Hexcavator

Operations Manual

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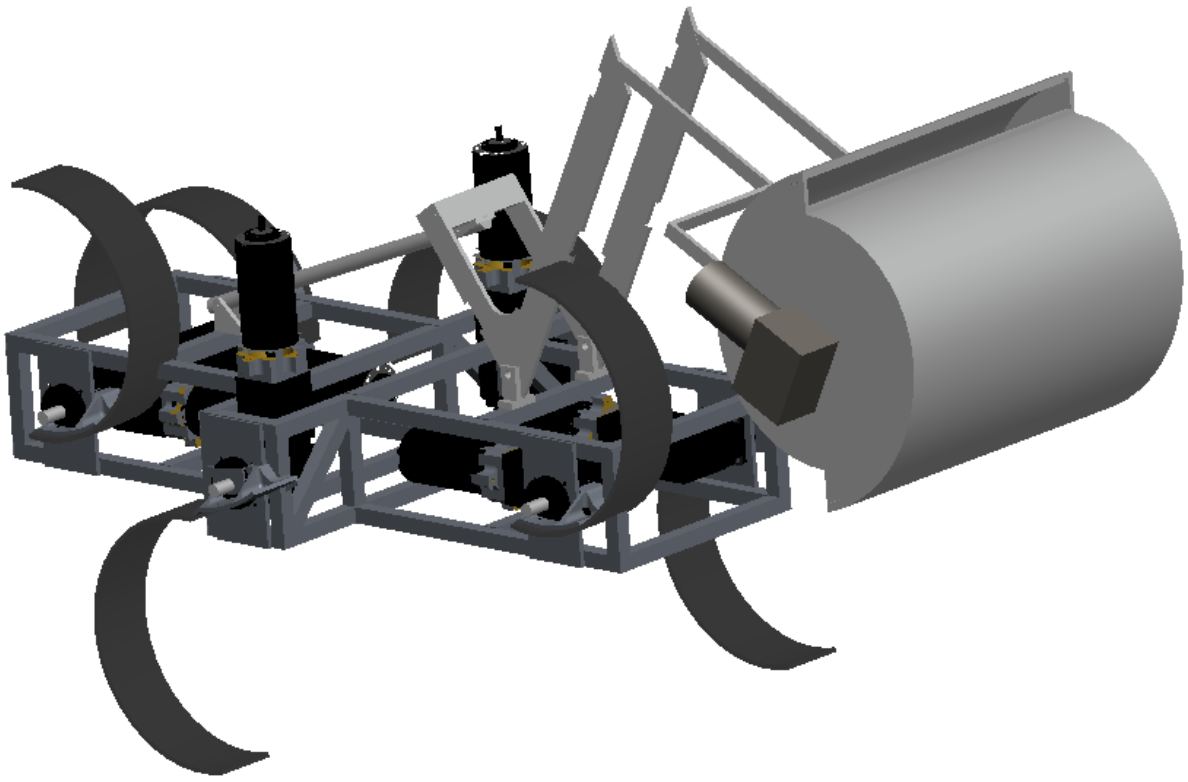

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Introduction

This robot is intended for the NASA Lunabotics Competition at Kennedy Space Center. The purpose of the competition is to develop a robotic platform capable of locomotion and excavation on extra-terrestrial surfaces. The robot is capable of walking across uneven terrain and over obstacles two-thirds the height of the legs. The robot is also capable of excavating sand like substances, carry it on-board the robot, and deposit it into a designated bin. When the robot is not in use, the legs roll up in the air for more concise package. Figure 1 is a functional diagram of the robots communications system.

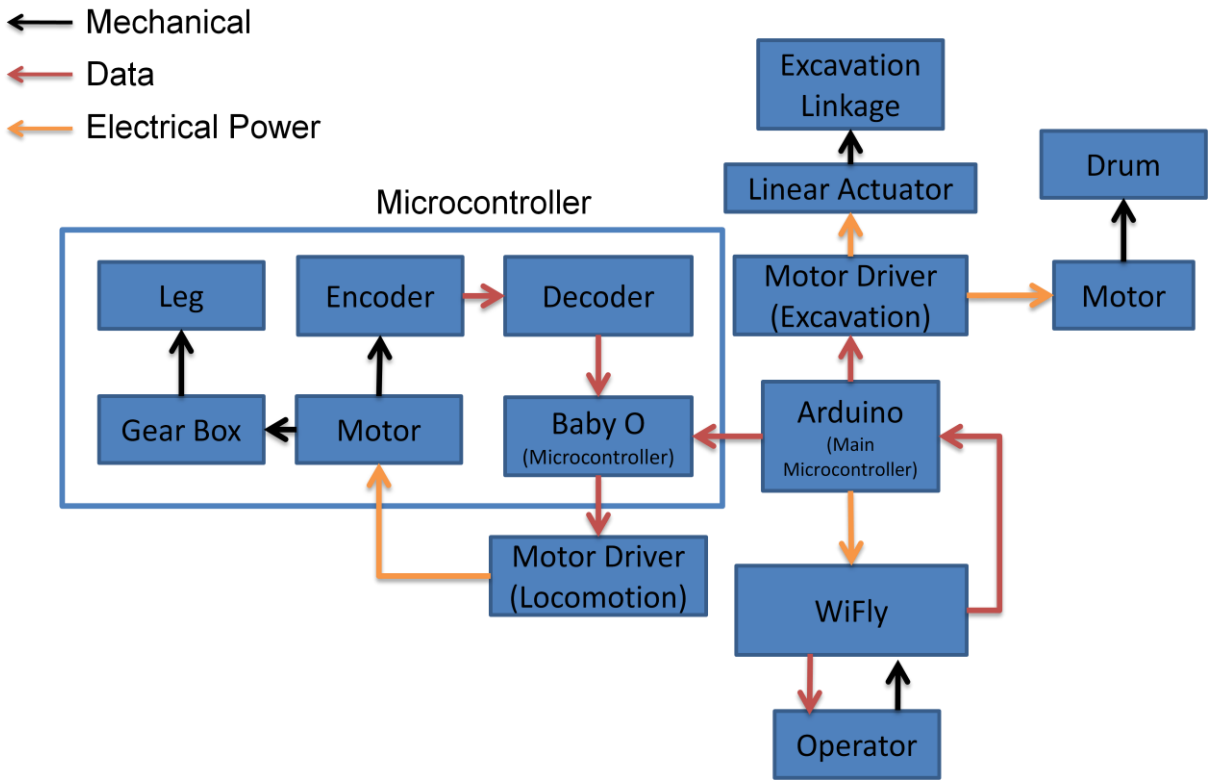

Figure 1: Hexacator's Function Diagram demonstrating the robot's communication system.

Systems

The robot will come in two major pieces. The frame, locomotion, legs and electronics will be housed in the robot body. The frame, motors and legs are pictured in Figure 2.

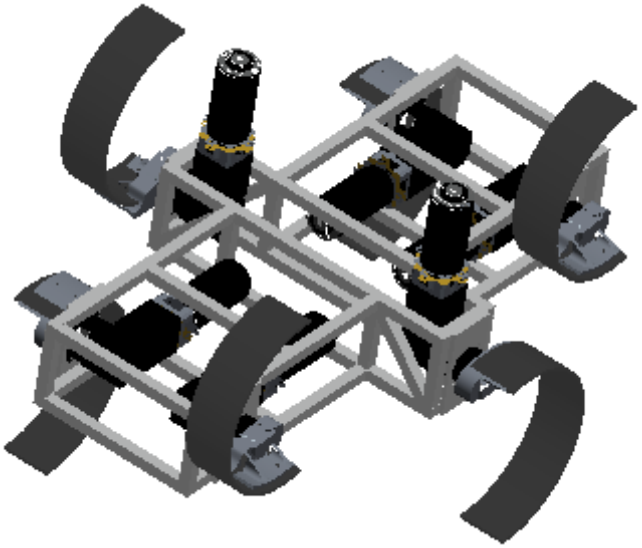

Figure 2: The robot body: frame, motors and legs.

The linear actuator is necessary for driving the excavation system will come separately from the other components, pictured in Figure 3.

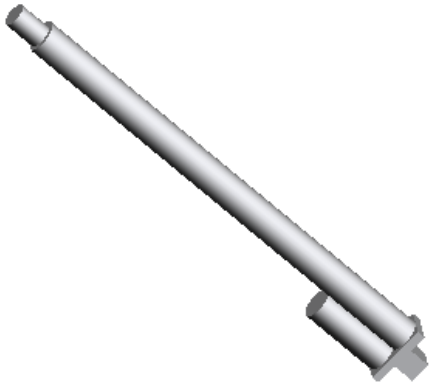

Figure 3: Linear actuator for excavation system.

Finally the excavation drum and linkage combination will also come separately, pictured in Figure 4.

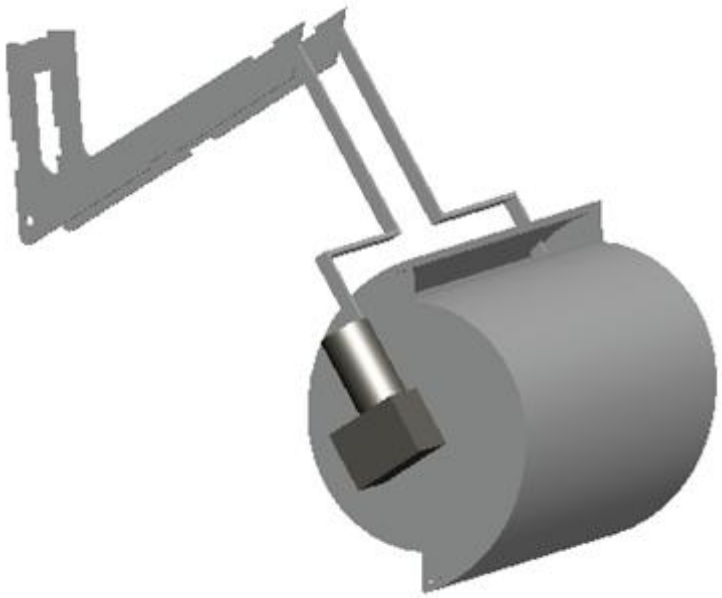

Figure 4: The drum, linkage combination from the excavation system.

Major Components

The major components for Hexcavator are outlined in this section. The purchased manufactured components are listed in Table 1, as well as their quantity, their manufacturer, part number and the cost at this document was updated.

Component	Quantity	Manufacturer	Part Number	Price
Excavation Drum Motor	1	The Robot Market Place	226-300	$ 84.49
Excavation Linear Actuator	1	Firgelli Automations	FA-240-S-12-12	$ 109.99
Locomotion Motors	6	Maxon Motors	403044	$ 828.00
Motor Drivers	6	DIY BIN	OSMC Intersil HIP3081A	$ 218.95
Main Microcontroller	1	SparkFun Electronics	Arduino Mega 2650	$ 84.95
Microcontrollers: Baby O's	3	Pololu	Baby Orangutan B-328	$ 19.95
Drum Motor Driver	1	Dimension Engineering	SyRen 25	$ 74.99
Locomotion Batteries	2	Battery Space	Powerizer PL-9759156-10S-MTM-G	$ 413.05
Excavation Batteries	1	Battery Space	Powerizer: CU-J214	$ 280.95
Red Safety Button	1	Euchner USA	ED252L	$ 129.24

Table 1: Description of the commercially purchased components for Hexcavator.

There were several custom made components for the Hexcavator, built in the STRIDe Labratory. They are listed below.

The frame was welded together from Aluminum 6061, and is depicted below in Figure 5.

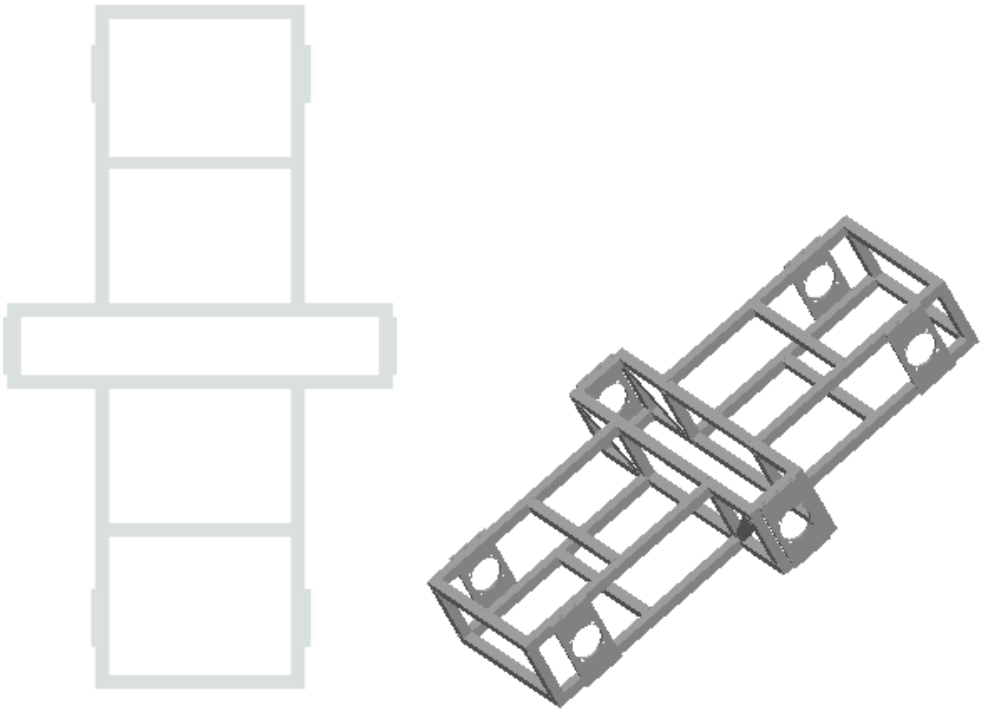

Figure 5: The Hexcavator frame.

The six legs for are constructed from carbon fiber, depicted below in Figure 6.

Figure 6: Hexcavator's legs which are made from carbon fiber.

There are six leg mounts to attach the legs to the motors which drive them. They are constructed from Aluminum 6061 and shown in Figure 7 below

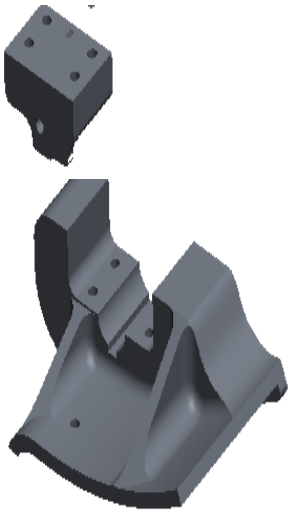

Figure 7: Leg mounts which were machined from Aluminum 6061.

There were no commercially available motor controller circuits that suited the application. A custom made one was created and is depicted below in Figures 8 and 9. Three of these were used on the robot for a pair of legs, which then communicate with the main Arudina Mega 2650 motor controller. Figure 8 is a picture image of the circuit, and Figure 9 is the circuit diagram.

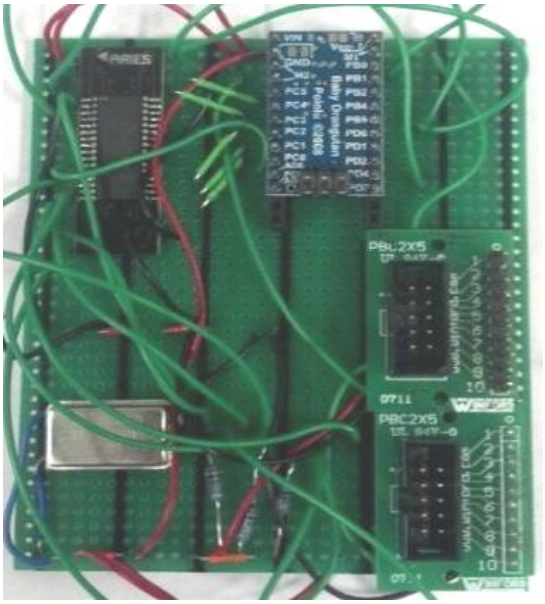

Figure 8: The custom made motor control circuit. Three of these were used on the robot for a pair of legs, which then communicate with the main Arudina Mega 2650 motor controller.

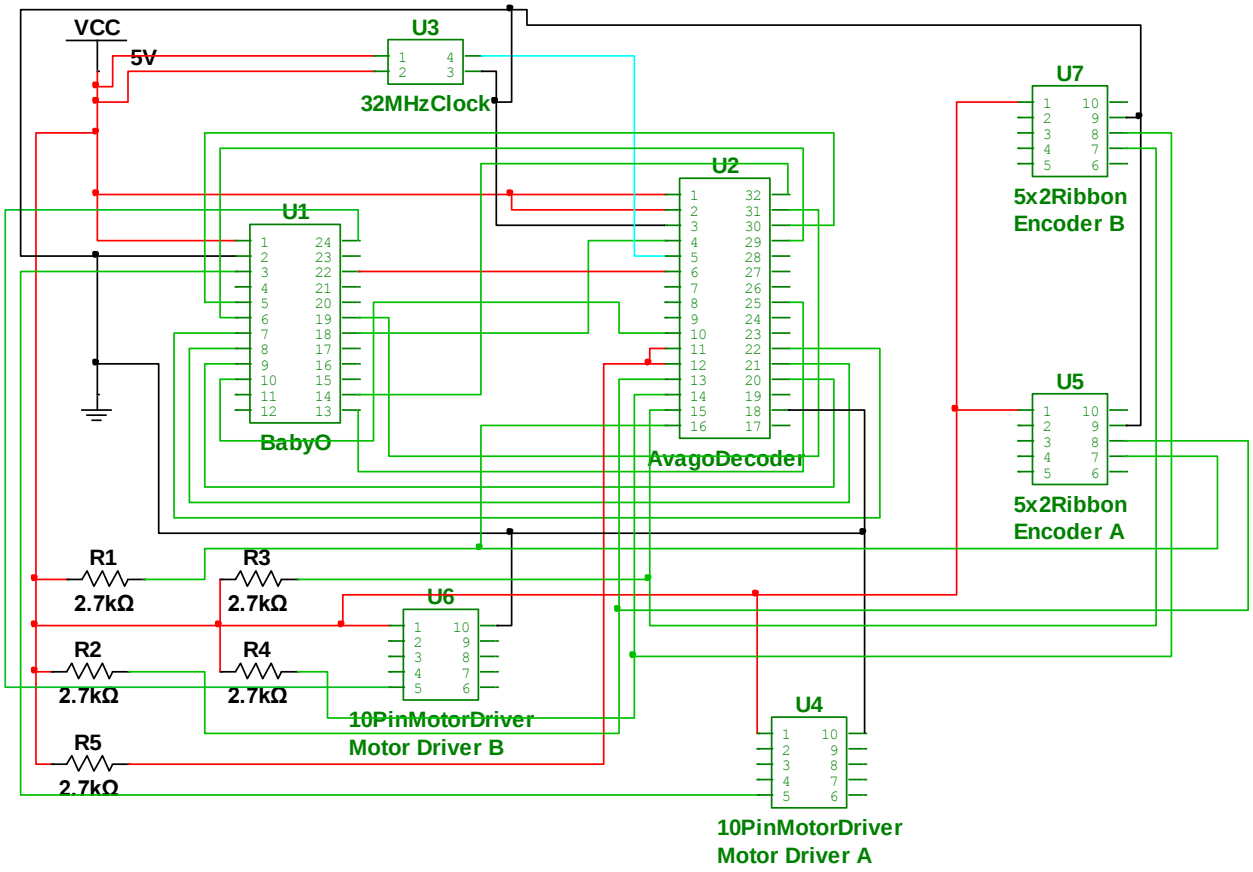

Figure 9: The custom made motor controller circuit diagram.

Instruction of Assembly and Mounting of Excavation System

The excavation system for the Hexcavator robot comes in three main parts. These parts are the Hexcavator body (containing all the electrical components and attached legs), linear actuator and excavation linkage; these are shown in Figures 2, 3 and 4 respectively. The linkage will be mounted to the frame of the robot via mounting brackets located on the second cross member, depicted in Figure 10. These will require the use of two of the 0.25 inch diameter, one inch long steel mounting pins as well as four circlips, the pins are depicted in Figure 10. The two linkage mounting points will be then placed between the mounting brackets and the pins will be inserted through the 0.25 inch mounting holes. A close up image of the mounting brackets used to mount the linkage is shown in Figure 11. These will be secured by the circlips attached on either side of each pin. After this is completed, the excavation linkage will be secured to the Hexcavator robot. Then the linear actuator (the end that does not extend) needs to be attached using pins to the mounting bracket on the rear of the robot, shown in Figure 12. Then the other end of the linear actuator will be affixed to the excavation linkage using the attached mounting bracket, shown in

Figure 13. Both ends of the linear actuator are attached via a pin with a cotter pin to keep them in place. Figure 14 depicts how the excavation system is to be mounted to the Hexcavator body.

Figure 10: The pins used to mount the linkage to the excavation system.

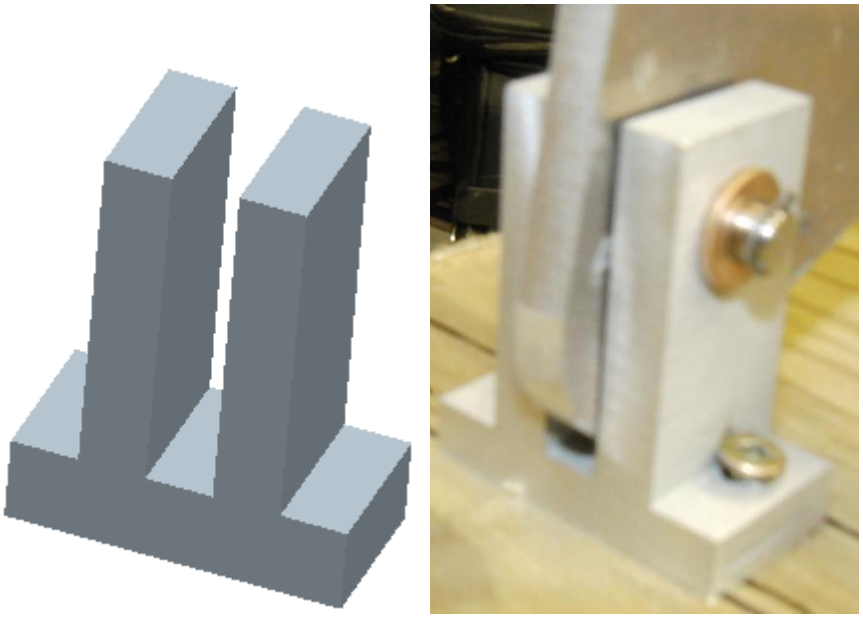

Figure 11: Close up image of the mounting brackets used to attach the linkage to the Hexcavator body.

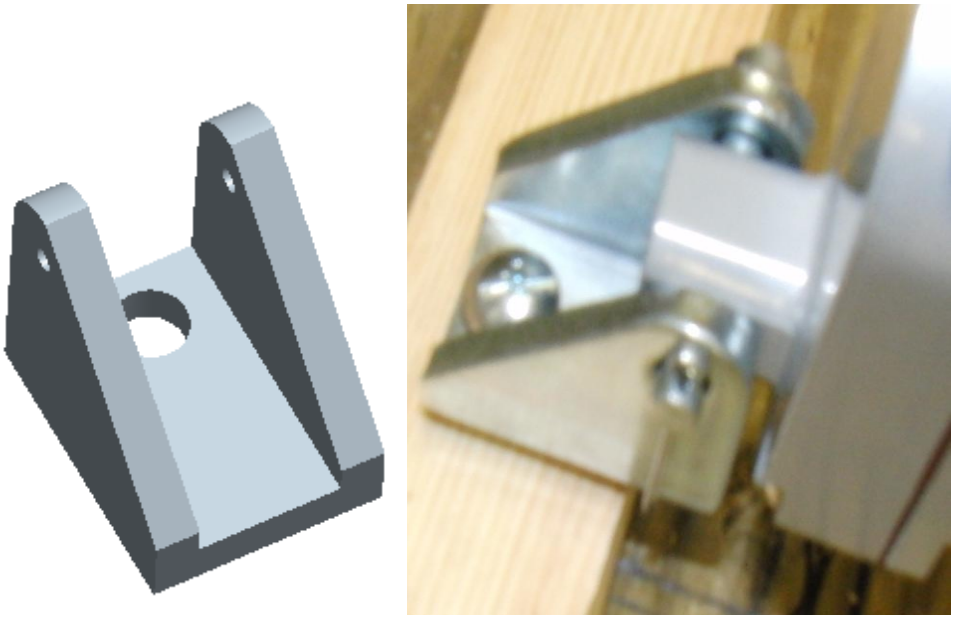

Figure 12: A close up image of the mounting brackets used to mount the linear actuator to the frame.

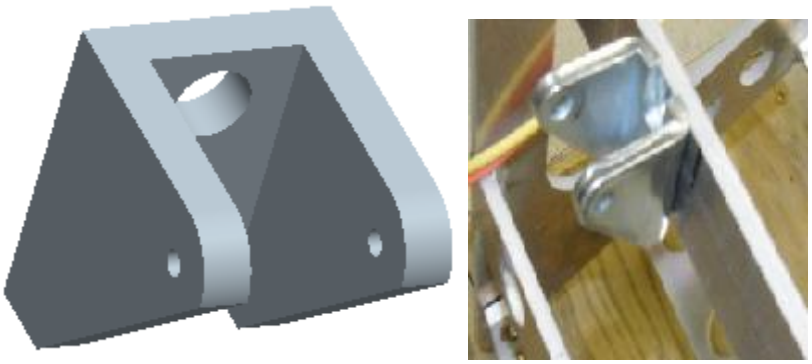

Figure 13: The mouting braket used to affix the linear actuator to the excavation linkage.

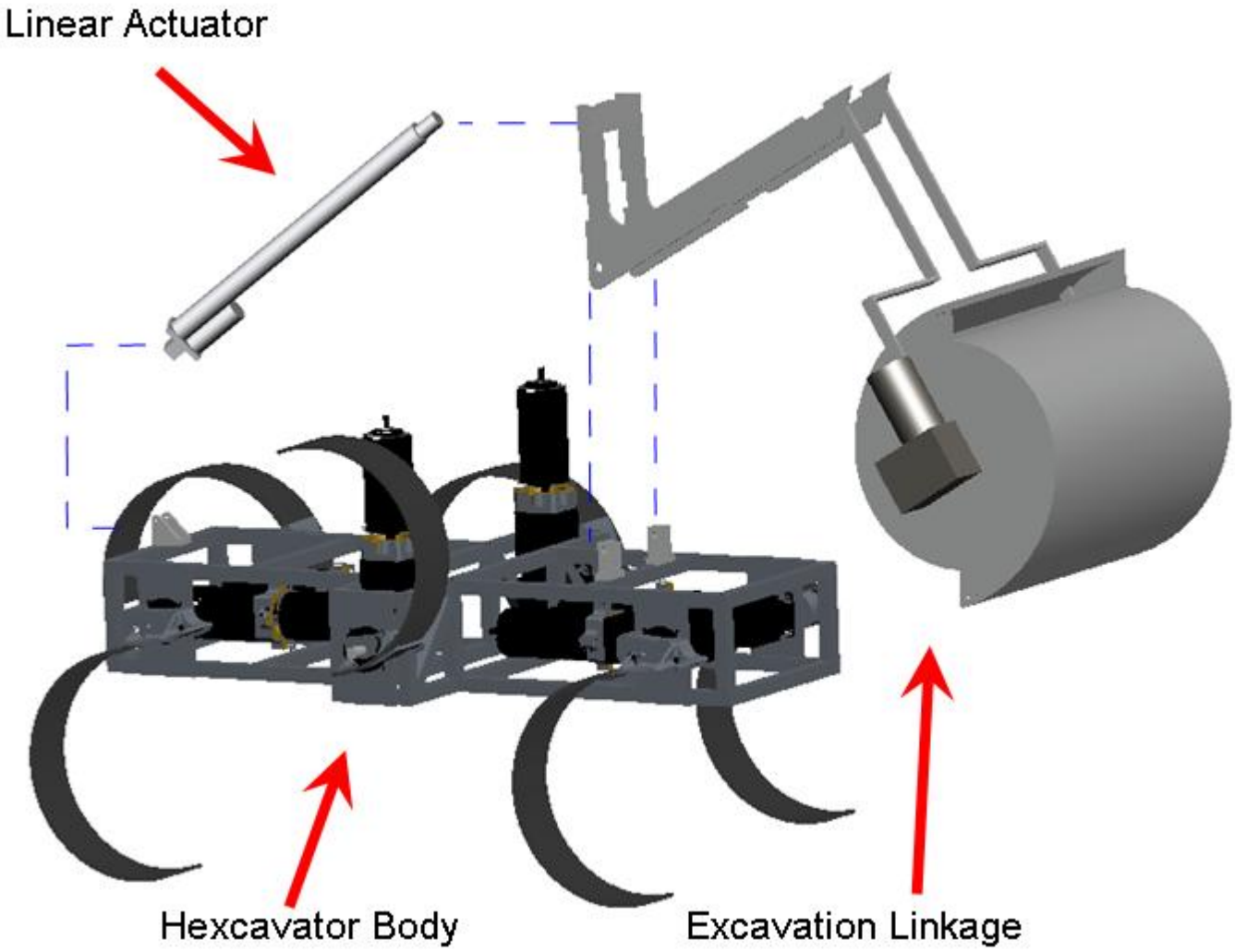

Figure 14: The exploded view depicting how the linkage and linear actuator are to be assembled to the Hexcavator body.

Operating Procedures

The only device needed to control the robot is a laptop with a wireless network card and a hyperterminal program. The program that was used on the test laptop was Microsoft's stock hyper-terminal program.

Once the hyper-terminal program is open, a connection needs to be established. The WiFly is set up as an ad-hoc network, so directly connect to it using the WiFly's address, 192.254.1.1:2000. When connected, a "Hello" message will appear in the hyper-terminal window.

After receiving the welcome message, Hexcavator and the excavation system can now receive commands. Here is a list of the current commands we have:

Hexcavator commands

- '1' – Makes robot take four steps
- '2' – Makes the robot stand
- '4' – Moves the three legs that make up the tripod gate 180°
- 'r' – Resets the decoders on the motor control circuit
- '0' –Stops the robot in its current position

Excavation commands

- 'a' – Extend excavation arm
- 's' – Retract excavation arm
- 'd' – Spin drum clockwise to collect regolith
- 'f' – Spin drum counter clockwise to dump regolith

Currently, the controls are very basic but since the competition is in a month, there is ample time to refine and create the commands.

Safety Information

The legs are very dangerous and should be treated as though. Keep all body parts and valuables away from the robot while operating. Should the robot go awry, press the large emergency stop button to immediately disconnect all power and stop the robot.

The robot itself has several built in fuses so that if the robot draws too much current, they will automatically disconnect the power from the motors.

Future Work

Obviously the platform is currently unfinished. The main things to make this platform ready for industry are to develop a GUI interface to make the robotic interface more user friendly. The robot will also be outfitted with a cover which will be sealed with silicone to prevent dust interference with the electronics.