the 3D production pipeline

overview

• basic steps to make a 3d animation
• why do we need a production pipeline?
• what is the production pipeline?
• a tour through the various departments at Pixar

• no details, just a general picture
image synthesis steps

image synthesis

• geometry
image synthesis

- geometry + materials

image synthesis

- geometry + materials + lights
image synthesis

- geometry + materials + lights = picture

image synthesis

- frame the picture using the camera
image synthesis

- time to move...

image synthesis

- movement (rigid objects and camera)
image synthesis

- movement + deformation

image synthesis

- movement + deformation = animation
why do we need a pipeline?

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

• requires big budgets and big organizations
  - $ 100 M per movie often

• need a solid structure to bring the creative process from conception to final
what is the production pipeline?

- logical organization of the steps required to produce an animated feature film
- overlaps with the company organizational structure
  - departments, budgets

pipeline organization

- every company has its own pipeline
- every movie changes the pipeline
  - requirements are changing
  - save money
  - increase the quality of the movie
organization

- a movie requires a lot of time and people

- how do you keep the project focused?
  - vision
  - budget
  - execution
  - smart people that sign up to the vision

key figures

director
producer
lead technical director
lead animator
key figures: director

• creative lead
• POV: the movie is a creative feast
• responsible for the look and story-telling aspects
• final word on all the artistic decisions

• at Pixar, often the story’s author

key figures: producer

• executive lead
• POV: the movie is a product
• responsible for the budget aspects
• final word on all monetary decisions
key figures: lead TD

- technical lead
- POV: the movie is a project
- responsible for the technical dept.
- final words on the implementation
- turns the director requests in technical solutions that match the budget

key figures: lead animator

- animation lead
- POV: the movie is a play
- responsible for the animation dept.
- he can be consider to be the lead actor for the movie
pipeline organization

the simplified pipeline

• many departments

- Story
- Editorial
- Art
- Casting
- Modelling
- Shading
- Painting
- Rigging
- Set
- Dressing
- Layout
- Animation
- Simulation
- Effects
- Lighting
- Rendering
- Rendering
the simplified pipeline

• preproduction

Story  Editorial  Art  Casting
Modelling  Shading Painting  Rigging  Set Dressing
Layout  Animation  Simulation  Effects
Lighting  Rendering

the simplified pipeline

• characters and sets

Story  Editorial  Art  Casting
Modelling  Shading Painting  Rigging  Set Dressing
Layout  Animation  Simulation  Effects
Lighting  Rendering
the simplified pipeline

- movement

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<th>Story</th>
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<th>Art</th>
<th>Casting</th>
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the simplified pipeline

- final images

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the simplified pipeline

- vertical hierarchy too

```
Story  Editorial  Art  Casting
Modelling  Shading Painting  Rigging  Set Dressing
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Lighting  Rendering
```

• what was I doing?

```
Story  Editorial  Art  Casting
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```
pipeline “stages”

story development

- everything begins with a story!
- storyboarding
- process
  - first idea
  - script and drawings that represent the story
  - trial and error process
    - story is told many times and refined over time
story development

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story development

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story pitch

• first time the story is publicly presented

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
  - but we start with the story before we have video
art development

- develop the look-and-feel of the movie
  - characters and Sets
  - follow it through production
  - make most of the high-level artistic decisions

- traditional media
  - sketches, pastels, sculptures

- process
  - start with real world objects
  - develop look: shape, colors, materials
  - develop expressions and movements
  - for characters, sculptures are developed
art development - characters

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art development - characters

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art development - environments

© Pixar/Disney

art development - environments

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casting

- voices have to match your characters

dialogue recording

- useful for animation reference
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
character modeling

environment and prop modeling
environment and prop modeling

shading

- defines the material properties
  - colors
  - light reflectance properties
  - textures
- process
  - study of real world objects
  - understanding the physics of their appearance
  - understand the important appearance aspects
    - e.g. what make fur like fur (and not hair or grass)?
    - e.g. what makes metal look old?
  - match with overall look of the movie
shading

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
set dressing

- creates sets out of props
- prepares a stage for acting
layout

- defines the camera
  - starting position
  - framing - which objects are seen
  - movement
- defines basic object positions
  - starting point for animation
- story boarding used as reference
animation

- character movement and expression

process
- study realistic motion
- develop a style of motion for the movie
- very similar to acting
- often develop entire new body language
  - fish smiling?

animation

- keyframed animation
  - movement is specified by changing individual controls on characters at various frames
  - similar to 2d animation
  - used by Pixar and PDI

- motion capture
  - movement is recorded using live actors
  - editing to fix problems
  - used by Sony Imageworks, Weta
animation

- very time consuming!
  - requires big budgets and long development times
- today biggest distinction between large studios and smaller ones
- hard to develop “economy of scale”
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
simulation

effects

- natural media: water, fire, smoke
- weather: snow, rain, wind
- special effects: explosions, morphing

- very specific
- encompasses modeling, animation and shading
effects

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effects

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effects

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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

particulate matter
surge and well caustics murk reflection refraction

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rendering

- compute the final images

interesting dichotomy

- stylized characters, look, movement
- based on physically correct building blocks
  - movement: character animation vs. cloth/hair simulation
  - shading: colorful surface material vs. subsurface scattering
  - lighting: “shadow-less” lights vs. global illumination
shot progression

Finding Nemo
Progression Reel - School
Storyboards

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shot progression

© Pixar/Disney

shot progression

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what’s the take home message?

• movies are huge endeavors
  - big budgets
  - strong production structure
  - people with very different skills
    • story telling
    • art
    • technical
    • research and development

• not too much artistic freedom

• a lot of challenging technical issues
  - images we could not make before

what’s the take home message?

• if you are an artist
  - not too much artistic freedom
  - think about players in an orchestra
    • you’ve got the music, the director and the other players
  - specialist or generalist?

• if you are more technical
  - a lot of challenging technical issues
    • images we could not make before
    • cutting costs with better tools
  - have to understand artists and movie making
    • that’s where the money come from
acknowledgements

• Pixar Animation Studios
  - permission to use the materials in this presentation was kindly provided by Pixar Animation Studios