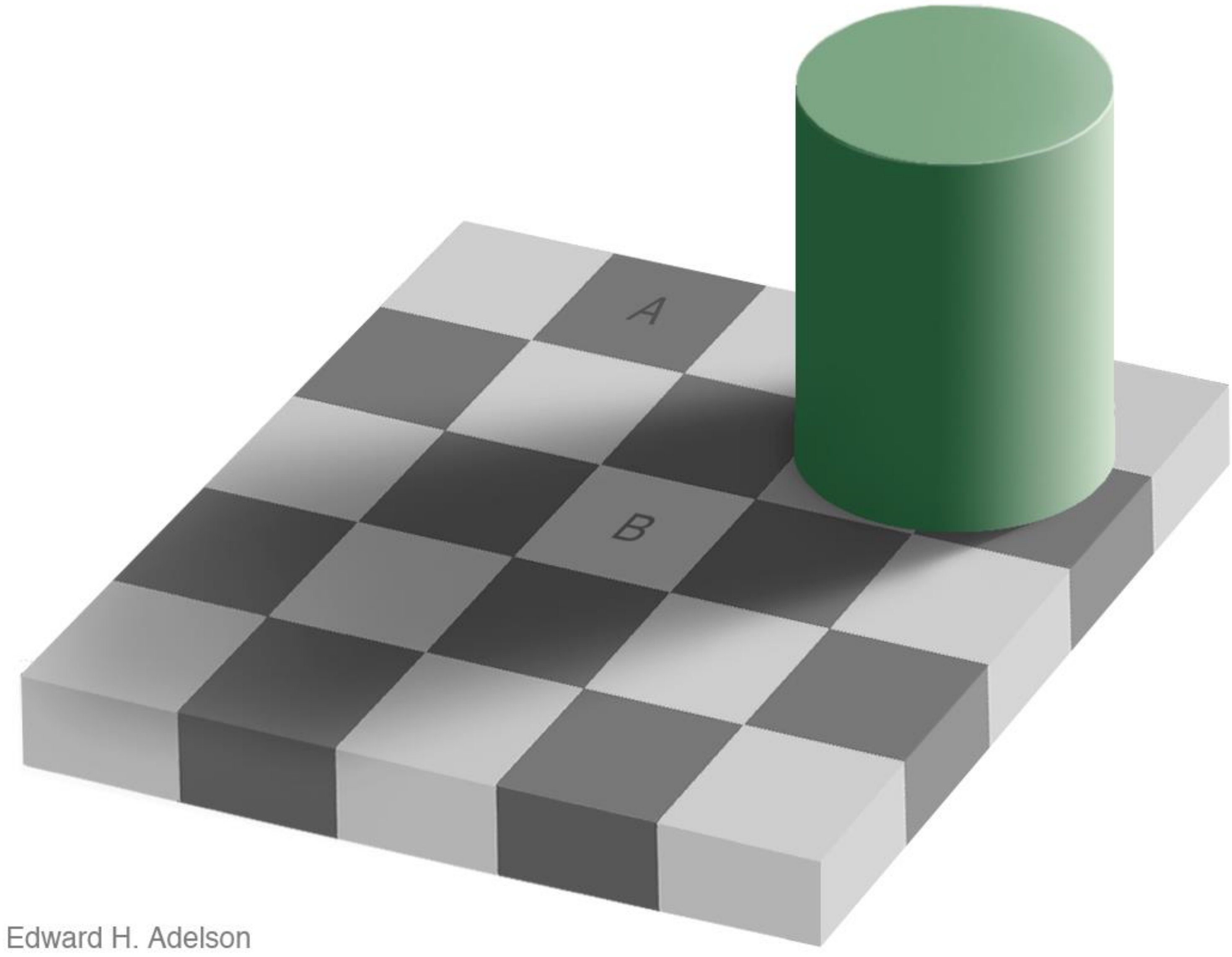
CS 277 - Experimental Haptics
Lecture 11

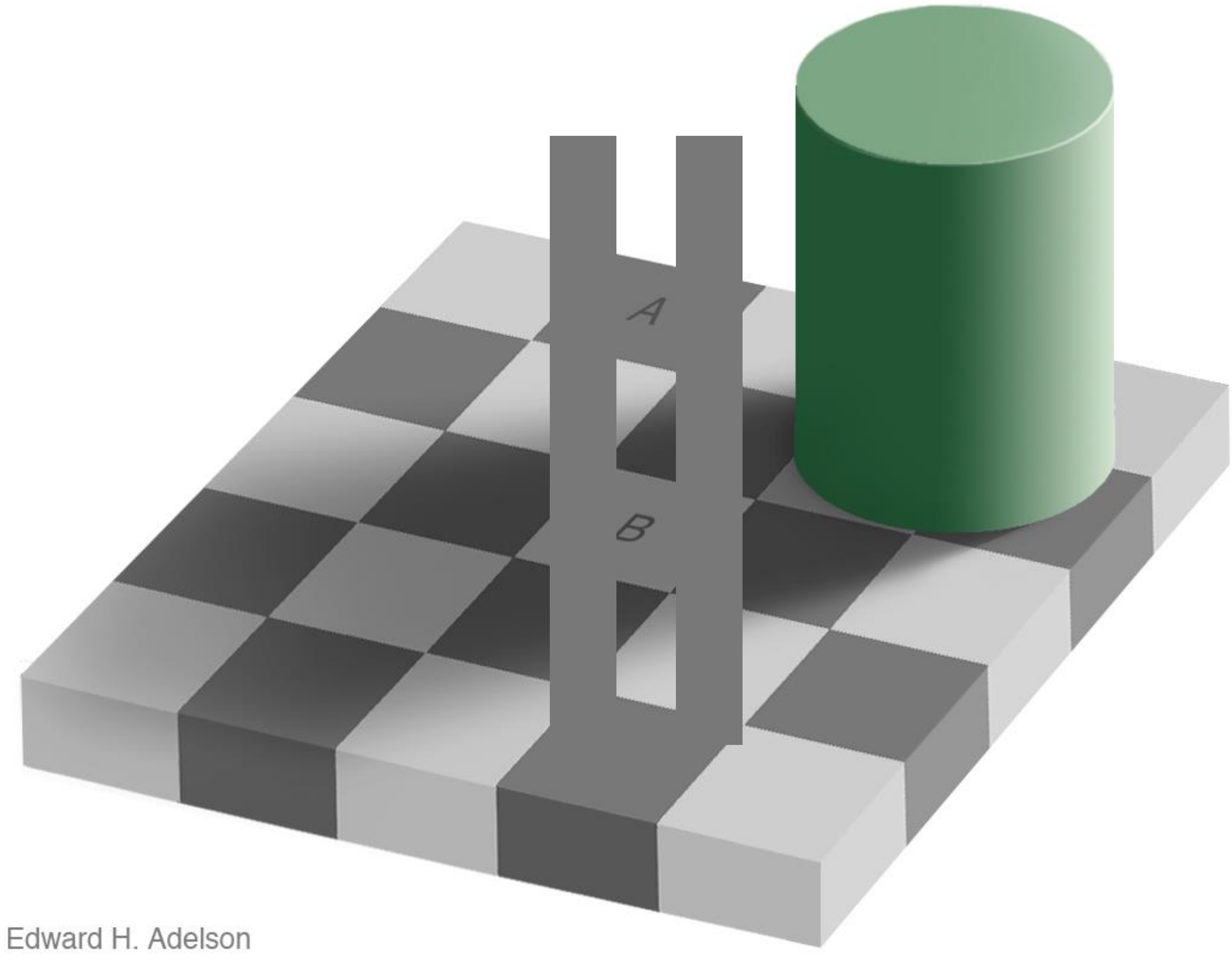
# Haptic Illusions

# Haptic Illusions: an Informal Definition

Haptic rendering effects that may

- Contribute to the realism of a VE
- Cut your interface a break taking advantage of limitations in the human perceptual system


A
B
Edward H. Adelson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# A list of illusions that we will cover

- Rendering stiff virtual objects
  - i.e. how to take advantage of humans' poor perception of position
- Rendering stiffer / softer deformable objects
  - i.e. how visual perception dominates haptics
- Rendering very high resolution models
  - i.e. taking advantage of asymmetries of the haptic sense
- Rendering smooth objects: force shading
  - i.e. reality is not a mesh
- Rendering frictional effects
  - i.e. rendering pure shapes doesn't really feel right
- Rendering textures
  - i.e. there is more to objects than just friction

# A list of illusions that we will cover

- Rendering 3D shapes using 2 DOFs
  - i.e. how to project positions and forces on smaller rank vectorials spaces
- Rendering 2D shapes using 1 DOF
  - i.e. how work can be your ally (and your enemy)
- Rendering small bumps to feel **large**
  - i.e. how our sensitivity to force direction is not that good
- Rendering **large** virtual environments using small devices
  - i.e. how to take advantage of humans' poor perception of position
- Rendering fast cars without moving much
  - i.e. our vestibular sense is also pretty limited

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# Rendering Stiff Objects

DEMO

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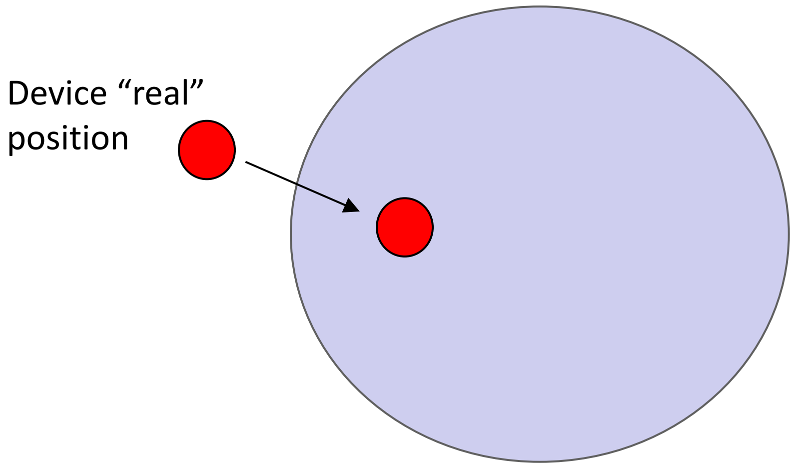
- This is an effect that you should be familiar with
- Basic idea:
  - Real device position will ALWAYS be inside of virtual object



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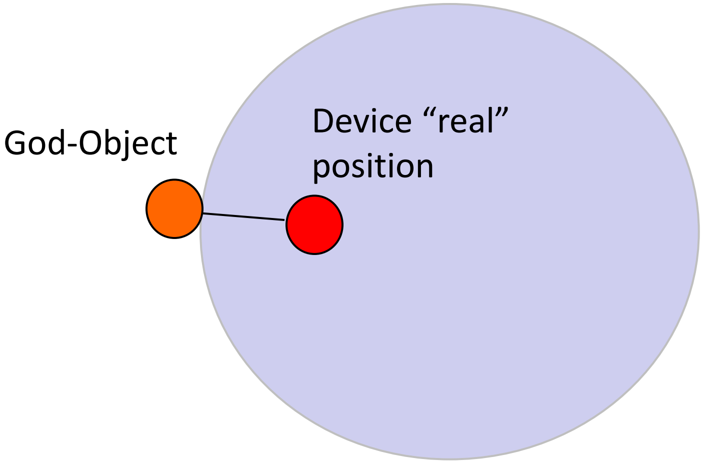
- This is an effect that you should be familiar with
- Basic idea:
  - Real device position will ALWAYS be inside of virtual object
  - All God-object like algorithms find a point on the surface
  - Such point can be used to compute forces
  - and as a visual representation of your finger



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- Basic idea:
  - Real device position will ALWAYS be inside of virtual object
  - All God-object like algorithms find a point on the surface
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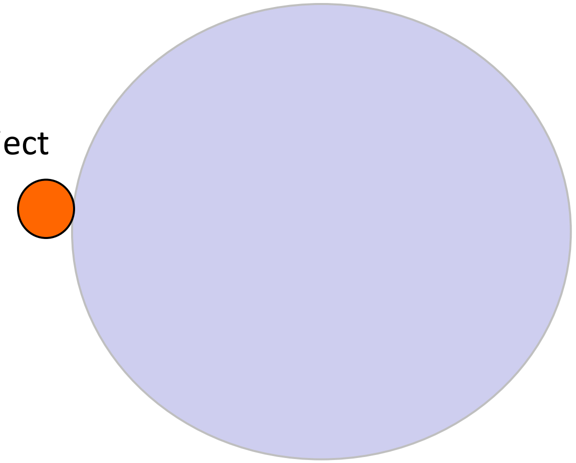
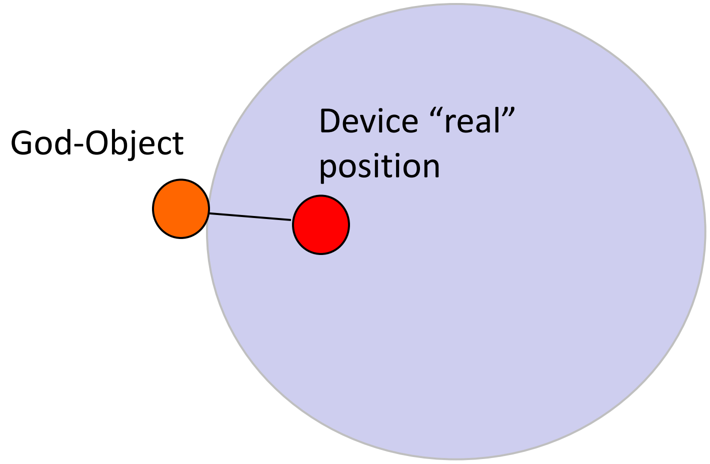
  - and as a visual representation of your finger
- Hiding "real" position visually aids the illusion of a stiff object



# Rendering Stiff Objects

- Why does this work?
  - Visual feedback dominates our absolute position perception



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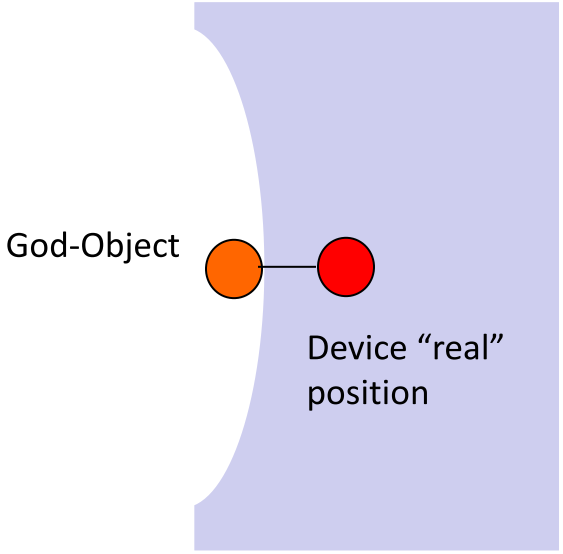
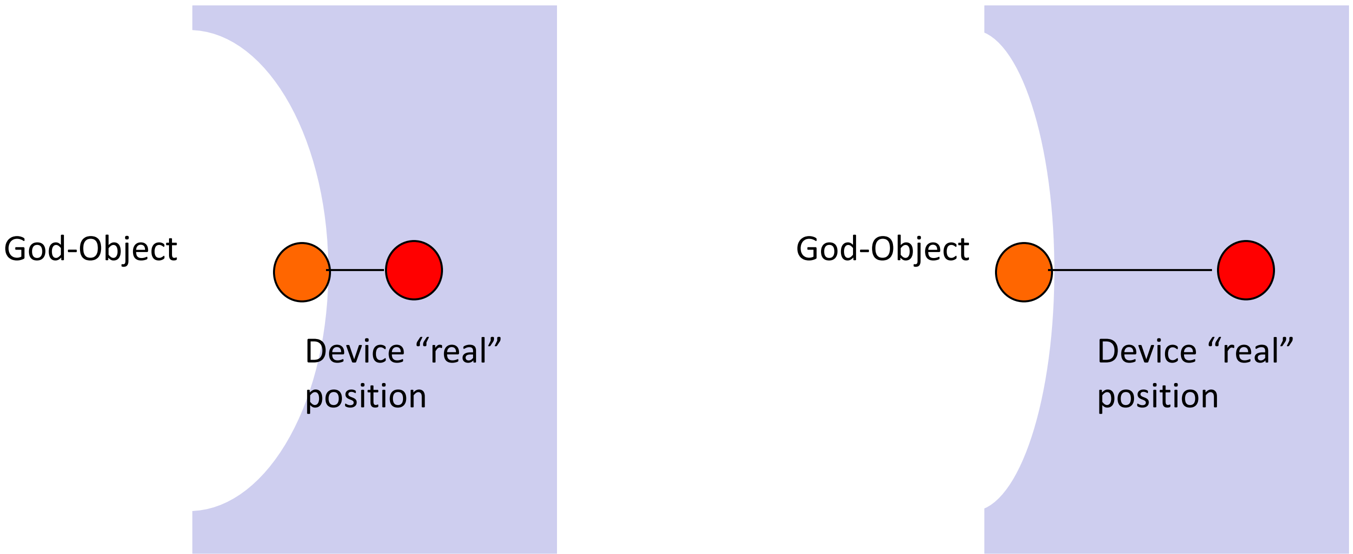
- Similar to what we just discussed, but a step further
- Basic idea:
  - Deformable objects change shape when applying forces to them
  - The amount of deformation and real position of device do NOT have to match



# Rendering Stiff Objects

- Similar to what we just discussed, but a step further
- Basic idea:
  - Deformable objects change shape when applying forces to them
  - The amount of deformation and real position of device do NOT have to match
- You can completely reverse the relationship between force and deformation



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# Rendering High Resolution Models

DEMO

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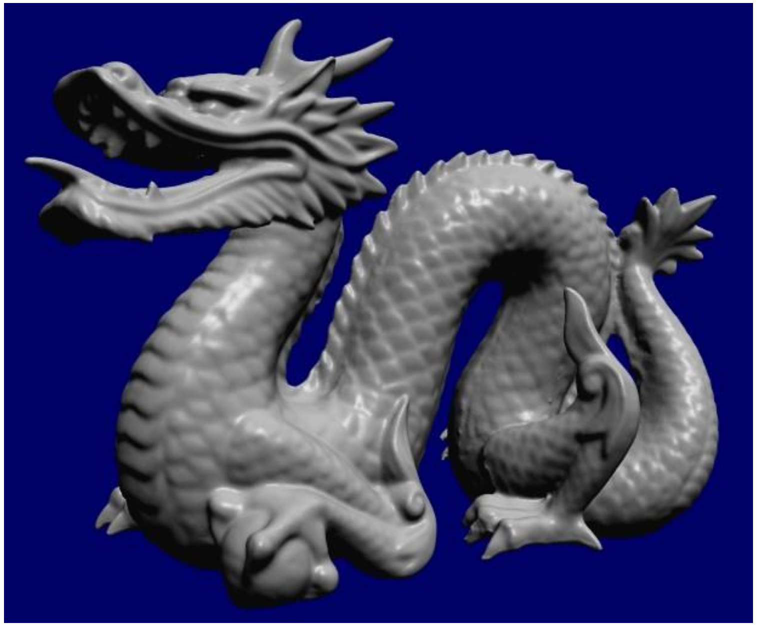
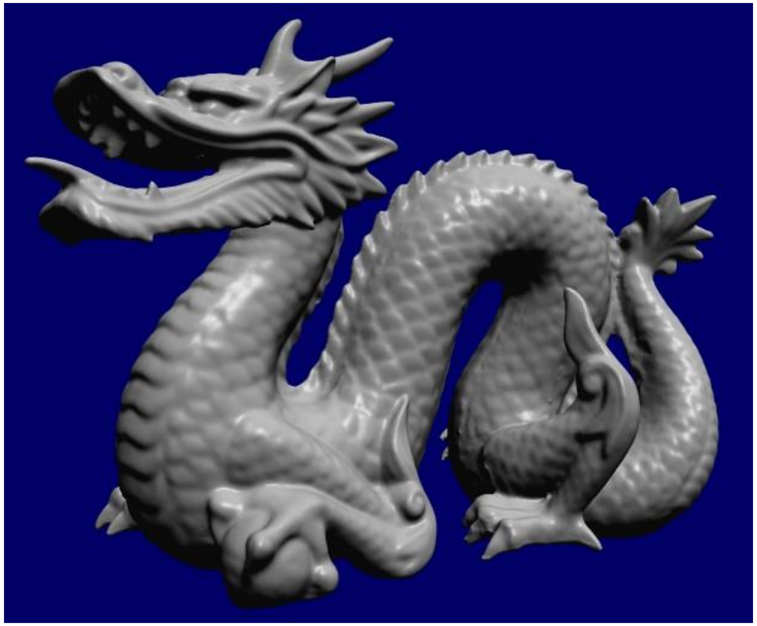
- Complicated surface may limit your haptic rendering rates



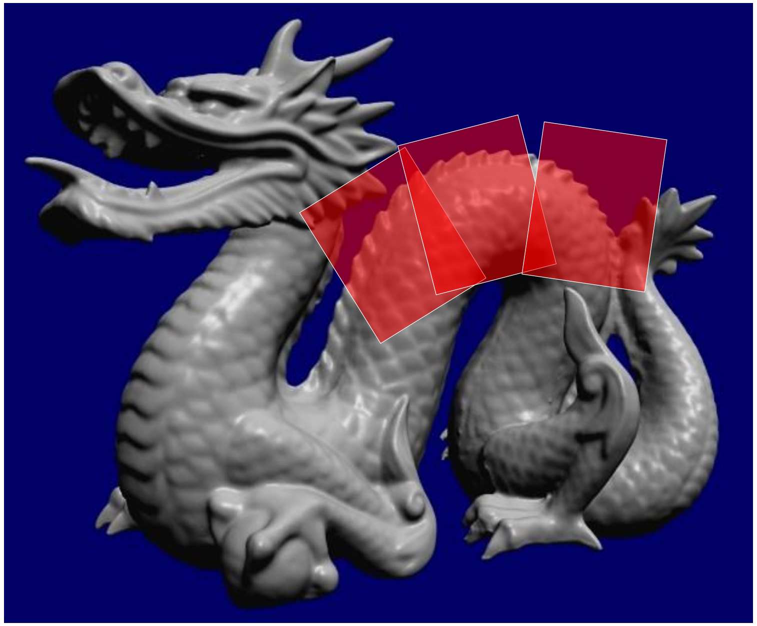
# Rendering High Resolution Models

- Complicated surface may limit your haptic rendering rates
- Decoupling collision detection and haptic rendering can help rendering stiffer objects



# Rendering High Resolution Models

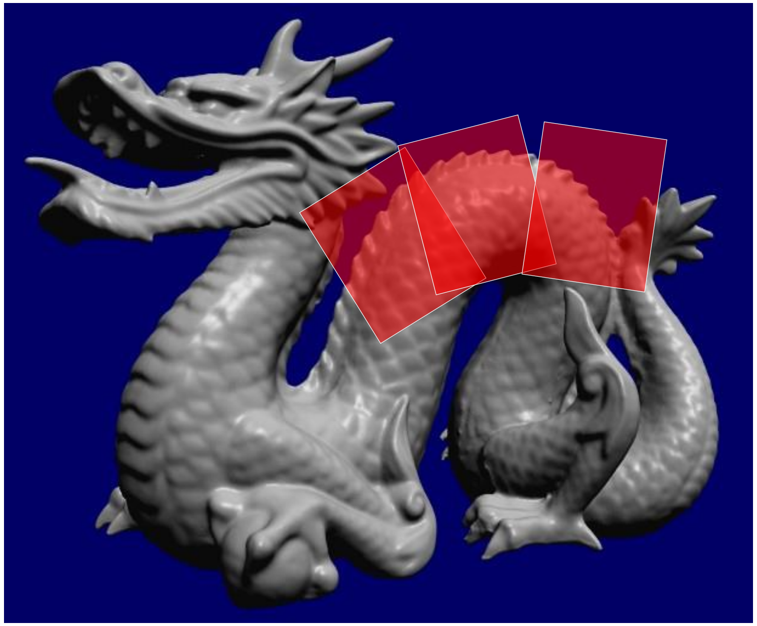
- Slow thread computes a new "local model" that approximates object surface but is simple (e.g plane, sphere, …)
- Fast thread computes fast collision detection and force rendering with local model



# Rendering High Resolution Models

**Why does this work?**

- Max hand bandwidth is about 5Hz in motion => local model computation can be slow
- But we perceive up to KHz => collision detection and force response needs to be as fast as possible



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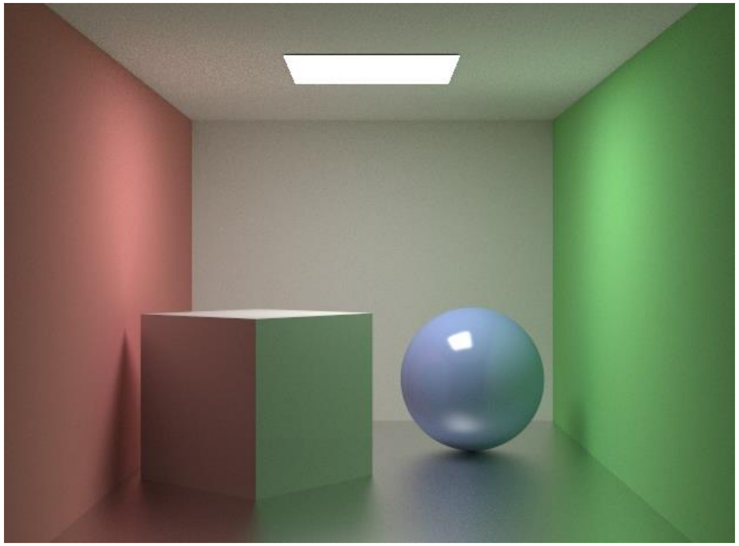
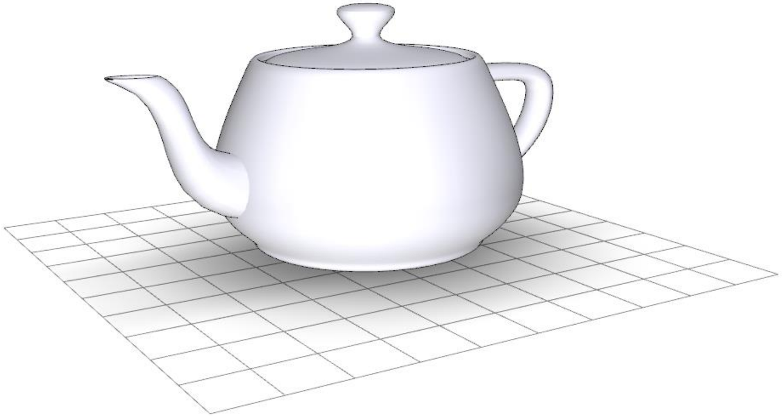
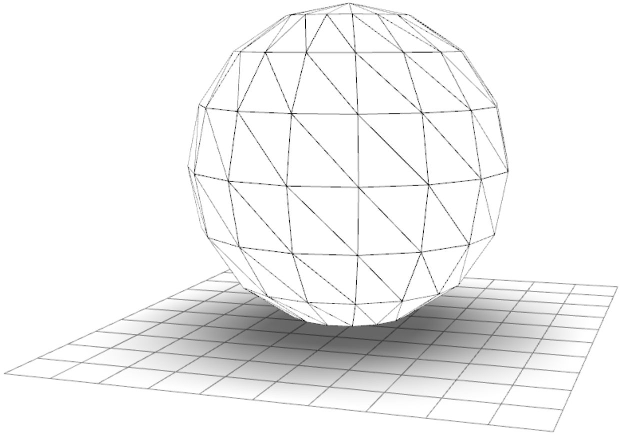
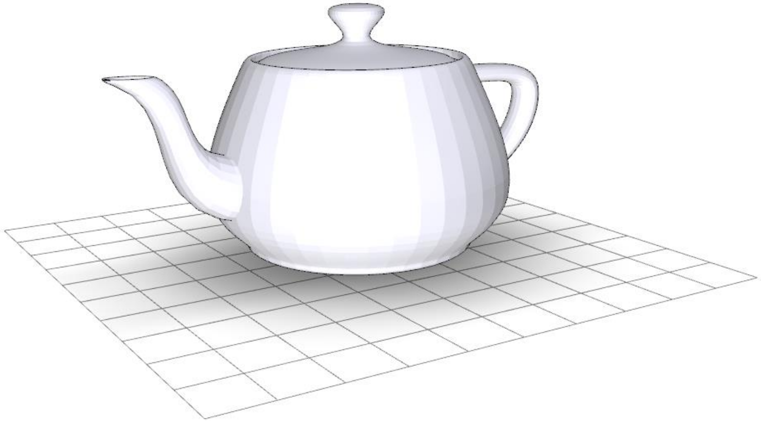
# Light Shading

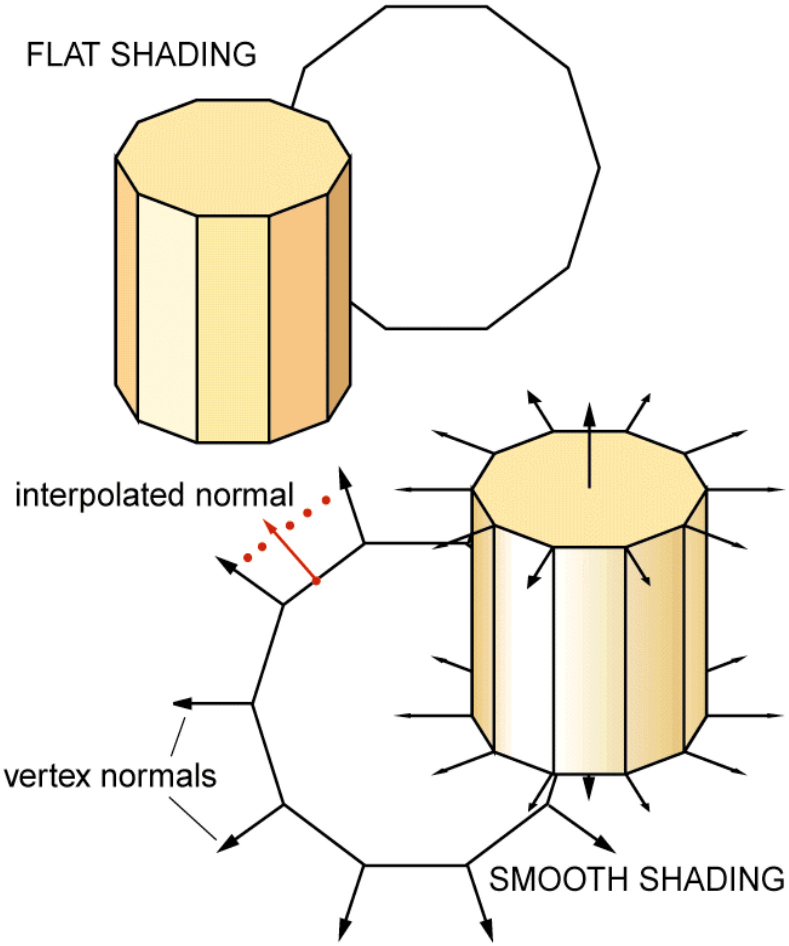








# Force Shading




## Graphic Shading

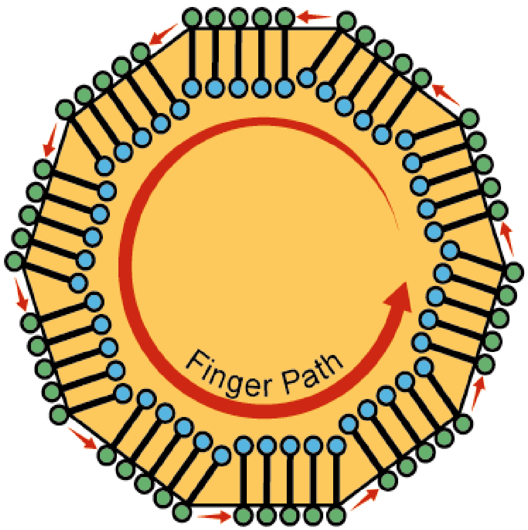
- eliminate color discontinuities

## Haptic Shading

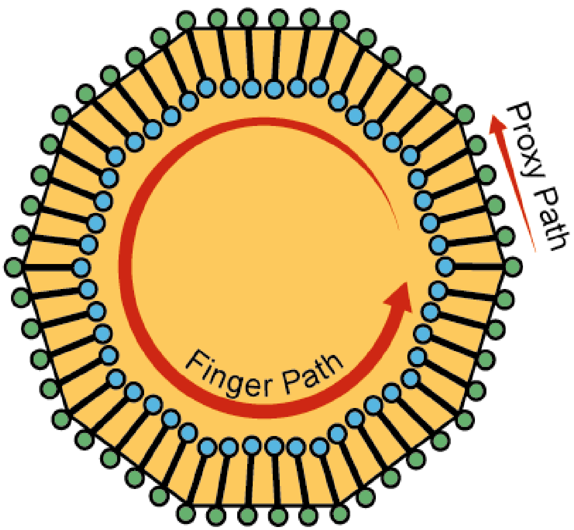
- eliminate force discontinuities

# Force Shading

Interpolate vertex normals across polygon to get continuous, smooth normals (just like Phong shading in graphics)




Faceted Cylinder




Shaded Cylinder

# Force Shading

DEMO

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# Friction Effects

DEMO

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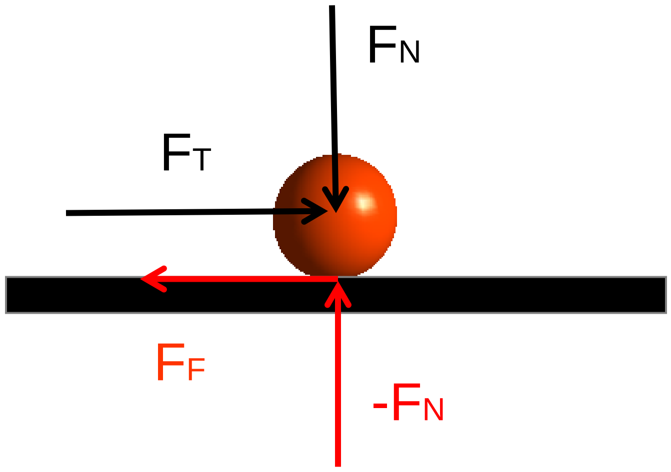
Friction is the force resisting the relative motion of solid surfaces, fluid layers, or material elements sliding against each other.

**Amontons' 1st Law**:
The force of friction is directly proportional to the applied load.

**Amontons' 2nd Law**:
The force of friction is independent of the apparent area of contact.

**Coulomb's Law of Friction**:
Kinetic friction is independent of the sliding velocity.

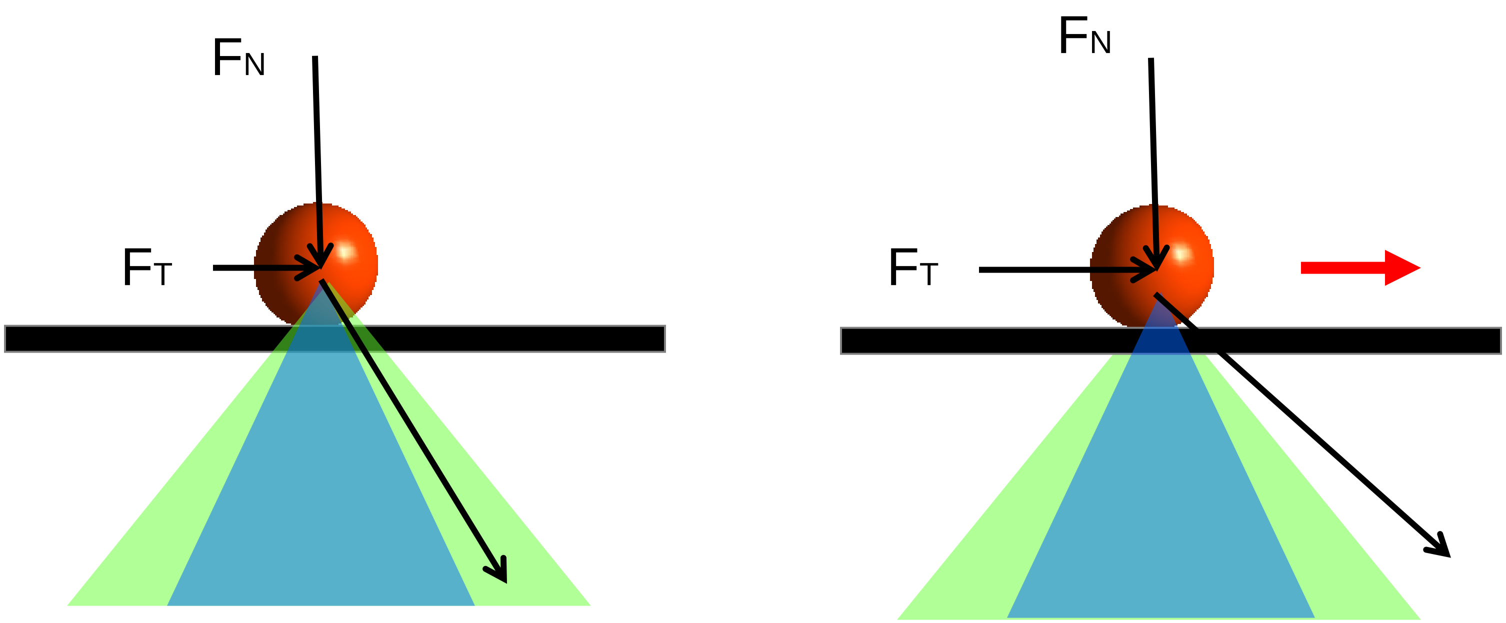



Coulomb friction:

$$F_F \leq \mu \cdot F_N$$

# Friction Effects

Static friction

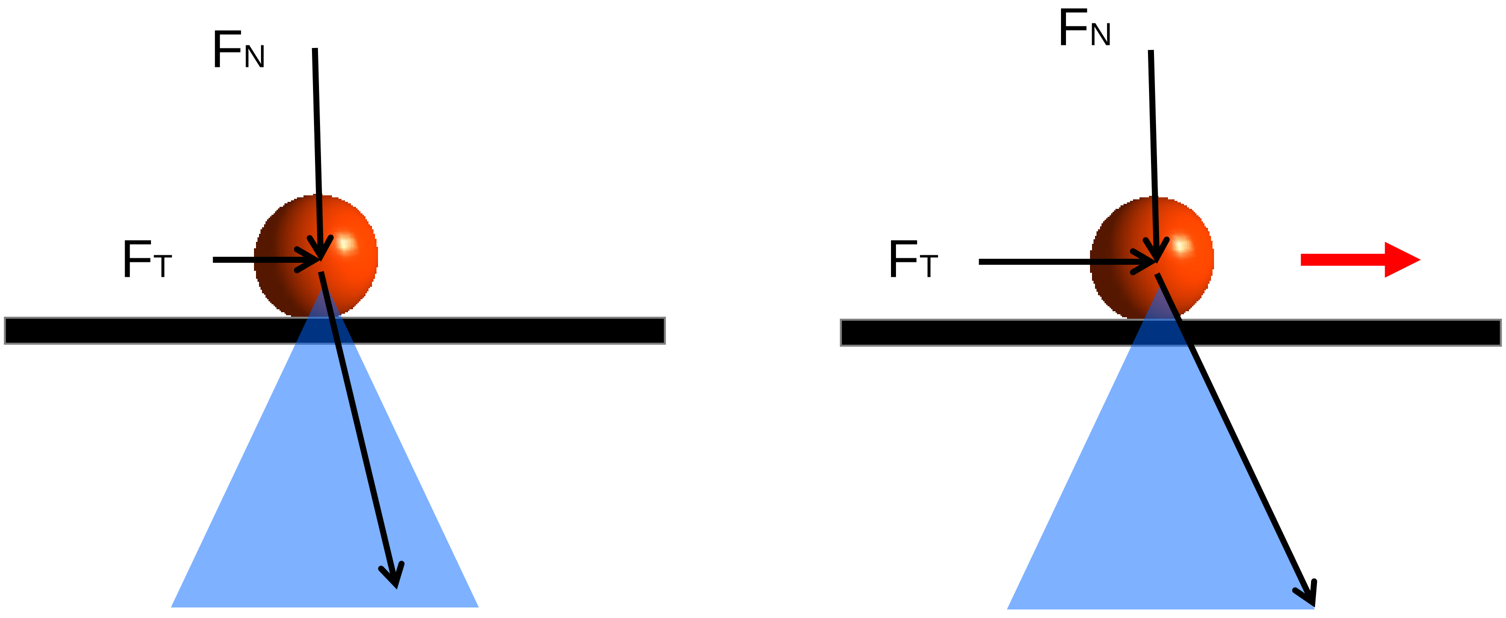



static friction cone

$$F_F \leq \mu_S \cdot F_N \qquad \mu_D < \mu_S$$

# Friction Effects

Kinetic friction




dynamic friction cone

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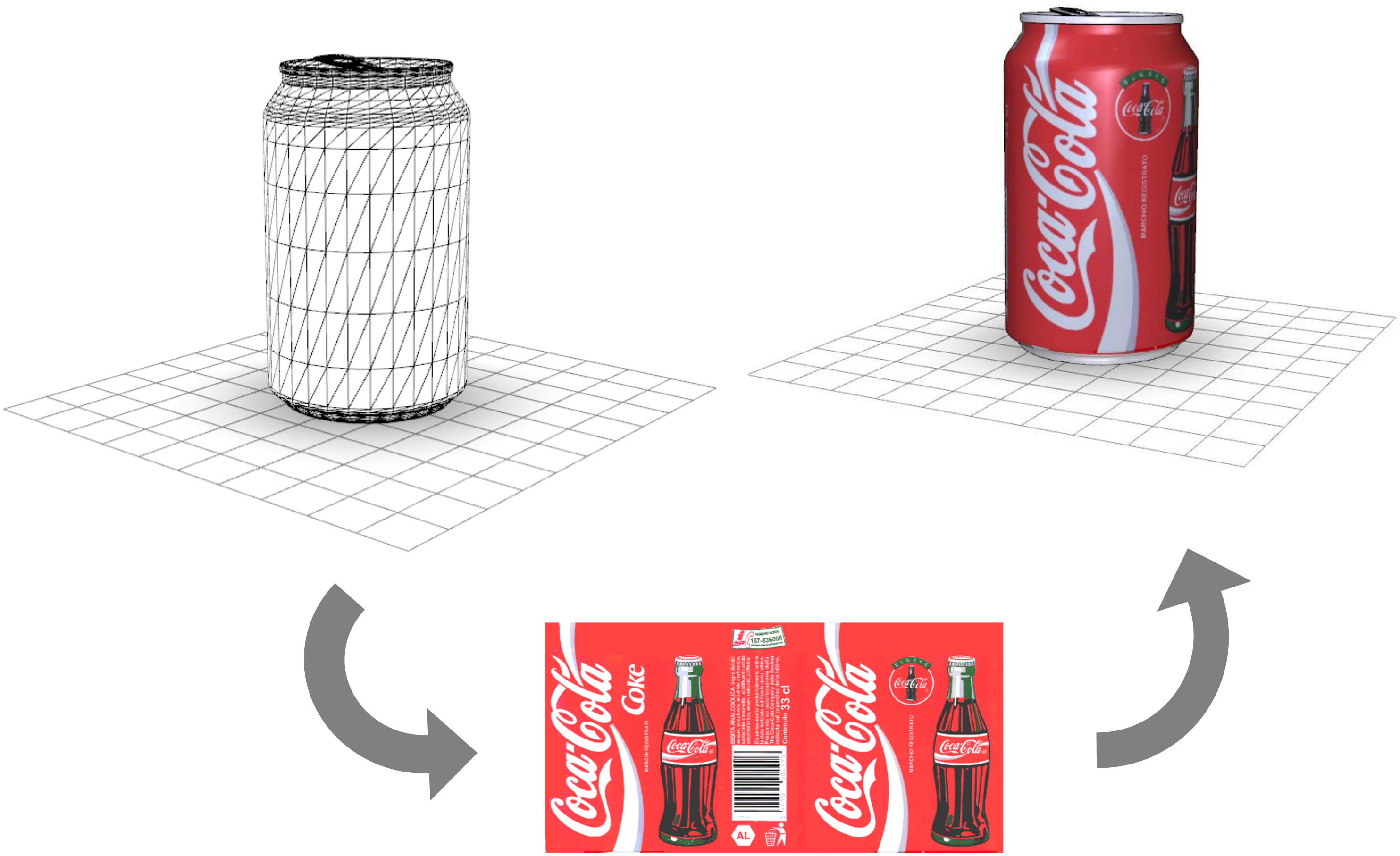

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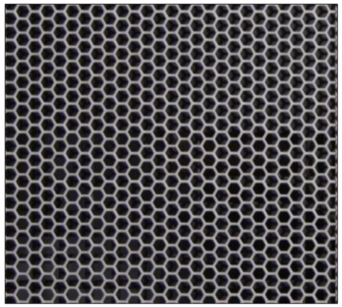
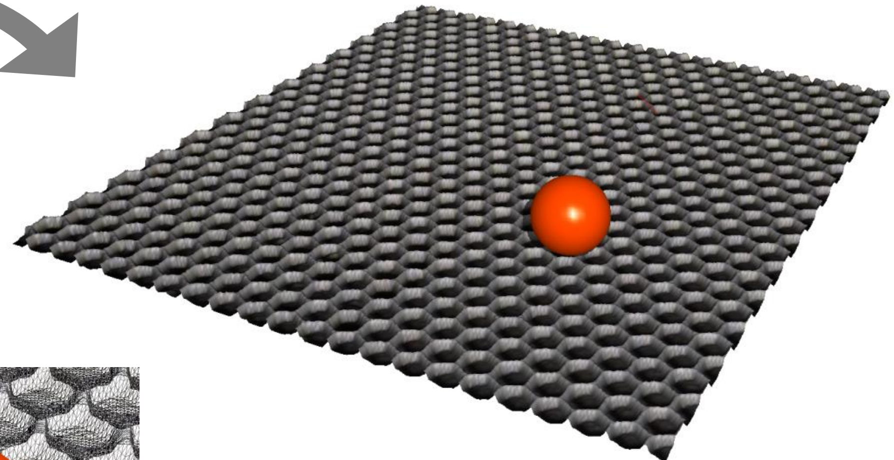
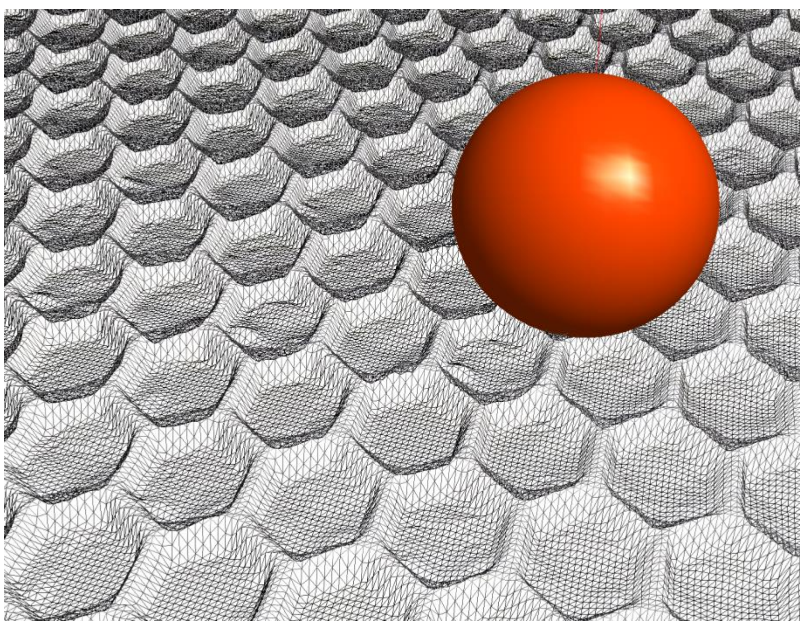


2D texture map





3D height map (~80'000 triangles)

# Haptic Texture