

Mid-Term Progress Report



Lunar Regolith Excavator Student Competition Team 15: Hexcavator

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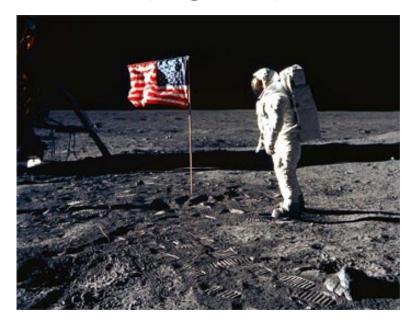
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Seth Murphy Devin Walden



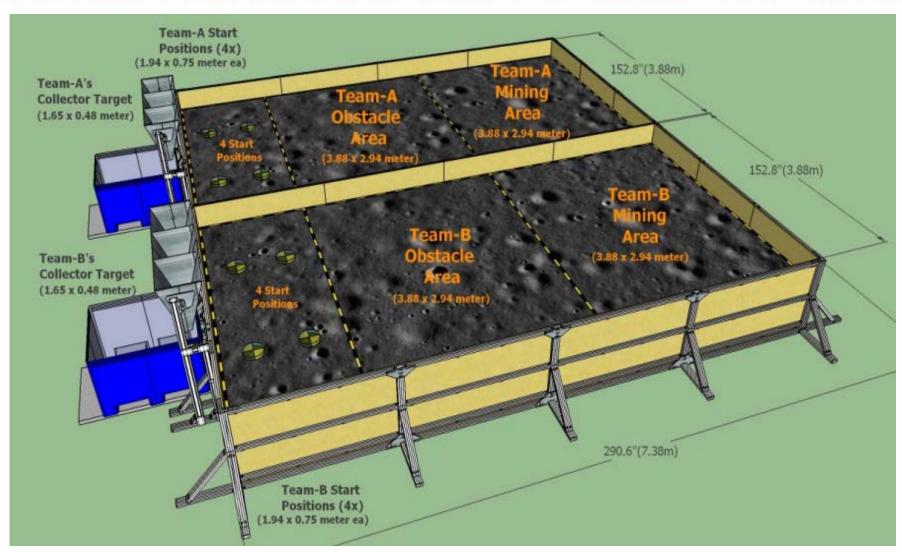
Project Inspiration

- NASA's Third Annual Lunabotics Competition
- Competition Date: May 22, 2012
- Determine feasibility of lunar inhabitance
 - Analyzing lunar soil (regolith)





Competition Area





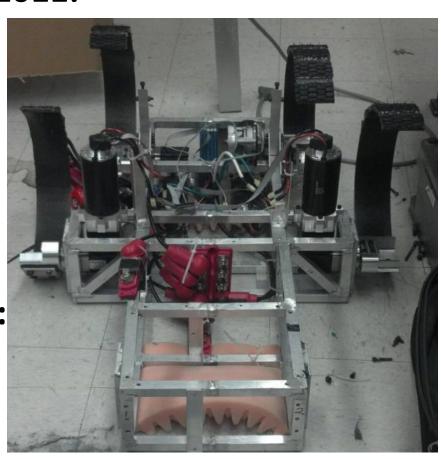
Previous Hexcavator Efforts

Completed as of August 2011:

- Frame
- Legs
- Motors
- Batteries
- Stop Button

Needs as of August 2011:

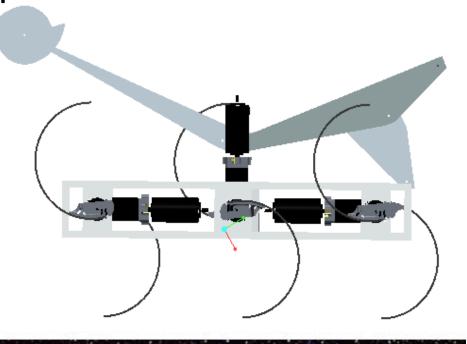
- Excavation
- Controls





Approach

- Locomotion Scheme
- Excavation Design
- Inter-robotic communication
- Wireless Communication
- Cost Analysis
- Time Line

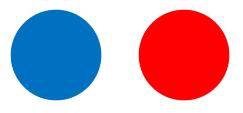


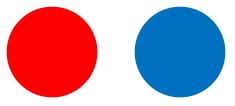


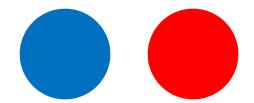
Locomotion

- Hexapedal walker
- Alternating tri-pod gait
- C-Legs
- Uses Bueheler Clock











Excavation Design Status



- Linkage moves correctly
- Fixed Length waiting for new part
- Testing in Sand when new link done



Excavation Design Status

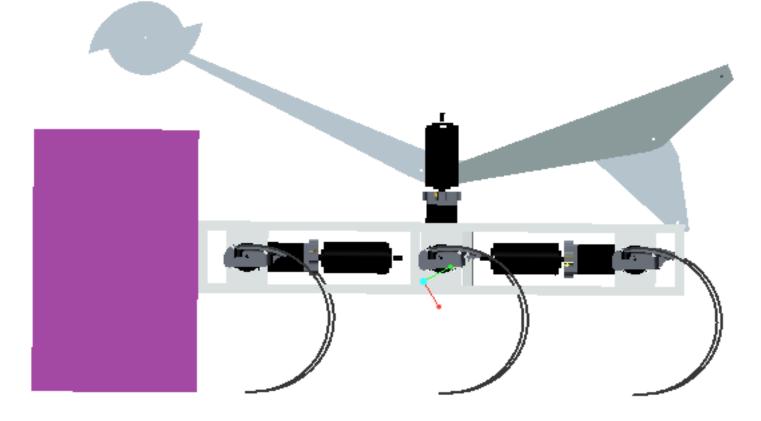


- Forked Arms Status
- Lateral Instability
- Drum Rotation



Excavation Design Future Goals

- Testing lateral instability
- Testing loading and unloading





Intra-Robotic Communication Status

Previously

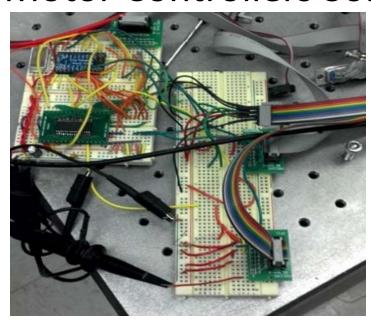
- Two legs moving unsynchronized with a simplistic control law
- Have required disconnect system

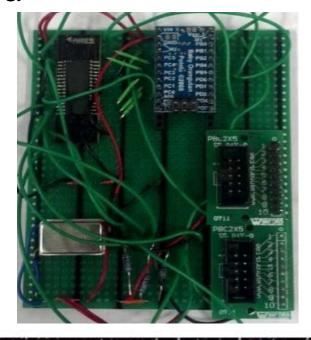


Intra-Robotic Communication Status

Current Electronics

- Two legs moving in a synchronized gate
- Have required disconnect system
- Motor Controllers Soldered







Intra-Robotic Communication Status

Current Mechanics

- All 6 legs and motors mounted
- Motor driver mounts fabricated



Two Legged Motion





Future Work

Future Work

- Tune gates for walking
- Integrate with wireless communications
- Add control for excavation

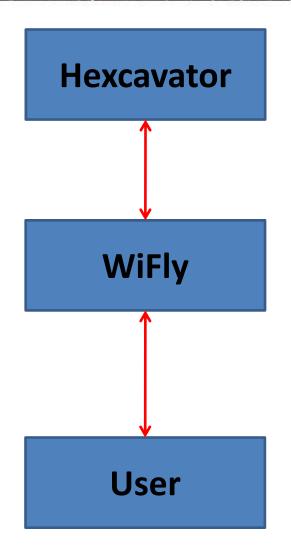


Wireless Communication

- NASA required
- Previously
 - Unable to communicate
 - Coding
- Currently
 - Reverse to Data Mode
 - Use Wifly Tester
 - Unable to communicate to Wifly from PC



Wireless Communication



Current Status

•Able to communicate from WiFly to Computer

In Progress:

- SPI-UART Bridge Connection
- Passing Serial Data



Cost Analysis

Components	Cost	Quantity	Total Cost	
Bushings	\$ 0.72	50	\$ 36.00	
PC104	\$ 691.00	1	\$ 691.00	
Aluminum (Excavation)	\$1,445.22	1	\$ 842.22	
ABS Plastic (Excavation)	\$42.43	1	\$ 42.43	
Steel Shafts	\$ 41.60	1	\$ 41.60	
CirClips (Pack of 10)	\$ 8.50	5	\$ 42.50	
Motor for Excavation	\$ 359.34	2	\$ 718.68	
Motor for Drum	\$ 249.99	2	\$ 499.98	
WiFly	\$ 84.95	5	\$ 424.75	
Baby O	\$ 19.00	5	\$ 95.00	
Motor Drivers	\$ 220.00	4	\$ 880.00	
Voltage Regulators	\$13.49	5	\$ 67.45	
Decoders	\$13.10	5	\$ 65.50	
Clocks	\$5.49	7	\$ 38.43	
Copper Sheet	\$58.99	1	\$ 58.99	
Travel Expenses (Estimated)	\$1,880.85	1	\$ 1,880.85	
Total			\$ 6,425.38	

Total Budget: \$9000

• FAMU/FSU College of

Engineering: \$2000

• National Space Grant: \$ 4000

•Northrop Grumman \$3000



Gantt Chart

	October	November				March	April
	1 2 3 4	5 6 7 8 9	10 11	12 13 14 15 16	17 18 19 20	21 22 23 24	25 26 27 28 29
Research (Complete)							
Prototype 1a:							
Walking Platform							
Initial Prototype of Excavation							
(Complete)							
Prototype 1b:							
Excavation Design (Complete)							
Prototype 2:							
Wireless Walking Robot with Excavation							
Prototype 3:							
Walking Robot in Rough Terrain							



Questions?









References

- U. Saranli, M. Buehler and D. E. Koditschek, "RHex: A Simple and Highly Mobile Hexapod Robot", International Journal of Robotics Research, vol. 20, no. 7, pp. 616-631, 2001
- www.sparkfun.com
- Roboteq. Hdc2450_datasheet. 20 July 2010. PDF.
- Maxon Motors. RE-65-353294_11_EN_084. May 2011. PDF.
- "Robot Power Products Open Source Motor Control (OSMC)." Robot Power. Web. 04 Dec. 2011.
 http://www.robotpower.com/products/osmc_info.html.
- Lloyd, Sonny, Matt McFadden, Don Jennings, and Robert L. Doerr. Osmc_project_documentation_v4_21. 24 Dec. 2001. PDF.



Customer Requirements

- Initial dimensions: 1.5m x 0.75m x 0.75m
- Maximum weight: 80kg
- WiFi Communication
- Capable of operating in lunar environment
 - Obstacles and craters
- Minimum regolith excavated: 10kg
 - Two, ten minute attempts
- Emergency stop button





CPU Stack

Advantech PCM-3355

- Cost: \$247.00

- CPU: AMD LX800 500MHz

- Ports: 2 USB, 2 RS-232,

1 RS-485

- Operating System: Windows CE 6.0 Pro Embedded



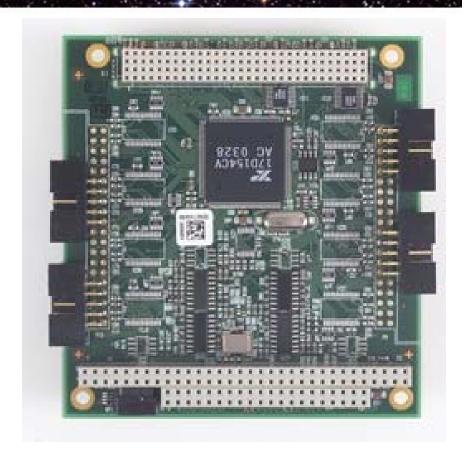


Serial Port Stack

- Advantech PCM-3644

- Costs: \$144.00

- Ports: 8 RS-232





- Digital I/O Stack
 - Advantech PCM-3724
 - Cost: \$79.00
 - Ports 48 I/O ports
 - All configurable
 - Logic: 5V TTL





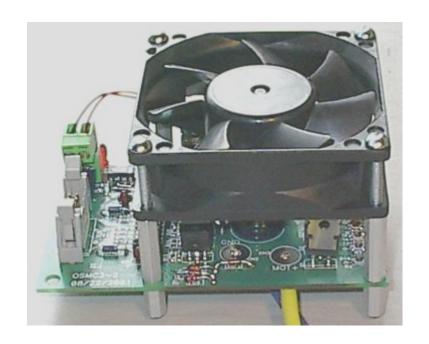
- Testing Procedure
 - Communicate with PC/104 with WiFly
 - Control motor with PC/104
 - Incorporate all three devices
- Motor control mechanism
 - Difficulties due to legged robot





Motor-Driver

- OSMC Motor-driver
- Intersil HIP4081A
- 160A continuous
- 400A surge
- Voltage control





Decoder Chip

- HCTL2023-SC
- 102,400 counts per revolution
- 32bit
 - Used to track multiple revoultions
- Single Byte Read

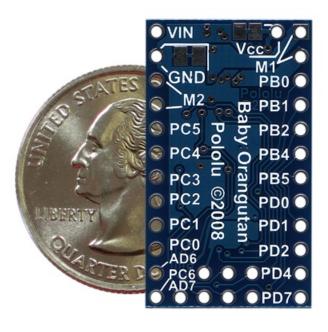


		BYTE SELECTED			
SEL1	SEL2	MSB	2ND	3RD	LSB
0	1	D4			
1	1		D3		
0	0			D2	
1	0				D1



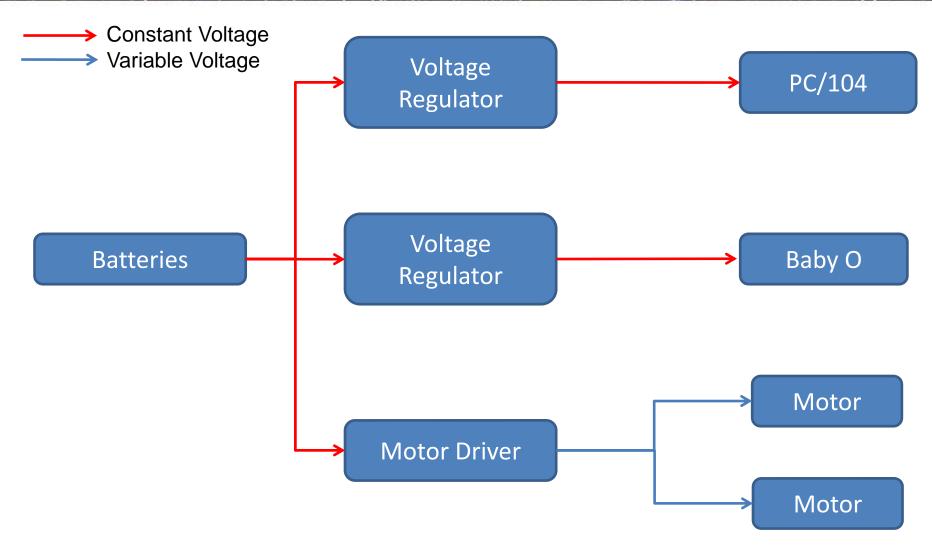
Baby Orangutan

- Atmega 328P
- •20MHz
- •18 I/O lines
- •1.2" x 0.7"
- •1.5g





Power Flow Chart





Batteries

- Rated for 37V
- Actual output about 42V
- •Run in Parallel for 37V potential and double current





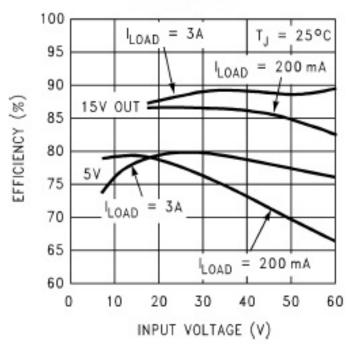
Voltage Regulator

Part No: LM2576HV-5.0

$$I_o = 0.5 \text{ to } 3.0 \text{ A}$$

 $V_{in} = 8V \text{ to } 60V$
 $V_o = 5V$

Efficiency





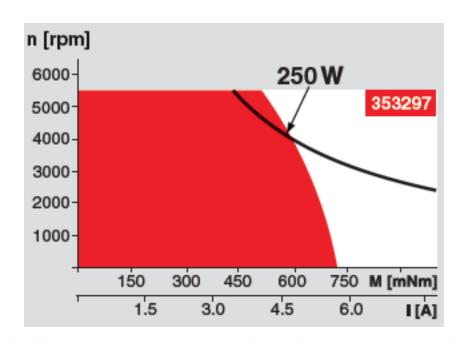






Motor

Nominal voltage = 18V Nominal torque = 442mNm Nominal current = 10A Stall torque = 14 Nm Starting current = 296A Nominal speed = 3,150rpm



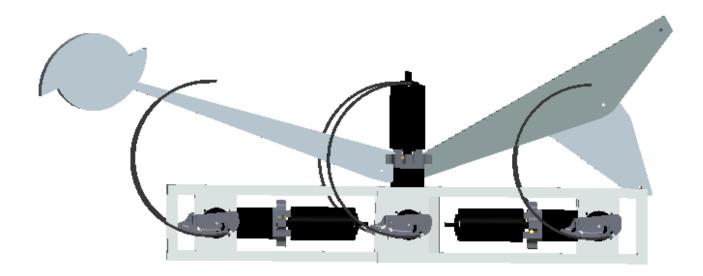




Excavation Conditions

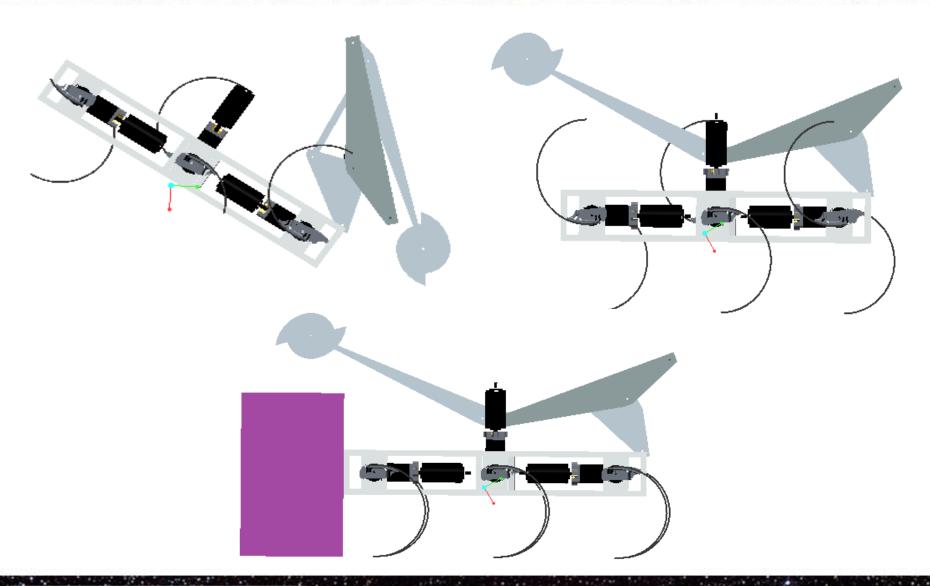
- Hexcavator initial dimensions:
 - 38.97cm x 123.01cm x 75cm
 - Mass: 67kg
- Measured while sitting

- Dimensions of Lunarena:
 - 7.38m x 3.88m x 0.62m





Major Positions





- Windows CE 6.0 Pro Embedded
 - Costs: \$18.00
 - Requirements: 1GB on storage
 - Restrictions: 512 MB RAM
 - Restricted by OS
 - Benefits: Advantech Software
 - Not compatible with Linux
 - Costs \$20.00
 - Makes interfacing with stacks easier



Complete Gantt Chart

	October November Dec. Ianuary February March April
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 25
Research Determine which previous components can be utilized.	
Locomotion Schemes and Controls. Design excavation system.	
Spec out Controllers and Motor Drivers.	
•	
Protoype 1a: Walking Platform Purchase motor contorllers, microcontrollers and decoders.	
Program controllers.	
Test walking indoors.	
Test walking on flat ground outside.	
Test walking in sand pit.	
Test turning in confinded enviornments.	
Initial Protoype of Excavation	
Design Iterations.	
Find simulant for excavation.	
Laser cut protoype from plastic.	
Determine if existing frame will be used.	
f necessary, redesign frame.	
Protoype 1b: Excavation Design	
Build first functional prototype.	
Testing getting soil from loosley compacted ground.	
Test getting soil from compacted ground.	
Develop and test a dumping mechanisim.	
Design control system for excavation system.	
Prototype 2: Wireless Walking Robot with Excavation	
Attach Excavation to walking platform.	
Test moving with attached excavation.	
Refine extraction control and mechanism.	
Test depositing soil into bin.	
Make Robot wireless.	
Prototype 3: Walking Robot in Rough Terrain	
Test combined system's ability to navigate obstacles.	
Refine locomotion control for excavation over uneven ground.	
Test picking up soil on uneven ground.	
Prepare for final demonstration.	



LunaBin

