Animation
What is Animation?

- Animation is the rapid display of a sequence of images to create an illusion of movement.
- The most common method of presenting animation is as a motion picture.
- Humans require 16 HZ minimum; 24 Hz used for films; 30Hz used for TV.
Animation

- Each frame is a photograph of a drawing
- Each drawing differs slightly from the one before it
- The drawings are photographed one-by-one
How do you generate Animation?

- Typical examples include:
  - Keyframing (specified by hand)
  - Data-Driven (motion capture)
  - Procedural (rules, flocks)
  - Simulation (laws of physics)
History of Animation

• Paleolithic cave paintings
  – animals depicted with multiple legs in superimposed positions, attempting to convey the perception of motion
History of Animation

• Zoetrope
  
  • As the cylinder spins, the user looks through the slits at the pictures
  
  • The user sees a rapid succession of images, producing the illusion of motion
  
  • The earliest known zoetrope was created in China around 180 AD (may have existed in China even 300 or so years before that)
History of Animation

• Phenakistoscope
  • A spinning disc attached vertically to a handle
  • A series of drawings around the disc's center
  • A series of equally spaced radial slits
  • The user spins the disc and looks through the moving slits at the disc's reflection in a mirror
  • Invented by a Belgian physicist Joseph Plateau in 1841
History of Animation

• Praxinoscope
  – Invented in France in 1877 by Charles-Émile Reynaud
  – Improved on the zoetrope by replacing slits with an inner circle of mirrors
  – In 1889, Reynaud invented an improved version that allowed one to project the images onto a screen
History of Animation

• Flip book
  – In 1868, John Barnes Linnett patented it under the name *kineograph* ("moving picture")
  – It was the first form of animation to employ a linear sequence of images rather than a circular set
History of Animation

• Cinematograph
  – Invented in 1895 by the Lumiere brothers
  – Fed the linear film through with a hand operated crank
  – Projected the images onto a large screen
  – Original films were 17 meters long and lasted 50 seconds
  – Took their “film projector” around the world, charged admission for movies
Hollywood

- First film studio established in Hollywood in 1911, followed by 15 more later that year
- Charlie Chaplin Studios established in 1917
- Silent Film Era until 1929
- 1st Academy Awards in 1929
Golden Age of Hollywood

- 1927-1963
Stop Motion

- Create and tell non-physical non-real-world stories
- Physically manipulate real-world objects and photograph them one frame at a time to create the illusion of movement

Click for movie
Stop Motion

- Gumbasia, the first clay animation
- A short film produced in 1953 and released on September 2, 1955
- Produced by Art Clokey, who went on to create the classic series, “Gumby” and “Davey and Goliath”, using the same technique
Cartoons

- Produced in large numbers in the Golden Age of Hollywood, and usually shown before feature films
- First animated full length film: Snow White in 1937 (took 4 years to make)
- Moved to TV in the 1950’s, when TV became popular
  - Flintstones: first successful prime time TV cartoon
Cel Animation

• The drawings are drawn in layers, and stacked before photographing them
• Saves time because the background and static objects only need to be drawn once
• Can archive and reuse canned animation cycles (sequences of cels) for running, jumping, etc.
Key Frames

• Need to stay cost efficient
  • Advanced artists model a set of key poses or key frames for the characters
  • Beginner artists would fill in the motion in between these key poses
Cartoon Computer Animation

- Traditional Animation was replaced with 2D Computer Animation circa 1990 while still using the concepts of static backgrounds, key framing, animation cycles, etc.
Arcade Games

- Space Invaders 1978; Pac Man 1980; Donkey Kong 1981
- Golden Age of Arcade Games 1978-1985
Game Consoles

- Atari 1977 (2\textsuperscript{nd} gen); Nintendo 1985 (3\textsuperscript{rd} gen); SNES 1991 (4\textsuperscript{th} gen); Playstation 1995 (5\textsuperscript{th} gen)
- there were no 1\textsuperscript{st} gen true consoles – just dedicated hardware e.g. Pong
3D Video Games

- Nintendo 64 (5th gen) and Super Mario 64 released in 1996 and widely popularized 3D video games
- Playstation 2 2000; Nintendo Gamecube 2001; Xbox 2001 (all 6th gen)
3D Computer Animated Films

- Toy Story 1995, Pixar Animation Studios
3D Computer Animated Films

• 3D figures are rigged with a virtual skeleton
• The limbs, eyes, mouth, clothes, etc. are moved by the animator on key frames
• Positions in between key frames are filled:
  – Brute Force
    • Manually set values for every frame
    • Extremely expensive
  – Traditional Keyframing
    • In-between frames are specified by beginners
    • Still extremely expensive
  – Computer Keyframing
    • In-between frames are computer generated
    • Relatively cheap
• Finally, the animation is rendered
Principles of Animation

- John Lasseter
  - Animator, film director, chief creative officer at Pixar and Walt Disney Animation Studios, Principal Creative Advisor for Walt Disney Imagineering
  - Oversaw all of Pixar's films and associated projects as executive producer
  - Directed Toy Story, A Bug's Life, Toy Story 2, Cars, and Cars 2
Various principles in action

Flour Sack animation

Ron Zorman, animator at Pixar, known for Finding Nemo, The Incredibles, WALL-E, Up, etc.
Principles of Animation

• Squash and Stretch
• Timing
• Slow in Slow out
• Anticipation
• Follow through and Overlapping Action
• Staging
• Exaggeration
• Solid Drawing and Appeal
Squash and Stretch

• Defining the rigidity and mass of an object by distorting its shape during an action
  • The volume should remain constant

• Very important in facial animation


"Principles of Traditional Animation Applied to 3D Computer Animation", SIGGRAPH 87
Timing

• Spacing actions to define the weight and size of objects and the personality of characters.

Timing for animation, Harold Whitaker, John Halas, Focal Press, 2002
Slow In Slow Out

• The spacing of the “in-between” drawings between the extreme poses
  • Mathematically, it refers to the second- and third-order continuity of motion
  • Grouping the in-betweens closer to an extreme to be more expressive or realistic

"Principles of Traditional Animation Applied to 3D Computer Animation", SIGGRAPH 87.
Anticipation

• An action has three parts
  • The preparation for the action - this is anticipation
  • The action
  • The termination of the action
• Prepare audience for the next movement and direct their attention to a certain part of the screen

Follow through and Overlapping Action

• Follow through is the termination of an action
  • Actions are generally carried past their termination point

• Overlapping means to start a second action before the first action has completely finished
  • This keeps the interest of the viewer, since there is no dead time between actions

Staging

• The presentation of an idea so that it is clear
  • Lead the viewers eye to where the action will occur
  • Only one idea should occur at a time

Cartoon Animation, Preston Blair, Walter Foster, 1984
Exaggeration

- Exaggerate to make the action more believable and expressive
- Also done by stage actors
  - (Along with many of the other principles...)

Cartoon Animation, Preston Blair, Walter Foster, 1984
Solid Drawing and Appeal

- Solid drawing stresses the importance of three-dimensional shapes, accurate anatomy, and animation work that has a sense of weight, balance, light, and shadow.

- Appeal is a quality of charm, pleasing design, simplicity, communication, or magnetism.
  - E.g. in creating an appealing character pose, avoid “twins” where both arms or legs are in the same position doing the same thing.

CG Humans are Hard

- As the characters get more and more real, quality becomes extremely important.
- But even state of the art animation, geometry, rendering, simulation, etc. can lead to disturbing zombie-like characters.
- It’s difficult to remove enough errors to make humans seem real.
CG Humanoids are Easier

- On the other hand, it seems quite easy to slap together a completely unrealistic robot, and make it endearing
- We respond quite positively to human like characters as long as they’re not too human
- And we’re quite forgiving of any lack of realism
Uncanny Valley

This portion of the graph reflects Mori's article: On the Uncanny Valley.
Uncanny Valley

• Stay on the left side of the valley
• Don’t shoot for real, shoot for “stylized”
  – Much easier than real
• Alterations to make less human
  – “Futuristic” humans
  – Military suits
  – Super powers
Animating via Simulation

- Describe motion using the laws of physics, biomechanics, and various other equations
- Then automatically generate animation by solving the relevant equations
- If the equations are valid/adequate and can be solved with minimal errors, then one can automatically generate realistic animations
- Minimizing human time in specification of key frames, while increasing the need for computational resources
  - In fact, simulation can take an excessive amount of computer and wall clock time
- One still needs to set initial and boundary conditions, various material parameters, geometric constraints, design algorithms and controls, etc.
- It’s definitely not a panacea, but has been invaluable for many aspects of computer animation
  - Smoke, fire, water, explosions, destruction, clothing, flesh, hair, etc…
# Animation vs. Simulation

<table>
<thead>
<tr>
<th>Animation</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active</strong></td>
<td><strong>Passive</strong></td>
</tr>
<tr>
<td>controllable, expressive, stylized motion</td>
<td>automatic generation, no need (or less need) for by hand manipulation</td>
</tr>
<tr>
<td>hard to make look realistic, tedious to specify every detail</td>
<td>follows physics laws and equations, often easier to make look realistic</td>
</tr>
</tbody>
</table>
What can we simulate?

- One can draw a line between animation and simulation at various levels
- Take character animation as an example:

<table>
<thead>
<tr>
<th>Animation</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion of the body</td>
<td>Passive motion of cloth</td>
</tr>
<tr>
<td>Motion of bones</td>
<td>Passive deformation of flesh</td>
</tr>
<tr>
<td>Signals in the nerve system</td>
<td>Responses of the muscles and passive motion of bones</td>
</tr>
<tr>
<td>Brain activity</td>
<td>Signals transferred in the nerve system</td>
</tr>
</tbody>
</table>