Intro to Animation

Computer Animation:

What is animation?

Modifying scene parameters as a function of time

Why animate?

- Provides more information
- Interaction heightens immersion
- Fun

Principles of Animation

1. *Squash and Stretch* -- rigidity & mass by distortion
2. *Timing* -- weight & size & even personality by spacing action
3. *Anticipation* -- preparation
4. *Staging* -- unmistakably clear presentation of ideas
5. *Follow Through and Overlapping Action*
   -- relationship to the next action
6. *Straight Ahead Action and Pose-To-Pose Action*
   -- 2 contrasting approaches
7. *Slow In and Out* -- subtlety of timing and movement.
8. *Arcs* -- path of natural movement
9. *Exaggeration* -- accentuating the essence
10. *Secondary Action* -- action resulting from another
11. *Appeal* -- make the audience enjoy watching.

[Lasseter'87]

Overview

1) Scripting
2) Keyframing
3) Kinematics
4) Motion Processing
5) Higher Level Animation
6) Dynamics and Simulation

Example of Scripting

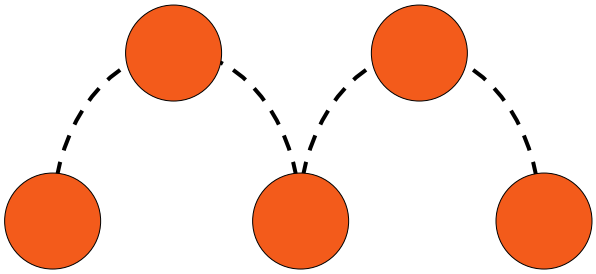
Specifying the parameters at every frame

```
define spinningCube()
   rotAngle = pi*frameNumber / 50

define carScript()
   carTranslation = 10*(frameNumber / 100)
   wheelRotation  = pi*frameNumber / 5
```

Keyframing

Specify only the important frames,
interpolate the frames in-between

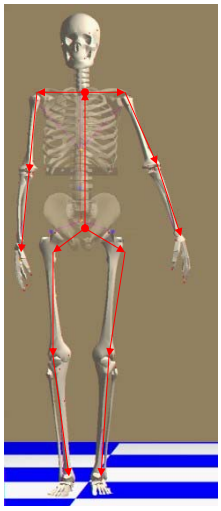


What and how to interpolate is important

KINEMATICS

The study or specification of motion, independent of the underlying physics that created the motion

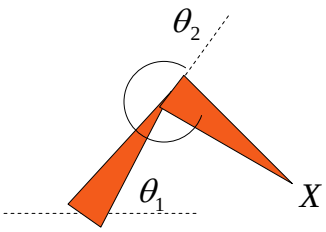
Articulated Figure:
A figure made up of a series of links (bones) connected at joints



FORWARD KINEMATICS

Given the character's state, calculate its pose

$$X = f(\theta)$$

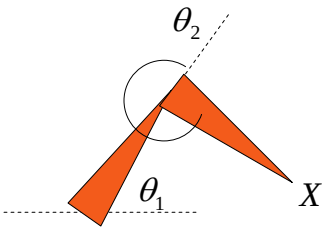


$$X = \begin{bmatrix} l_1 \cos\theta_1 + l_2 \cos(\theta_1 + \theta_2) \\ l_1 \sin\theta_1 + l_2 \sin(\theta_1 + \theta_2) \end{bmatrix}$$

Inverse Kinematics

Given the character's pose,
calculate its state

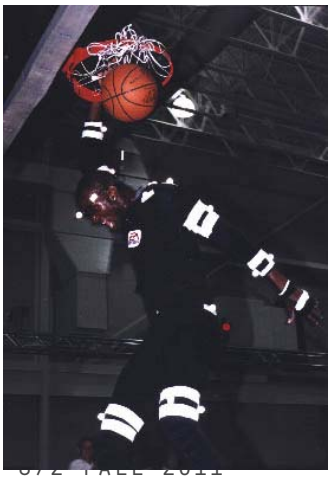
$$\theta = f^{-1}(X)$$



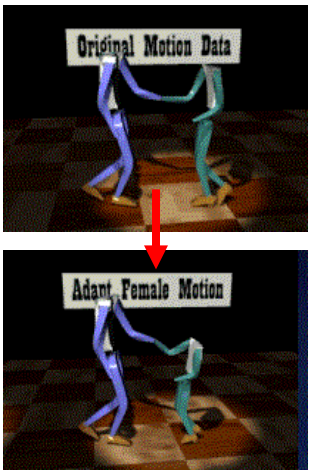
$$\theta = \begin{bmatrix} \dfrac{-(l_2 \sin\theta_2)x + (l_1 + l_2\cos\theta_2)y}{(l_2 \sin\theta_2)y + (l_1 + l_2\cos\theta_2)x} \\ \cos^{-1}\dfrac{(x^2 + y^2 - l_1^2 - l_2^2)}{2l_1 l_2} \end{bmatrix}$$

Motion Processing

Motion Capture



Motion Editing



Behavioral Animation

Animating by describing an actor's behavior

An actor's behavior defines how the actor interacts with other actors and the environment

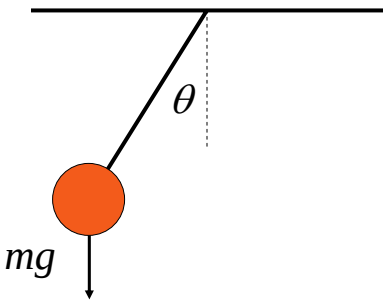
```
TRex()
  if(player is close)
    eatPlayer()
  else if(can see player)
    chasePlayer()
  else
    wander()
```


Behavioral Animation

 Useful for crowd animations

Dynamics

Using "physics" to define the animation



Model choice is important

(1)

$$\dot{X} = V$$

$$\dot{V} = \frac{F}{m}$$

(2)

$$\dot{X} = V$$

$$\dot{P} = F$$

$$\dot{\theta} = \omega$$

$$\dot{L} = T$$

Can use "augmented" laws of physics

Dynamics – Particle Systems

Particle Systems [Reeves83]

Represent "fuzzy" objects (such as fire, smoke) as a collection of particles

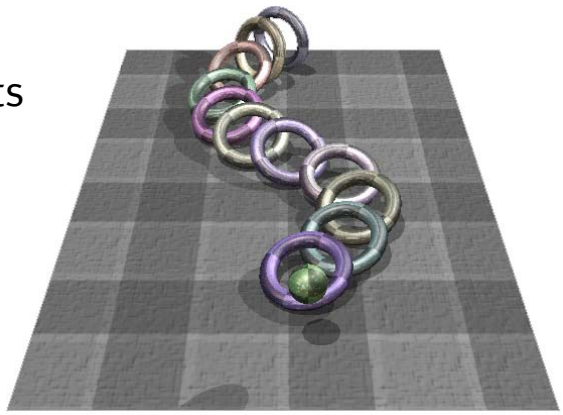
Particles contain local state

- Position
- Velocity
- Age
- Lifespan
- Rendering properties

Dynamics – Rigid Bodies

Rigid Bodies

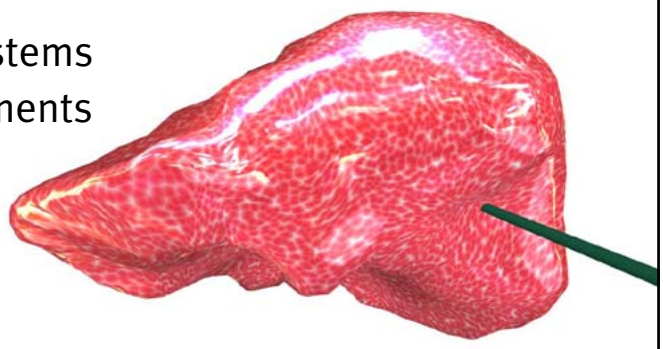
- Integration
- Collisions
- Constraints



Dynamics – Deformable Objects

Deformable Objects

- FFD
- Spring systems
- Finite Elements



Dynamics – Cloth

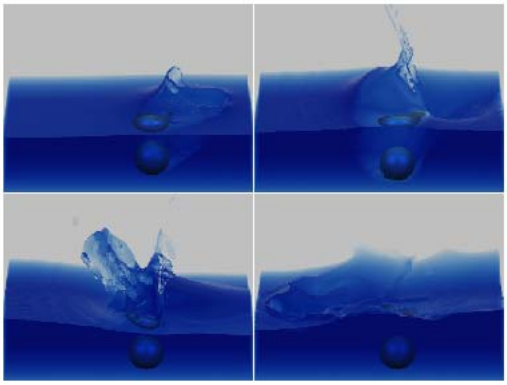
Cloth Simulation

- Stable Integration
- Adaptivity
- Material Properties

Dynamics – Fluids

Fluid Simulation

- Navier Stokes, plus *lots* of topology changes



[Foster & Fedkiw '01]

Real Time Animation

Zelda

Offline Animation – Anything Goes

Final Fantasy

Pixar movies

Be Careful: Zombie Line

[Entis'07]