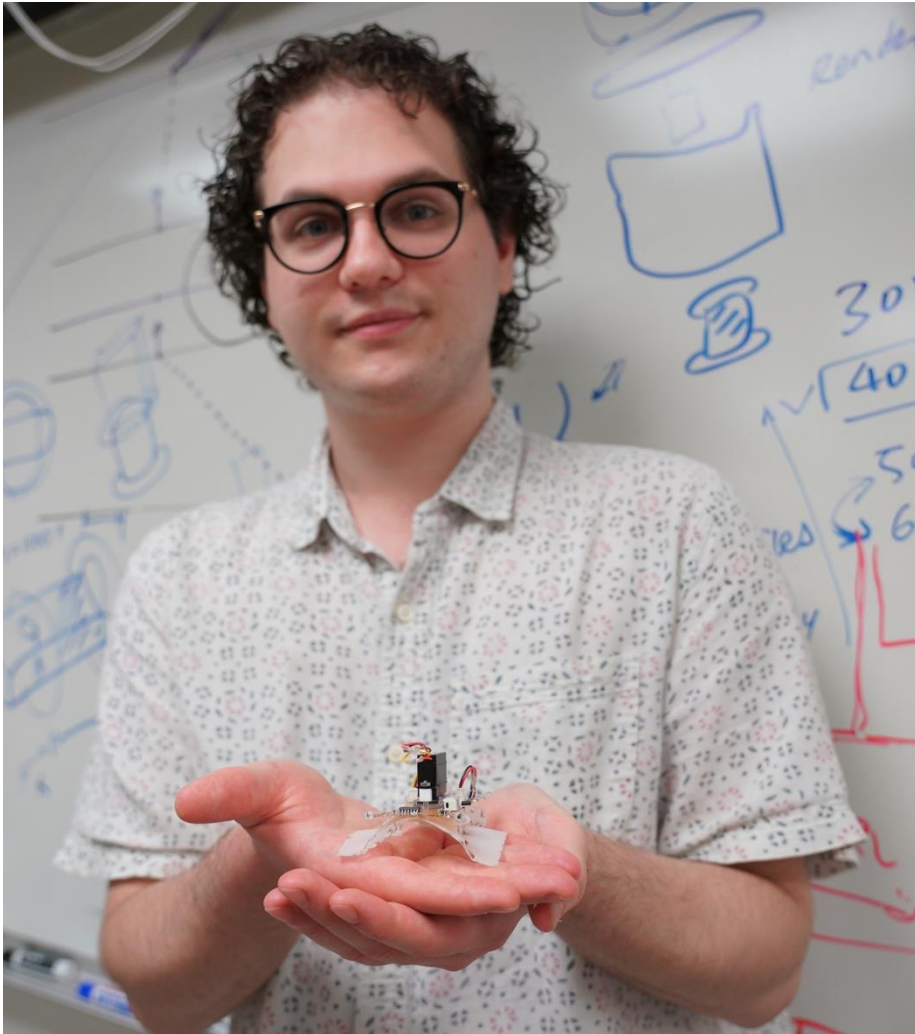


Supporting Project-Based Robotics Education in High Schools through 3D Design Software

Daniel Feshbach

Computer and Information Science PhD Student

Sung Robotics Lab, University of Pennsylvania

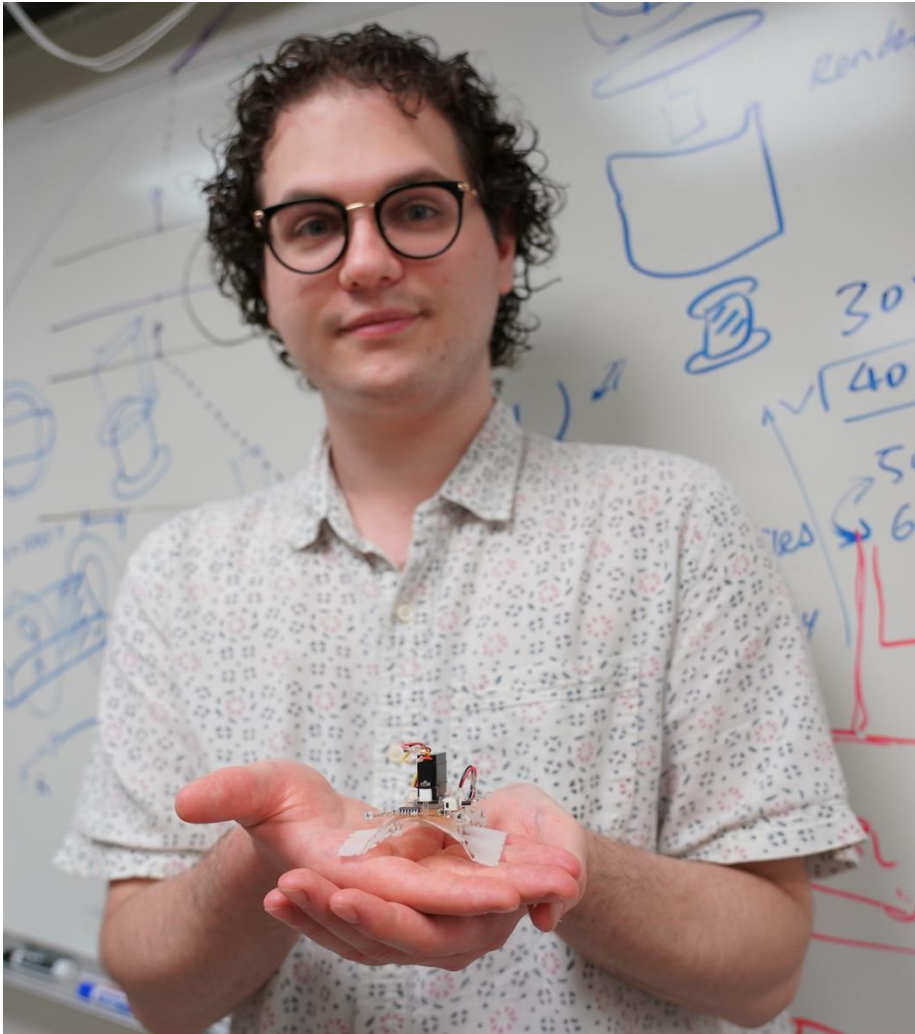


Daniel Feshbach

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 - Year 6 of 7, applying for academic jobs next cycle
 - Advisor: Cynthia Sung (Mechanical Engineering)
- Work on getting computers to help us design robot mechanisms

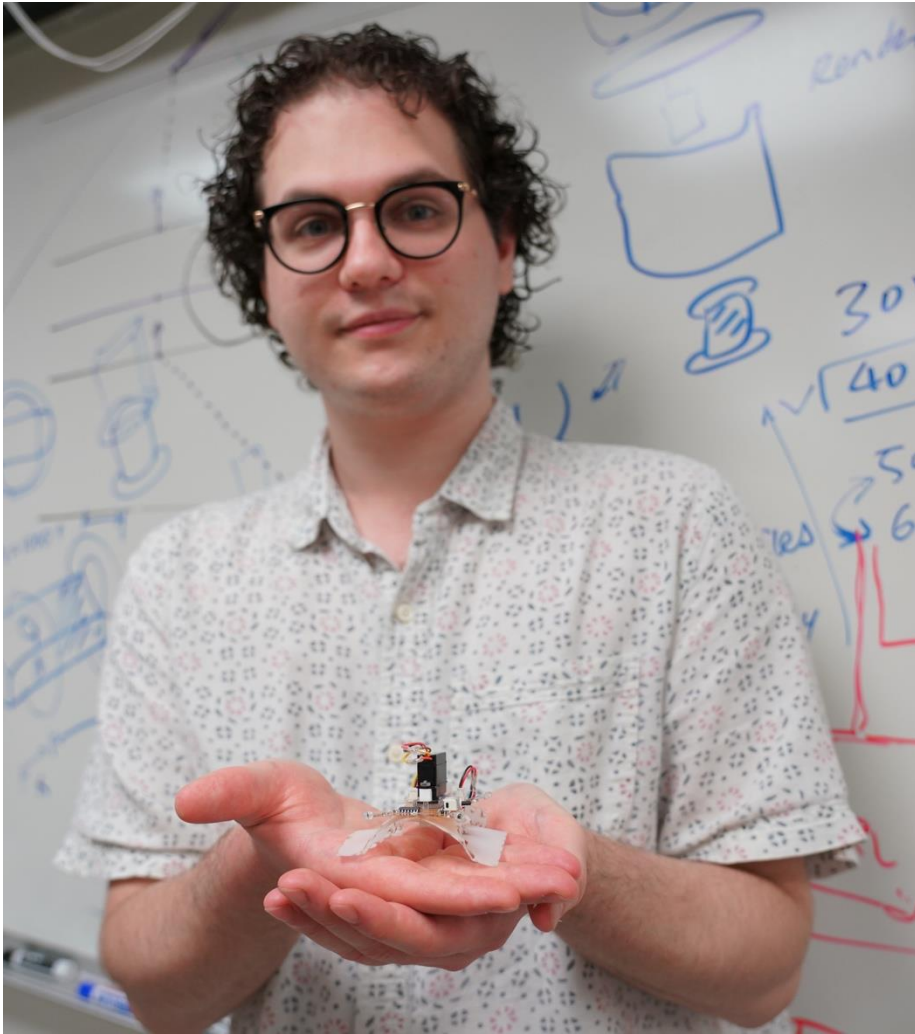


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- PGAEF project:
 - Researching how design software and educational context shapes how students think about themselves as designers/engineers



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 - Researching how design software and educational context shapes how students think about themselves as designers/engineers
 - Penn students (through ABCS class next Fall) supporting a series of hands-on robotics activities in a West Philly High School physics class
 - Using interactive design tool I've been developing

Middle Mouse Button: Pan Around W: Translate E: Rotate Delete: Delete Joint X: Select X Axis Y: Select Y Axis Z: Select Z Axis

File

Save Chain

Load Chain

Export Crease Pattern

Current units: Centimeter (cm)

Edit Dimensions

Edit Grid

Options

Undo

Redo

Hide Grid

Import Mesh

Import Mesh

Scale:

Clear Mesh

☒ Mesh Visibility

Camera Controls

☒ Rotate Camera☐ Pan Camera

Create New Chain

Number of Sides: 4

Radius: 1

Create Chain

Cancel

Add Joints

Add Prismatic Joint

Add Revolute Joint

Add Waypoint

Add Tip

Edit Dimension

Edit Joints

☐ Add to Root

Delete Joint

Min State $\leq$ Current State $\leq$ Max State

Enter state

☒ Propagate☒ Local Orientation

Rotate

Enter angle in degrees



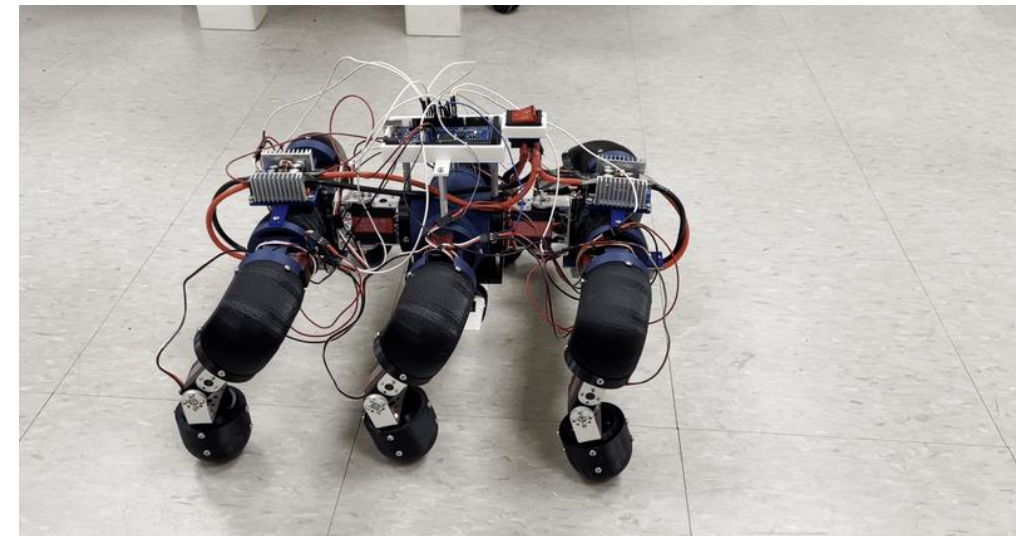
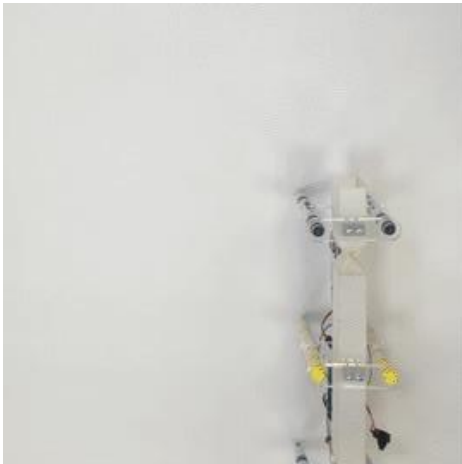
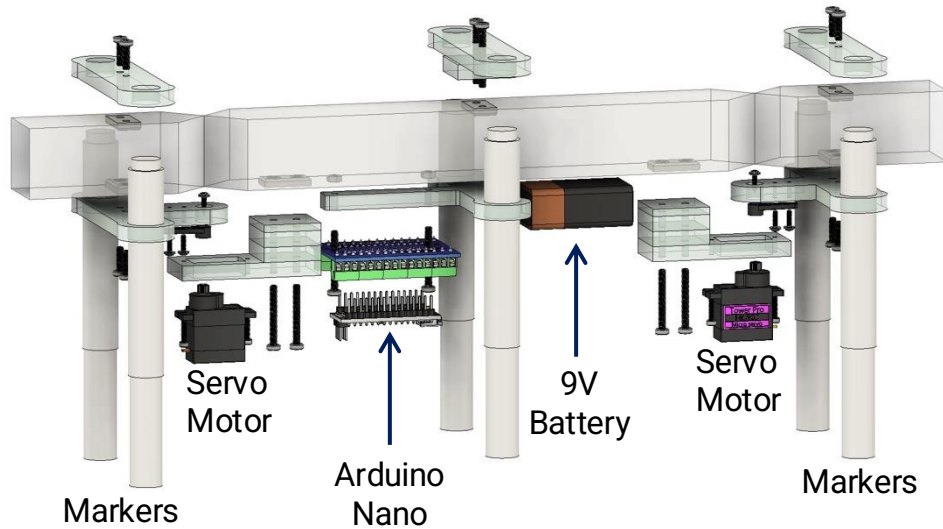
Translate

Enter distance

Chain Radius:

Joint Range of Motion:

Attaching Motors and Electronics



See <https://sung.seas.upenn.edu/research/kinegami/> for broader project details and full list of project personnel. Support for this project has been provided in part by the National Science Foundation through Grants 2322898, 1845339, and 1138847, and by the Army Research Office under Grants W911NF-24-1-0090 and W911NF1810327.

What do students
**think they are
capable of
creating?**

How do they **think
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Customizing a
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leads to a **feeling of
ownership** over the
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Technical

Design Software

- Abstractions simplifying design space
- Operations presented to user
- Partial automation

Manufacturing Techniques

- Difficulty
- Affordability
- Rapid Prototyping

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Educational

Curriculum

- Problem-solving learning
- Hands-on experiences

Mentoring

- Navigating design process
- Encouragement
- Role modeling

ABCS Course Fall 2026

- Course Title: Pre-College Robotics Education in Philadelphia Schools
 - Penn students visit West Philly High School physics class to support robotics projects
 - Visit once a week for an 80-minute class period, ~11 sessions
 - Undergrad elective in school of engineering

	High School Students	Penn Students
Curriculum/ Topics		
Learning Outcomes		

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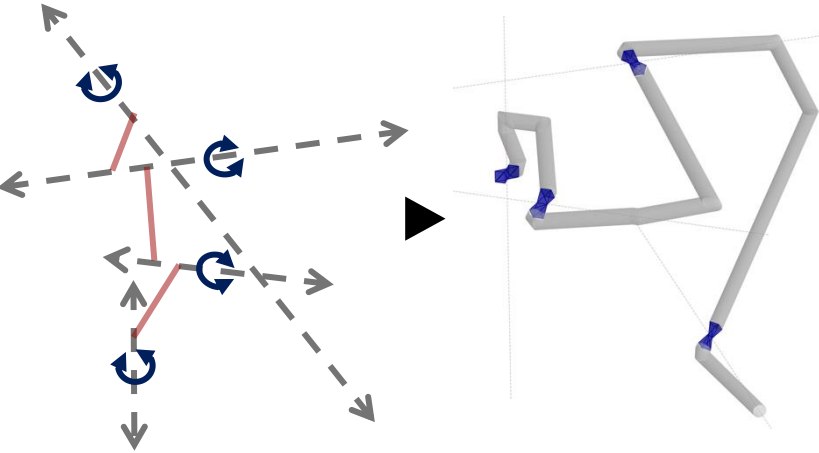
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Learning Outcomes	• Learn to move back and forth between models/abstractions, prototypes, and experiments • Develop confidence and excitement that they are capable of making robots and becoming engineers	• Become effective mentors/teachers of project-based learning in engineering • Create curricular materials that can support similar projects being run by other teachers independently

Thesis Overview

Automated Design

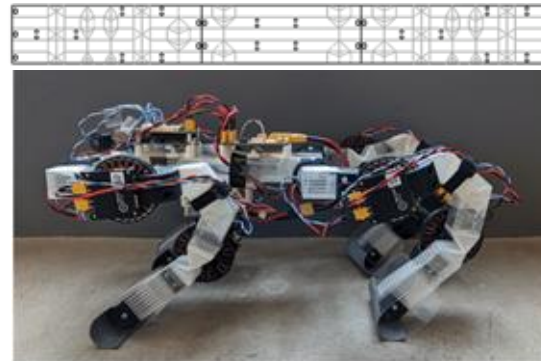


- Input:
 - Joints (number, type, size)
 - Kinematics (available motions)
- Output: mechanism shape
 - Joint positions/directions
 - Link shapes (tubes)
- Mathematical guarantees about what can be designed

Low-barrier Manufacturing

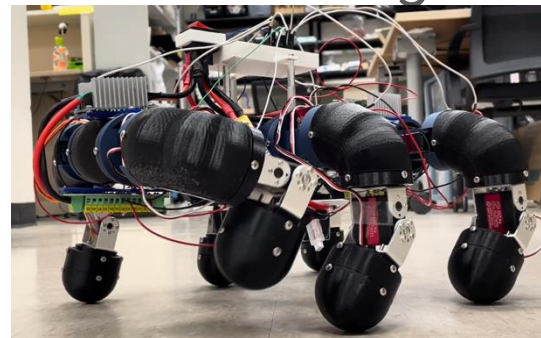
Programs generate files for easy, fast, affordable manufacturing

Origami

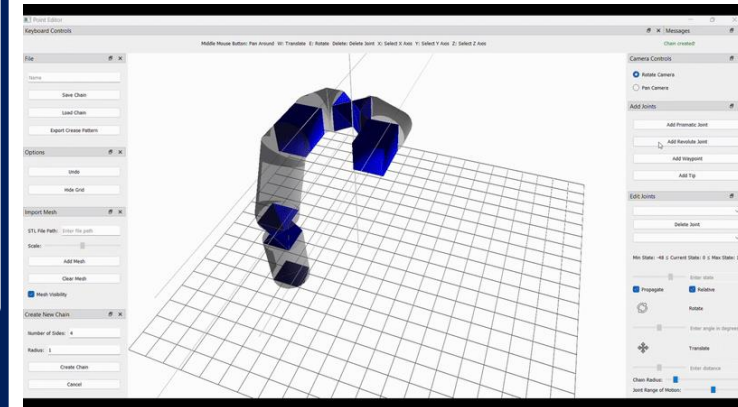


[Dynamic Origami Quadruped, led by Wei-Hsi Chen]

3D Printing



Interactive Design



- Visualizes designs and how joints can move
- No programming/math
- Exports design files
- Rooted in guarantees about tubes