# Demos & Schedule

*Bolded times are scheduled demos.

1 - Fast autonomous UAV flight in GPS-denied conditions **(:00, :30)**
2 - Maneuverable Piccolissimo 2 **(:15, :45)**
3 - Decentralized Planning with Shared Semantic Representation for Multiple Robots **(:00, :30)**
4 - Soft Hybrid Aerial Vehicle via Bistable Mechanism
5 - Kod*lab Legged Robot Demos - **May 23 only**
6 - Self-Assembling Modular Robot for Extreme Shapeshifting (SMORES-EP)
7 - Building Dynamics Models through Contact Discontinuities
8 - Model Zoo: A Growing "Brain" That Learns Continuously
A Model for Perimeter-Defense Problems with Heterogeneous Teams
9 - Reactive Motion Policy Learning: A Dynamical Systems Approach
10 - Analysis of a Flock of Visually Similar Birds in an Outdoor Aviar
11 - CMOS Integrated, Sub-1mm Robots
12 - Quori: A Community-Informed Design of a Socially Interactive Humanoid Robot **(:00, :15, :30, :45)**
13 - Reconstructing 3D Humans from Images
14 - Lifelong Learning of Occupancy Grid Prediction
15 - Event Based Cameras
16 - Safety-critical Learning, Optimization, and Control
17 - Variable Topology Truss
18 - Cassie Locomotion Controllers
19 - Multi-robot Air-ground Collaborative Semantic Mapping and Localization (:15, :45)
20 - Autoware Autonomous Go-Kart **(:00, :30)**
21 - ScaLAR Lab Demos **(:00, :15, :30, :45)**
22 - Origami-inspired Robot that Swims via Jet Propulsion
23 - Know Thyself: Transferable Visual Control Policies through Robot-Awareness
24 - Building with Found Material

# Industry Spinoffs & Friends

A - Treeswift
B - IQ Motion Control - **May 23 only**
C - Exyn Technologies - **May 23 only**
D - Pennovation Works
E - LF Intelligence
F - Ghost Robotics - **May 23 only**

## Thank you for visiting the GRASP Lab!

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General Robotics, Automation, Sensing & Perception Lab

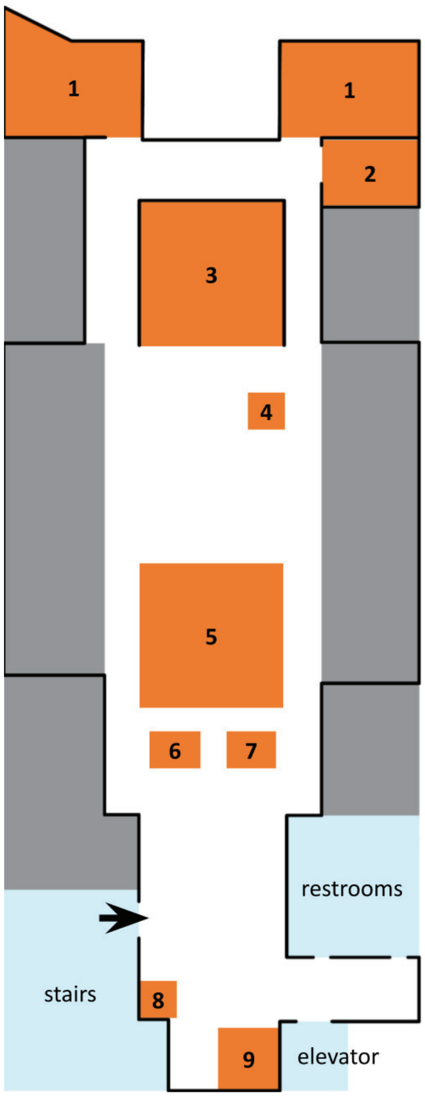
# GRASP LAB TECHNICAL TOURS

## May 23 & 27, 2022

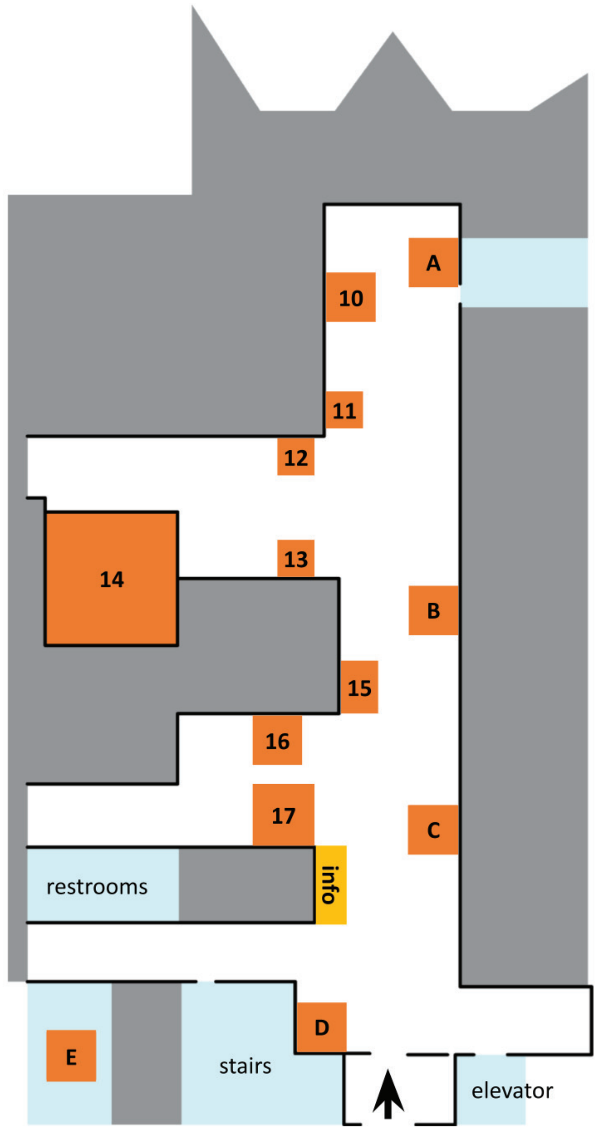
Make sure to check out our website & add us on social media.

https://www.grasp.upenn.edu/

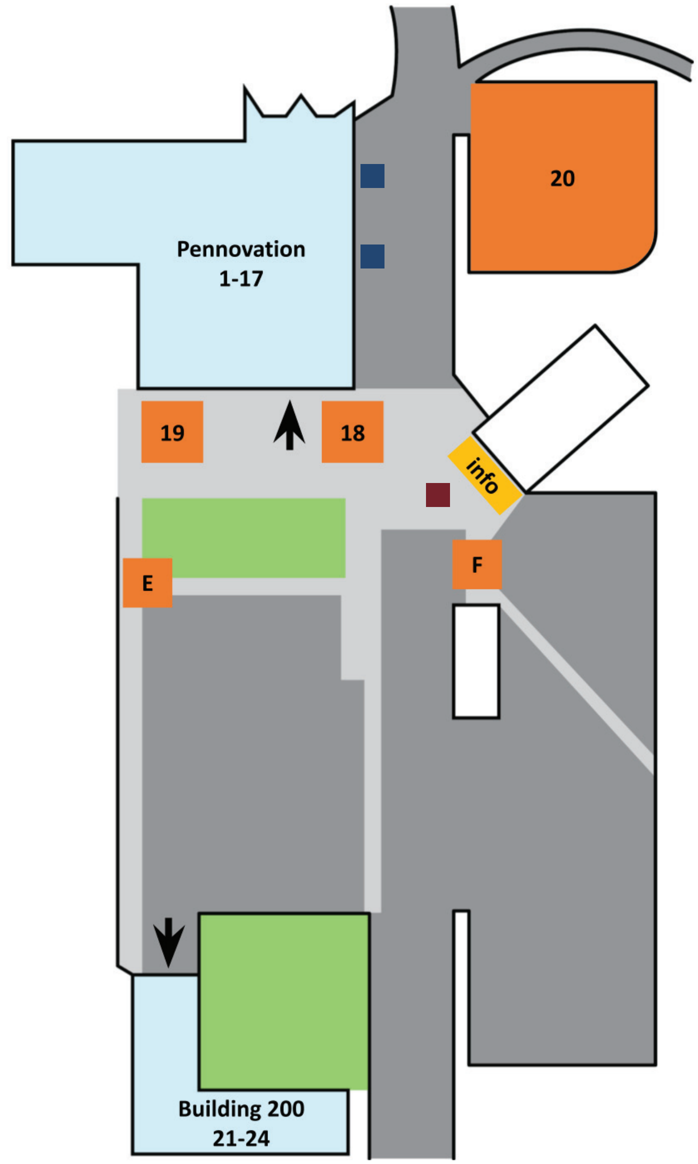
## PERCH (3rd floor)




## Pennovation (1st floor)




## Pennovation Campus




# "Find Out About"

**Mapping and localization:** 1, 14, 19, 20, A, C, E

**Design and fabrication:** 4, 6, 11, 17, 24, B

**Learning-based control:** 7, 8, 9, 16, 23

**Computer vision:** 10, 13, 15, 23

**Human-robot interaction:** 9, 12, 13

**Aerial vehicles:** 1, 2, 3, 4, 19, A, B, C

**Legged locomotion:** 5, 18, F

**Manipulation:** 7, 9, 23, 24

**Swimming robots:** 21, 22

Pickup/Dropoff

Food Trucks

2

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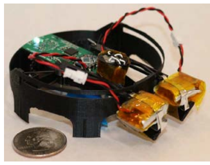
Northwestern University

## Maneuverable Piccolissimo 2

A. Curtis, B. Strong, V. Dornadula, J. Wang, S. Folk, T. Kulesza, E. Steager, M. Rubenstein, M. Yim



We present Maneuverable Piccolissimo 2 (MP2), a relatively simple, inexpensive, autonomous UAV capable of precise control in 3D space with only a single actuator. Our research is focused on making MP2 a swarm-capable flyer for applications in aerial swarm algorithms and collective behaviors.

agc@u.northwestern.edu

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## Decentralized Planning with Shared Semantic Representation for Multiple Robots

Yuwei Wu, Yuezhan Tao, Dinesh Thakur, Vijay Kumar

We present a decentralized multi-agent planning framework integrating with shared semantic representation. The collision avoidance among multiple robots is guaranteed by leveraging dynamic primitives and corridor-based trajectory optimization.

https://www.kumarrobotics.org/

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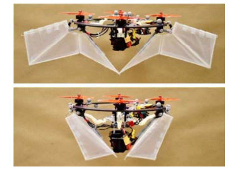
UCLA

## A Soft Hybrid Aerial Vehicle via Bistable Mechanism

J. Weakly*, X. Li*, M. Li, T. Agarwal, S. Ho, C. Jiang, C. Sung



The Soft Hybrid Aerial Vehicle uses a **bistable mechanism** to switch between a **quadrotor mode** and a **fixed wing mode**. When the robot accelerates through a hand-designed flight maneuver, the vehicle transitions and folds or unfolds the origami wings.

https://sung.seas.upenn.edu, jmcw@seas.upenn.edu

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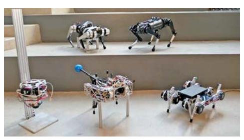
KODLAB

## Kod*lab Legged Robot Demos

S. Rozen-Levy, A. Stewart-Height, J.D. Caporale, W.-H. Chen, T. Topping, T. Greco, D. Koditschek



This demo highlights the variety of legged robots developed and used by Kod*lab. The robots are controlled using compositional methods leveraging dynamical systems theory to find formal guarantees.

https://kodlab.seas.upenn.edu/

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MOD LAB — NSF

## Self-Assembling MOdular Robot for Extreme Shapeshifting (SMORES-EP)

A. Kim, C. Liu, M. Yim

T. Tosun, Y. Mantzouratos, D. Edgar, S. Khanna, M. Whitzer, T. Tsabedze, H. Kim, J. Davey, N. Kwok, Q. Lin, J. Daudelin, G. Jing, H. Kress-Gazit, M. Campbell

SMORS-EP is a hybrid self-reconfigurable modular robot. Each module has **four degrees of freedom** and **four connectors using electro-permanent (EP) magnets**. Modules are able to adapt themselves to various scenarios by changing the morphology autonomously.

www.modlabupenn.org/smores-ep/
anthjkim@seas.upenn.edu

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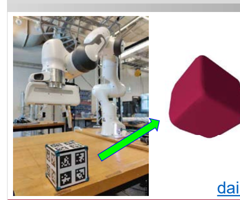
DAIRLab — Dynamic Autonomy & Intelligent Robotics

## Building Dynamics Models through Contact Discontinuities

Bibit Bianchini*, Mathew Halm*, Kausik Sivakumar*, Michael Posa



Through motion capture of a small number of **robot interactions**, **ContactNets** can infer inertial, geometric, and frictional quantities of **unknown objects** undergoing frictional contact via a novel **mechanics-inspired learning** problem.

code →

dair.seas.upenn.edu, {bibit,mhalm,kausik}@seas.upenn.edu

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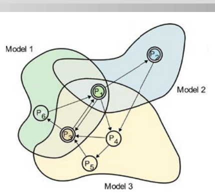
## Model Zoo: A Growing "Brain" That Learns Continually

Rahul Ramesh, Pratik Chaudhari




We show that machine learning models benefit from splitting the learning capacity, when tackling multiple tasks. To this end, we propose Model Zoo: an algorithm inspired by boosting that identifies synergistic sets of tasks.

rahulram@seas.upenn.edu

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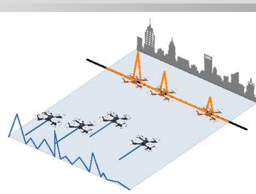
DEVCOM ARMY RESEARCH LABORATORY

## A Model for Perimeter-Defense Problems with Heterogeneous Teams

Christopher D. Hsu, Mulugeta A. Haile, and Pratik Chaudhari



We develop a model of the multi-agent perimeter-defense game to show how an adaptive defense is organized.

Our method, inspired by the human immune system, embodies the features of heterogeneity in teams, limited resource allocations, local information, and decentralization.

PI: chsu8@seas.upenn.edu

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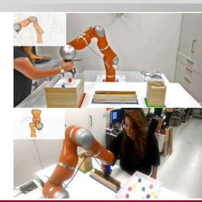
LASA — EPFL

## Reactive Motion Policy Learning: A Dynamical Systems Approach

N. Figueroa* and A. Billard



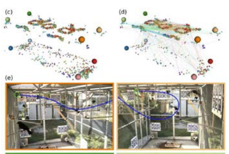
By defining a motion policy as a dynamical system (DS) with stability and convergence guarantees a robot can react and adapt to perturbations and changes in the task imposed by a human operator. Such DS-based motion policies can be learned from a small set of demonstrations (<5) thanks to a physically-consistent trajectory learning scheme.

https://nbfigueroa.github.io/ nadiafig@seas.upenn.edu

**10**

# Analysis of a Flock of Visually Similar Birds in an Outdoor Aviary

Marc Badger, Shiting Xiao, Yufu Wang, Bernd Pfrommer, Marc Schmidt, and Kostas Daniilidis



At the UPenn Aviary we study bird behavior with computer vision and machine learning methods. In this work we capture detailed interactions among individuals in a social group which is foundational to our study of animal behavior and neuroscience.

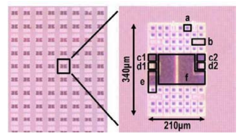
https://aviary.sas.upenn.edu/

**11**

# CMOS integrated, sub-1mm robots

Maya Lassiter[1,2], Li Xu[3], Jungho Lee[3], Will Reinhardt[1,2], Lucas Hanson[1,4], David Gonzalez-Medrano[1,2], Xiao Wu[3], Yejoong Kim[3], Makoto Yasuda[5], Masaru Kawaminami[5], Dennis Sylvester[3], David Blaauw[3], Marc Z. Miskin[1,2]

[1:] UPenn, GRASP Lab, [2:] UPenn, Electrical and Systems Engineering, [3:] U. Michigan, Electrical Engineering and Computer Science, [4:] UPenn, Physics and Astronomy, [5:] United Semiconductor Japan




On this table, you can find one of our robots under a microscope. The machine is too small to see with the naked eye, but contains solar cells for power [a], integrated legs [b], temperature sensors [c], electric field sensors [d], an optical communication system [e] and a microprocessor with programable memory [f].

mmiskin@seas.upenn.edu, mayala@seas.upenn.edu

**12**

# Quori: A Community-Informed Design of a Socially Interactive Humanoid Robot

Andrew Specian[1], Ross Mead[2], Simon Kim[1], Maja Matarić[3] and Mark Yim[1]

1: University of Pennsylvania, 2: Semio, 3: University of Southern California

See **Quori** In Action

Platforms for socially interactive robotics can be limited by cost or lack of functionality.

**Quori** is a **novel**, **affordable**, socially **interactive** humanoid robot platform for facilitating non-contact human-robot interaction **(HRI) research**.

https://www.quori.org, aspecian@seas.upenn.edu

**13**

# Reconstructing 3D Humans from Images

Nikos Kolotouros, Wen Jiang, Xuntong Liang, and Kostas Daniilidis

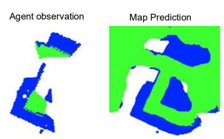
Reconstructing 3D humans provides important context within images that we interact with every day. Understanding humans within a scene provides critical information for robotic systems from commercial to industrial.

https://www.seas.upenn.edu/~nkolot/projects/prohmr/

**14**

# Lifelong Learning of Occupancy Grid Prediction

G. Georgakis, M. Hussing, D. Kent, S. Lee, K. Schmeckpeper, S. Shaji, K. Vedder, K. Daniilidis, E. Eaton



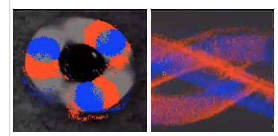

Occupancy map prediction aims to capture layout priors in indoor environments by learning to predict occupancy information outside the field-of-view of the agent. This allows agents to anticipate obstacles in novel environments. We extend our prediction algorithm to a lifelong learning setting, demonstrating a service robot capable of updating its prediction module to handle changing environments over a long-term deployment.

https://ggeorgak11.github.io/uncertainty-nav-project/ https://lifelongml.seas.upenn.edu/

**15**

# Event Based Cameras

Kenneth Chaney, Claude Wang, Fernando Cladera, Anthony Bisulco, CJ Taylor, and Kostas Daniilidis



Event based cameras are novel asynchronous sensors that provide a wide array of benefits in the field of robotics and computer vision. Here we show demos relating to these advantages.

**17**

# Variable Topology Truss

A. Spinos, J. Bae, D. Carroll, C. Liu, T. Kientz, S. Park, E. Park, S. Lee, T. Tsabedze, D. Edgar, S. Jeong, B. Kim, Y. Weng, S. Yu, B. Grimaldi, W. Li, R. Guan, Y. Moon, S. Ryu, S. Ahn, A. Bera, A. Ren, E. Skorniakova, F. Collins, T. Seo, J. Kim, F. C. Park, M. Yim.

Variable Topology Trusses (VTT) are modular, self-reconfigurable, parallel robots that consist of high-extension-ratio linear actuators connected by reconfigurable spherical joints. The concept was originally developed to shore damaged buildings in disaster zones.

https://www.modlabupenn.org/variable-topology-truss/
spinos@seas.upenn.edu, jhbae@seas.upenn.edu

**18**

# Cassie Locomotion Controllers

William Yang, Yu-Ming Chen, Brian Acosta, Michael Posa

We will demonstrate recent results for dynamic walking and running on the Cassie bipedal robot. Approaches use impact-invariant control[1] to mitigate uncertainty when landing on the ground and optimal reduced order models[2] for high-performance, real-time planning.

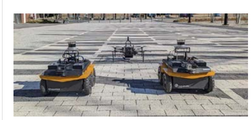
yangwill, yminchen, bjacosta, posa @ seas.upenn.edu

[1]Yang, William, and Michael Posa. "Impact invariant control with applications to bipedal locomotion." *(IROS)* 2021.
[2] Chen, Yu-Ming, and Michael Posa. "Optimal reduced-order modeling of bipedal locomotion." *(ICRA)* 2020.

**19**

# Multi-Robot Air-Ground Collaborative Semantic Mapping and Localization

I. Miller, F. Cladera, CJ Taylor, V. Kumar



Our ground robots **localize** themselves in a **semantic map** built by aerial robots or satellite images. They execute GPS waypoint missions without using GPS, including detecting and **georeferencing objects**. Data is transmitted back to the basestation and to other robots through a **distributed database**.

https://www.kumarrobotics.org, iandm@seas.upenn.edu

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## Autoware Autonomous Go-Kart

R. Mangharam, T. Nagy, M. Endler, A. Zhu, B. Acosta, R. Udayagiri, A. Alavi, S. Agarwal, W. C Francis, A. Prabhu, S. Gupta

A custom autonomous vehicle for the evGrand Prix 2022 competition. It can race on an optimized raceline and avoid dynamic obstacles. It is a complete AV platform that can be used for further AV research.

It is equipped with a custom-built Drive-by-Wire solution and sensor mounting. The sensors include LiDAR, 9-axis IMU, RGB camera, and Septentrio mosaic-H GNSS receiver.

Autoware.org, Rahul Mangharam <rahulm@seas.upenn.edu>

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## Collective Swimming Using Modboats

G. Knizhnik, T. Z. Jiahao, M. Yim, M. A. Hsieh

Underactuated robots powered by single motors are capable of complex collective motions. They can dock and reconfigure to build large mobile ocean-going platforms for scientific research or function as resupply bases for quadrotors or other mobile platforms.

https://www.modlabupenn.org/modboats/

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## Environmental Monitoring and Adaptive Sampling using Heterogeneous Robot Teams

Forest fires, oil spills, motions of human and animal crowds exhibit complex patterns across various spatiotemporal scales. Heterogeneous robot teams are better at sampling and fusing multiresolution data needed to model and track these multiscale dynamic processes.

The Scalable Autonomous Robot Lab (Hsieh et al.) https://scalar.seas.upenn.edu/

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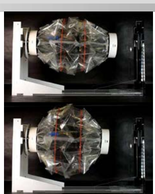
## Origami-inspired robot that swims via jet-propulsion

D. Chen, Z. Yang, S. Panchanadam, B. Baraki, G. Chen, C. Sung



The robot leverages an origami-inspired skin that can change its body shape to ingest and expel water, creating a jet that propels it forward similarly to cephalopods. When it is underwater, the robot can move forward at 6.7 cm/s (0.2 body lengths/s), with a cost of transport of 2.0.

https://sung.seas.upenn.edu/, dschen@seas.upenn.edu

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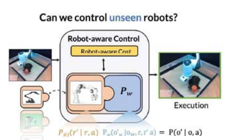
## Know Thyself: Transferable Visual Control Policies through Robot-Awareness

Edward Hu, Kun Huang, Oleh Rybkin, Dinesh Jayaraman




Policies trained on one robot generalize poorly to new robots, requiring additional data collection and retraining.

Our method, Robot-aware Control (RAC), trains visual policies that transfer zero-shot to new robots.

seas.upenn.edu/~hued/rac, hued@seas.upenn.edu

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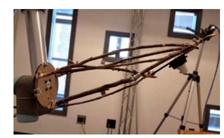
## Robust Robotic Solutions: Building with Found Material

D. Carroll, M. Yim



Made from tree branches, this arm demonstrates the ability to accurately design and build with found material. Envisioned for deployment in low-income regions where access to and maintenance of robot arms is limited and expensive, recycling these materials into existing robots lets us engineer robust, cost-effective robotic systems.

https://www.modlabupenn.org/, cdevin@seas.upenn.edu