Computer Animation

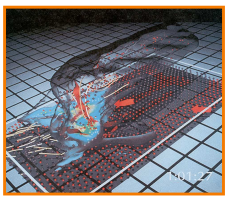
Thomas Funkhouser
Princeton University
C0S 426, Fall 1999

Computer Animation

- What is animation?
  - Make objects change over time according to scripted actions

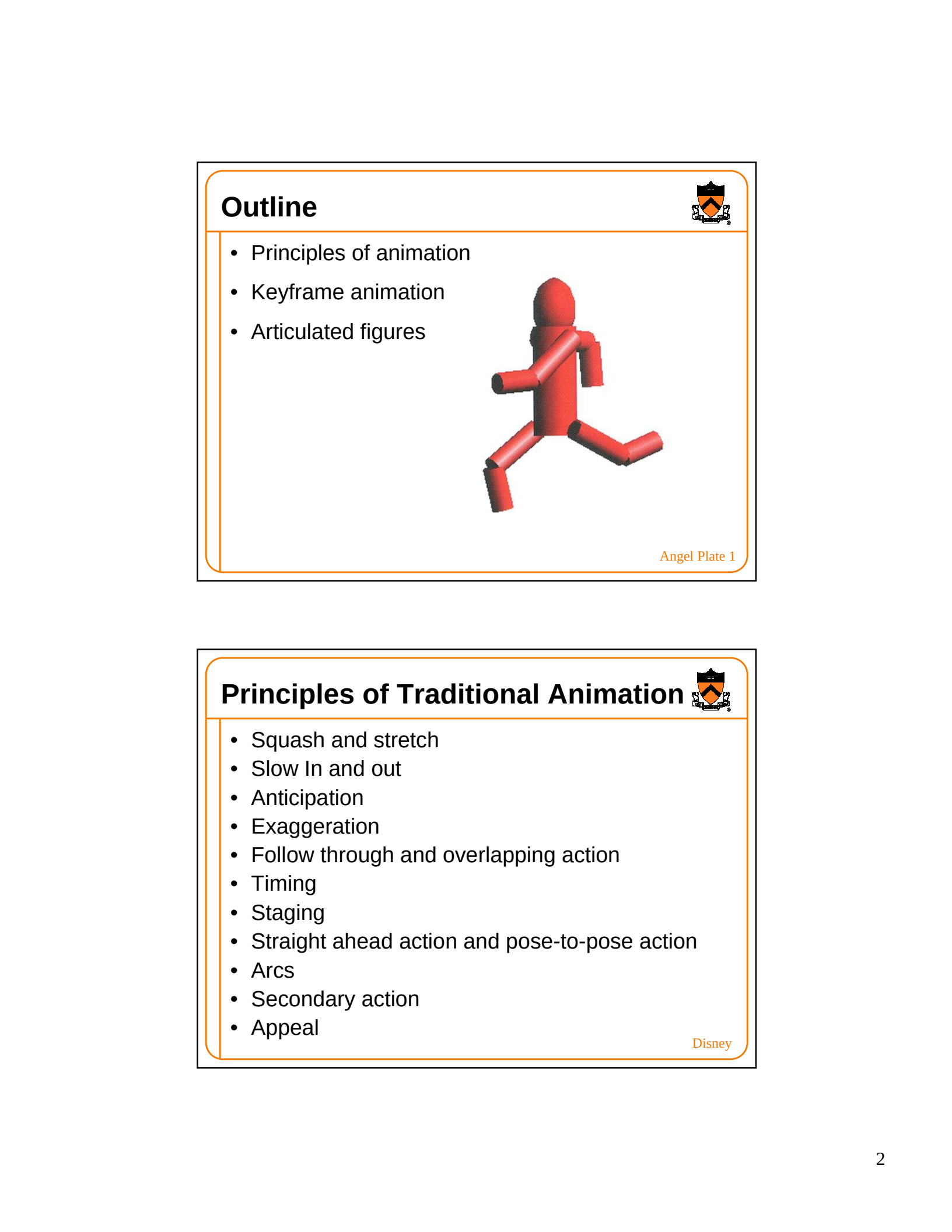
Pixar

- What is simulation?
  - Predict how objects change over time according to physical laws



University of Illinois

Outline



- Principles of animation
- Keyframe animation
- Articulated figures

Angel Plate 1

Principles of Traditional Animation

- Squash and stretch
- Slow In and out
- Anticipation
- Exaggeration
- Follow through and overlapping action
- Timing
- Staging
- Straight ahead action and pose-to-pose action
- Arcs
- Secondary action
- Appeal

Disney

Principles of Traditional Animation

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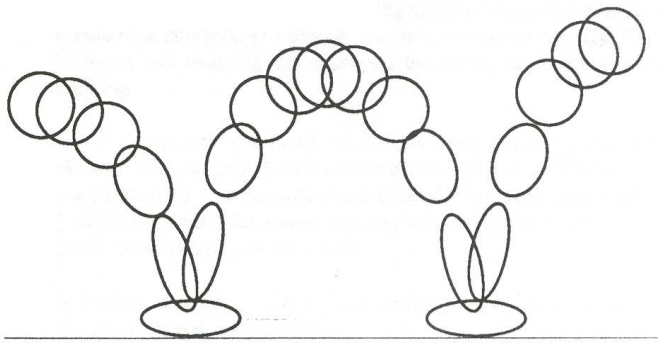
Disney

Principles of Traditional Animation

- Squash and stretch



Lasseter '87

Principles of Traditional Animation

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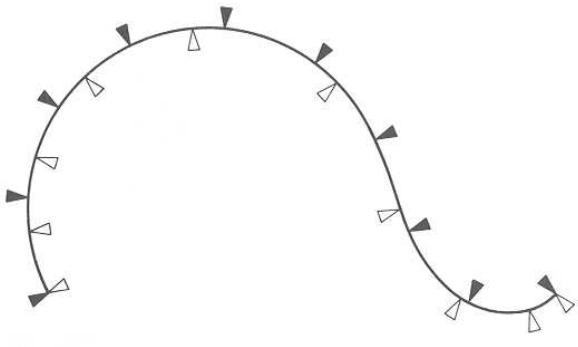
Disney

Principles of Traditional Animation

- Slow In and Out



Watt Figure 13.5

Principles of Traditional Animation

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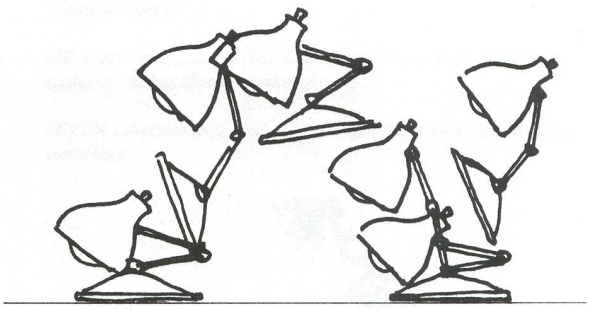
- Arcs
- Secondary action
- Appeal

Disney

Principles of Traditional Animation

- Anticipation (and squash & stretch)



Lasseter '87

Principles of Traditional Animation

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Disney

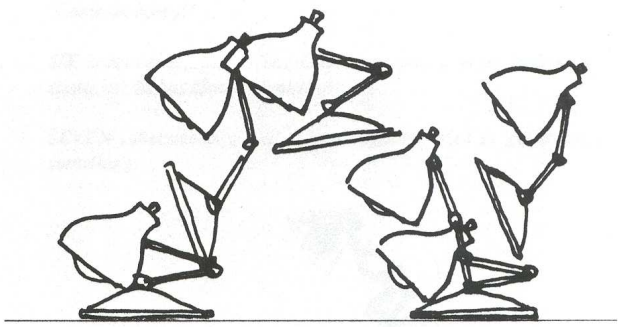
Computer Animation

- Animation pipeline
  - 3D modeling
  - Motion specification
  - Motion simulation
  - Shading, lighting, & rendering
  - Postprocessing

Pixar

Keyframe Animation

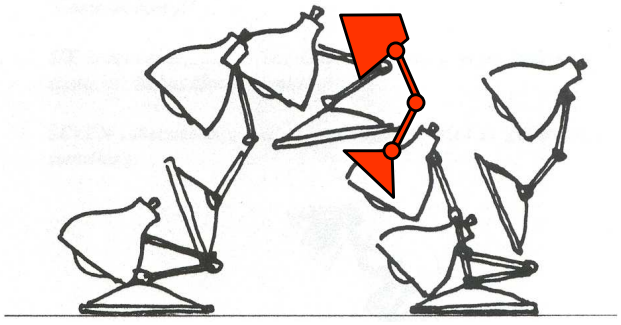
- Define character poses at specific time steps called “keyframes”



Lasseter ‘87

Keyframe Animation

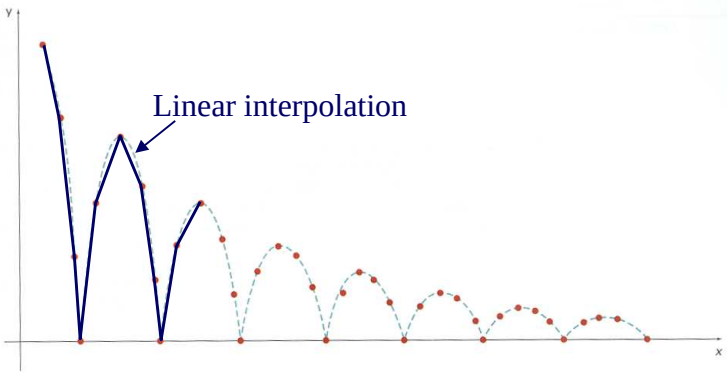
- Interpolate variables describing keyframes to determine poses for character in between



Lasseter ‘87

Keyframe Animation

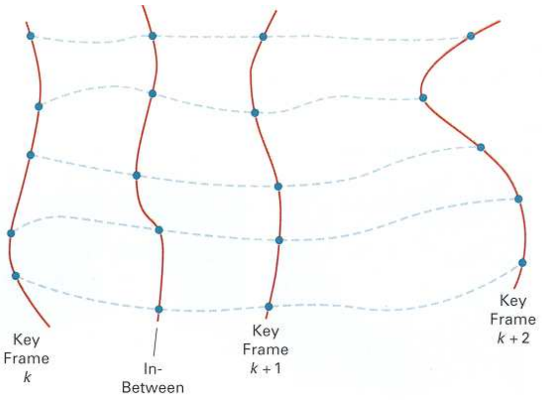
- Inbetweening:
  - Linear interpolation - usually not enough continuity



H&B Figure 16.16

Keyframe Animation

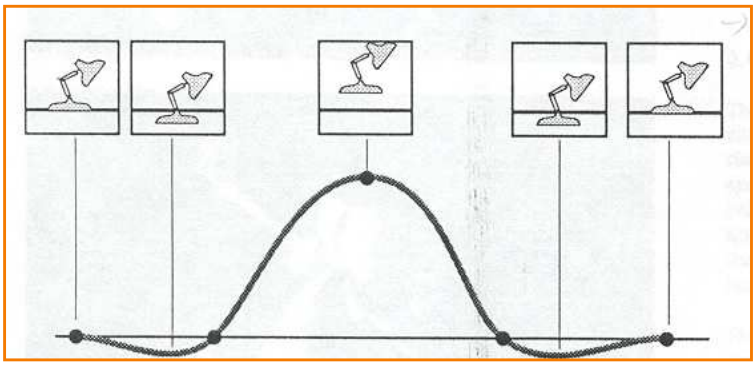
- Inbetweening:
  - Spline interpolation - maybe good enough



H&B Figure 16.11

Keyframe Animation

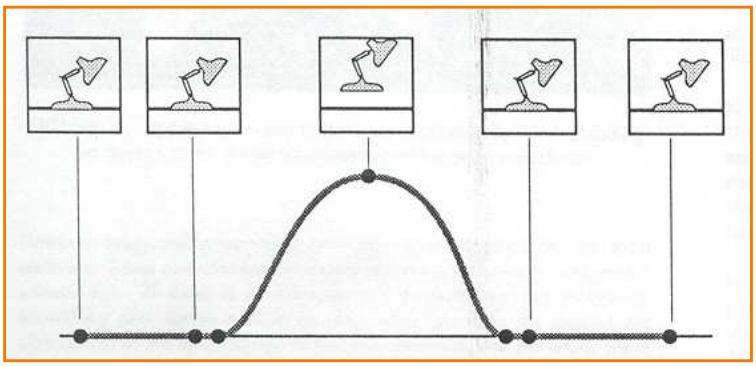
- Inbetweening:
  - Cubic spline interpolation - maybe good enough
    - » May not follow physical laws



Lasseter '87

Keyframe Animation

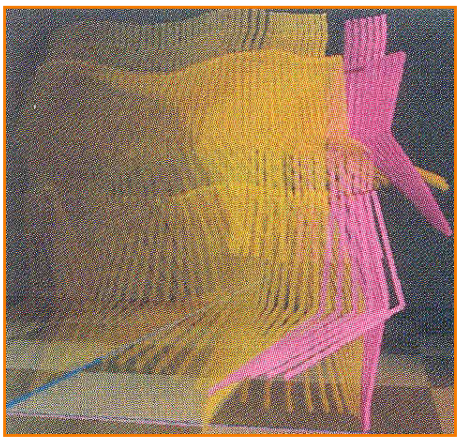
- Inbetweening:
  - Cubic spline interpolation - maybe good enough
    - » May not follow physical laws



Lasseter '87

Keyframe Animation

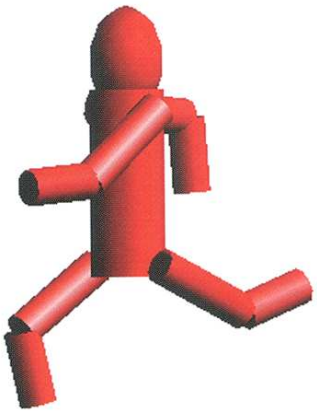
- Inbetweening:
  - Inverse kinematics or dynamics



Rose et al. '96

Outline

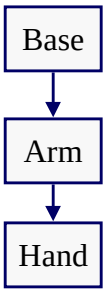
- Principles of animation
- Keyframe animation
- Articulated figures



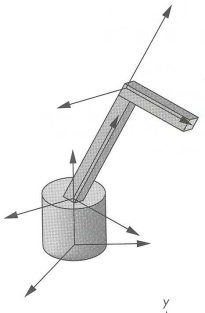
Angel Plate 1

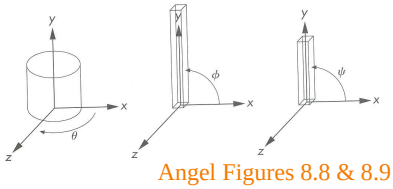
Articulated Figures

- Character poses described by set of rigid bodies connected by “joints”



Scene Graph

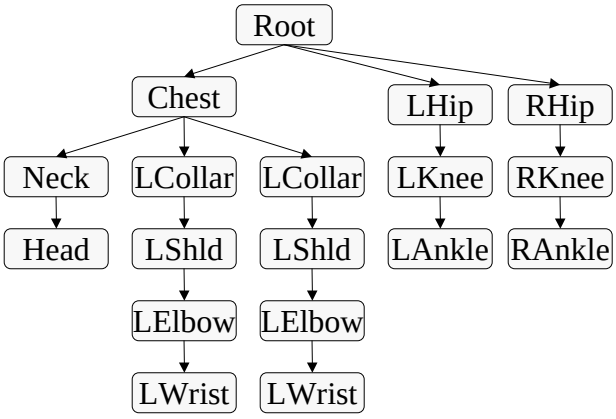


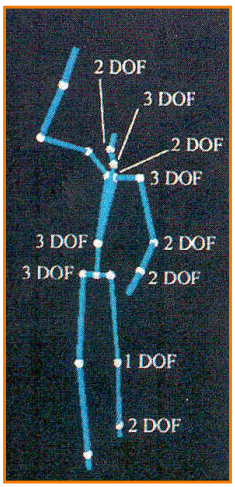


Angel Figures 8.8 & 8.9

Articulated Figures

- Well-suited for humanoid characters

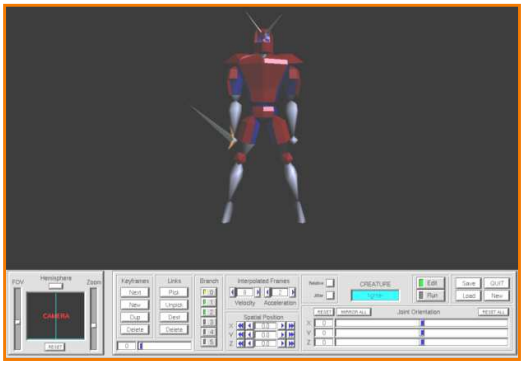




Rose et al. ‘96

Articulated Figures

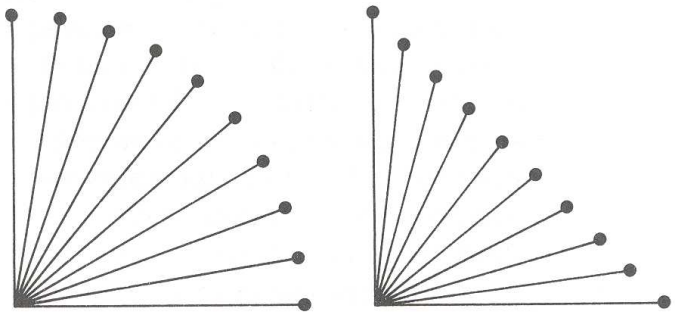
- Joints provide handles for moving articulated figure



Mike Marr, COS 426, Princeton University, 1995

Articulated Figures

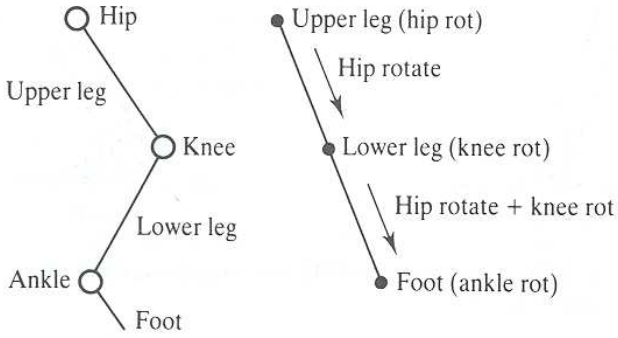
- Inbetweening
  - Compute joint angles between keyframes



Watt & Watt

Example: Walk Cycle

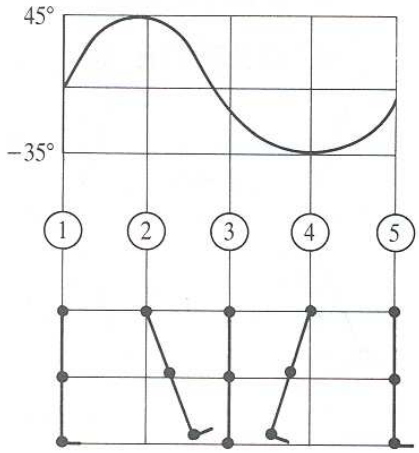
- Articulated figure:



Watt & Watt

Example: Walk Cycle

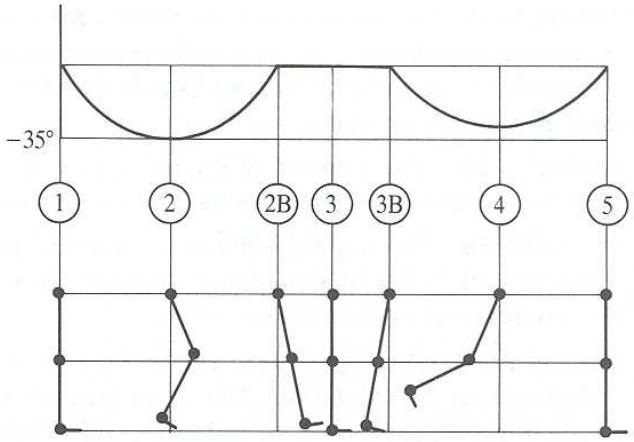
- Hip joint orientation:



Watt & Watt

Example: Walk Cycle

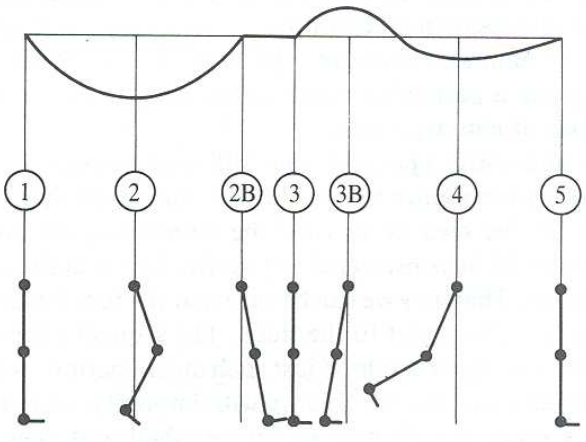
- Knee joint orientation:



Watt & Watt

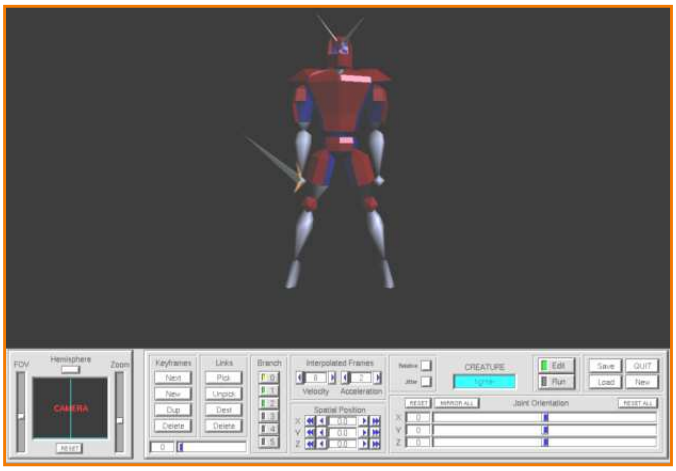
Example: Walk Cycle

- Ankle joint orientation:



Watt & Watt

Example: Run Cycle



Mike Marr, COS 426, Princeton University, 1995

Example: Ice Skating

(Mao Chen, Zaijin Guan, Zhiyan Liu, Xiaohu Qie, CS426, Fall98, Princeton University)

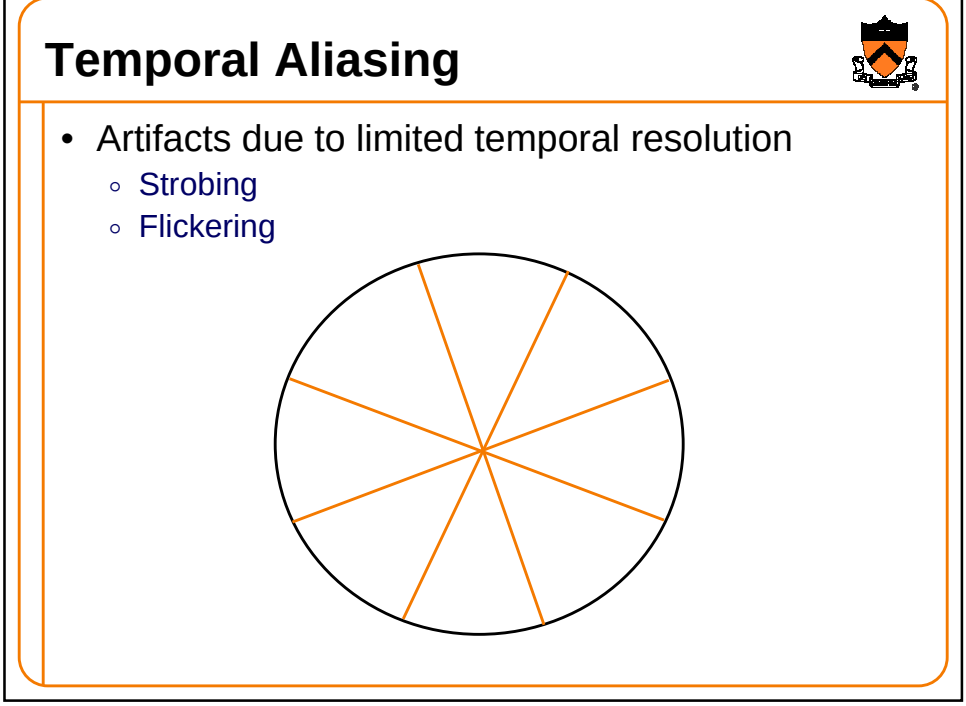
Example: Ballboy

Fujito, Milliron, Ngan, & Sanocki
Princeton University

Challenges of Animation

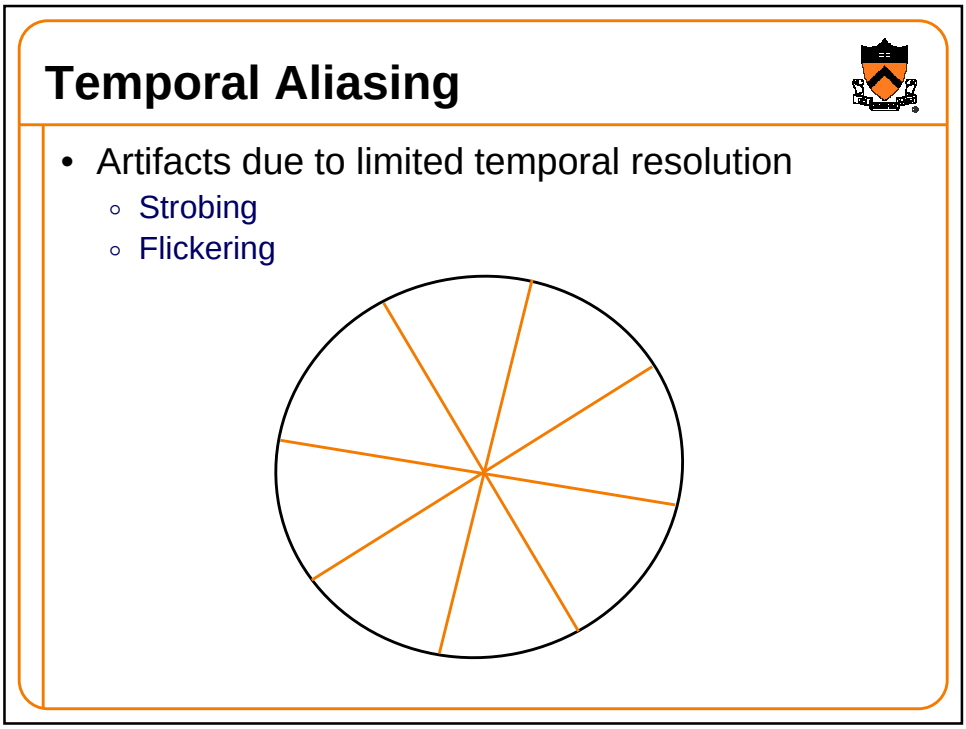
- Temporal aliasing
  - Motion blur

Temporal Aliasing



- Artifacts due to limited temporal resolution
  - Strobing
  - Flickering

Temporal Aliasing



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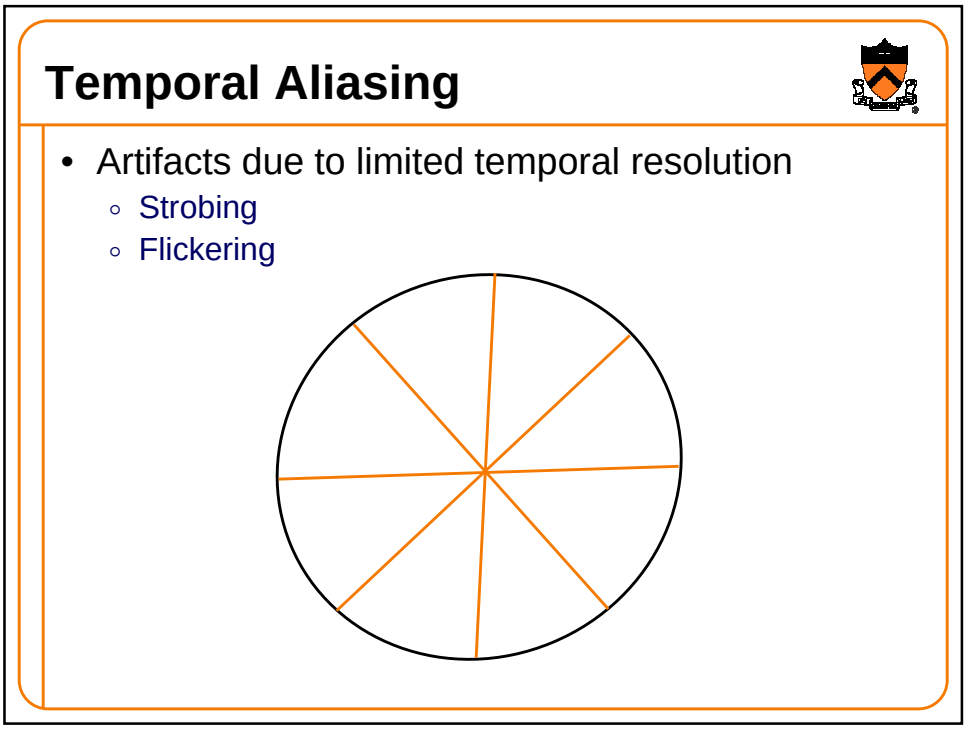

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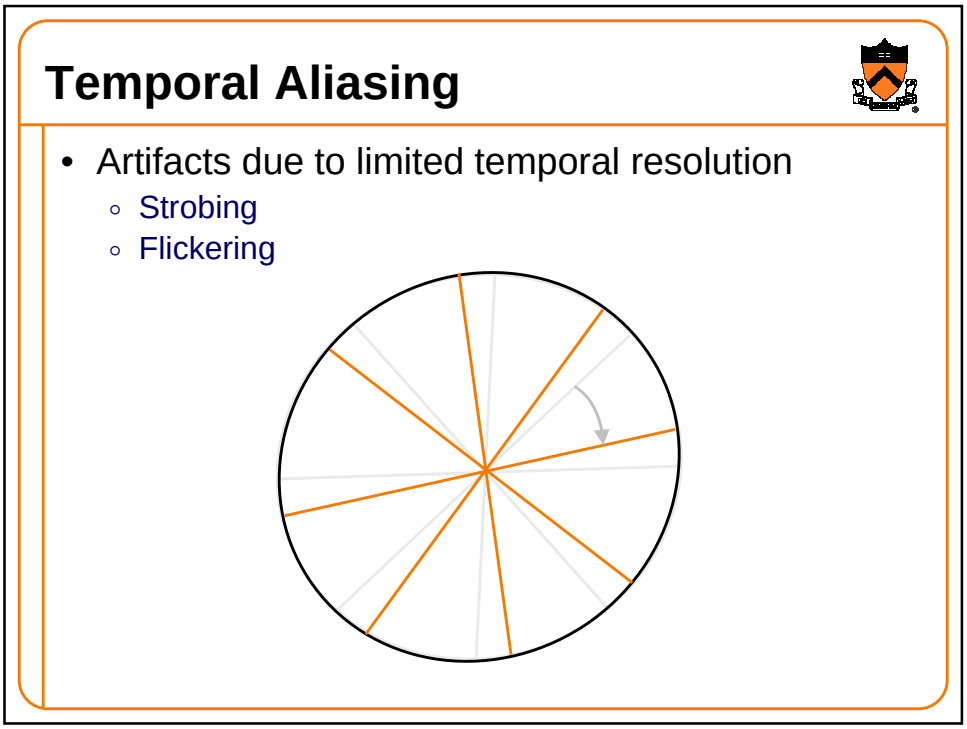

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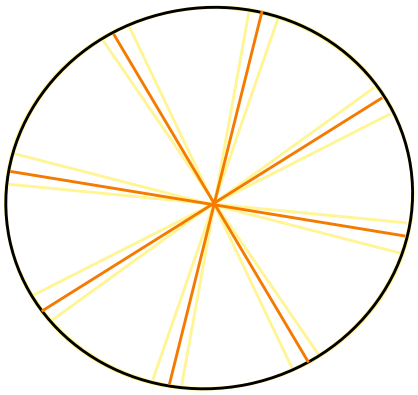
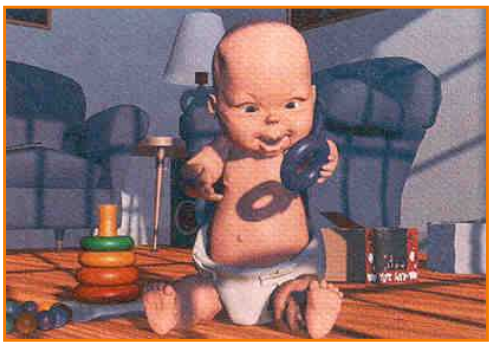
Motion Blur

- Composite weighted images of adjacent frames
  - Remove parts of signal under-sampled in time



Summary

- Animation requires ...
  - Modeling
  - Scripting
  - Inbetweening
  - Lighting, shading
  - Rendering
  - Image processing



Pixar