

Design and Fabrication of Soft Robotic Actuators

Independent Study

Course Overview:

The objective of this independent study course is to provide a thorough knowledge and understanding of the design, fabrication, and testing processes involved in creating useful soft actuators. This course will be heavily hands-on and project based, and will involve a great deal of exploration in the field of soft robotic actuators. Each week, the student will complete assigned readings and apply this knowledge to the relevant section of the class project. Because this research involves a new and ever-changing field, no textbook exists for this class; instead, readings will be based on research papers relevant to the topic. During weekly meetings, the student will meet with Dr. MacCurdy to discuss class material and ask any relevant questions about the reading assignments or weekly tasks. The final deliverables for this course will be a comprehensive report and presentation that describe the different design and fabrication methods explored in the class and compare their efficacies using empirical data from testing.

Literature:

- N. El-Atab, R. B. Mishra, F. Al-Modaf, L. Joharji, A. A. Alsharif, H. Alamoudi, M. Diaz, N. Qaiser and M. M. Hussain, "Soft Actuators for Soft Robotic Applications: A Review," Advanced Intelligent Systems, vol. 2, no. 10, p. 37, 2020.
- J. Hiller and H. Lipson, "Automatic Design and Manufacture of Soft Robots," IEEE Transactions on Robotics, vol. 28, (2), pp. 457-466, 2012.
- Zolfagharian et al, "Evolution of 3D printed soft actuators," Sensors and Actuators. A. Physical., vol. 250, pp. 258-272, 2016.
- G. Runge, J. Peters and A. Raatz, "Design optimization of soft pneumatic actuators using genetic algorithms," in 2017, . DOI: 10.1109/ROBIO.2017.8324449.
- F. Schmitt et al, "Soft Robots Manufacturing: A Review," Frontiers in Robotics and AI, vol. 5, pp. 84-84, 2018.
- C. Tawk and G. Alici, "A Review of 3D-Printable Soft Pneumatic Actuators and Sensors: Research Challenges and Opportunities," Advanced Intelligent Systems, vol. 3, (6), pp. 2000223-n/a, 2021.
- O. D. Yirmibesoglu et al, "Direct 3D printing of silicone elastomer soft robots and their performance comparison with molded counterparts," in 2018, . DOI: 10.1109/ROBOSOFT.2018.8404935.
- T. Hainsworth et al, "A Fabrication Free, 3D Printed, Multi-Material, Self-Sensing Soft Actuator," IEEE Robotics and Automation Letters, vol. 5, (3), pp. 4118-4125, 2020.

Weekly Schedule

Week #	Module	Topics Covered	Reading Assigned
Week 1	Actuator Design	Survey of Current Methods	Soft Actuators for Soft Robotic Applications: A Review (pp 1-15)
Week 2	Actuator Design	CAD representations of actuators	Soft Actuators for Soft Robotic Applications: A Review (pp 16-31)
Week 3	Actuator Design	CPPN/Isosurface representations of actuators	Automatic Design and Manufacture of Soft Robots
Week 4	Actuator Design	Voxel representations of actuators	Evolution of 3D printed soft actuators
Week 5	Actuator Design	Algorithms to optimize actuator structures	Design optimization of soft pneumatic actuators using genetic algorithms
Week 6	Actuator Fabrication	Survey of Current Methods	Soft Robots Manufacturing: A Review (pp 1-7)
Week 7	Actuator Fabrication	Fabrication using a cast elastomer	Direct 3D printing of silicone elastomer soft robots and their performance comparison with molded counterparts
Week 8	Actuator Fabrication	Single-material FDM Printing	Soft Robots Manufacturing: A Review (pp 8-13)
Week 9	Actuator Fabrication	Multi-material FDM printing	A Review of 3D-Printable Soft Pneumatic Actuators and Sensors: Research Challenges and Opportunities (pp 1-7)
Week 10	Actuator Fabrication	Inkjet Printing	A Review of 3D-Printable Soft Pneumatic Actuators and Sensors: Research Challenges and Opportunities (pp 8-14)
Week 11	Actuator Testing	Survey of Important Testing Metrics	A Fabrication Free, 3D Printed, Multi-Material, Self-Sensing Soft Actuator
Week 12	Actuator Testing	Setting up Test Fixtures and Equipment	No reading assigned.
Week 13	Actuator Testing	Experimentally Testing Actuators	No reading assigned.
Week 14	Actuator Testing	Analysis of Test Data	No reading assigned.
Week 15	Final Report/Presentation	Compilation of Project Results	No reading assigned.