Computer Graphics

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http://www.cs.pdx.edu/~fliu/courses/cs447/

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Last time

☐ Ray tracing

Today

- ☐ Animation

- ☐ Final Exam
  - ■ To-know list available
  - ■ December 06 (Monday) 17:30-19:00

Animation

- Animation is about bringing things to life

- Technically:
  - Generate a sequence of images that, when played one after the other, make things move
  - One image is called a *frame*
    - 24 frames per second for film, resolution approx 1600x1200, good anti-aliasing
    - 30 frames per second for NTSC video, resolution less than 640x480
    - 60+ frames per second for "twitch" computer games, 640x480 or higher resolution
  - Interlacing: Display every second row for one frame, every other row for the next. Used in NTSC TV and older monitors

Perceptual Issues

- ☐ We perceive many still images in rapid succession as continuous motion
  - ■ Even if there is a transition period between the images
  - ■ Can even put distracters in and motion is still perceived
- ☐ You can be fooled, however, if the flicker rate is incorrect
- ☐ The frame rate for film was perceptually chosen

Animation Issues

- When evaluating an animation technique or application, the following things should be considered:
    - How fast can the images be generated?
    - How easy is it to control the appearance of the animation?
    - How much human expertise is required to generate the animation?
    - Can the animation be generated in response to a user's action (interactive animation)?
- Application driven: Different applications have different requirements:
    - Feature film animation is different from interactive gaming animation

The 11 Principles

- ☐ Developed at Disney over the 1920s and 1930s
- ☐ Described by John Lasseter (Pixar) 1987
- ☐ Squash-and-Stretch, Timing, Anticipation, Follow Through and Overlapping Action, Straight Ahead Action and Pose-to-Pose Action, Slow In and Out, Arcs, Exaggeration, Secondary Action, Appeal
- ☐ Basically, principles are driven by:
  - ■ Perceptual factors, such as directing the viewer's attention and smoothing the motion for easier perception
  - ■ Conveying emotion through motion

Pixar Lamp

https://www.youtube.com/watch?v=Hzkm9E3pYMw

Basic Animation Techniques

- Keyframe animation
  - Animator specifies important positions throughout the animation – the *keyframes*
  - Someone or something fills in the intermediate frames – *inbetweening*, or just *'tweening*
- Motion capture
  - System captures motion data from a real enactment of the animation
  - The data then drives a virtual character or object
- Procedural animation
  - A set of equations or rules are evaluated to determine how the animation behaves

Keyframing

- The original way to animate, and still the most common form for feature animation
  - Process has shifted to computers, but basic approach is the same
- Underlying technique is *interpolation*
  - The in-between frames are interpolated from the keyframes
  - Originally done by armies of underpaid animators
  - Now done with computers
  - Which of the techniques that we have learned about is used extensively for keyframe animation?

Interpolation

- Interpolating splines are smooth curves that interpolate their control points
  - For example, **Cardinal cubics** (Shirley book ch. 15.5.3)
- Perfect for keyframe animation
- Typically, time is directly associated with the parameter value, controlling speed

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Keyframes
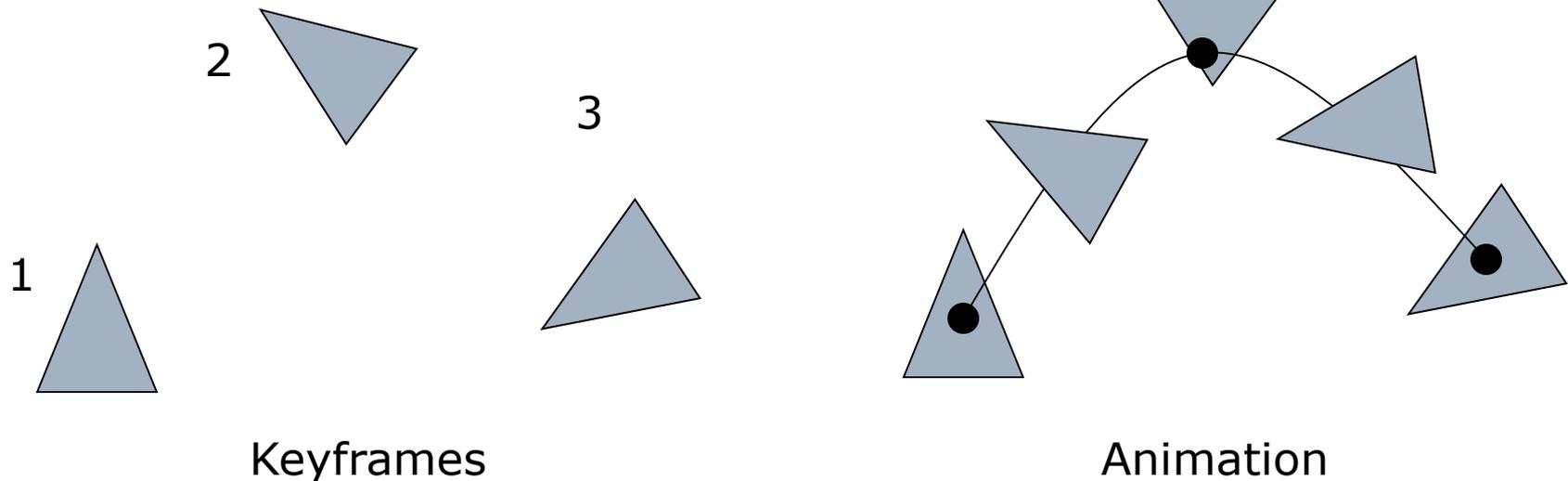
Animation

More Interpolation

- ☐ Anything can be keyframed and interpolated
  - ■ Position, Orientation, Scale, Deformation, Patch Control Points (facial animation), Color, Surface normals...

- ☐ Special interpolation schemes for things like rotations
  - ■ Use *quaternions* to represent rotation and do spherical interpolation

- ☐ Control of parameterization controls speed of animation

Motion Capture

☐ Extract data from real-world people acting out a scene

☐ Many techniques for getting the data:

■ Optical – take video and extract motion

■ Magnetic/Radio – attach magnets, transponders and use sensors to get location

■ Mechanical methods of extracting motion (for small motions)

☐ Most methods have some problems, all are limited in the complexity of the scenes they can capture

■ Solution: Break scenes into smaller pieces and re-construct later

Motion Capture Example

From http://www.batou.fr/wp-content/uploads/motion_capture_1.jpg

Motion Capture in Use

- Motion capture is one of the primary animation techniques for computer games
  - Gather lots of snippets of motion capture
    - e.g.: Several ways to dunk, dribble, pass
  - Arrange them so that they can be pieced together smoothly
  - At run time, figure out which pieces to play to have the character do the desired thing
- Problems: Once the data is captured, it's hard to modify for a different purpose

Face animation

https://www.youtube.com/watch?v=ohmajJTcpNk

Thies, etc. Face2Face: Real-time Face Capture and Reenactment of RGB Videos. CVPR 2016

Procedural Animation

- Animation is generated by writing a program that outputs the position/shape/whatever of the scene over time
- Generally:
    - Program some rules for how the system will behave
    - Choose some initial conditions for the world
    - Run the program, maybe with user input to guide what happens
- Advantage: Once you have the program, you can get lots of motion
- Disadvantage: The animation is generally hard to control, which makes it hard to tell a story with purely procedural means

Particle Systems

- A particle has:
    - A position in the world
    - Rules for how it moves over time
    - Rules for how it is drawn
- A particle system:
    - Controls when particles are created and destroyed
    - Makes sure that all the particles are updated

Smoke Particle System

- ☐ Constantly create particles
- ☐ Particles move upwards, with *turbulence* added
  - ■ Ken Perlin: An academy award
- ☐ Draw them as partially transparent circles that fade over time
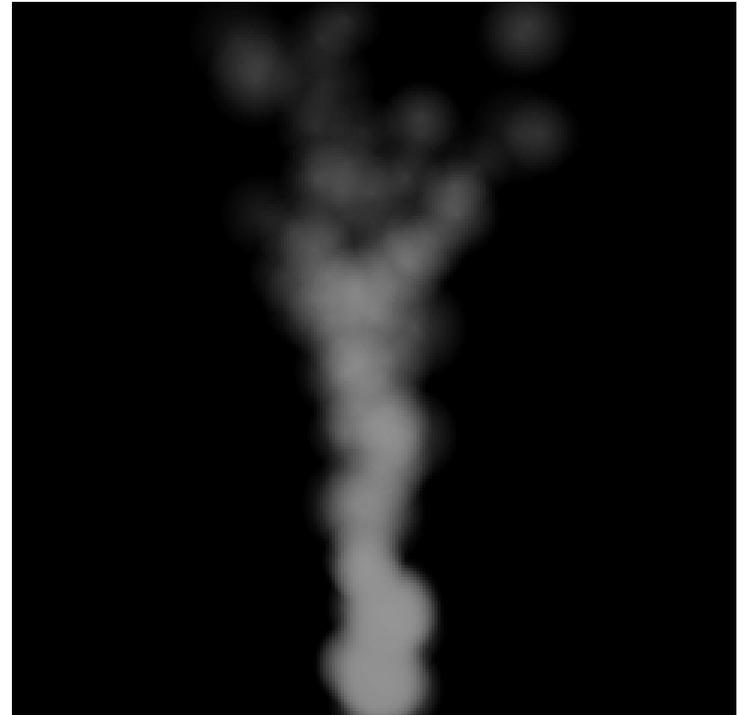
Movie Particle Systems

- ☐ Particle systems are the standard way of doing smoke and water spray

- ☐ Examples from Perfect Storm (lots of water)

  - ■ All images from Industrial Light and Magic (ILM)

Basic Ocean

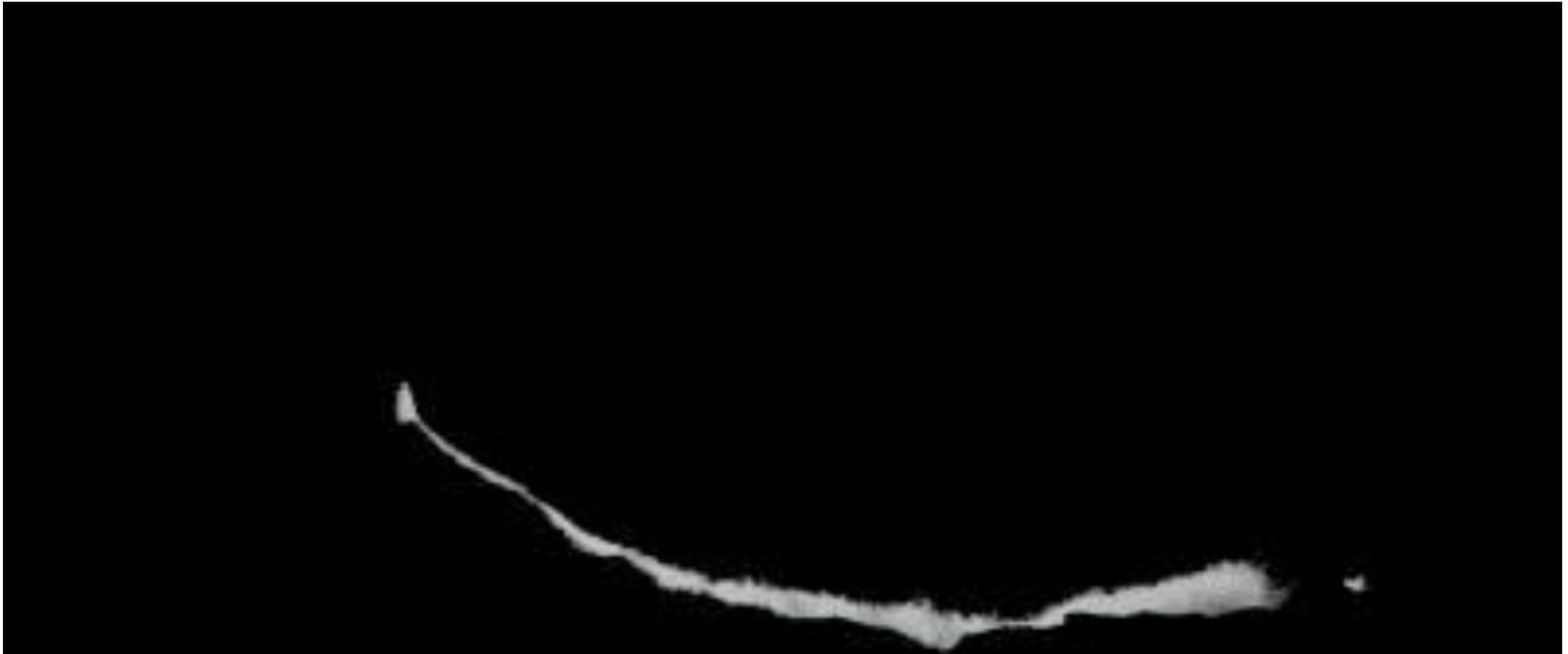☐ Ocean created with *Computational Fluid Dynamics*

Flowing Water

☐ Water from previous frame flowing over boat

Boat's Spray
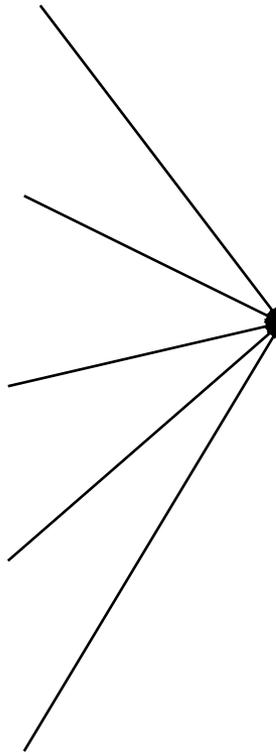
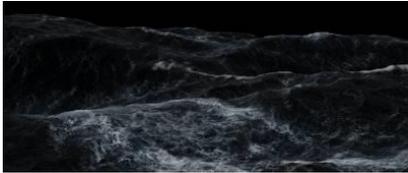☐ Particles are created where the boat meets the ocean

Impact Spray

☐ Particles created where boat and ocean hit hard

Perfect Storm – Composite

Fei et al. https://www.youtube.com/watch?v=xvyGpBKevLM

Spring-Mass Systems

- ☐ Model objects as systems of springs and masses
- ☐ The springs exert forces, and you control them by changing their rest length
- ☐ A reasonable, but simple, physical model for muscles
- ☐ Advantage: Good looking motion when it works
- ☐ Disadvantage: Expensive and hard to control
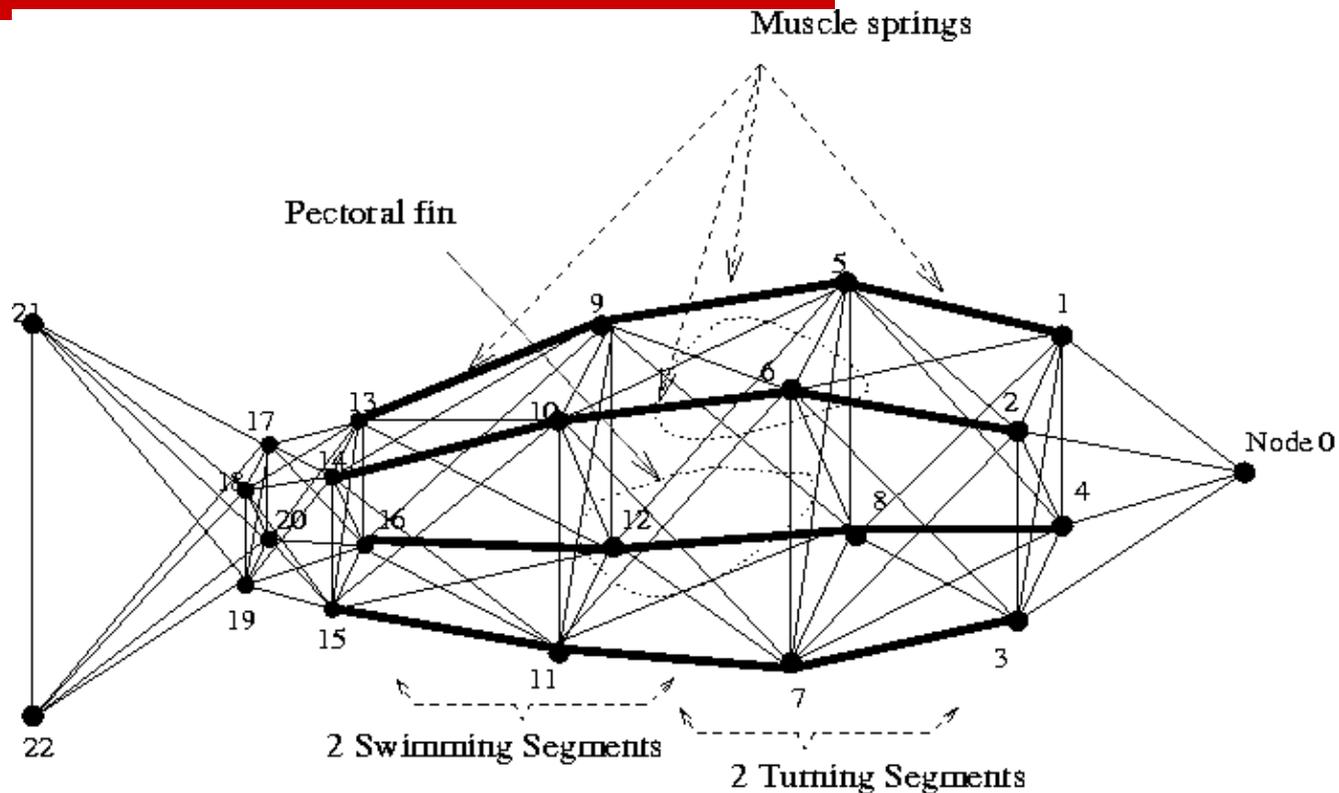
Spring mass fish

Figure 4.1: The biomechanical fish model. Black dots indicate lumped masses. Lines indicate deformable elements at their natural, rest lengths.

Spring mass fish

http://www.dgp.toronto.edu/~tu/animations.html

https://www.youtube.com/watch?v=aP1_XkCdAaE

Physically-Based Models

- ☐ Create a model based on the physics of a situation, and just solve for what happens
- ☐ Has been applied to:
    - ■ Colliding rigid objects
    - ■ Cloth
        - ☐ An example: http://www.youtube.com/watch?v=04nXlhdPxB4&noredirect=1
    - ■ Water
    - ■ Smoke
        - ☐ https://www.youtube.com/watch?v=7cC-_-aqx18
    - ■ Squishy objects
    - ■ Humans
    - ■ New ones every year
- ☐ Problem: Expensive, hard to control, and not necessarily realistic

Cloth Simulation

Jiang et al. https://www.youtube.com/watch?v=eGtB0VXJsuI
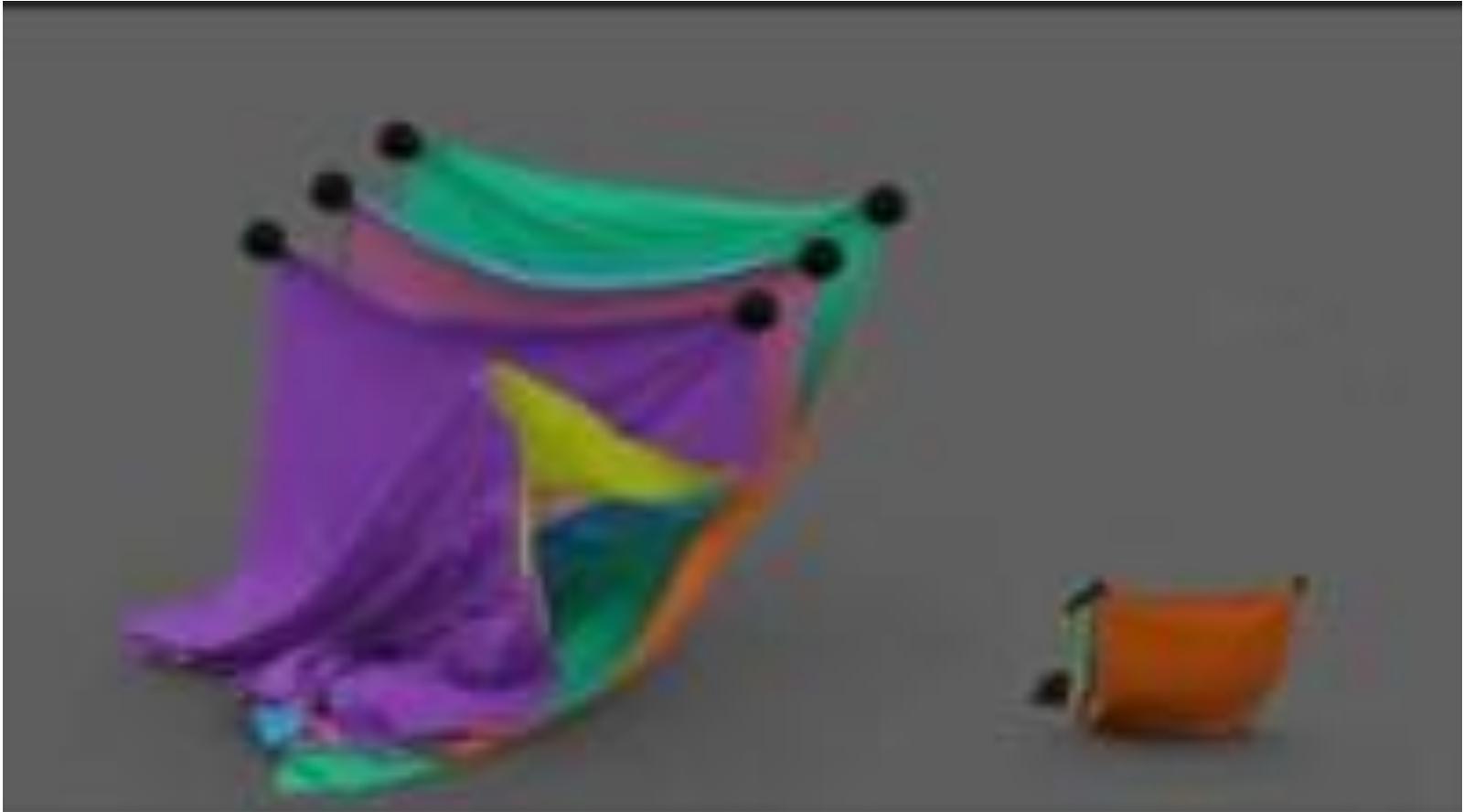
Mixing Techniques

- Techniques can be mixed and matched in the same animation
- For example, apply physical secondary motion on top of key-framed primary motion
  - Particularly appropriate for cloth
- Mix motion capture and physics:
  - Motion captured person kicks a ball which is then physically simulated to find out where it goes

Animation Summary (brief)

Technique	Control	Time to Create	Computation Cost	Interactivity
Key-Framed	Excellent	Poor	Low	Low
Motion Capture	Good at time of creation, after that poor	Medium	Medium	Medium
Procedural	Poor	Poor to create program	High	High

Current Challenges

- Human characteristics
  - Hair animation and rendering
  - Skin rendering
  - Facial animation
  - Realistic subtle motion
- High quality real time
  - Fluids, hair, physics
  - Realistic lighting and shading
- Control with quality
  - Making it easier for artists and directors to get the results they want

FUTURE OF VR

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https://www.youtube.com/watch?v=Q-gse_hFkJM

Next Time

☐ Final Exam