Needs Assessment Project Scope

EML 4551C – Senior Design – Fall 2011 Deliverable

Team # 15

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Table of Contents

Needs Assessment

From May 21st to 26th, 2012, the National Aeronautics and Space Administration (NASA) will be hosting the Third Annual Lunabotics Mining Competition at Kennedy Space Center. The goal of this competition is to further advance lunar and planetary robotics. Each team will build a robot capable of excavating regolith (lunar soil) and depositing it into a bin at the other end of the competition area. The robot will also be required to traverse an obstacle area. The competition takes place in an enclosed area, while the team is in a mock command area communicating to the robot via wifi. Winners are determined using a points based system.

Project Scope

Problem Statement

The goal of NASA's Lunabotics Mining Competition is to design a robot capable of operating and mining on the moon's surface. The largest obstacle is designing such a robot is the traversing the terrain. Regolith is an extremely dense and fine soil that is easily disturbed. The robot will be required to walk across this terrain, navigating obstacles, excavate lunar soil and then walk back across the obstacles to deposit the regolith in the lunar bin. The excavating Lunabot can be remotely operated, but an autonomous design would be ideal. The primary challenges will be to develop a regolith-resistant design which can communicate wirelessly, have minimal vehicle mass, consume minimal amounts of both energy and power, and demonstrate some level of autonomy [2]. Last year's senior design team developed a robot for the 2011 competition. Due to a power surge and limited time frame, last year's robot was rendered unusable and did not compete (shown below in Figure 1). The motor controllers overheated during the power surge and were no longer useable. Additionally, since the team did not budget their time well there was no excavation system, the robot was not dirt resistant and the controls scheme was incomplete. Some portions of 2011 team's robot are still useable, while others need to be redesigned or thrown out completely. The detailed steps to develop an improved robot are outlined in the methodology section.

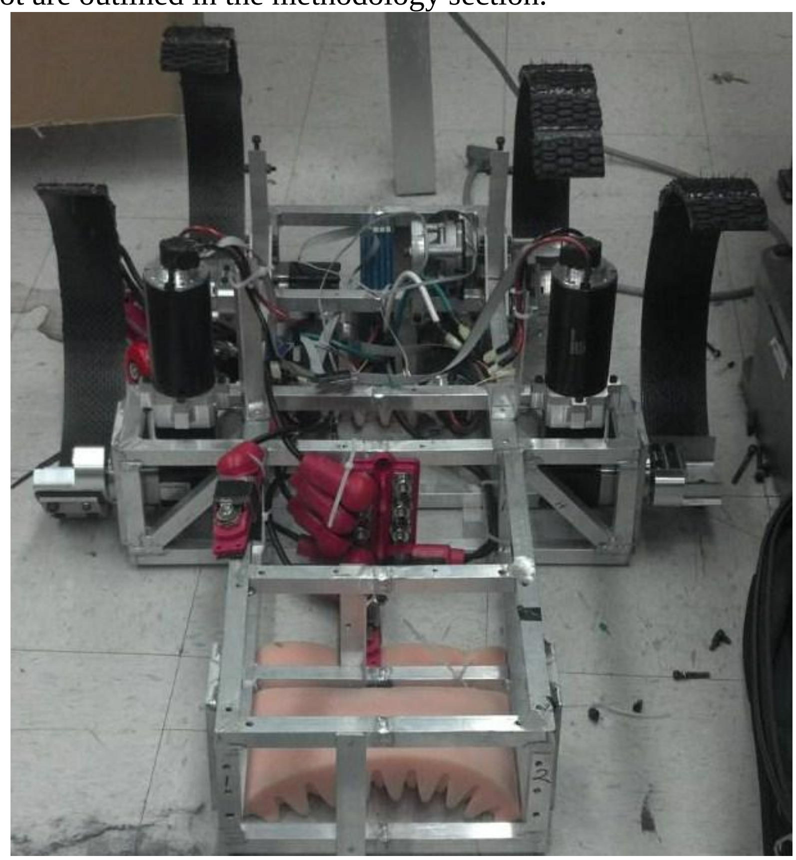

Figure 1: The 2010-2011 FAMU/FSU College of Engineering Lunabot that was developed for the NASA competition. Due to unfortunate circumstances, this robot was not able to compete in the Second Annual NASA Lunabotics Mining Competition.

Objective

To design a robot which can traverse the regolith terrain and its inherent obstacles, excavate regolith from the mining area and traverse back across the terrain to deposit the excavated regolith into the Lunabin within the time constraints dictated by the competition. This will be achieved by having minimal weight, power consumption and with the maximum level of autonomy possible.

Justification and Background

NASA has placed an open call for robots that are capable of traversing a simulated lunar terrain. Robots would make planetary exploration easier, safer and more realistic. Robots can take the place of humans in space exploration and feed all necessary data back to the command center. However, robots need to be able to handle the environment and terrain in which they will be working in. As previously stated, regolith is extremely difficult to work with. Issues from the past teams have included clogging of drive systems, disruptions of electronic components, and lack of visibility due to dust. The 2010-2011 Lunabotics team came up with an innovative idea to solve these issues. The solution came in the form of a hexapedal walking robot based off of the RHex family of robots, shown below in Figure 2. The RHex platform has been proven to easily traverse difficult terrain; such as dealing with obstacles and diverse soils. The same leg design, motors and emergency stop button developed last year will be used on the robot that will be competing this year; this year's team will develop an excavation system, a modified frame and a new control system.

Figure 2: One of the RHex robots which served as inspiration for the original robot [1].

Methodology

Due to the group using a pre-existing body, many mechanical aspects such as frame, legs and attachments have already been designed. Our group has chosen to keep the current legs, attachments and motors. However, the body may be redesigned when the excavation system is designed. A complete list of what needs to be accomplished to develop a successful Lunabot is listed below:

Research

- In-depth analysis of what minor components on the previous design can be utilized.
- Do an in-depth analysis of what needs to be replaced and designed.
- Locomotion schemes/controls.
- Excavation.
- Controllers and motor drivers.

Design

- Design and prototype excavation system and determine if current frame can be altered to fit our design. If not, design new frame.
- Design control system:
  - Create a system to power Lunabot.
  - Program movement control for the motor drivers.
  - Create a communications system for remote control.
  - Determine necessary sensors.
  - Create movement controls for the motor drivers.
- Prototype an overall design (including electronics).
- Purchase controller.

Build

- Test control design.
- Determine what materials can be purchased with budget.
- Purchase metals, plastics, composites and electronics.
- Purchase drivers and decoders.
- Combine chosen designs to come up with a final overall design of the robot.
- Integrate controls system.
  - Encoders with the decoders.
  - Motors with motor drivers.
  - MCU with the decoders and drivers.
- Create Communication system that uses WiFi to control the Lunabot.
- Program kill switch to completely stop Lunabot.

Test

- Find testing stimulant.
- Test robot locomotion in regolith simulant.
- Test excavation system in regolith simulant

- Test the system to find deficiencies and make necessary changes to system to improve the robots locomotion and excavation system.
- Test and improve complete robot.

If there is enough money in the budget and time to make the robot autonomous, implement the following alterations to the design control system:

- Create a communications system for remote start.
- Program micro controller to read from GPS so that the Lunabot is able to detect its position.
- Program micro controller to allow Lunabot to choose its own best path.
- Create an automatic excavation/dumping system.

Constraints

Due to the limitations caused from working on the moon, there are constraints for the robot. The specific contest constraints are dictated by the competition rules set by NASA, the original set can be found at [2]. Here is a summary of the constraints:

- Lunabot has a mass limit of 80kg.
  - Subsystems on the Lunabot used to transmit the commands/data and video to the telerobotic operators are counted toward the 80kg mass limit.
  - Equipment not on the Lunabot used to receive data from and send commands to the Lunabot for the telerobotic operations is excluded from the 80kg mass limit.
- Lunabot must be self-powered: provided its own onboard power. No facility power will be provided to the Lunabot.
- Lunabot must stay in defined competition arena, which is shown in Figure 3.

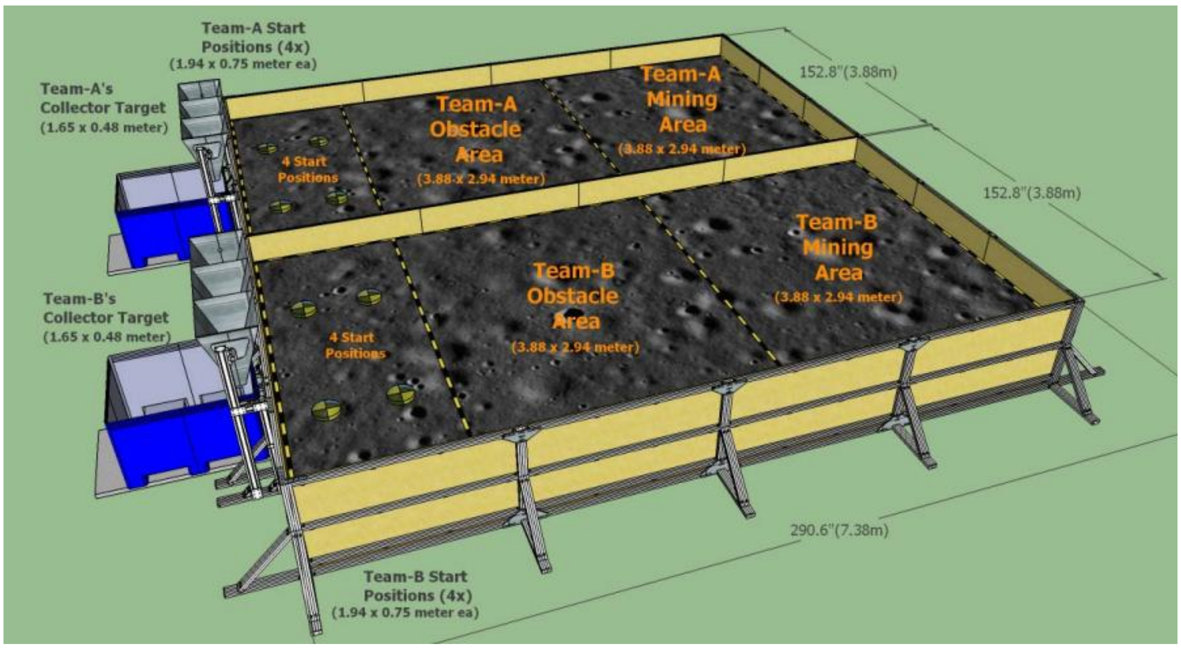

Figure 3: The mining area where the robot will be operating during the competition. The Lunabin is located to the left of the picture [2].

- All parts of Lunabot must be under the team's control at all times.
- Each team will have two, ten minute, attempts to mine and deposit at least 10kg of regolith.
  - Regolith can only be excavated from mining area defined above in Figure 3.
- The regolith must be deposited in the LunaBin in order to count towards the 10kg of regolith which can be seen below in Figure 4.
  - LunaBin will be 0.5m from top of regolith surface.
  - Opening will be 1.65m long and 0.48m wide.
  - No secondary container (i.e. bag or box) may be deposited inside LunaBin.
  - Regolith must be deposited in LunaBin in its raw state.

- A target can be attached to LunaBin for navigation purposes. The target must be attached during set up time.

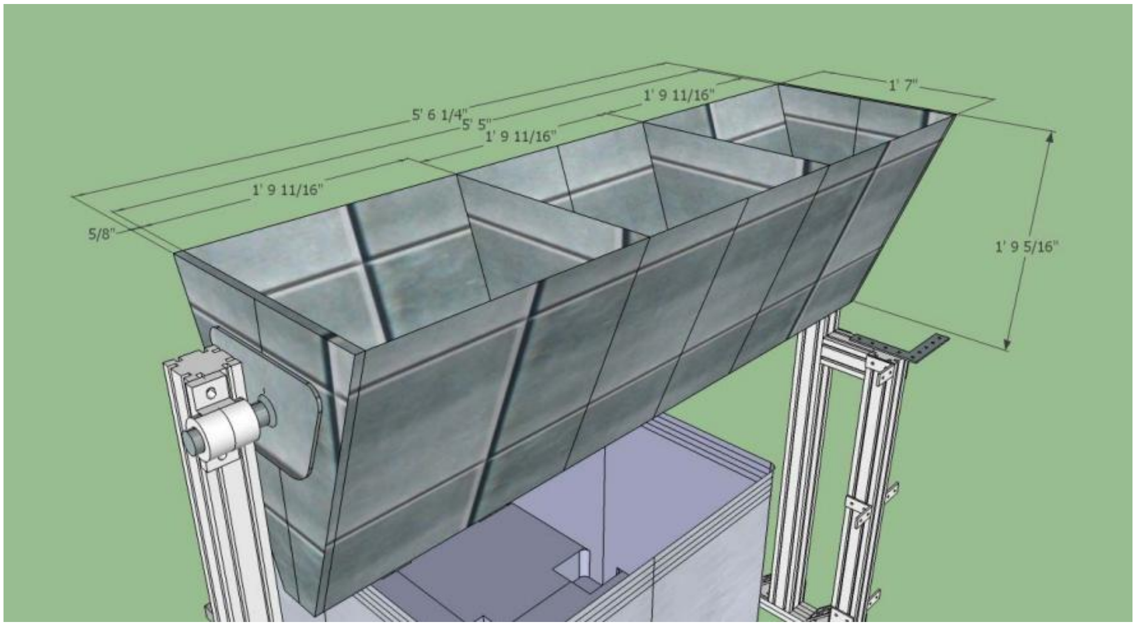

Figure 4: Diagram of the Lunabin that the regolith will be deposited after it is excavated by the robot [2].

- Be capable of navigating three randomly placed obstacles.
  - Each obstacle will have a diameter of approximately 20cm to 30cm and a mass of 7kg to 10kg.
- Be capable of navigating two craters, no wider than 30cm.
- Be capable of overcoming the naturally occurring rocks in regolith.
- No ramming of the walls.
- Must be equipped with an easily accessible red emergency stop button (kill switch) of minimum 5cm diameter on the surface of the Lunabot (with no steps required to access). This must stop the Lunabot's motion and disable all power to the Lunabot with on push motion of the button. The button should disconnect the batteries form all controllers (high current, forklift type button) and it should isolate the batteries from the rest of the active subsystems as well.
- No physical access to robot is allowed during competition; autonomous or telerobotic operations only.
  - Telerobotic operators are only allowed to use data and video from the Lunabot and NASA video monitors.
- Set up a wireless communication system using WiFi and dedicate a unique IP address
- Record and report the amount of energy consumed by the Lunabot during the competition.
- Provide some regolith dust tolerant design features.

- Cannot employ any fundamental physical processes (e.g. suction or water cooling in the open lunar environment), gases, fluids or consumables that would not work in a lunar environment.
- The Lunabot cannot penetrate the regolith surface with more force than the weight of the Lunabot before the start of each competition attempt.

Expected Results

By May 21st, 2012 the team will have created a wirelessly controlled robot capable of excavating regolith and traversing the competition's lunar area. The system will use power effectively and conservatively. It will be capable of sending applicable data back to the command center. The robot will also be capable of some level of autonomy and will be capable of operating and mining on the moon's surface.

Works Cited

[1] McGill University. Centre for Intelligent Machines. 2011. 1 October 2011 <http://www.cim.mcgill.ca/~neville/RHex/indexRHex.html>.

[2] National Aeronautics and Space Administration. Lunabotics Mining Competition. 2011. 29 September 2011 <http://www.nasa.gov/offices/education/centers/kennedy/technology/lunabotics.html>.