Three-Dimensional Computer Animation

Visual Imaging in the Electronic Age

Donald P. Greenberg

December 3, 2020

Lecture # 22
Luxo & Luxo Jr.  1986
Toy Story
1995
Inside Out

2015
3D Animation

Pixar
Why do we need an animation production pipeline?

• Animated full-length features are huge endeavors
  – Up to 5 years from conception to final (2 years in production)
  – > 500 people involved

• Currently requires big budgets and big organizations
  – $100 M - $150M per movie

• Needs a very organized structure to bring the creative process from conception to final product
What is the animation production pipeline?

• Logical organization of the steps required to produce an animated feature film

• Every company has its own pipeline

• Every movie changes the pipeline
  – Requirements are changing
  – Save money
  – Increase the quality of the movie
There are 49,516 of these sketches in the movie’s story reel.

The goal is to begin to define the style and lighting scheme of the frame (shot).

3 / PROPS Toys are positioned in the 3-D “dressed set.” The director can fine-tune the camera’s movement to best capture the action.
4 / LAST DETAILS The amount of labor spent on each character depends on its prominence in the final shot. Background toys are given simple textures and basic movements.
5 / FINALE Surfaces—walls, clothing, faces—are fed through rendering software that simulates light and shadow. An average frame takes more than seven hours of computing time to render. This one required eleven hours.

The simplified pipeline

• Many departments

- Story
- Art
- Casting
- Editorial
- Modeling
- Shading Texturing
- Rigging
- Backgrounds
- Layout
- Animation
- Simulation
- Effects
- Lighting
- Rendering
Jan Pinkava – *Storyboard*,

GERI'S GAME
(Pencil)
Jan Pinkava – *Storyboard*,

GERI’S GAME
(Pencil)
The control mesh for Geri’s head, created by digitizing a full-scale model sculpted out of clay.
Subdivision surfaces
Story Development
Story Pitch

- First time the story is publicly presented
Art Development

• Develop the look-and-feel of the movie
  – Characters and Sets
  – Follow it through production
  – Make the most of the high-level artistic decisions

• Traditional media
  – Sketches, Pastels, Sculptures

• Process
  – Start with real world objects
  – Develop the look: shape, colors, materials
  – Develop expressions and movements
  – For characters, sculptures are developed
Bob Pauley – Woody and Buzz, Toy Story (Pencil)
Pete Docter – Sullivan and Mike (Marker)
Art Development - Characters
Art Development - Environments
Casting

- Voices have to match your characters
Dialogue Recording

• Useful for animation reference
Editorial

• The keeper of the flow
  – Study the timing of actions in the movie

• Manage the editing of the movie
  – Prepare the various releases

• Similar to a traditional studio
The Simplified Pipeline

- Characters and Sets
Modeling

• Defines the shape

• Process
  – Starts with art data
    > Drawings
    > Sculptures (sometimes scanned)
  – Recreate geometry in the modeling environment

• Models have to
  – Look good – to please the eye
  – Be functional – to fit in the pipeline
  – Work when deformed – for animation
Character Modeling
Environment and Prop Modeling
Shading/Texturing
Character Rigging

- Prepares a character for animation
  - Defines the deformation of the shape
    > Shape changes when the character moves
  - Defines controls for animators
- Process
  - Start with art data
  - Work with animation to test the look and controls
Rigging
Computer Skeletal Animation

- Moving your hand with Forward Kinematics
  - Involves individually rotating each joint in order to get the hand to a specific location
  - To move hand, must first rotate whole arm, then rotate lower arm
Computer Skeletal Animation

- Moving your hand with Inverse Kinematics
  - Position of the hand determines the position of the arm joints
  - Because all parts of the arm are connected, if hand moves → arm moves
Backgrounds

• Creates sets out of props
• Prepares a stage for acting
The Simplified Pipeline

- Movement

- Story
- Art
- Casting
- Editorial
- Modeling
- Shading
- Texturing
- Rigging
- Backgrounds
- Layout
- Animation
- Simulation
- Effects
- Lighting
- Rendering
Layout

• Defines the camera
  – Starting position
  – Framing – which objects are seen
  – Movement
• Defines basic object positions
Animation

• Keyframed animation
  – Movement is specified by changing individual controls on characters at various frames
  – Used by Pixar and DreamWorks

• Motion capture
  – Movement is recorded using live actors
  – Used by Sony Imageworks, Weta

• Very time consuming!
  – Requires big budgets and long development times

• Today it is the biggest distinction between large studios and smaller ones
Animation

© Pixar/Disney

fish acting.comp.85
Simulation

• Not possible to animate everything

• Physically-based animation
  – Movement is computed to simulate physics

• Applications
  – Humans: hair, cloth, skin
  – Natural media: water, fire, smoke
  – Special effects: explosions
Effects

• Natural media: Water, Fire, Smoke
• Weather: Snow, Rain, Wind
• Special effects: Explosions, Morphing
• Encompasses modeling, animation and shading
The Simplified Pipeline

- Final images

- Story
- Art
- Casting
- Editorial
- Modeling
- Shading
- Texturing
- Rigging
- Backgrounds
- Layout
- Animation
- Simulation
- Effects
- Lighting
- Rendering
Lighting

• Defines scene illumination

• Process
  – Study real world footage
  – Study material/light interaction
    > Simple materials: plastic, woods, etc.
    > Complex materials: metals
    > Characters: skin, hair
  – Start with art images
  – Add and change lights to obtain the final picture
Lighting

Lighting
Lighting

- Particulate Matter
- Surge and Well
- Caustics
- Murk
- Reflection Refraction
Rendering

• Compute the final images
The Simplified Pipeline

- Vertical hierarchy too
Shot Progression
Shot Progression

Finding Nemo
Progression Reel - School
Storyboards

© Pixar/Disney

Nemo_Progression_School.comp.85
Should one go into the computer animation industry today?
Pixar Approximate Employee Distribution

Creative:
- Story: 60
- Art: 70
- Layout: 40
- Total: 170

Production:
- Layout: 40
- Anim: 150
- TD: 150
- GT/FX: 100
- Lighting: 120
- Editorial: 30
- Post: 60
- Total: 650

Technology:
- Research/Tools: 170
- Renderman: 25
- Total: 195

Total: 1,200 employees

2011
Success depends on a good story!
‘Coco’ Scores Another Strong Thanksgiving Debut for Disney

$71M opening weekend
Success depends on a good story! But production is a big risk!
<table>
<thead>
<tr>
<th>Rank</th>
<th>Title (click to view)</th>
<th>Studio</th>
<th>Lifetime Gross / Theaters</th>
<th>Opening / Theaters</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Finding Dory</td>
<td>BV</td>
<td>$486,295,561</td>
<td>4,305</td>
<td>6/17/16</td>
</tr>
<tr>
<td>2</td>
<td>Shrek 2</td>
<td>DW</td>
<td>$441,226,247</td>
<td>4,223</td>
<td>5/19/04</td>
</tr>
<tr>
<td>3</td>
<td>Toy Story 3</td>
<td>BV</td>
<td>$415,004,880</td>
<td>4,028</td>
<td>6/18/10</td>
</tr>
<tr>
<td>4</td>
<td>Frozen</td>
<td>BV</td>
<td>$400,738,009</td>
<td>3,742</td>
<td>11/22/13</td>
</tr>
<tr>
<td>5</td>
<td>Finding Nemo</td>
<td>BV</td>
<td>$380,843,261</td>
<td>3,425</td>
<td>5/30/03</td>
</tr>
<tr>
<td>6</td>
<td>The Secret Life of Pets</td>
<td>Uni.</td>
<td>$368,384,330</td>
<td>4,381</td>
<td>7/8/16</td>
</tr>
<tr>
<td>7</td>
<td>Despicable Me 2</td>
<td>Uni.</td>
<td>$368,061,265</td>
<td>4,003</td>
<td>7/3/13</td>
</tr>
<tr>
<td>8</td>
<td>Inside Out</td>
<td>BV</td>
<td>$356,461,711</td>
<td>4,158</td>
<td>6/19/15</td>
</tr>
<tr>
<td>9</td>
<td>Zootopia</td>
<td>BV</td>
<td>$341,268,248</td>
<td>3,959</td>
<td>3/4/16</td>
</tr>
<tr>
<td>10</td>
<td>Minions</td>
<td>Uni.</td>
<td>$336,045,770</td>
<td>4,311</td>
<td>7/10/15</td>
</tr>
</tbody>
</table>
End