Nicholas Naclerio

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EDUCATION

Ph.D., Mechanical Engineering *2017-2023*
University of California, Santa Barbara
Dissertation: "Leveraging compliance and anisotropy to address robotic challenges"
GPA: 3.71/4.0

B.S., Mechanical Engineering *2013-2017*
Duke University
Senior capstone: "Implementing paddle shifters for Formula SAE"
GPA: 3.65/4.0

RESEARCH and WORK EXPERIENCE

Postdoctoral Researcher *2023-present*
Hawkes Lab, PI: Elliot Hawkes, UC Santa Barbara

- Developing plant root inspired anchoring device for reduced gravity sensor placement.
- Preparing autonomous payload to test anchoring device in reduced gravity.

NASA Space Technology Research Fellow *2019-2023*
Hawkes Lab, PI: Elliot Hawkes, UC Santa Barbara

- Published how granular fluidization and tip-extension enable robotic burrowing in *Science Robotics* [3].
- Designed a root-like robotic anchoring device for low gravity environments.
- Developed an autonomous payload to test my anchoring device in lunar gravity on a NASA suborbital spaceflight.
- Studied how tip-extension and other plant root behaviors can minimize reaction forces and maximize anchoring forces in robotic burrowing.

Graduate Student Researcher *2017-2023*
Hawkes Lab, PI: Elliot Hawkes, UC Santa Barbara

- Addressed challenges of soft, tip-extending "vine" robots including materials, retraction, steering, tip-mounts, and more [4, 6, 10, 12, 13, 16-18].
- Invented a simple fabric pneumatic artificial muscle with fast operation and low hysteresis by exploiting textile anisotropies [5].
- Designed a continuously variable harmonic drive that uses a gecko-inspired dry adhesive instead of gear teeth [7].

- Explored a micro-featured dielectric elastomer actuator design that is more robust to dielectric breakdown.
- Built wind tunnel experiment to verify analytical model [2] of wake behind an annular wind turbine

Undergraduate Research Assistant *2015 - 2016*
Nonlinear Dynamics Lab, PI: Dr. Brian Mann, Duke University
- Developed apparatus to study delayed feedback dynamics in coupled pendulums.
- Designed and built apparatus to test model of a novel, non-linear energy sink [8].

Ocean Energy Senior Design *2016 –2017*
Duke University
- Multidisciplinary project to harvest ocean energy to power buoy sensors and lights.
- Evaluated dynamics of buoy designs using with 3D printed prototypes in wave tank.

Shell Ocean Discovery X-Prize *2016*
Duke University
- Multidisciplinary project to map ocean floor using a heavy-lift UAV and diving sonar pod.
- Designed and tested buoyancy system for sonar pod using solid fuel rocket engines.

Co-President / Principle Engineer *2013 - 2017*
Formula SAE Motorsports Team, Duke University
- Led team to finish 36th/120 my senior year, our best placement since I joined.
- Advised subsystem leaders, taught design and fabrication skills.
- Redesigned drivetrain subsystem to reduce weight/parts.
- Designed paddle shifter buttons for implementing semi-automatic shifting.
- Redesigned wheel hubs to accommodate switch from 12″ to 10″ rims.

Hydro Power Engineering R&D/Operations Intern *Summer 2016*
Cube Hydro, Bethesda, MD
- Analyzed/inspected equipment failures, prepared repair instructions.
- Developed model to help predict future water flow to hydro plants.

Biomedical Assay Automation Intern *Summers 2012-2013*
Sequenta, Inc., South San Francisco, CA
- Designed automated protocols on a liquid-handling robot for gel electrophoresis and PCR preparations previously done by hand.
- Experimental identified defective PCR primers within a large, multiplexed pool; findings used to optimize now commercially launched clinical test.

HONORS and AWARDS

Fiona and Michael Goodchild Graduate Mentoring Award, UCSB	2022
Best Application Paper Award Finalist, IROS	2021
Robotics and Automation Magazine Best Paper Award, IEEE	2020
Space Technology Research Fellow, NASA	2019-2023
Graduate Research Fellowship awardee, NSF	2019
Mechanical Engineering Department Merit Fellowship, UCSB	2018
Graduate Merit Fellowship, UCSB	2017
Dean's List, Duke University	Fall '13, '15, '16, Spring '16
Pi Tau Sigma	2016
Eagle Scout Award	2012

SERVICE and TEACHING EXPERIENCE

Research mentor *2017-Present*

Hawkes Lab, UC Santa Barbara

- Mentored numerous undergraduate, master's, and PhD students highlighted below.

Undergraduate mentees

- *Daniel Chuyang Chen* (2022-present): Studying how to predict anchor failure in real time using force and displacement data.
- *Hicham Ben Abdallah* (2022-2023): Programing and testing for suborbital payload project.
- *Sahil Naik* (2022-2023): Electrical integration, testing, and programing for suborbital payload project.
- *Haotong Han* (2022-present): Studying how to predict anchor failure in real time using force and displacement data.
- *Andrew Krohn* (2022-present): Designed new regolith container for suborbital payload project. Designing self-contained anchoring devices.
- *Jonathan Sun* (2021-2022): Electrical lead of my Blue Origin capstone team, who I hired to continue the project over the summer.
- *Nick Lysek* (2021-2022): Leader of my Blue Origin capstone team.
- *Sean Chu* (2021-2023): Author on my upcoming journal paper on root-like robotic anchoring.
- *Shivani Deglurgar* (2021): UCSB FLAM student. Authored conference paper on her work.
- *William Heap* (2019-present): Authored a journal paper [1] and an award finalist conference paper [10]. NSF GRFP awardee, PhD student at Stanford.
- *Luis Ramirez* (2019): UC LEADS student [13]. NSF GRFP awardee. PhD student at Yale.
- *Ruby Gans* (2018): UCSB FLAM student.
- *Sydney Austin* (2018): UC LEADS student.
- *Sicheng Wang* (2017-2021): Authored a conference paper [12]. PhD student at Perdue.
- *Aaron Nguyen* (2017-2021): Authored a conference paper [11]. At SpaceX.

Master's student mentees

- *Theodore Model* and *Dean Passanini* (2022): Designed and built an untethered self-anchoring device for my root-like robotic anchoring project.
- *Hayden Stapleton* and *Daniel Pekin* (2019): Designed and built a device to track the position of my burrowing robot.

PhD student mentees

- Helped every younger PhD student in our lab write their first conference paper within six months of starting their program: *Anna Alvarez* [9], *Matt Devlin* [14], *Charlie Xiao* [15], and *David Haggerty* [17].

Senior Capstone Projects
UC Santa Barbara College of Engineering

Assistant Project Advisor *2022-2023*

- "SALR", development of jumping robot to access permanently shadowed Lunar craters.
- "Apical Robotics", development of large-scale vine robot for industrial pipe inspection.

Project Sponsor *2021-2022*

- "Test of Robotic Intrusion in Low-g", project to build a device to test my burrowing and anchoring work on a reduced gravity Blue Origin spaceflight in early 2023.
- Provided direct guidance to 11 mechanical and electrical engineering students.
- Students designed and built a complete prototype including a regolith container, anchoring device, penetrometer, compressed air system, electronic system, and chassis with strict design constraints.

Project Advisor *2021-2022*

- "Design of a low-gravity regolith excavation and containment system for the lunar environment", project to develop a modular regolith excavator attachment for a human-scale lunar vehicle.
- Students designed and built a working prototype that was integrated with the lunar mobility vehicle and could quickly excavate and deposit regolith.

Teaching Assistant

UCSB, Soft Robotics (graduate level) *Winter 2022*
UCSB, Product Design *Spring 2018*
Duke, Devices for the Developing World *Spring 2017*
Duke, Dynamics *Spring 2016*

Science Fair Project Advisor *2019-2021*
Santa Barbara County Science Fair

- Advised two junior-high student projects per year.

- One of my students won a Best in Division award at the 2021 Santa Barbara Science Fair.

Technical Proposal Advisor *2019*
NASA L'SPACE Proposal Writing and Evaluation Experience Academy
- Advised undergraduate students on their proposal "Lunar Soft Vine Robot for Subsurface Exploration."

Education Outreach Volunteer *2017-2019*
Materials Research Lab, UC Santa Barbara
- Shared soft robotics with K-12 students and educators through tactile demonstrations.

Strength Training Intern *2017-2018*
Athletic Performance Center, UC Santa Barbara
- Taught club sport athletes proper weightlifting and strength training techniques.

Reviewer at Large *2018-present*
- *Science Robotics*
- IEEE: *Robotics and Automation Letters*, *Robotics and Automation Magazine*, ICRA, IROS, RoboSoft
- *Frontiers in Robotics and AI*

PUBLICATIONS

Google Scholar profile: 483 citations as of 7/16/23

Journal Papers

1. Heap, W. E., Keeley, C. T., Yao, E. B., **Naclerio, N. D.***, & Hawkes, E. W.* (2022). Miniature, Lightweight, High-Force, Capstan Winch for Mobile Robots. *IEEE Robotics and Automation Letters*, 7(4), 9873-9880. *Contributed equally.
2. Kaufman-Martin, S., **Naclerio, N.**, May, P., & Luzzatto-Fegiz, P. (2022). An entrainment-based model for annular wakes, with applications to airborne wind energy. *Wind Energy*, 25(3), 419-431.
3. **Naclerio, N. D.,** Karsai, A., Murray-Cooper, M., Ozkan-Aydin, Y., Aydin, E., Goldman, D. I., & Hawkes, E. W. (2021). Controlling subterranean forces enables a fast, steerable, burrowing soft robot. *Science Robotics*, *6*(55). **Cover article.**
4. Haggerty, D. A., **Naclerio, N. D.,** & Hawkes, E. W. (2021). Hybrid Vine Robot with Internal Steering-Reeling Mechanism Enhances System-Level Capabilities. *IEEE Robotics and Automation Letters*, *6*(3), 5437-5444.
5. **Naclerio, N. D.**, & Hawkes, E. W. (2020). Simple, low-hysteresis, foldable, fabric pneumatic artificial muscle. *IEEE Robotics and Automation Letters*, 5(2), 3406-3413.

6. Coad, M., Blumenschein, L., Cutler, S., Zepeda, J. R., **Naclerio, N.**, El Hussieny, H., ... & Okamura, A. (2019). Vine Robots: Design, Teleoperation, and Deployment for Navigation and Exploration. *IEEE Robotics & Automation Magazine*. **IEEE Robotics and Automation Magazine Best Paper Award.**
7. **Naclerio, N. D.**, Kerst, C. F., Haggerty, D. A., Suresh, S. A., Singh, S., Ogawa, K., ... & Hawkes, E. W. (2019). Low-cost, continuously variable, strain wave transmission using gecko-inspired adhesives. *IEEE Robotics and Automation Letters*, *4*(2), 894-901.
8. Pennisi, G., Mann, B. P., **Naclerio, N.**, Stephan, C., & Michon, G. (2018). Design and experimental study of a Nonlinear Energy Sink coupled to an electromagnetic energy harvester. *Journal of Sound and Vibration*, 437, 340-357.

Refereed Conference Papers

9. Alvarez, A., Devlin, M. R., **Naclerio, N. D.**, Hawkes, E. W. (2022). Jumping on Air: Design and Modeling of Latch-mediated, Spring-actuated Air-jumpers. In *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).* (pp. 13220-13226). IEEE.
10. Heap, W. E., **Naclerio, N. D.**, Coad, M. M., Jeong, S. G., & Hawkes, E. W. (2021, September). Soft Retraction Device and Internal Camera Mount for Everting Vine Robots. In *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 4982-4988). IEEE. **IROS Best Application Paper Award Finalist.**
11. Nguyen, A. K., Russell, A., **Naclerio, N**., Vuong, V., Huang, H., Chui, K., & Hawkes, E. W. (2020, May). A tri-stable soft robotic finger capable of pinch and wrap grasps. In *2020 IEEE International Conference on Robotics and Automation (ICRA)*(pp. 9028-9034). IEEE.
12. Wang, S., Zhang, R., Haggerty, D. A., **Naclerio, N. D**., & Hawkes, E. W. (2020, May). A dexterous tip-extending robot with variable-length shape-locking. In *2020 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 9035-9041). IEEE.
13. Selvaggio, M., Ramirez, L. A., **Naclerio, N. D**., Siciliano, B., & Hawkes, E. W. (2020, May). An obstacle-interaction planning method for navigation of actuated vine robots. In *2020 IEEE International Conference on Robotics and Automation (ICRA)*(pp. 3227-3233). IEEE.
14. Devlin, M. R., Young, B. T., **Naclerio, N. D.**, Haggerty, D. A., & Hawkes, E. W. (2020). An untethered soft cellular robot with variable volume, friction, and unit-to-unit cohesion. In *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 3333-3339). IEEE.
15. Xiao, C., **Naclerio, N. D**., & Hawkes, E. W. (2019, November). Energy Harvesting across Temporal Temperature Gradients using Vaporization. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 7170-7175). IEEE.
16. Ozkan-Aydin, Y., Murray-Cooper, M., Aydin, E., McCaskey, E. N., **Naclerio, N.**, Hawkes, E. W., & Goldman, D. I. (2019, April). Nutation Aids Heterogeneous Substrate Exploration in a Robophysical Root. *In IEEE International Conference on Soft Robotics (RoboSoft)* (pp. 172-177).

17. IEEE. Haggerty, D. A., **Naclerio, N. D.**, & Hawkes, E. W. (2019, November). Characterizing environmental interactions for soft growing robots. In *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 3335-3342). IEEE.
18. **Naclerio, N. D.**, Hubicki, C. M., Aydin, Y. O., Goldman, D. I., & Hawkes, E. W. (2018, October). Soft robotic burrowing device with tip-extension and granular fluidization. In *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 5918-5923). IEEE.

PRESENTATIONS

Conferences

"Principles in plant roots enable robotic self-anchoring", presentation at *APS March Meeting*, Las Vegas, NV, 2023.

"Principles in plant roots enable robotic self-anchoring: design, experiments, and preparation for the Moon", poster presentation at *Gordon Research Conference in Robotics,* Ventura, CA, 2022.

"Robotic burrowing and self-anchoring inspired by plant roots", invited virtual presentation at the workshop "Grand challenges for burrowing soft robots" at *IEEE International Conference on Soft Robotics (RoboSoft)*, 2022.

"Vine Robotics", *MARS Conference*, Ojai, CA, 2022 (demo support and presenter assistant).

"Simple, low-hysteresis, foldable, fabric pneumatic artificial muscle," virtual presentation at *IEEE International Conference on Robotics and Automation (ICRA),* 2020.

"Investigating Growth and Granular Fluidization in a Minimally Invasive Burrowing Robot" virtual talk at APS March Meeting, 2020.

"Low-cost, continuously variable, strain wave transmission using gecko-inspired adhesives," poster presentation at *IEEE International Conference on Robotics and Automation (ICRA)*, Montreal, Canada, 2019.

"Soft, vine robots for construction," invited talk at the workshop "Automation in Construction: Artificial Intelligence and Robots for the Realization of Smart Buildings" at *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Macau, China, 2019.

"Soft robotic burrowing device with tip-extension and granular fluidization," podium presentation at *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Madrid, Spain, 2018.

Invited talks

"Plant-root inspired self-anchoring in reduced gravity" talk for NASA Glenn Research Center, Cleveland, OH, 2023.

Invited judge for UCSB Grad Slam first round: chemistry and physics, UCSB, 2023.

Invited panelist for Theta Tau engineering and robotics career discussion, UCSB, 2023.

"Soft robots could save your life", invited talk at Arrowsmith's Wine Bar in Solvang, CA, 2022.

"Vine robots: design challenges and unique opportunities", invited talk to the PRISMA Lab at the University of Naples Frederico II in Naples, Italy, 2022.

"My Career in ME So Far", invited podium presentation to the UCSB ASME club, 2021.

"Controlling Subterranean Forces to Enable a Fast, Steerable, Burrowing Soft Robot", virtual talk for NASA Space Technology Mission Directorate "Extreme Access" R&D Portfolio Review, 2021.

"Controlling Subterranean Forces to Enable a Fast, Steerable, Burrowing Soft Robot" invited virtual talk at the Carnegie Mellon University seminar series on robotic locomotion, 2021.

"Controlling Subterranean Forces to Enable a Fast, Steerable, Burrowing Soft Robot" virtual talk for NASA Glenn Research Center, 2021.

"Controlling Subterranean Forces to Enable a Fast, Steerable, Burrowing Soft Robot" virtual talk for NASA JPL Mobility and Robotics Section, 2020.

PATENTS

N. Naclerio and E. Hawkes, "Self-anchoring burrowing device for anchoring and sensor placement with low reaction force", patent application.

N. Naclerio, D. Goldman and E. Hawkes, "Method to deploy subsurface sensors and sensorized skins with an everting burrowing device", patent application.

Hawkes, Elliot, and **Nicholas Naclerio**. "Soft robotic device with fluid emission for burrowing and cleaning." U.S. Patent 11,633,849, issued April 25, 2023.

N. Naclerio and E. Hawkes, "Continuously variable inverse harmonic drive", provisional patent application.

N. Naclerio and E. Hawkes "Simple, low-hysteresis, foldable, fabric pneumatic artificial muscle", patent disclosure.

W. Heap, **N. Naclerio**, and E. Hawkes "Internal device for attaching cameras and tools to the tip of a pneumatic, tip-extending robot, and an internal pneumatically driven device", patent disclosure.

PRESS

Veritasium YouTube video with over 32M views "This unstoppable robot could save your life," 2021.

"Digital Dig." *Ripley's Believe it or Not: Escape the Ordinary*. Jordie R. Orlando. Ripley Publishing, 2022. 136. Print.

Burrowing robot press: UCSB, BBC Science Focus, Inside Science, Digital Trends, Advanced Textiles, *Tremors* Meme, among others (Altmetric) 2021.

Top of Mind with Julie Rose, live satellite radio interview and podcast "Vine Robots," 2021.

KCLU radio segment "South coast scientists create vine like robot that could be used in medicine and disaster relief," 2019.

CBS Innovation Nation TV segment "Robots that grow as they slither along," 2019.

GRANTS

NSF Division of Physics, "Dynamic deformable structures in forced granular interactions", (PIs: Daniel Goldman and Elliot Hawkes). *Helping write and providing preliminary data.* In preparation.

NASA Flight Opportunities (lunar gravity suborbital flight) "Testing a root-like burrowing device in Lunar conditions," (PIs: **Nicholas Naclerio** and Elliot Hawkes). *Wrote and manage. Flight in* 2023.

NASA Early Career Award, "Highly mobile, self-anchoring robots for coordinated, high-force environmental interaction", (PI: Elliot Hawkes), $600k. *Provided preliminary data and figures.* 2020-2023.

NASA Space Technology Research Fellowship, "Burrowing Robot for Extraterrestrial Soil Sampling and Anchoring," (Fellow: **Nicholas Naclerio**), $294k+. *Wrote and manage.* 2019-2022.

NSF Graduate Research Fellowship, "Tip-Extension and Granular Fluidization, the Science Behind a Burrowing Robot", (Fellow: **Nicholas Naclerio**). $46k/year. *Wrote*. (Declined in favor of NASA fellowship). 2019.

Georgia Institute of Technology (NSF), "Root dynamics and control in heterogeneous soft substrates," (PI: Elliot Hawkes), $21k. *Provided preliminary data.* 2019-2022.

Lockheed Martin Co., "Vine robots for non-destructive testing", (PI: Elliot Hawkes), $95k. *Managed, performed technology demonstrations at Lockheed Martin.* 2019.

Honda R&D Co., "Novel variable transmission technology", (PI: Elliot Hawkes), $100k. *Managed.* 2018-2020.

PERSONAL INTERESTS

Olympic style weightlifting: USAW Level 1 weightlifting coach certificate, former president of the UCSB Weightlifting Club

Languages: English (native), Mandarin (elementary), Spanish (elementary)

Outdoors: cycling, hiking, running, ocean sports, photography, international travel

TECHNICAL SKILLS

- Design for:
  - Soft robotics
  - Robotic mechanisms
  - Pneumatic systems
  - Granular media and regolith
  - Electrostatics
  - Wind tunnel testing
  - Underwater
  - MIL-spec vibration
  - MIL-spec EMI
- Fabrication and material processing:
  - Rapid prototyping
  - 3D printing
  - Machine shop
  - Cleanroom microfabrication
  - Soft lithography
  - Textiles
  - Polymers
  - Sheet metal
- Electronics:
  - Microcontrollers
  - DC brushed, brushless, and stepper motors
  - Motor drivers and controllers
  - Analog and digital sensors and amplifiers
  - Serial, I2C, SPI communication
- Computer programs:
  - Solidworks (and FEA)
  - Autodesk Inventor
  - MasterCam
  - GibbsCam
  - MATLAB
  - Arduino/C++
  - Microsoft Office suite
  - LaTeX