Catherine Pavlov

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Education

Carnegie Mellon University — Pittsburgh, PA
Doctor of Philosophy in Mechanical Engineering — 2023

California Institute of Technology — Pasadena, CA
Bachelor of Science in Mechanical Engineering with Honors — 2016

Professional & Research Experience

Robotics Mechanical Engineer, NASA JET PROPULSION LABORATORY Advanced Robotic Systems Group — **2023 – 2024**

Mars Sample Recovery Helicopter:

- Spearheaded development of gravity offload system. Developed hardware and software for a system performance characterization testbed. Diagnosed performance anomalies in inherited hardware, and identified architectural changes to improve performance.

In-Space Assembly and Manufacturing:

- Drove research-stage development of system for in-space assembly and manufacturing of large structures in space. Broke key technical challenges into testable experiments, designed and fabricated testbeds, and used experimental results to direct conceptual designs.
- Mentored graduate students on both critical subtasks and independent research. Taught practical design principles, oversaw hardware fabrication, and guided research direction.

Graduate Research Assistant, CARNEGIE MELLON UNIVERSITY Robomechanics Lab — **2016 – 2023**
NASA Space Technology Research Fellow — 2018 – 2022
Jean-Francois and Catherine Heitz Scholar — 2020 – 2022
Carnegie Mellon Presidential Fellow — 2016 – 2017

Nonprehensile Terrain Manipulation:

- Pioneered work in the use of planetary rover wheels for modification of natural terrain - defined the space of terrain manipulation for wheeled rovers, which adds functionality to space rovers without adding hardware.
- Developed novel model of soil flow around a rover wheel and validated it on trenches dug both in a lab setting and with a NASA Mars rover prototype in the Atacama Desert. The model evaluates many times faster than standard approaches, making it viable for real-time use with low computing resources.
- Constructed a high-precision, low-cost testbed to evaluate wheel-terrain interaction using only COTS parts and at-home manufacturing capabilities. Used testbed to collect a dataset of wheel forces over a wider range of wheel states than existing literature.
- Expanded on existing wheel-terrain interaction models to enable wheel-based manipulation through the creation of a 3D terramechanics model. The newly developed model covers a wider range of wheel operational states than previously explored in the literature.

Rover Mobility Actuator Failure Analysis & Compensation:

- Assessed impact of individual motor failure on a prototype of NASA's VIPER lunar rover. Concluded that loss of a wheel drive motor is catastrophic, while steer and suspension actuators require reducing the maximum allowed terrain slope angle.
- Integrated the 3D terramechanics model with optimization techniques to automatically generate driving strategies that allow rovers to compensate for actuator failure. Demonstrated open-loop compensation for mobility degradation on a rover.

Microspine Robots for High-Angle Mobility:

- Spearheaded novel use of microspine technology that leverages the same mechanical compliance in a robot leg for both running and climbing abilities on a hexapedal robot.
- Invented new fabrication technique for microspine flexures using additive manufacturing, which drastically reduced both design iteration time and required manufacturing resources.
- Derived model of leg stiffness for automatic generation of robot leg geometry.

Intern, NASA JET PROPULSION LABORATORY — **Summer 2014 & 2015**
Doris Everhart Summer Undergraduate Research Fellow — Summer 2015
Homer J. Stewart Summer Undergraduate Research Fellow — Summer 2014

- Independently performed all mechanical and electrical design, testing, and fabrication of a robot for 3D mapping of Hawaiian volcanic vents. Built functional robot from the ground up both summers.
- Performed field work imaging volcanic vents with the robot in March 2015. Work resulted in high-fidelity 3D maps of Mauna Ulu fissures and novel insights into volcanic vent formation mechanisms. Co-authored a geology paper on our findings.

Professional & Research Experience, Continued

Research Assistant, CARNEGIE MELLON UNIVERSITY Planetary Robotics Lab **Summer 2016**

- Designed test setup and experimental plan for analyzing a novel locomotion concept for planetary rovers operating in soft soils.

Graduate Teaching Assistant, CARNEGIE MELLON UNIVERSITY **Fall 2017 & 2018**

- Taught junior-level Mechanical Design course for 120 students. Led team of seven Teaching Assistants in crafting design challenge assignments, mentoring student teams, holding office hours, fabricating test equipment, creating and maintaining course documents, purchasing course materials, and grading homework, reports, and presentations.
- Taught junior-level Dynamics course for 180 students. Responsible for leading recitations, holding office hours, and grading exams.

Undergraduate Teaching Assistant, CALIFORNIA INSTITUTE OF TECHNOLOGY **Fall 2015**

- Taught sophomore-level Solid Mechanics course for 30 students. Responsible for holding office hours as well as grading homework assignments and exams.

Skills

Design, Prototyping, Fabrication and Electronics

Mechanical design and prototyping, 3D printing and 3D printer maintenance, lathe, mill, CNC mill, waterjet & laser cutter, microcontrollers, electronic prototyping, soldering, selection and assembly of electrical COTS parts and systems

Software & Programming Languages

SolidWorks, MATLAB, Git, LaTeX, Python and C, Adobe Photoshop, Illustrator & Premiere Pro

Selected Publications

Catherine Pavlov and Aaron M. Johnson. *A Terramechanics Model for High Slip Angle and Skid with Prediction of Wheel-Soil Interaction Geometry*. Journal of Terramechanics, February 2024.

Catherine Pavlov. *Off-Nominal Rover Driving: Terrain Manipulation and Degraded Mobility Compensation.* Carnegie Mellon University, 2023.

Paul Nadan, Dinesh K. Patel, **Catherine Pavlov**, Spencer Backus, and Aaron M. Johnson. *Microspine Design for Additive Manufacturing.* IEEE/RSJ International Conference on Intelligent Robots and Systems 2022.

Catherine Pavlov and Aaron M. Johnson. *Field Experiments in Nonprehensile Terrain Manipulation with Planetary Exploration Rovers*. International Symposium on Artificial Intelligence, Robotics and Automation in Space (i-SAIRAS), October 2020.

Renee Jessica Wallace, **Catherine Pavlov,** and Aaron Johnson. *Design of Microspine-Enhanced Spring Legs for Robotic Running and Climbing*. Dynamic Walking, May 2020.

Matt Martone, **Catherine Pavlov**, Adam Zeloof, Vivaan Bahl, and Aaron M Johnson. *Enhancing the Vertical Mobility of a Robot Hexapod Using Microspines*. Technical Report arXiv:1906.04811 [cs.RO], arXiv, 2019.

Catherine Pavlov; and Aaron M. Johnson. *Soil Displacement Terramechanics for Wheel-Based Trenching with a Planetary Rover.* IEEE Intl. Conference on Robotics and Automation, pages 4760–4766, Montreal, Canada, May 2019.

Carolyn E. Parcheta, **Catherine A. Pavlov**, Nicholas Wiltsie, Kalind C. Carpenter, Jeremy Nash, Aaron Parness, Karl L. Mitchell. *A robotic approach to mapping post-eruptive volcanic fissure conduits*. Journal of Volcanology and Geothermal Research, Volume 320, 2016, Pages 19-28.

Leadership

Instructor, Rock Climbing & Mountaineering Schools – EXPLORERS CLUB OF PITTSBURGH	2018 – 2023
Rock Climbing Chair, Explorers Club – CARNEGIE MELLON UNIVERSITY	2017 – 2023
President, Explorers Club – CARNEGIE MELLON UNIVERSITY	2020 – 2021
Visiting Instructor, CAD & 3D Printing Course – GWEN's GIRLS ACADEMIC SUCCESS INITIATIVE	2021 – 2023
Mentor, Women in Mechanical Engineering – CARNEGIE MELLON UNIVERSITY	2018 – 2021
Red Cross First Responder/Health Advocate, Blacker House – CALIFORNIA INSTITUTE OF TECHNOLOGY	2014 – 2016