Pietro Sainaghi

Graduate Research Assistant
Mechanical and Aerospace Engineering
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Research: www.researchgate.net/profile/Pietro-Sainaghi

Research Interests

Design and manufacturing of compliant systems, origami-inspired mechanisms, and rigid-body linkages. Specific areas of interest include: architected materials (a.k.a. Mechanical metamaterials), mechanical computation and learning, precision flexure systems, MEMS, origami-inspired design.

Education

Ph.D., University of California, Los Angeles, Mechanical Engineering, Expected June 2025
Topic: "Using Mechanical Neural Networks to Design Metamaterials"
Attending from 01/23, GPA: 3.954/4.000

M.S., University of California, Los Angeles, Mechanical Engineering, December 2022
Attended 09/21 to 12/22, GPA: 3.957/4.000

B.S., University of Notre Dame, Mechanical Engineering, May 2021
Attended 08/17 to 05/21, GPA: 3.754/4.000, Honors: Cum Laude
Scholarship: Hesburgh International Scholar Experience

Experience

Research

Graduate Research Assistant from 09/22 to present
Flexible Research Group
PI: **Jonathan Hopkins**
University of California, Los Angeles (UCLA), Los Angeles, CA

Developed theory and methods relative to the uses and applications of mechanical neural networks, active architected metamaterials capable of learning mechanical behaviors in real time through the optimization of the stiffness values of tunable beams. Managed and conducted research for projects to showcase capabilities and applications to be used as case studies for this type of device. These projects include:

- Comparison on optimization algorithms used in mechanical neural networks, funded by AFOSR. Development of simulation environment for mechanical neural networks, validation with physical environment, statistical analysis and comparison of performance for both physical and simulation environments for multiple tuning optimizers.
  From 09/22 to 12/22
- Design of meso-scale mechanical neural networks, funded by AFOSR. Preliminary design, component and assembly design, finite element simulation and design optimization for micro-scale flexure systems actuated through resistive-heating-driven thermal actuators.
  From 11/22 to present
- Development of a paradigm for allowing mechanical neural networks to design metamaterials, funded by AFOSR. Algorithmic analysis of optimization-driven design with discrete parameters, design of negative-stiffness elements used in stiffness-tuning for beams, design, finite element analysis, design optimization, testing, assembly of modular discrete-stiffness beams, validation of the effectiveness of mechanical-neural-network-driven metamaterial design.
  From 12/22 to 06/23
- Analysis and simulation on the generalization, continuation, and regression capabilities of mechanical neural networks, funded by AFOSR. Linear algebra studies on functional approximation, studies on neural network activation functions, development of theoretical framework for functional continuation, analysis and performance evaluation of the generalization capabilities of a mechanical neural network.
  From 10/23 to present

Graduate Research Assistant from 01/22 to 08/22
Bionics Lab
PI: **Jacob Rosen**
University of California, Los Angeles (UCLA), Los Angeles, CA
Contributed to the design of a medical exoskeleton that employs impedance-admittance control of serial manipulators connected to human limbs, and controlled through a virtual-reality user interface to be used for stroke-recovery applications. Managed and conducted research for projects relative to the deployment and implementation of this type of device. These projects include:

- Development of virtual-reality user interface for training users and patients, self-funded. Study on real-time motion tracking and kinematic analysis, implementation of kinematic and dynamic model in virtual reality environment, study on communication protocols for real-time control and data-loss management.
- Design, analysis, and assembly of tension systems used to prevent resonance, funded by Jacob Rosen. Design, finite element analysis, assembly, validation of cable tensioning system.

Undergraduate Research Assistant from 01/20 to 05/21
Computational Mechanical Design Lab
PI: **Mark Plecnik**
University of Notre Dame, Notre Dame, IN
Developed an origami-inspired design theory to produce deployable one-piece linkages out of carbon fiber composite for aerodynamic applications. Managed and conducted research relevant to design and fabrication methods to be used as case studies for this theory.

- Development of composite layup techniques to reproduce origami folds, funded by the Jordan Family. Experimental analysis and validation of matrix-reinforcement combinations for non-homogeneous composites, studies on controlled discontinuities in composite matrix structures.
- Design of a deployable, one-piece, carbon fiber composite active aerodynamic spoiler, funded by Mark Plecnik. Study on layup techniques for branching composite linkages, design of linkage structure with variable transmission ratio, layup, manufacturing, and actuation of active aerodynamic spoiler using novel techniques.

Undergraduate Research Assistant from 03/19 to 09/19
Hanjaya-Putra Research Group
PI: **Donny Hanjaya-Putra**
University of Notre Dame, Notre Dame, IN
Contributed to study on the rejuvenation of vascular progenitor cells through bioengineered nanoparticles. Conducted work relevant to the validation of these nanoparticles. This projects includes:

- Analysis and validation of nanoparticle effectiveness through the analysis of in-vitro cells using image recognition, funded by Donny Hanjaya-Putra. Cell culture materials and methods, use of image-recognition algorithm for recognizing bio markers for protein concentration, statistical analysis of nanoparticle effectiveness in response to varying protein concentrations.

Other Experience

Supermarket Cashier from 06/21 to 08/21
Al Portico - Via Freita
Livigno, SO, Italy
Cashier and restocking duties in duty-free supermarket for touristic destination. In charge of the following sections: soda, beer, pasta, snacks.

Resident Assistant from 08/20 to 05/21
Keough Hall 3A - University of Notre Dame
Rector: Fr. Brogan Ryan
Notre Dame, IN
Resident assistant (RA) in student dormitory.
Duties include:

- Addressing lockouts to rooms
- Night duty twice a week
- Addressing student emergencies and crises

International Student Ambassador - HISE Team from 08/18 to 05/21
Office of Admissions - University of Notre Dame
Supervisor: Mary de Villiers
Notre Dame, IN
In charge of international student outreach and fair evaluation of accomplishment in non-US school systems.
Duties Include:

- Phone calls to address questions from international applicants
- Preparation of admission packets for international students
- Organization of the Hesburgh International Scholar Experience (HISE)

Summer Hall Staff from 06/18 to 08/18
Ryan Hall - University of Notre Dame
Supervisor: Ben Wood
Notre Dame, IN
Desk staff in dormitory used for conference housing and alumni reunions.
Duties Include:

- Desk duty three times a week
- Addressing lockouts to rooms
- Night duty three times a week

Camp Staff from 06/18 to 08/18
Lyceum Alpinum - English Summer Camp
Supervisor: Tiziana Tuena
Zuoz, Switzerland
Staff at summer camp for middle school and high school students, fully offered in English.
Duties Include:

- Night duty three times a week
- Guiding campers to and from sports and activities
- Held origami classes once a week
- Organizing activities and entertainment

Publications

Journal Publications

[3] Lee RH, **Sainaghi P**, Hopkins JB. Comparing Mechanical Neural-Network Learning Algorithms. Journal of Mechanical Design. 2023;145(7):071704.

[2] Hopkins JB, Lee RH, **Sainaghi P**. Using binary-stiffness beams within mechanical neural-network metamaterials to learn. Smart Materials and Structures. 2023;32(3):035015.

[1] Bui L, Edwards S, Hall E, Alderfer L, Round K, Owen M, **Sainghi P**, Zhang S, Nallathamby PD, Haneline LS, Hanjaya-Putra D. Engineering bioactive nanoparticles to rejuvenate vascular progenitor cells. Communications Biology. 2022;5(1):635.

Conference Papers (Peer Reviewed)

[2] **Sainaghi P**, Lee R, Hopkins JB. The Importance of Precision in Mechanical Neural Networks that Learn Behaviors. 38th ASPE Annual Meeting. Boston, MA. 2023.

[1] **Sainaghi P**, Plecnik M. Methods for Folding Linkages Out of Carbon Fiber. In: Larochelle P, McCarthy JM, editors. Proceedings of the 2022 USCToMM Symposium on Mechanical Systems and Robotics. Cham: Springer International Publishing; 2022. p. 100–15. (Mechanisms and Machine Science; vol. 118).

Google Scholar Publication Metrics

Citations: 22
H-Index: 2
I10-Index: 1

Press and Featured Work

New Invention Restores Life-Saving Cells. SciTechDaily. August 5, 2022.

Nanoparticle 'backpacks' restore damaged stem cells. Science Daily. July 7, 2022.

Teaching

Teaching Assistant

Course: Engineering for Systems Assurance
Instructor: Kenneth Kung
School: University of California - Los Angeles
Summer 2024, Summer 2023, Summer 2022
Syllabus: Systems are constructed to perform complex functions and services. In systems engineering, we understand the needs of users, analyze the basic and derived requirements, create the various system architecture products, design and integrate the various components, then perform verification and validation before field the system into the operational environment. These complex systems surround us, and impact our daily activities. We want to know these systems are doing exactly what they are designed to do, nothing more and nothing less. This course studies how to create a system that is trustworthy, dependable, and can continue to function despite sustaining

damages.

Course: Computer Security
Instructor: Kenneth Kung
School: University of California - Los Angeles
Spring 2024, Spring 2023
Syllabus: Basic and research material on computer security.
Topics include basic principles and goals of computer security, common security tools, use of cryptographic protocols for security, security tools (firewalls, virtual private networks, honey pots), virus and worm protection, security assurance and testing, privacy, applying security principles to realistic problems, and new and emerging threats and security tools.

Course: Systems Engineering
Instructor: Kenneth Kung
School: University of California - Los Angeles
Fall 2023, Fall 2022
Syllabus: Introduction and analysis of the major elements of the system engineering process, interspersed with examples drawn from real projects. The course includes the complete system life-cycle (requirements, design, implementation, test, deployment, operations and maintenance, disposal), and also includes special discussions of key leverage points, key lessons-learned from actual large projects.

Course: Engineering of Complex Systems
Instructor: Kenneth Kung
School: University of California - Los Angeles
Spring 2022
Syllabus: Holistic view of engineering discipline, covering lifecycle of engineering, processes, and techniques used in industry today. Multidisciplinary systems engineering perspective in which aspects of electrical, mechanical, material, and software engineering are incorporated. Three specific case studies in communication, sensor, and processing systems included to help students understand these concepts. Special attention paid to link material covered to engineering curriculum offered by UCLA to help students integrate and enhance their understanding of knowledge already acquired.

Course: Cell Biology Laboratory
Instructor: David Veselik, Michelle Whaley

School: University of Notre Dame
Spring 2021
Syllabus: This laboratory course exposes students to a variety of techniques in modern cell biology. Students will get hands-on experience in working with cultured cell lines, including sterile technique, media preparation, and passaging of cells. Individual experiments will include assessment of cell growth and apoptosis, examination of subcellular structure using fluorescent microscopy, separation and analysis of nucleic acids and proteins, enzyme assays, and measurement of cell cycle by flow cytometry. It provides an excellent introduction to the approaches routinely used in analysis of cells and their functions. Fall.

Course: Introduction to Linear Algebra and Differential Equations
Instructor: Laurence Taylor
School: University of Notre Dame
Spring 2018, Spring 2019, Fall 2019
Syllabus: An introduction to linear algebra and to first-and second-order differential equations. Topics include elementary matrices, LU factorization, QR factorization, the matrix of a linear transformation, change of basis, eigenvalues and eigenvectors, solving first-order differential equations and second-order linear differential equations, and initial value problems.

Professional Service

Society Membership

American Society of Mechanical Engineering (ASME), from 08/19 to present
International Honor Society for Mechanical Engineering Pi Tau Sigma, from 01/21 to present
Scientific Research Honor Society Sigma Xi, from 10/23 to present
American Society of Precision Engineering (ASPE), from 11/23 to present

Reviewing Service

Reviewed Articles for the Journals: Science Robotics [2024]

Conference Oral Presentations

[3] **Sainaghi P**, Gray A, Luo C, Hopkins JB, Cullinan MA. Design and Fabrication of Flexure-Based, Meso-Sized, Thermally-Actuated, Bidirectional Linear Transducer. International Design Engineering Technical Conferences & Computers and Information in Engineering (IDETC/CIE) Conference 2024. Washington, DC. 2024.

[2] **Sainaghi P**, Lee R, Hopkins JB. The Importance of Precision in Mechanical Neural Networks that Learn Behaviors. 38th ASPE Annual Meeting. Boston, MA. 2023.

[1] **Sainaghi P**, Plecnik M. Methods for Folding Linkages Out of Carbon Fiber. In: Larochelle P, McCarthy JM, editors. Proceedings of the 2022 USCToMM Symposium on Mechanical Systems and Robotics. Cham: Springer International Publishing; 2022. p. 100–15. (Mechanisms and Machine Science; vol. 118).

Patents

[Provisional Filing] **Sainaghi P**, Gray A, Luo C, Hopkins JB, Cullinan MA. Mechanical Neural Network driven by Flexure-Based, Meso-Scale, Bidirectional Thermal Actuators.

Origami Design

As a hobby, folding and designing origami models of various complexity levels since childhood. Origami art is closely tied to mathematical concepts such a circle packing and graph theory, which are actively used for the main design paradigm of this discipline, called Tree Theory. All designs are created using pen and paper, but software is used to create crease patterns and instructions.

Website Link: https://pietrosainaghi.wixsite.com/my-site/own-designs

Models

Complexity rating using OrigamiUSA criteria [https://origamiusa.org/difficulty].

- Just a desert shrub, nothing to see here (2024) [Super Complex]
- Camaron, a Strictly-Mexican Shrimp (2024) [Low Intermediate]
- Ophis Pteros, ver. 2.5 (2024) [Super Complex]
- Pure Daisy (2023) [High Intermediate]
- Lurker of the Deeps (2023) [High Intermediate]
- Guardian Dragon, ver 2.0 (2023) [Super Complex]
- Radial Shell (2023) [High Intermediate]
- Treasure of the Desert (2022) [Complex]
- Ophis Pteros, ver 1.0 (2022) [Super Complex]
- Joshua Tree Shrubs (2022) [Complex]
- Guardian Dragon, ver 1.5 (2021) [Super Complex]
- Gaping Dragon, ver 1.0 (2019) [Super Complex]
- Guardian Dragon, ver 1.0 (2018) [Super Complex]
- Wyvern (2018) [Complex]
- Quetzalcoatl (2017) [Complex]
- Keough Roo (2017) [Intermediate]
- Tarantula, ver 2.1 (2017) [Complex]
- Hilbert's Tree (2017) [Intermediate]
- Stag Beetle (2016) [Complex]
- Firebug (2015) [Complex]
- Flour Beetle (2015) [Complex]
- Gandalf on Eagle (2014) [Intermediate]
- Simple Scorpion (2013) [Intermediate]
- Modular Circle (2012) [Intermediate]

Game Development CurseForge Project: Meatballcraft, Dimensional Ascension

Hobby project with minor partnerships.
Main developer for Meatballcraft, an open-source Minecraft 1.12 modpack built using Forge mods and custom scripting.

The gameplay focus of the modpack incorporates factory-game traits such as logistics, factory-building, and automation with classic roleplaying elements such as exploration, puzzle-solving, and combat.
It started as a solo project, but it has grown thanks to skilled community members who have developed modules and libraries to improve development and gameplay, community-driven testing and bug-reporting, and a dedicated art team.

Website: https://legacy.curseforge.com/minecraft/modpacks/meatballcraft
GitHub: https://github.com/sainagh/meatballcraft
Discord Community: https://discord.gg/WVvVm7aWh3
Download Count: 151'586
Discord Community Members: 5'032
Partners: BisectHosting, Overwolf, Craft Down Under

Main Tasks:
Coding: ZenScript, JSONs, XMLs, Java
Main contributor, small-to-medium contributions from volunteers for larger scripts
Art: GIMP pixel art
Started as sole contributor, now mostly done through a team of volunteer artists
Writing: story arcs and lore
Main contributor, specific volunteers in charge of specific areas (E.G. History of Weapons)
Community Management: moderation of Discord Server, reading suggestions and bug reports
Managed by self and moderation team of 5 people
Marketing & Social Media: Reddit, YouTube, TikTok
Promotional posts and/or videos for update announcements
Playthrough videos from unaffiliated content creators

Community Service

- Currently volunteering at the 'Casa del Migrante' immigrant home in Tijuana, Mexico. Cooking Italian food, and folding origami with the children.
- Volunteer tutoring of high school students in Math and English during undergraduate.
- Singing for residents of Elderly Home in Sondrio during high school.
- Volunteer tutoring of middle school students in Math during high school.