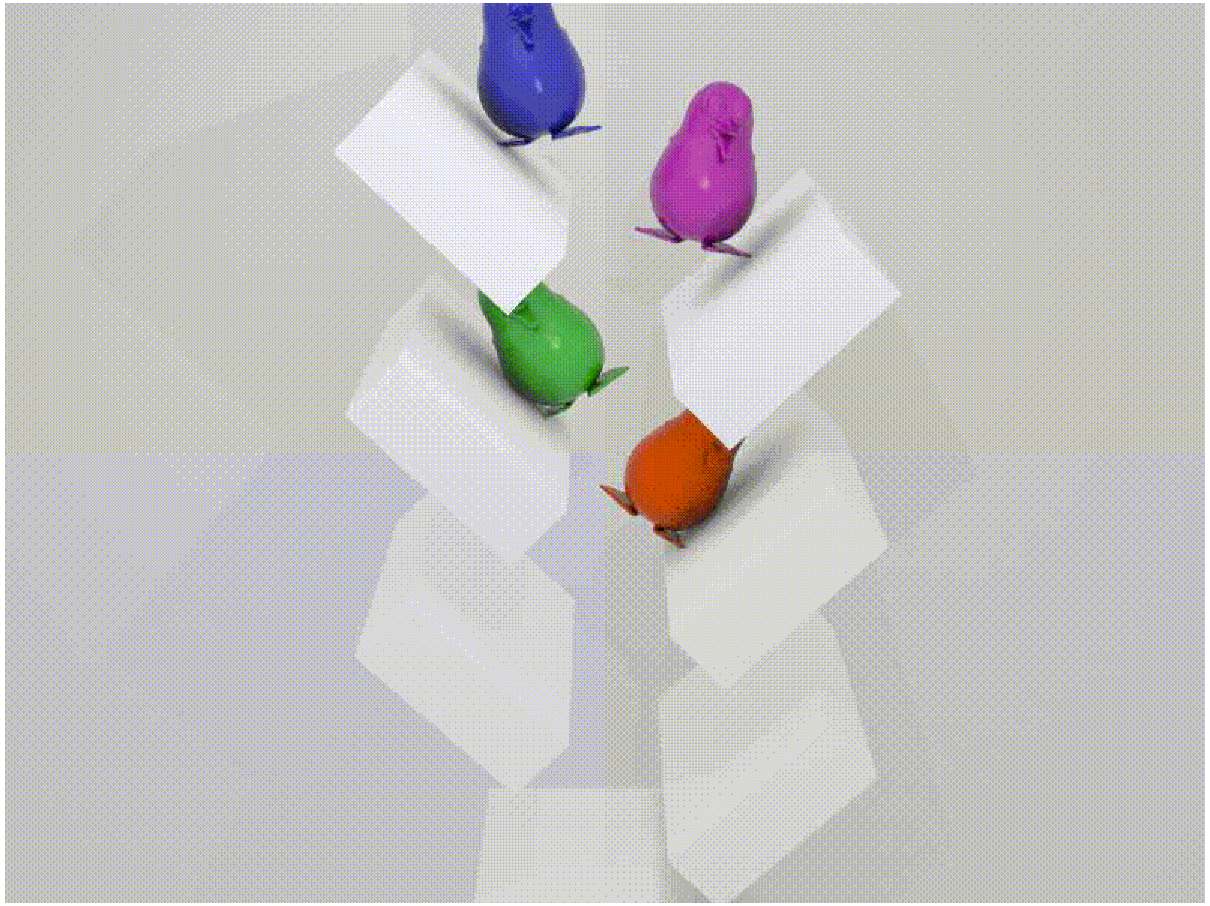
Intro to Physics Based Animation



Announcements

Tutorial on Friday for bonus homework assignment stuff and/or questions about theory for exam prep

Bonus assignment due Sunday 16 August

Office hours after lecture

Final exam Saturday 22 August at 9pm (according to vote)

Course Evaluations!

Physics Based Animation

Today:

General Overview

Physics Based Animation course assignments

- 1D Mass Spring System
- 3D Mass Springs
- 3D FEM (Finite Element Method)
- Cloth Simulation
- Rigid Body Simulation
- Rigid Body Collision Resolution

Any Questions?

What is physics based animation?

Using the laws of physics to simulate “accurate” movement of digital objects

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Making simulations perfectly accurate is hard and often not possible.

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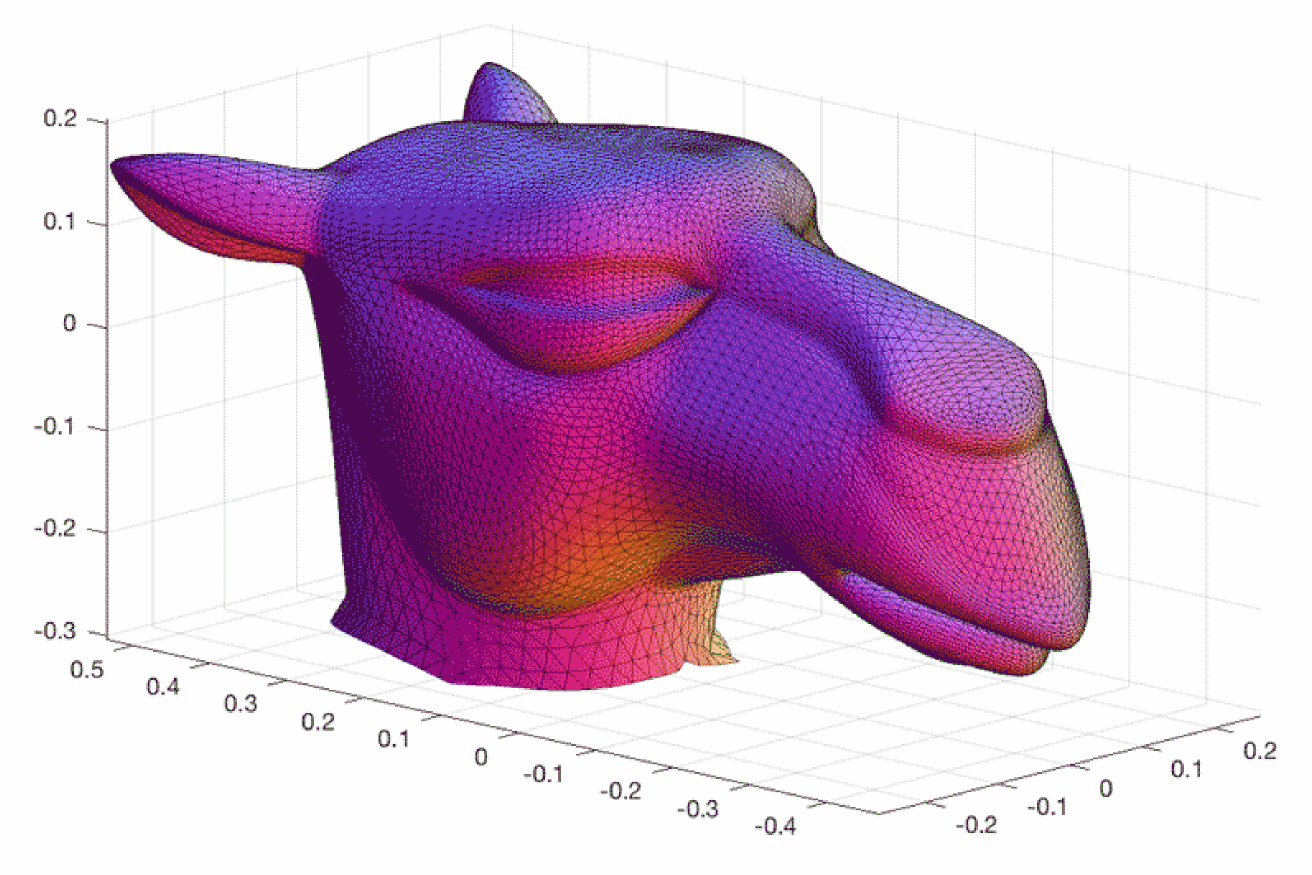
Accuracy can be:
1. Perceived
2. Numerical

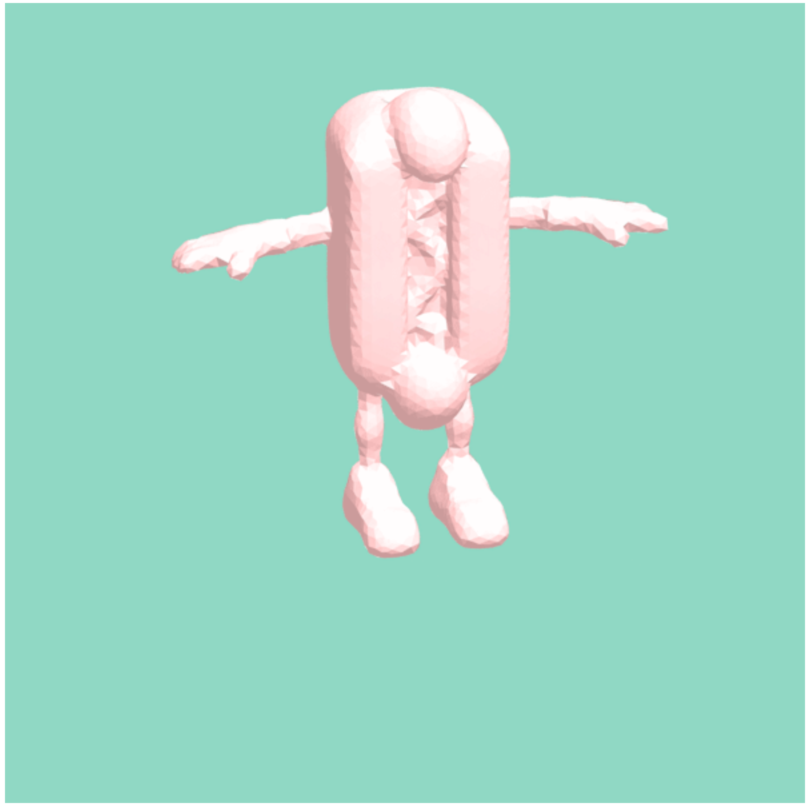
What is physics based animation?



https://siggraphfails.tumblr.com/

What is physics based animation?

Bugs!



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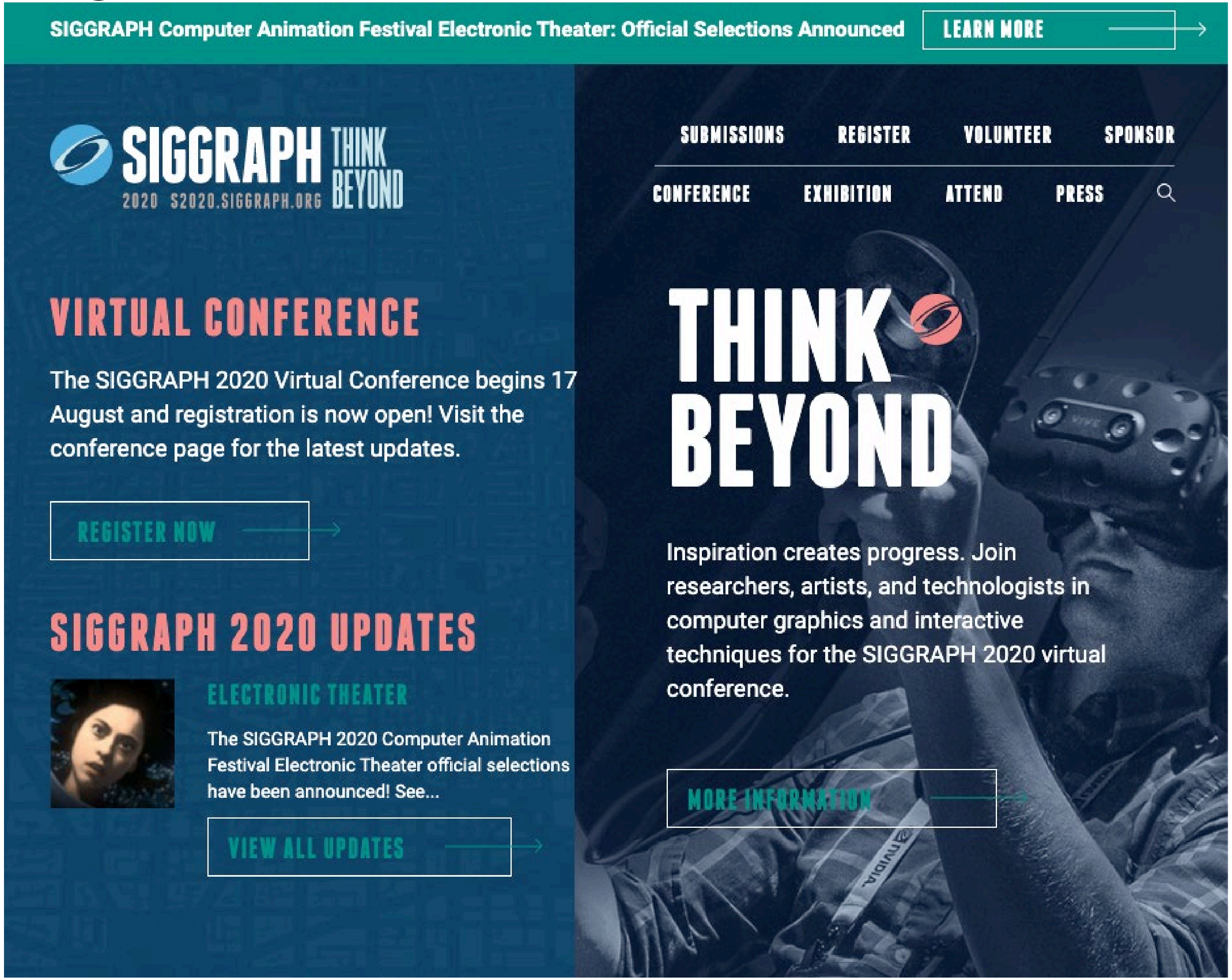
What is physics based animation?

http://computeranimation.org/

What is physics based animation?



https://s2020.siggraph.org/

In practice

In practice

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In practice

Course Structure (at least when I took it)

Lectures on math and algorithms – slides + ipad annotations

- Discuss the problem in the continuous setting (energies, derivatives)
- Then move onto the discrete analog (matrices, usually sparse, sometimes need symbolic packages to compute derivatives for you)
- Read papers + README to implement assignments

6 assignments
Course project
Course participation – showing up and talking in class

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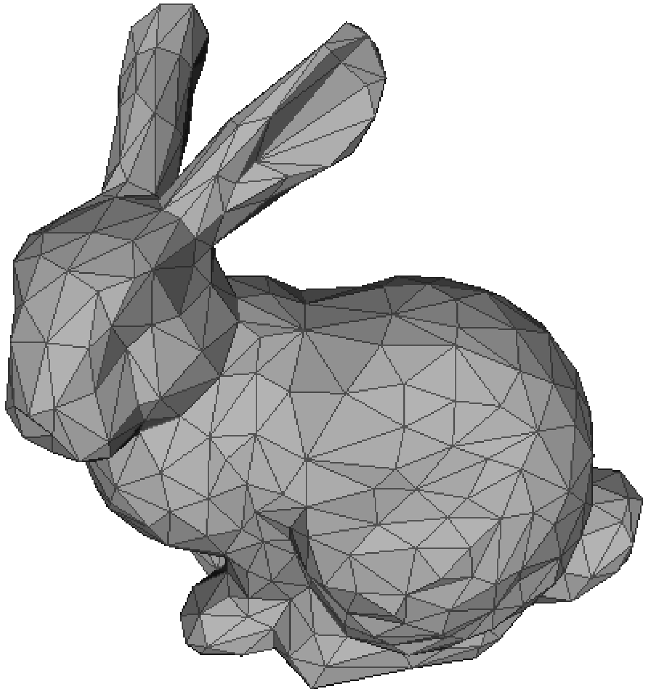
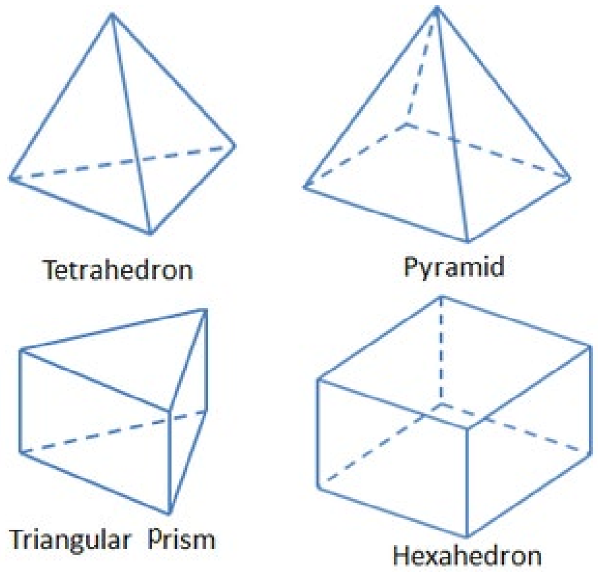
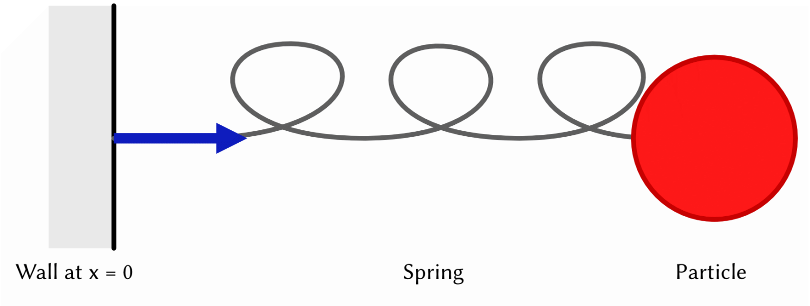
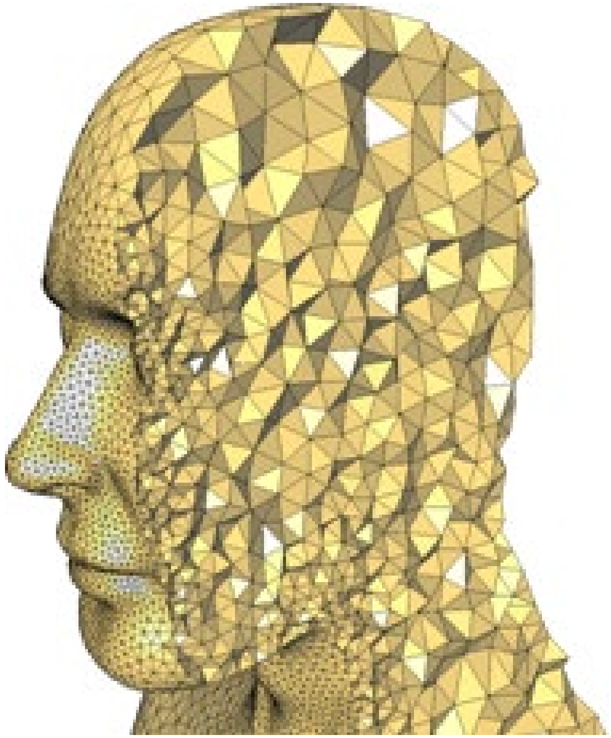
http://diwlevin.webfactional.com/researchdb/

Fundamentals









https://en.wikipedia.org/wiki/Types_of_mesh#Tetrahedron

Fundamentals

Newton's laws of motion in physics	
LAW #1	A body at rest will remain at rest, and a body in motion will remain in motion unless it is acted upon by an external force.
LAW #2	The force acting on an object is equal to the mass of that object times its acceleration, $F = ma$.
LAW #3	For every action, there is an equal and opposite reaction.

Assignments

1D Mass Spring

Familiarize with the tools used in the course:
C++, Eigen, some libigl functions

Learn time integration schemes for a 1D spring

Visualize it using a cow!
https://github.com/dilevin/CSC2549-a1-mass-spring-1d

3D Mass Spring System

3D mass spring systems! (much like the concepts of A8, particles connected by springs)

Extend first assignment

Instead of minimizing energy, use linearly implicit time integration

Use projection matrices for pinned vertices
https://github.com/dilevin/CSC2549-a2-mass-spring-3d

Finite Element Method

Very common numerical method

Divides space into “finite elements”

Represent any quantity inside as a linear combination of basis functions
http://www.femdefo.org/

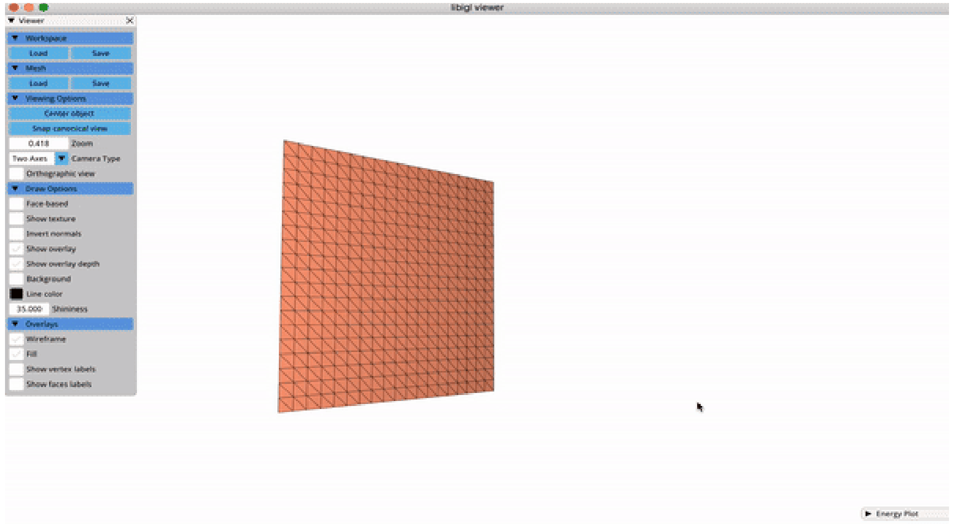
Optimize using Newton’s method + line search
https://github.com/dilevin/CSC2549-a3-finite-elements-3d

Cloth simulation

Use triangles as finite elements (not a mass spring system)

Simulating a 2D object (cloth) in a 3D world

Simple collision detection with spheres



https://github.com/dilevin/CSC2549-a4-cloth-simulation

Rigid Bodies

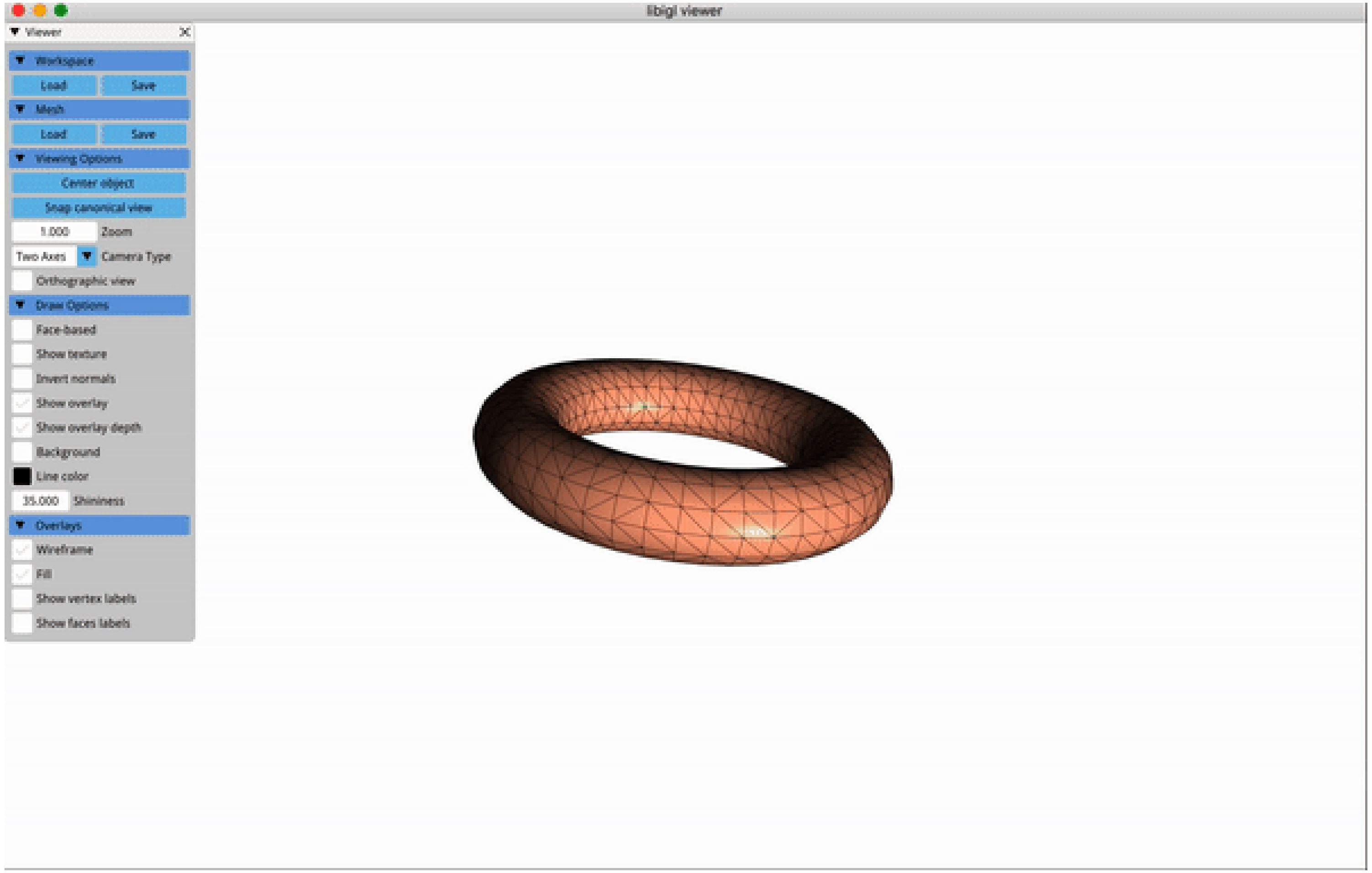
Rigid bodies do not deform!

So let’s not waste time on finite elements inside the volume

Easier! … but actually hard in a different way. Need to take the derivative of a rotation matrix 😮

https://github.com/dilevin/CSC2549-a5-rigid-bodies

Rigid Bodies



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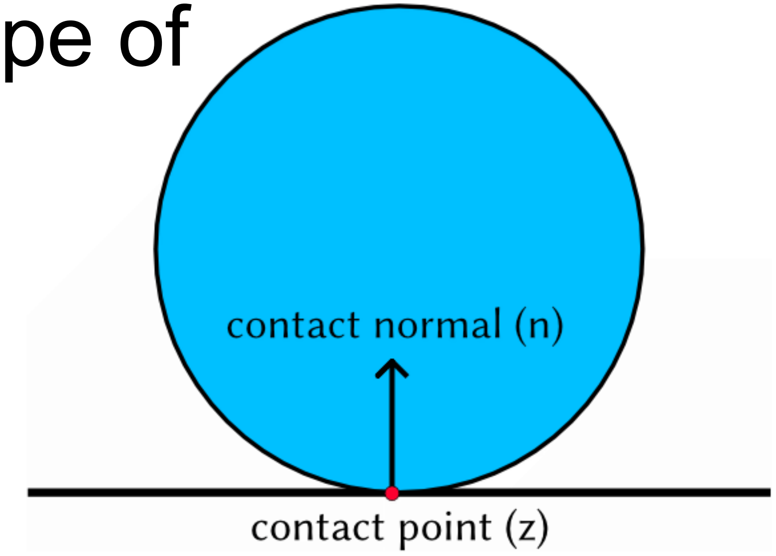
Rigid Body Contacts

Introduce the contact force, only non-zero when objects are in contact

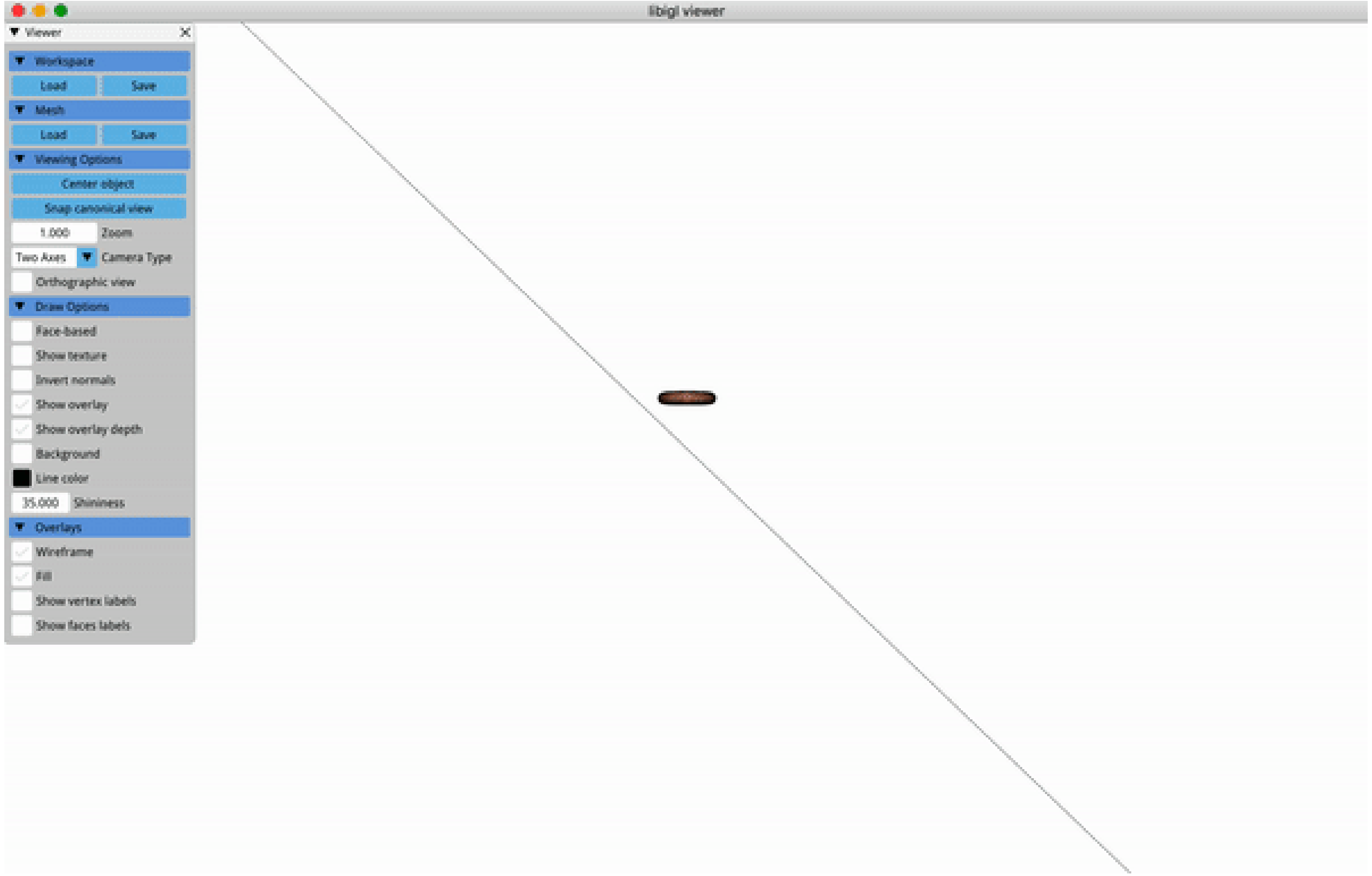
Define and setup constraints

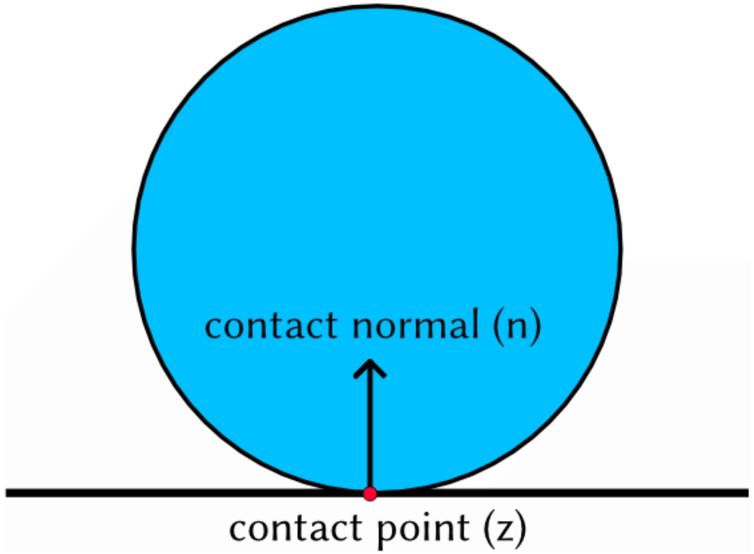
Solving multi-point contact with Projected Gauss Seidel – an iterative method for a certain type of problem (linear complementarity problem)



https://github.com/dilevin/CSC2549-a6-rigid-body-contact

Rigid Body Contacts





https://github.com/dilevin/CSC2549-a6-rigid-body-contact

Done for Today

Office hours now