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; 30 Hz used for TV.
Animation

- Each frame is a photograph, drawing, or computer generated image
- Each frame differs slightly from the one before it
- Viewing the frames in rapid succession implies “motion”
How Animation is Generated

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

• Paleolithic (old stone age) cave paintings
  – animals depicted with multiple legs in superimposed positions to convey the perception of motion
History of Animation

• Zoetrope
  • As the cylinder spins, one looks through the slits at the pictures
  • One sees a rapid succession of images, producing the illusion of motion
  • The earliest known zoetrope was created in China around 180 CE (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
  – Improved on the zoetrope by replacing slits with an inner circle of mirrors
  – Invented in France in 1877 by Charles-Émile Reynaud
  – In 1889, he invented an improved version that allowed one to project the images onto a screen
History of Animation

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

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

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

Click for movie
Stop Motion

- Gumbasia was 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; usually shown before feature films

• First animated full length film: Snow White, 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, since 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 filled 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.
Question #1

• LONG FORM:
  • Give a brief history of animation.

• SHORT FORM:
  • What is your favorite movie?
  • Was there an important character, environment, or scene in that movie that required special effects (i.e. something that one could not go out and film with a video camera)?
Arcade Games

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

- there were no 1\textsuperscript{st} gen consoles – just dedicated hardware e.g. Pong 1975
- Atari 1977 (2\textsuperscript{nd} gen); Nintendo 1985 (3\textsuperscript{rd} gen); SNES 1991 (4\textsuperscript{th} gen); Playstation 1995 (5\textsuperscript{th} gen)
3D Video Games

- Nintendo 64 (5th gen) & Super Mario 64, both 1996, widely popularized 3D video games
- Playstation 2 2000; Nintendo Gamecube 2001; Xbox 2001 (all 6th gen)
- Playstation 3 2006; Nintendo Wii 2006; Xbox 360 2005 (all 7th gen)
- Playstation 4 2013; Wii U 2012; Xbox One 2013 (all 8th gen)
Nintendo Switch
Question #2

- LONG FORM:
  - Give a brief history of video games.

- SHORT FORM:
  - What is the first video game you can recall ever playing? About how old were you?
  - What is the last video game you can recall playing? When was that?
  - What is your favorite video game? Why?
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

"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.
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 the 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...)
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 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
Question #3

• LONG FORM:
• Briefly describe each of the principles of animation.
• What is the uncanny valley?

• SHORT FORM:
• What is your favorite non-human character in a book, TV-show, feature film, or game?
• How do they relate to the uncanny valley?
Animating via Simulation

- Describe motion using the laws of physics, biomechanics, and various other equations and rules
- Then automatically generate animation by solving the relevant equations
- If the equations are valid/adequate and can be solved robustly with minimal errors, then one can automatically generate realistic animations
- Minimizing human time in the 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>
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</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>
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