Computer Graphics

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Fall 2014

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

12/03/2014

Last time

- Ray tracing

Today

- Animation
- Homework 5 due 12/03, in class
- Final Exam: 17:30-19:20, December 8, 2014
  - To-know list available

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

Basic Animation Techniques

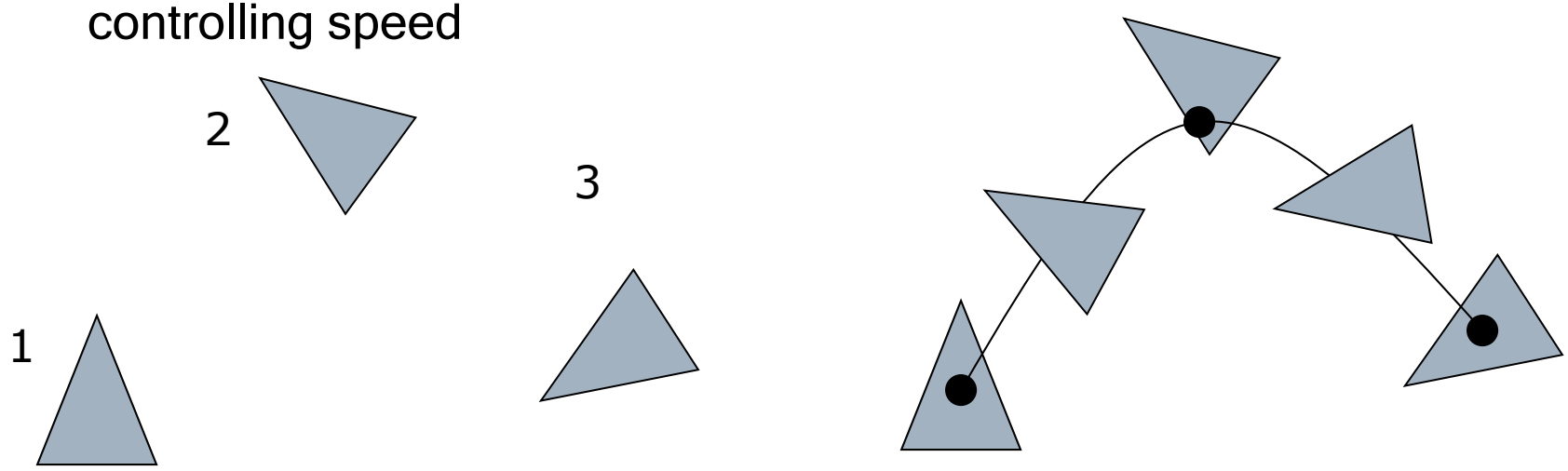
- Keyframe animation
  - Animator specifies important positions throughout the animation – the *keyframes*
  - Someone or something fills in the intermediate frames – *inbetweening*, or just *'tweening*
- Motion capture
  - System captures motion data from a real enactment of the animation
  - The data 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



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

Procedural Animation

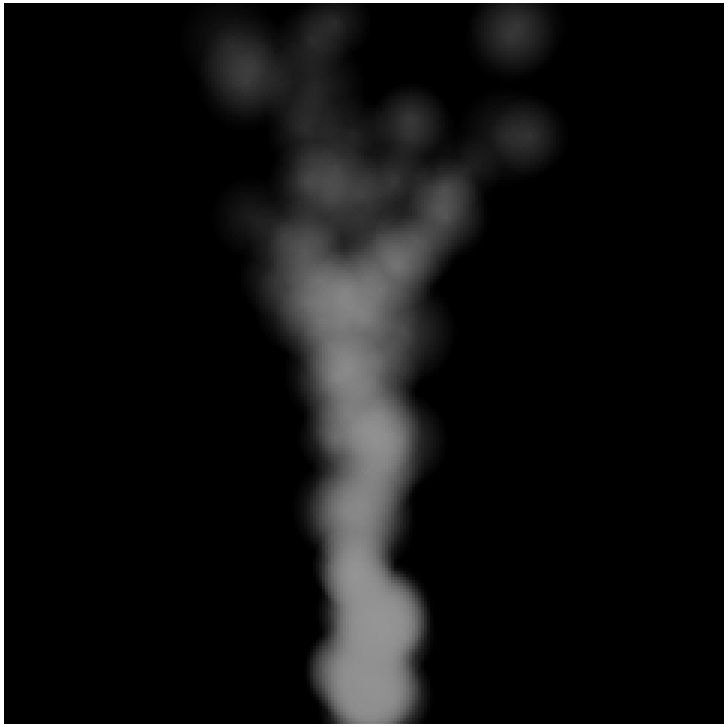
- Animation is generated by writing a program that outputs the position/shape/whatever of the scene over time
- Generally:
  - Program some rules for how the system will behave
  - Choose some initial conditions for the world
  - Run the program, maybe with user input to guide what happens
- Advantage: 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

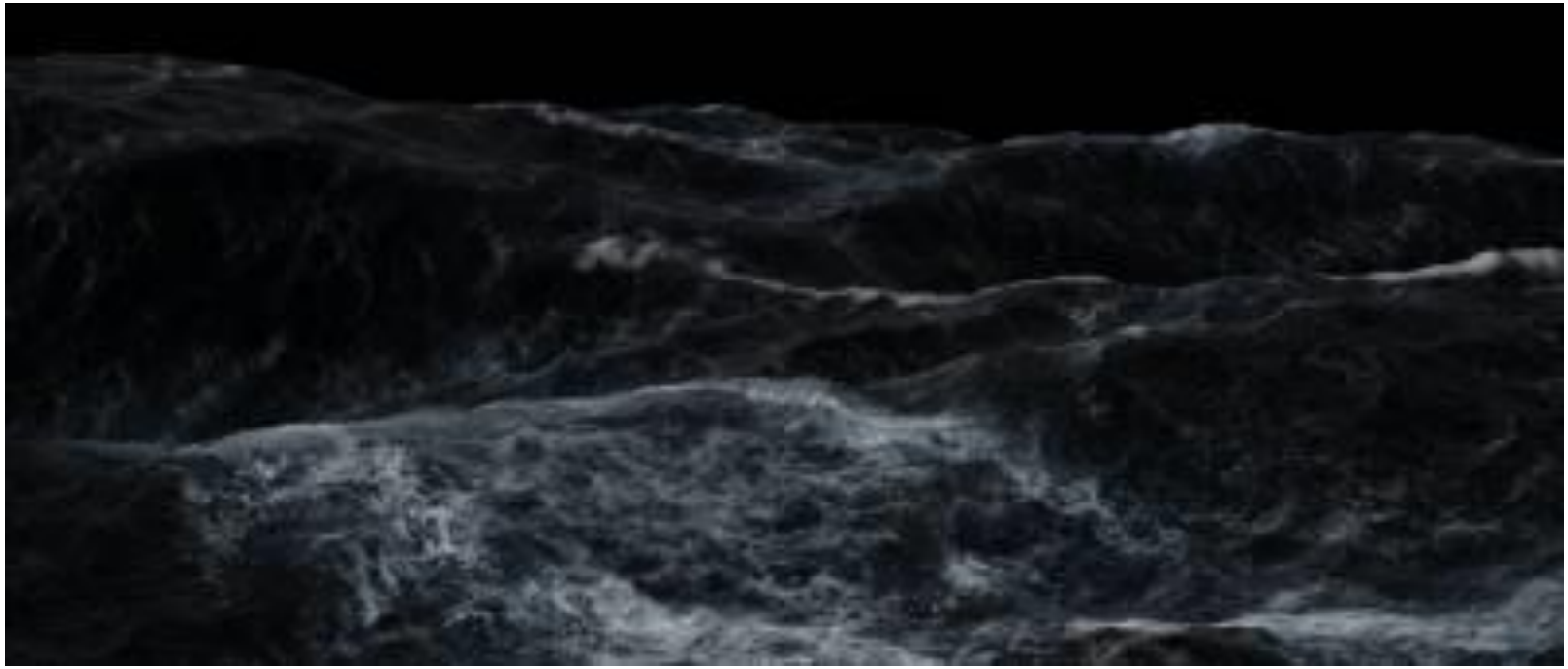


Movie Particle Systems

- 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*

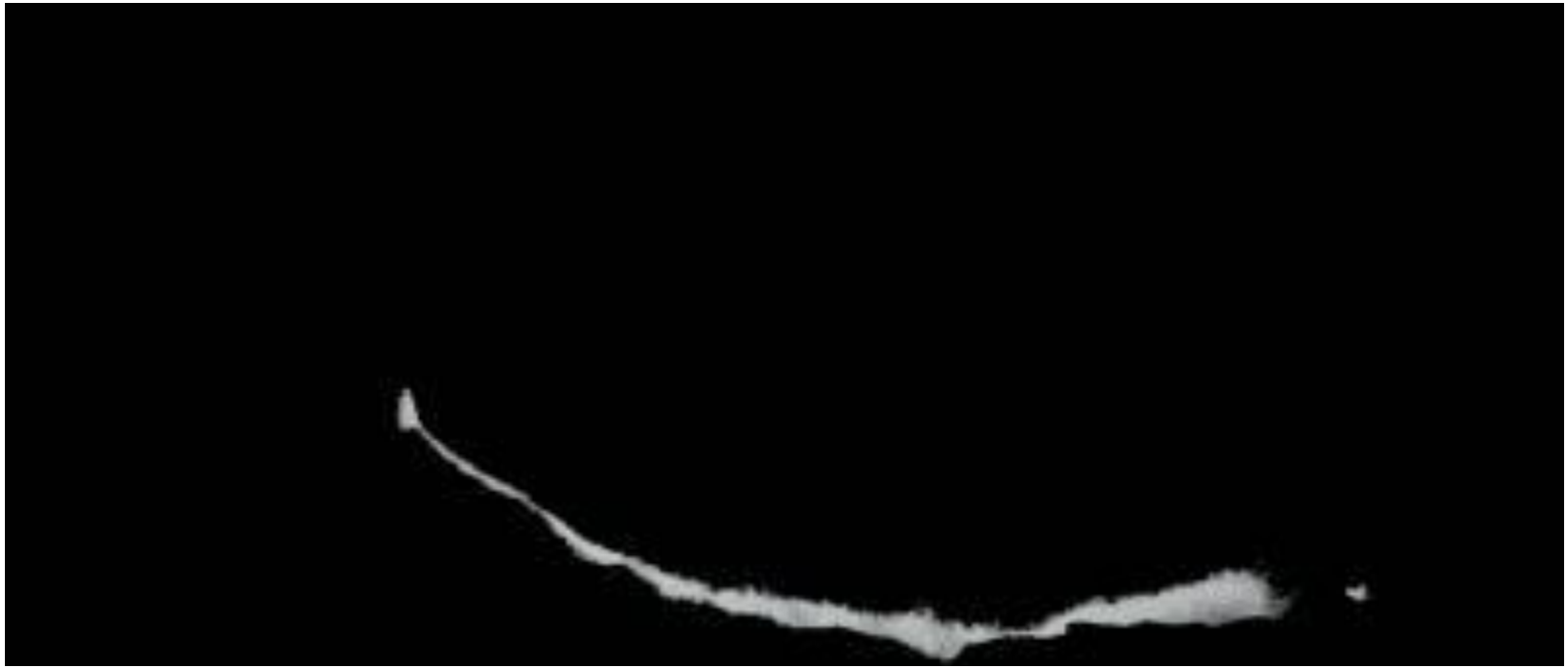


Flowing Water

- Water from previous frame flowing over boat

Boat's Spray

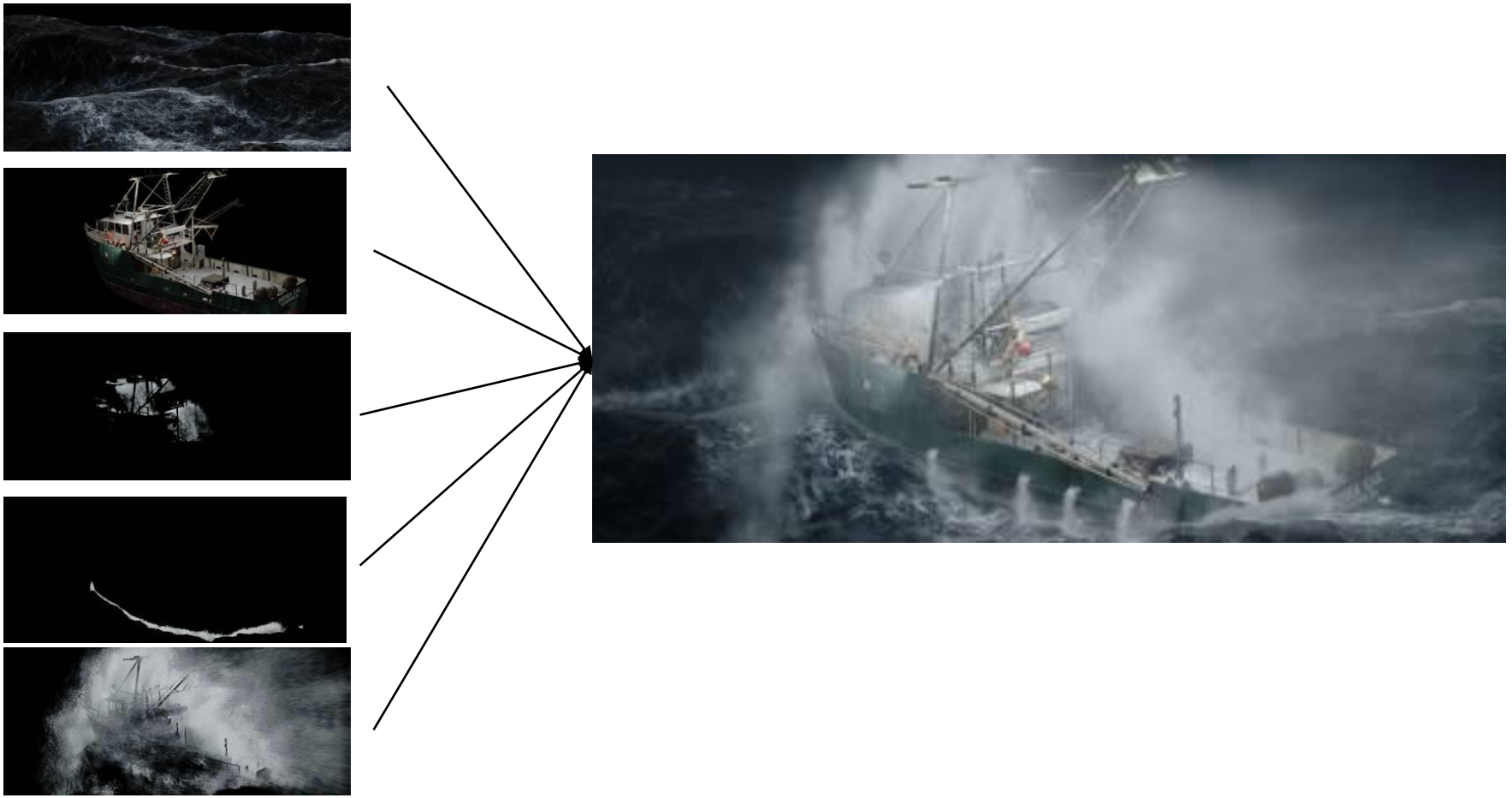
- Particles are created where the boat meets the ocean



Impact Spray

- Particles created where boat and ocean hit hard

Perfect Storm - Composite



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

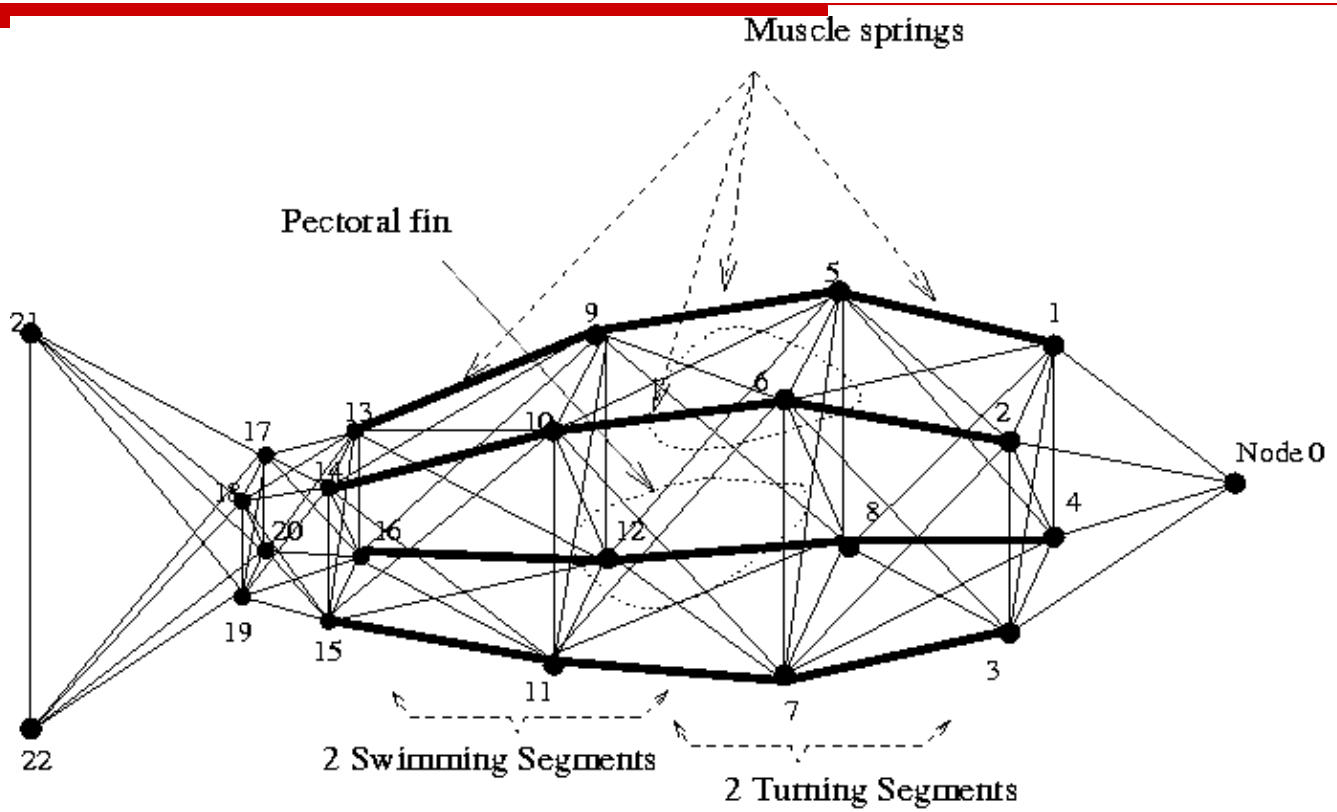
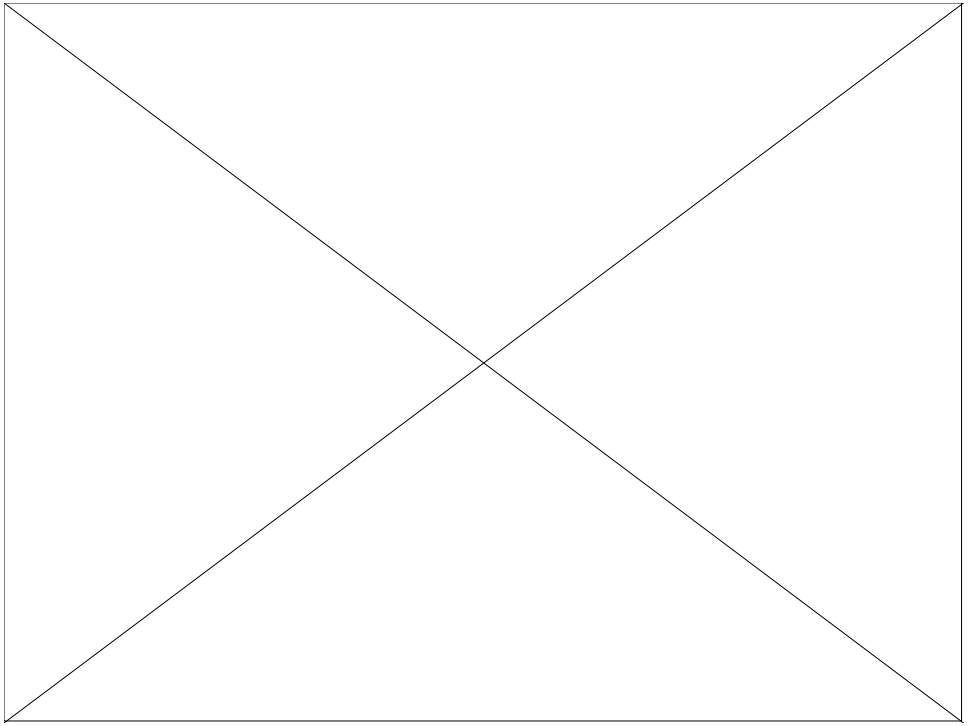


Figure 4.1: The biomechanical fish model. Black dots indicate lumped masses. Lines indicate deformable elements at their natural, rest lengths.

Due to Xiaoyuan Tu, http://www.dgp.toronto.edu/people/tu

Spring mass fish



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

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

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
  - Walking, running, climbing
- 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

Next Time

- Final Exam