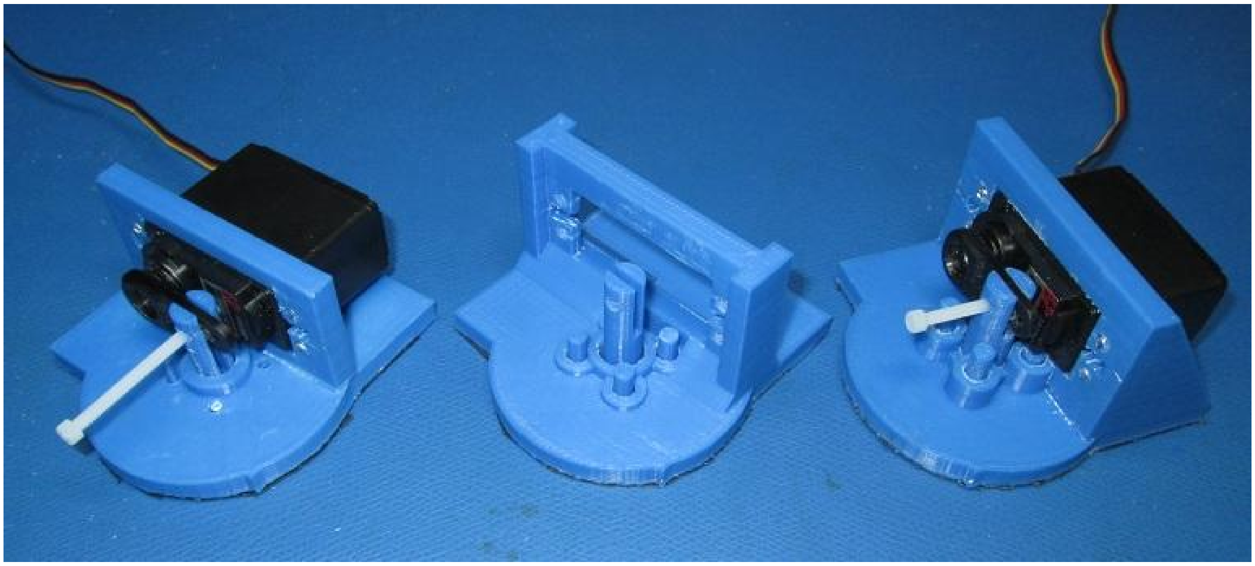

Figure 1: Prototype Gallery. From left to right, magnetic foot prototypes mk. i, ii, and iii

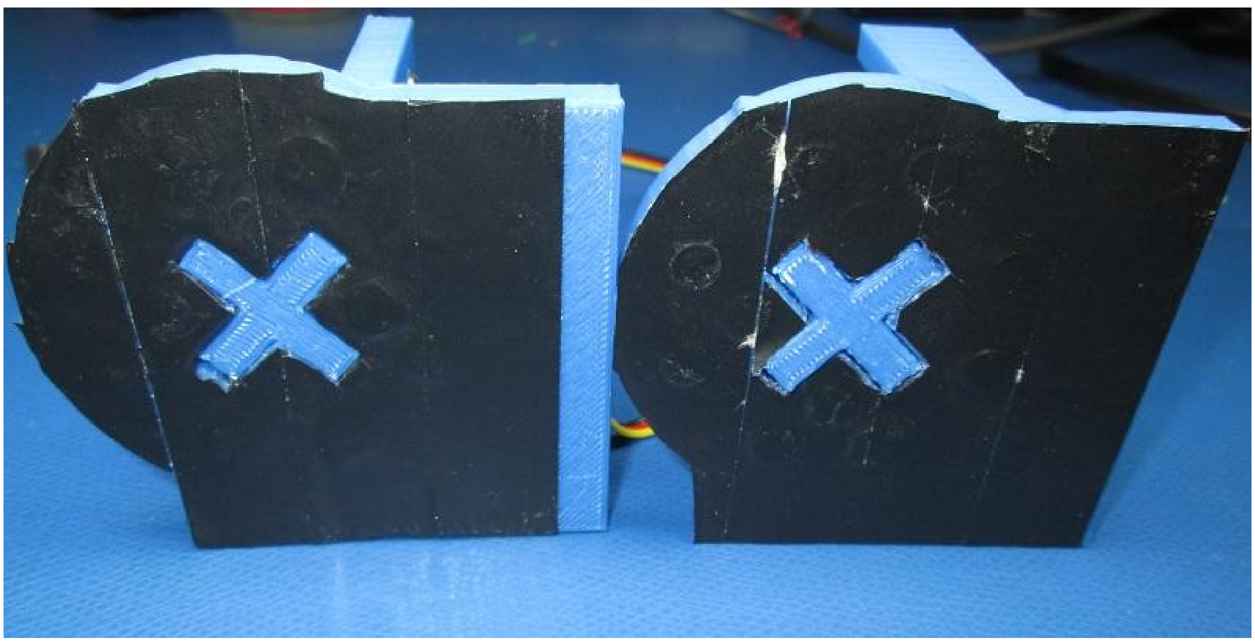

Figure 2: Contrasting fabrication methods. Left: Clamped against a wood block. Right: Clamped against napkins and sheet metal (note the improved definition and uniformity of magnet discs)