SAND2015-5836PE

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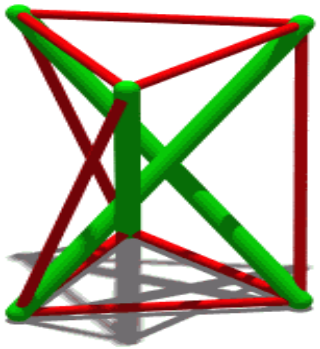
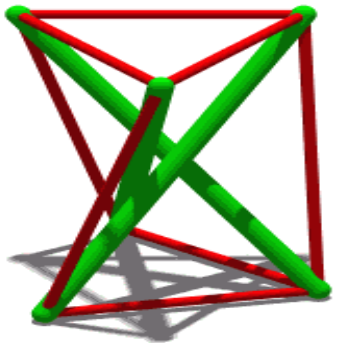
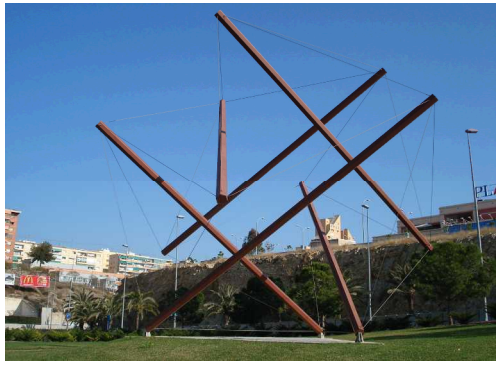
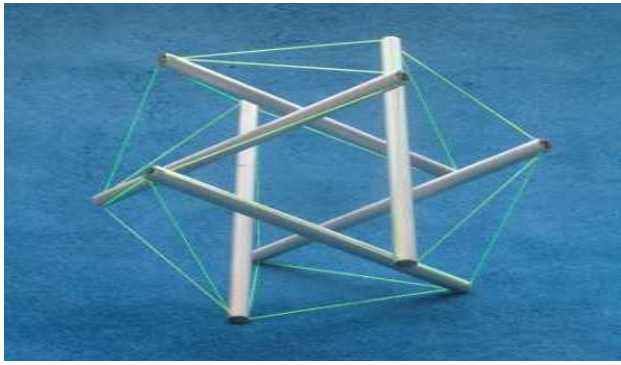

Tensegrity

Donovan Glasgow

July 17, 2015

U.S. DEPARTMENT OF ENERGY | National Nuclear Security Administration

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Left: "Tensegrity simple 3 RL" https://commons.wikimedia.org/wiki/File:Tensegrity_simple_3_RL.png#/media/File:Tensegrity_simple_3_RL.png Center: "SECCIONS DES AUREES: ESTRUCTURA TENSEGRITY EN ALICANTE." Alicantevivotest. 25 Mar. 2009. Web. 10 July 2015. Right: Pars, Marcelo. "A Tensegrity Well-known." Tensegrity. Web. 10 July 2015.

Background

- Cibola High School
- STAR program
- Mentor: Joe Bishop

What is Tensegrity?

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- Structural principle
- Members in tension or compression
- Summer project: analyze these unique structures

Examples of Tensegrity

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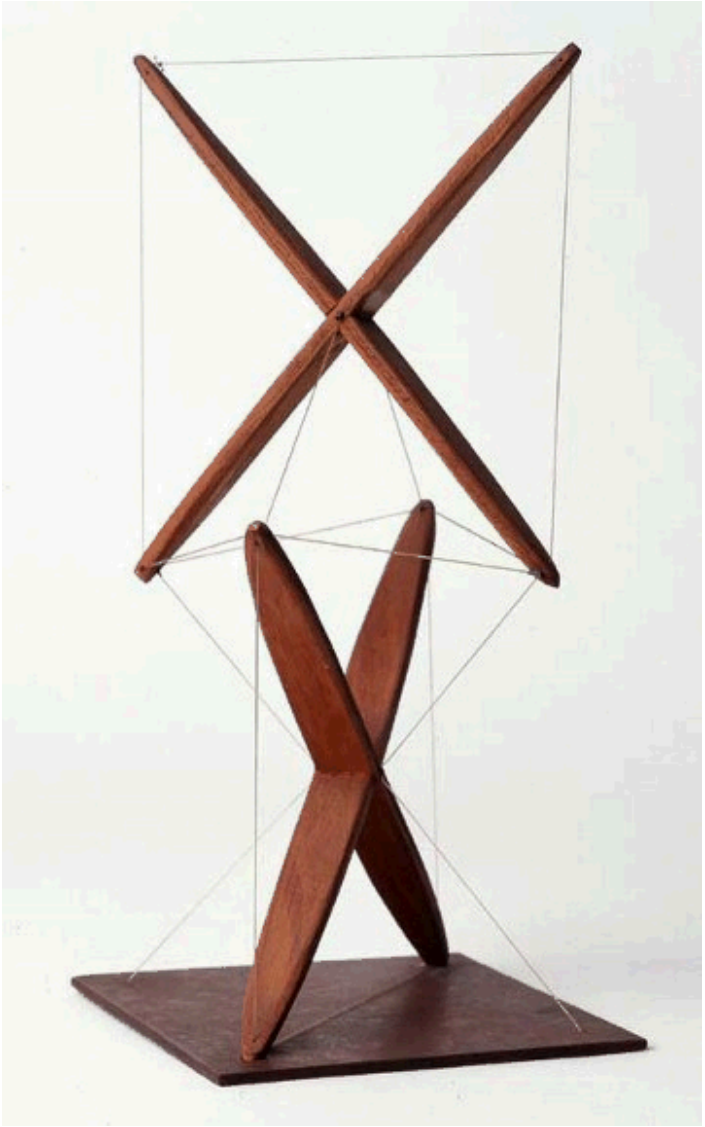

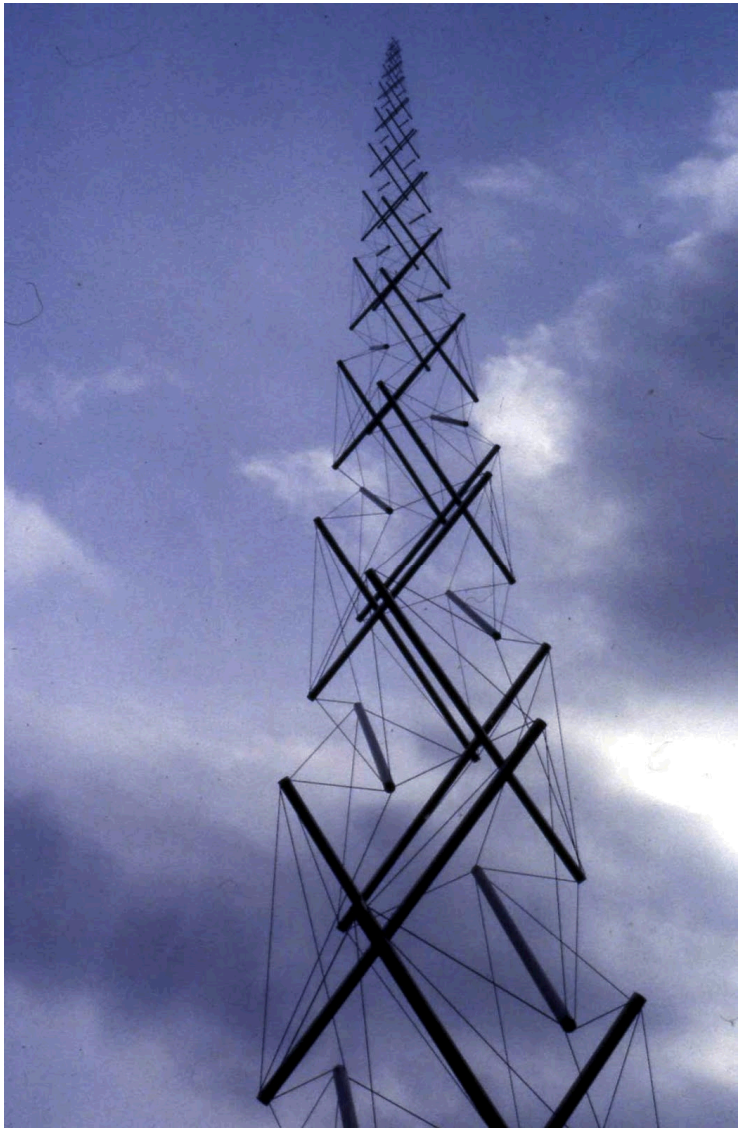

Left: "Experiment Number 1." *Cerebrovortex*. 23 July 2013. Web. 10 July 2015

Right: Peterson, Ivars. "Needle Tower." *The Mathematical Tourist*. 22 May 2010. Web. 10 July 2015.

Why Should we Study Tensegrity?

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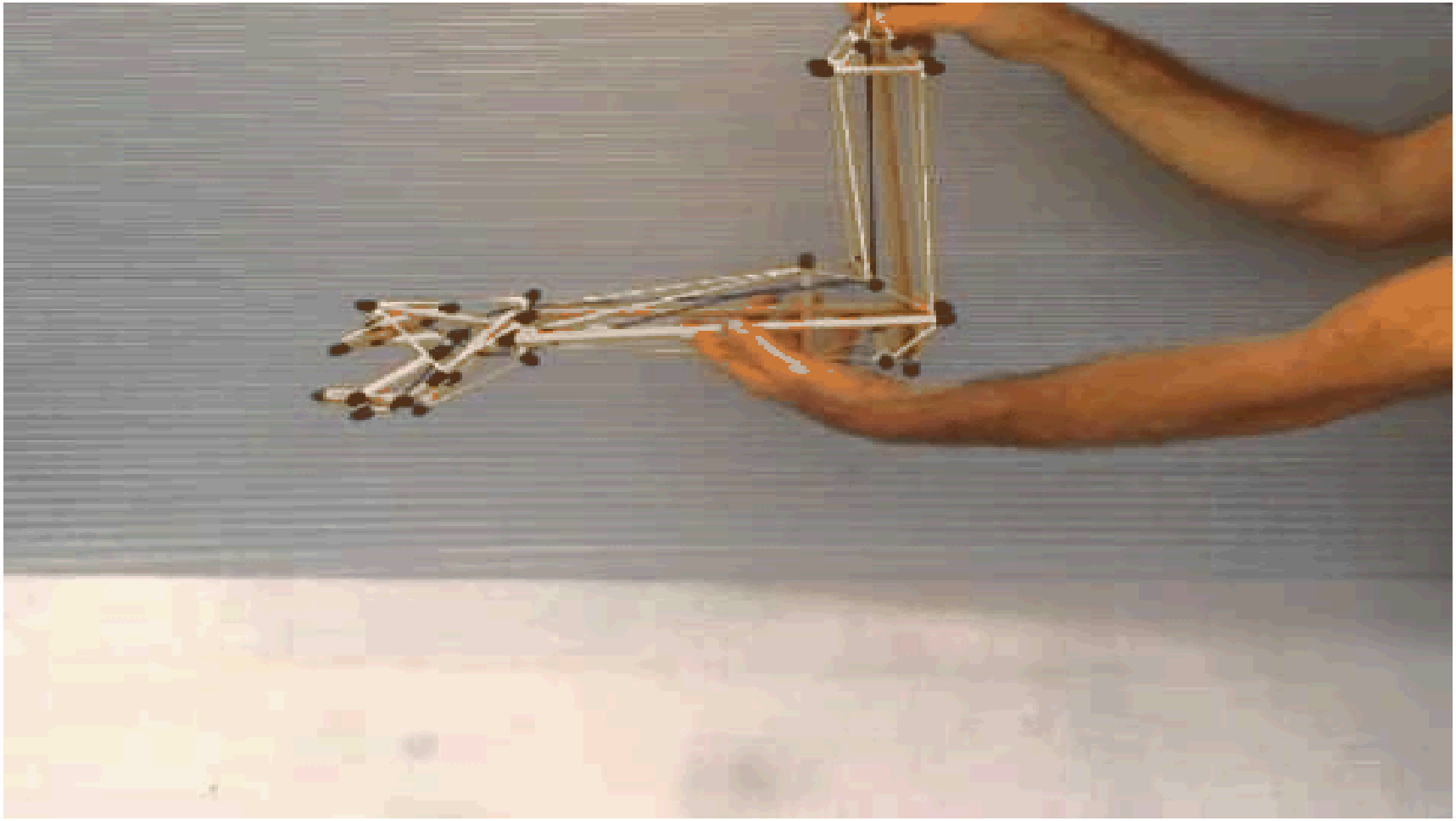
- Benefits:
  - Lightweight
  - Minimal material
  - Can be controlled
- Wide variety of applications, from biology to robotics to architecture

Applications – Prosthetics

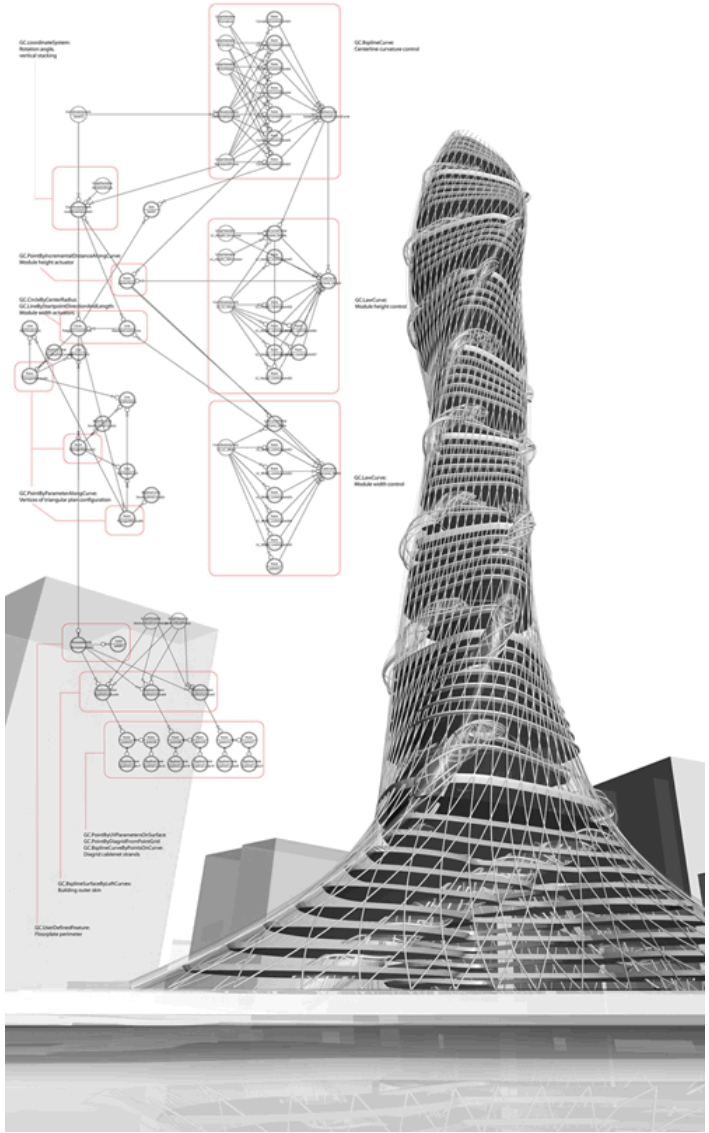


Flemons, Tom. "Tensegrity Arm." *YouTube*. YouTube, 4 Sept. 2012. Web. 10 July 2015.

Applications - Robotics

Flemmons, Tom. "Tensegrity Mast." *YouTube*. YouTube, 4 Sept. 2012. Web. 10 July 2015.

Applications – Architecture



Fagerström, Gustav. "Tensegrity Tower by Fagerström."
Tensegrity Wiki. 2007. Web. 10 July 2015.

Applications—Space Travel

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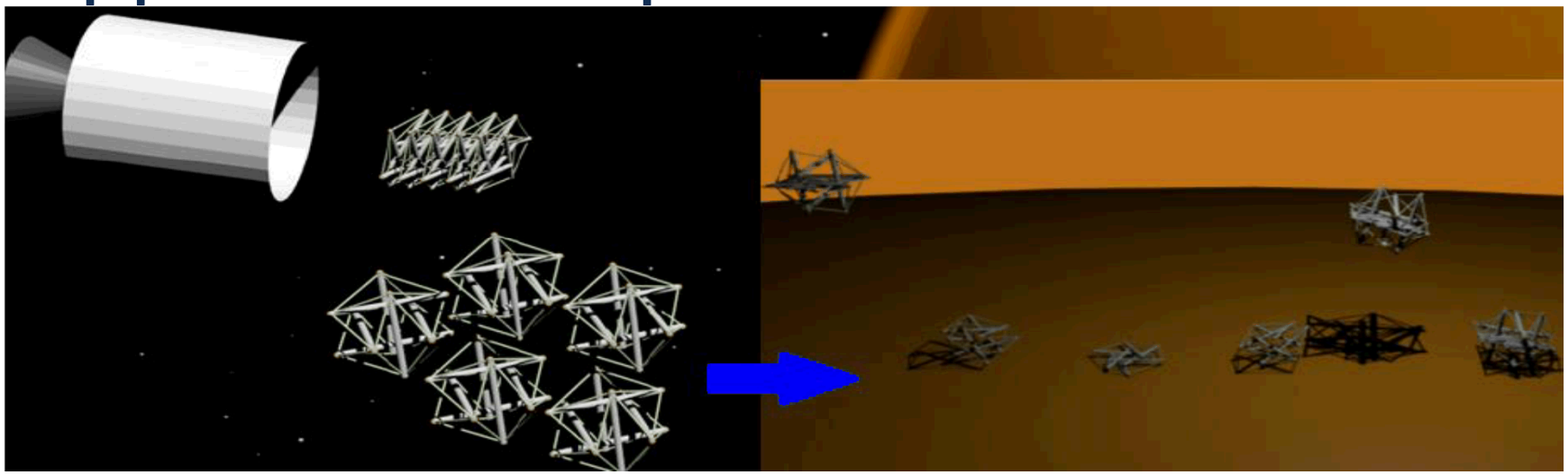

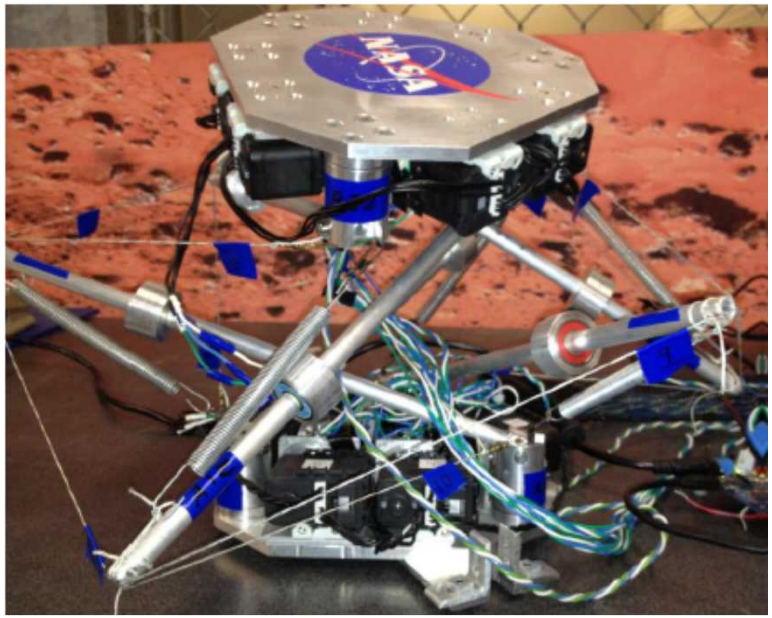

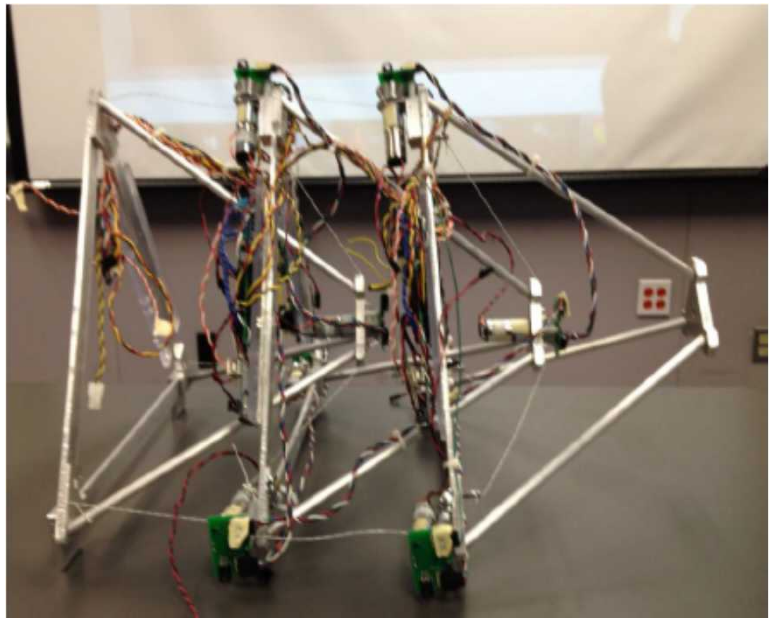

Summer Project

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- Overall goal: analyze these structures using the software *Abaqus*.

- Mini goals:
  1. Learn *Python*
  2. Understand some basic concepts in mechanical engineering
  3. Build a small tensegrity model
  4. Learn *Cubit*, create the structure in *Cubit*
  5. Learn basics behind *Abaqus*
  6. Create a Python script to output coordinates, input into *Abaqus*
  7. Learn and use *Ensight* to view *Abaqus* simulations

Challenges Overcome

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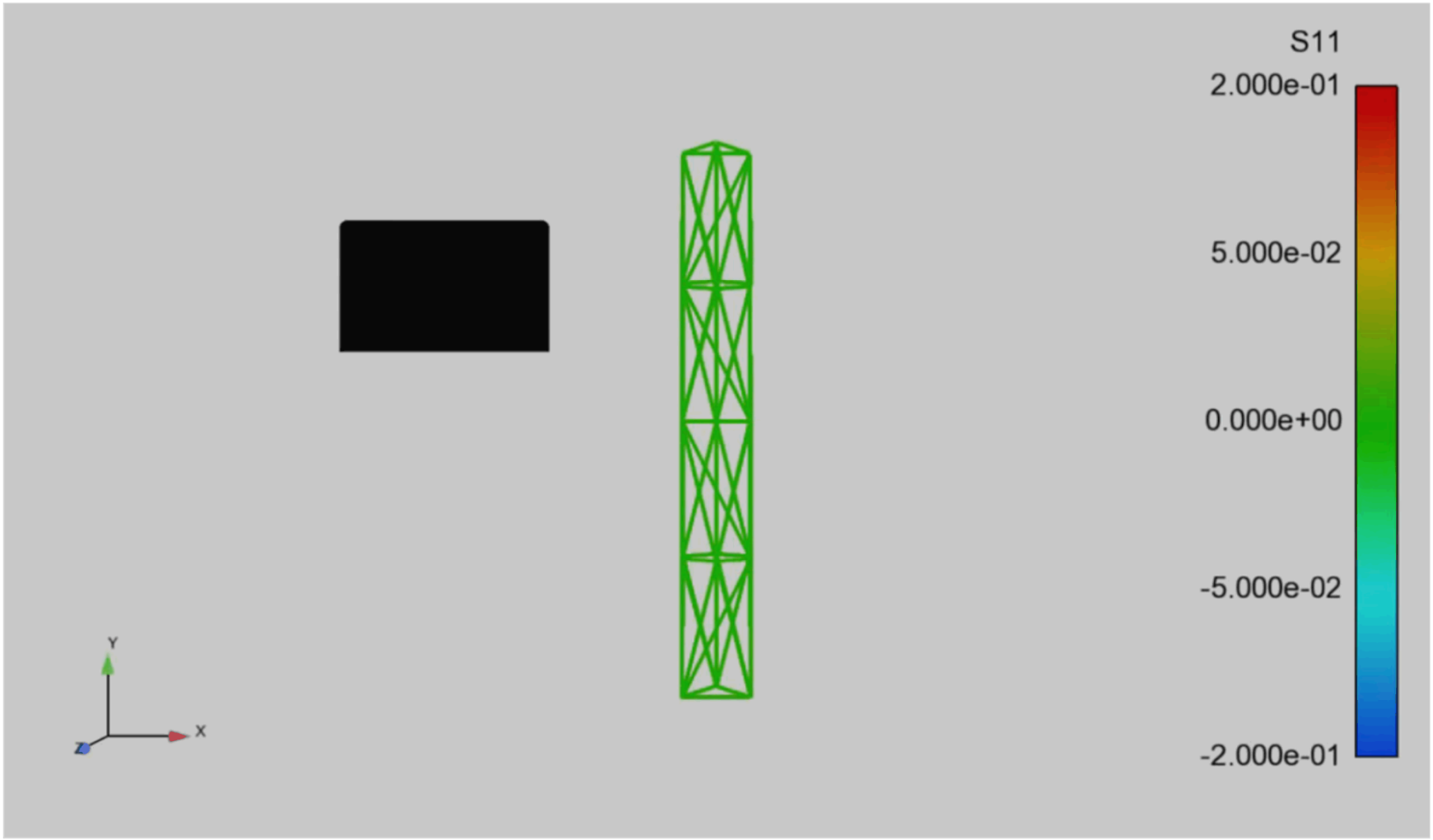
- 1st Python program:

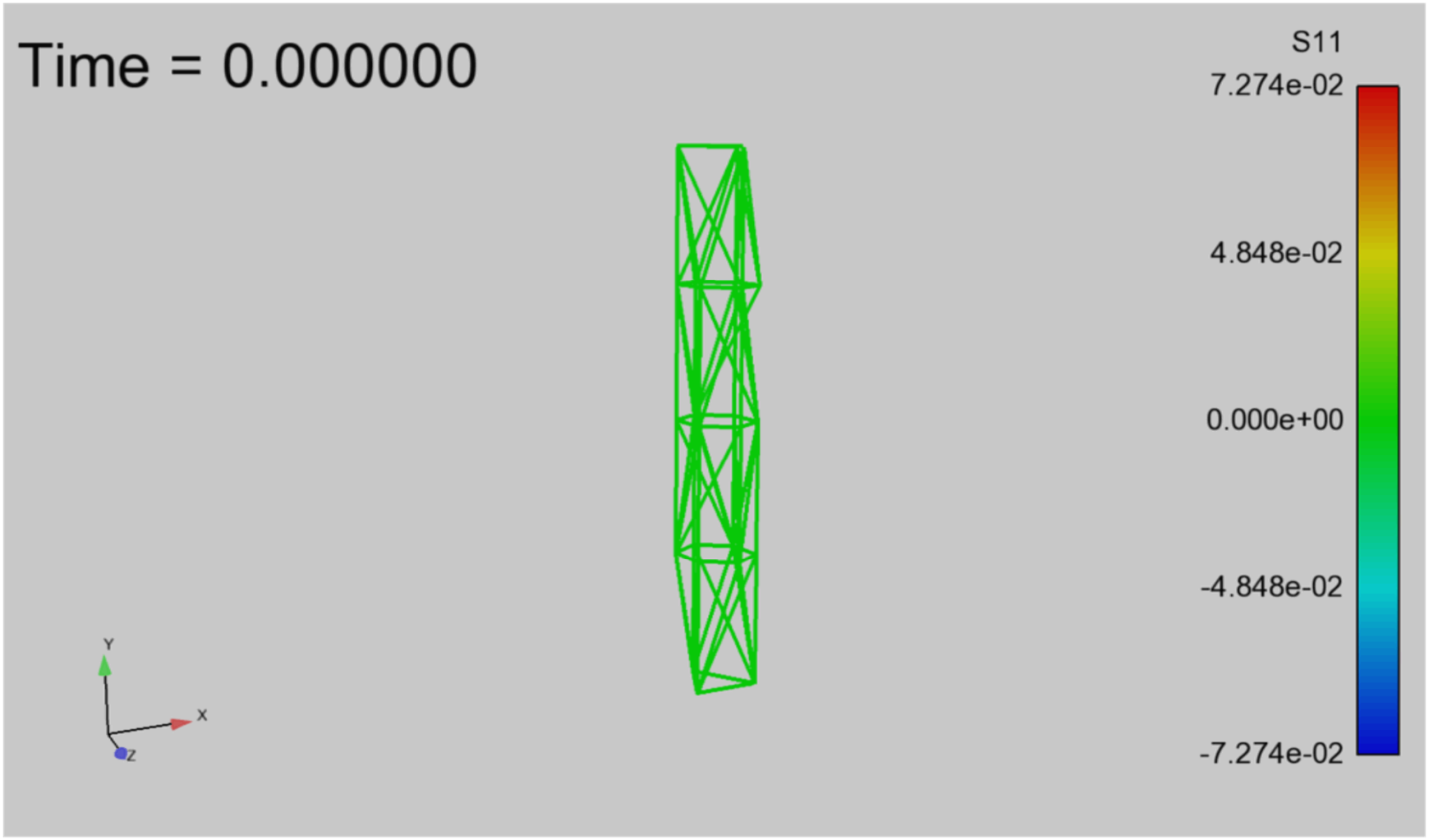
```
stories = input("How many stories? ")
vertices = stories * 6
vertex_list = []
for i in range(1, vertices + 1):
    vertex_list.append(i)
Def story_a():
    for i in vertex_list:
        vertex_a = (0.0, 6* i, 0.0)
        vertex_b = (1.5, 6 * i, -3.0)
        vertex_c = (3, 6 * i, 0.0)
        print vertex_a, vertex_b, vertex_c
        if i == stories - 1:
            break
if stories %2 == 0:
    story_a(), story_b()
else:
    story_x(), story_y()
```

Challenges Overcome

- Tutorials on tensegrity towers

Findings

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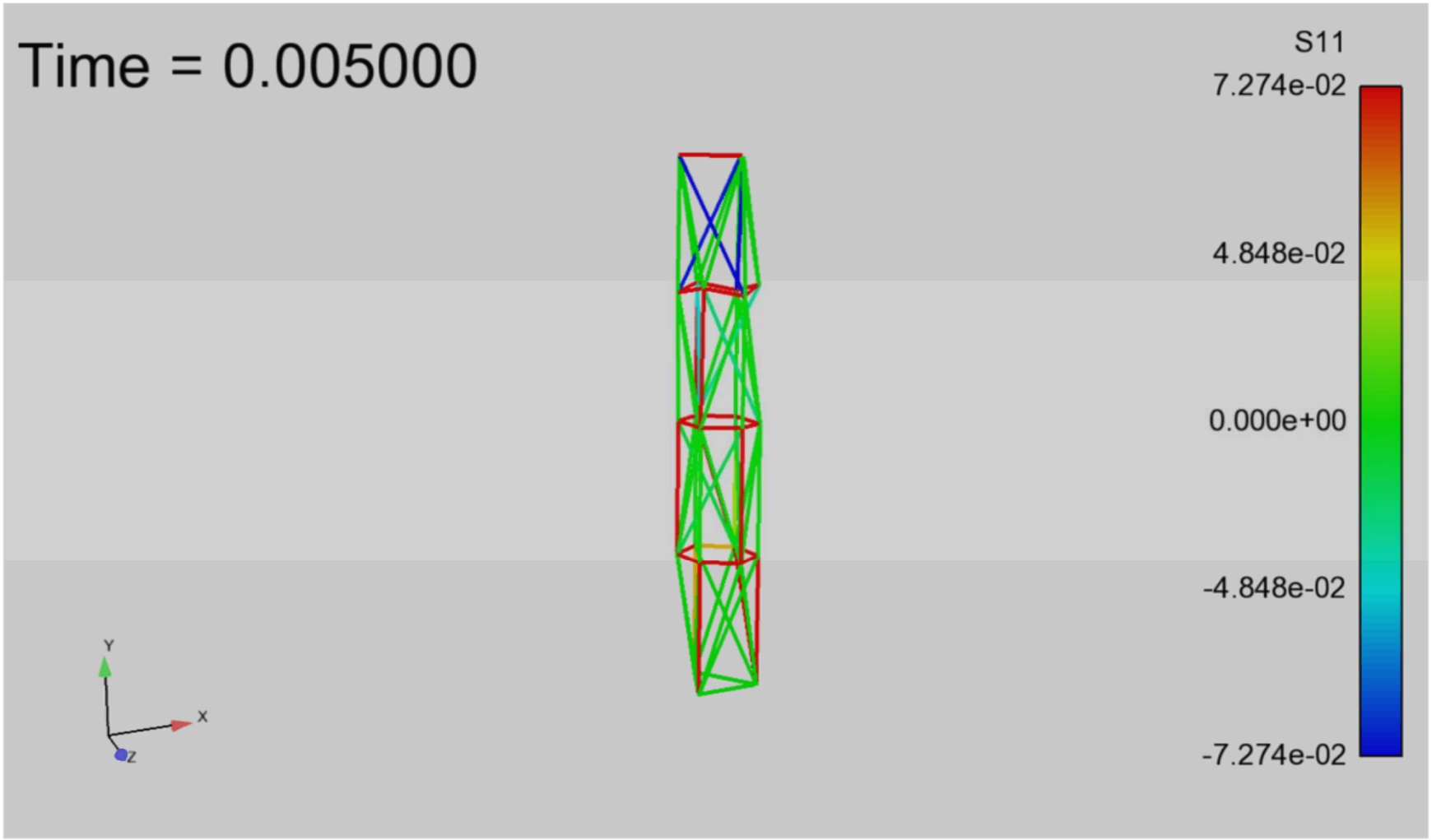
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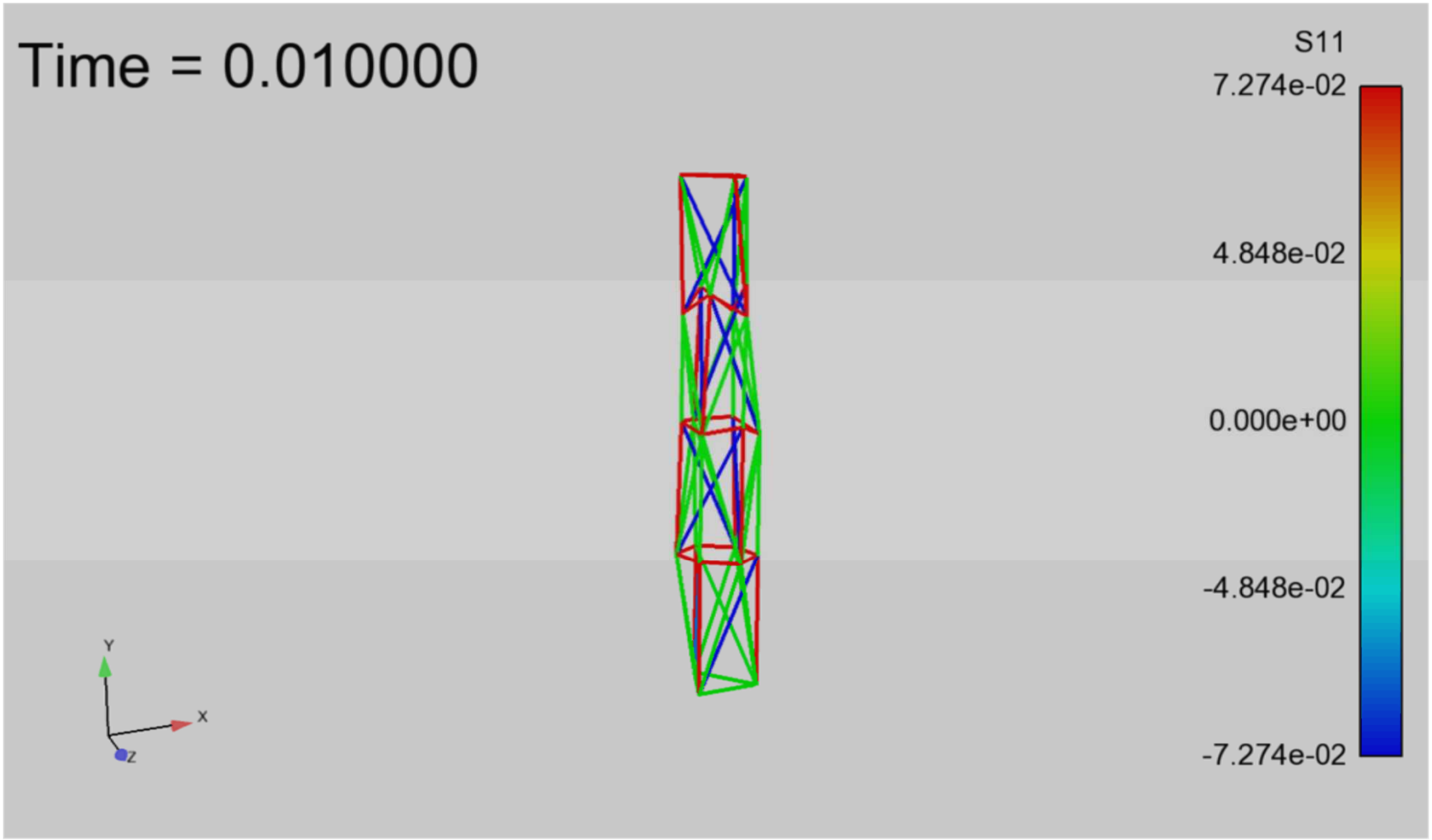
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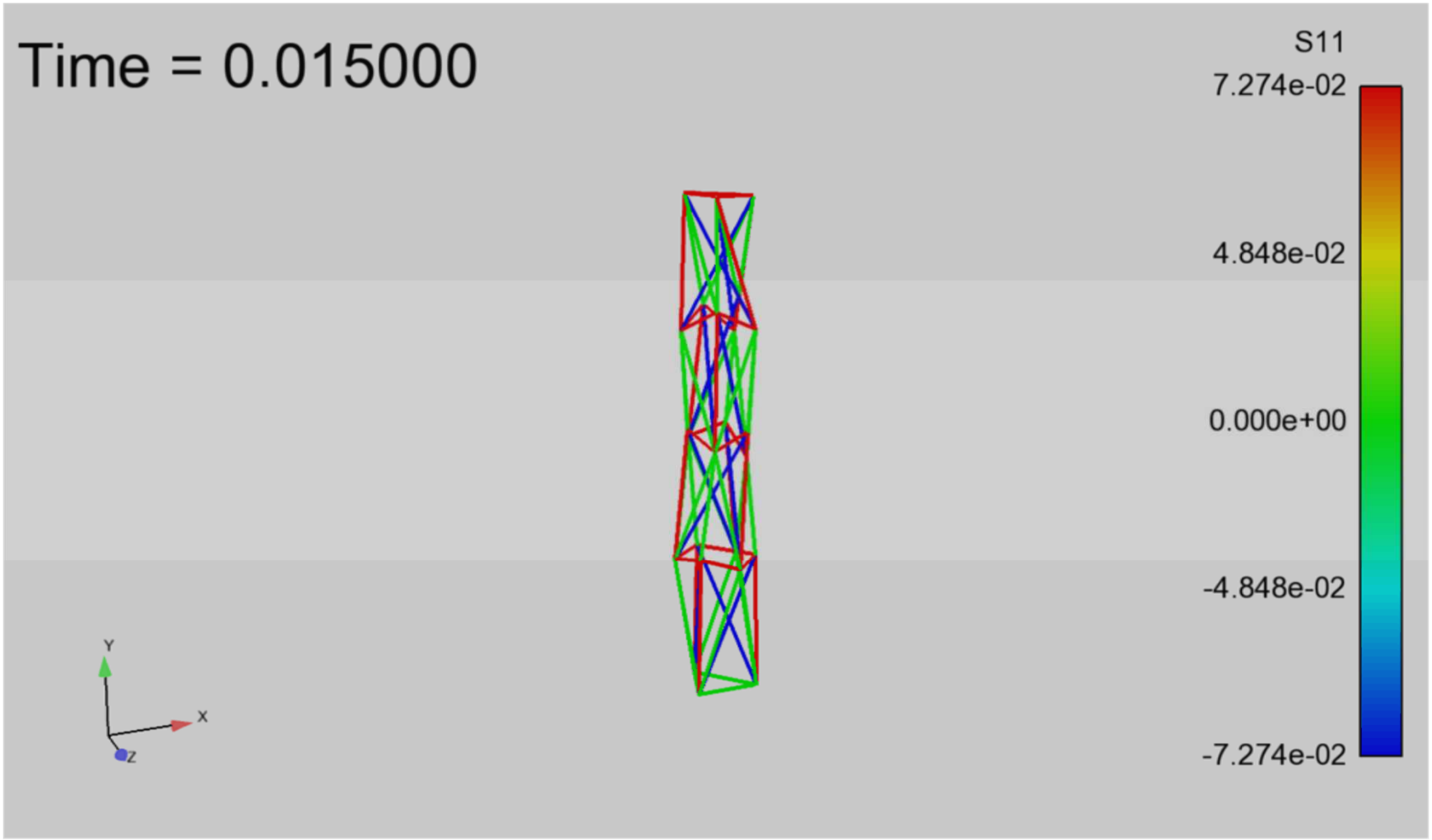
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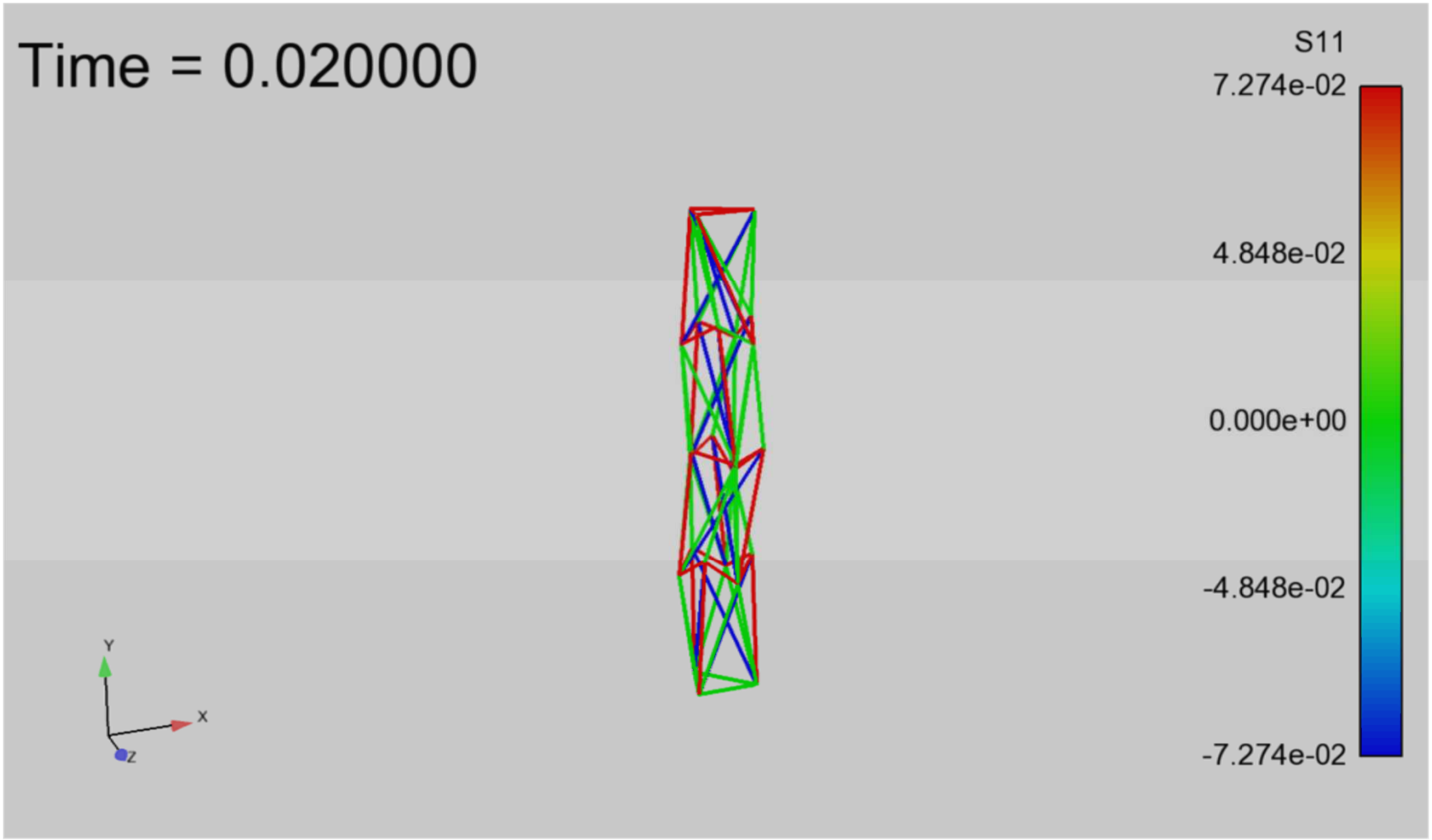
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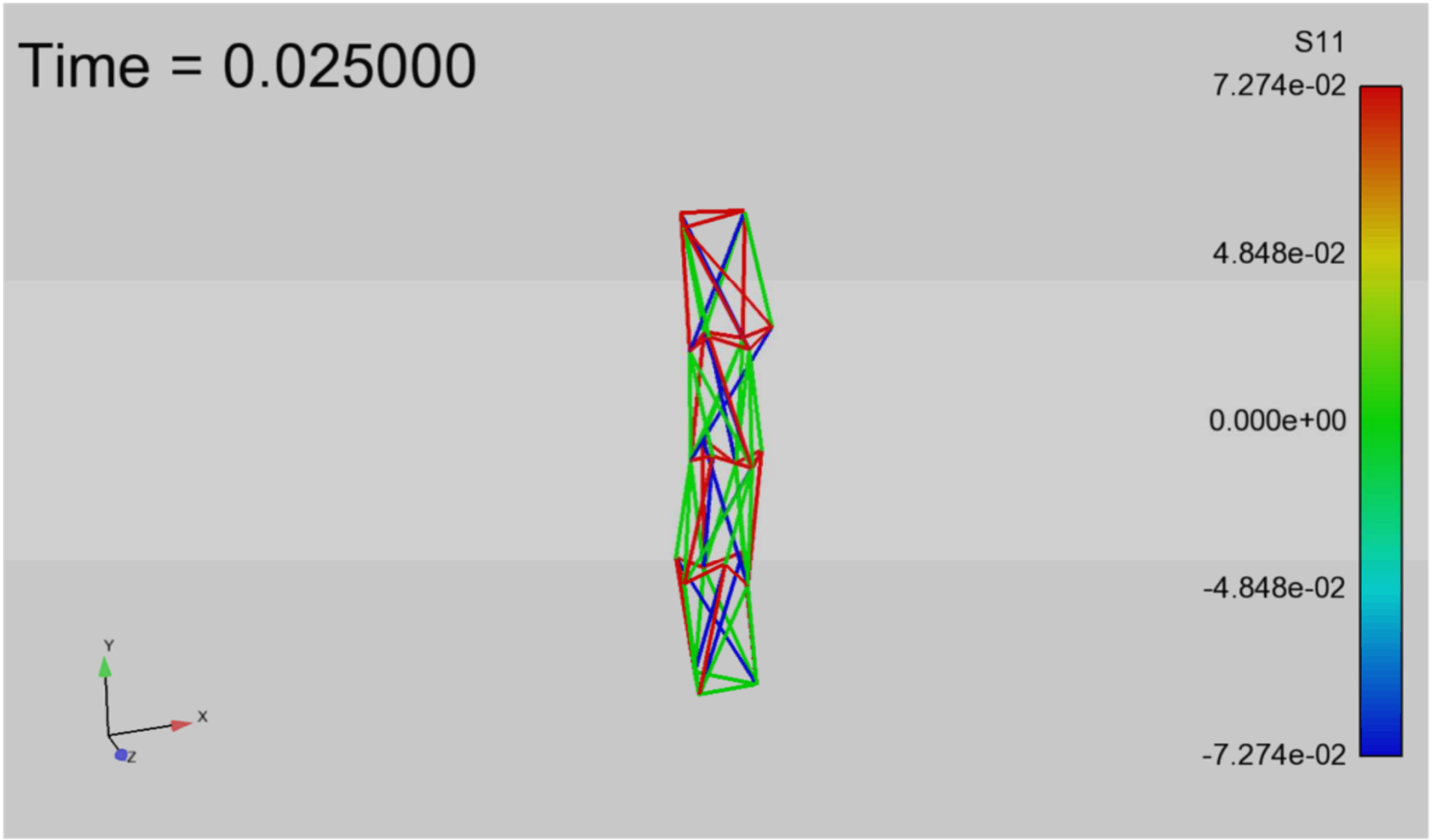
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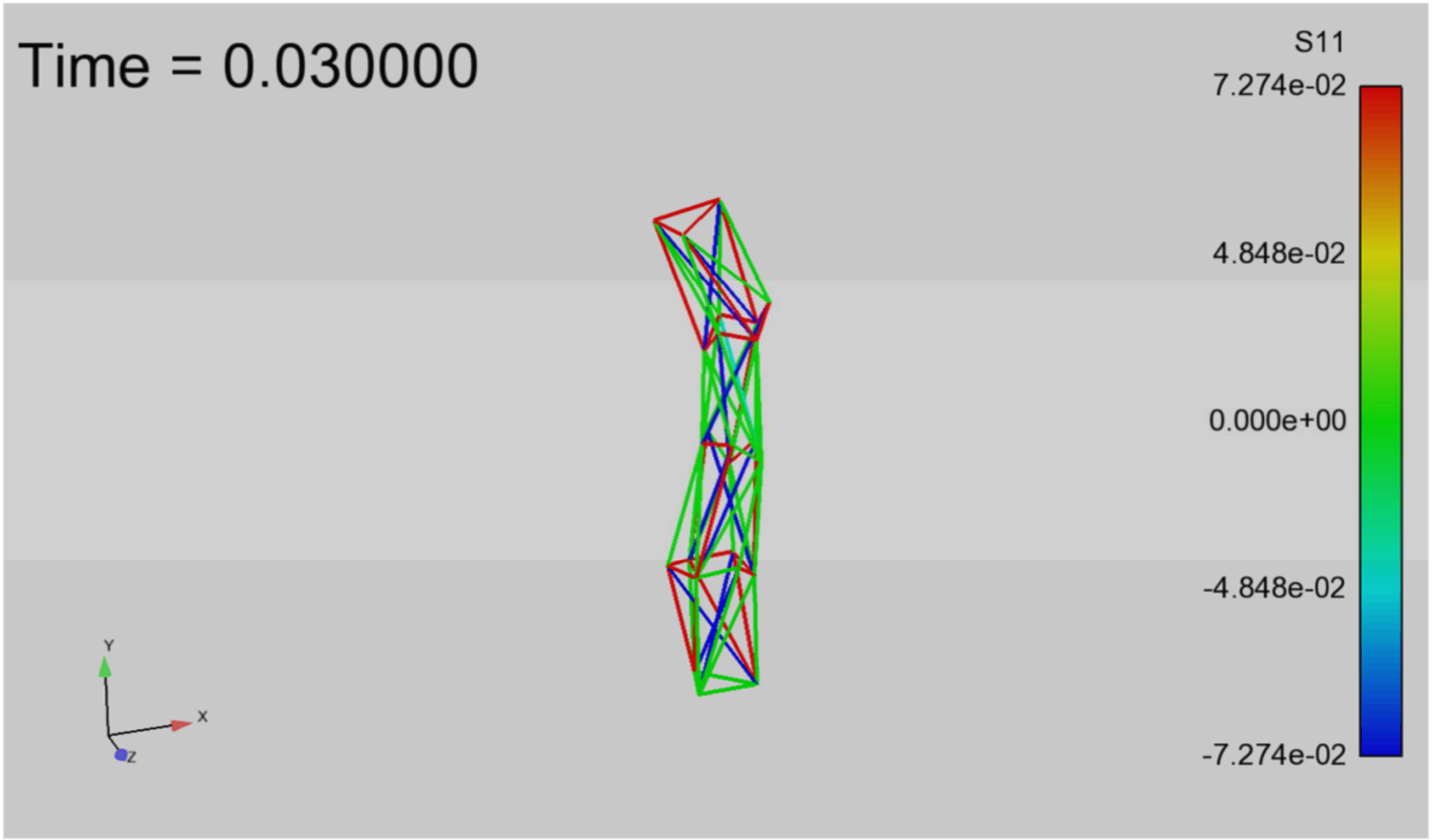
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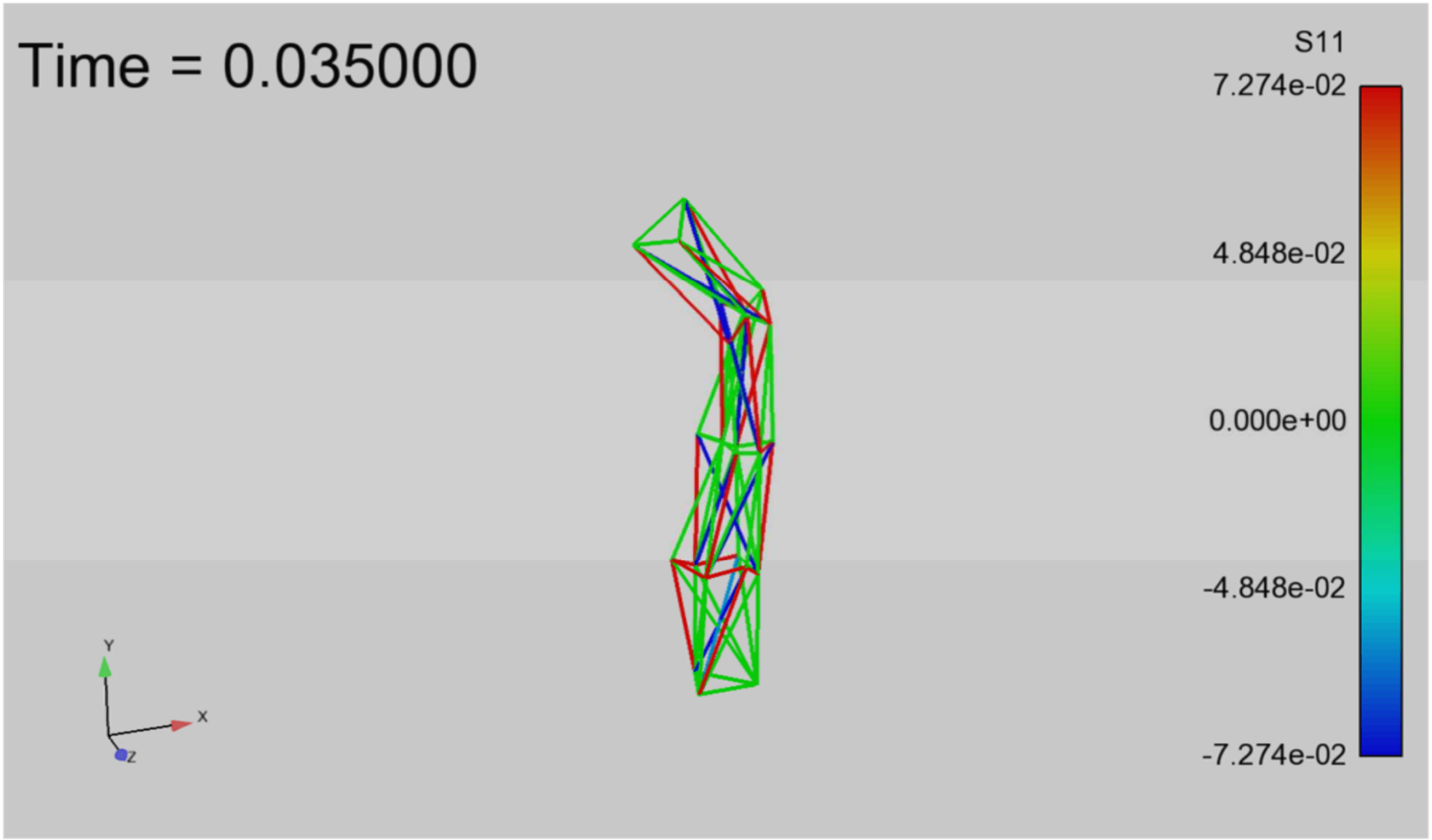
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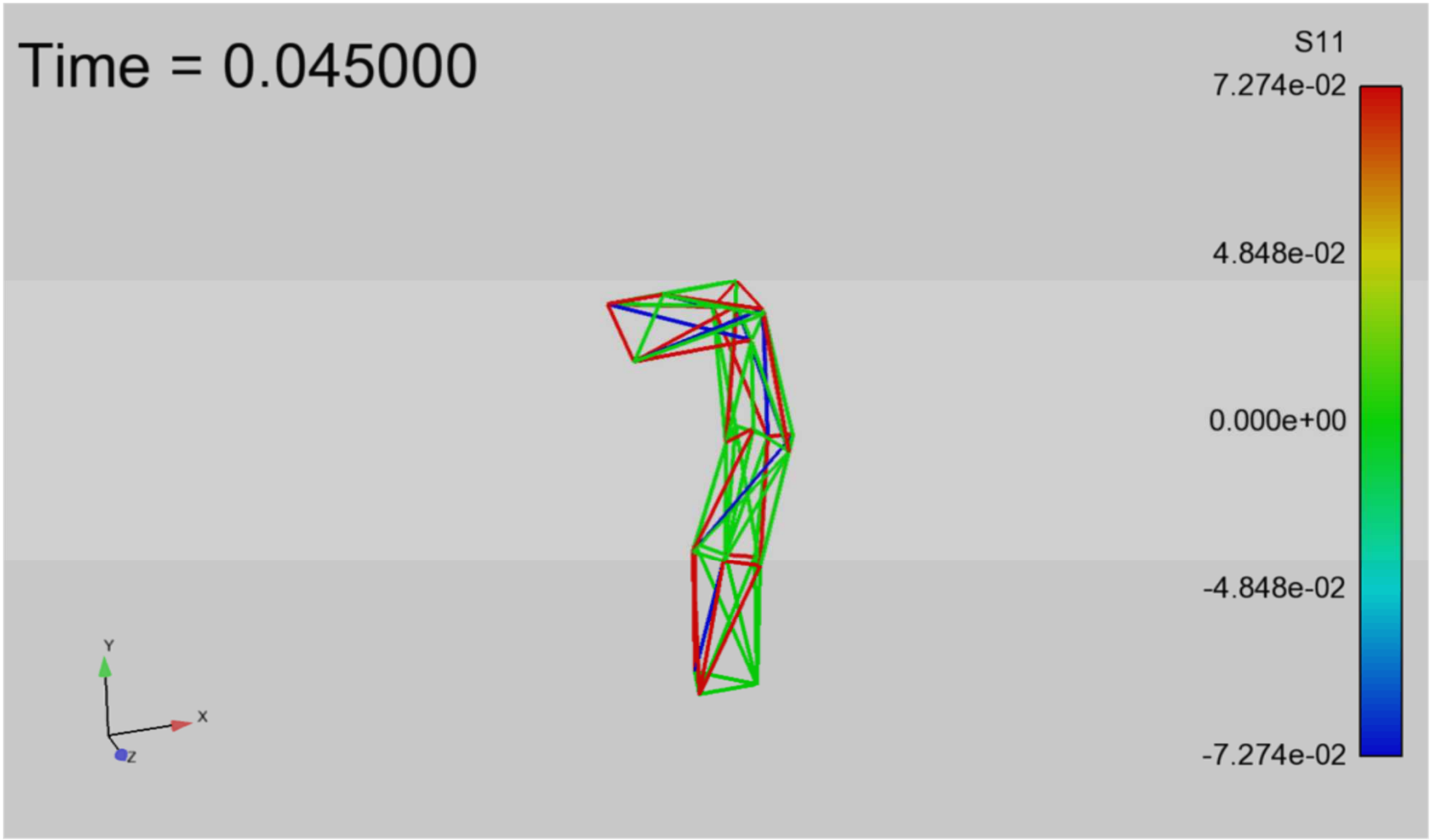
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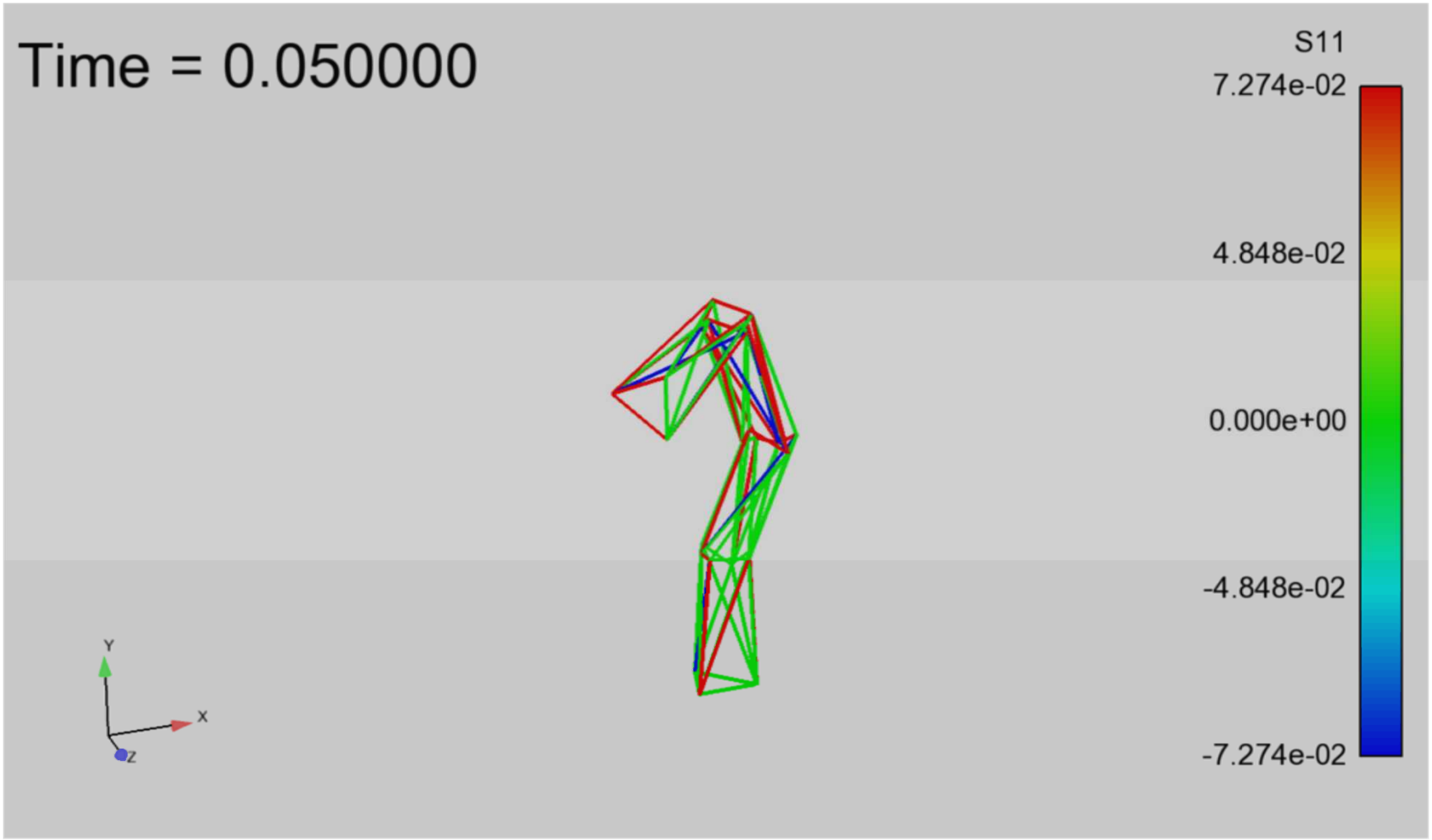
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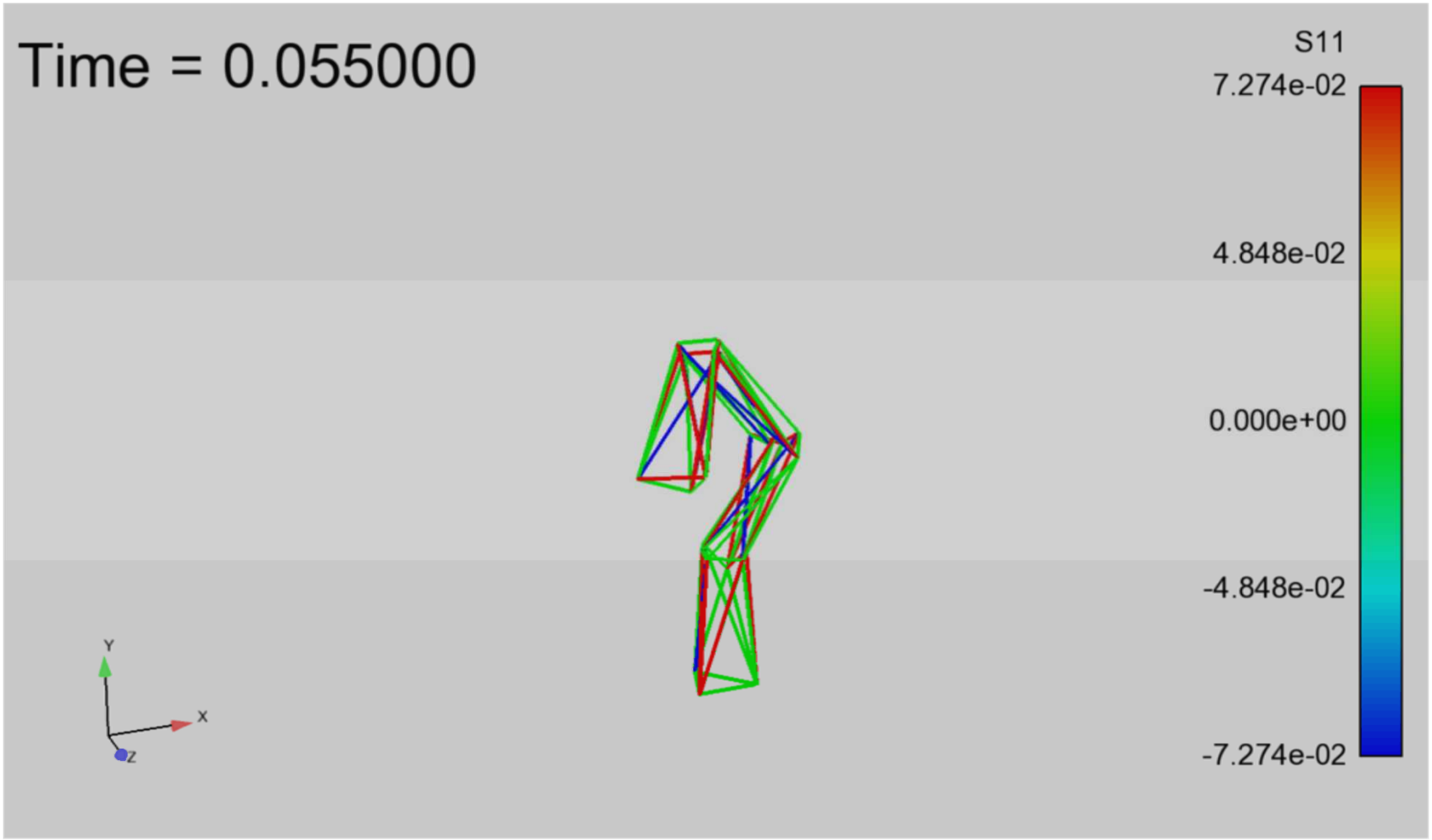
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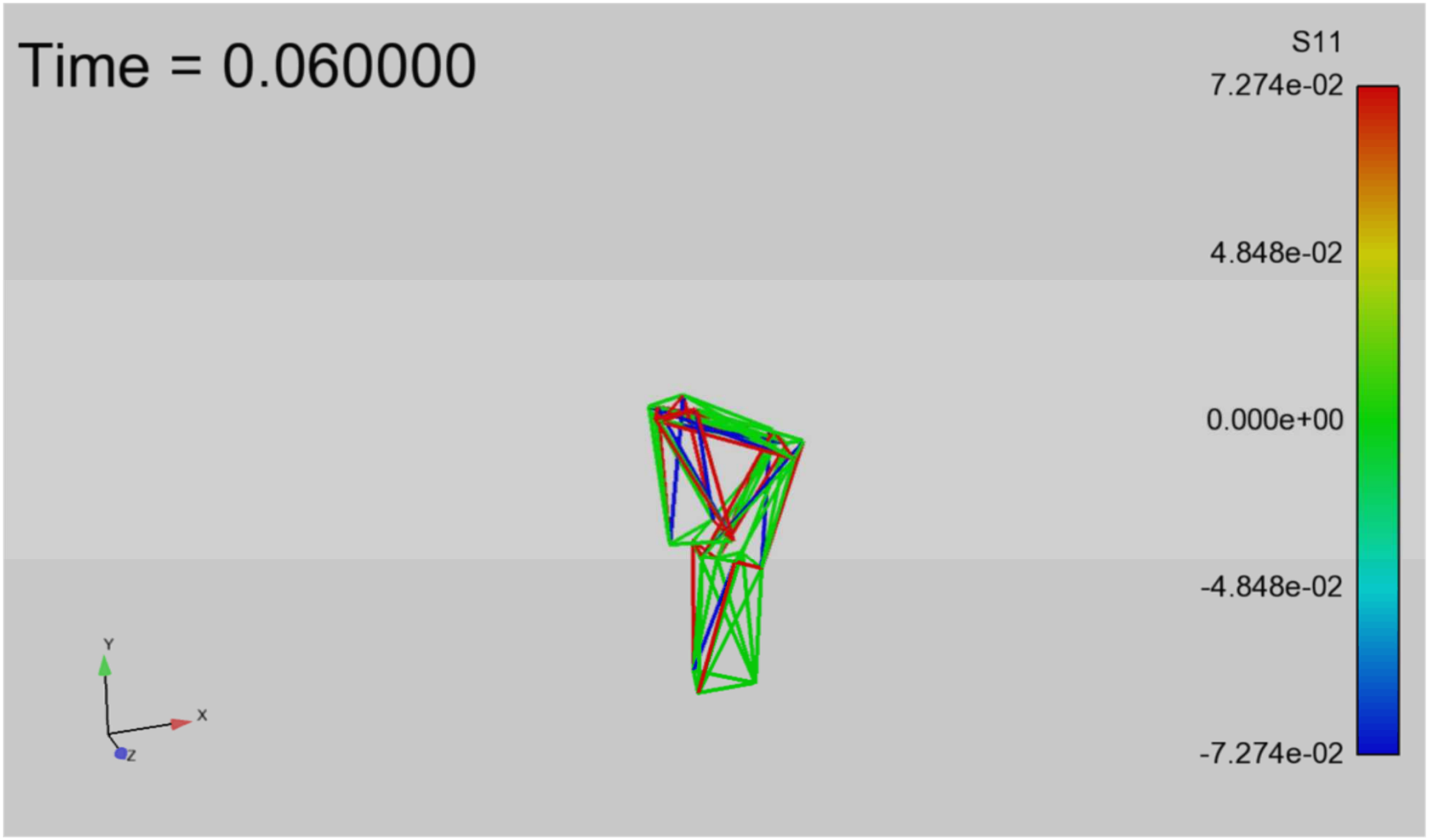
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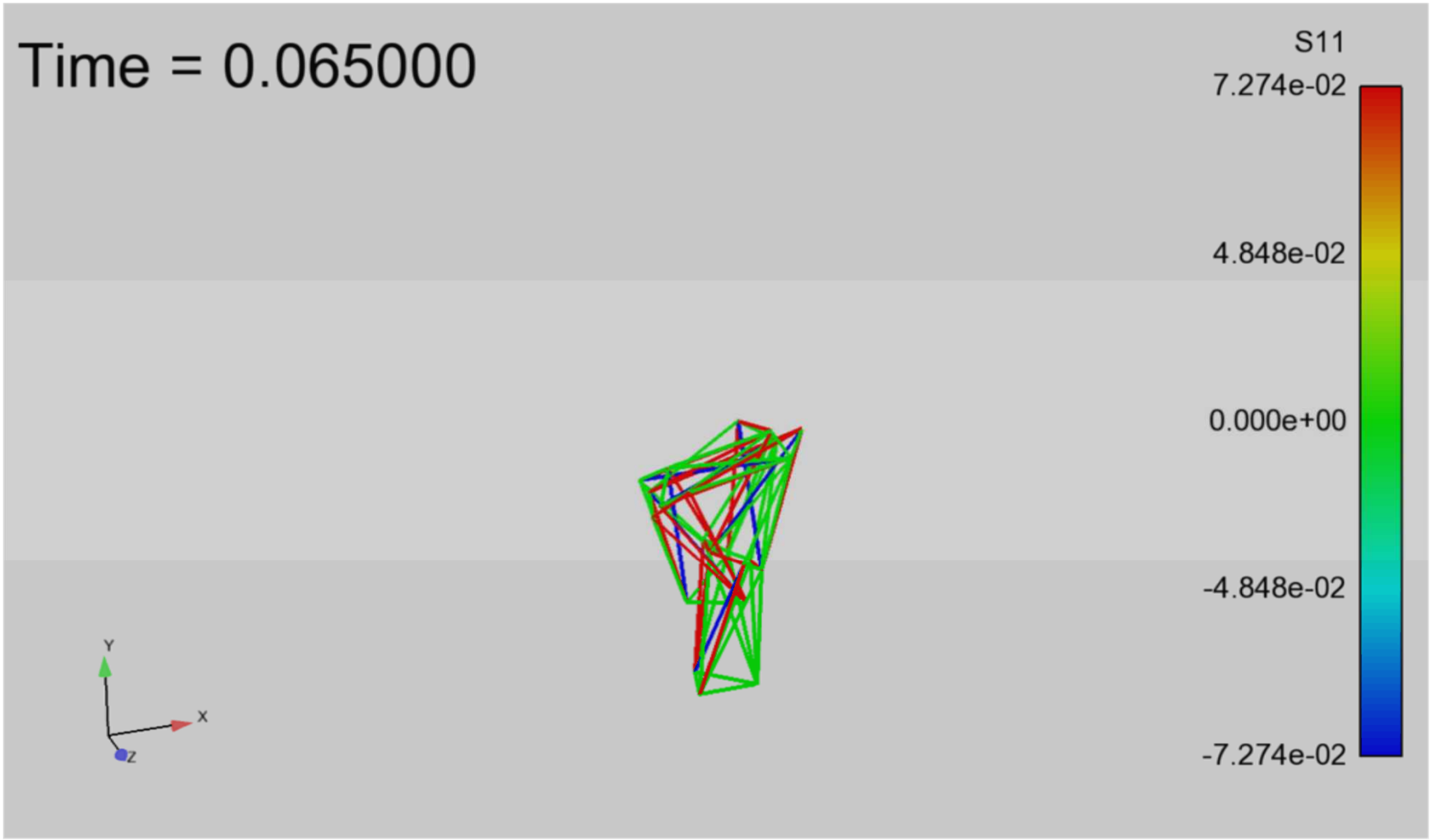
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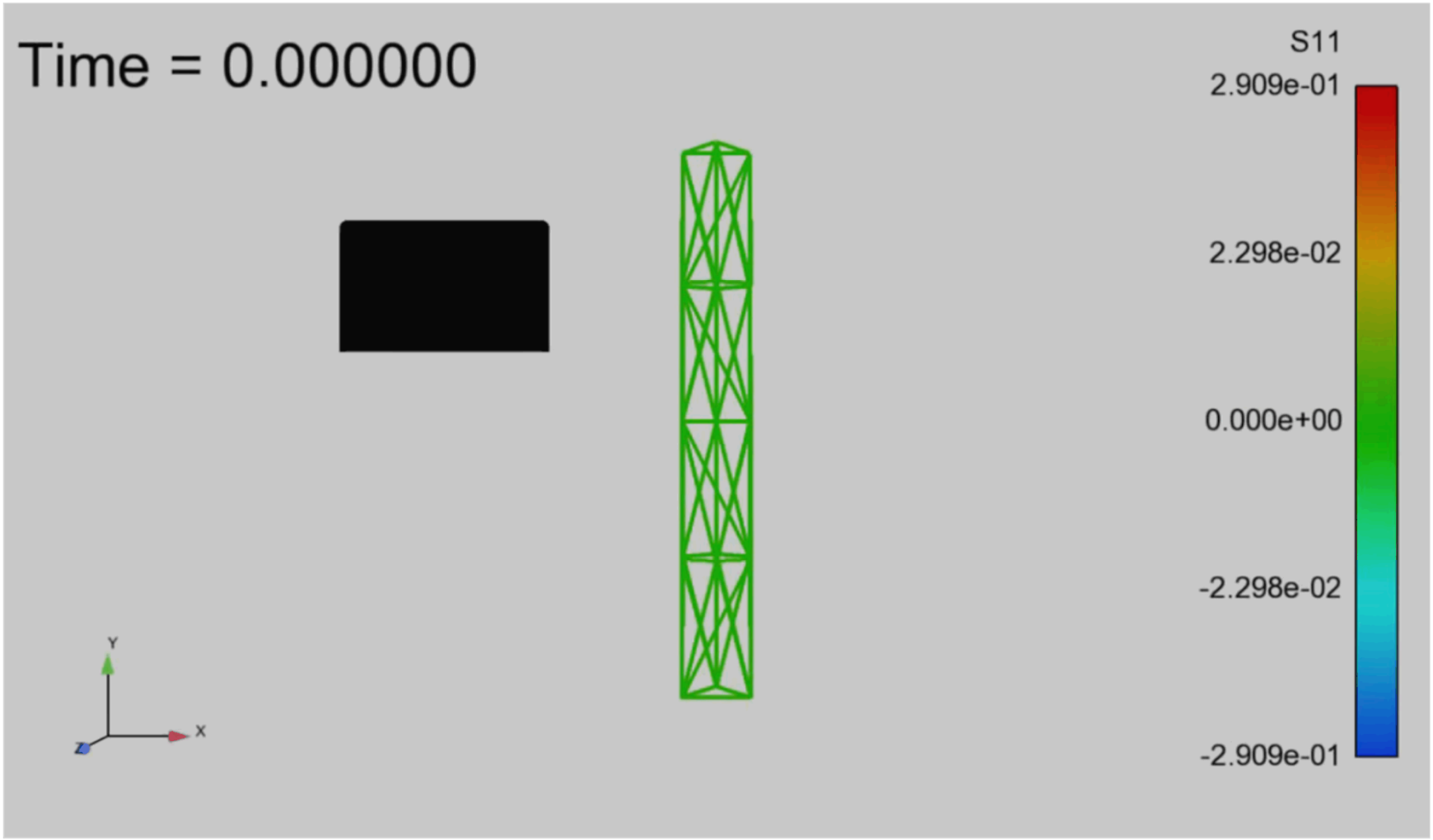
Kevlar and Brass



Summary

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- This summer I:
  1. Learned *Python*, *Cubit*, *Abaqus*, and *Ensight*
  2. Utilized those programs to analyze tensegrity structures
  3. Found that…
  4. Went through the engineering process

College

- Gained real experience
- Computer engineering an option

Next Steps

- Investigate more complex tensegrity structures
- Research more applications Sandia may be interested in
  - Impact resistance
  - Robotics
  - Carbon Nanotubes

Questions

Sandia National Laboratories

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