LUNABOTICS Mining Test Bed

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USR UTAH STUDENT ROBOTICS

Introduction

Utah Student Robotics (USR) has built a lunar rover to compete in the NASA LUNABOTICS competition. USR wants to test multiple bucket drum excavator designs and determine the forces and torques acting on the drum while it is mining a lunar regolith. We built a test bed that provides analysis of X-Y forces and torques on the drum, monitors current drawn by the drive motors, and correlates these measurements to the excavator's depth in regolith simulant. In addition to these engineering analyses, the test bed is IP60 rated (fully dustproof), user-friendly, and operable by one person.

Objectives

The goal of this project was to build a test bed:

- That is easy to operate
- Provides X-Y force and torque analysis on USR's bucket drum excavator
- Measures depth-force relations
- Monitors motor current

Design Specifications

Table 1. Selection of most critical design specifications

Metric	Specification	Unit	Value	Range
1	X-Y force accuracy	N	±5	X: 0 – 67.78 Y: 0 – 341.94
2	Torque accuracy	kg·cm	±1	0 – 138.23
3	Excavator depth accuracy	cm	±0.1	0 – 45
4	Motor current accuracy	mA	±100	0 – 4400
5	Rotational drive speed	RPM	33 ± 5	28 – 38
6	Total cost	USD	≤600	

Design Features

Our LUNABOTICS Mining Test Bed contains the following features that accomplish our design specifications:

- 2 S-type load cells for Y-direction force measurements
- 2 bar-type load cells for X-direction force measurements
- 2 student designed and fabricated torque transducers
- 2 motors that rotate the bucket drum excavator
- A linear actuator that moves the lower hub vertically

Figure 2 shows the lower subassembly in two parts, including labels for each key component.

Final LUNABOTICS Mining Test Bed

Figure 1. CAD model (left) and final fabricated test bed (right)

LUNABOTICS Mining Test Bed Lower Subassembly

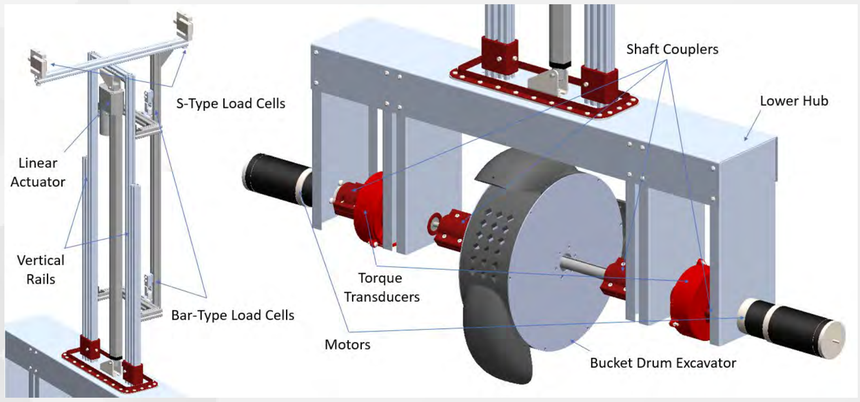

Figure 2. Lower subassembly viewed in two parts: components providing vertical motion and x- and y-force sensing (left) and the lower hub with components providing rotational motion and torque sensing (right)

Acknowledgements

We would like to extend our sincerest gratitude to Utah Student Robotics for allowing us to use their lab, tools, and spare parts. This project would not have been possible without their support and specifically, the help and partnership of Evan Cleveland with USR.

Results

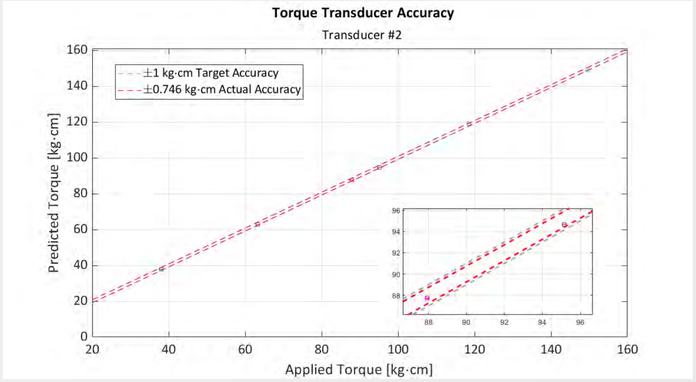

Figure 3. Data from torque transducer testing that shows accuracy within ±0.746 kg·cm with 95% confidence

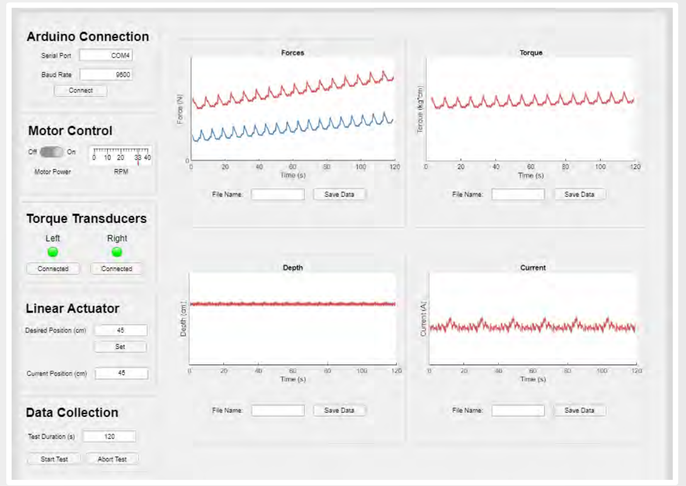

Figure 4. Graphical user interface output showing X-Y forces, torque, depth, and current measurements with simulated data

- X-Y force measurements are accurate to within ±5 N
- Torque transducers are accurate to within ±0.746 kg·cm
- Excavator depth measurements are accurate to within ±0.5 cm
- Motor current measurements are accurate to within ±100 mA
- Rotational drive speed is accurate to within ±1 RPM
- Final cost of the system is $552.40

Conclusion

The LUNABOTICS Mining Test Bed meets all but one of its requirements: the excavator depth measurement accuracy. The test bed succeeds in all other areas, including X-Y force measurements, torque measurements, motor current measurements, rotational drive speed, and total system cost.