Computational Understanding of Complex Physical Systems

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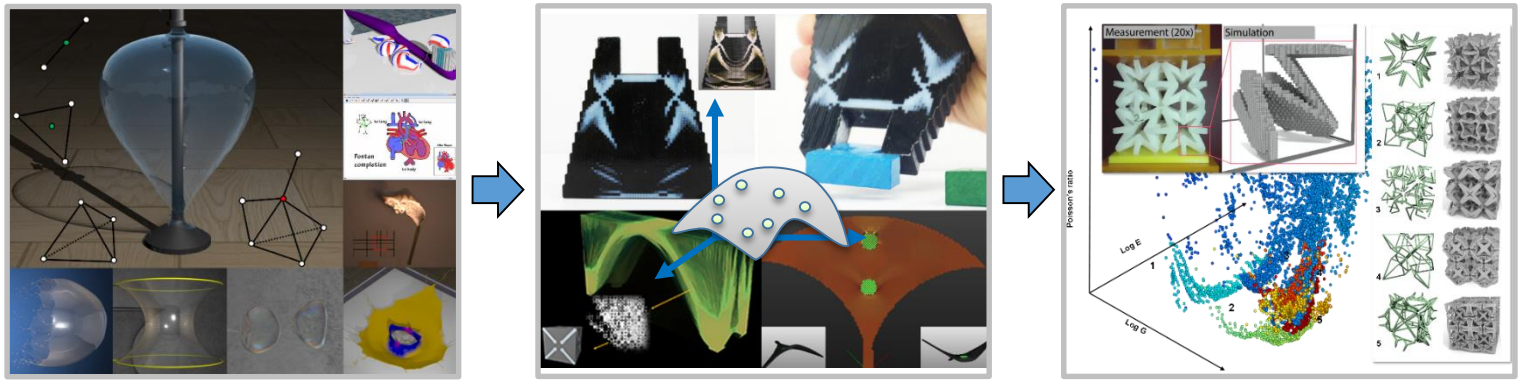
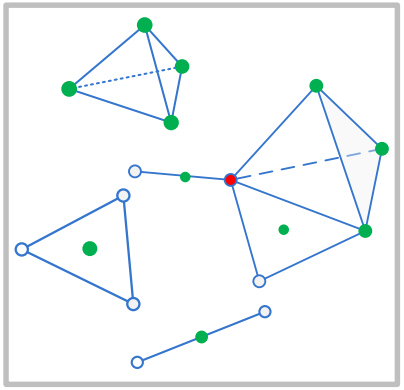


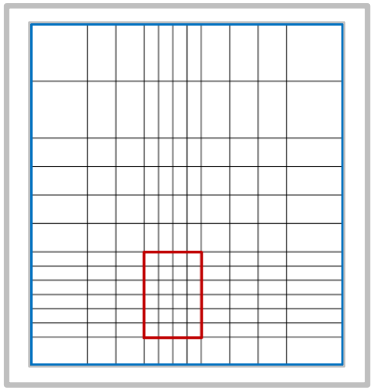
CSAIL

Q1: How to create simulations for complex systems?

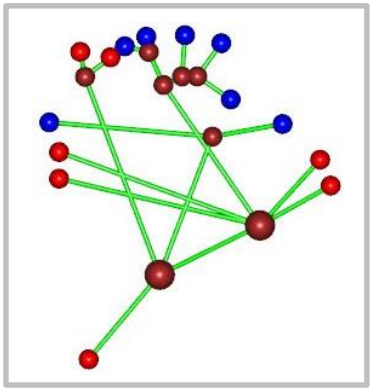
- Geometric structures, PDE solvers, and meshing algorithms for complex fluid simulation



Simplicial Complexes

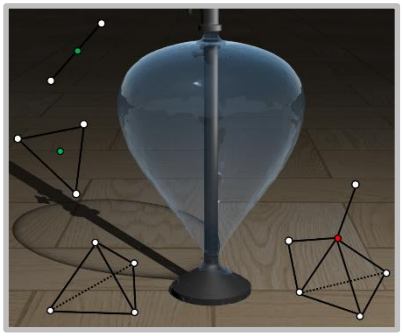


Far-Field Grid

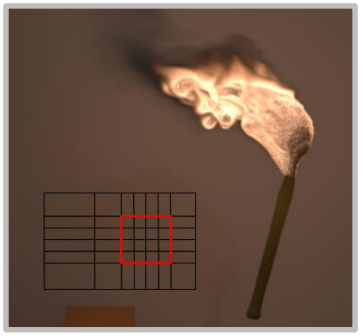


Hydraulic Graph

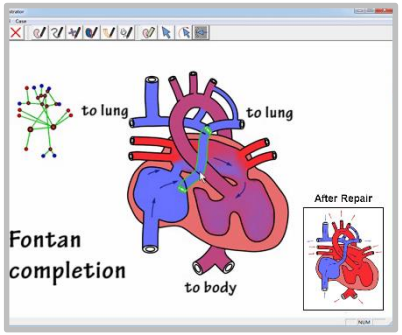
Parametrized Sticks



Codimensional Fluids



Large-Domain Fluids



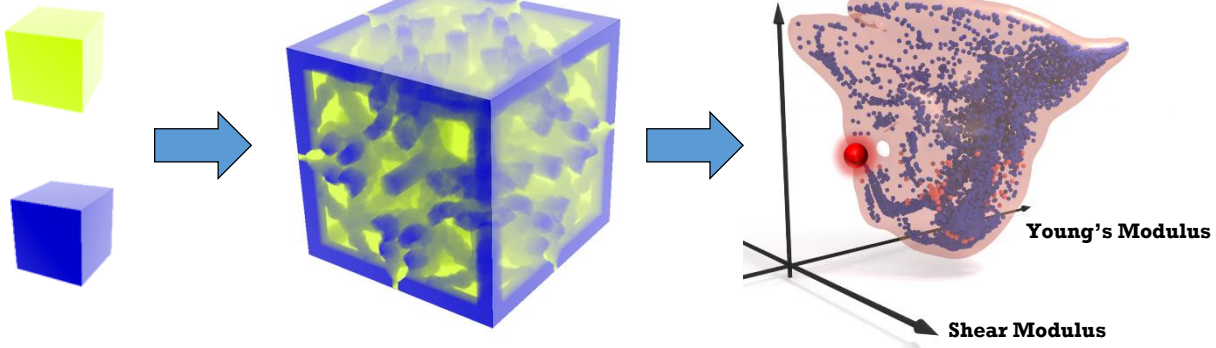
Sketching Hearts

Customized Drones

[Zhu et.al. SIGGRAPH 2013, 2014, 2015, SIGGRAPH Asia 2011] [Du et.al. SIGGRAPH Asia 2017]

Q2: How to build mappings between simulation and function?

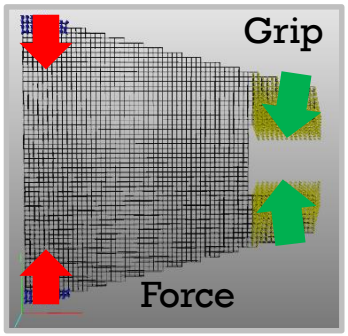
- Multi-scale topology optimization on 3D printing voxel level

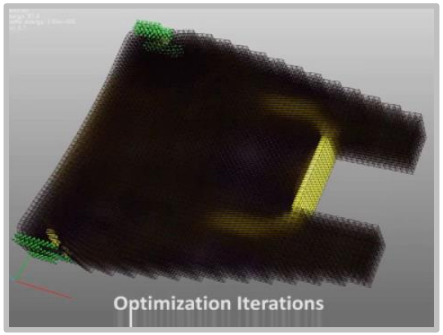


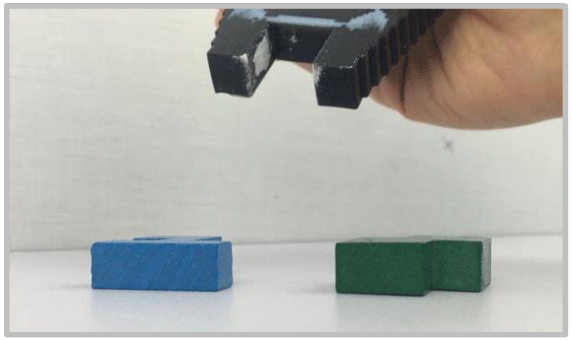
Base Materials | Microstructure | Material Property Gamut

Continuous Constraints

Discrete Mapping





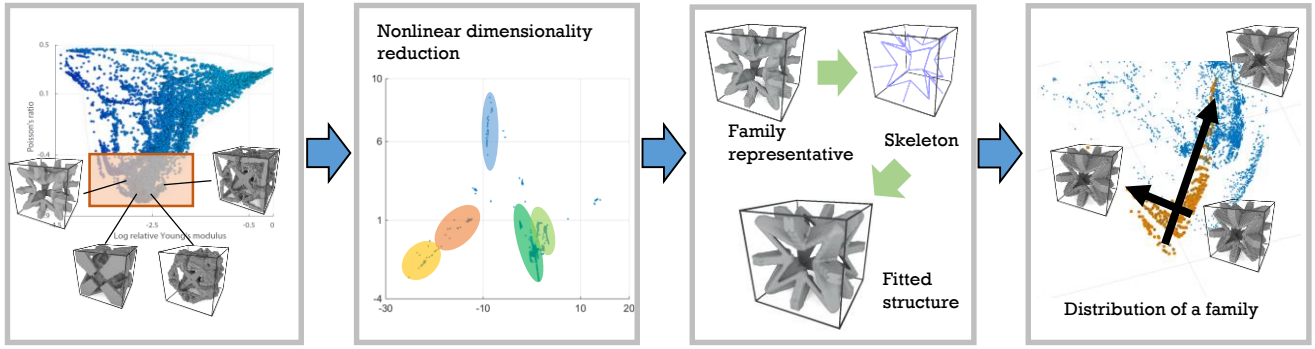


Design Goal | Topology Optimization | 3D Printed Functional Gripper

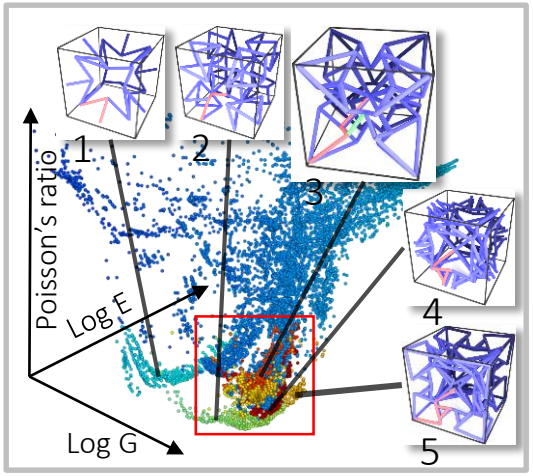
[Zhu et.al. ACM Trans. Graph. 36:5 (2017)]

Q3: How to discover mechanisms with extremal properties?

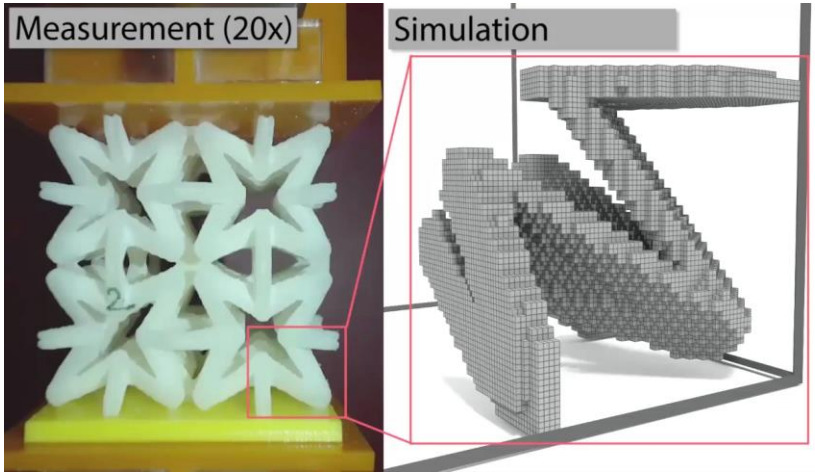
- Automate the discovery of new microstructural materials



Input: Gamut | Identify Families | Fit Templates | Reduce Parameters



Five families of new materials with extremal auxetic properties have been discovered



Experimental Validation

[Chen et.al. Science Advances (to appear), 2018]

Future Plans at Purdue University

- Research Vision
  - Simulation tools to investigate complex physical systems
    - Natural phenomena, biological systems, soft robots, etc.
  - Computational approaches to automate scientific discovery
    - Physical simulation, data generation, and machine learning
  - Automated cyber-physical system design and understanding
    - Agile drones, fast walkers, efficient swimmers
- Potential Collaborations
  - Department of Computer Science
    - Computational Science and Engineering, Graphics and Visualization, Machine Learning and Information Retrieval, etc.
  - College of Engineering
    - Biomed Engineering, Manufacturing, Materials, Mechanical Systems, etc.