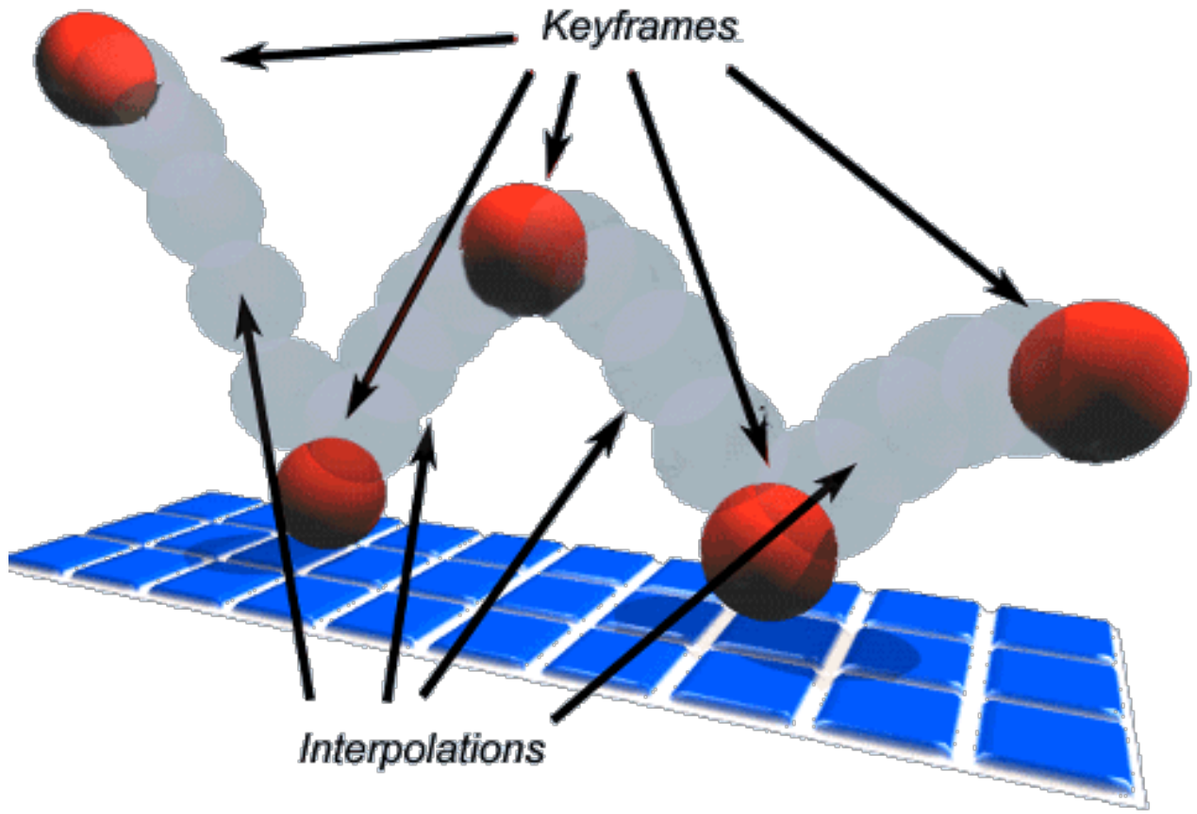



# Computer Graphics

Lecture 33

**Animation, briefly**

# Animation

# Animation

- Time-varying scene/model.
  That's pretty much it.

# Animation

- Time-varying scene/model.
  That's pretty much it.

- Big challenges:

# Animation

- Time-varying scene/model.
  That's pretty much it.

- Big challenges:
  - tedium

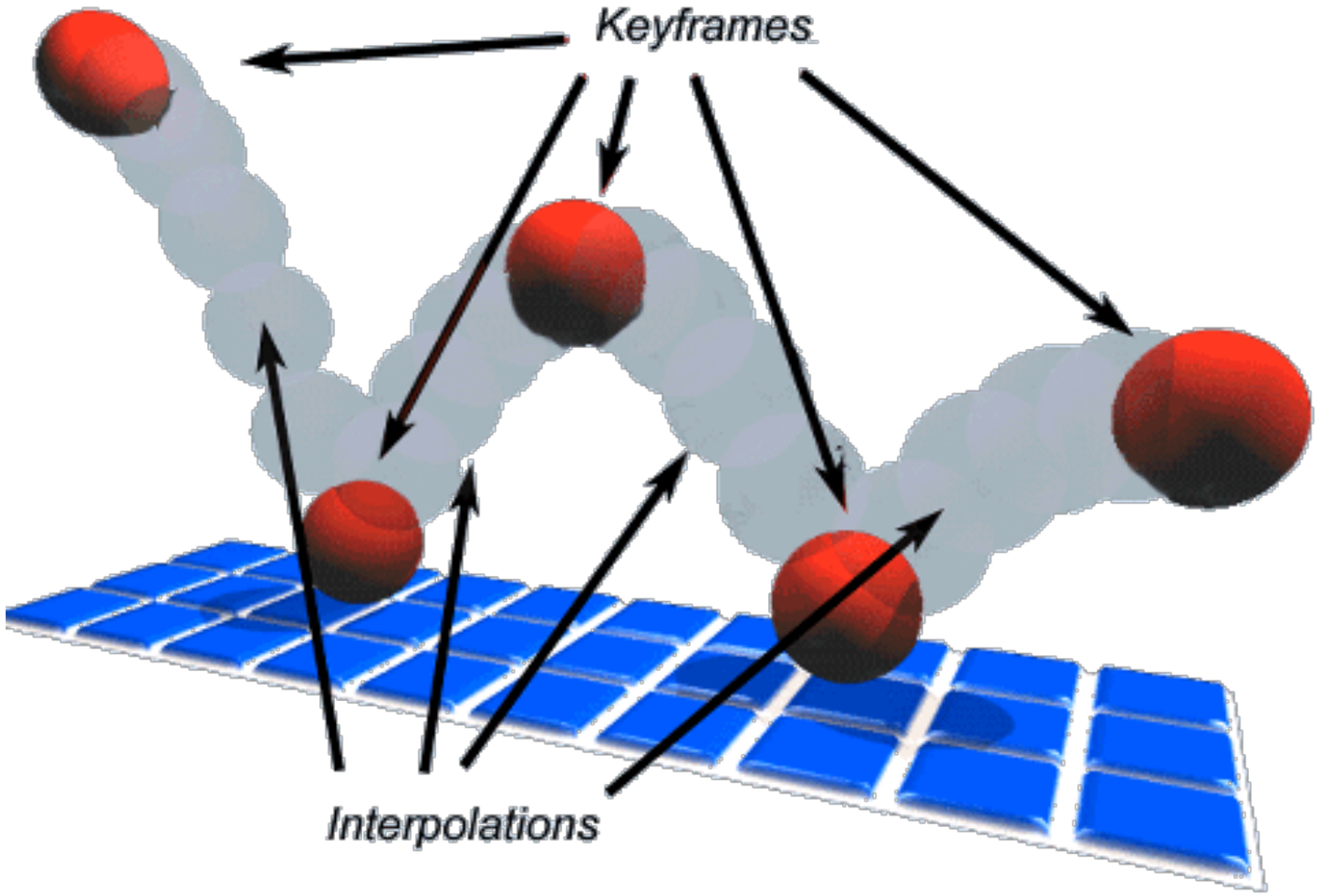
# Animation

- Time-varying scene/model.
  That's pretty much it.

- Big challenges:
  - tedium
  - realism

# Animation - Tedium

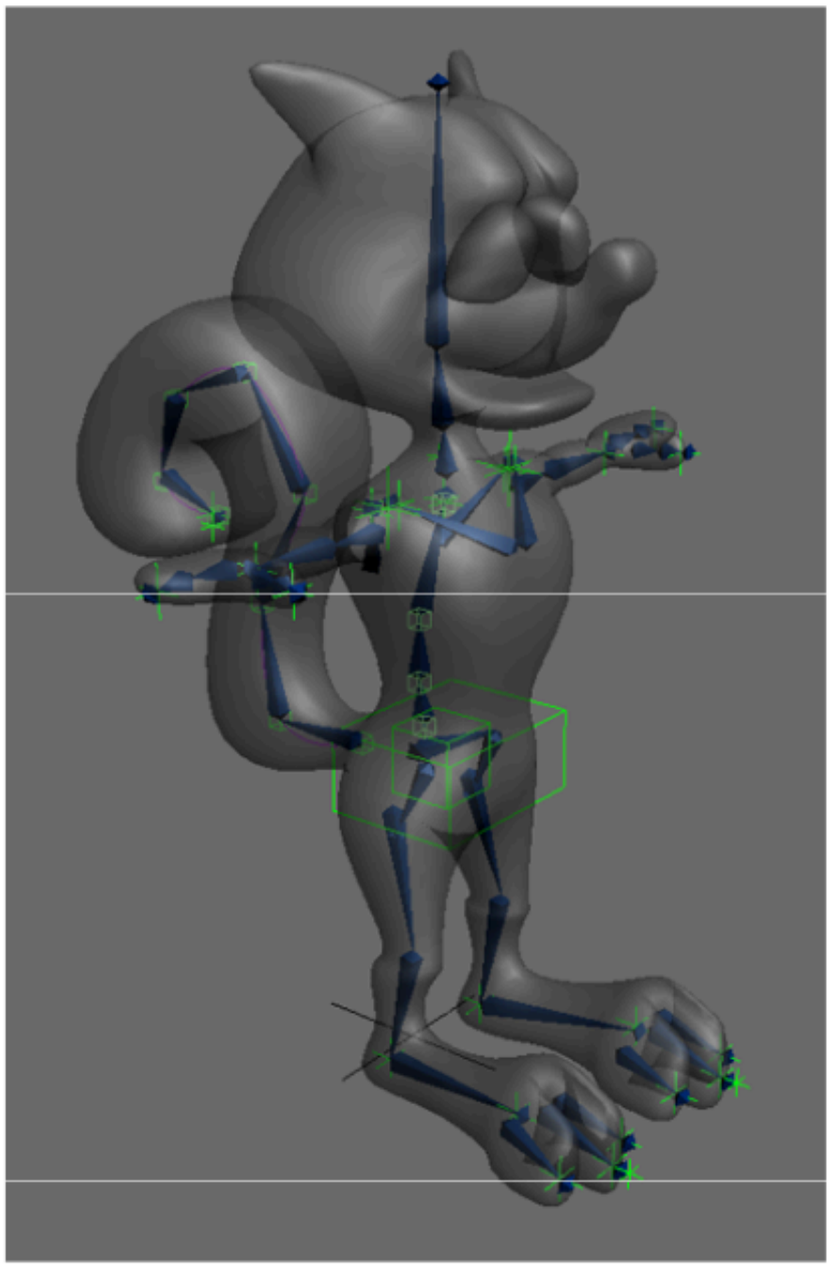
- **Keyframing** + interpolation




**Linear** interpolation? **Spline** interpolation?

# Animation - Tedium

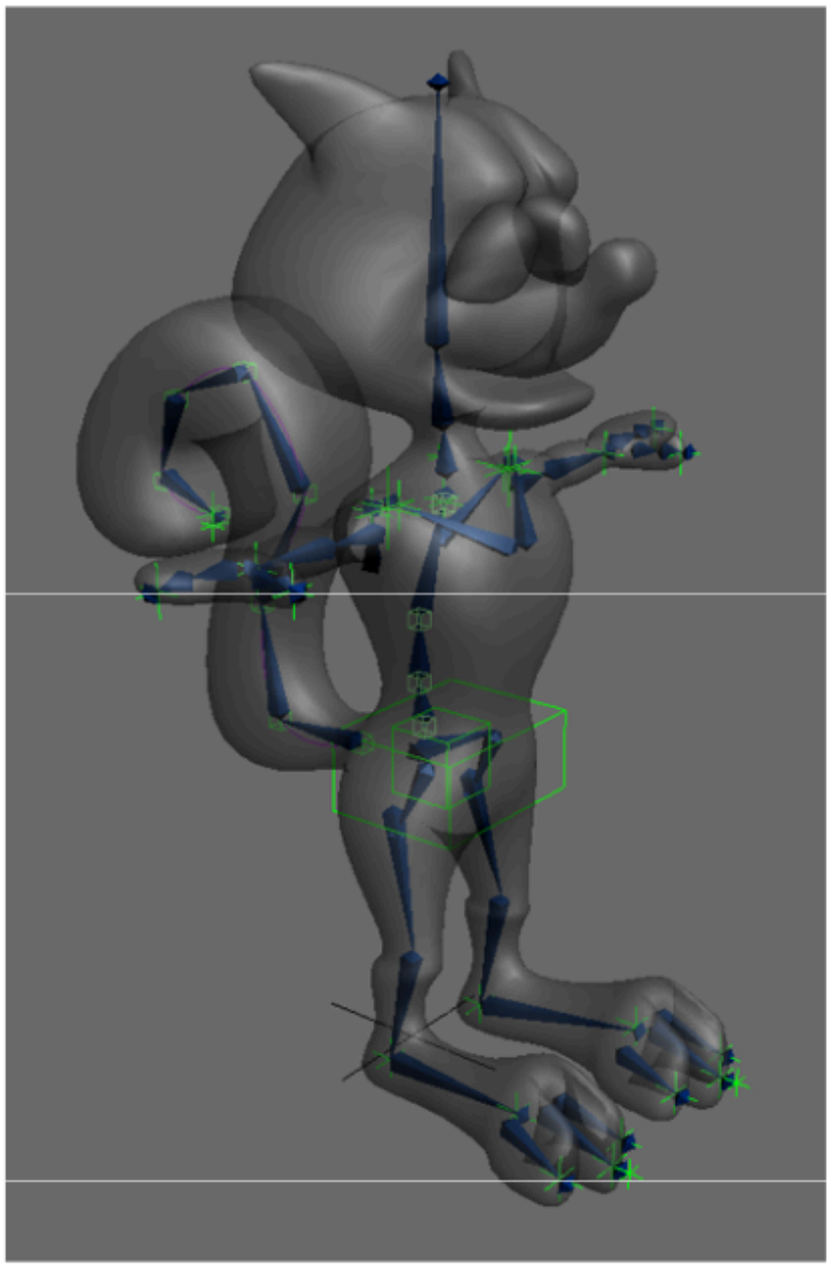
- **Rigging**



- 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

# Animation - Tedium

- **Rigging**

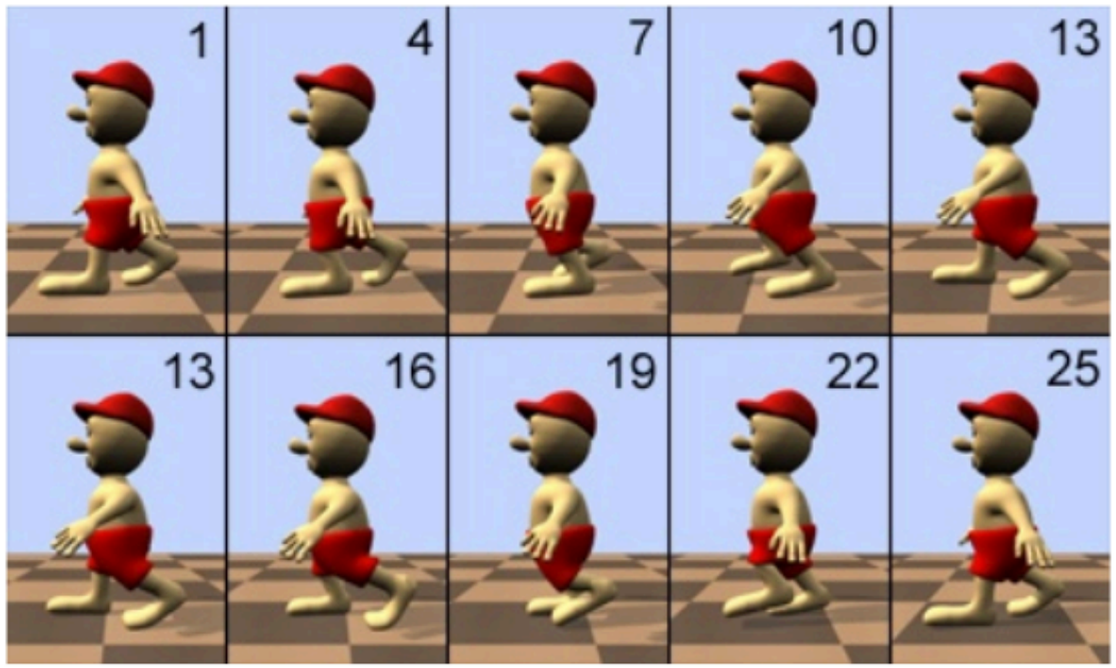


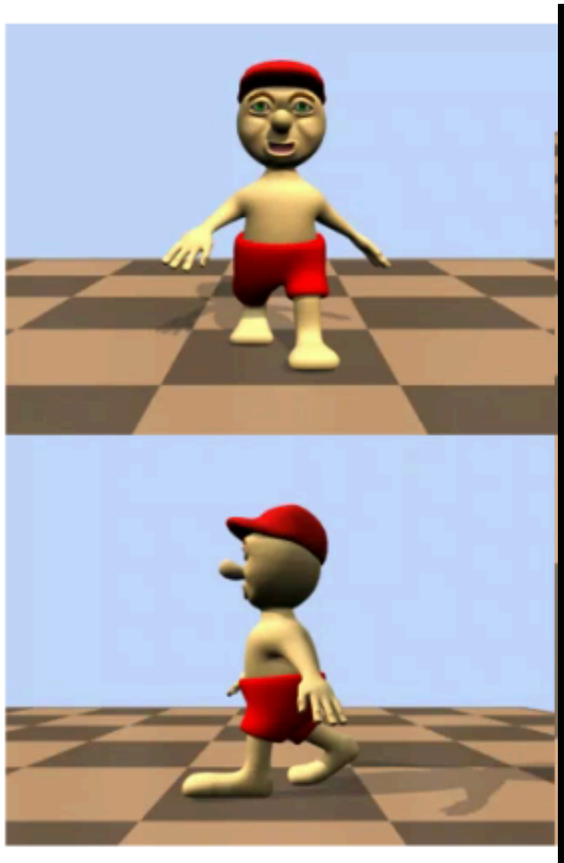
- Surface is deformed by a set of *bones*
- Bones are in turn controlled by a smaller set of *controls*
- The controls are useful, intuitive DOFs for an animator to use

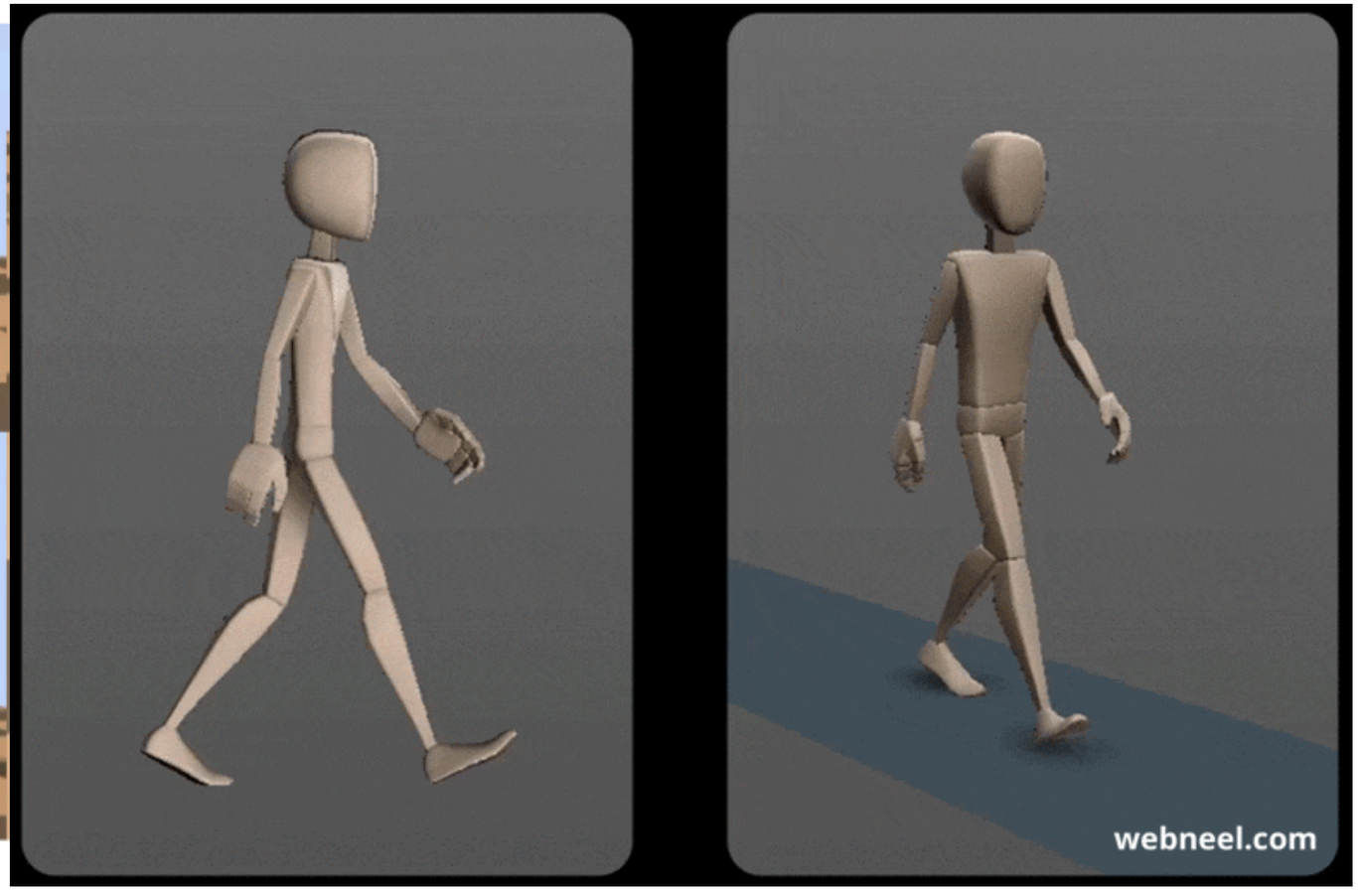
Modeling DOF != Animation DOF

# Animation - Tedium

## Walk cycle



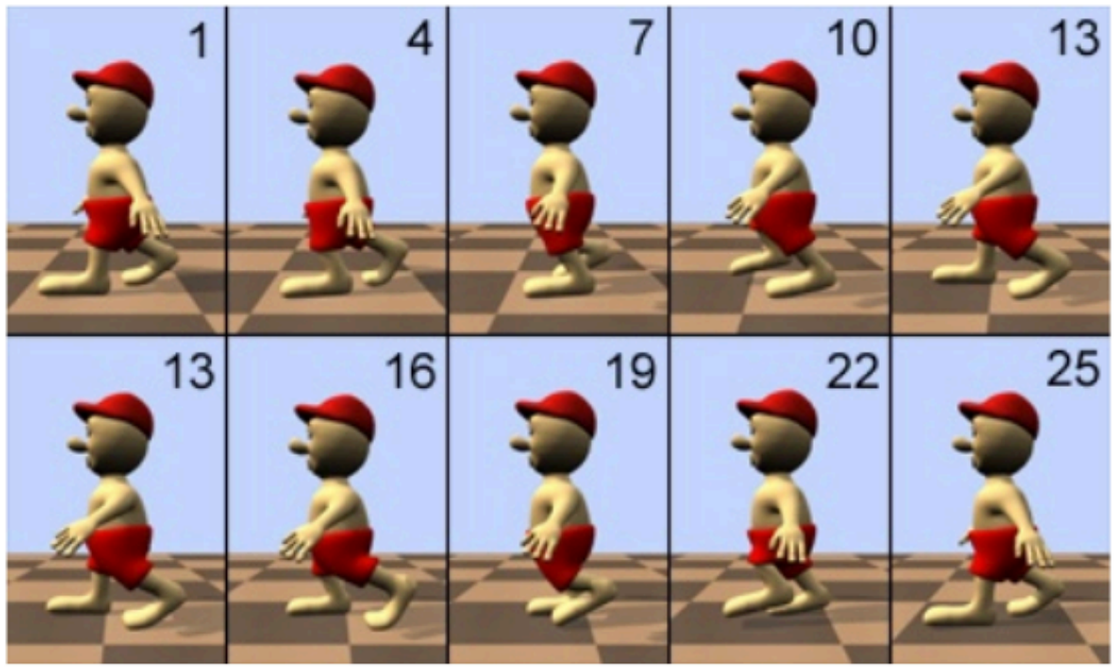



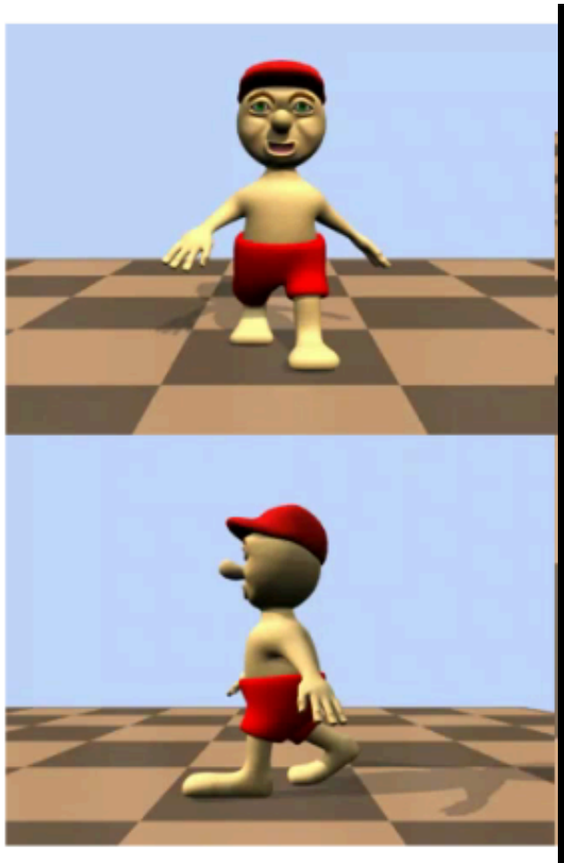


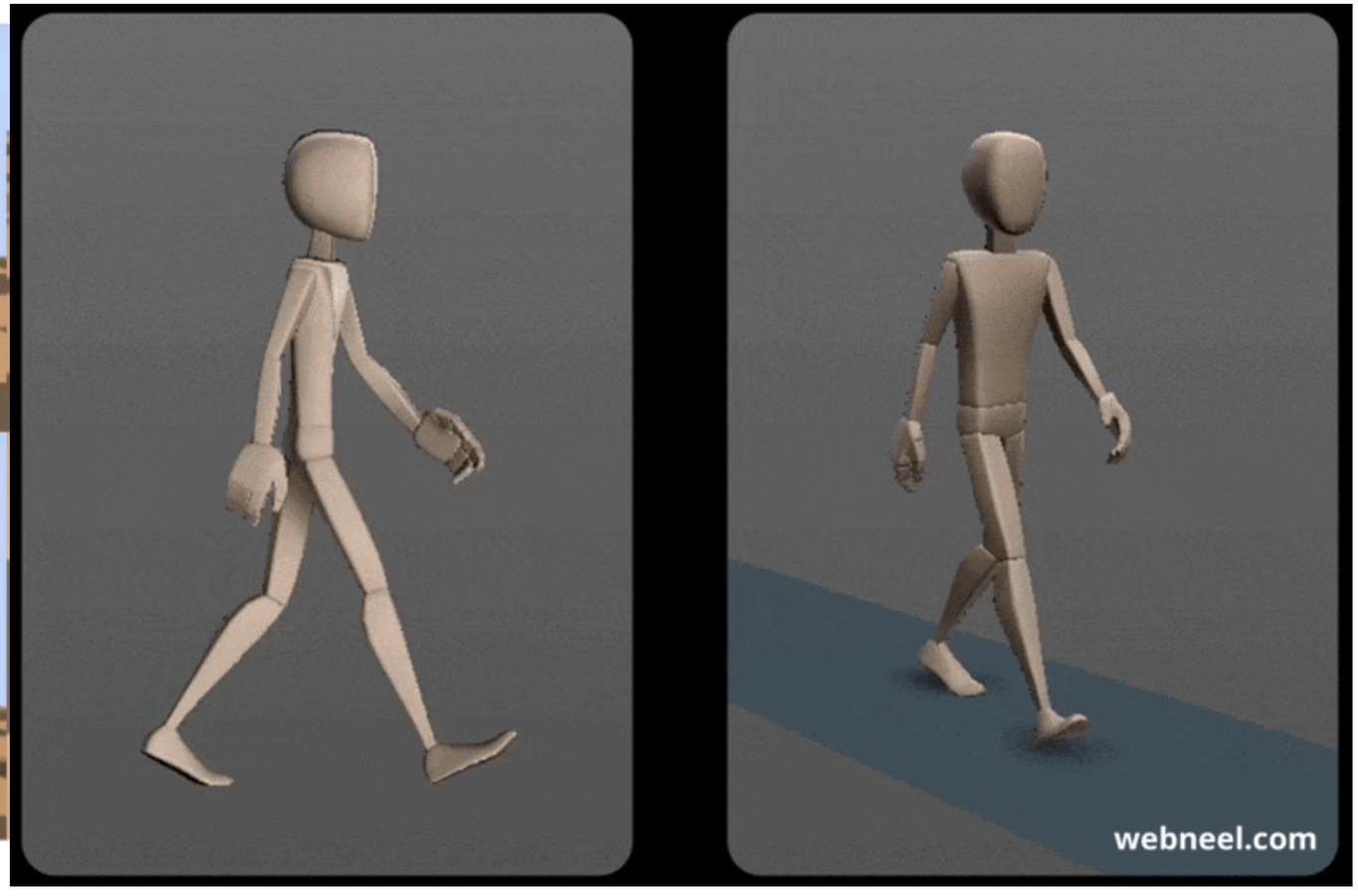

[Christopher Lutz http://www.animationsnippets.com]

# Animation - Tedium

## Walk cycle



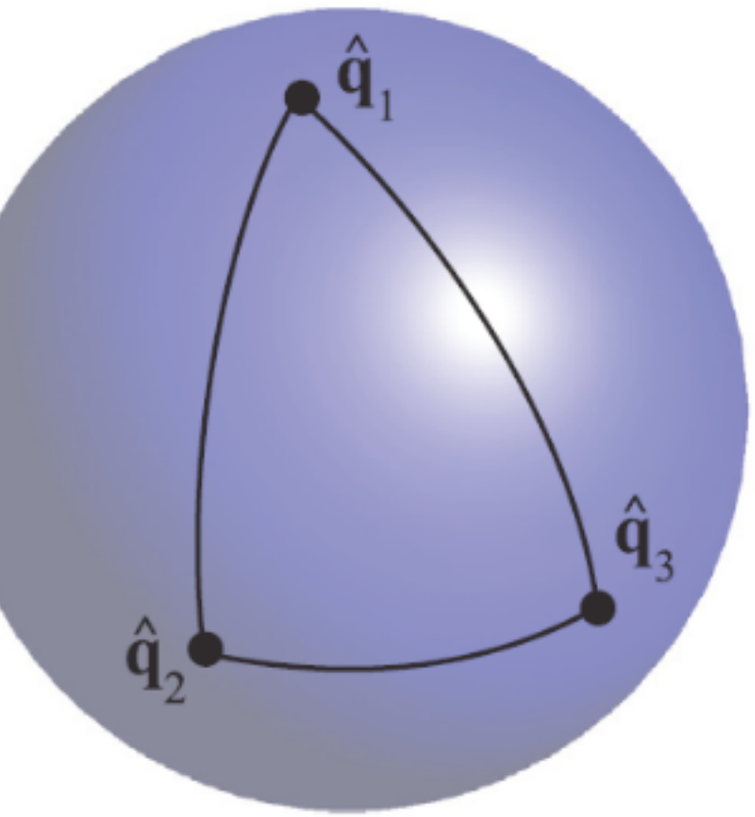






[Christopher Lutz http://www.animationsnippets.com]

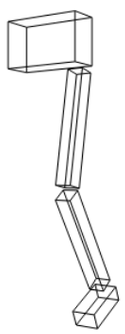
# Interpolating Rotations

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

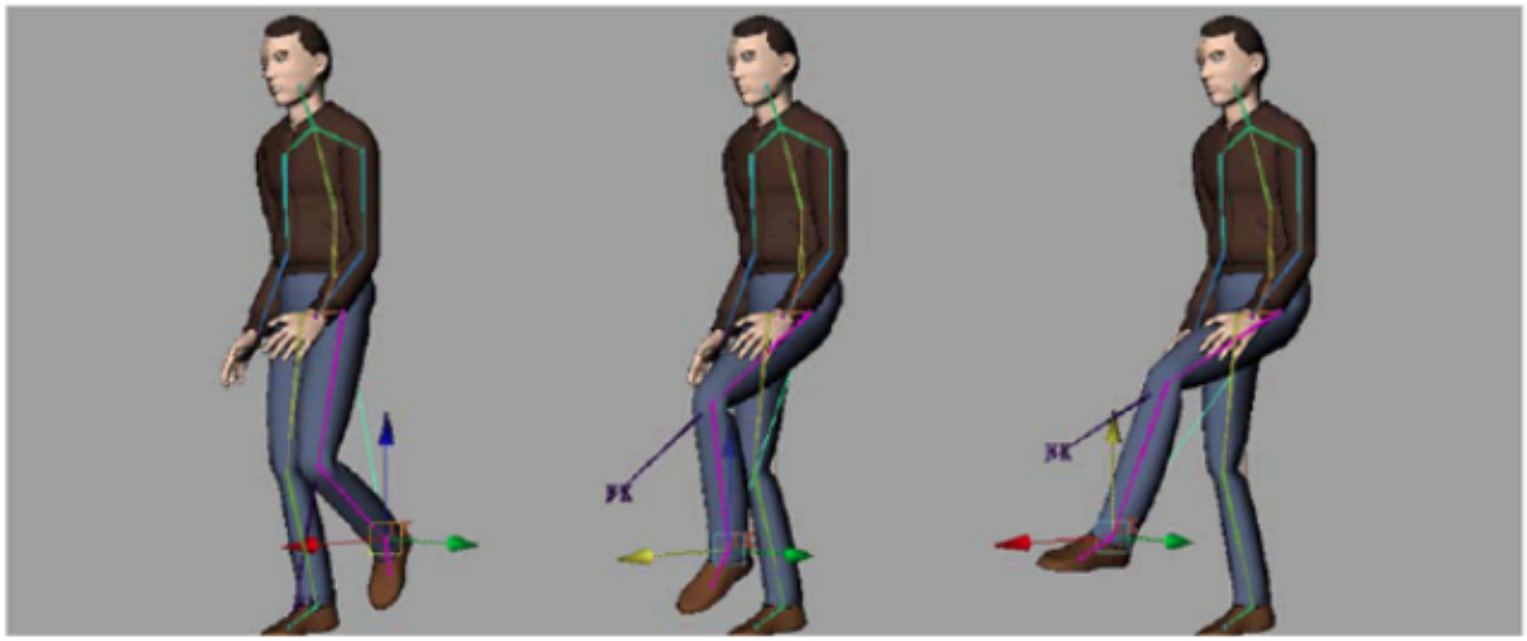



- Quaternions are one answer
  - 4D vectors that make spherical interpolation nicer

# 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

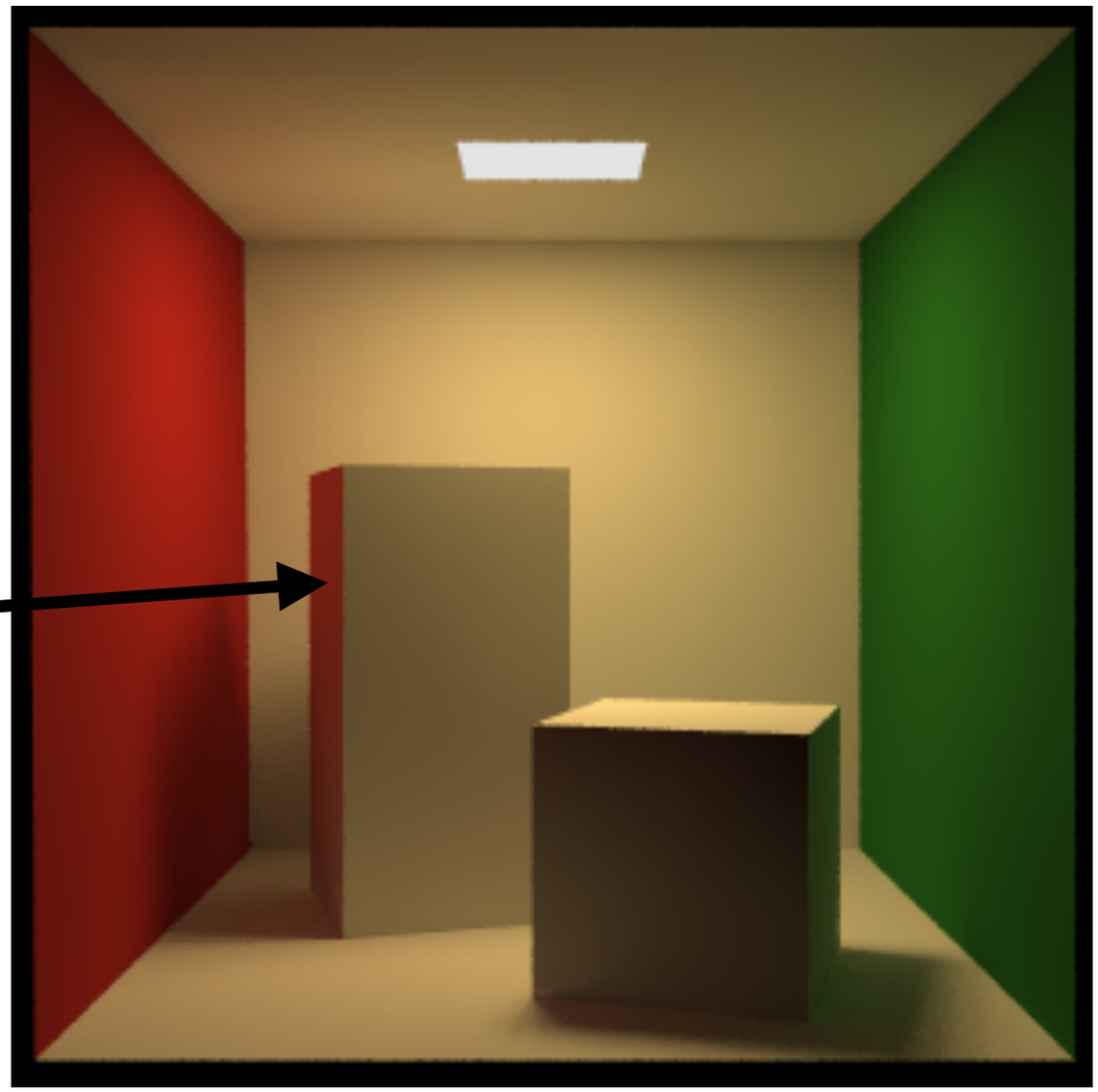
Mechanical

Optical

# Questions?

# Global Illumination

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



global illumination effects

# Global Illumination: Direct vs Indirect

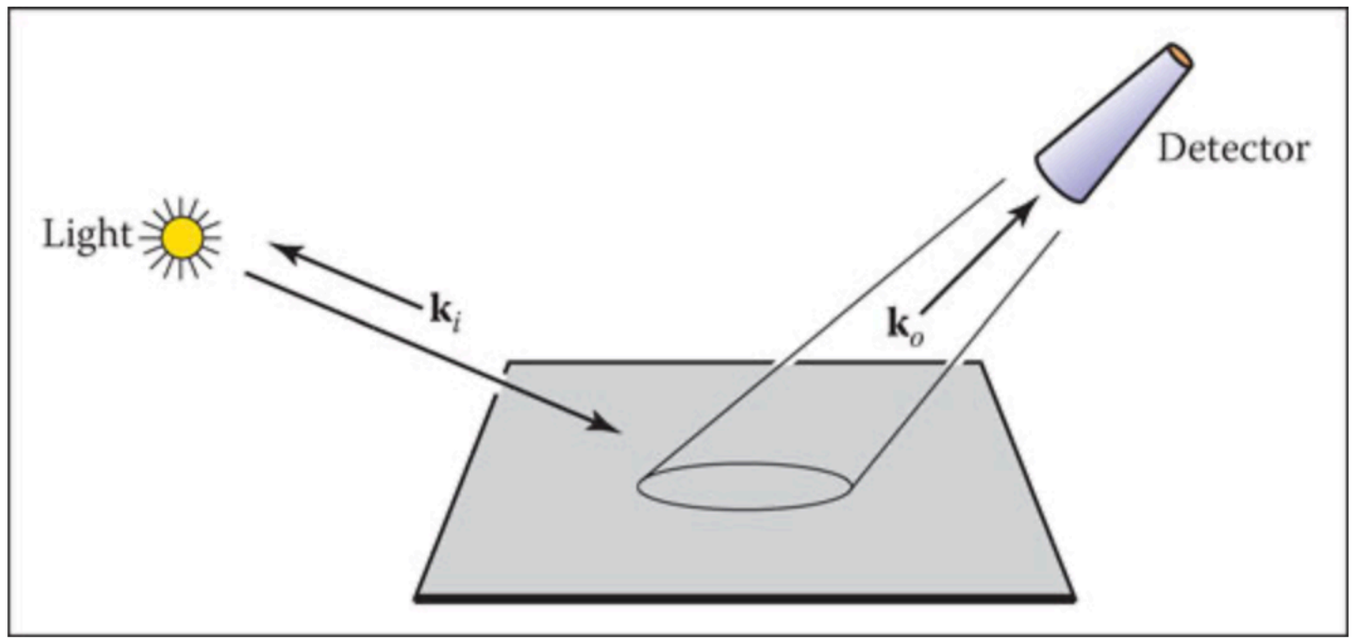
Indirect only

Direct only

Both

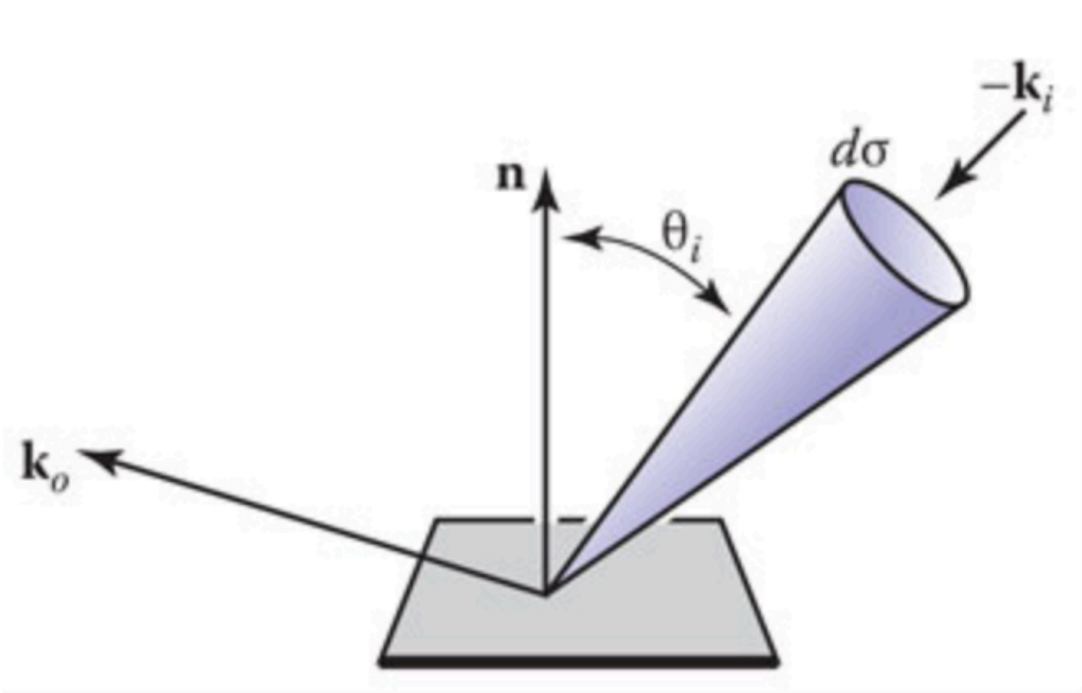
# Light Transport: BRDF

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



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

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



# 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