Mass Inferencing Model Creation and Deployment to the RASSOR Lunar Excavation Robot

Nashir A. Janmohamed*, Joseph M. Cloud†, Kurt Leucht‡, Evan A. Bell§
Brad C. Buckles¶, Michael A. DuPuis‖
NASA Kennedy Space Center, KSC, FL, 32899

The Regolith Advanced Surface Systems Operations Robot (RASSOR) Excavator [1] is a teleoperated mobile robotic platform with a unique space regolith excavation capability. The Intelligent Capabilities Enhanced RASSOR research project [2] developed functionality for inferencing regolith mass ingested during RASSOR operation, enhancing RASSOR's ability to successfully complete ISRU missions. To teleoperate or run autonomously, it is crucial for the quantity of regolith mass ingested by RASSOR to be available as a system state for efficient operation. For example, during autonomous operation, RASSOR should navigate and move to a processing plant to offload the collected regolith when the drums are full; without knowledge of how much mass is in the drums, this type of high-level planning is not possible. Four distinct modeling approaches were employed in developing a mass inferencing approach that could work on RASSOR. All take in system states, such as arm/drum positions, velocities, currents, voltages, and robot pose, and output a mass prediction for each set of the robot's bucket drums.

1) **A neural network model that takes a vector of normalized system states;**
2) **A model that uses the integrated power consumption of an arm-raise (normalized by velocity);**
3) **A model that uses average drum current over a variable length interval of the drum disengaged from the surface; and**
4) **A real-time estimation model that aggregates excavation drum current.**

The developed models run in real time, outputting predictions for the front and rear drums, timestamp of the last prediction, and total mass in RASSOR's drums. Further testing is required to validate the arm-raise model (2), though initial tests indicate reasonable performance (<10% mean error) on the hardware. The linear fit of average drum-current model (3) had a front value of $R^2 = 0.99$ and a rear value of $R^2 = 0.98$ on the validation dataset. This model currently has the best performance on unseen data. The real time model (4) is still in development, though initial results on a small subset of the training data show that it has high accuracy in predicting the increase in mass during excavation. Though work remains to be done with deploying a high-fidelity model to the physical system that makes predictions with error below the desired threshold, the modular architecture for model development allows quick adjustment of parameters to increase model fidelity. This architecture can also be adapted to use lunar excavation data to create models that are reflective of RASSOR's dynamics when operating on the lunar surface. The results are promising as it has been shown that models can be developed that accurately estimate excavated regolith mass.

*Intern, Advanced Engineering Development Branch, NE-L6.
†Robotics Engineering Trainee, Advanced Engineering Development Branch, NE-L6, and AIAA Member.
‡AST, Software Branch, NE-XS.
§AST, Structures & Mechanisms Design Branch, NE-XD.
¶AST, Exploration Systems & Development Office, UB-E0.
‖Principal Investigator - Robotics and Autonomous Systems, Advanced Engineering Development Branch, NE-L6.

References

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