Ira A. Fulton Schools of Engineering
Arizona State University
School of Electrical, Computer and Energy Engineering

Electrical Engineering Capstone Design Project

Robotic Explorer for Hypothesized Surfaces

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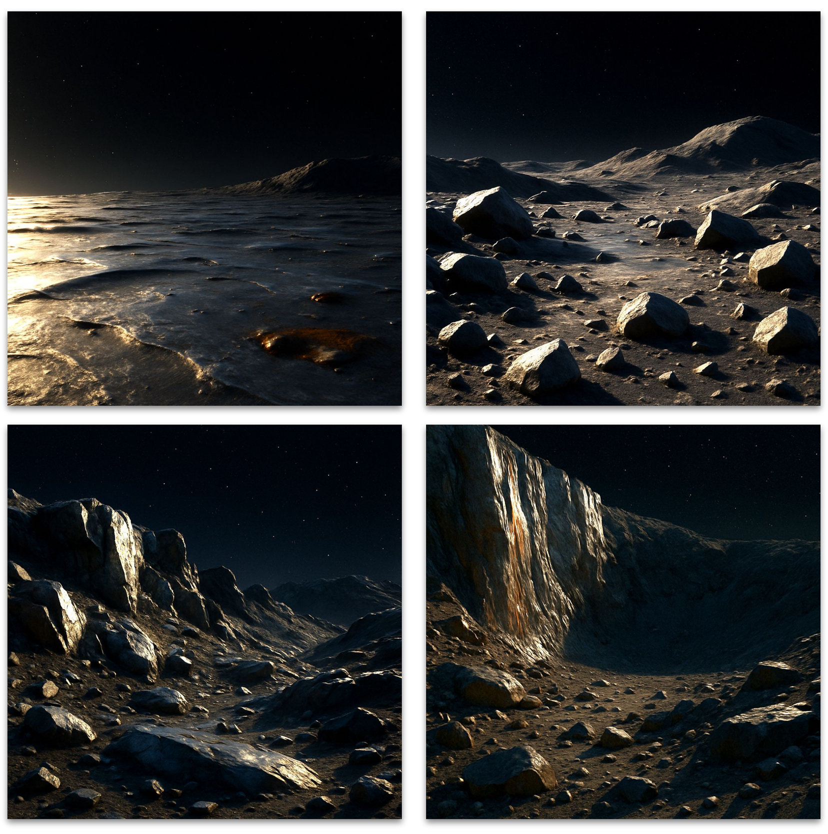
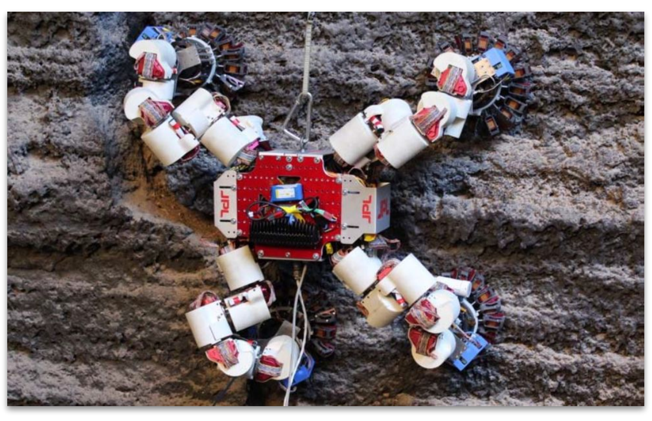
Introduction

- Team 30 has designed a modular sensory acquisition system for the LEMUR-3 NASA rover to inform path planning and surface classification in the theoretical surface exploration phase of the Psyche Mission



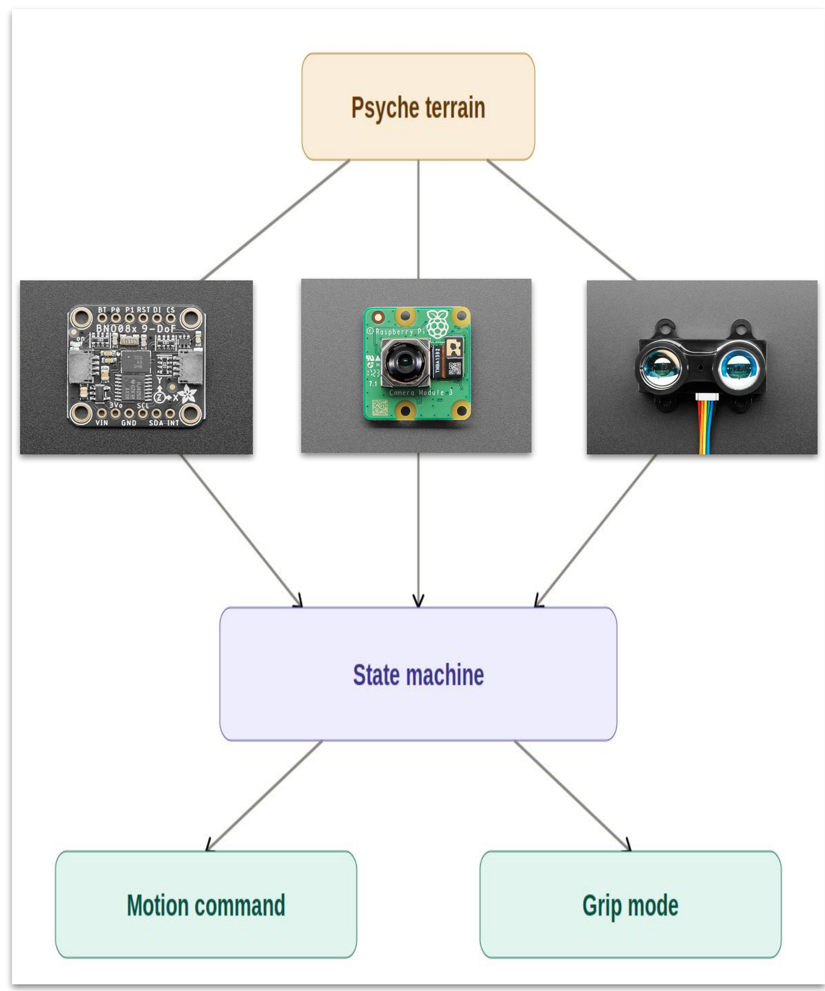
Theoretical Psyche Surfaces



LEMUR-3 Rover

Concept and Theory

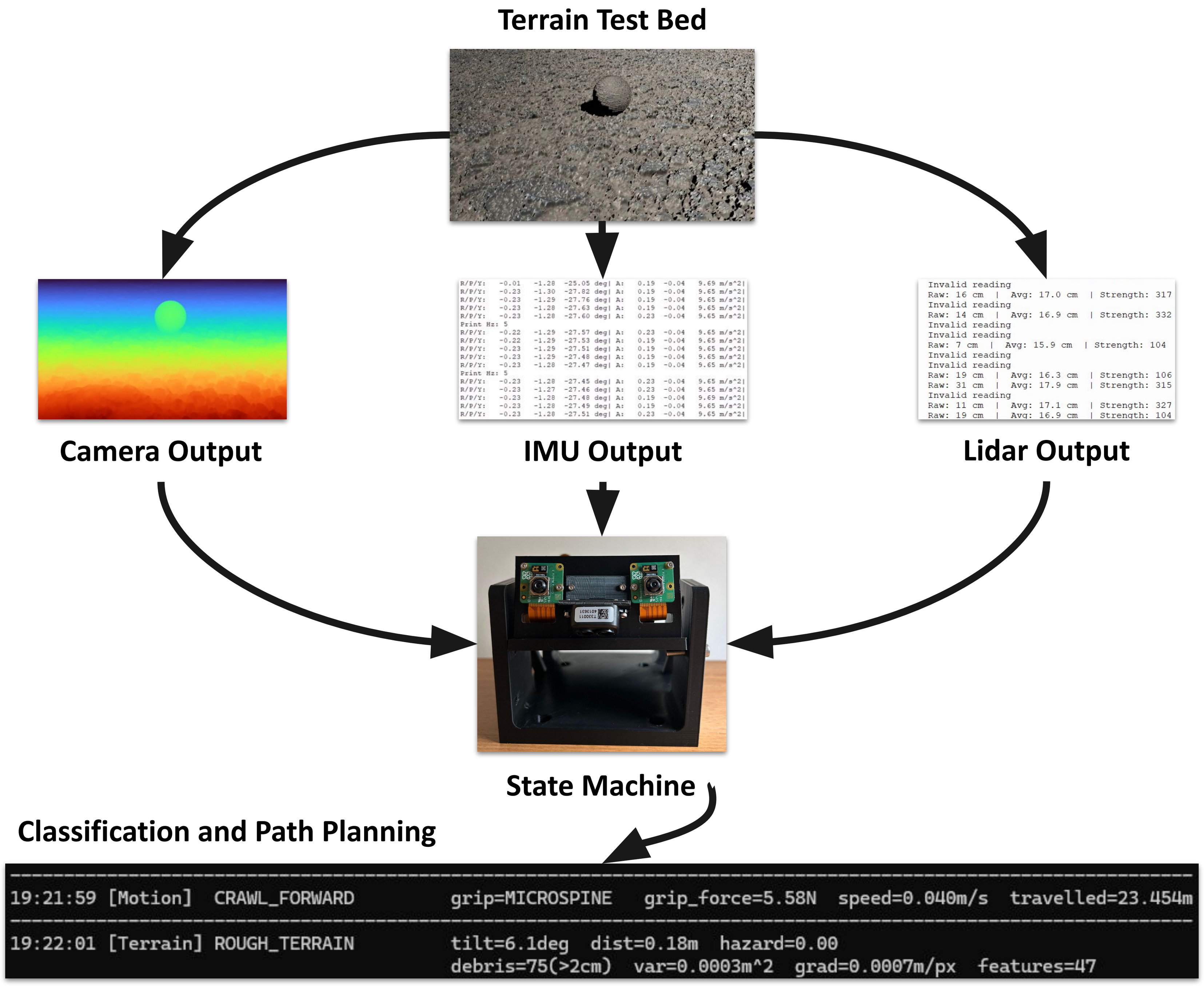
- IMU uses orientation and motion sensing to track rover movement, detect stationary states, and support navigation stability in low gravity environments
- Lidar sensor measures distances to surrounding terrain by emitting laser pulses and timing their reflections, enabling precise proximity detection of terrain
- Cameras use stereo disparity to construct a depth map of the immediate terrain for classification, and the horizon for path planning
- State Machine organizes the input data and controls the flow of different states, classification of surfaces, next rover move, strength and type of foot gripping, hazard mode



Sensory Input Diagram

Testing Results

- IMU - testing for motion detection accuracy, including sensitivity to slow movements and stationary detection reliability
- Lidar - testing for distance accuracy with varying lighting and terrain conditions
- Cameras - testing for depth accuracy, especially in conditions of metallic/reflective surfaces and variable lighting as well as hazard detection
- State Machine - integrated sensors into stack and trained ML algorithms for accurate classification and motion

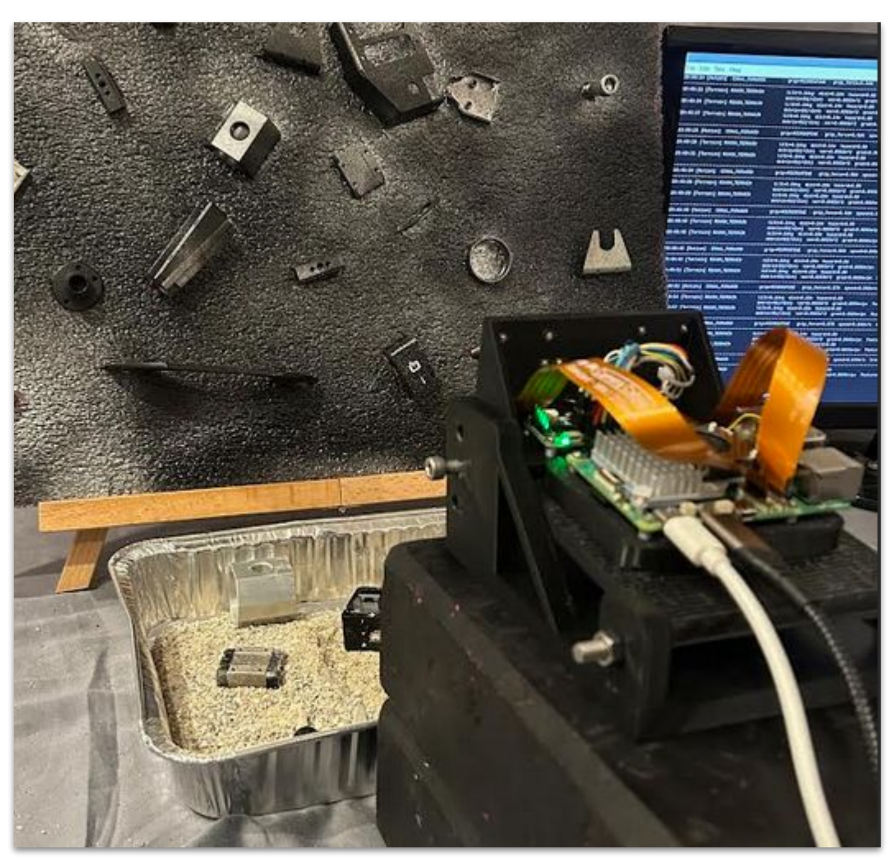


Conclusion

- IMU - successfully implemented motion sensing solution that provides reliable orientation tracking and motion detection to support rover state awareness and navigation stability
- Lidar - verified to provide accurate proximity and drop-off detection to feed into the state machine
- Cameras - successfully implemented visual solution that is resilient to expected Psyche conditions (reflective/heterogeneous/metallic regolith) to inform state machine for classification and path planning
- State Machine - accurately classifies Psyche environments, cycles though states, and commands motion

Future Considerations

- IMU - drift mitigation and reliability
- Lidar - moving frame would allow for a sweep of distance point
- Cameras - wide angle lens, real-time disparity
- State Machine - inverse kinematics for full joint motion



Full Prototype of Autonomous Planetary Rover Sensor Stack

*This work was created in partial fulfillment of **Arizona State University** Capstone Course "**EEE 489**". The work is a result of the Psyche Student Collaborations component of NASA's Psyche Mission (https://psyche.ssl.berkeley.edu). "Psyche: A Journey to a Metal World" [Contract number NNM16AA09C] is part of the NASA Discovery Program mission to solar system targets. Trade names and trademarks of ASU and NASA are used in this work for identification only. Their usage does not constitute an official endorsement, either expressed or implied, by Arizona State University or National Aeronautics and Space Administration. The content is solely the responsibility of the authors and does not necessarily represent the official views of ASU or NASA.*