



# Pre-stretched Shell Simulation

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# Goal: Simulate the Behavior of a Bilayer Structure

- What we are modeling:
  - Bilayer structure created by pre-stretching one of the layers and putting the second layer on top
  - How does changing the shape of the stretched or unstretched layer affect the 3D shape produced?
  - How does changing the amount of pre-stretch affect the final 3D shape?

Pre-stretched layer  
(clear)

Unstretched layer  
(gray)

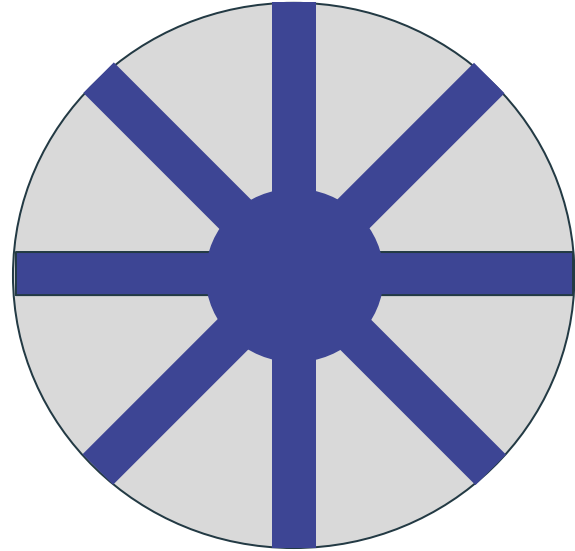


# Previous Work

- Kirigami Design<sup>[1]</sup>
  - You can cut your material into various 2D shapes
  - When you apply a force on the material, the 2D shape will influence the 3D shape
- Jellyfish Robot<sup>[2]</sup>
  - Made a soft jellyfish -> a possible application
  - Don't have simulations, only ran experiments
- Kirigami Skins with a Soft Actuator<sup>[3]</sup>
  - Soft actuators are robots that we can simulate - elastomer powered
  - Kirigami design is something we are also looking at
- Bilayer Actuator<sup>[4]</sup>
  - Graphene oxide in a polymer matrix

# What We are Working Towards

- Instead of the rectangular shape shown before, we want to simulate a hemispherical shape
- Gray region: pre-stretched material
- Blue region: material that has not been stretched
- This type of pattern produces a hemispherical 3D shape



# How We Plan to Get There

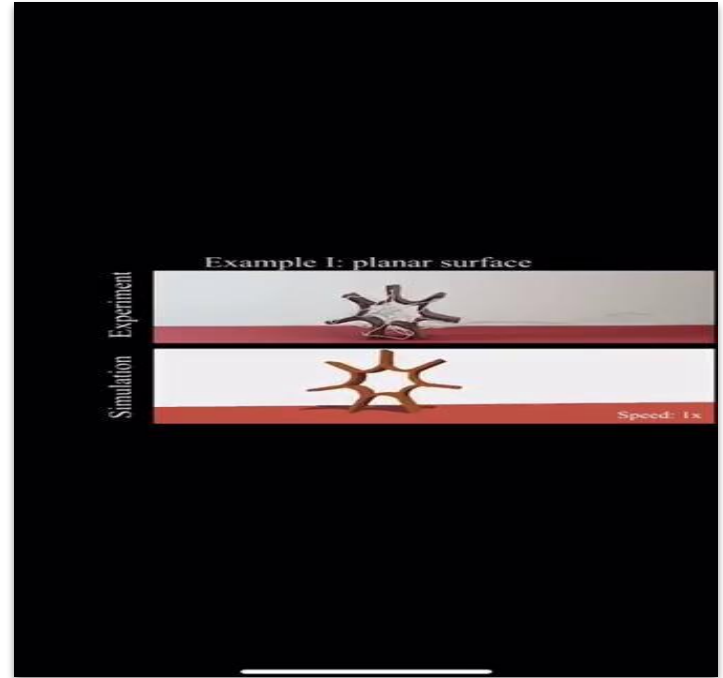
1. Start with a simple beam that has a natural curvature applied to it
  - a. To get practice with the basics of natural curvature
  - b. Based on HW 1
2. Model this system as a single layer shell
3. The pre-stretched component can be represented as a change in natural curvature over time
4. We choose which regions of the shell have this natural curvature
  - a. Allows us to test different shapes (different kirigami cuts)

# Applications/Future Work

- Soft Robotics
  - Soft actuator controlled by SMA wire or something similar
  - Jellyfish-like robots
- Trilayer simulation
  - Can vary the materials to mix and match material properties
  - Goal for our lab group right now
  - Can model more robust robots

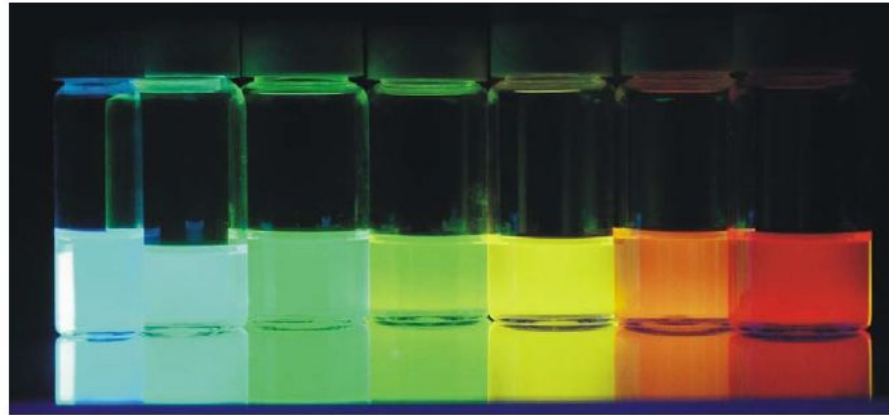
# Applications/Future Work

- Try to simulate the activity in the water

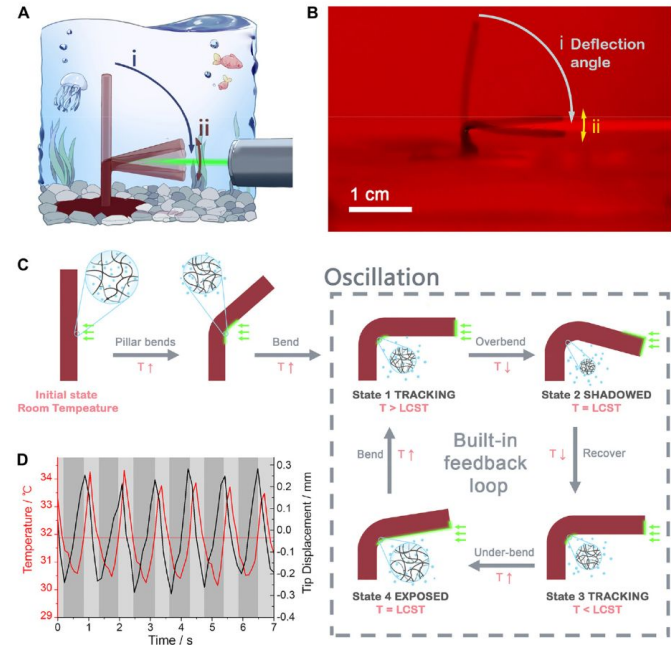


# Applications/Future Work

- Explore other possibilities to actuate the robot



2.3  $\longrightarrow$  5.5  
Size (nanometers)





Thank You!

# References

[1] <https://www.nature.com/articles/srep31067>

[2] <https://iopscience.iop.org/article/10.1088/0964-1726/18/8/085002/meta#sms305486fig2>

[3] <https://robotics.sciencemag.org/content/3/15/ear7555.full>

[4]

[https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.201401011?casa\\_token=-YB3AyqIYW0AAAAA%3AGXjMggc1AZQKshQOfLz6d-IBAK0QrLYaF1Ihz0IP75wfnPnbxPxqvPzOszWt0iRDI84XqFV5fqMSte8](https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.201401011?casa_token=-YB3AyqIYW0AAAAA%3AGXjMggc1AZQKshQOfLz6d-IBAK0QrLYaF1Ihz0IP75wfnPnbxPxqvPzOszWt0iRDI84XqFV5fqMSte8)