ZACHARY HAMMOND

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EDUCATIONAL BACKGROUND

Stanford University   MARCH 2021 | PALO ALTO, CA
Ph.D. in Mechanical Engineering
    ADVISOR: Sean Follmer
    THESIS TITLE: Design, modeling, and control of compliant shape-changing robotics
    RESEARCH AREAS: Manipulation planning, grasp optimization, motion planning, dynamic modeling, mechanical design

University of California, Berkeley – College of Engineering   DECEMBER 2014 | BERKELEY, CA
Bachelor of Science in Mechanical Engineering
    GPA: 3.93

WORK EXPERIENCE

Intuitive Surgical
NAVIGATION HARDWARE ENGINEERING INTERN   2018-2019 | SUNNYVALE, CA

- Designed and constructed novel active and passive testing environments that simulated human surgical conditions.
- Programmed active environments to follow given trajectories and developed a graphical user interface to control the active environments easily.

Otherlab!
ENGINEERING INTERN   2014-2015 | SAN FRANCISCO, CA

- Designed a cutting head for a fiber optic laser cutter. This included assemblies for locating optical equipment, motion stages that focus optics and position the cutting head, and pneumatic channels for pressurized air
- Designed an embedded system for interfacing with and conditioning sensor feedback from cutting head.
- Tuned motion controller to position cutting head above work piece.
- Created testing apparatuses including a temperature controlled environmental chamber, a laser micrometer scanner, and a bending force measurement device.

The City of Anaheim
ENGINEERING INTERN – WATER SERVICES DEPT. AND ELECTRIC OPERATIONS DEPT.   SUMMER 2012 | ANAHEIM, CA

- Researched the benefit and cost of the installation of a secondary odor filtration system and composed a report for the city council arguing against the installation.
- Collaborated on the implementation of a computer program that automatically updated files on portable computers
- Applied a new inventory system to ensure reliable accounting and increase productivity of the plant operators

RESEARCH EXPERIENCE

Graduate Research Assistant
STANFORD SHAPE LAB, ADVISOR: DR. SEAN FOLLMER   2016 - PRESENT | PALO ALTO, CA

- Lead research on the design, modeling, and control of compliant shape changing robotics

Undergraduate Research Assistant
BERKELEY ROBOTICS AND HUMAN ENGINEERING LABORATORY, ADVISOR: DR. HOMAYOON KAZEROONI   2014 | BERKELEY, CA

- Designed control software and electronics enclosures for medical exoskeletons for people with mobility disorders

Undergraduate Research Assistant
POLY-PEDAL LAB, ADVISOR: DR. ROBERT FULL   2013 – 2014 | BERKELEY, CA

- Designed and programmed small robotic systems to correct their orientation after they become inverted. Based righting strategies off of the righting reflexes of a winged cockroach (Periplaneta americana).

Research Experience for Undergraduates Intern
NSF ERC EUV – KAPTEYN & MURNANE GROUP   SUMMER 2013 | BOULDER, CO

- Characterized and improved the signal-to-noise-ratio of a table-top EUV laser experiment by measuring and attenuating mechanical vibrations present on the optical table

Undergraduate Research Assistant

- Developed a numerical simulation to study the addition of hydrogen peroxide to methane fueled Homogeneous Charge Compression Ignition engines to explore how hydrogen peroxide may be used as a means of controlling the combustion event. analysis

SKILLS

Control: PID, model-based, motion planning, optimal control, optimization

Electronics: digital and analog circuits, sensors, actuators, embedded systems, Altium, EagleCAD, Ciruitmaker

Mechatronics: DC, BLDC, stepper, servo, linear motors, solenoids, pneumatics, motor drivers, gears, belts

Fabrication: laser cutting, 3D printing, mill, lathe, waterjet, CNC

Programing: C, C++, Matlab, Python, ROS, LabVIEW, Assembly

Composite Manufacturing: hand layup, vacuum infusion

CAD: SolidWorks, Inventor, AutoCAD, OnShape

Soft Materials: Sewing, silicone molding, soft actuators

PUBLICATIONS

Hammond, Z. M. & Follmer, S. (2021). Grasp analysis and manipulation kinematics for isoperimetric truss robots. In Press.

Stuart, A. D., **Hammond, Z. M.,** & Follmer, S. (2021). Balloon animal robots: Reconfigurable soft robots. In Preparation.

Hammond, Z. M. & Follmer, S. (2021). Pneumatic reel actuator: A variable stiffness, high-extension, pneumatic actuator. In Preparation.

Usevitch, N. S.*, **Hammond, Z. M**.*, Schwager, M., Okamura, A. M., Hawkes, E. W., & Follmer, S. (2020). An untethered isoperimetric soft robot. *Science Robotics*, *5*(40).
(*) These authors contributed equally.

Usevitch, N. S., **Hammond, Z. M.**, & Schwager, M. (2020). Locomotion of linear actuator robots through kinematic planning and nonlinear optimization. *IEEE Transactions on Robotics*, *36*(5), 1404-1421.

Slade, P., Gruebele, A., **Hammond, Z.,** Raitor, M., Okamura, A. M., & Hawkes, E. W. (2017, September). Design of a soft catheter for low-force and constrained surgery. In *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 174-180). IEEE.

Usevitch, N., **Hammond, Z.,** Follmer, S., & Schwager, M. (2017, September). Linear actuator robots: Differential kinematics, controllability, and algorithms for locomotion and shape morphing. In *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 5361-5367). IEEE.

Hammond, Z. M., Usevitch, N. S., Hawkes, E. W., & Follmer, S. (2017, May). Pneumatic reel actuator: Design, modeling, and implementation. In *2017 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 626-633). IEEE.

Hammond, Z. M., Mack, J. H., & Dibble, R. W. (2016). Effect of hydrogen peroxide addition to methane fueled homogeneous charge compression ignition engines through numerical simulations. *International Journal of Engine Research*, *17*(2), 209-220.

PRESENTATIONS

"A soft, untethered isoperimetric robot." Presentation and poster at Bay Area Robotics Symposium, Berkeley, CA, November 2019.

"A soft, untethered isoperimetric robot." Poster at System X Conference, Berkeley, CA, November 2019.

"Variable stiffness linear actuator robot." Presentation and poster at 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Madrid, Spain, October 2018.

"Assistive device for rock climbing with soft actuators." Poster at the Stanford Mechanical Engineering Research Conference, Stanford, CA, 2016.

"The addition of hydrogen peroxide to methane fueled homogeneous charge compression ignition engines through numerical simulation." Presentation at ASME Undergraduate Research Symposium, Dearborn, MI, October 2013.

"Vibration characterization and attenuation of noise on a table-top extreme ultra-violet laser." Presentation at NSF REU Symposium, Boulder, CO, August 2013.

SELECTED PRESS FOR RESEARCH

CNN	Watch robot change its shape like a 'Transformer'
IEEE Spectrum	Stanford Makes Giant Soft Robot From Inflatable Tubes
Voice of America	Detali (Russian Service)
Medium	This shape-shifting soft robot can perform multiple functions
Digital Trends	Stanford's shape-shifting 'balloon animal' robot could one day explore space
Inverse	A "Human-Scale Soft Robot" Could Make Deliveries in a Quarantine
Syfy	Baymax on Mars? Shapeshifting 'Soft' Robot Could [Literally] Transform Planet Exploration
TechRepublic	New robot developed at Stanford changes shape like a 'Transformer'

PATENTS

Okamura, A. M., Follmer, S., Hawkes, **Hammond, Z. M.,** Usevitch, N. S., Schwager, M., & Ballard, J. (2020). "Reconfigurable, Adaptable Robotic Structures." *U.S. Patent Application No. 17/017299.*

PROJECTS

Optimal control of truss robots: I applied optimal control techniques (calculus of variations and RRT*) to plan the motion of a tetrahedral truss robot so that the structures stiffness to external forces is maximized.

Maze exploring turtlebot: In this group project, my team programmed a turtlebot to explore a maze under human direction while building a map and identifying the locations of QR tags. Then the robot drove autonomously using an A* path planner and a lower level path tracking controller to visit each tag in a given order.

Competitive mobile robot: In this group project, my team built and programmed a mobile robot to play a head-to-head game consisting of capturing control points on the game board and shooting foam balls into a basket.

Other projects: Distributed control of truss robots, hovercraft, inverted pendulum, magnetic levitation

AWARDS AND HONORS

2019	NSF NRI Grant (contributed in conception, writing, and execution)
2016	NSF Graduate Research Fellowship Honorable Mention
2015	NSF Graduate Research Fellowship Honorable Mention
2015	The Rose Hills Foundation Science and Engineering Graduate School Fellowship
2013	ASME Undergraduate Research Competition Winner
2012	Tau Beta Pi, Engineering Honors Society
2011	Long Beach Rotary Club Scholarship

TEACHING

Design Impact Master's Project I (ME316A) STANFORD UNIVERSITY
    Course Assistant Fall 2020

Introduction to the Design of Smart Produces (ME 216M) STANFORD UNIVERSITY
Course Assistant Spring 2020

Electricity and Magnetism (Physics 3B) LONG BEACH CITY COLLEGE
Supplemental Instructor Fall 2011 – Spring 2012

General Physics – Mechanics (Physics 2A) LONG BEACH CITY COLLEGE
Tutor Fall 2011 – Spring 2012

MENTORING

Research Mentor, Anthony Stuart, *Reconfigurable soft robotic structures* 2019 - 2020
Research Mentor, James Niffenegger, *Amphibious truss structure robots* 2020
Research Mentor, Rosemond Ho, *Acoustic sensing on inflated membranes* 2020
Research Mentor, Kyle Skyllingstad, *Isoperimetric robot swarms for continuum robot arms* 2019
High School Research Mentor, James Ballard, *Torroidal drive mechanism for isoperimetric truss robots* 2019

ACADEMIC SERVICES

Reviewer 2018 - 2020
  UR 2020, TMECH 2019, TMECH 2019, CHI 2019, IROS 2018

Director of Academic Affairs and Co-founder 2014
  Mechanical Engineering Transfer Student Union

OUTREACH

Stanford Research Outreach 2016 - 2019
  Demonstrated STEM and robotics research for elementary to high school students from low income backgrounds

Berkeley Engineering Outreach 2012
  Taught low-income high school students how to rapid-prototype designs with household materials

Tau Beta Pi Science Labs 2012
  Brought a science experiment about density to local elementary schools

Long Beach Robotics Club Outreach 2011
  Exhibited underwater robot to children at local FIRST robotics competitions

Long Beach BLAST (Better Learning for All Students Today) 2010
  Tutored at-risk elementary school children in math

RELEVANT COURSEWORK

Robotics: Topics in Multi-limbed Manipulation; Topics in Advanced Robotics Manipulation; Principles of Robotic Autonomy; Medical Robotics; Intro. to Robotics

Control Theory: Intro. to Optimal Control and Dynamic Optimization; Multi-Robot Control, Communication, and Sensing; Analysis and Control of Nonlinear Systems; Intro. Control Design Techniques;

Mechatronics: Smart Product Design A, B, & C; Introduction to Sensors

Dynamics: Advanced Dynamics, Simulation & Control; Advanced Dynamics and Computation

Math: Convex Optimization I, Intro. to Linear Dynamical Systems

Programming: Programming Abstractions (in C++)

PERSONAL

Enjoys snowboarding, surfing, dog ownership, 3D printing, board games