Fall 2015

CSCI 420: **Computer Graphics**

13.1 Computer Animation

Hao Li

http://cs420.hao-li.com

Overview

Animation Production

Rigging

- Procedural
- Skeletal
- Anatomical

Posing

- Forward Kinematics
- Inverse Kinematics
- Advanced Methods (Style-Based IK + MeshIK)

Animation

- Keyframe Animation
- Motion Capture
- Physics-Based Character Animation

Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

Animation Production

1. **Story Board**
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

Animation Production

1. **Story Board**
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

Animation Production

1. Story Board
2. **Conceptual Art**
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

Concept Art

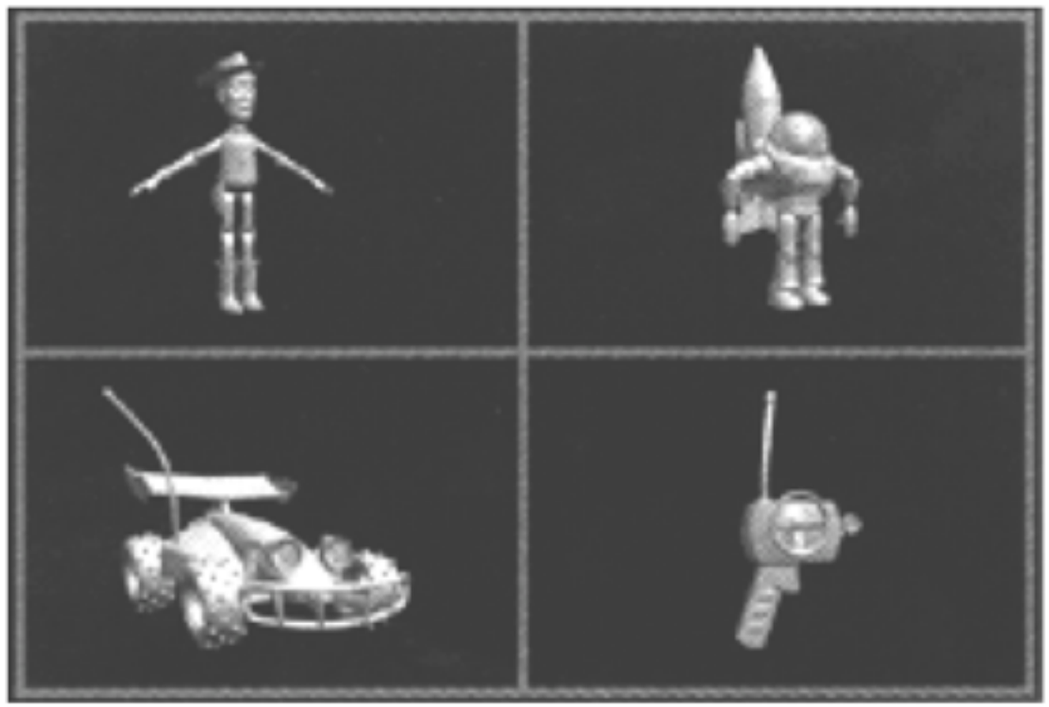

FILE NUMBER
E0013
Property of Paramount Pictures
Property of Paramount Pictures Corp.
Cantina
Location #
LOC-06
Set #
SET-039-EXT
APPROVAL STATUS
REFERENCE ONLY
ROUGH
FINAL
Description
Cantina
Approval Date
10/20/08
Approval Signature
NOTES
NEW SET NUMBER -PLEASE REPLACE
INDUSTRIAL
APPROVAL STATUS:
Ref. Only
WIP
Final
APPROVAL DATE:

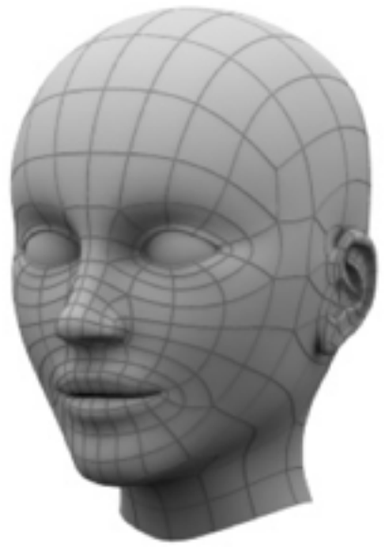
Animation Production

1. Story Board
2. Conceptual Art
3. **Recording**
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. **Modeling**
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering





Modeling

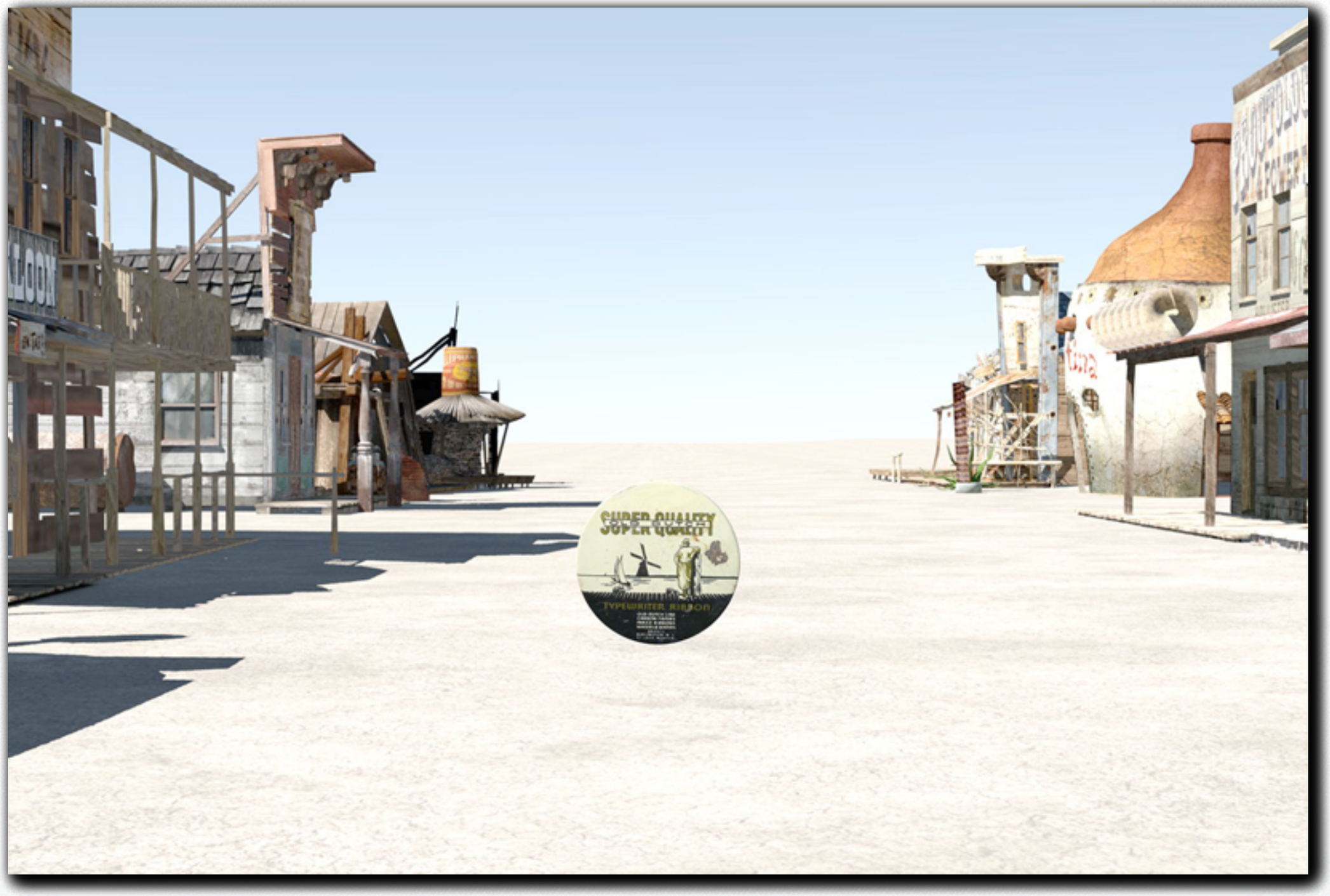
The creation of a 3D computer-generated asset, be it hard surface (planes, trains, automobiles) or organic (davy jones, dementors, or digital humans).

Hard Surface Modeling

Rango: The town of Dirt...

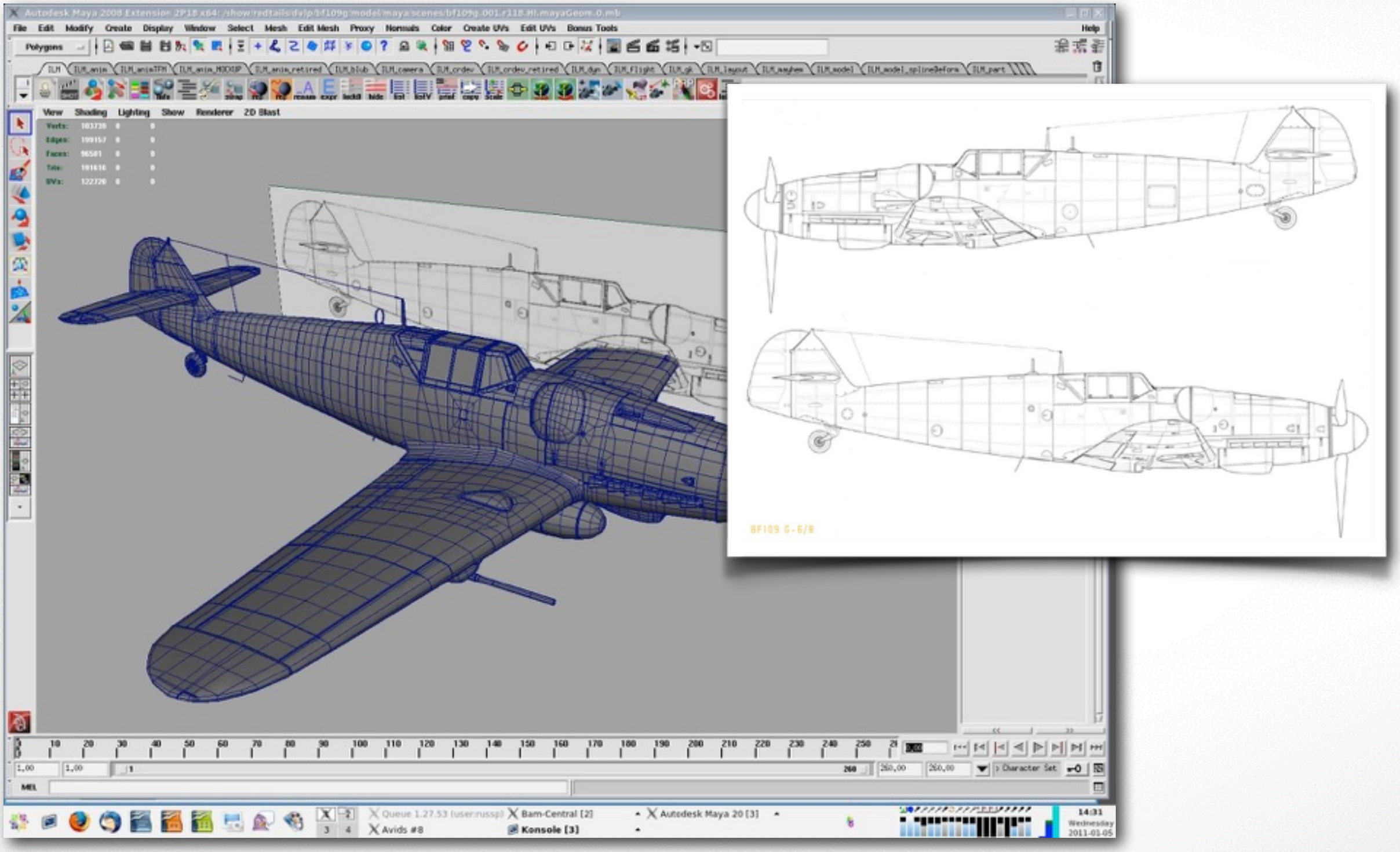
Hard Surface Modeling

... and all the assets



Hard Surface Modeling

Modeling in Maya using reference images...

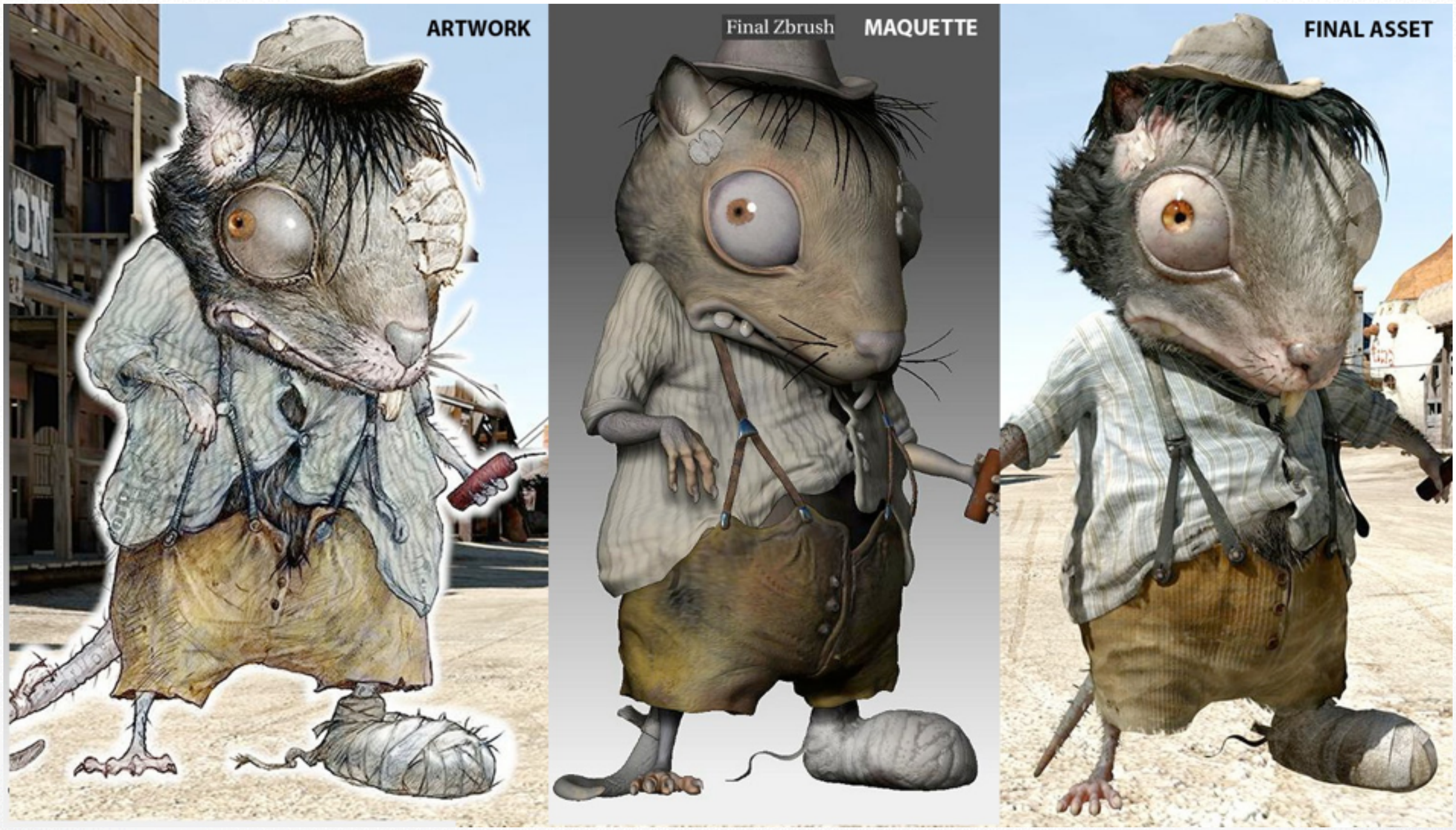


Hard Surface Modeling

final asset

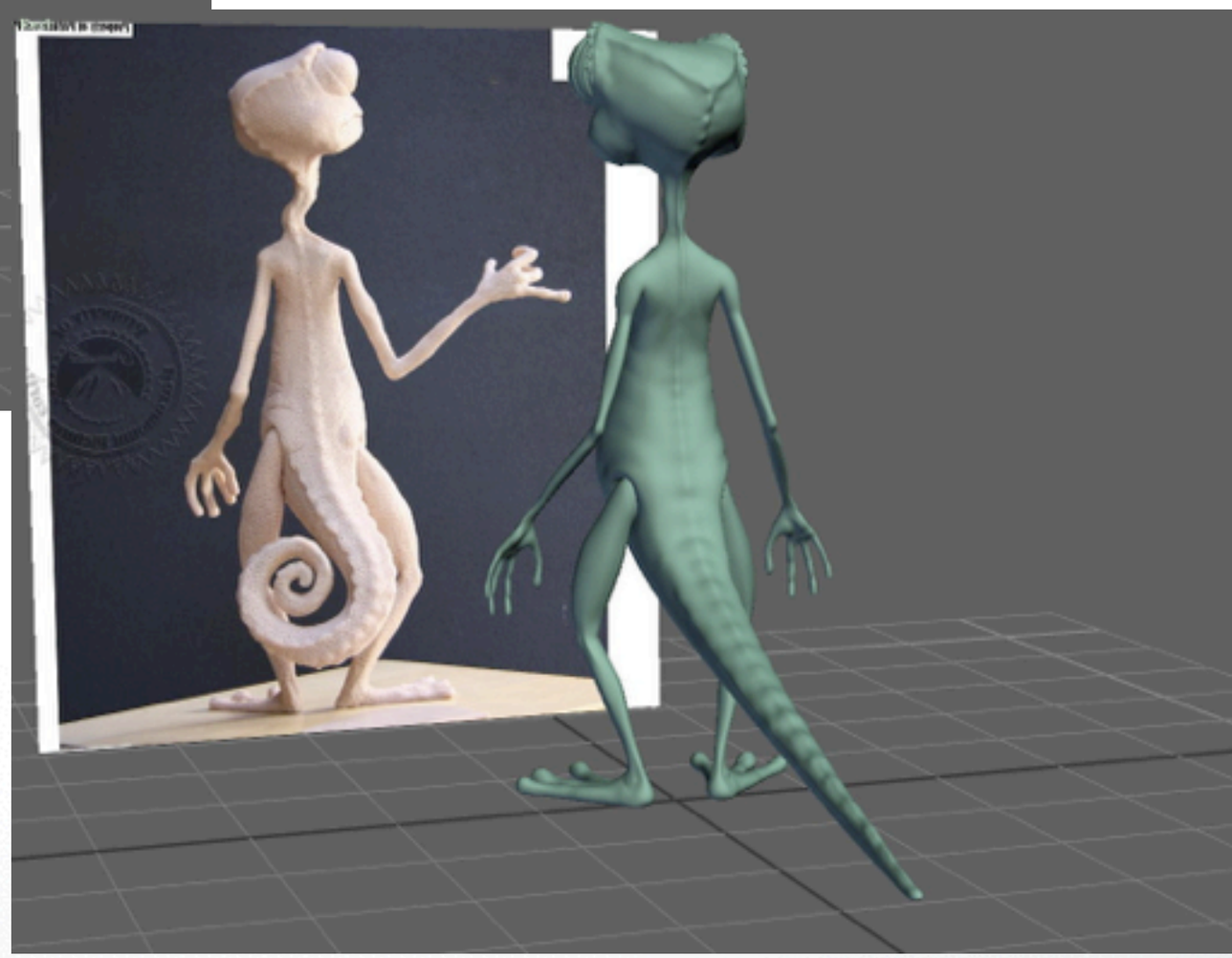
Creature Modeling

Rango: From Artwork to Maquette to Final Asset



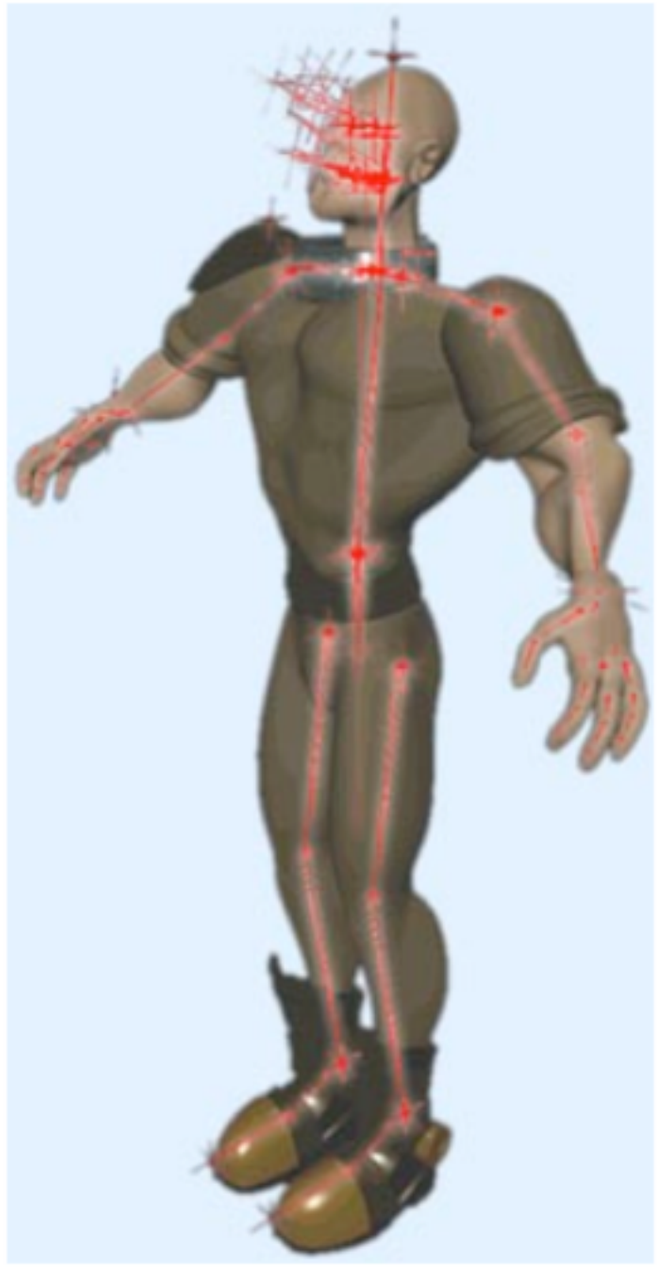
Creature Modeling

From Rango:
Modeling Using The Maquette
(Back Revisions)



Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. **Rigging**
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

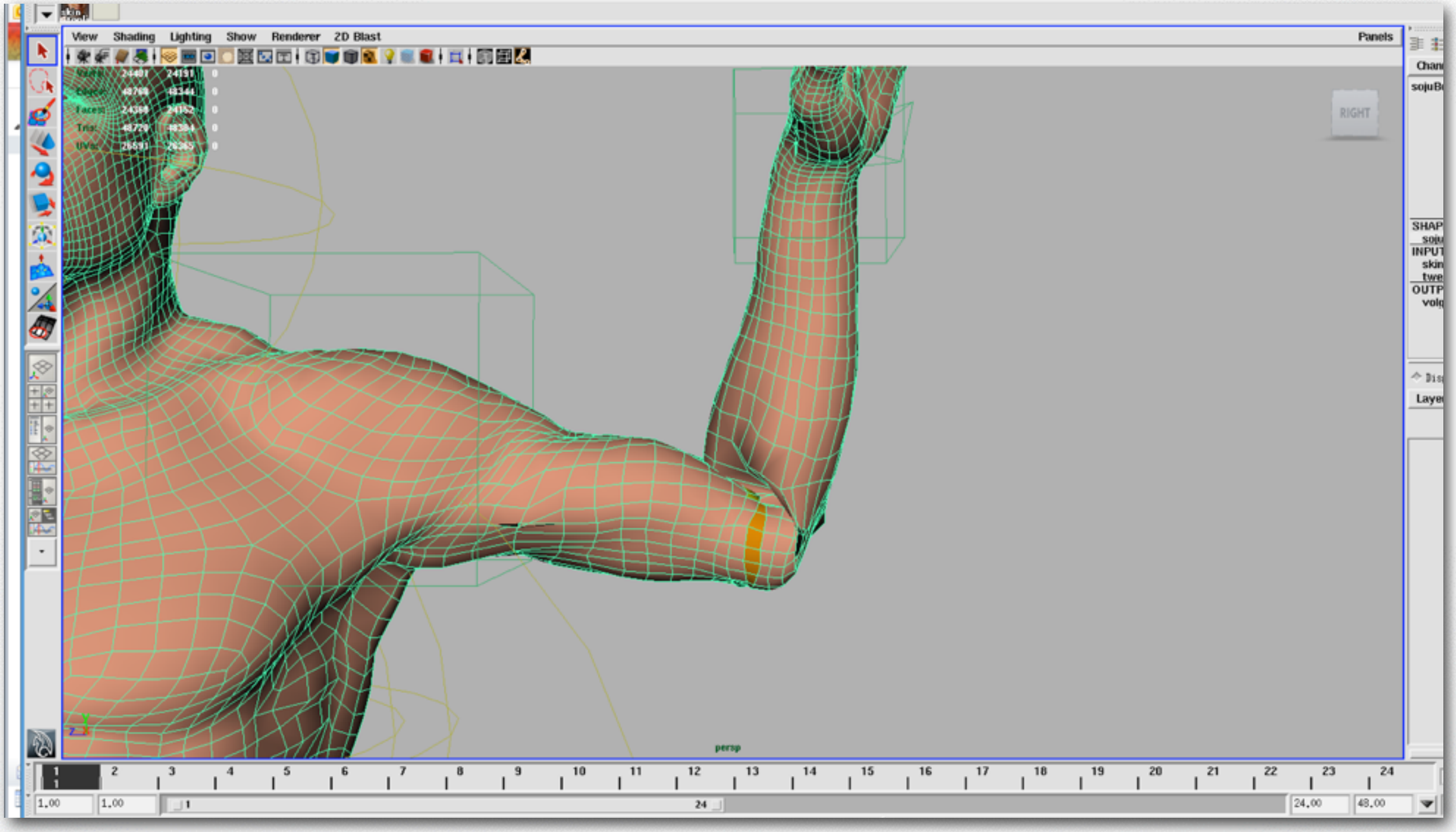


Creature Setup

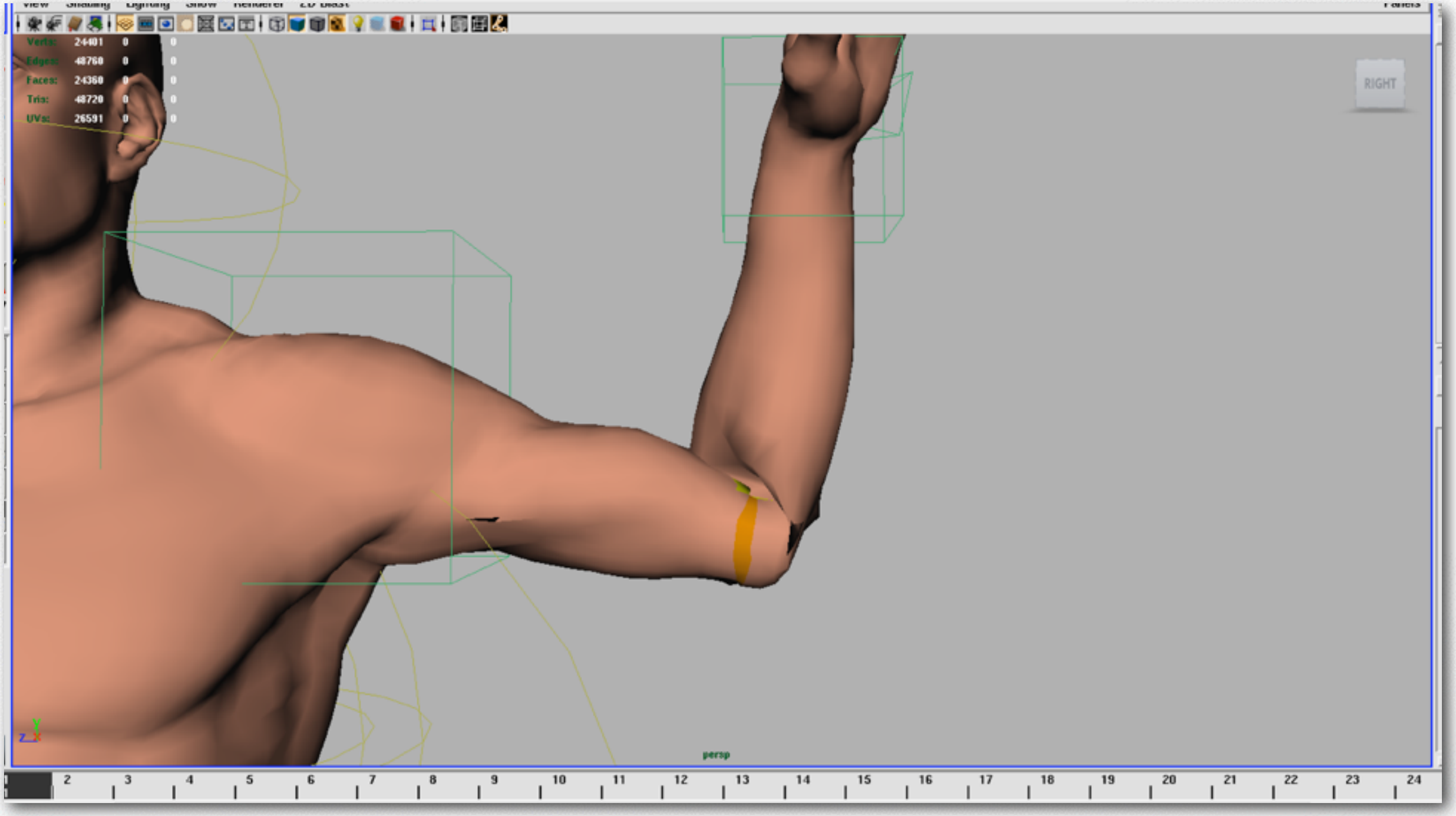
The process of preparing a creature for animation, including creature rigging, skinning, and simulation setup for things such as hair, feathers, flesh, muscles, and, in some cases, tentacles.

Rigging & Enveloping

Rigging & Enveloping

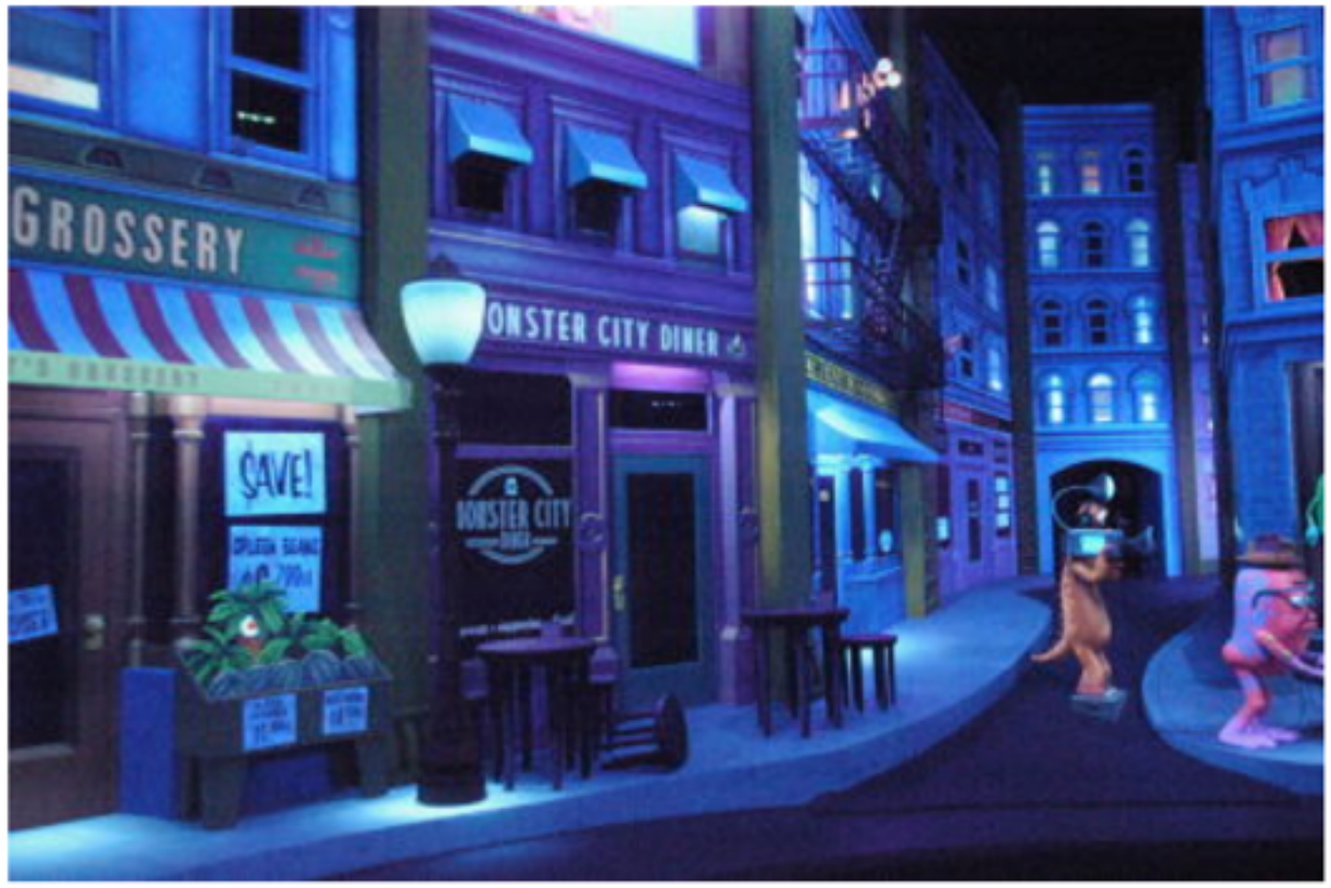


Rigging & Enveloping



Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. **Set Dressing**
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering



Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. **Layout**
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. Rendering

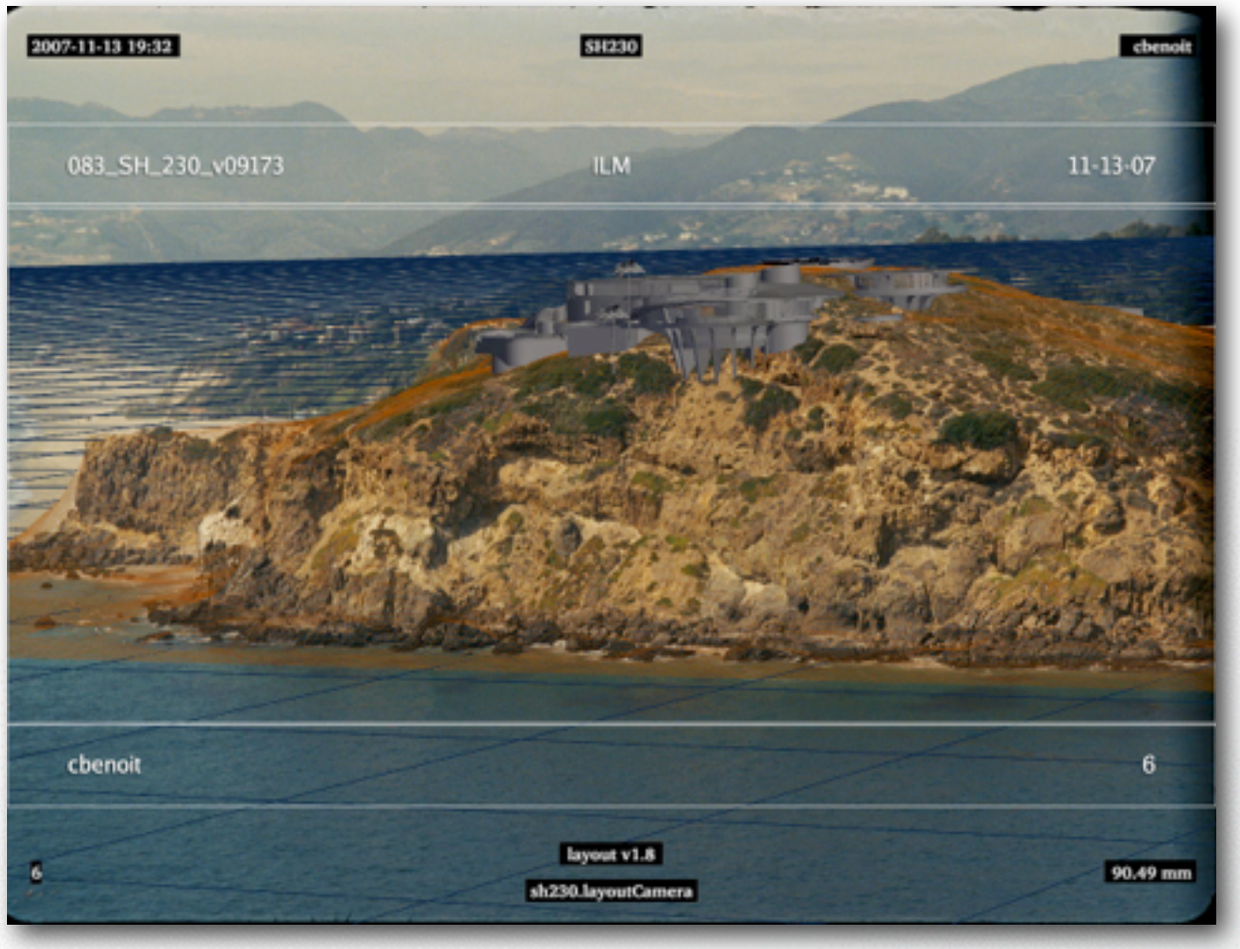
Mathmove & Layout

Matchmove: The process of replicating the real set, camera, and camera movement in a CG world so that 3D assets can be integrated with the live action plate.

Layout: The process of integrating camera matchmoves and “new” CG camera moves to create a framework for a sequence, including manipulating 2D and 3D elements and environment.

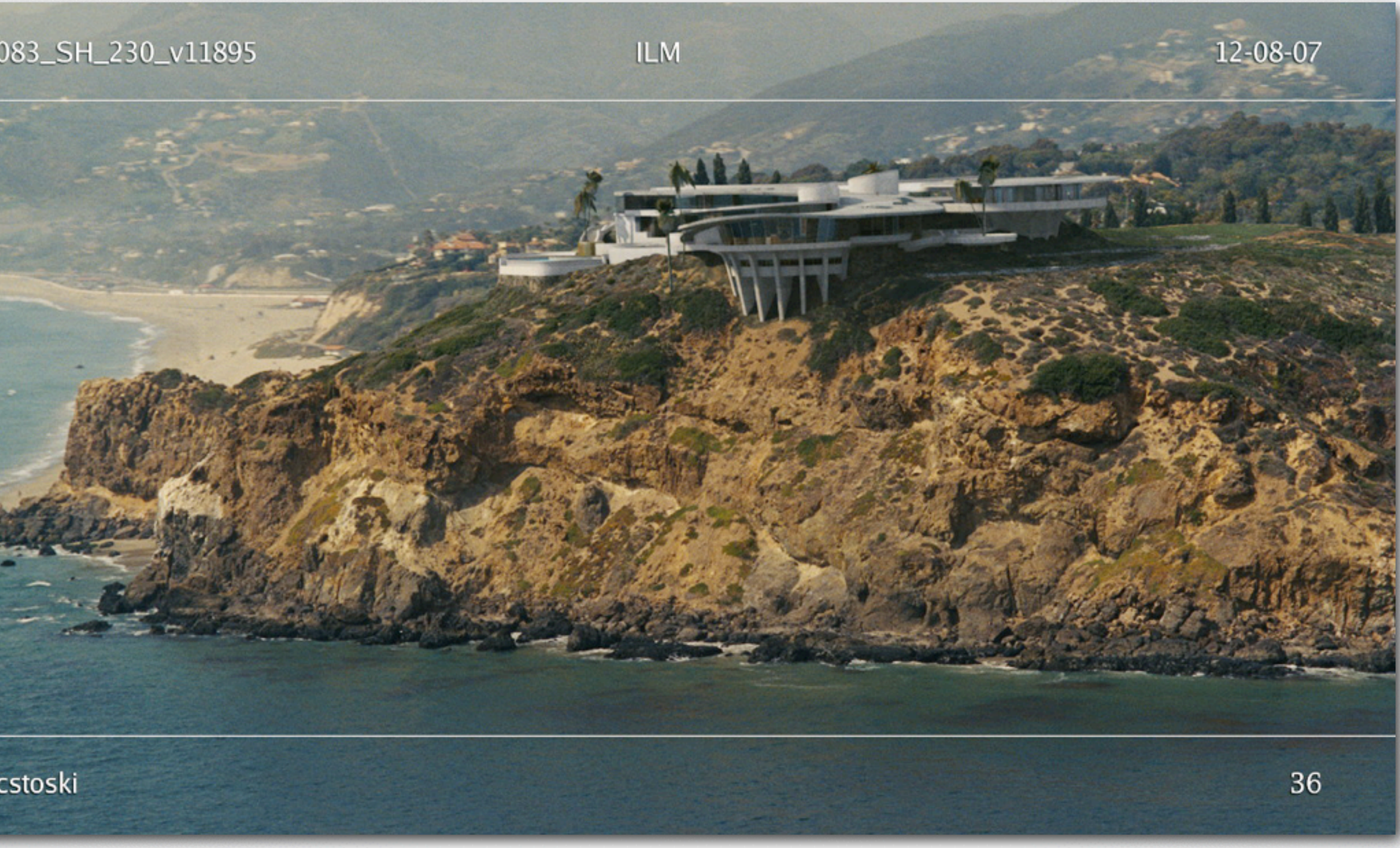
Mathmove & Layout

Matching camera move from original background plate



Mathmove & Layout

... allows adding cg elements to the shot

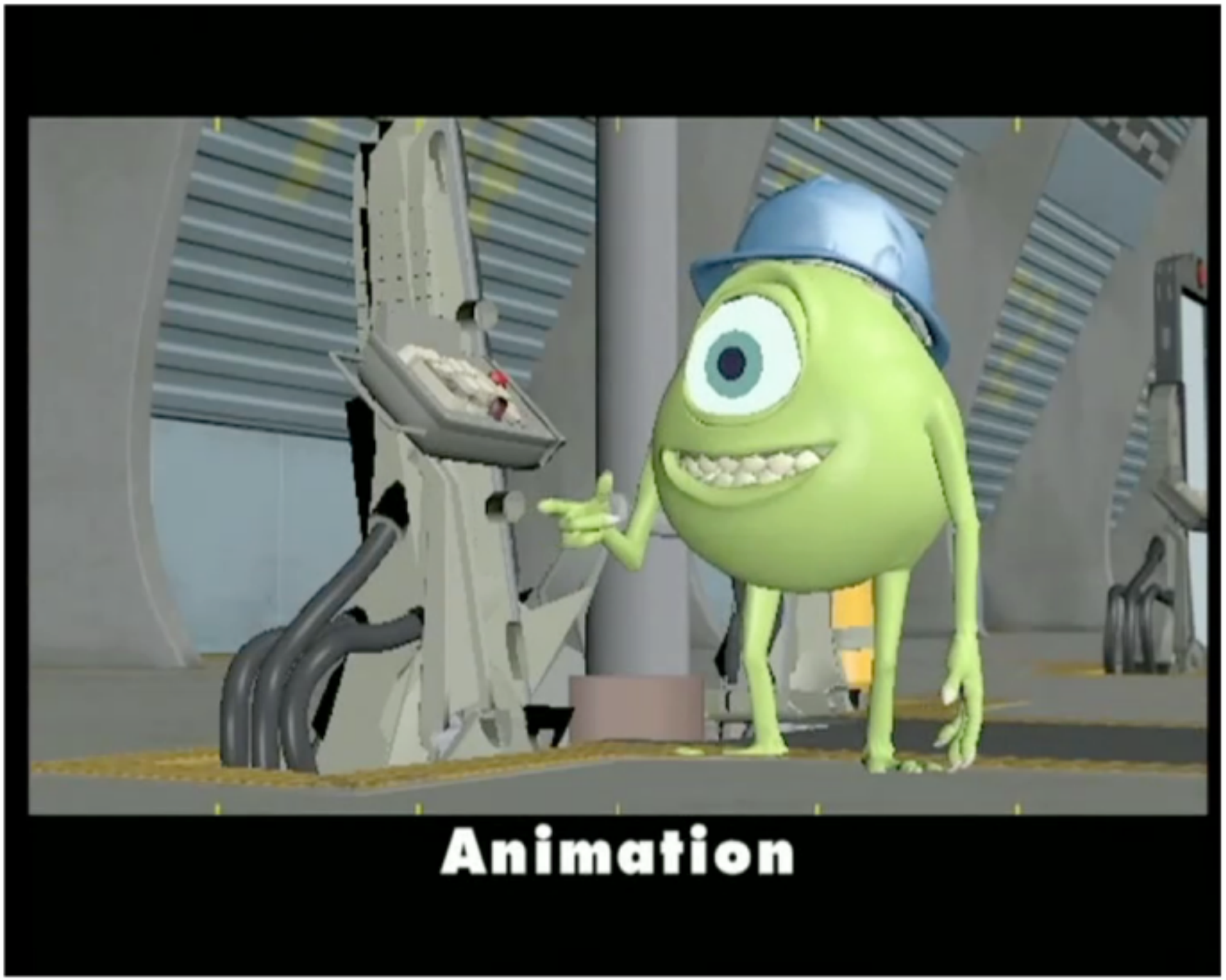


Mathmove & Layout

Using placeholder geometry...

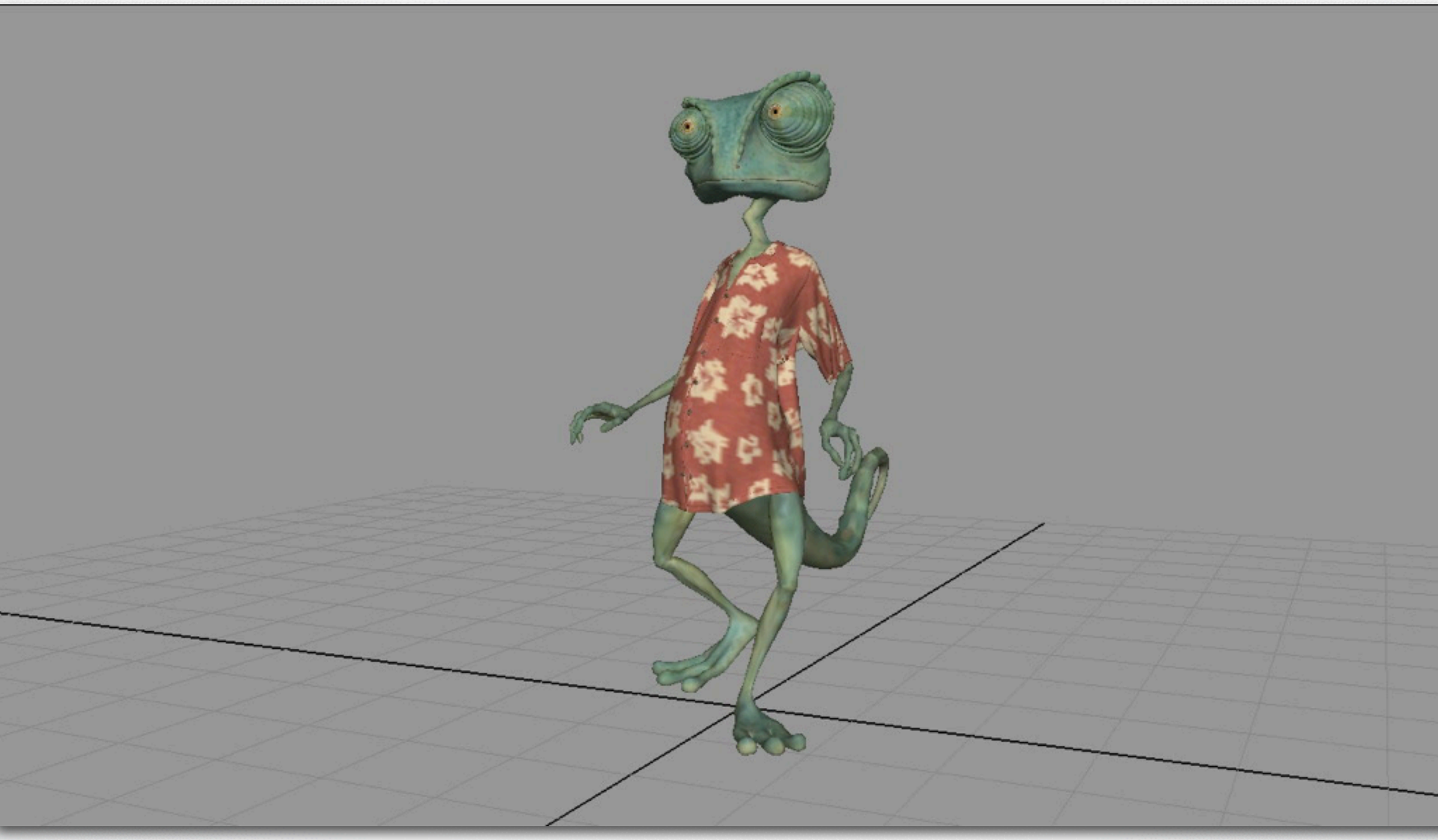
Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. **Animation**
9. Special Effects
10. Shading
11. Lighting
12. Rendering



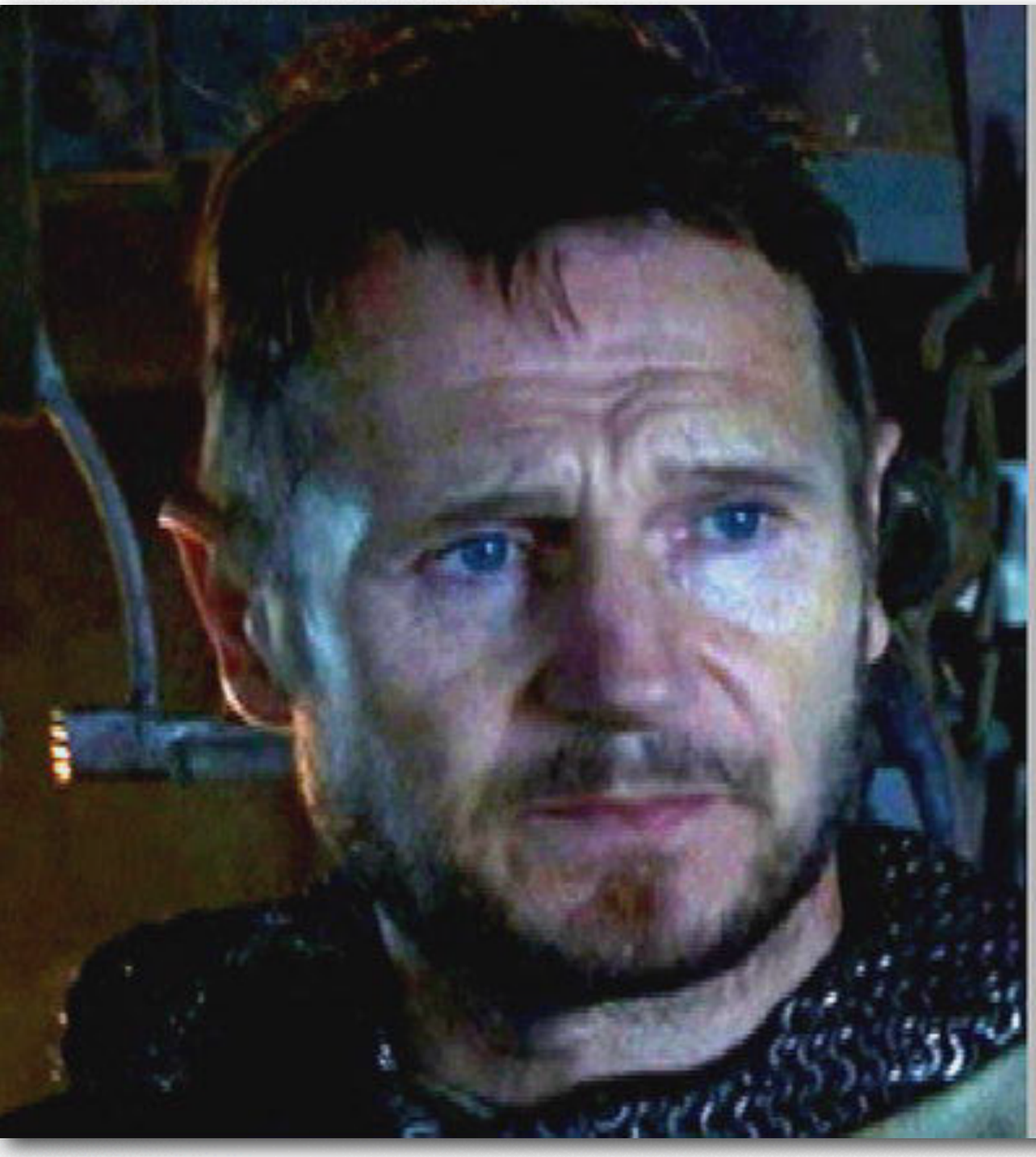
Animation

Rango: Character Walking Tests



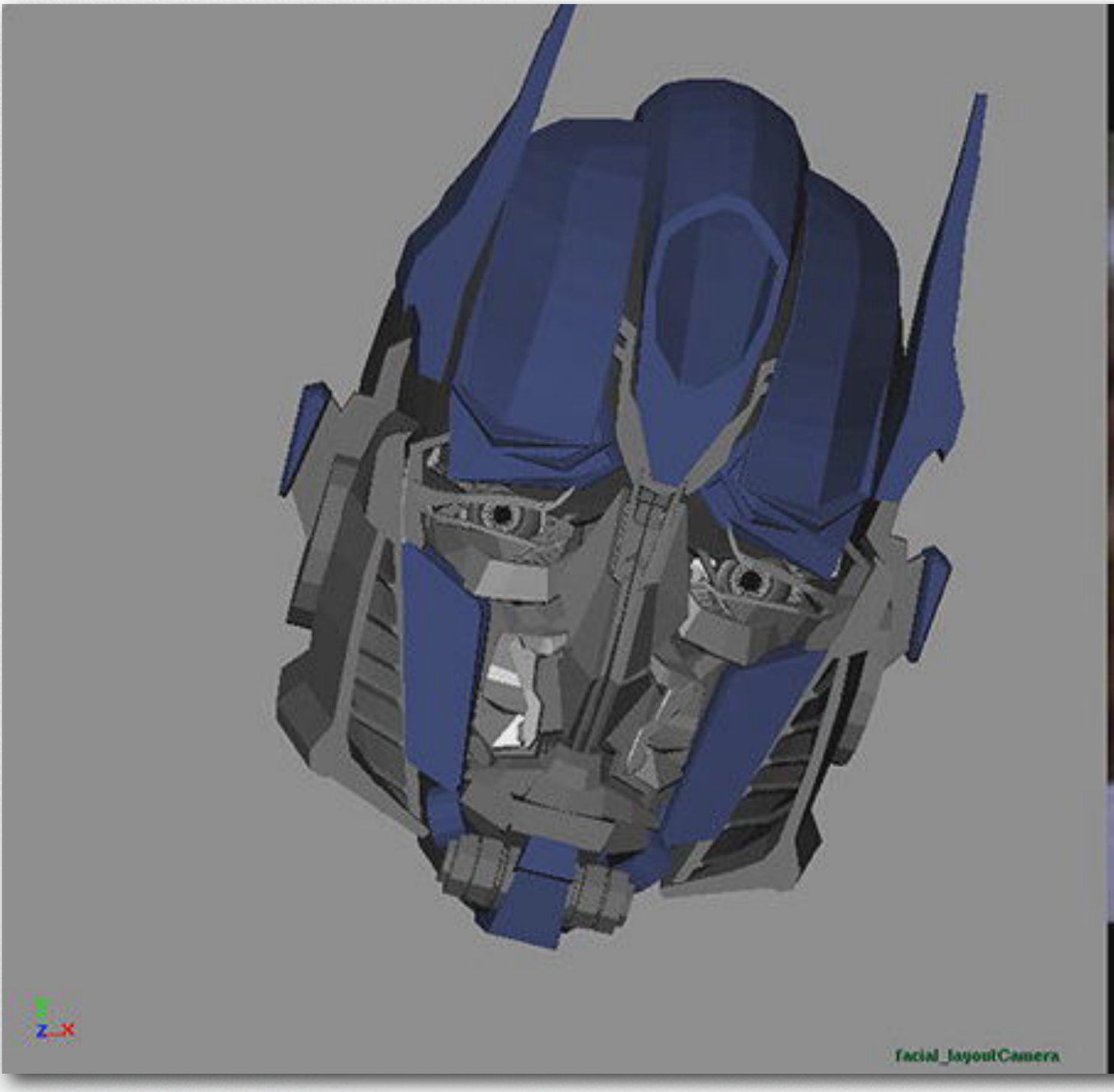
Animation

Transformers: Facial Animation Tests



Animation

Transformers: Facial Animation Tests



Animation

Transformers: Facial Animation Tests

Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. **Special Effects**
10. Shading
11. Lighting
12. Rendering

Creature Sim

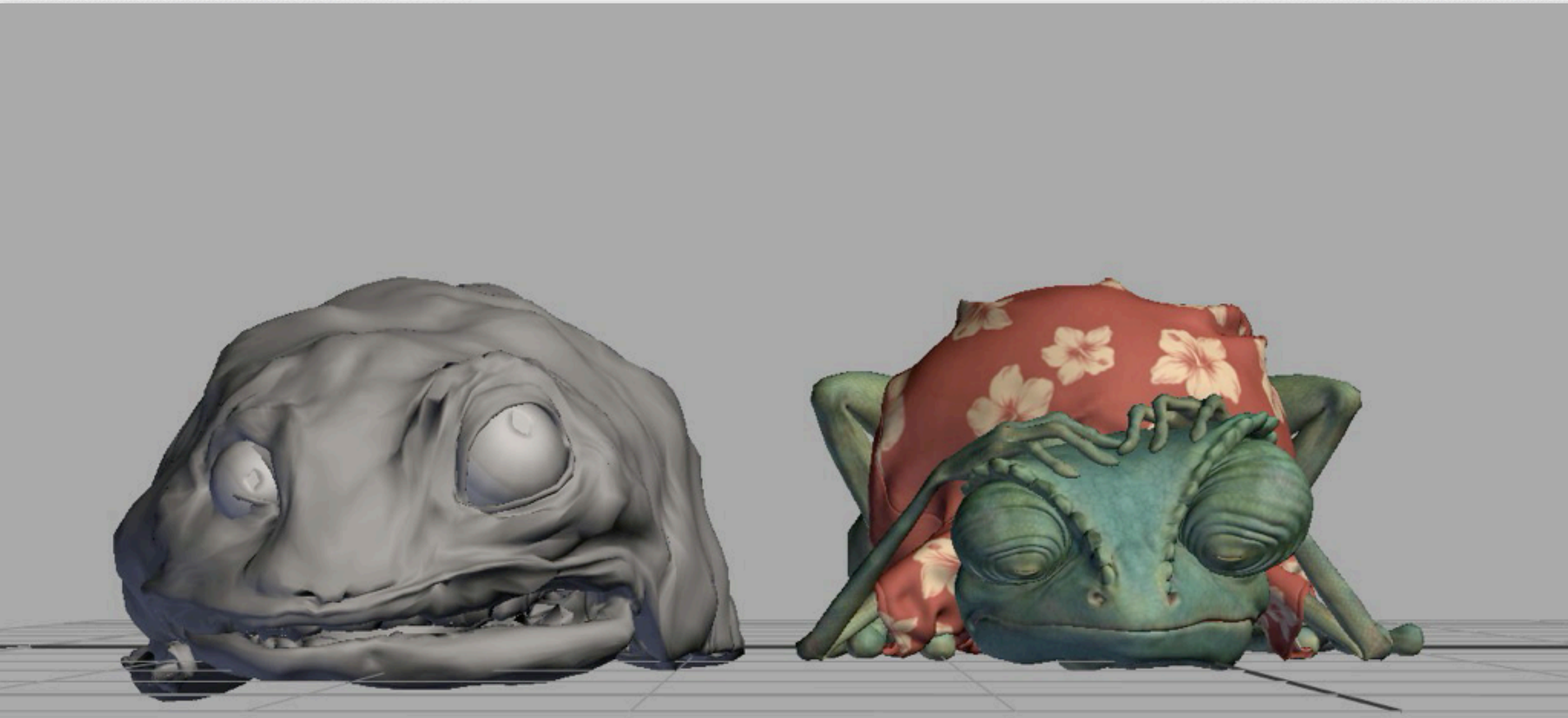
Rango: Cloth Examples

Creature Sim

The Last Airbender: Hair Examples

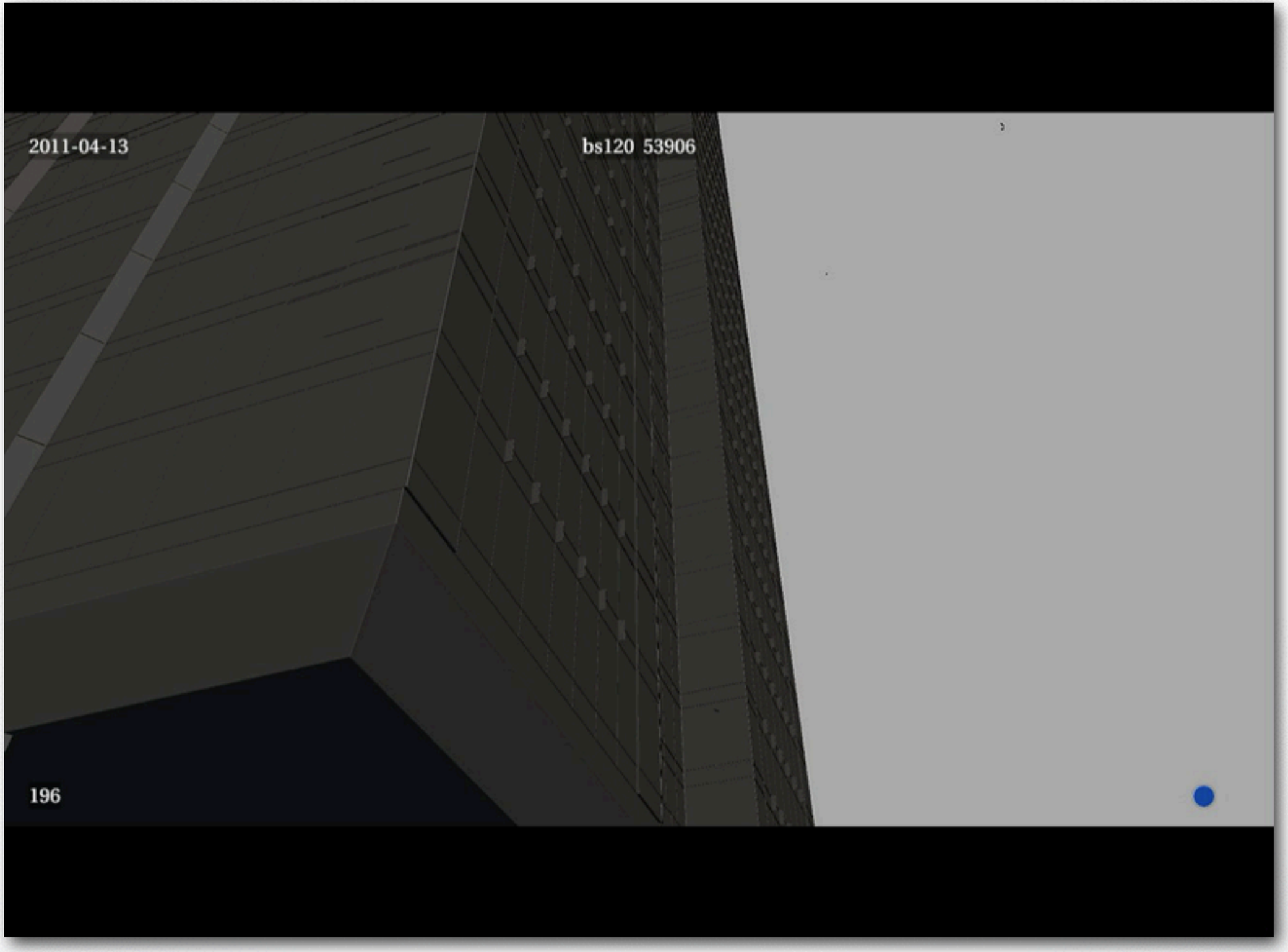
Creature Sim

Flesh



Creature Sim

... and also rigids



Creature Sim

when things go wrong ;-)

FX Sim

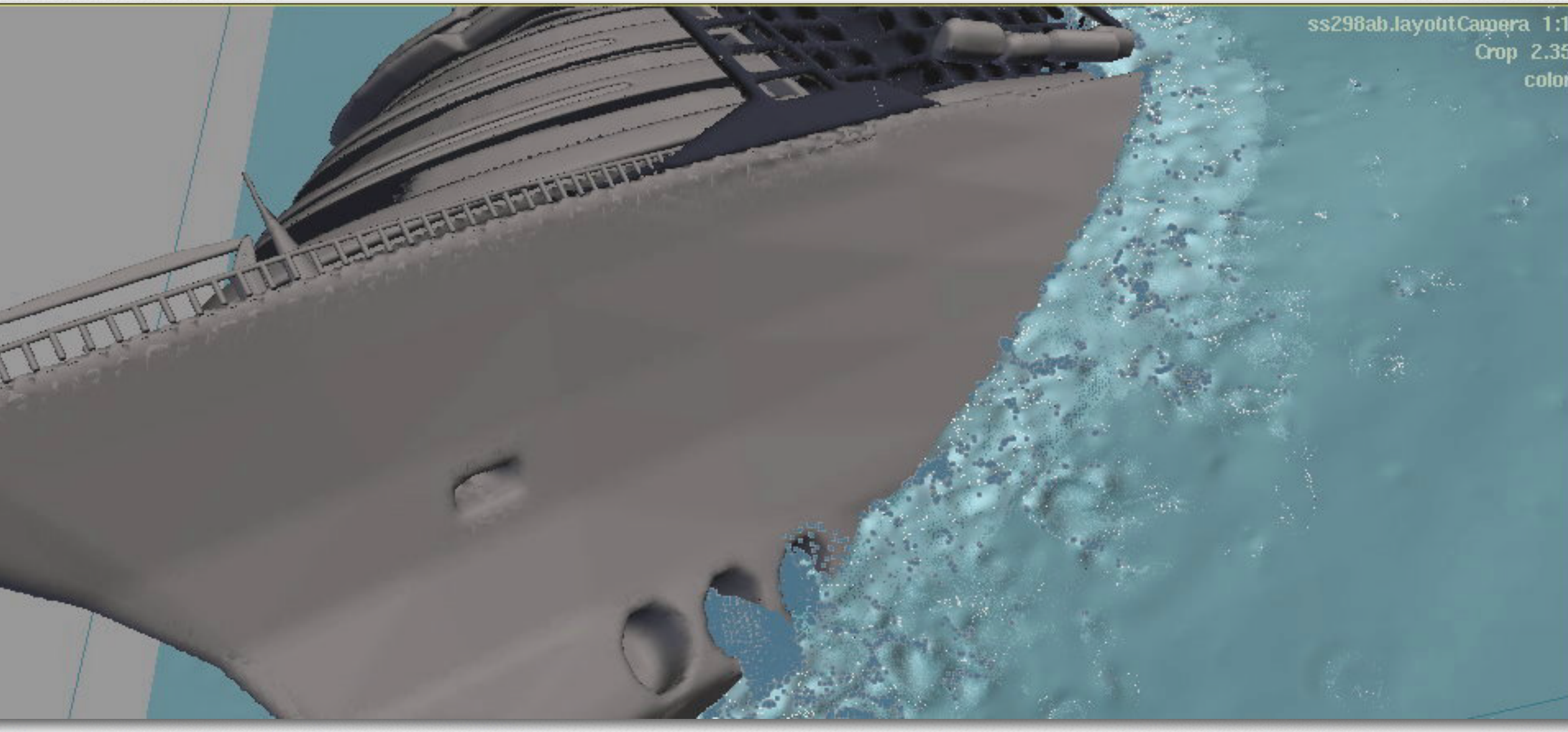
The process of applying forces (such as mass, velocity, and gravity) to particles and rigid bodies to animate items such as dust, wind, rain, fire, and smoke.

FX Sim

Harry Potter 6: Fire Simulations

FX Sim

Poseidon: Water Simulations



FX Sim

Poseidon: Water Simulations

FX Sim

Poseidon: Water Simulations

Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. **Shading**
11. Lighting
12. Rendering

Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. **Lighting**
12. Rendering

Lighting & Rendering

Lighting: The process of creating lights, assigning them attributes (color, intensity, direction, etc) and applying them in a scene to interact with CG assets.

Rendering: Calculating the effect of light on objects in a CG scene from the point of view of the camera, and creating a rendered element.

Lighting & Rendering

Final shot is composed of several render passes

Render Pass: Ironman & Warmachines

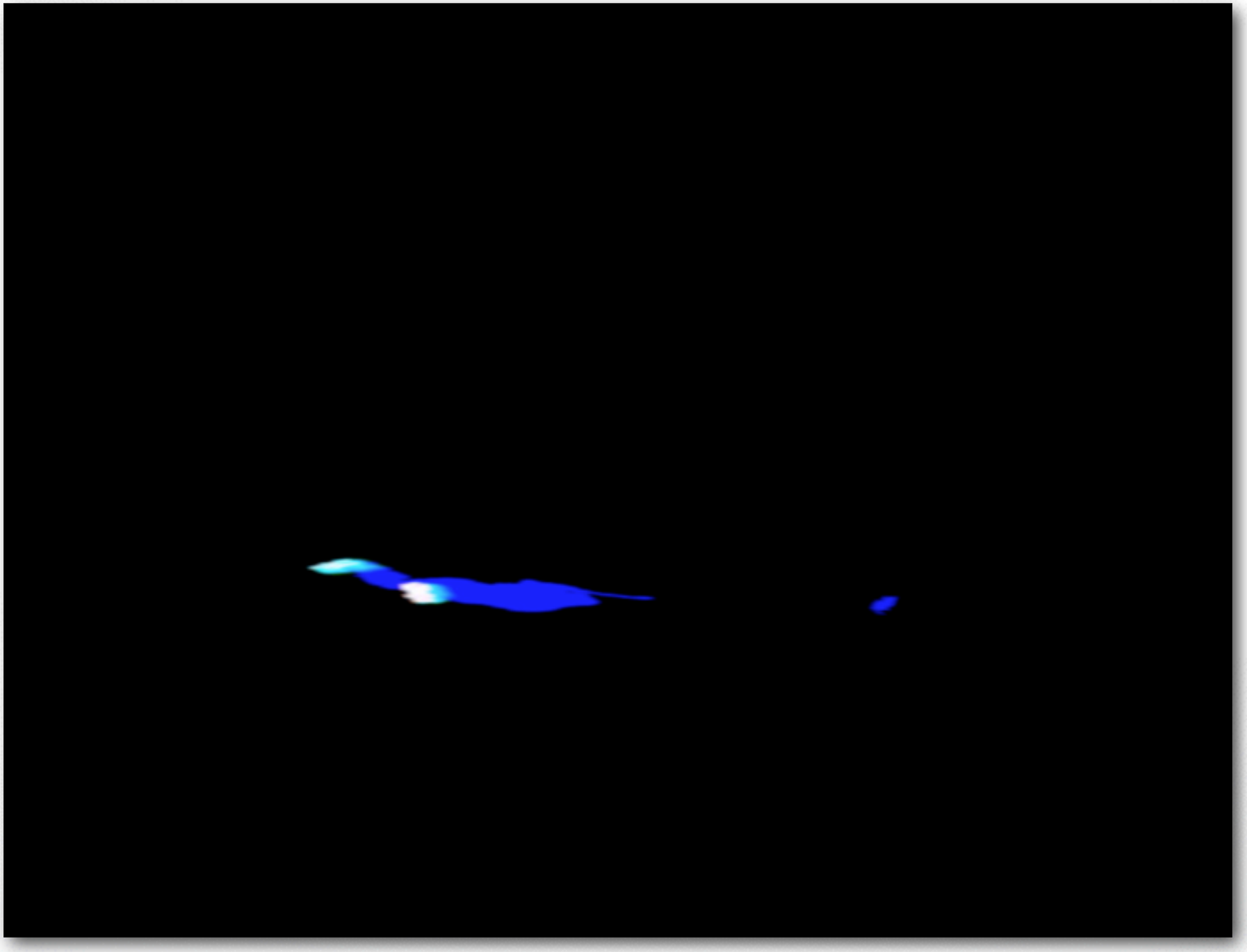
Render Pass of Army Drones

Lighting & Rendering

Render Pass of Marine Drones

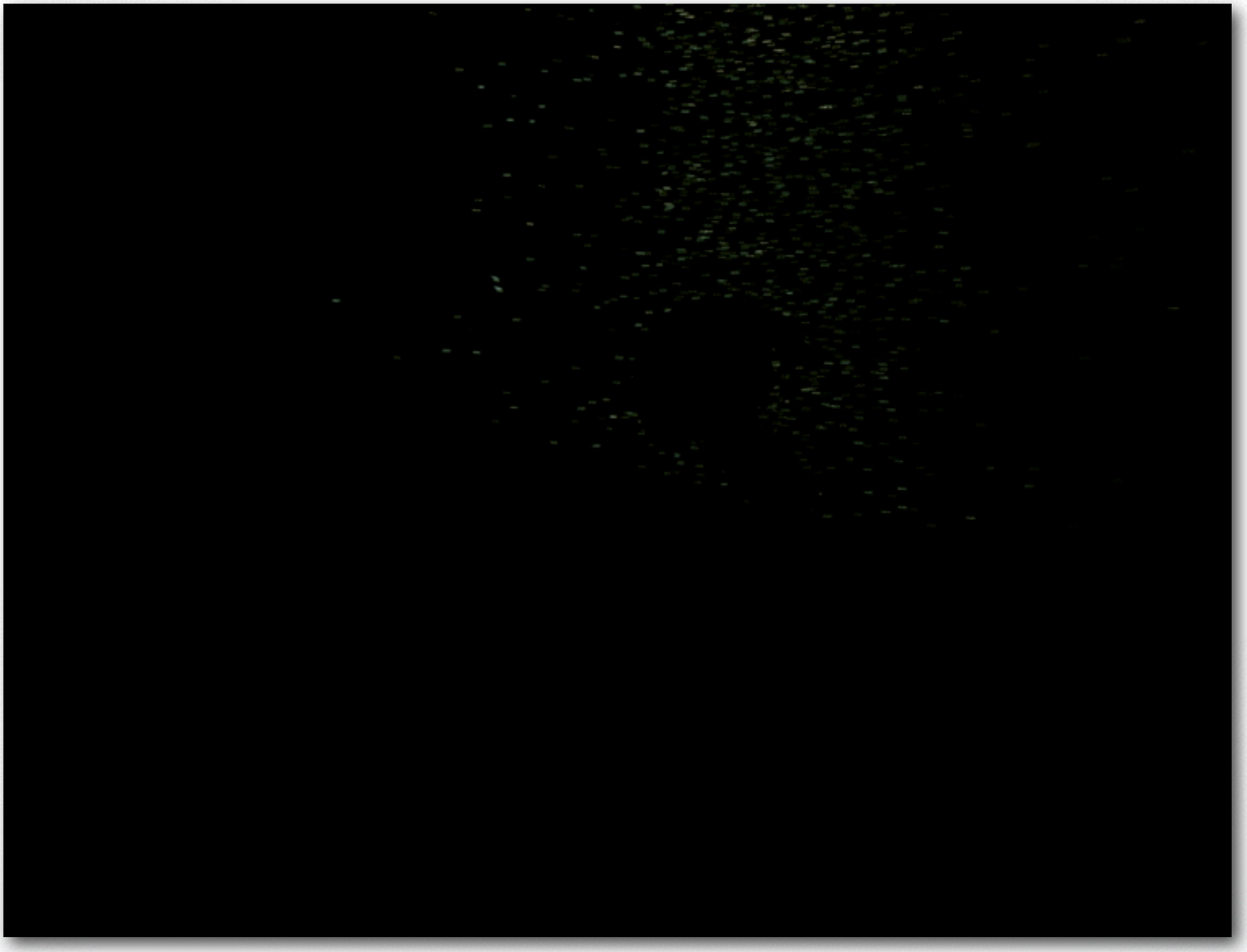
Render Pass of Navy Drones

Render Pass of Shadows



Lighting & Rendering

Render Pass of Cherry Blossom Simulation



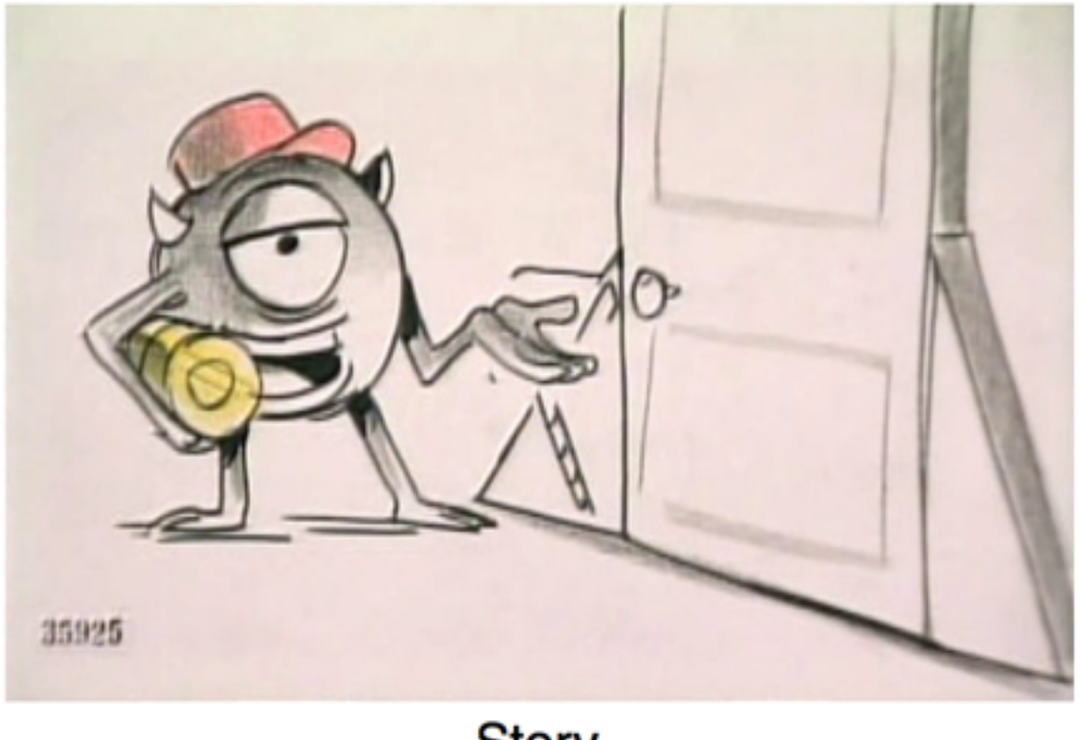
Lighting & Rendering

Can you spot the passes in the final shot...

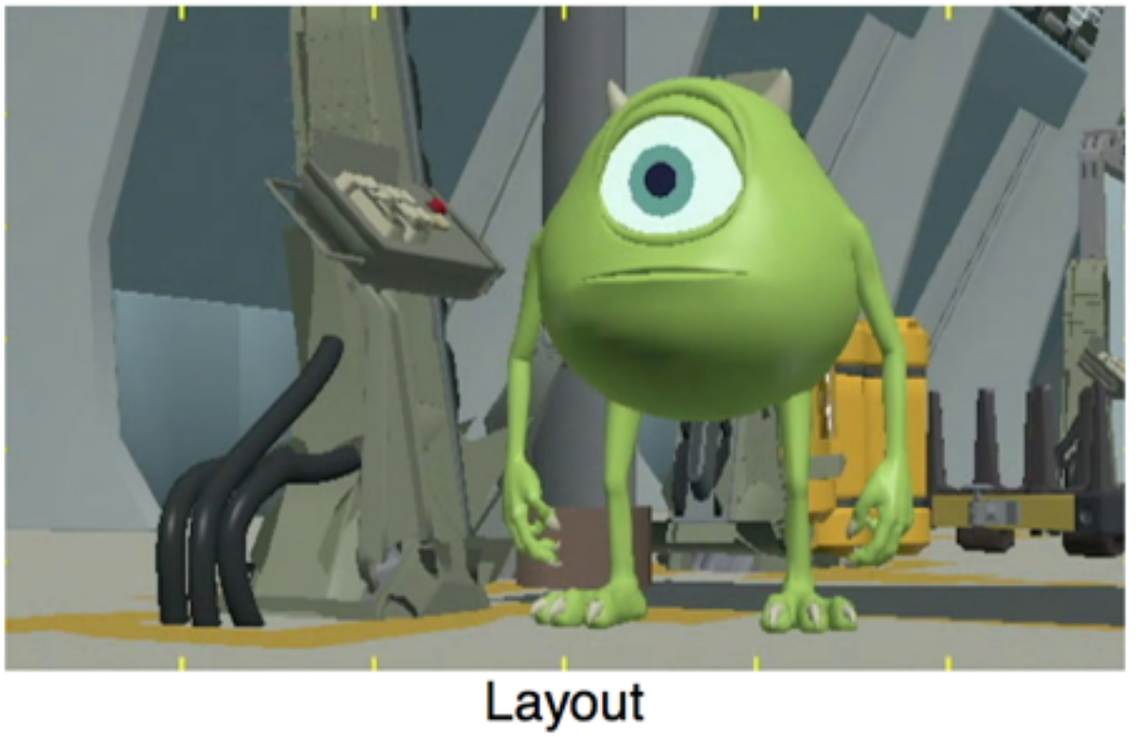
Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. Animation
9. Special Effects
10. Shading
11. Lighting
12. **Rendering**

Animation Production



Story



Layout

Animation

Final Rendering

Overview

Animation Production

Rigging

- Procedural
- Skeletal
- Anatomical

Posing

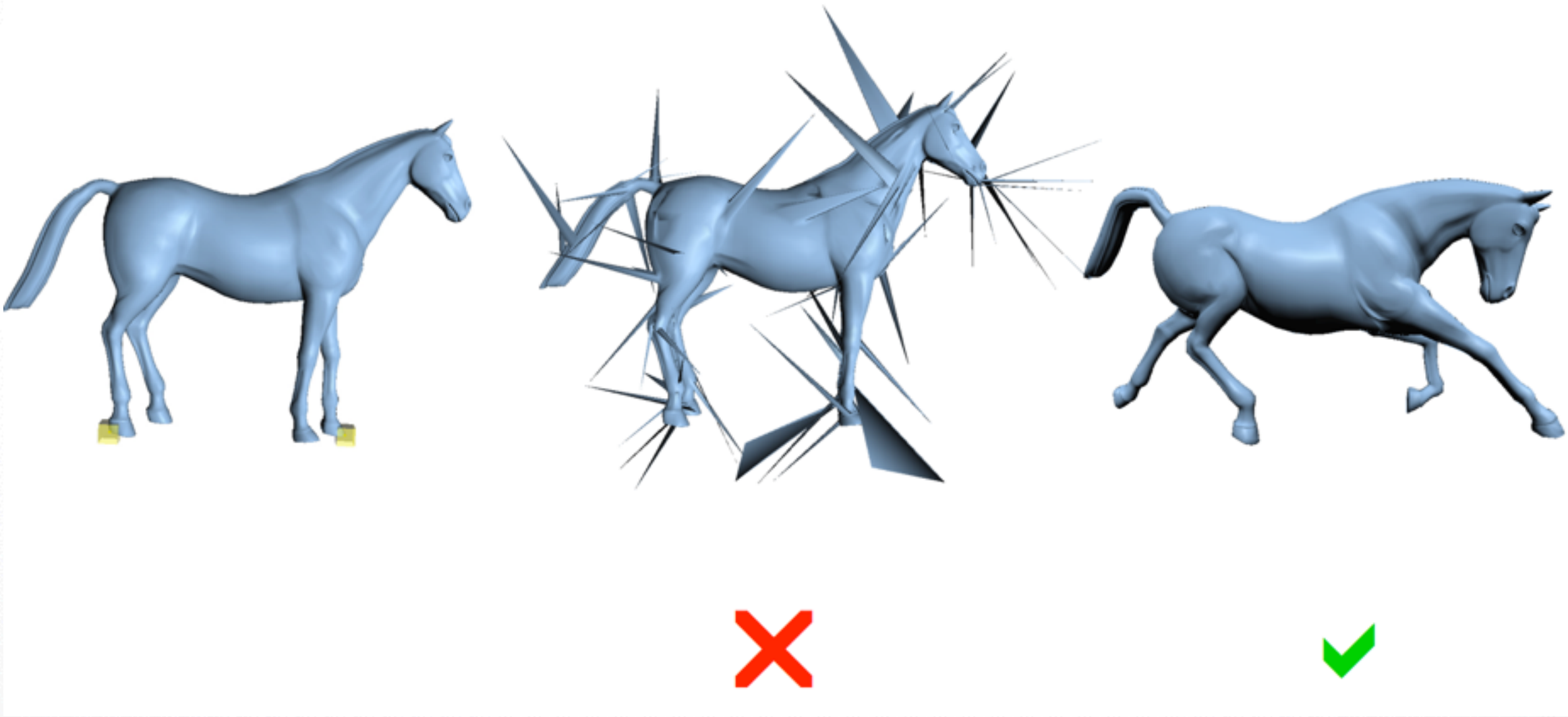
- Forward Kinematics
- Inverse Kinematics
- Advanced Methods (Style-Based IK + MeshIK)

Animation

- Keyframe Animation
- Motion Capture
- Physics-Based Character Animation

Rigging

- Parameterize meaningful deformations



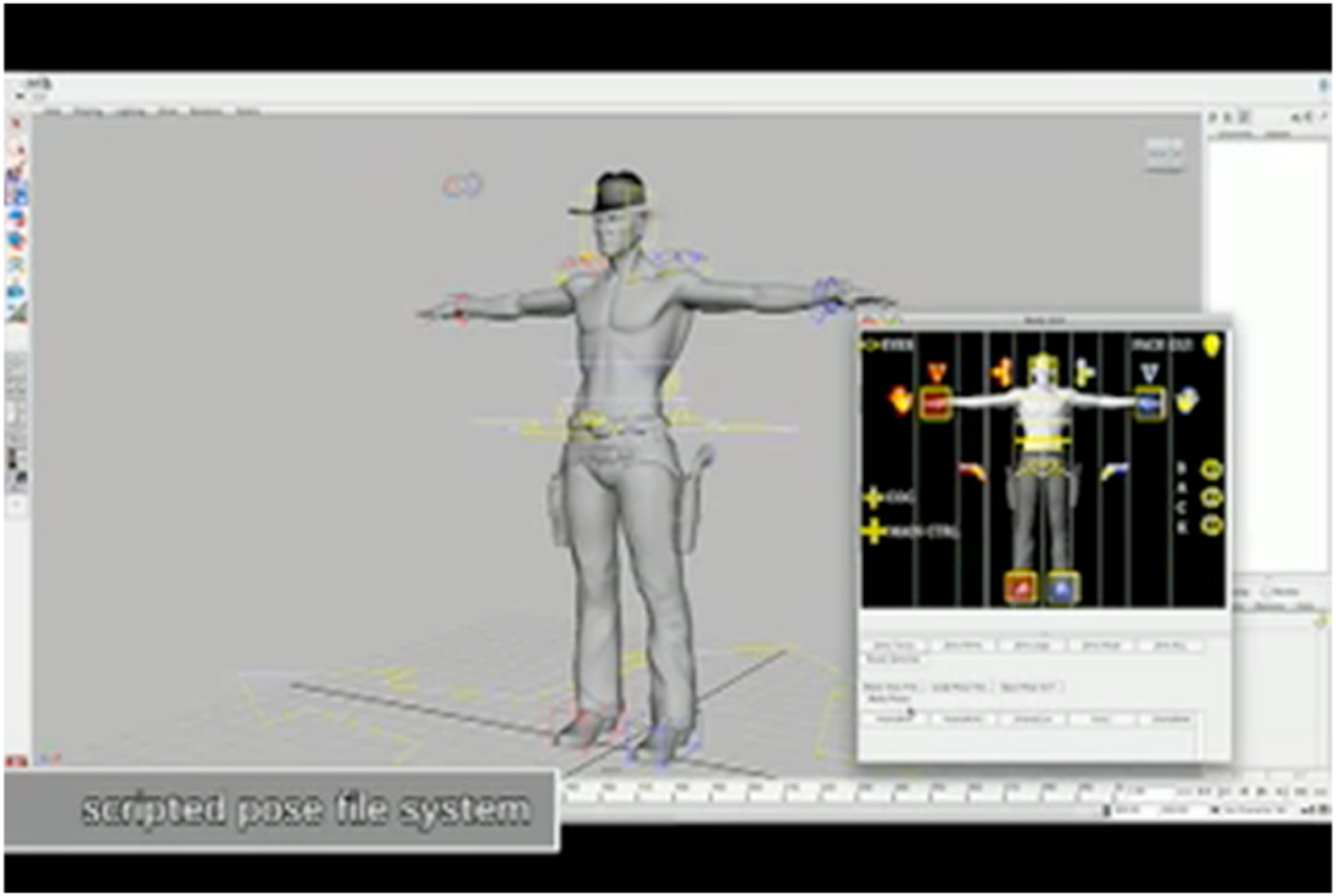
Rigging

- Augment character with controls to easily change its pose, create facial expressions, bulge muscles, etc.
- Rigging is like the strings on a marionette.
- Capture space of meaningful deformations.
- Varies from character to character.

Rigging

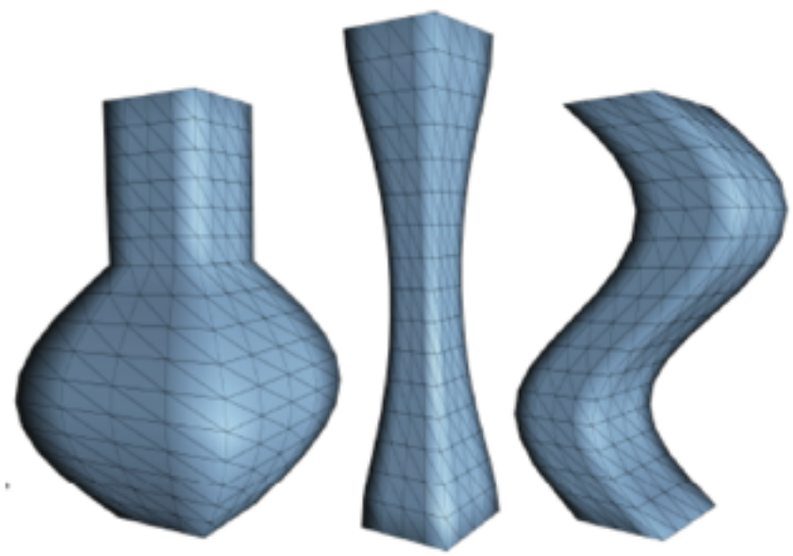
- Extremely important:
  - Determines final shape of the character
  - Quality of rigging deformations has large influence on quality of animation itself
  - Must encode every deformation animator needs to tell the story
- Expensive:
  - Manual effort
  - Both artistic and technical training

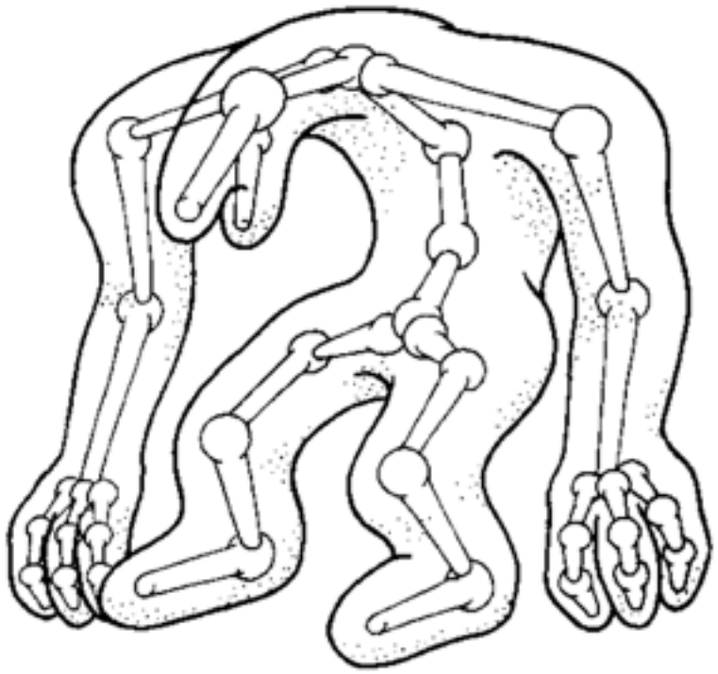
Rigging



Types of Rigging

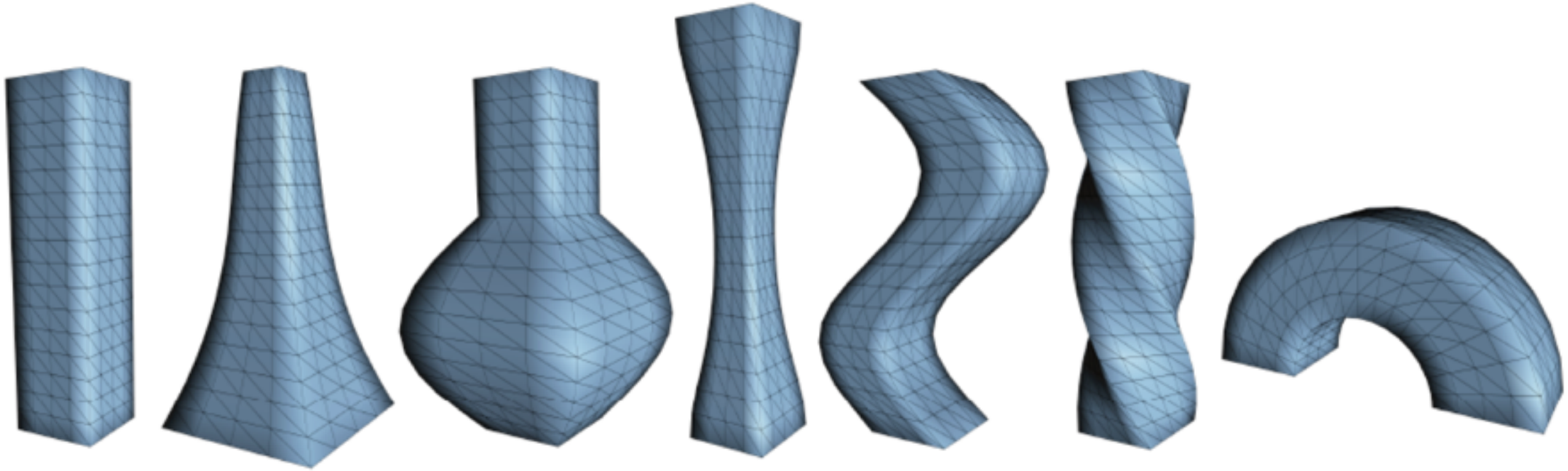
- Procedural Rigging
- Skeletal Rigging
- Anatomical Rigging





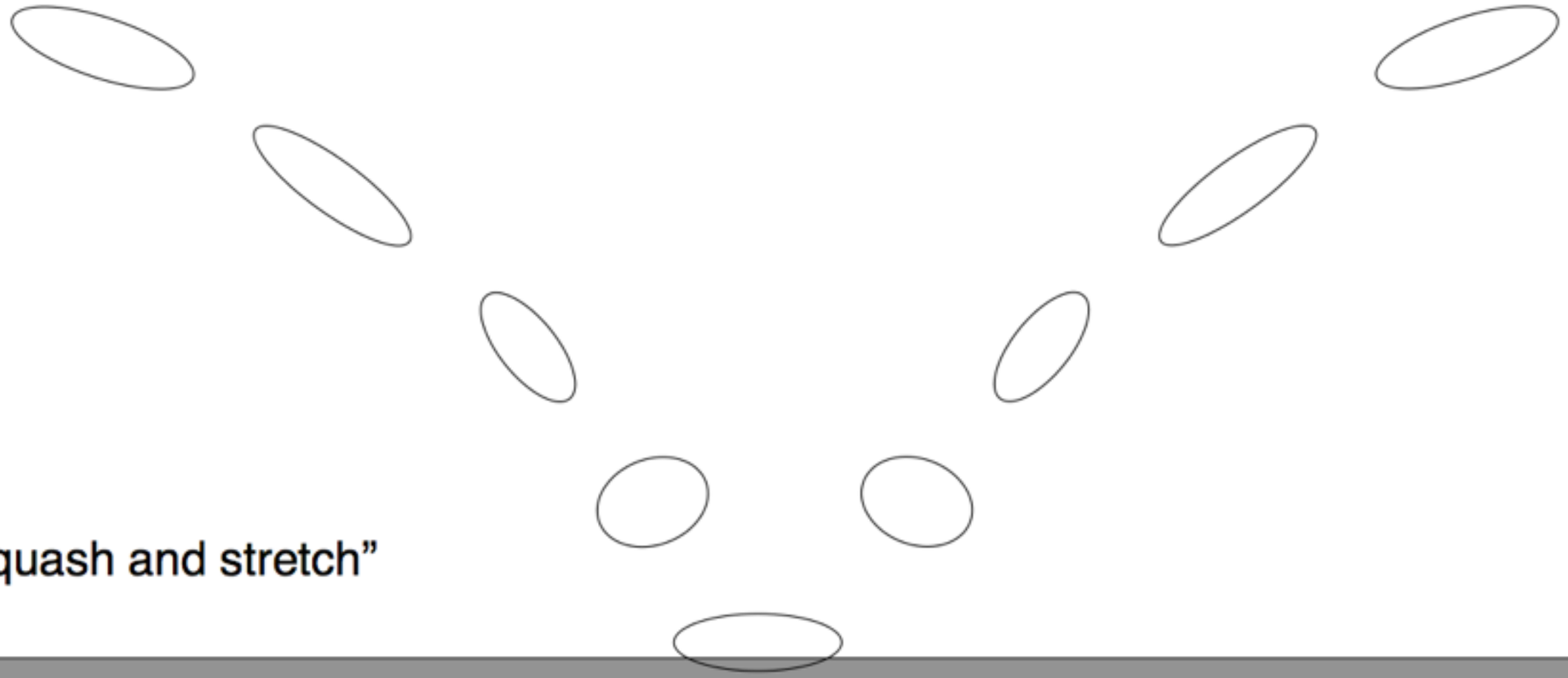
Non-Linear Deformation

- Barr's "global and local deformations."
- Non-linear deformations for bends, twists, tapering, bulges, etc.



Al Barr. Global and Local Deformations of Solid Primitives. SIGGRAPH 1984.

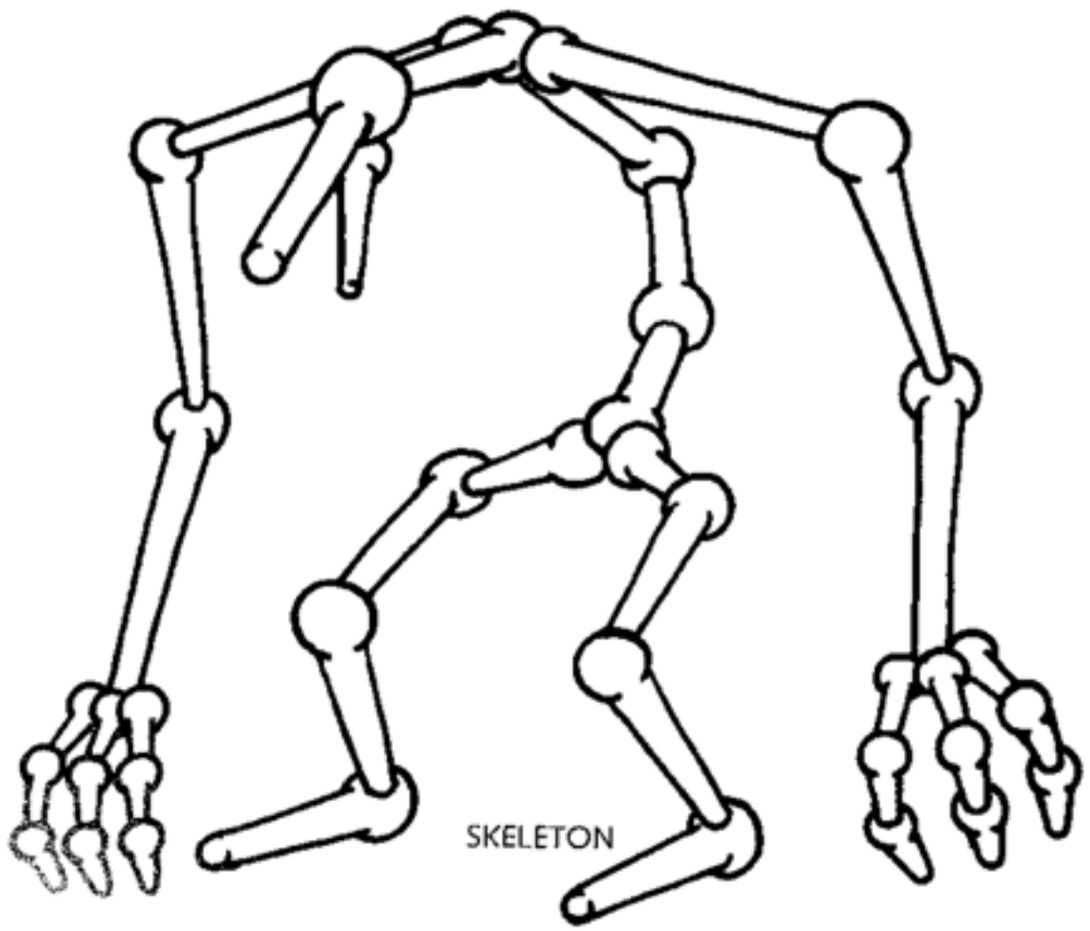
Non-Linear Deformation



"Squash and stretch"

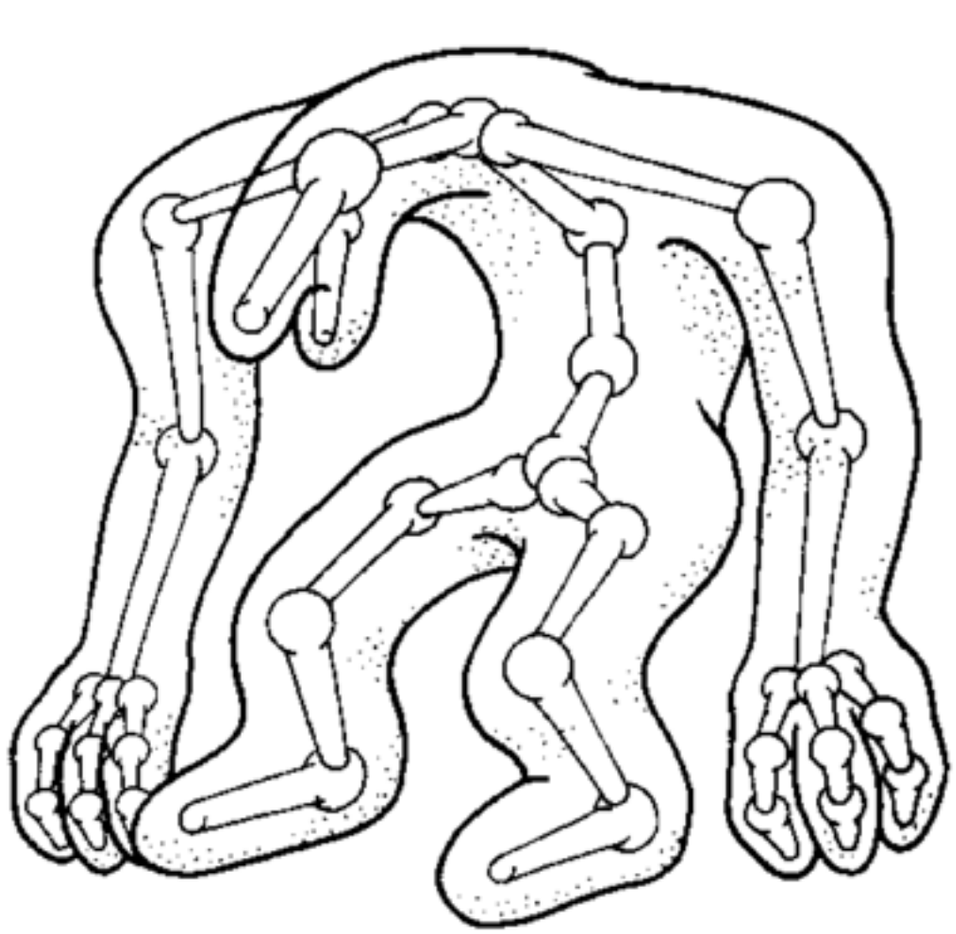
Skeletal Rigging

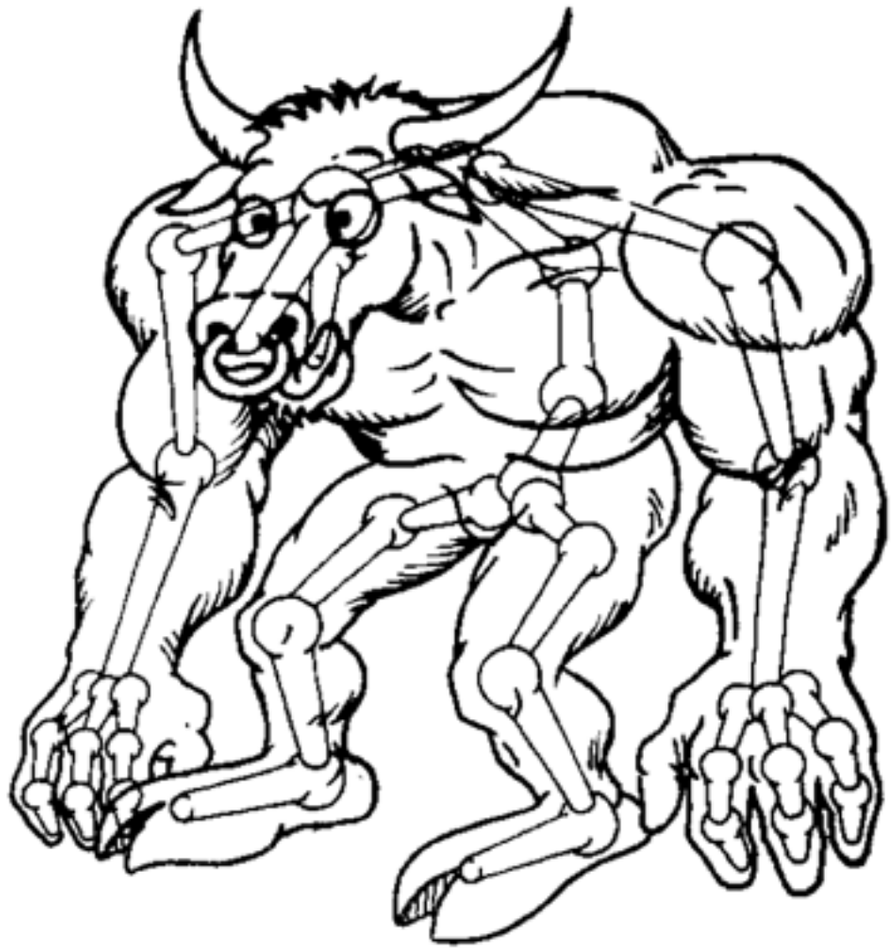
- Parameterize character deformation with a skeleton.
- Approximate actual skeleton of the character.



Skeletal Rigging

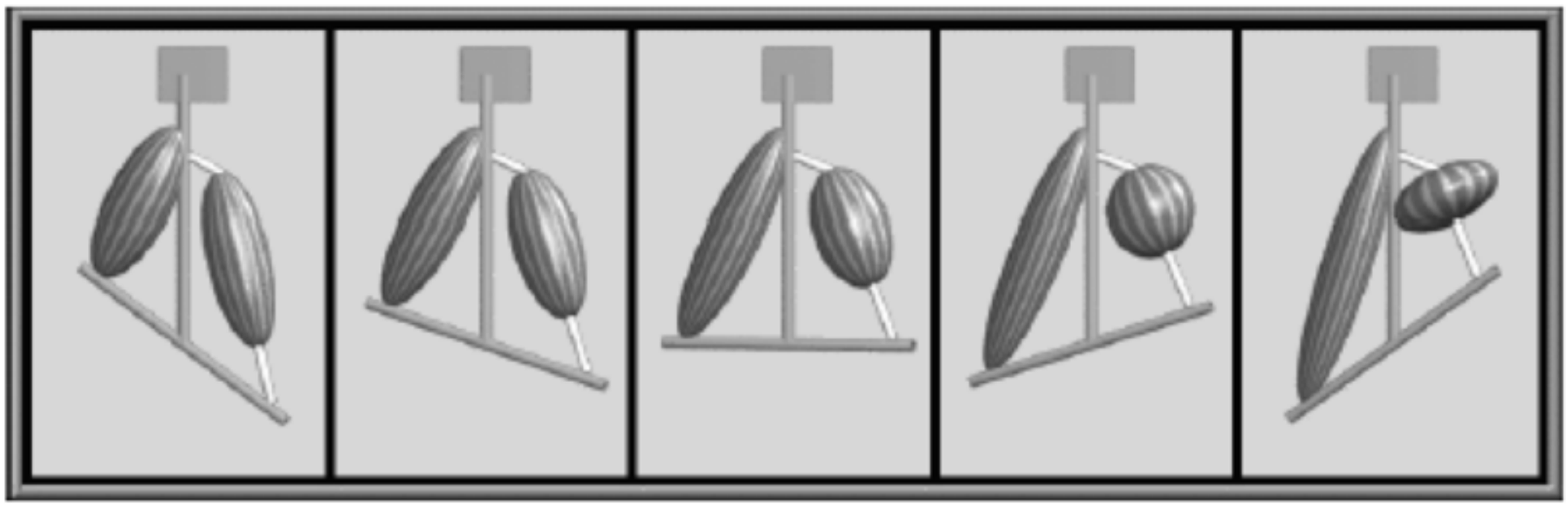
- Then add skin on top.





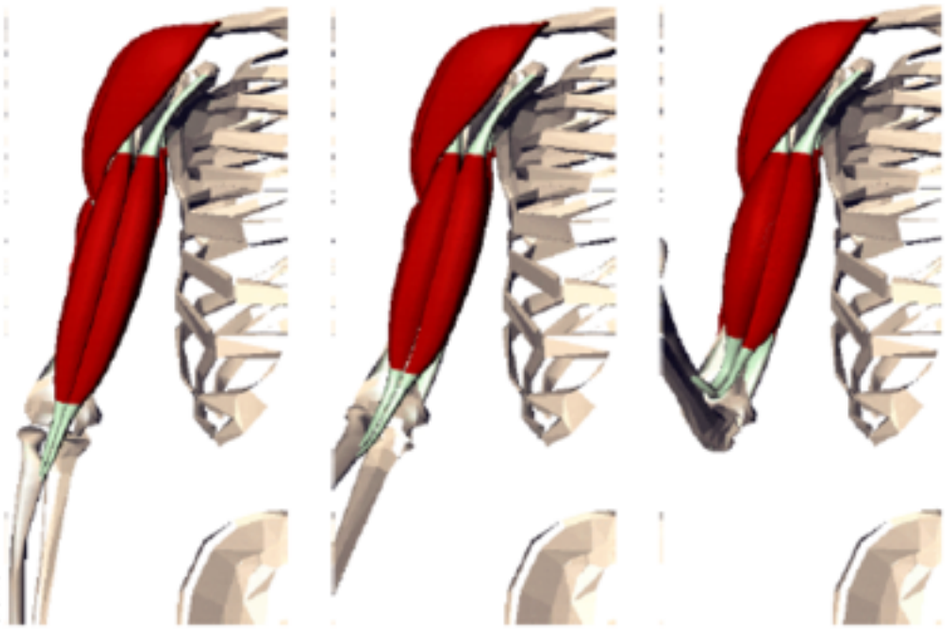
Anatomical Models

- Muscles are attached to bones, sometimes with tendons as well
- The muscles contract in a volume preserving way, thus getting wider as they get shorter

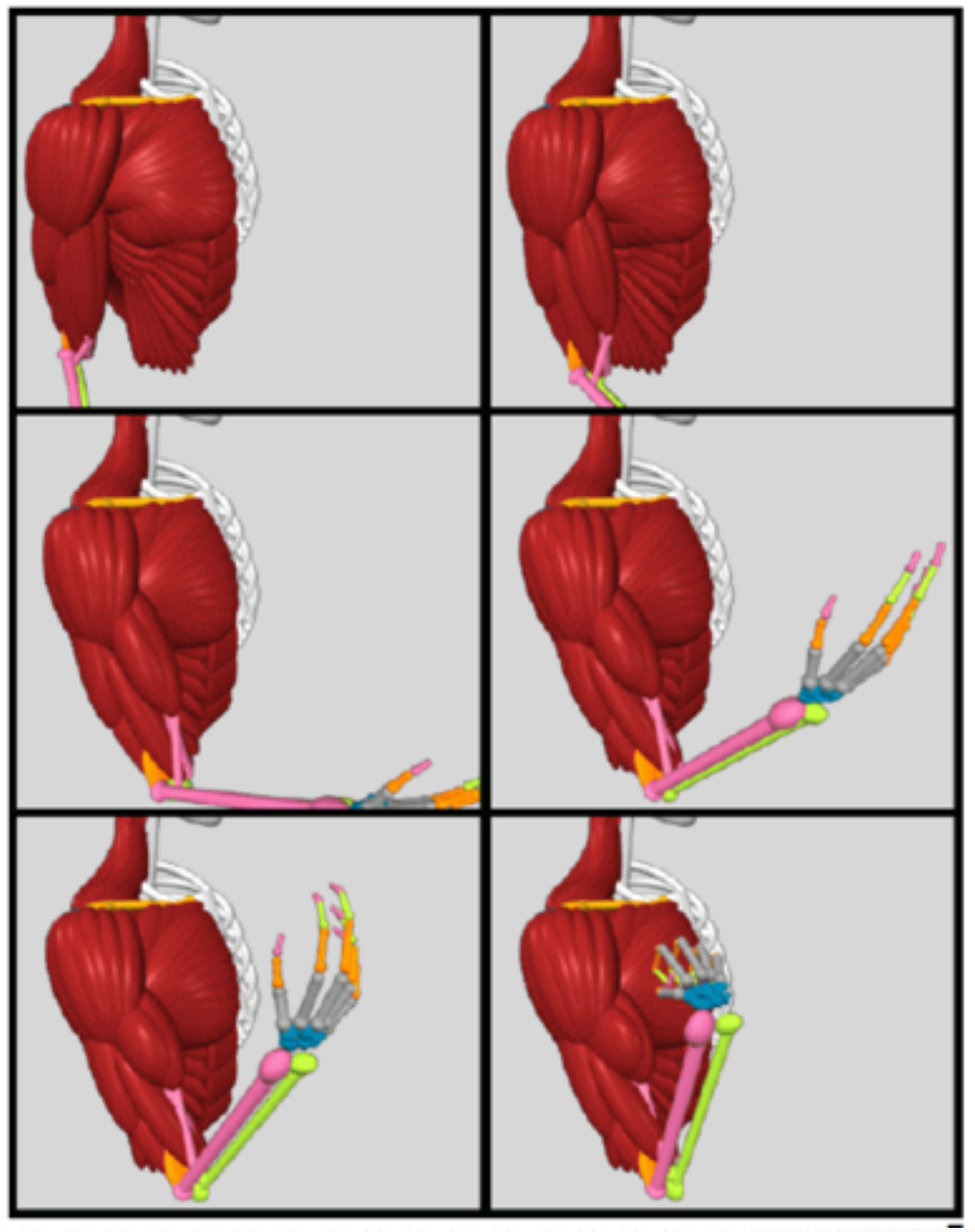


Anatomical Models

Complex musculature built up from lots of simple primitives.

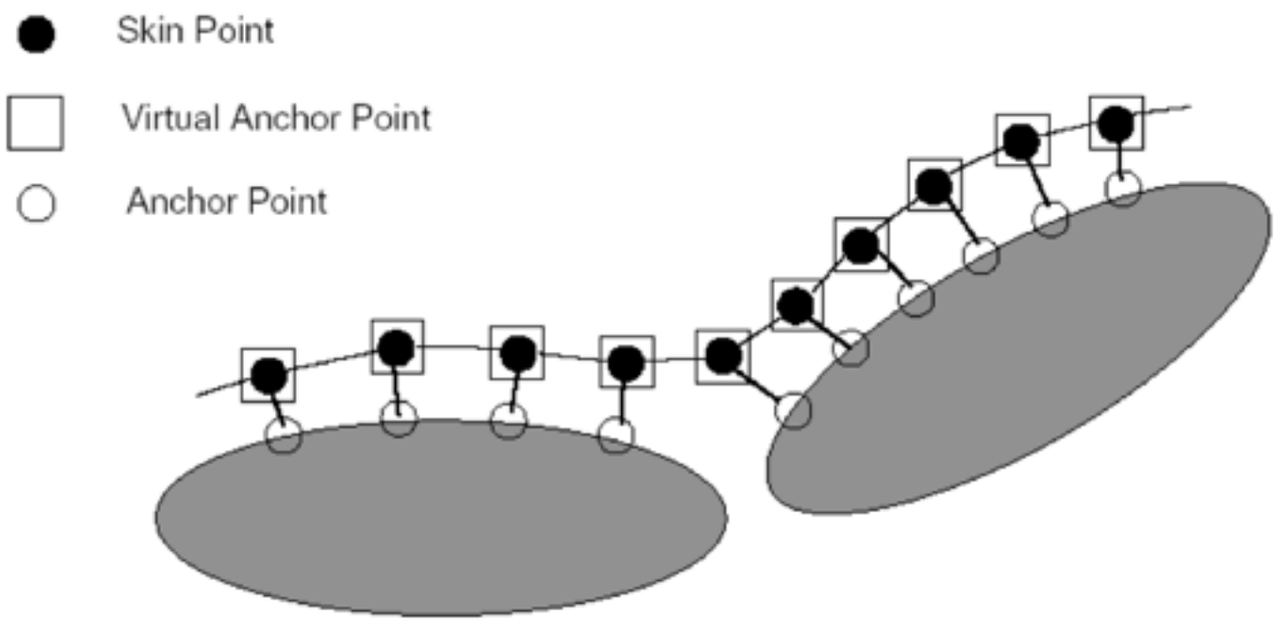


Anatomy-Based Modeling of the Human Musculature. Scheepers et al. SIGGRAPH 1997.



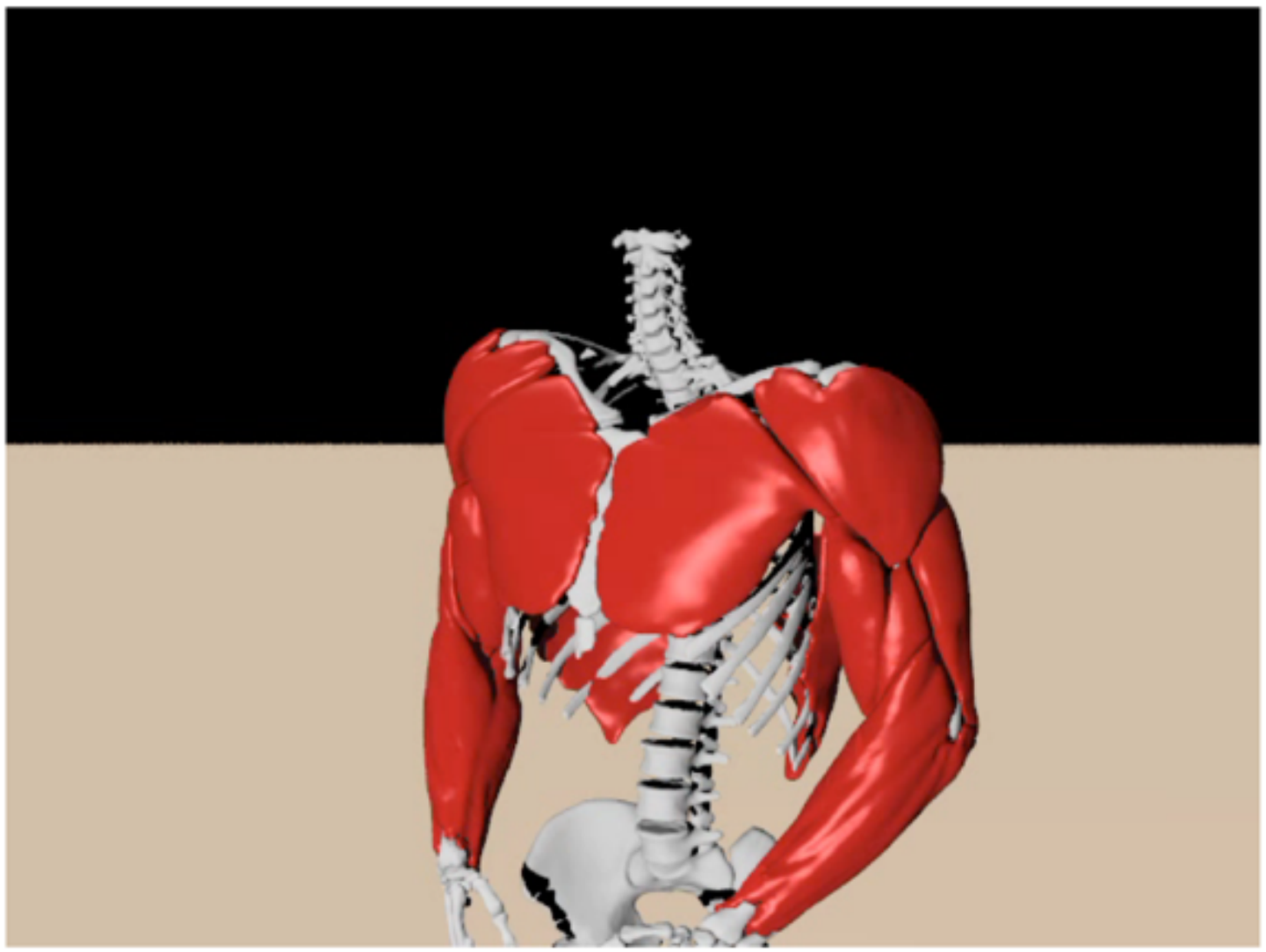
Anatomical Models

- Skin can be attached to the muscles with springs/dampers and physically simulated with collisions against bone & muscle



Anatomically based modeling, Wilhelms & Van Gelder, 1997

Anatomical Models



J. Teran, E. Sifakis, S. Blemker, V. Ng Thow Hing, C. Lau and R. Fedkiw, Creating and simulating skeletal muscle from the Visible Human Data Set, IEEE Transactions on Visualization and Computer Graphics, 11, 2005

Overview

Animation Production

Rigging

- Procedural
- Skeletal
- Anatomical

Posing

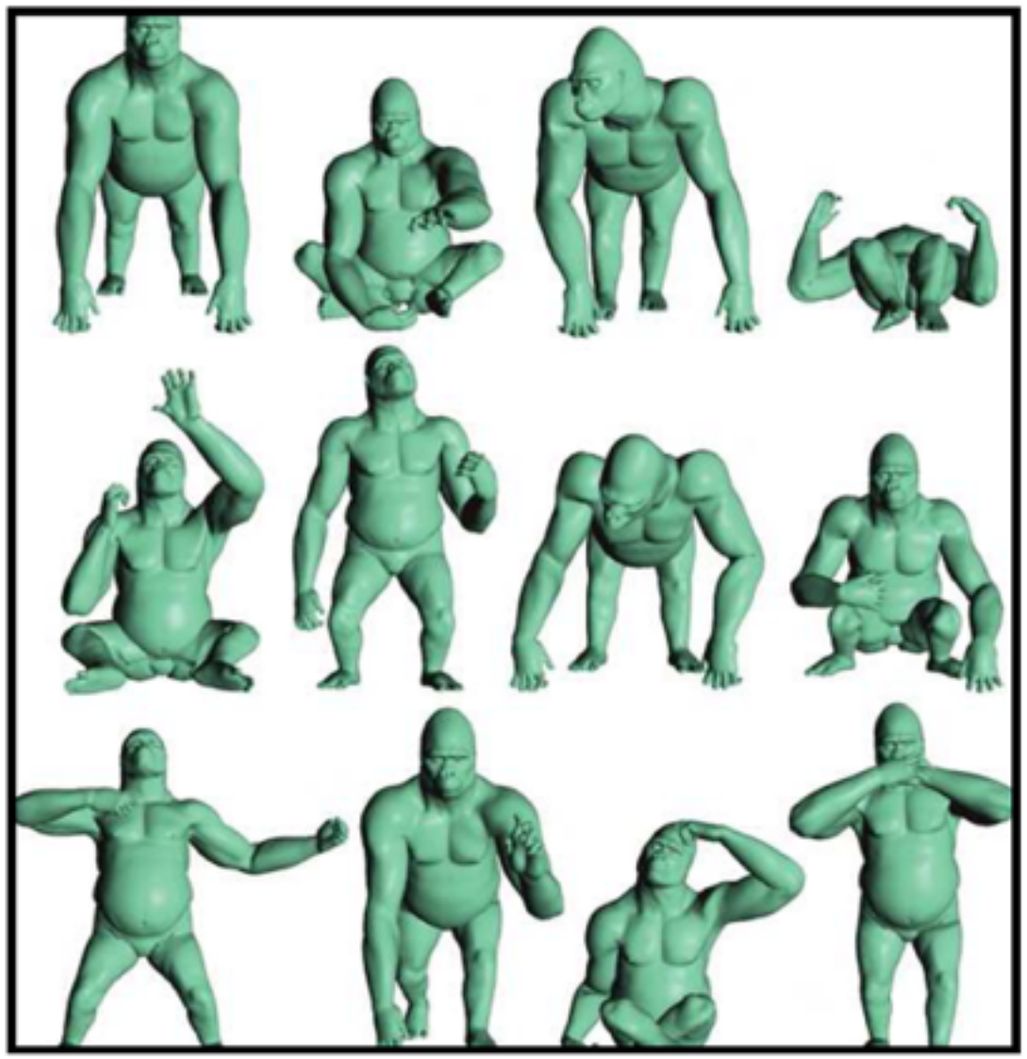
- Forward Kinematics
- Inverse Kinematics
- Advanced Methods (Style-Based IK + MeshIK)

Animation

- Keyframe Animation
- Motion Capture
- Physics-Based Character Animation

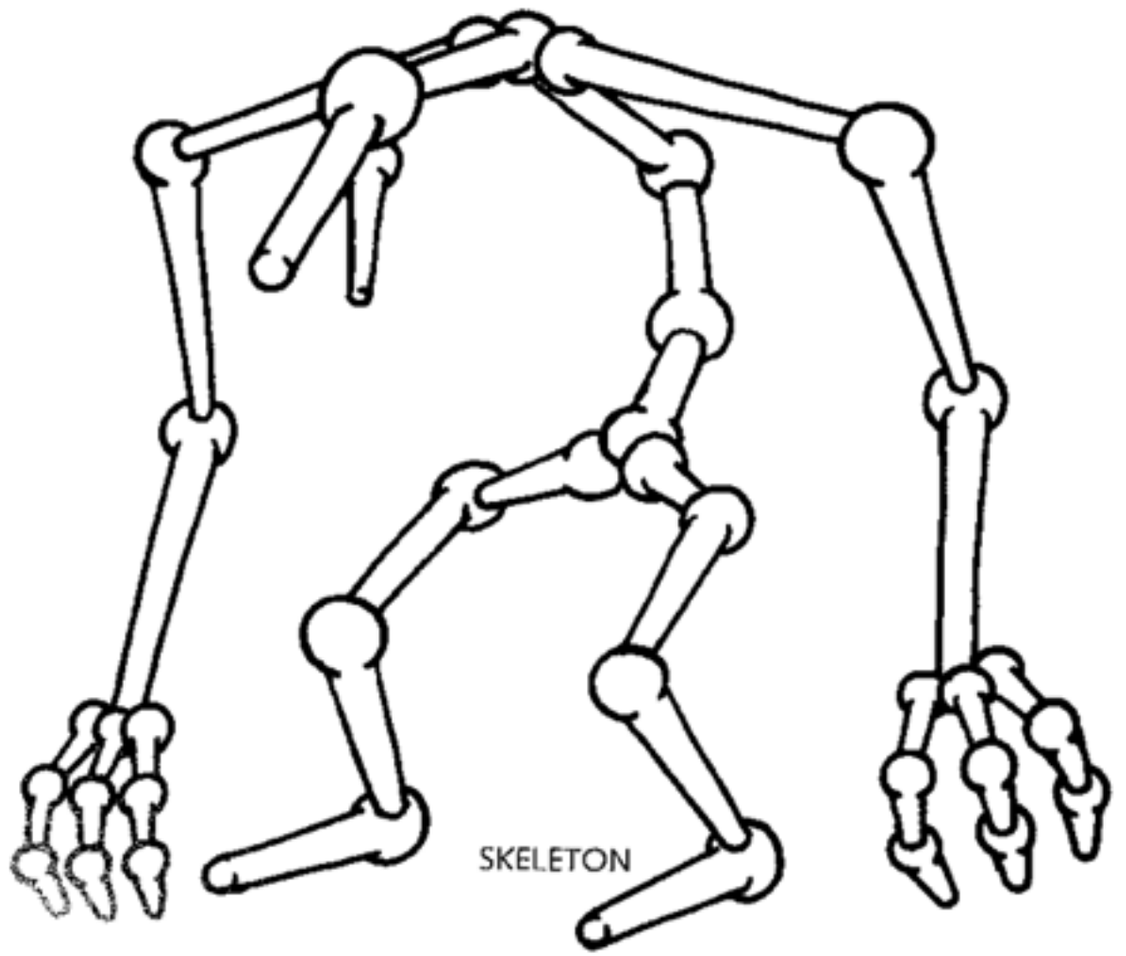
Posing

- Use the rigging controls to put the character into a given pose.



Forward Kinematics

- Given the joint angles, find the position of the "end effector" (ie, hand)
- Problem: unintuitive



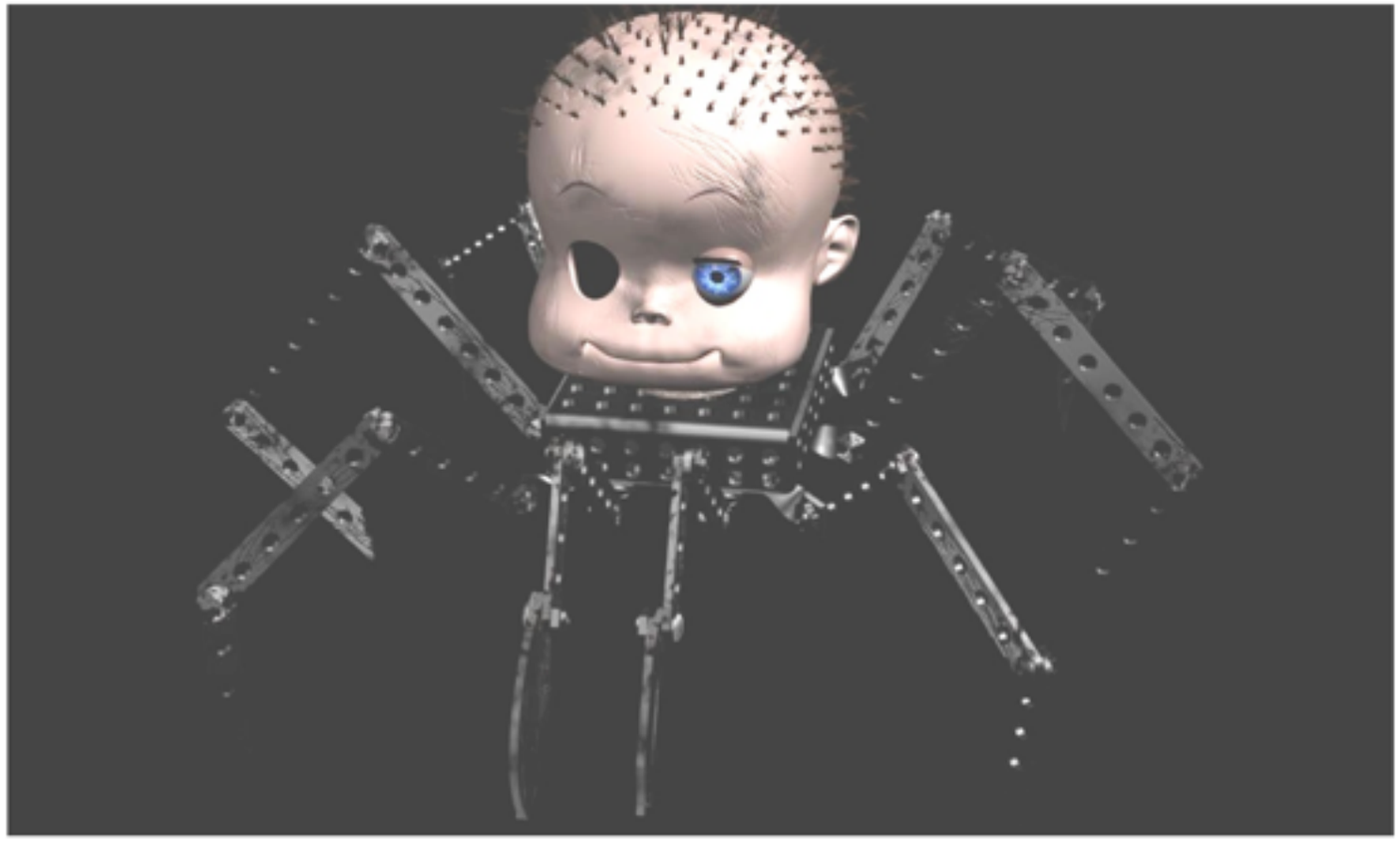
Inverse Kinematics

- Given the end effector position, find the joint angles.

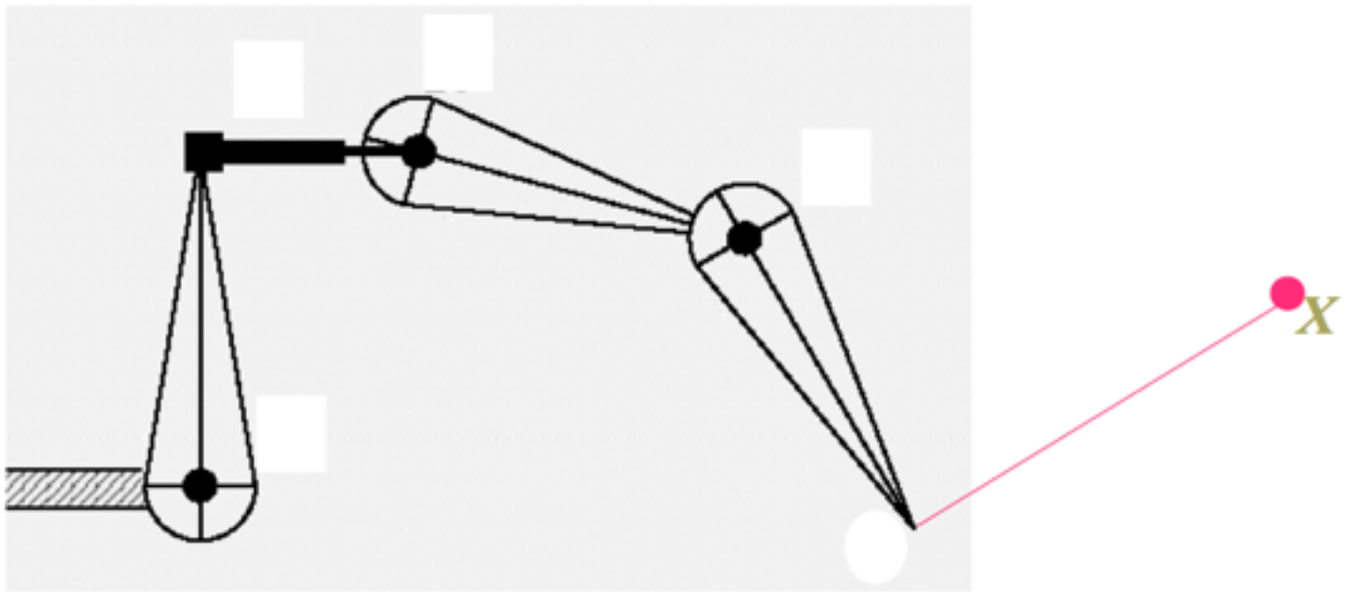
- Goals
  - Keep end of limb fixed while body moves
  - Position end of limb by direct manipulation
  - (More general: arbitrary constraints)

Three-link IK

- Can be solved with trigonometry
  - Extra parameter for choice of solution
  - Joint limits

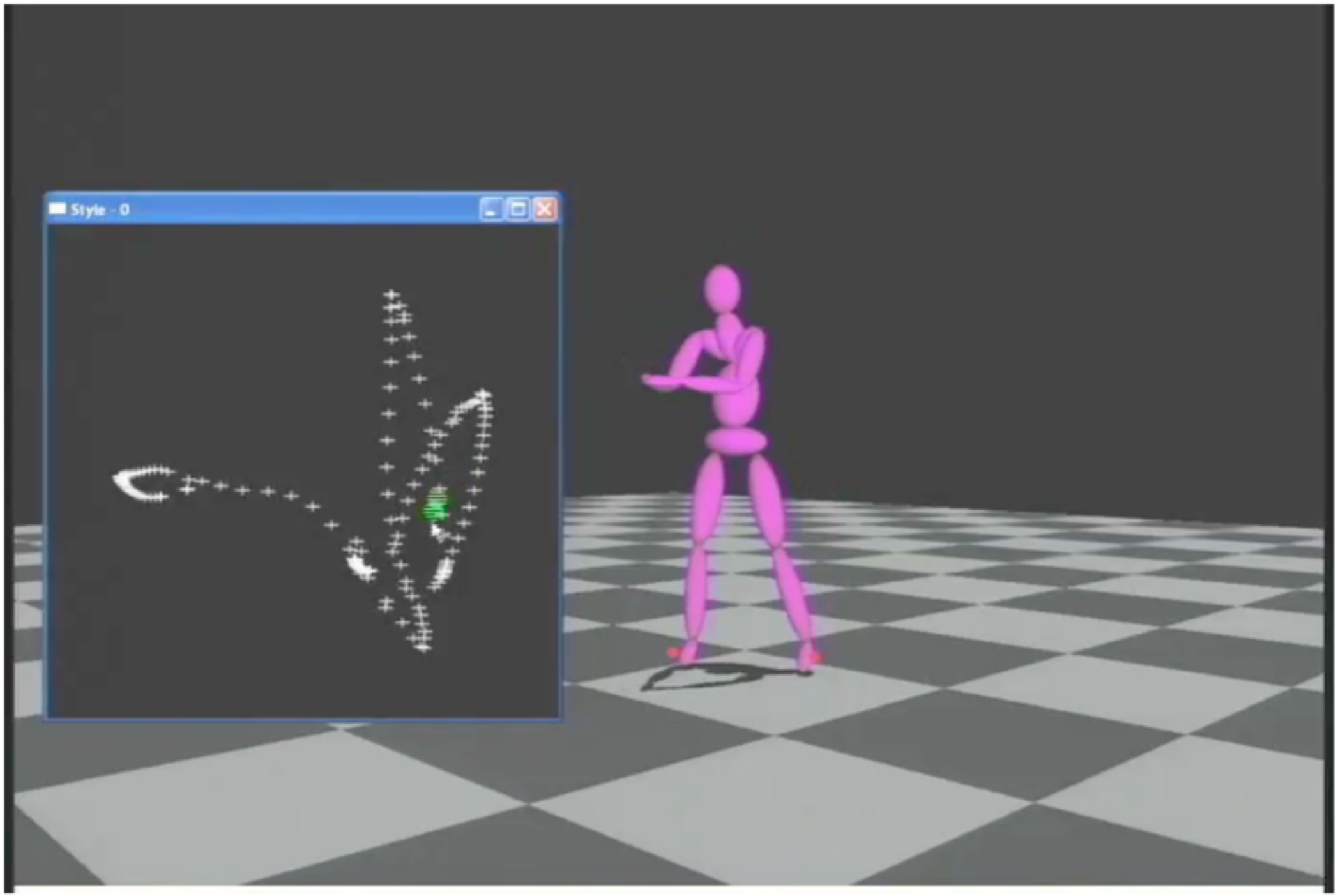


General N-link IK



- want f(θ) = X
  - θ is a vector of N link parameters (angles, extensions)
  - f(θ) is the position of the endpoint (2D coordinates)
  - X is the position of the target (2D coords)
- Given X, find θ

Style-Based IK



Overview

Animation Production

Rigging

- Procedural
- Skeletal
- Anatomical

Posing

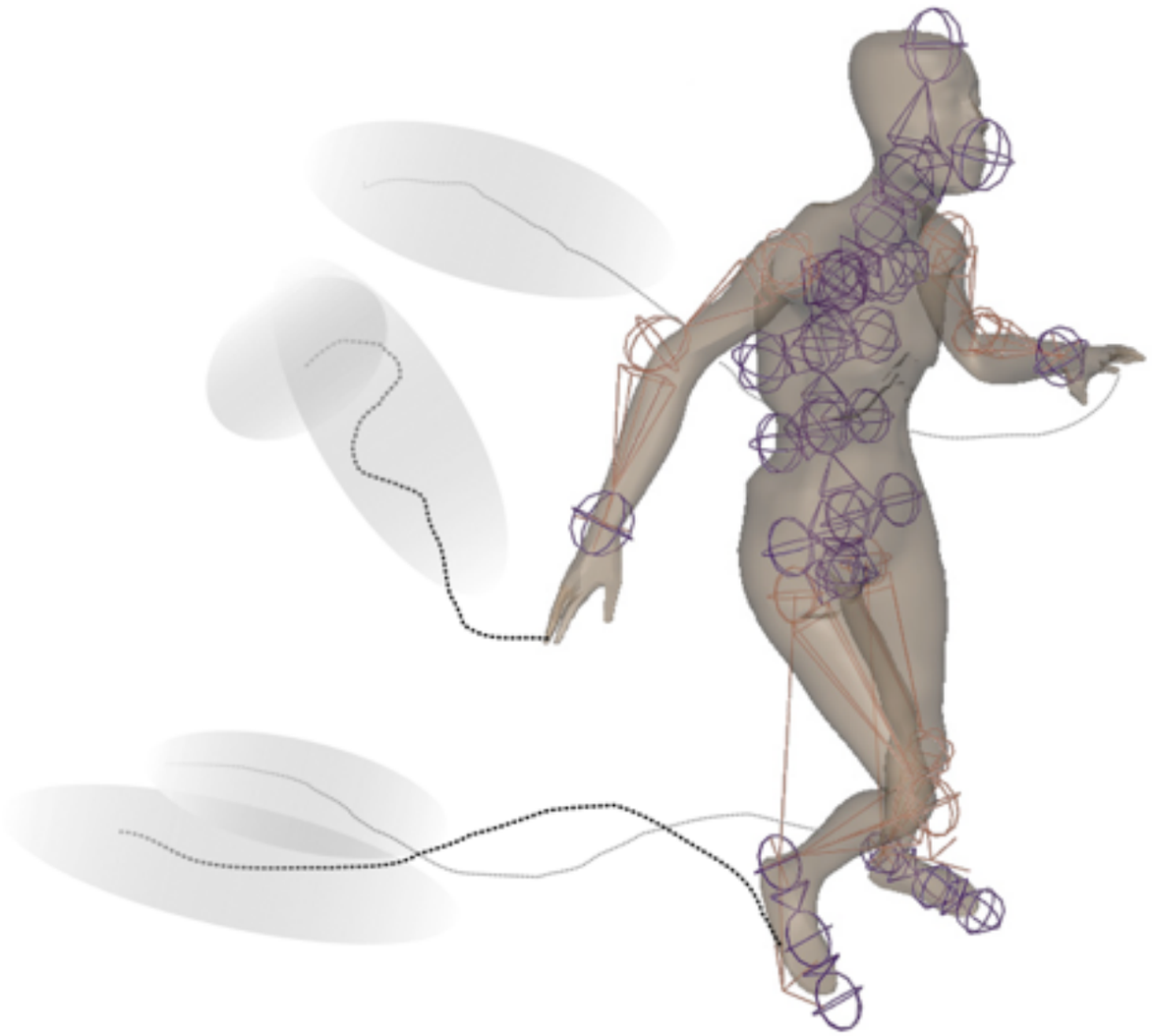
- Forward Kinematics
- Inverse Kinematics
- Advanced Methods (Style-Based IK + MeshIK)

Animation

- Keyframe Animation
- Motion Capture
- Physics-Based Character Animation

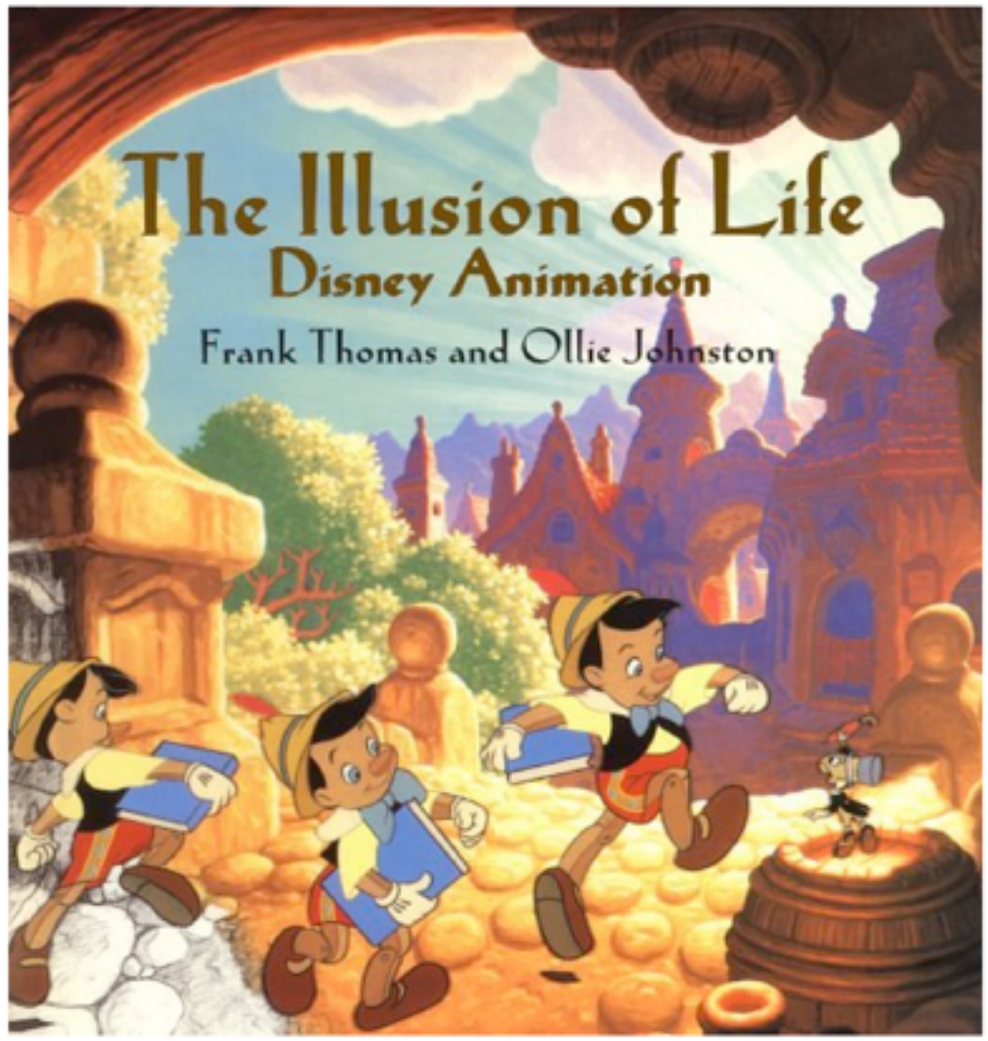
Animation

- Change the rigging parameters over time to generate continuous movement.

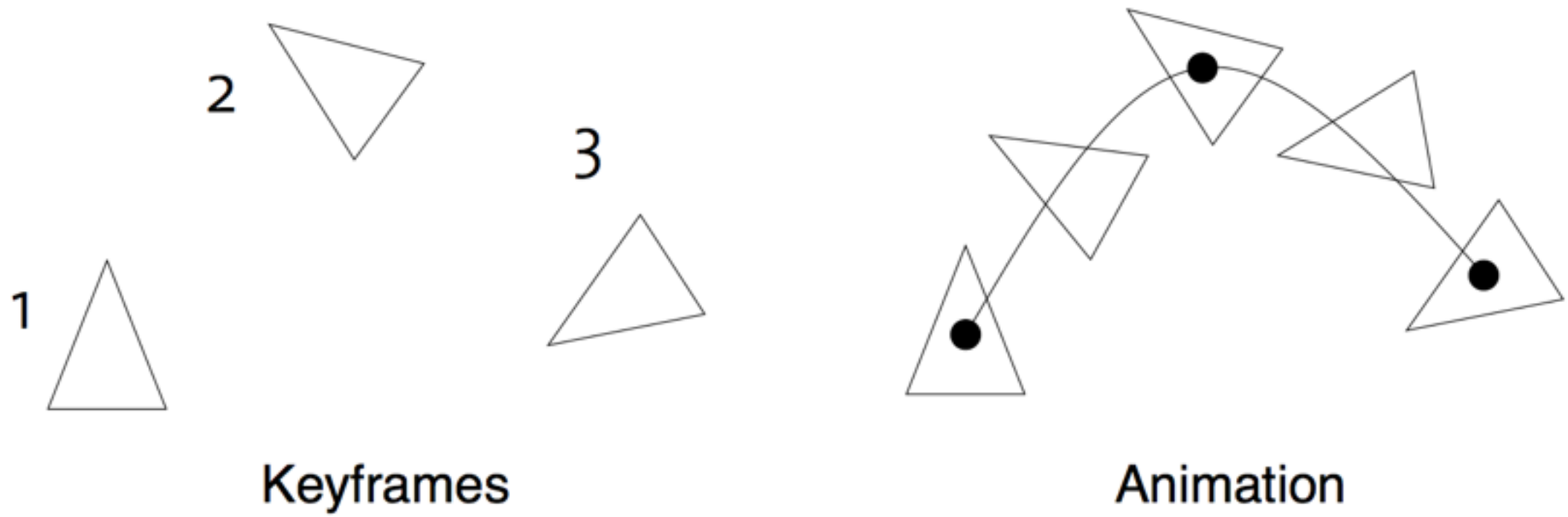


Keyframe Animation

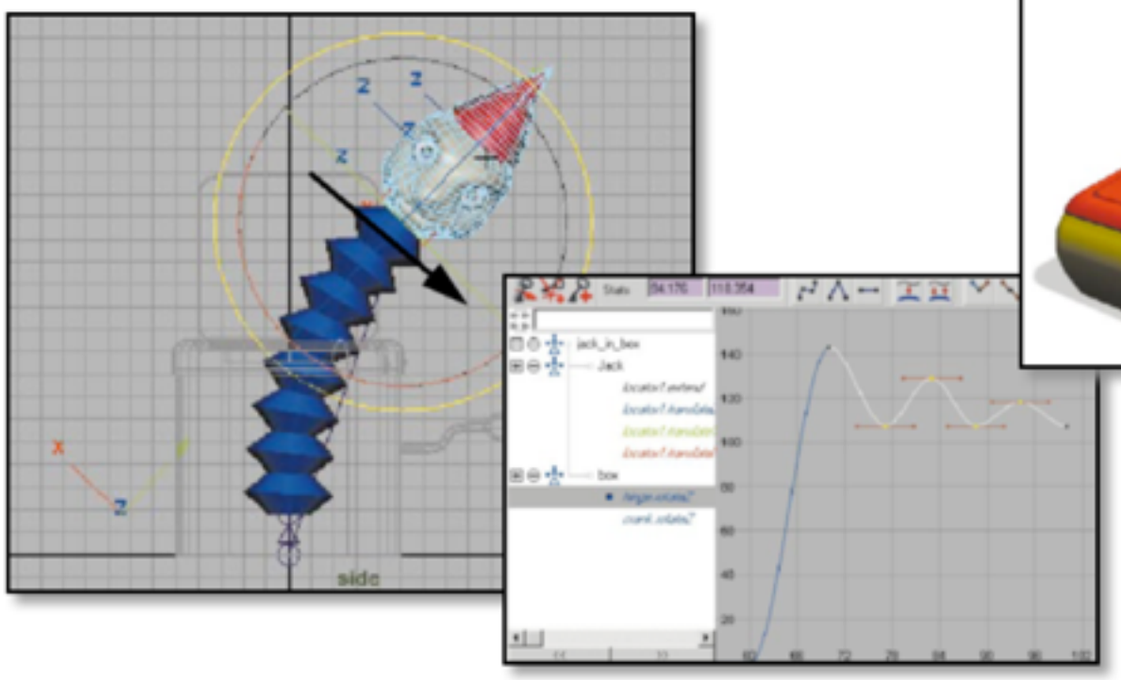
- Traditionally, animator draws character at "extreme" poses
- Fill in in-betweens
- Textbook "Illusion of Life"

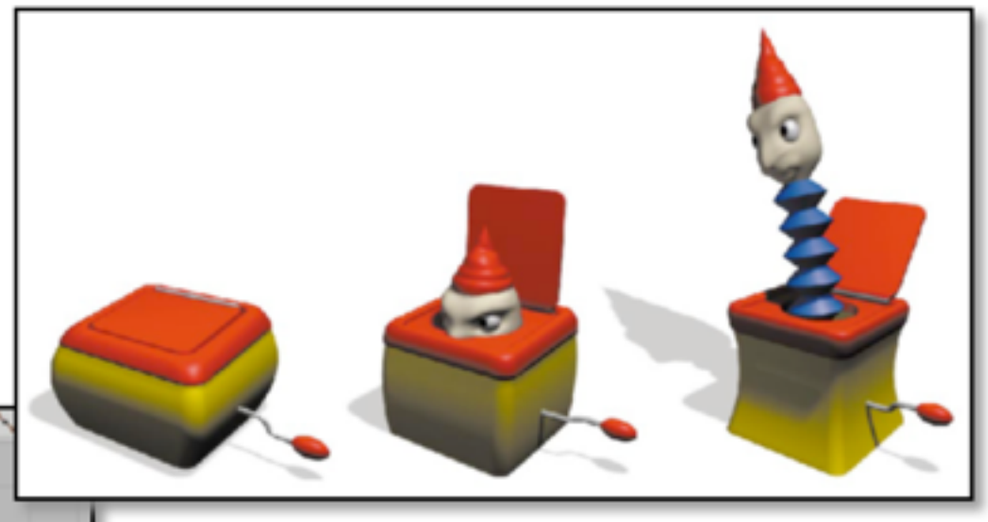


Keyframe Animation



Keyframe Animation





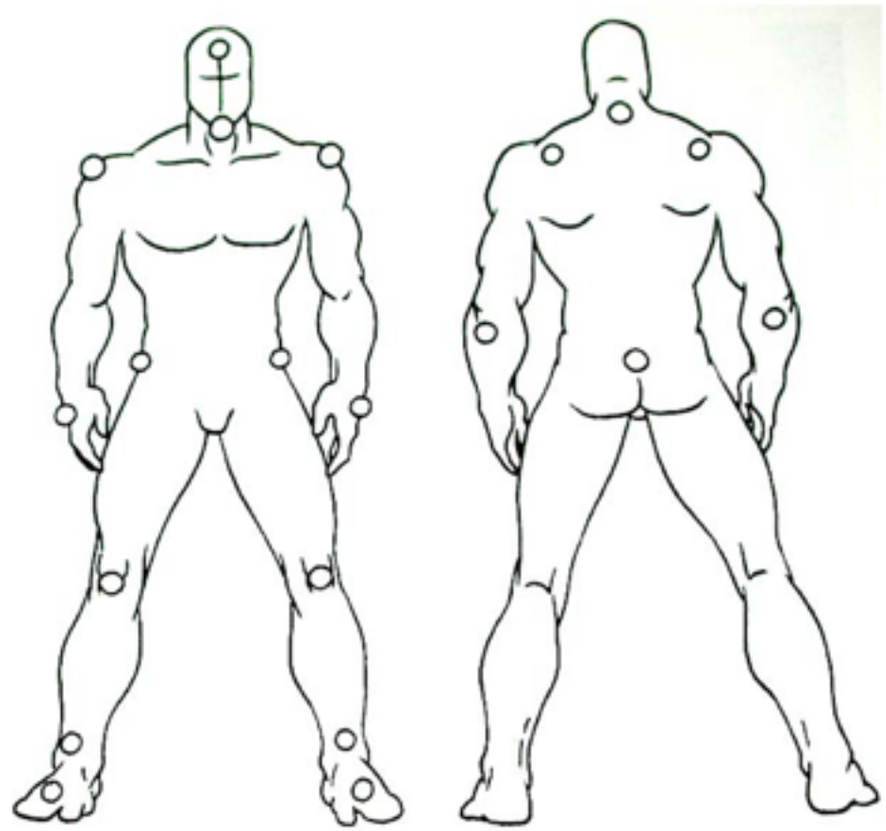
From *Learning Maya 2.0*

Keyframe Animation

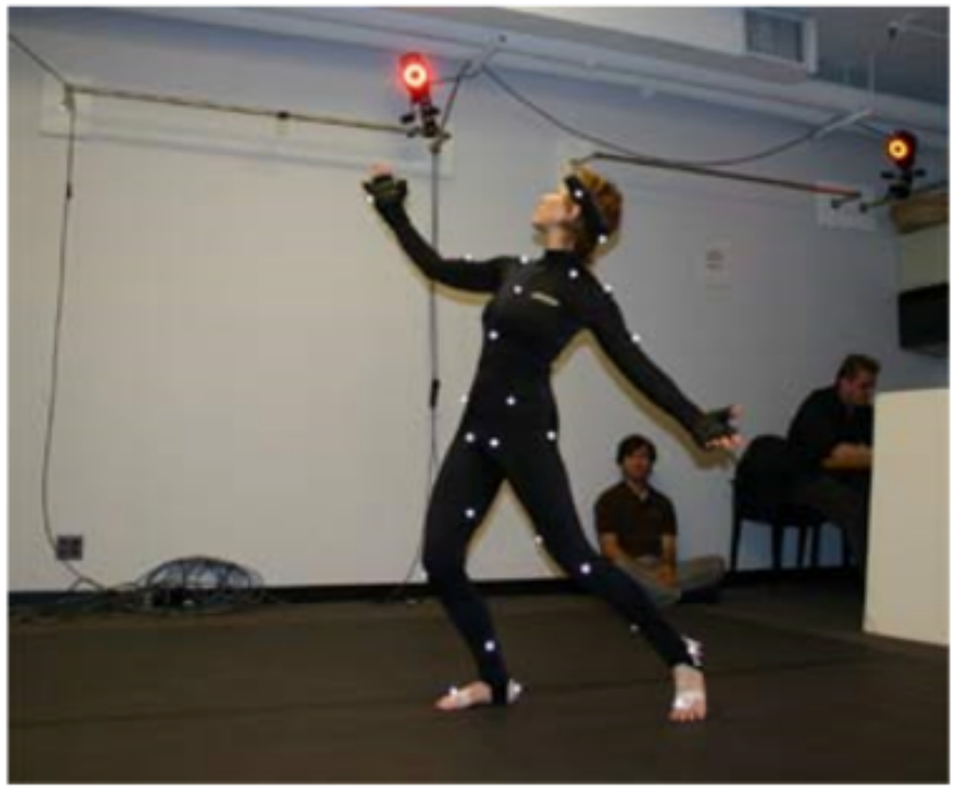
- Expressive! Gives artist total control
- But labor intensive even for talented artist

Motion Capture

- More realistic motion sequences can be generated by Motion Capture
- Extract data from real-world people acting out a scene
- Record live action



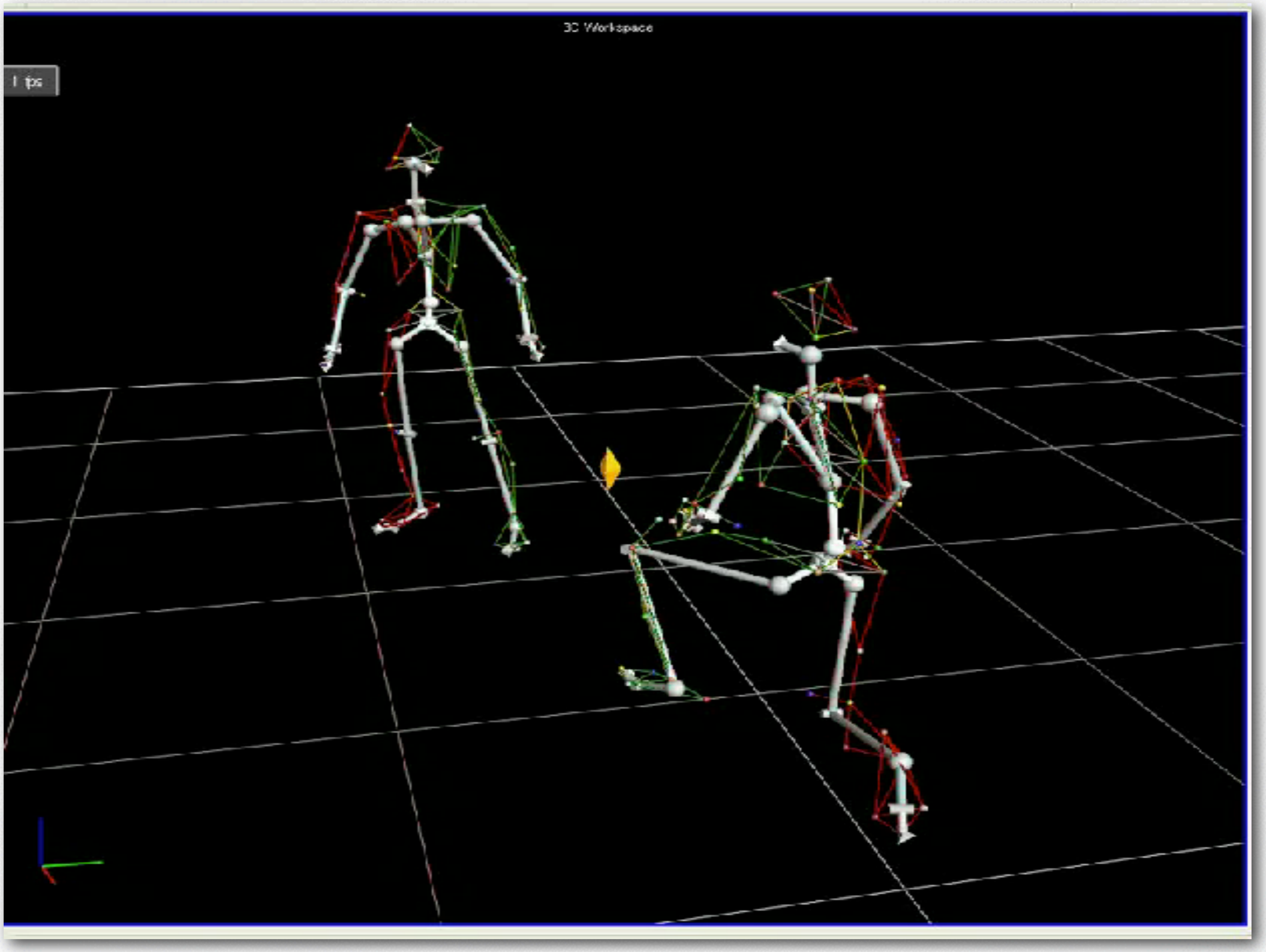
Optical



[Images from NYU and UW]

Motion Capture

Motion Capture



... becomes Mocap Data

IMocap

A new technique developed for Pirates of the Caribbean 2 that enabled ILM to capture performance on location while maintaining a relatively small footprint.

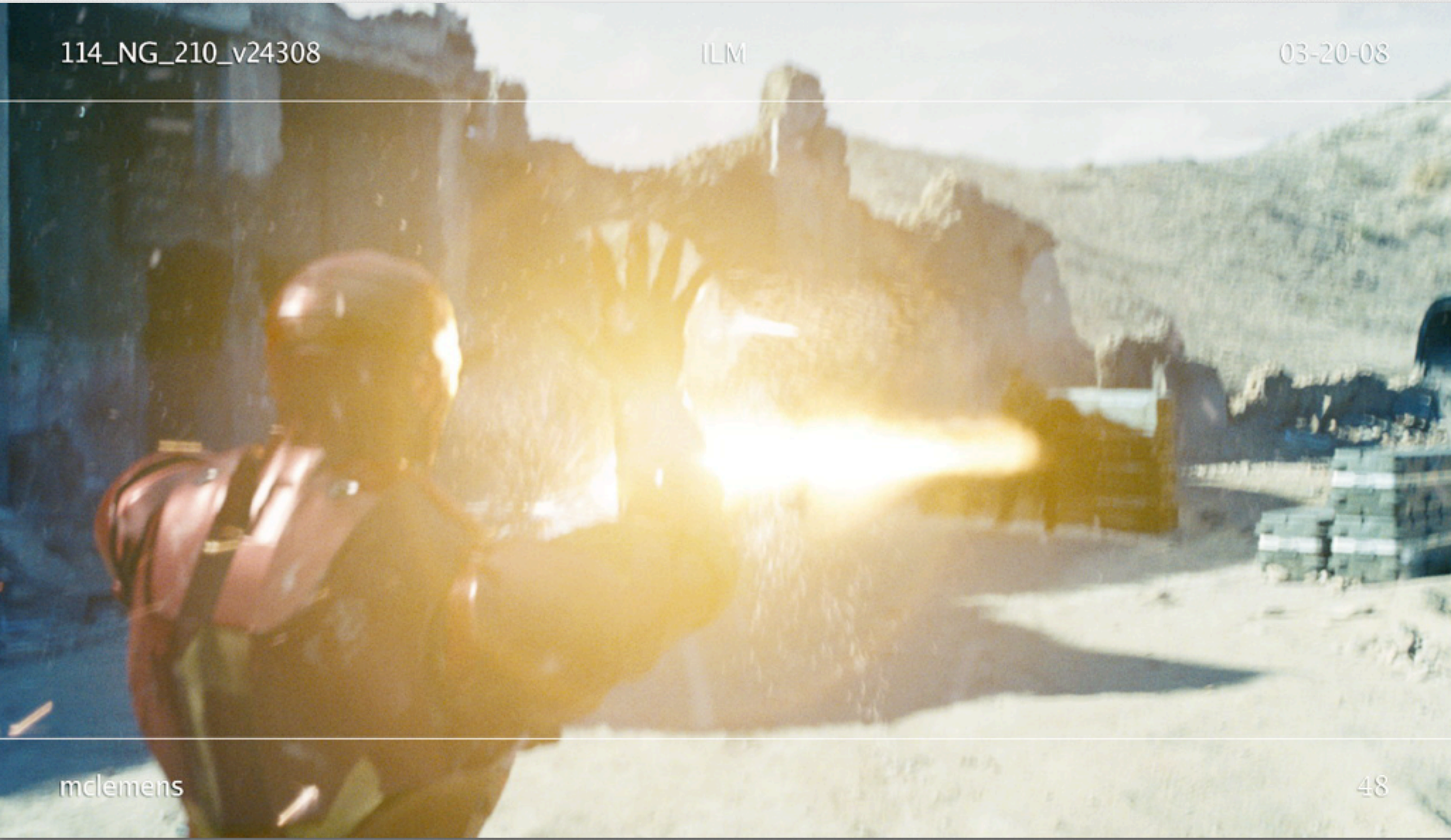
IMocap

IMocap

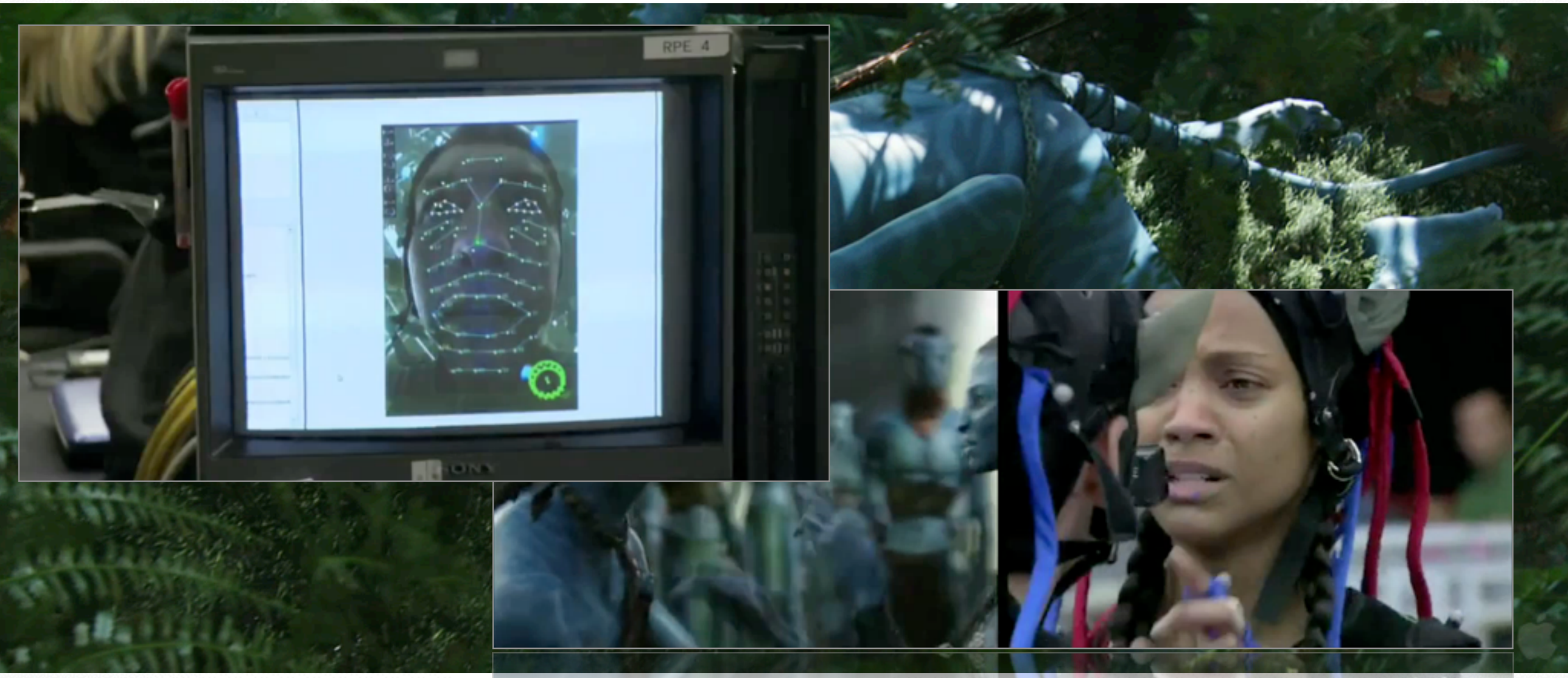

2008-03-13 16:32
NG210
talmage
114_NG_210_v23778
ILM
03-13-08
70
75
80
talmage
30
30
layout v2.2
ng210.layoutCamera
20.92 mm

IMocap

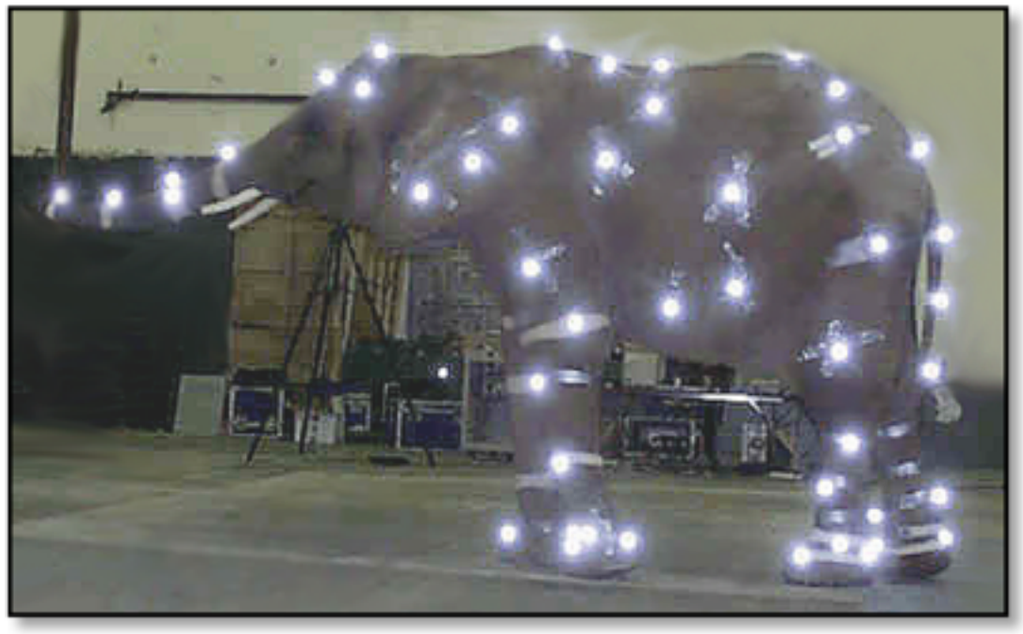
IMocap



Performance Capture

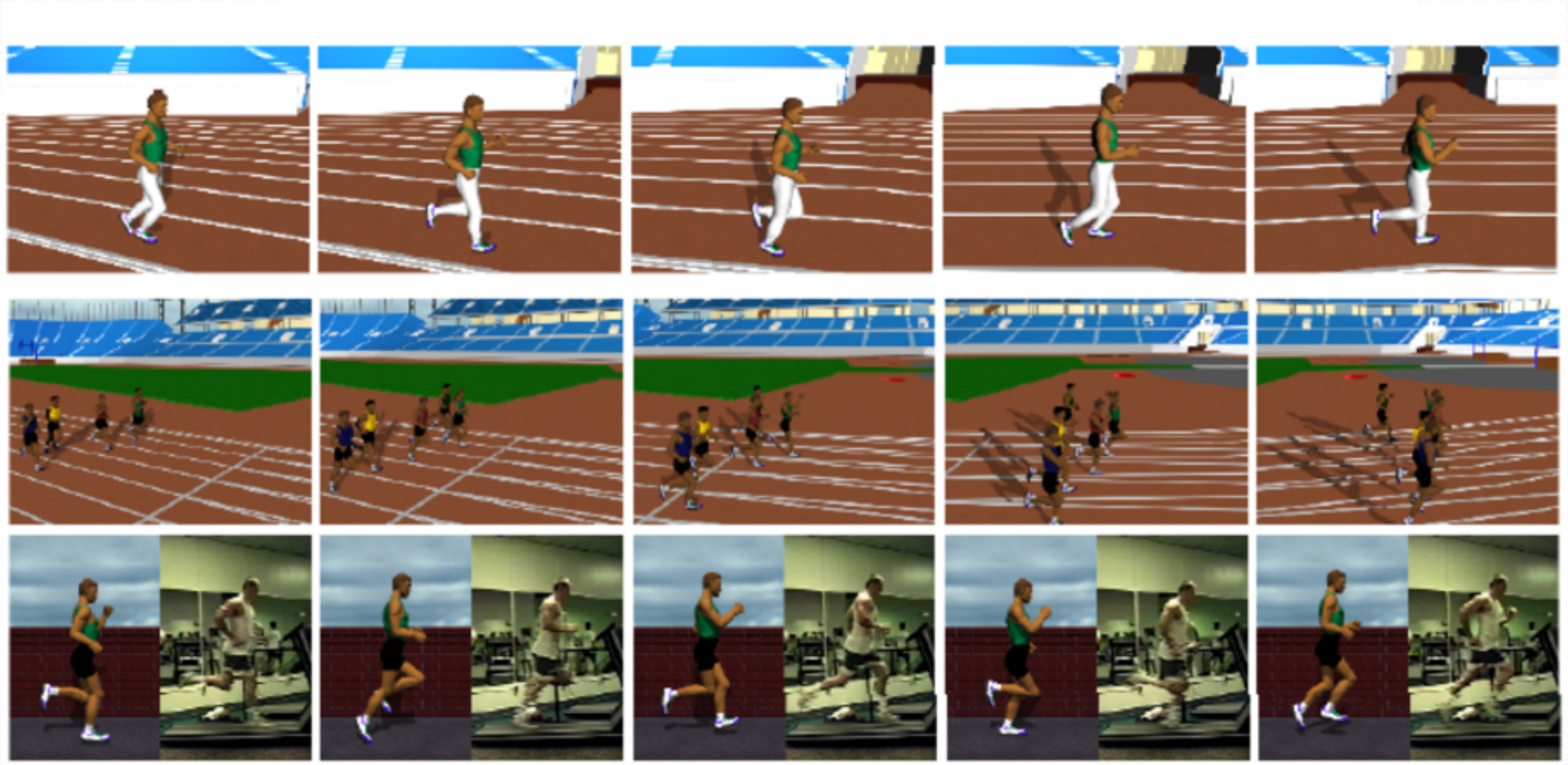


We can capture these…



Motion Capture???

Physics-Based Character Animation

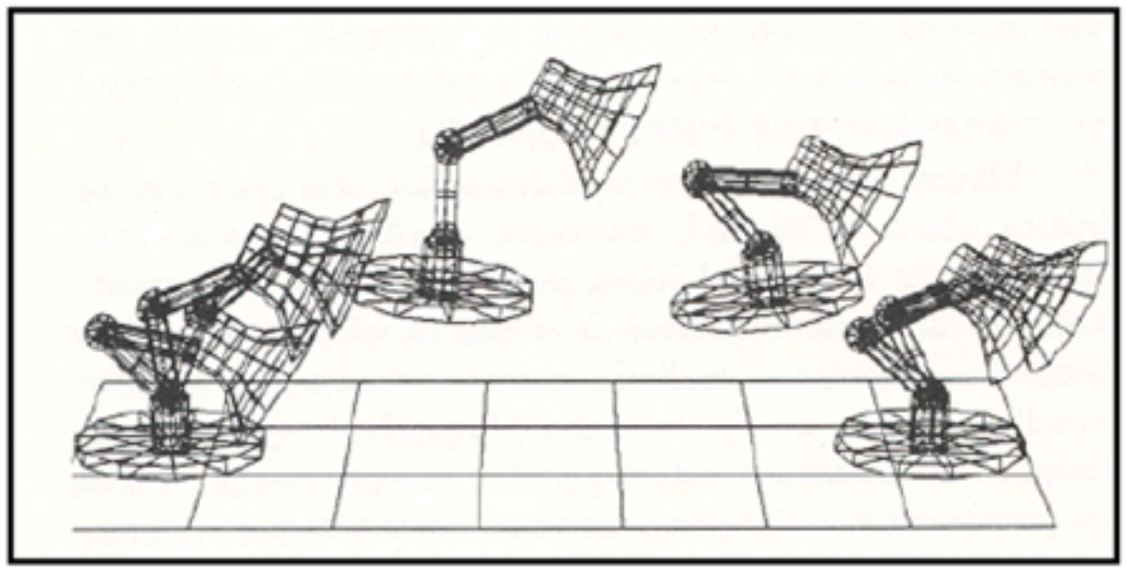


Olympic Running

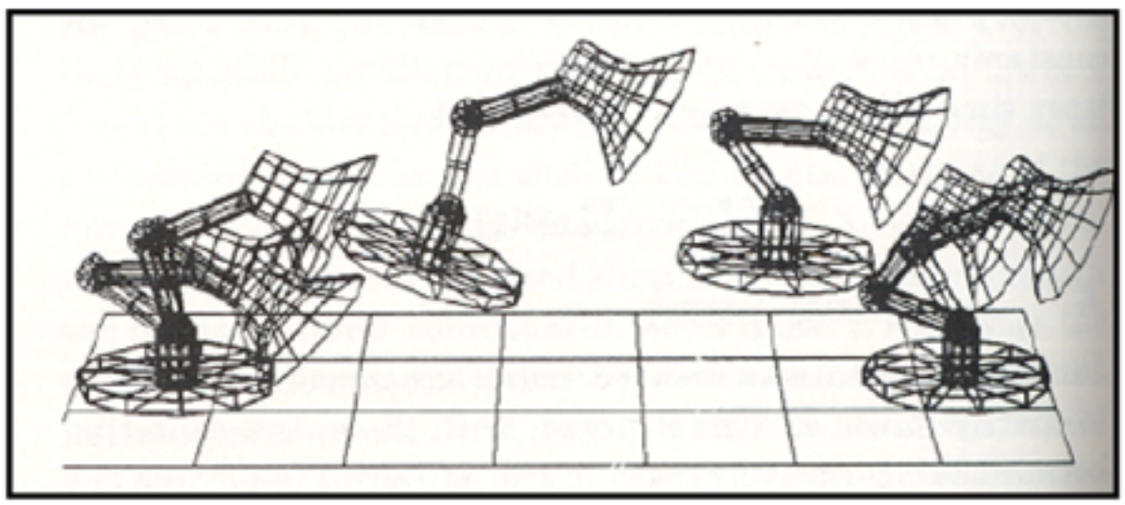
Physics-Based Character Animation

Vaulting, Cycling and Running

Space Time Constraints

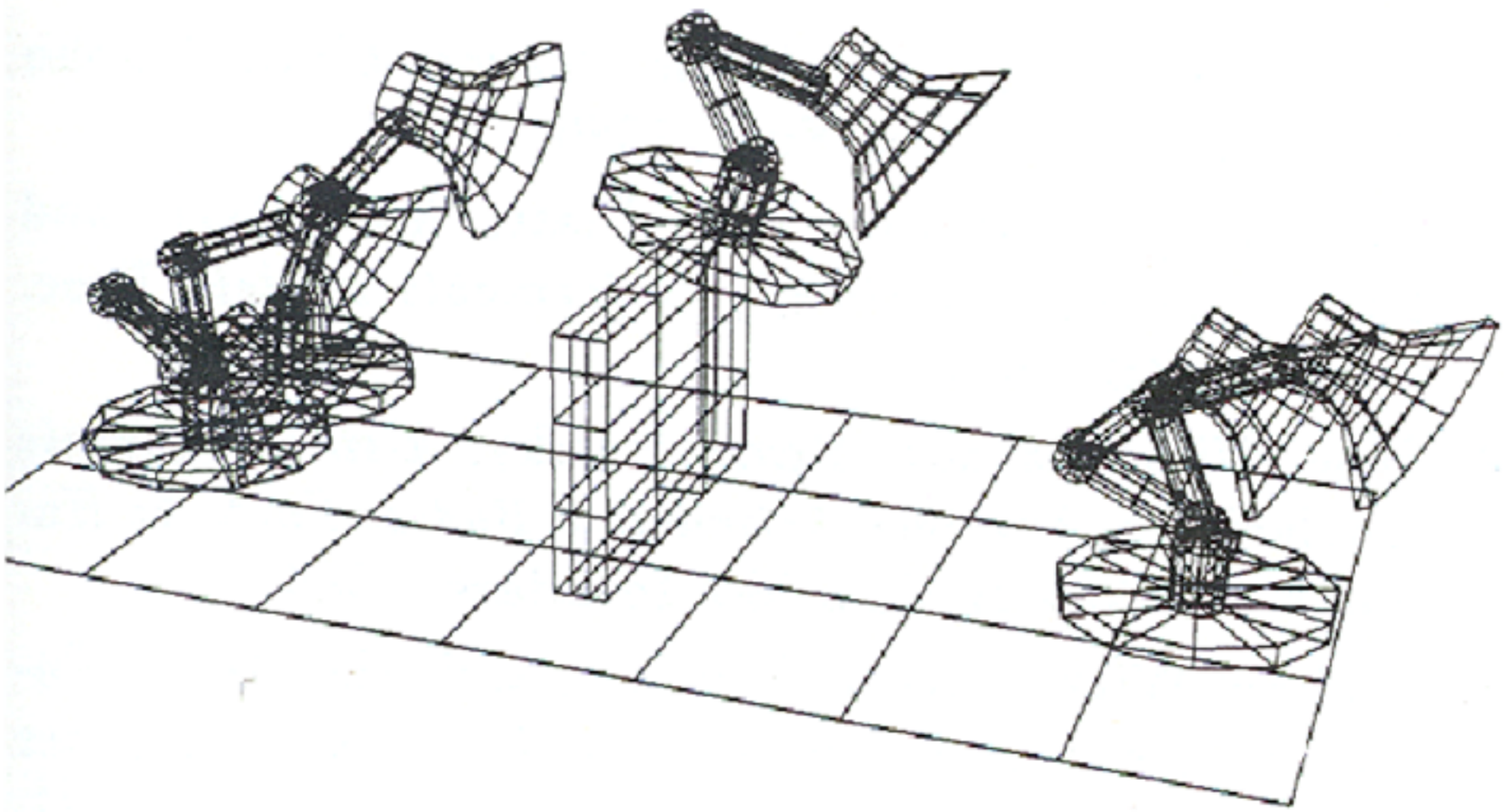


Original Jump



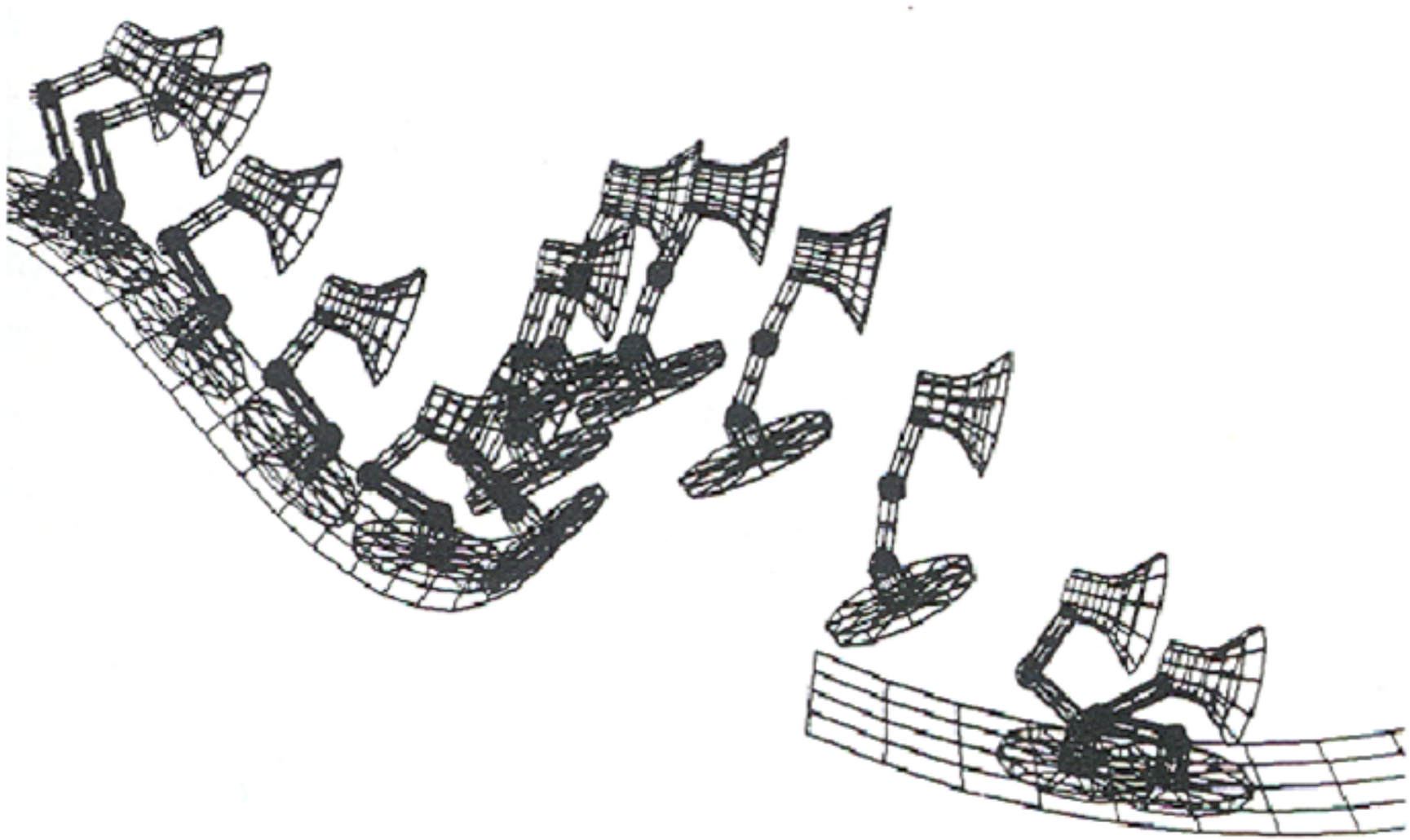
Heavier Base

Space Time Constraints



Hurdle

Space Time Constraints



Ski Jump

http://cs420.hao-li.com

Thanks!