History and Principles of Animation

Outline

- Heritage of animation
- Brief history of computer animation
- Principles of animation
- Production process of animation
- Digital production pipeline
Animation Heritage—Early Devices

- Persistence of vision
  - Shadow puppets
  - Flipbook
- Thaumatrope (1800s)
- Phenakistiscope (1830)
- Zoetrope (1834)

Animation Heritage—Early Devices

- Photograph
  - Muybridge (1885)

- Film projector (Edison, 1891)
Early “Traditional” Animation

- First animation using a camera
  - 1896, Georges Melies, moving tables
  - 1900, J. Stuart Blackton, added smoke
- First celebrated cartoonist
  - Winsor McCay
  - Little Nemo (1911)
  - Gertie the Dinosaur (1914)

Early Technical Developments

- 1910, Bray and Hurd
  - Patented translucent *cels* (formerly celluloid was used, but acetate is used now) used in layers for *compositing*
  - Patented gray-scale drawings (cool!)
  - Patented using pegs for *registration* (alignment) of overlays
  - Patented the use of large background drawings and panning camera
Disney

- Advanced animation more than anyone else
- First to have sound in 1928, Steamboat Willie
- First to use storyboards
- First to attempt realism
- Invented multiplane camera
  - Creating illusion of depth
  - Zooming
  - Parallax
  - Motion blur

Brief History of Computer Animation

- 1963 – Ivan Sutherland’s (MIT) Sketchpad
- 1970 – Evans and Sutherland (Utah) start computer graphics program (and a Company)
- 1972 – Ed Catmull’s (Utah) animated hand and face (later co-founded Pixar)
- 1970’s – Norm Badler (Penn) Center for Modeling and Simulation, Jack
Brief History of Computer Animation

- 1970’s – New York Institute of Technology (NYIT)
  Alvy Ray Smith (Cofounded Pixar and Lucas film) and Catmull developed Bbop
  - 3D key-frame articulated animation system
- 1980’s – Daniel and Nadia Magnenant-Thalmann (Swiss Universities) become European powerhouses

- 1977 – Starwars
- 1980’s – SGI founded, and Alias/Wavefront founded
- 1982 – Tron (first extensive use of graphical objs.)
- 1982 – Early use of particle systems (Star Trek II: The Wrath of Khan)
- 1986 – Young Sherlock Homes (first use of synthetic character in film)
Brief History of Computer Animation

- 1986 – First digital wire removal, *Howard the Duck*
- 1988 – First digital blue screen extraction *Willow*

More about animation/film history:
- Chapter 1 of Parent’s book
- http://www.filmsite.org/visualeffects.html

“There is no particular mystery in animation… it's really very simple, and like anything that is simple, it is about the hardest thing in the world to do.” Bill Tytla at the Walt Disney Studio, June 28, 1937.
Principles of Animation

- Thomas & Johnson, “The illusion of life: Disney Animation”
- John Lasseter, "Principles of Traditional Animation Applied to 3D Computer Animation", SIGGRAPH'87
- Squash and Stretch
- Anticipation
- Secondary Action
- Staging
- Pose to Pose
- Follow Through
- Slow in and Slow out
- Arcs
- Follow Through
- Secondary Action
- Timing
- Exaggeration
- Solid Drawing
- Appeal

Half-filled Sack of Flour

- Originated at Disney
- Famous excise for animation students
- Learning platform for animating
  - deformation
  - personality
  - emotions
Squash and Stretch

Example: Bouncing Ball

http://www.siggraph.org/education/materials/HyperGraph/animation
Anticipation and Staging

- Don’t surprise the audience
- Direct their attention to what’s important

Follow Through & Overlapping

- The termination of an action and establishing its relationship to the next action
- Audience likes to see resolution of action
- Discontinuities are unsettling
Combined

- Squash & stretch
- Follow through

Squash & stretch

Follow through

Which motion looks more natural/interesting?
- 2nd and 3rd order continuity increases realness

http://www.siggraph.org/education/materials/HyperGraph/animation
Secondary Motion

- An action that directly results from the primary action
- Increase realness/interest of a scene
- Should not detract the primary motion

Production Process of Traditional Animation

- Storyboard
  - Sequence of drawings with descriptions
  - Story-based description
- Voice recording
  - Easier to sync. animation to a scratch soundtrack
  - Earlier /Japanese animation are post-sync.
  - Final soundtrack with music/sound effects are post-processed
- Key frames
  - Draw a few important frames as line drawings
  - Motion-based description
Production Process (cont.)

- **Inbetweens**
  - Draw the rest of the frames

- **Painting**
  - Redraw onto acetate *Cels*, color them in
  - Traditional ink-and-paint
  - Digital ink-and-paint

Storyboarding

Storyboard/Voice of Toy Story

http://www.pixar.com/

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Key Frames / In-Betweens

- Highly skilled animator draws the important, or key frames
- Less skilled (lower paid) draw the in-between frames
Benefits of Layered Motion

- It’s useful to have multiple layers of animation
  - How to make an object move in front of a background?
  - Use one layer for background, one for object
  - Can have multiple animators working on different layers at the same time, avoid redrawing and flickering
- Transparent acetate allows multiple layers
  - Draw each separately
  - Stack them together on a copy stand
  - Transfer onto film by taking a photograph of the stack

Composition

Garrett Albright, Wikipedia
Computer-assisted Animation

- Computerized Cel painting
  - Digitize the line drawing, color it using seed fill
  - Eliminates cel painters
  - Widely used in production
  - e.g. Lion King

Computer-assisted Animation (cont.)

- Cartoon Inbetweening
  - Automatically interpolate between two drawings to produce inbetweens
  - Hard to get right
    - Often don’t look natural
    - What are the parameters to interpolate?
    - Not used very often
True Computer Animation

- Generate the image by rendering a 3D model
- Vary the parameters to produce the animation
- Brute force
  - Manually set the parameters for every frame
  - Still labor-intensive
- Computer keyframing
  - Lead animators create the important frames with 3D computer models
  - Computer draws the inbetween
  - Used widely in animation production

Digital Production Pipeline

- Story
- Storyboards
- Visual development
- Character design
- Scene layout
- Modeling
- Animation
- Shading and texturing
- Lighting
- Rendering
- Post production
- **Story & Storyboards**
  - The most important part of any animation
  - Starts from a simple idea
  - Iterative and refining the story

- **Visual development**
  - Look of scenes
  - Style of the animation
  - Creation of characters, environments, props, etc.
  - Involve painters, sculptors, illustrators, etc.

- **Character design**
  - Consists mostly of drawings, or sculptures
  - Body poses, facial expression, from multiple points of view

- **Scene layout**
  - Layout the 3D environment
  - Position and choreograph the camera movement
  - Remember camera and character motion within the scene
Modeling
- Create geometric models of environment, props, characters
- Set up internal skeleton and animation controls properly for that character’s behaviors

Rendering
- Frames can take hours to render
- 1800 frames for a single minute if animation
- In Toy Story, Pixar used a RenderFarm consisting of over 300 Sun and SGI machines.

Post production
- Sound track sync
- Titles
- Cuts and effects (dissolves, fades, etc)
Videos

- *Snow White and the Seven Dwarfs* (Disney, 1937)
  - first full-length hand-drawn animation (83 min.)
  - 750 artists, ~1000000 drawings, USD$1500000
  - Honorary Academy Award
    - "as a significant screen innovation which has charmed millions and pioneered a great new entertainment field."
- *Luxo Jr.* (Pixar, 1986)
  - Academy Award nominated for animation short

Next Week

- 3D rotation (chapter 2)
- Keyframing and interpolation (chapter 3)
- Kinematics