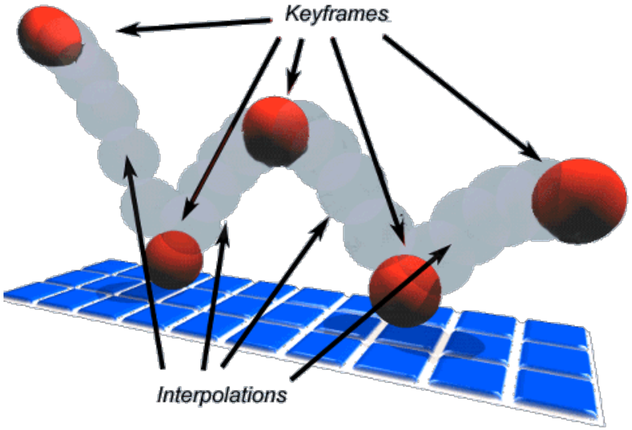
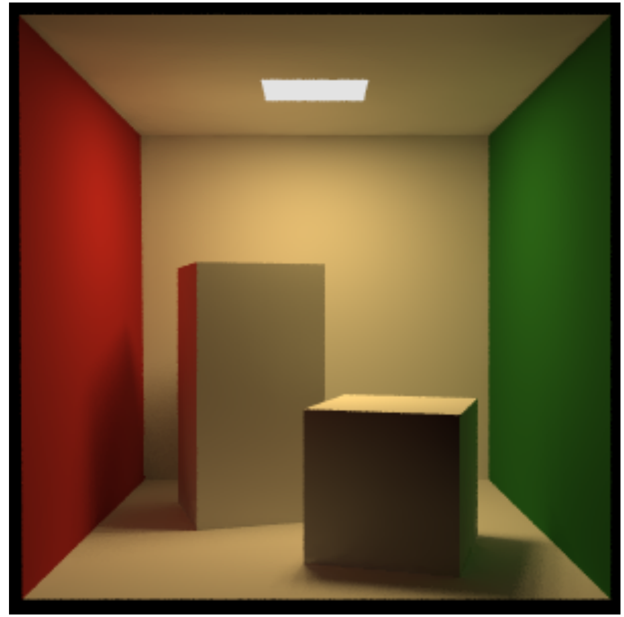




Computer Graphics

Lecture 32

What else are curves good for?

Animation, briefly

Global illumination, briefly

Curves are great, but.

https://youtu.be/AcFwH161XtM?t=68

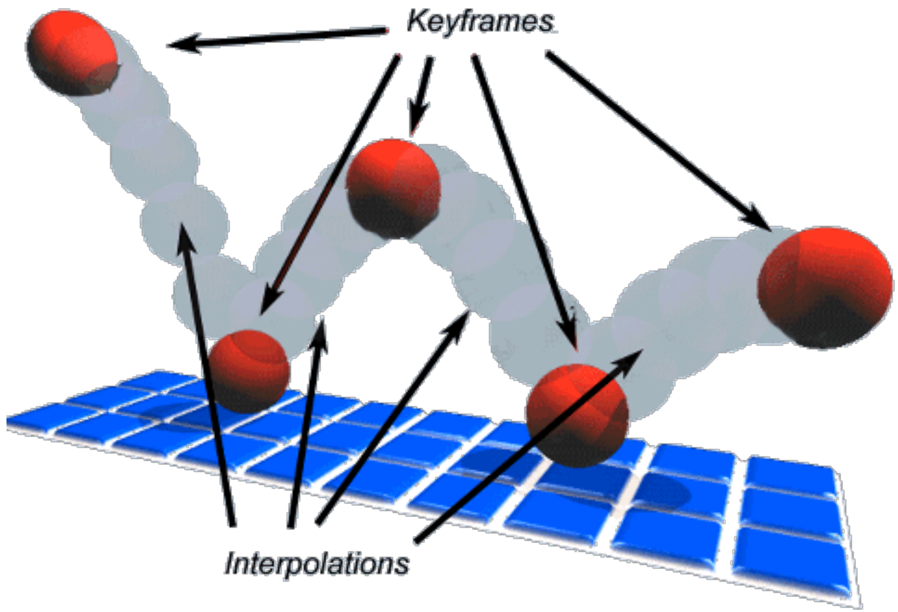
https://youtu.be/Zkx1aKv2z8o?t=1080

Animation

- Time-varying scene/model.
  That's pretty much it.
- Big challenges:
  - tedium
  - realism

Animation - Tedium

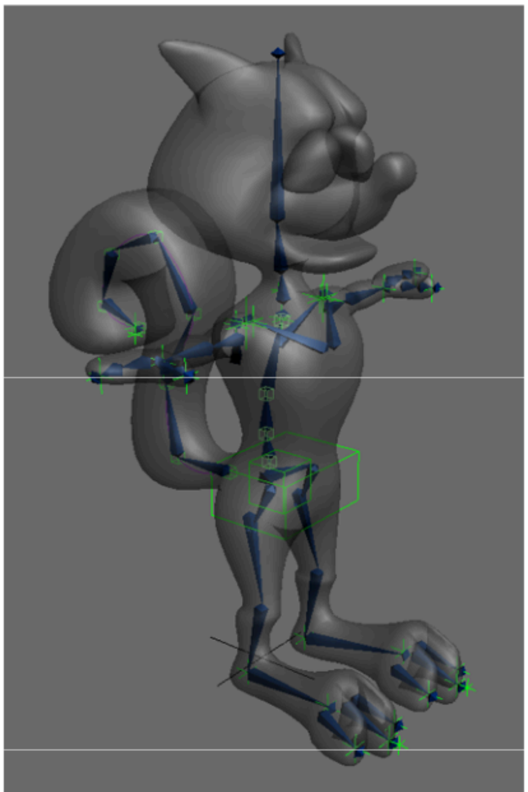
- **Keyframing** + interpolation



Linear interpolation? **Spline** interpolation?

Animation - Tedium

- **Rigging**

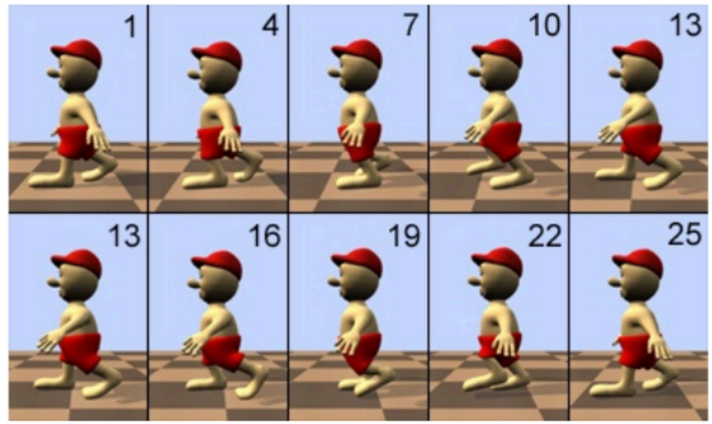


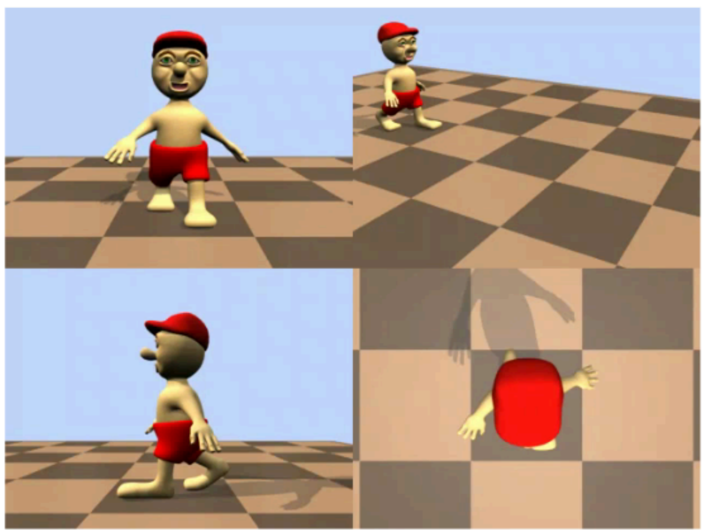
- Surface is deformed by a set of *bones*
- Bones are in turn controlled by a smaller set of *controls*
- The controls are useful, intuitive DOFs for an animator to use

Modeling DOF != Animation DOF

Animation - Tedium

Walk cycle

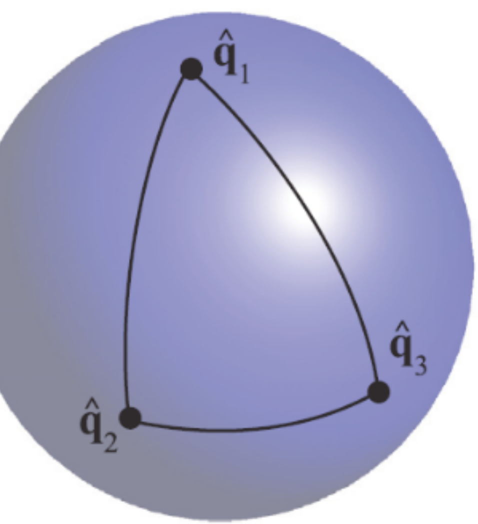




[Christopher Lutz http://www.animationsnippets.com]

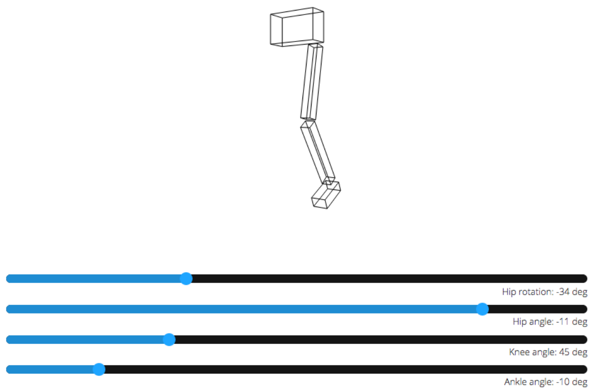
Interpolating Rotations

- Representation matters a lot - linear interpolation of rotation matrices are not rotation matrices.



- Quaternions are one answer
  - 4D vectors that make spherical interpolation nicer

Animation - Tedium



Forward Kinematics

Inverse Kinematics

Animation - Realism

- Tron (1982)
- Tron Legacy (2010)
- How to Train Your Dragon 2 (2014)

Animation - Realism

Motion capture

- A method for creating complex motion quickly: measure it from the real world

Animation - Realism

Motion capture in movies

[*The Two Towers* | New Line Productions]

Animation - Realism

Motion capture in games

Animation - Realism

- Motion capture technologies:

Magnetic

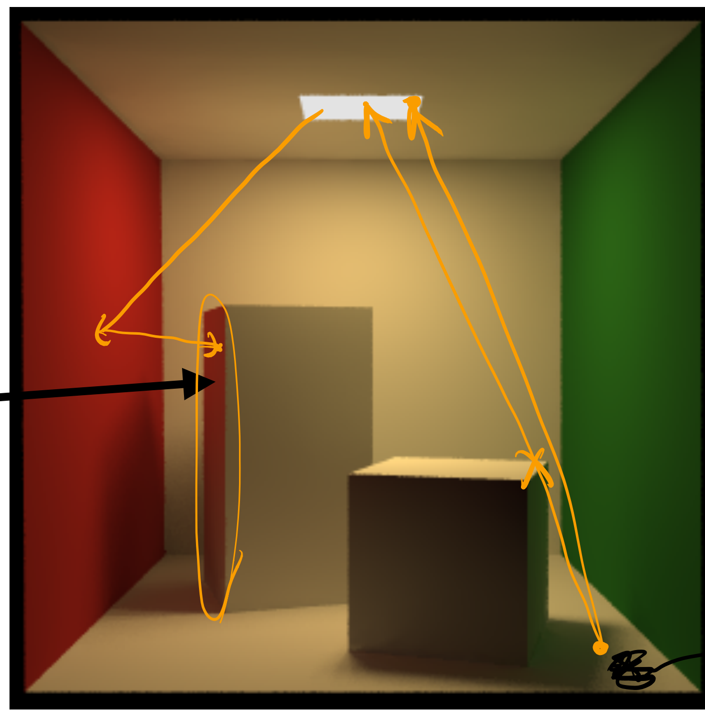
Mechanical

Optical

Global Illumination

Problem: light doesn't just come from light sources ("emitters", or "luminaires").

global illumination effects



Soft Shadows

Global Illumination: Direct vs Indirect

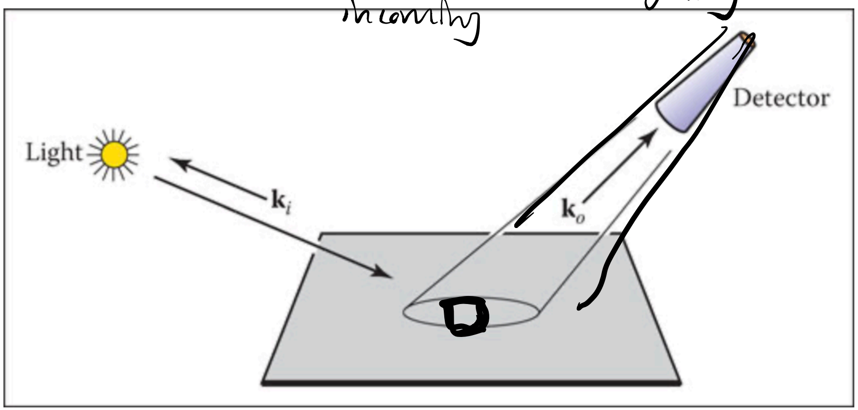
Indirect only   Direct only   Both

Light Transport: BRDF

Bidirectional Reflectance Distribution Function

$$\rho(\mathbf{k}_i, \mathbf{k}_o)$$

incoming outgoing



Lambertian:

$$\rho(k_i, k_o) = C = \frac{r}{\pi}$$

r ← fraction light reflected $\in [0, 1]$

Light Transport: The Transport Equation
AKA "The Rendering Equation"

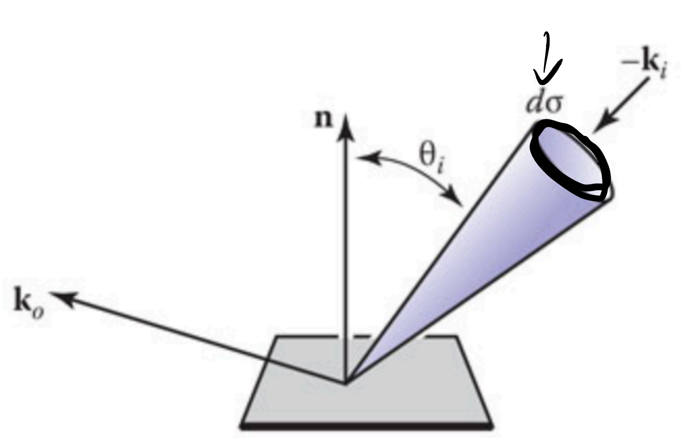
$$L_s(\mathbf{k}_o) = \int_{\mathbf{k_i}} \rho(\mathbf{k}_i, \mathbf{k}_o) L_f(\mathbf{k_i}) \cos\theta_i \, d\sigma_i$$

reflected light

surface

incoming light

recurse!



Particle Tracing

- One approach: shoot "particles" from lights, deposit units of light in textures on surfaces.
- Compute direct ray-object intersection to read off radiance image.
- Works OK for diffuse surfaces

Path Tracing

- Like ray tracing - rays start at eye
- Bounce around until they hit a light source (yikes!)
- Got an integral? Solve it!
  - numerically
    - using fancy sampling techniques

Fancy Sampling 1: Monte Carlo

Fancy Sampling 2: Importance Sampling

What else?

- Implicit modeling
- Radiometry and light transport
- Color theory
- Image/signal processing
- Perception science
- Visualization