# 11.2 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
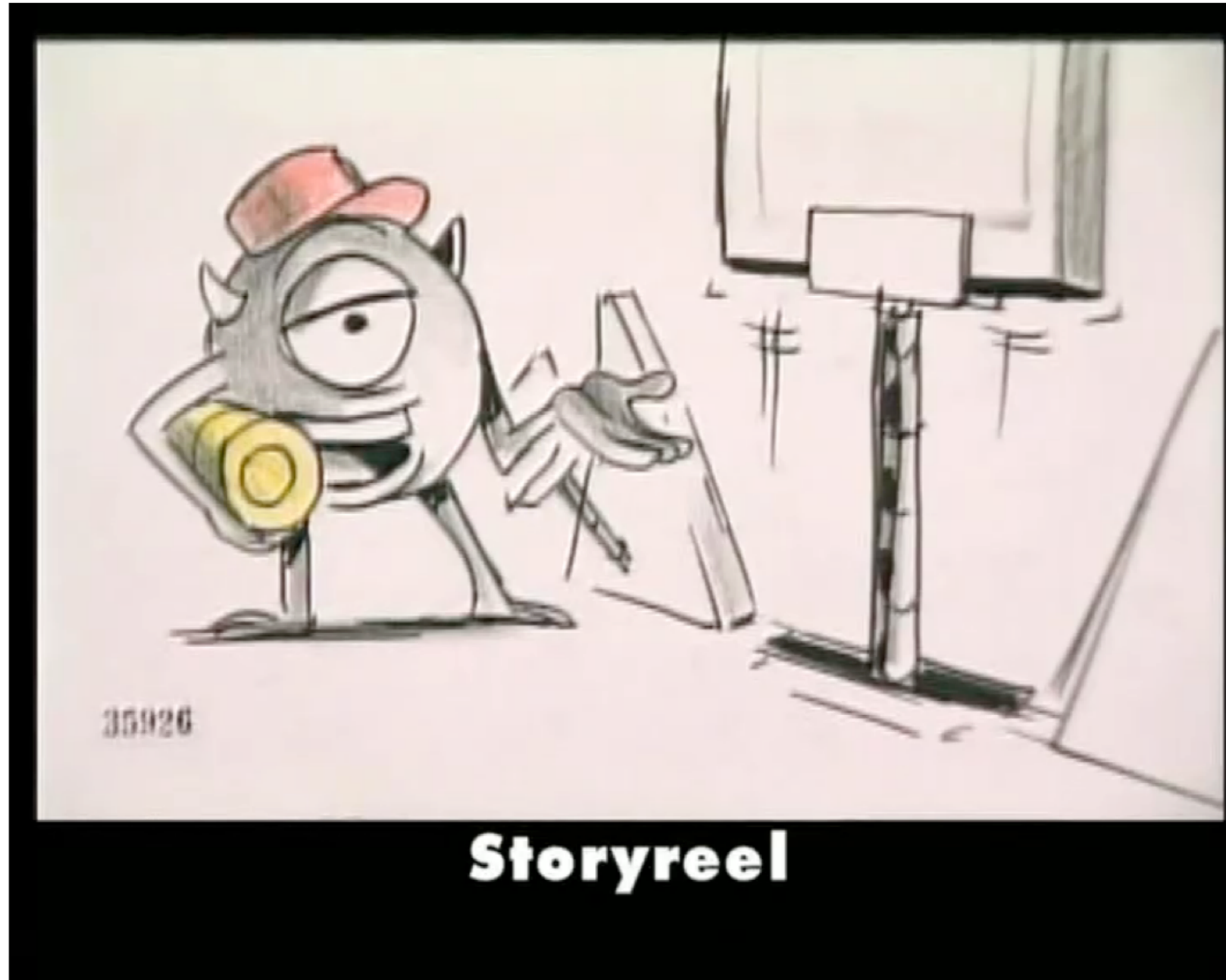9. Special Effects
10. Shading
11. Lighting
12. Rendering

# 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

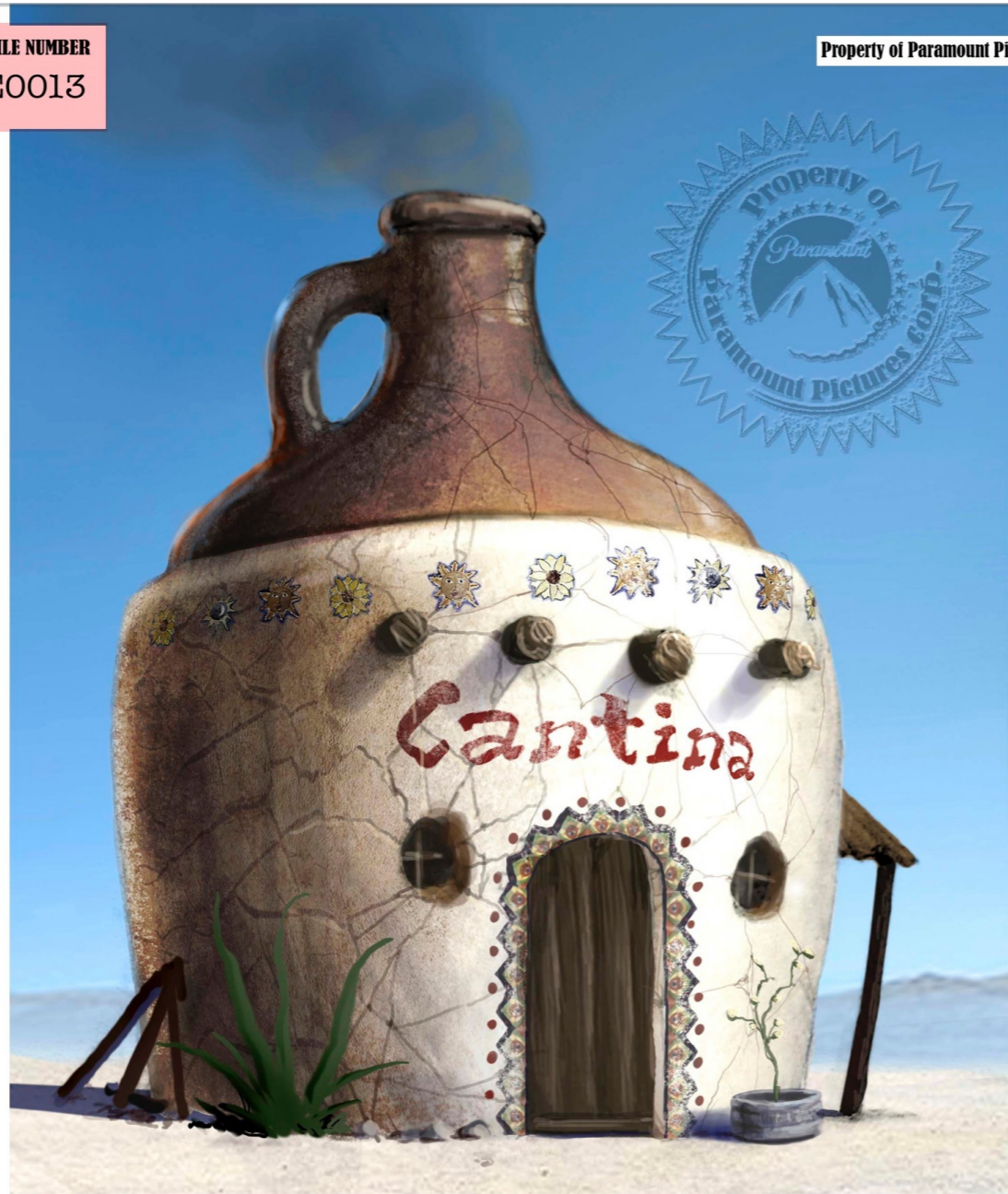# Animation Production

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



Storyreel

# 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

**FILE NUMBER**
E0013

Cantina

| Location # | | Set # | | APPROVAL STATUS | | | |
|---|---|---|---|---|---|---|---|
| | LOC-06 | | SET-039-EXT | REFERENCE ONLY ☐ | ROUGH ☐ | **FINAL** | ⭐ |
| **Description** | | | | | | | |
| Cantina | | | | Approval Date | | Approval Signature | |
| | | | | 10/20/08 | | | |
| **NOTES** | | | | | | | |
| NEW SET NUMBER - PLEASE REPLACE | | | | | | | |

INDUSTRIAL LIGHT & MAGIC

**APPROVAL STATUS:**
☐ Ref. Only  ☐ WIP  ☐ Final
**APPROVAL DATE:**

**APPROVAL STATUS:**
☐ Ref. Only  ☐ WIP  ☐ Final
**APPROVAL DATE:**

(...ariations)

# 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
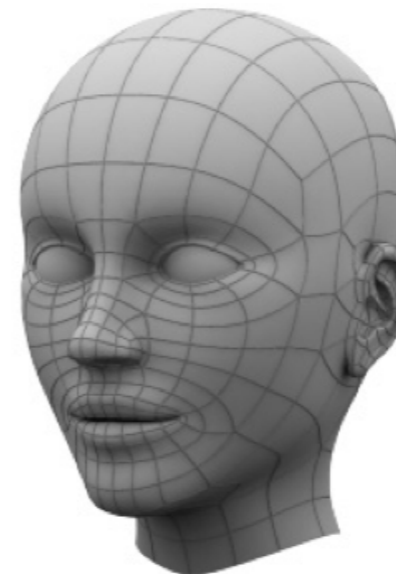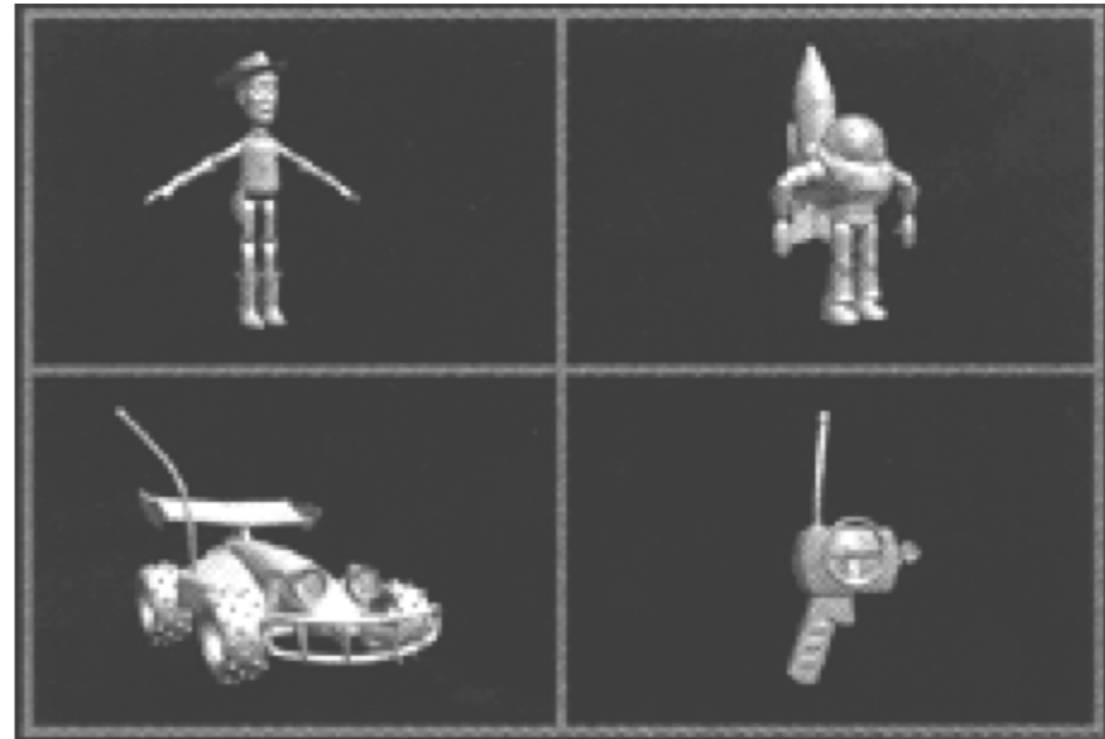
# Modeling

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

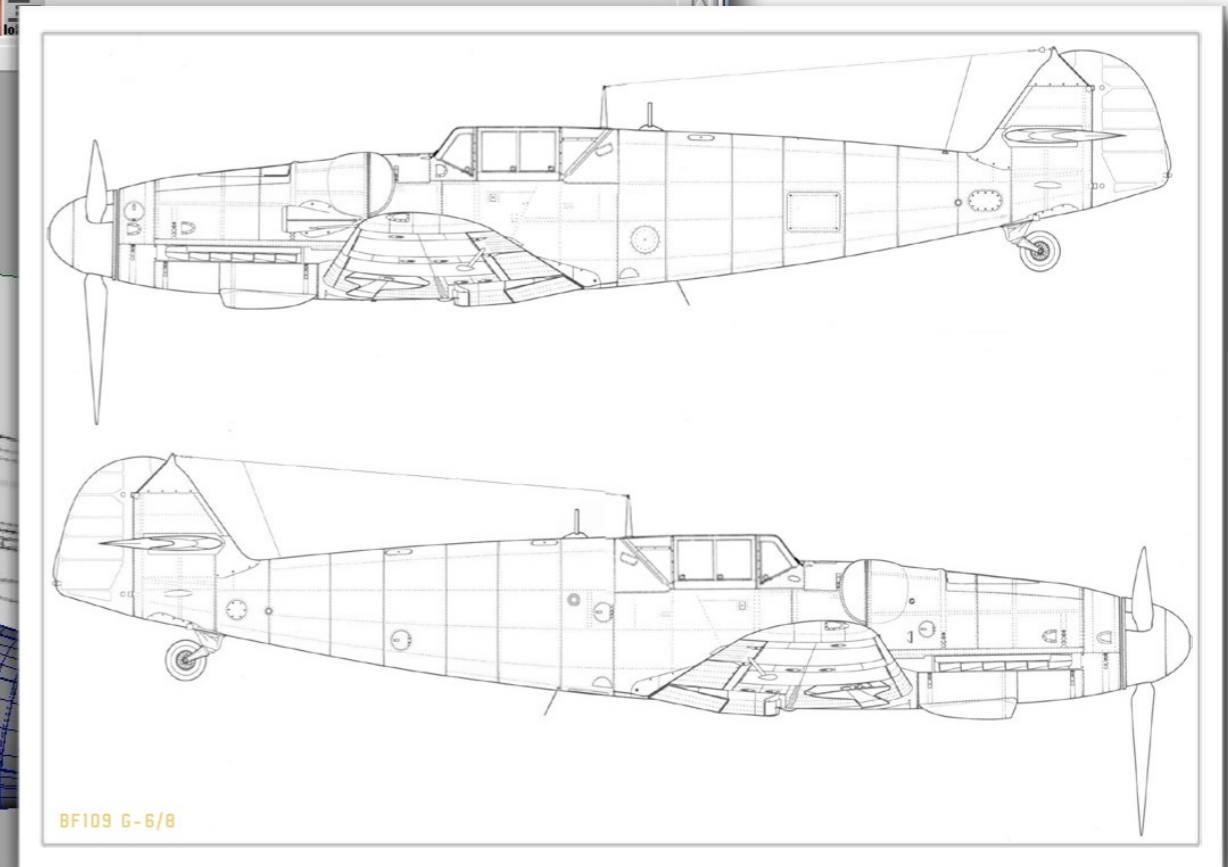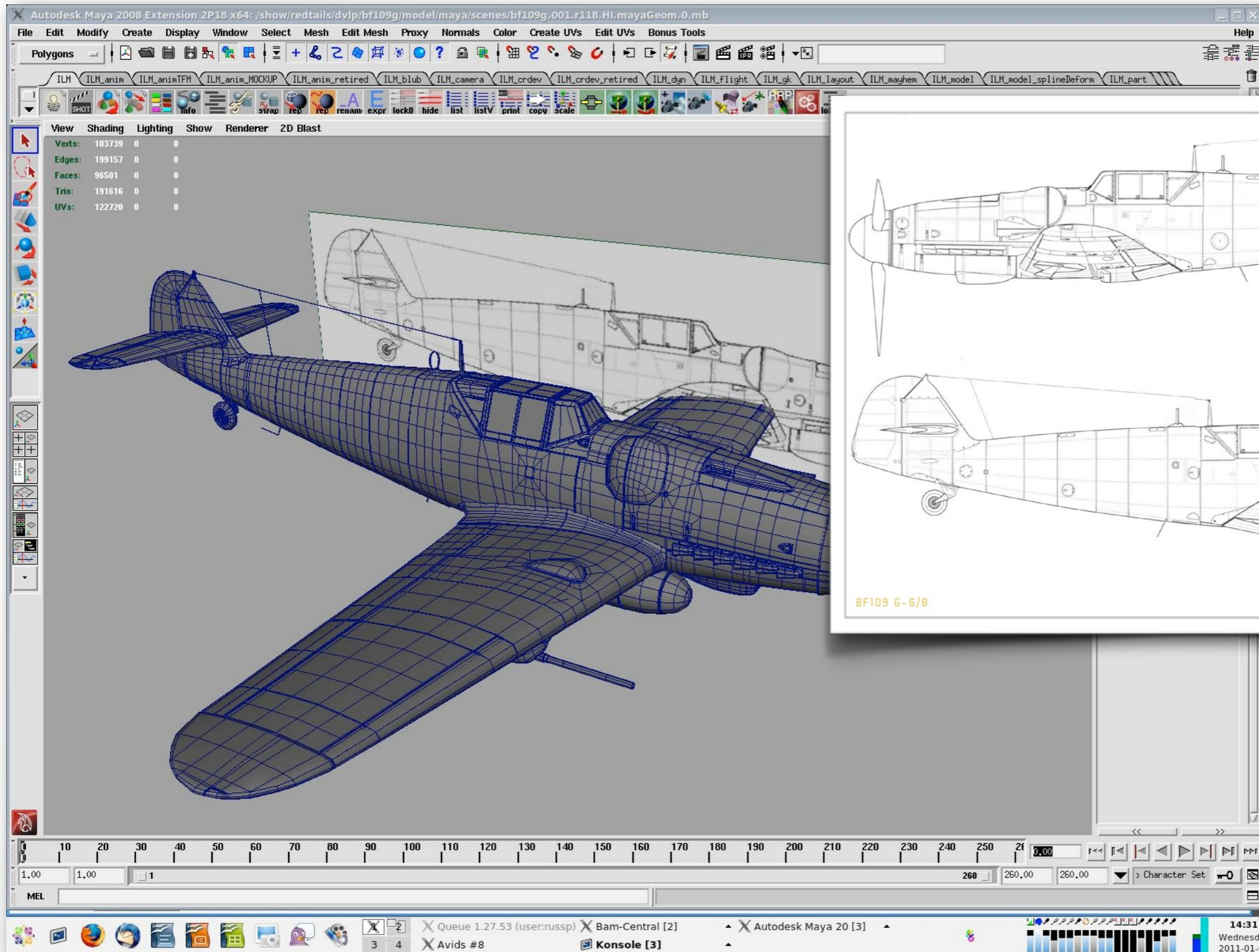# **Hard** Surface Modeling

Rango: The town of Dirt...

# Hard Surface Modeling
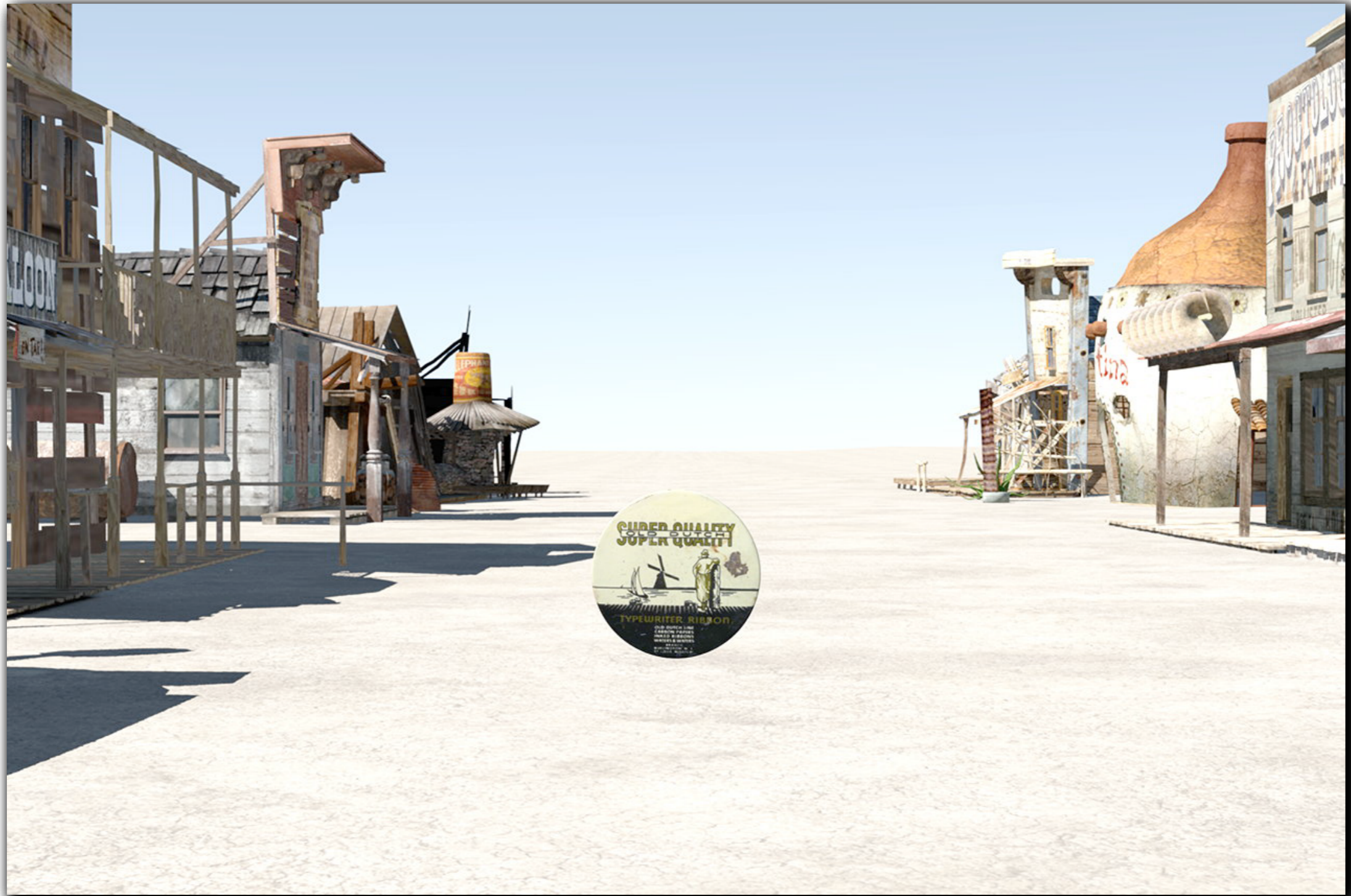
# Hard Surface Modeling

Modeling in Maya using reference images...

final asset



INDUSTRIAL
LIGHT & MAGIC

Y C G M R B

*redtails*

Shot: bf109g

CG COMP - Take 85

Date:    Sep 08 2010 03:10:57

PTS #:  CGRED-06596

artist: davew, td: davew;  HDR.bf109g bf109g.td.generic1.v33.7.zshot bf109g.turntable.0.ct;  Generic 1
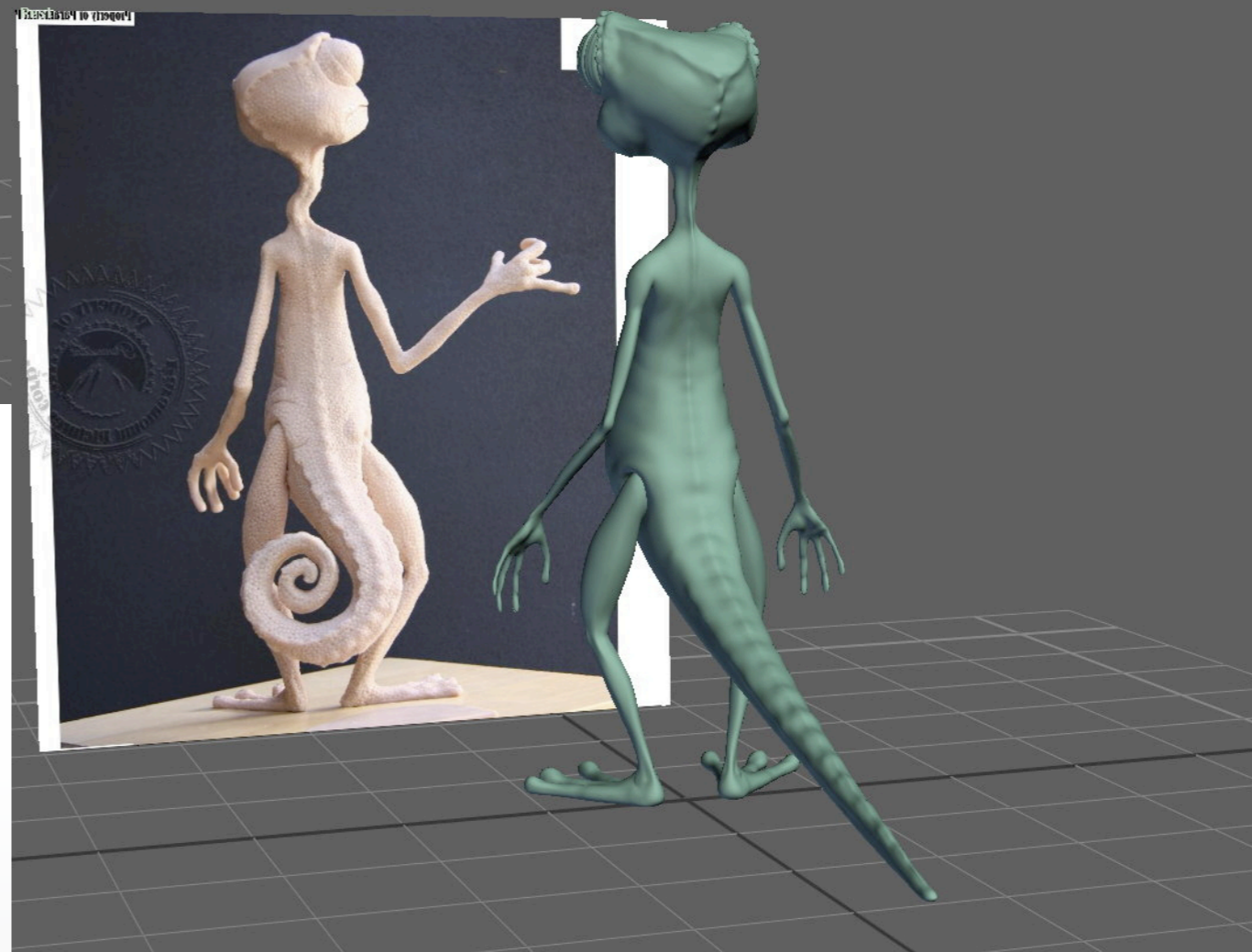variation w Gregs latest paint

Frame Range: 1-260

# **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
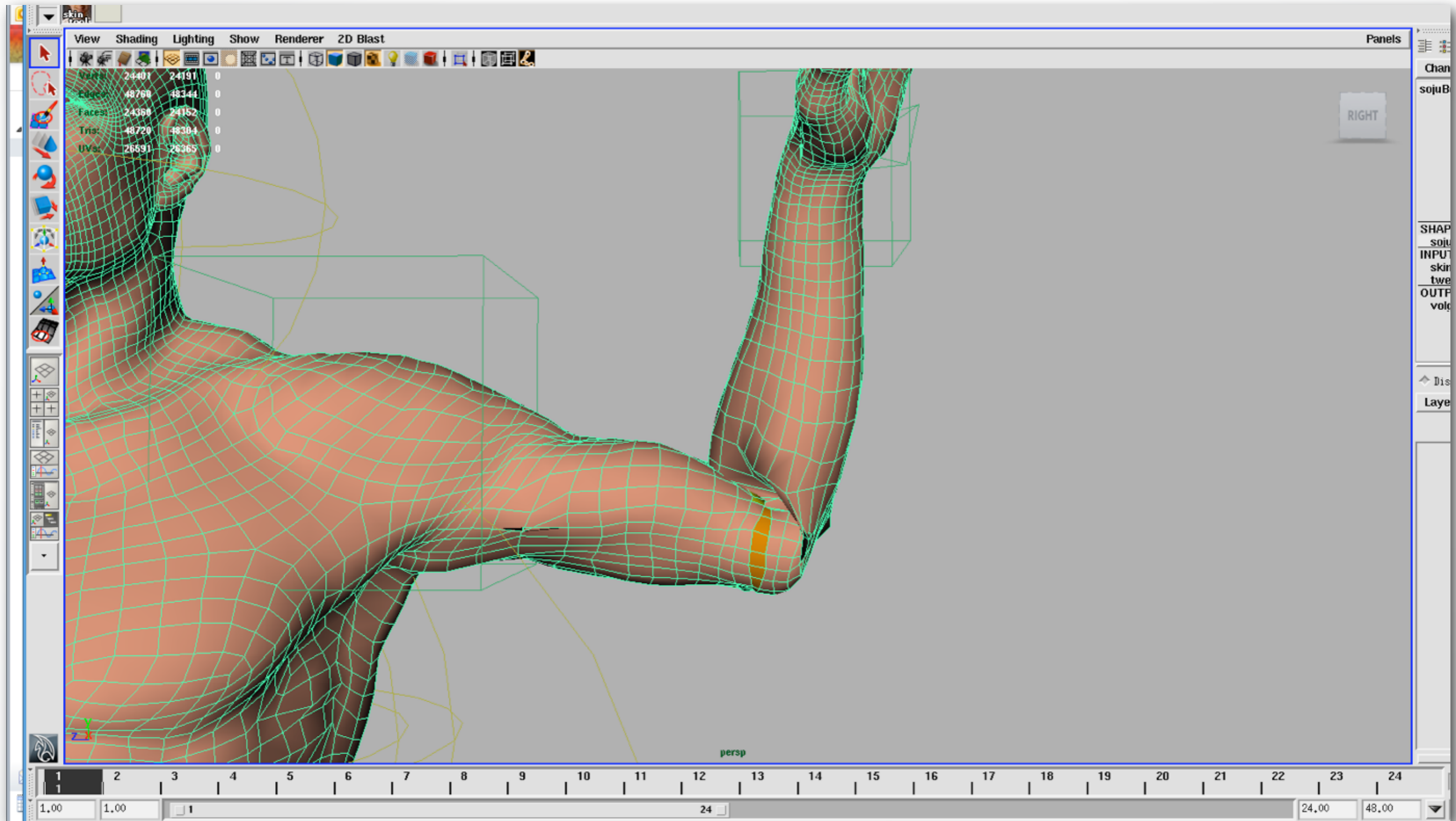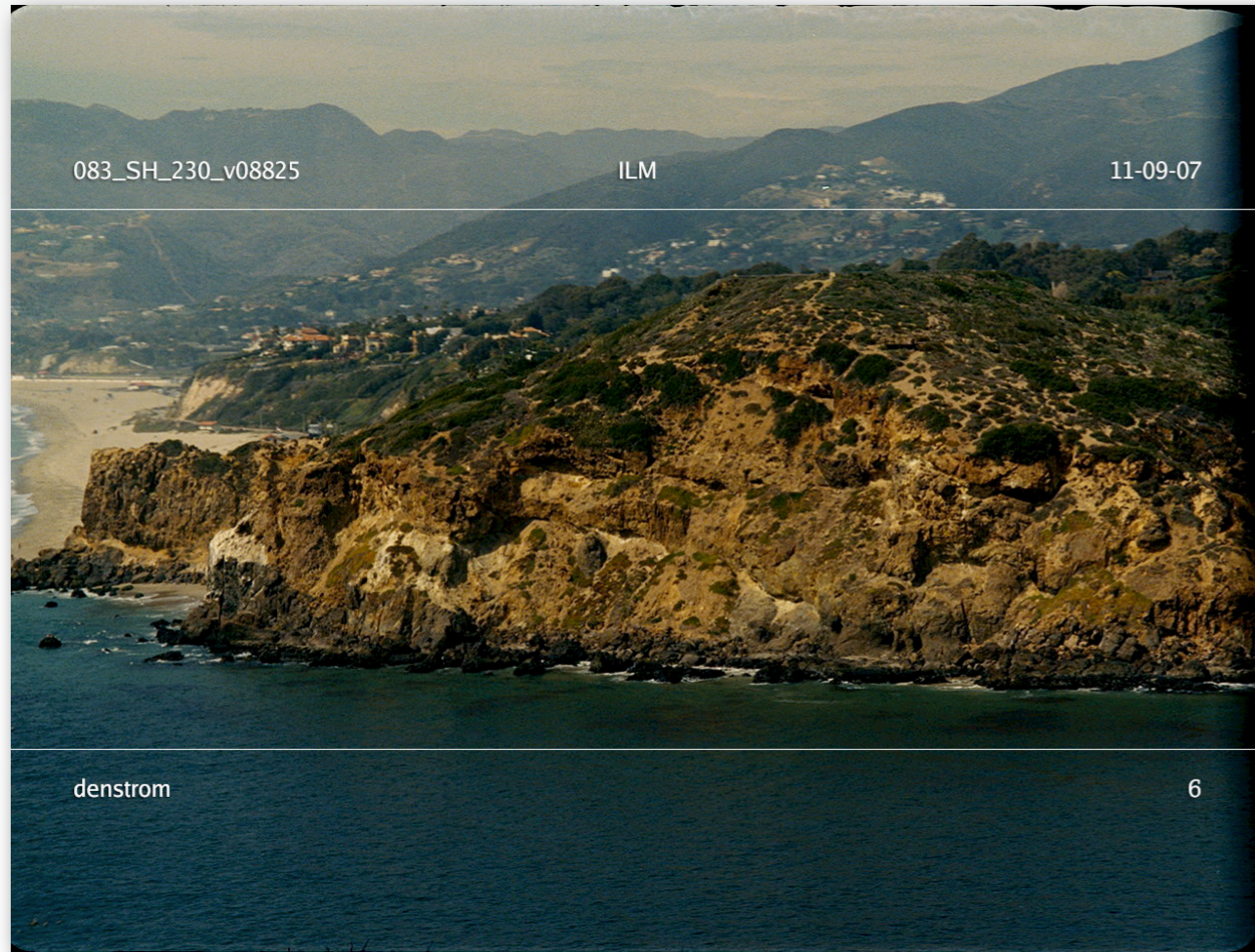11. Lighting
12. Rendering

# 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
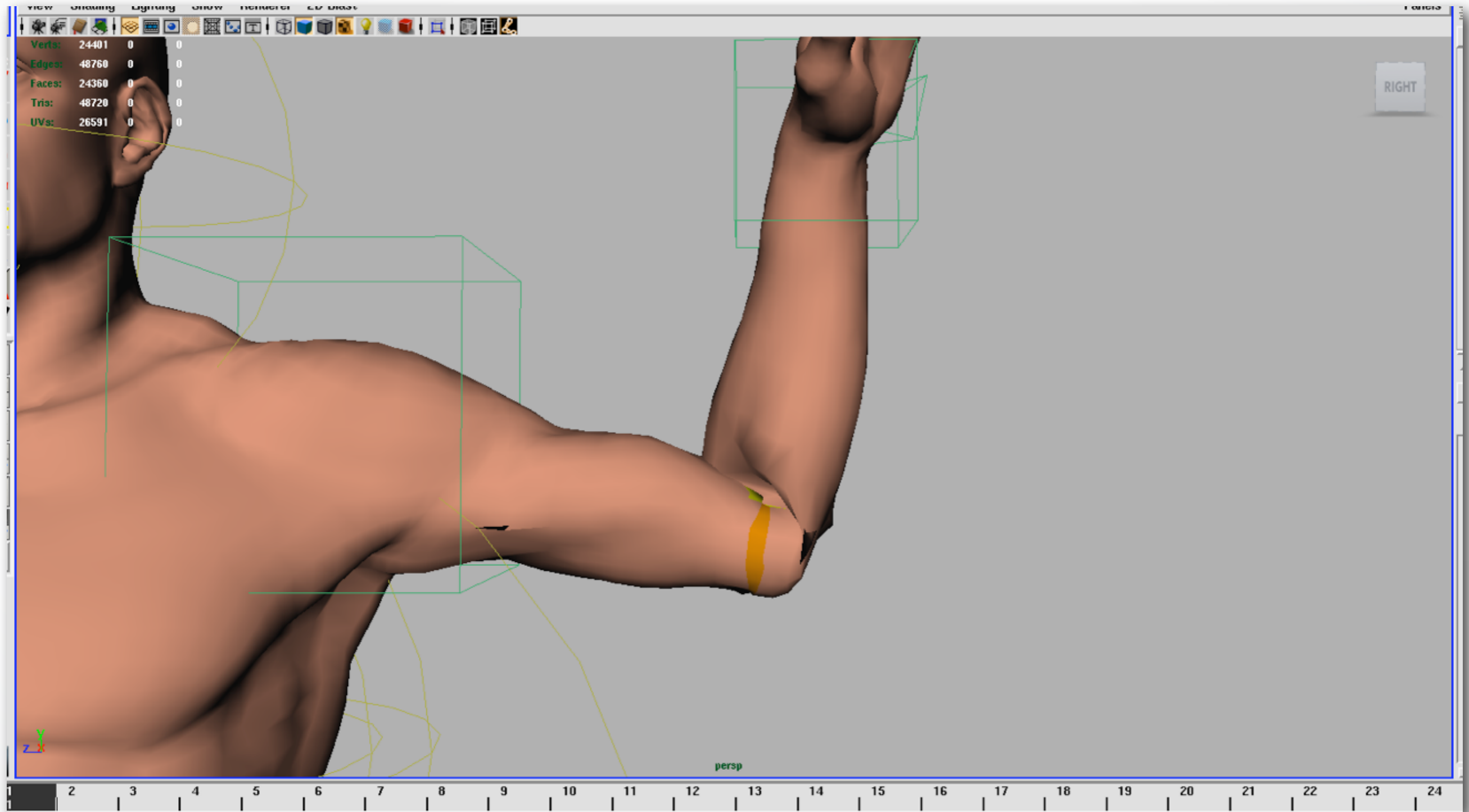
# Animation Production

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
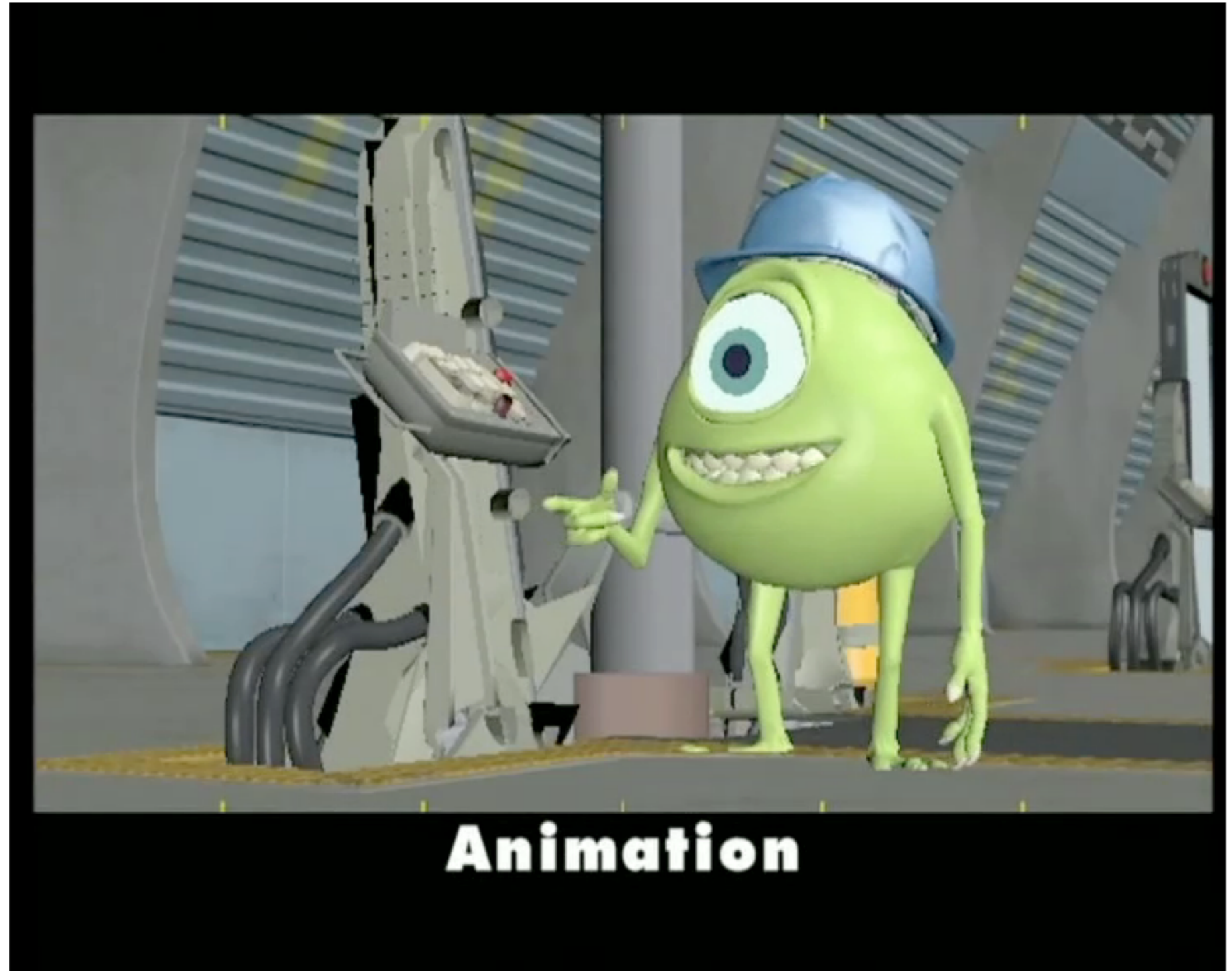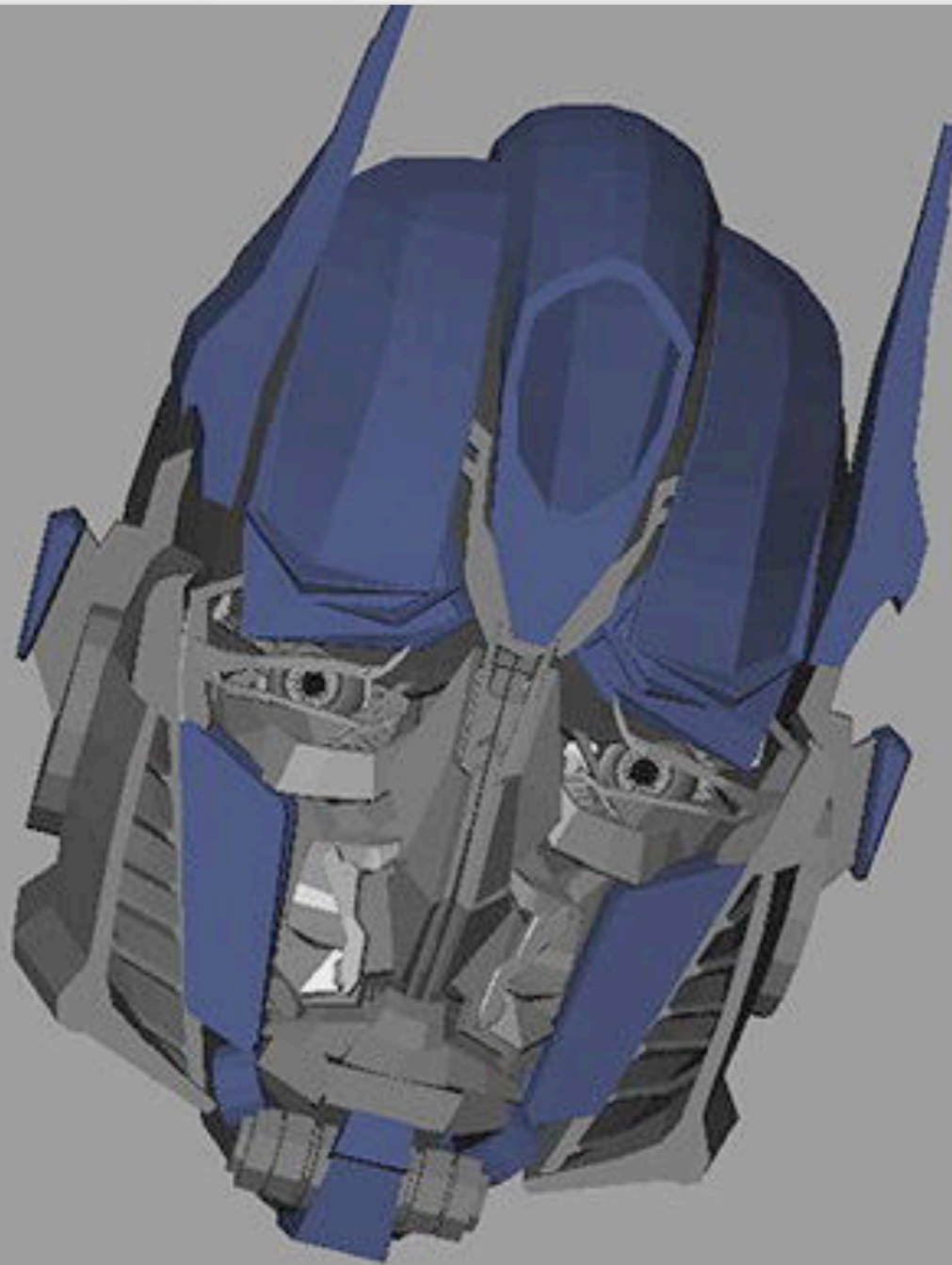
# Animation Production

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
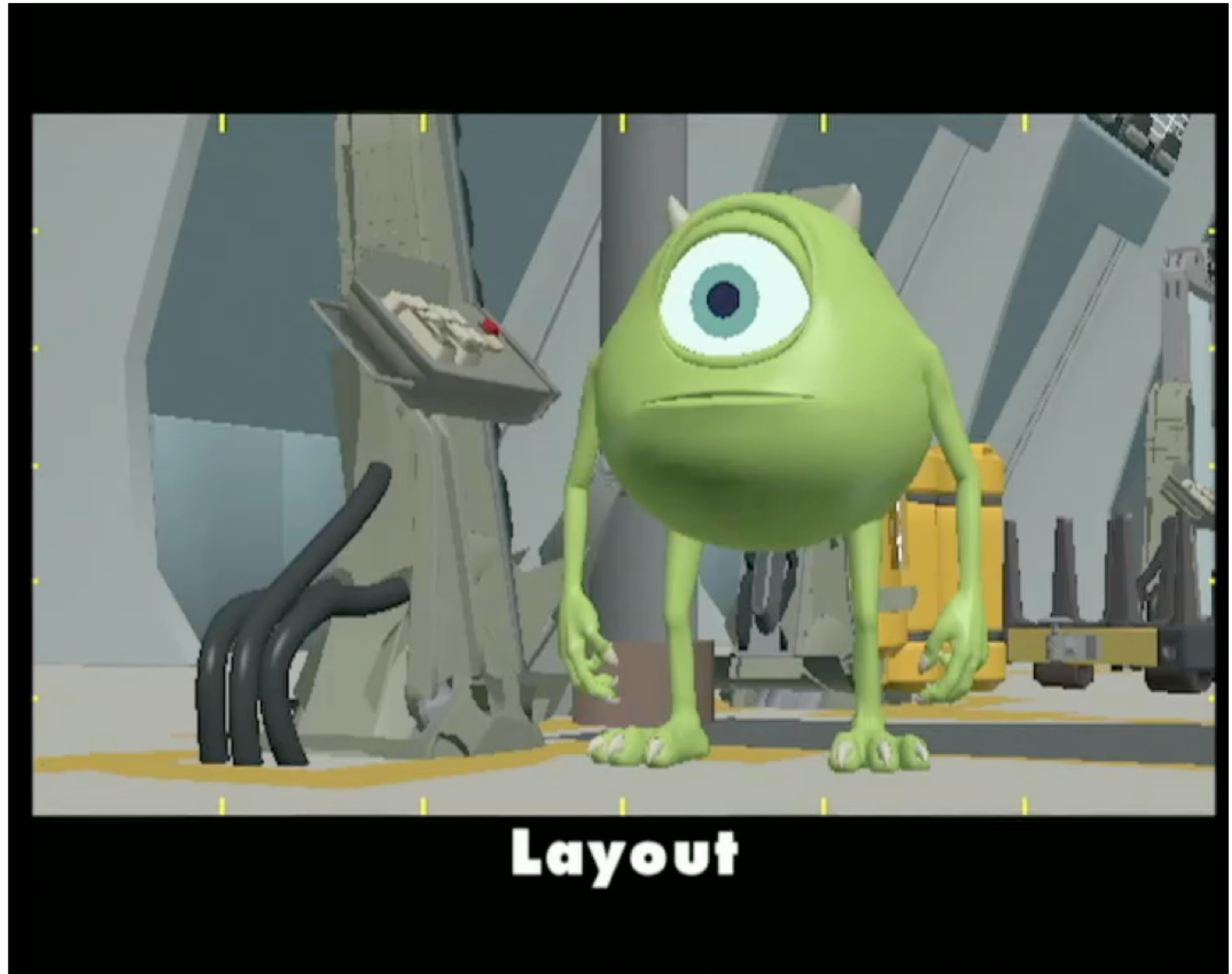


Layout

**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



083_SH_230_v08825    ILM    11-09-07

denstrom    6

Matching camera move from original background plate

2007-11-13 19:32    SH230    cbenoit

083_SH_230_v09173    ILM    11-13-07

cbenoit    6

6    layout v1.8    90.49 mm

sh230.layoutCamera
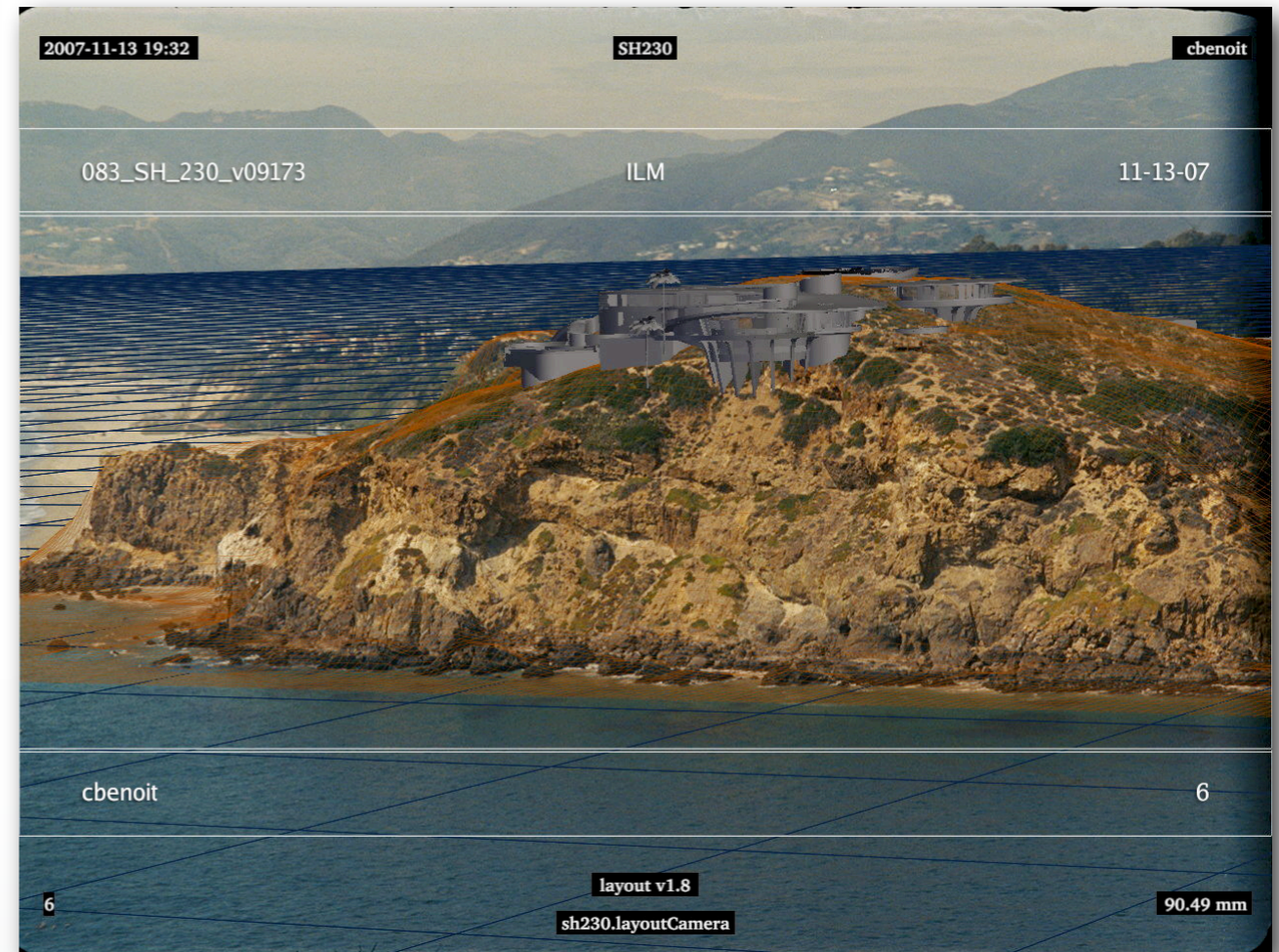
# Mathmove & Layout

... allows adding cg elements to the shot



083_SH_230_v11895          ILM          12-08-07

cstoski          36

# 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

Transformers: Facial Animation Tests

# Animation

Transformers: Facial Animation Tests

# Animation

Transformers: Facial Animation Tests
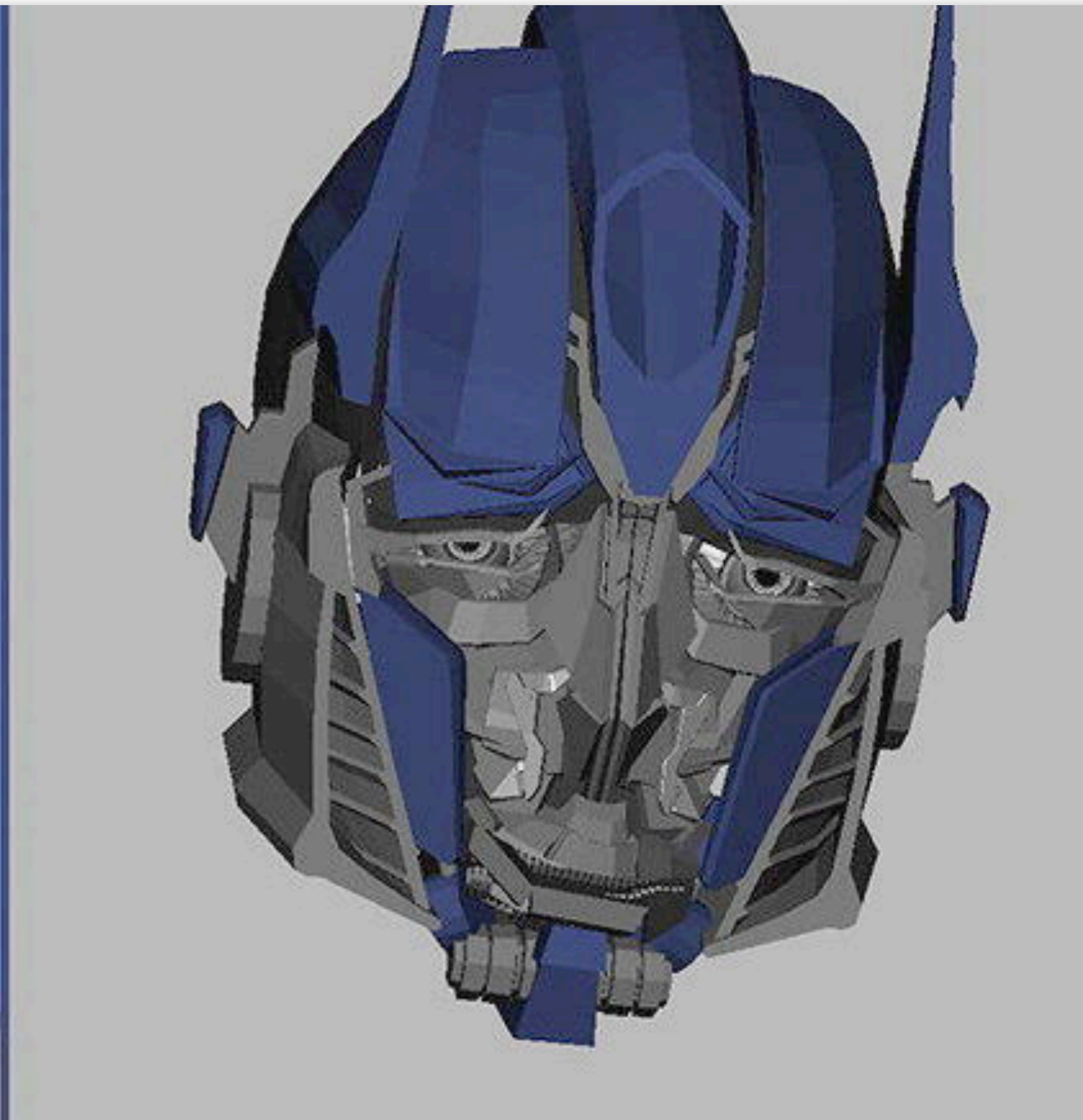
# Animation Production

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
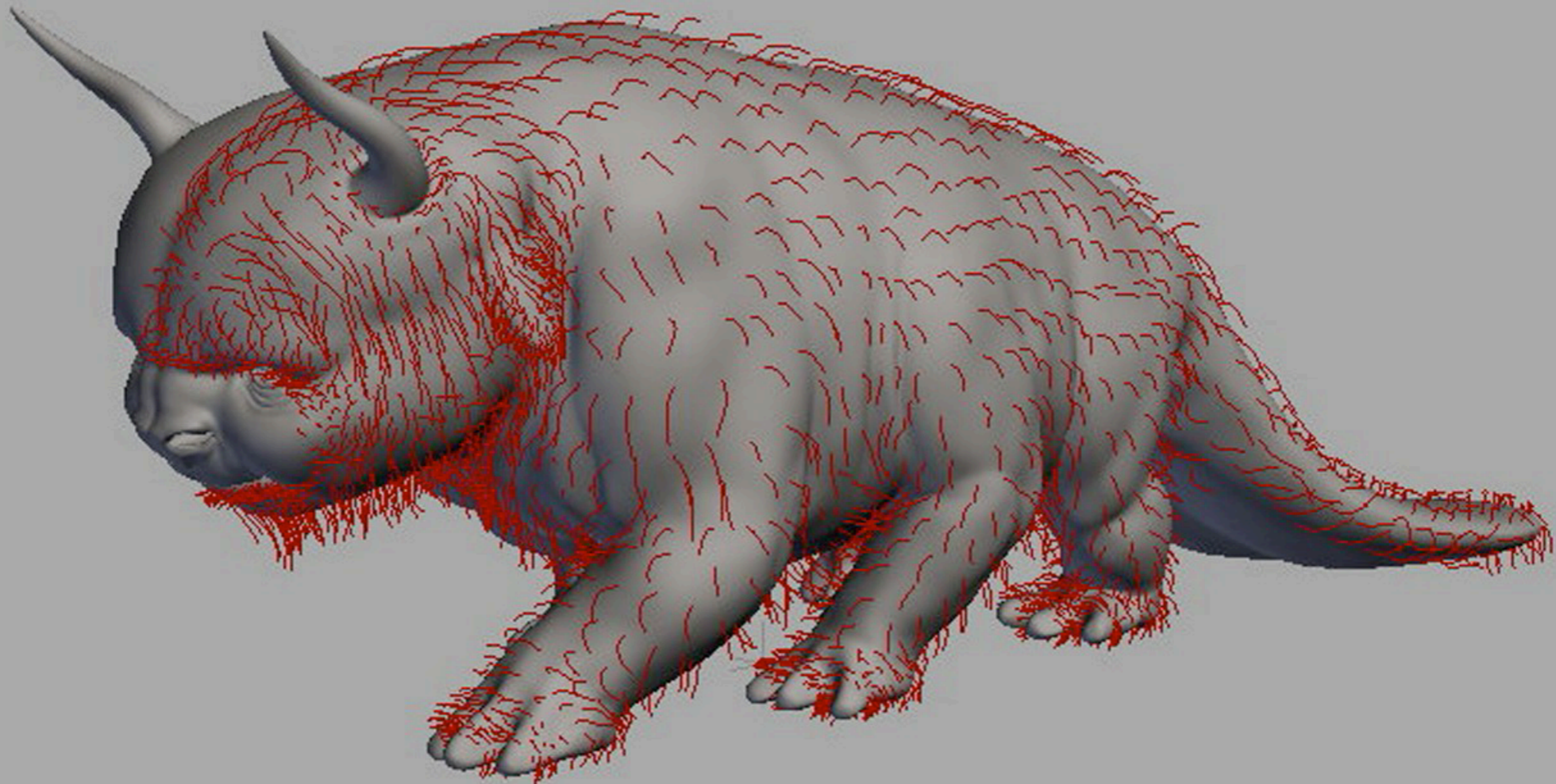
Flesh

# Creature Sim

... and also rigids
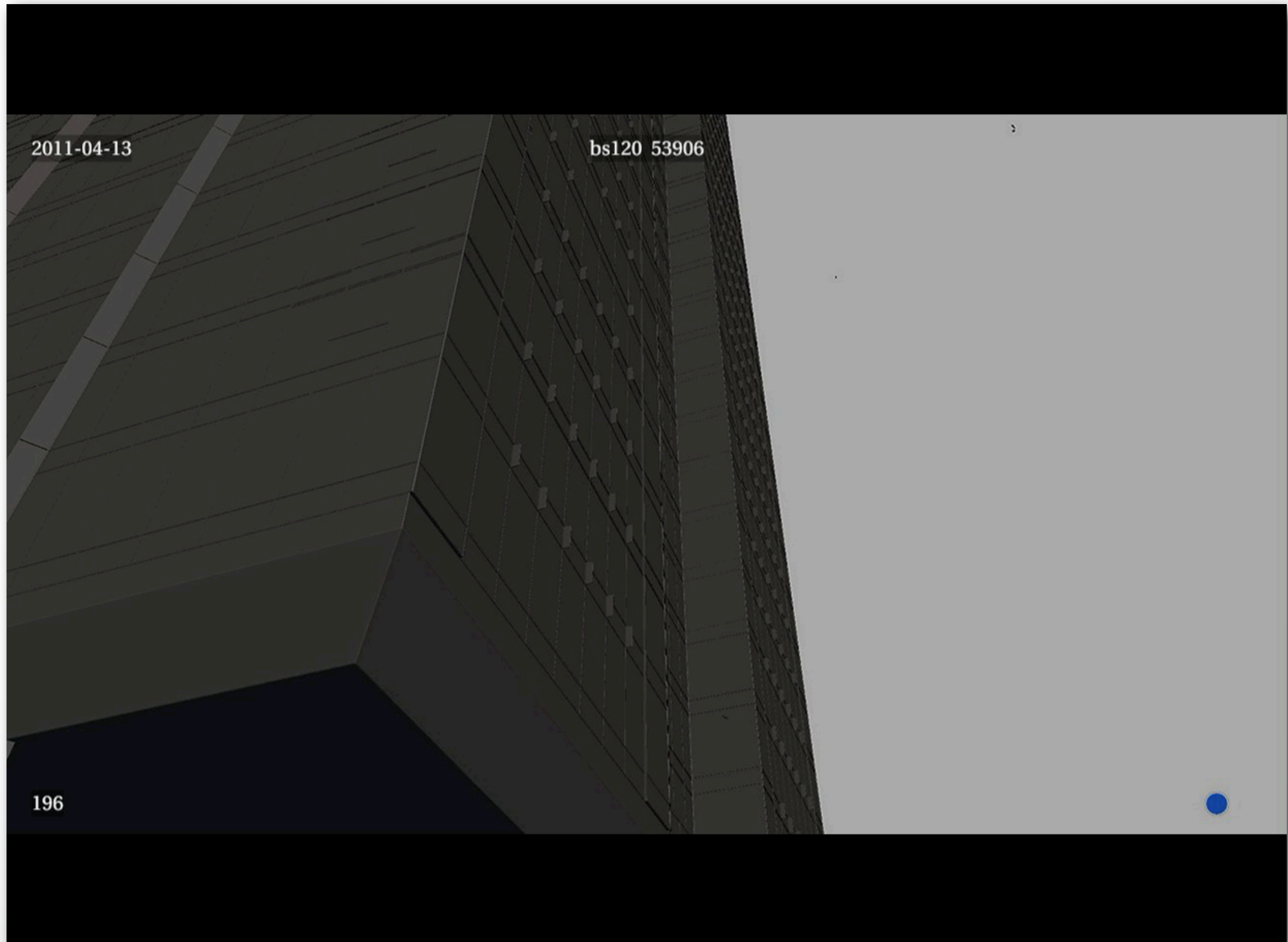
# Creature Sim

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
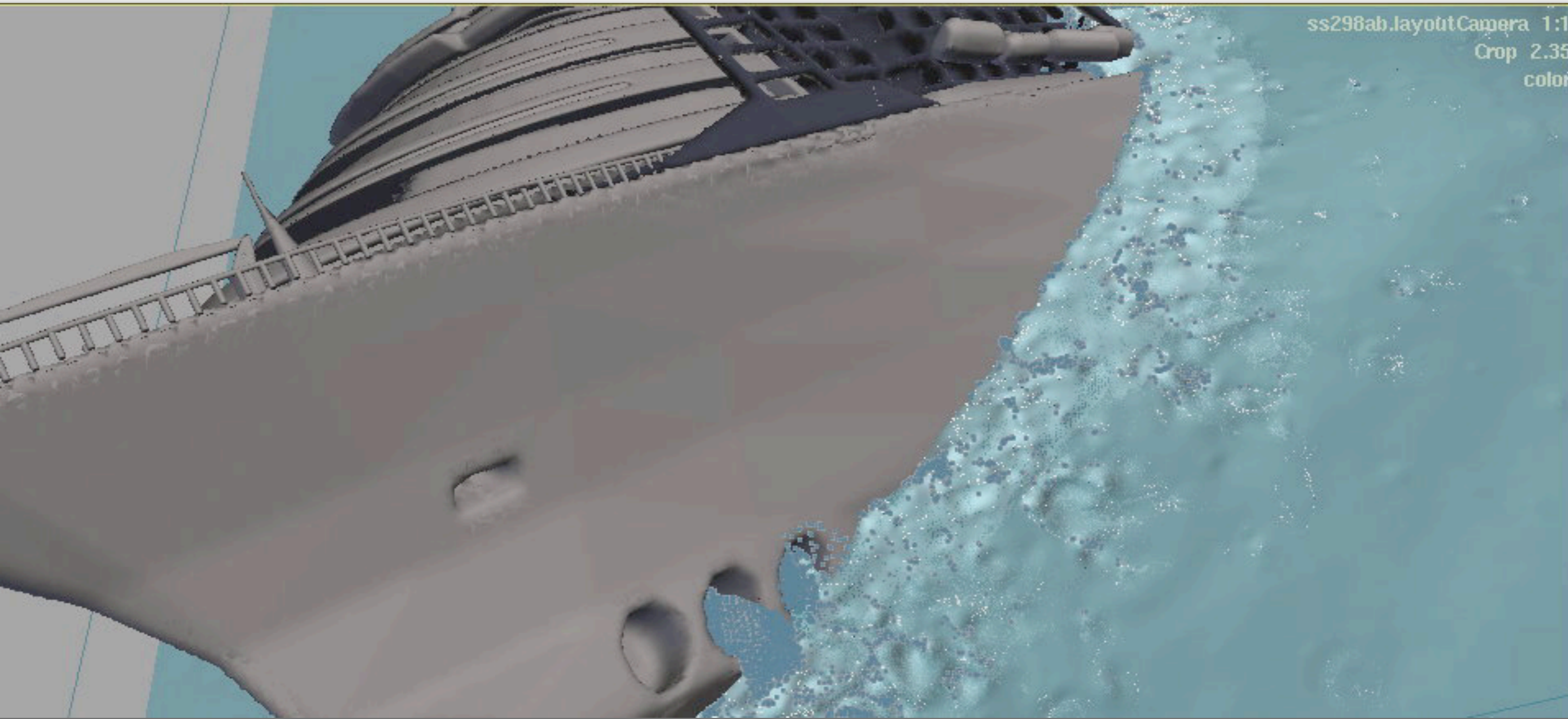
Poseidon: Water Simulations

# FX Sim

Poseidon: Water Simulations

# FX Sim

Poseidon: Water Simulations
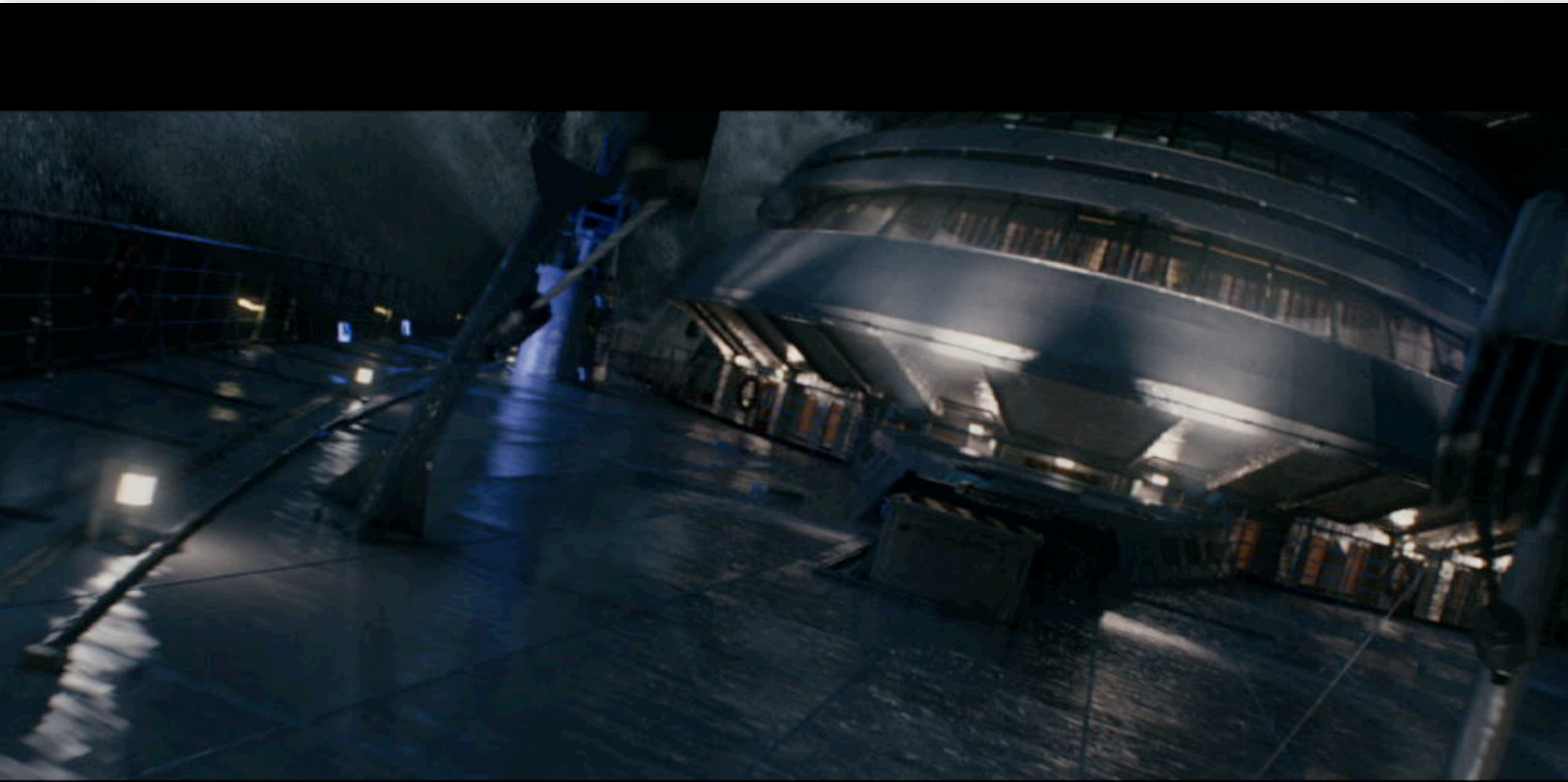
# Animation Production

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
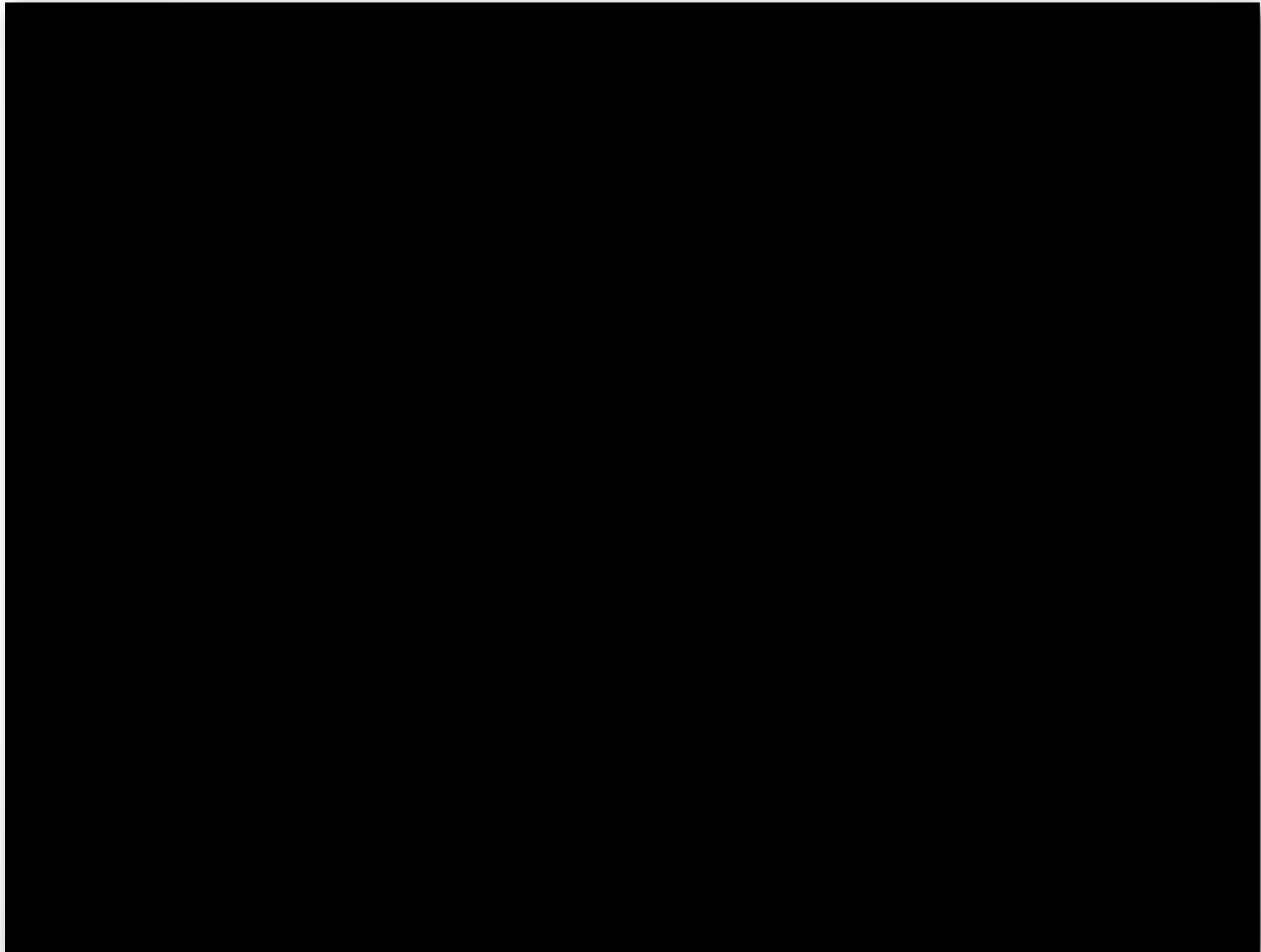
# Lighting & Rendering

Render Pass of Navy Drones
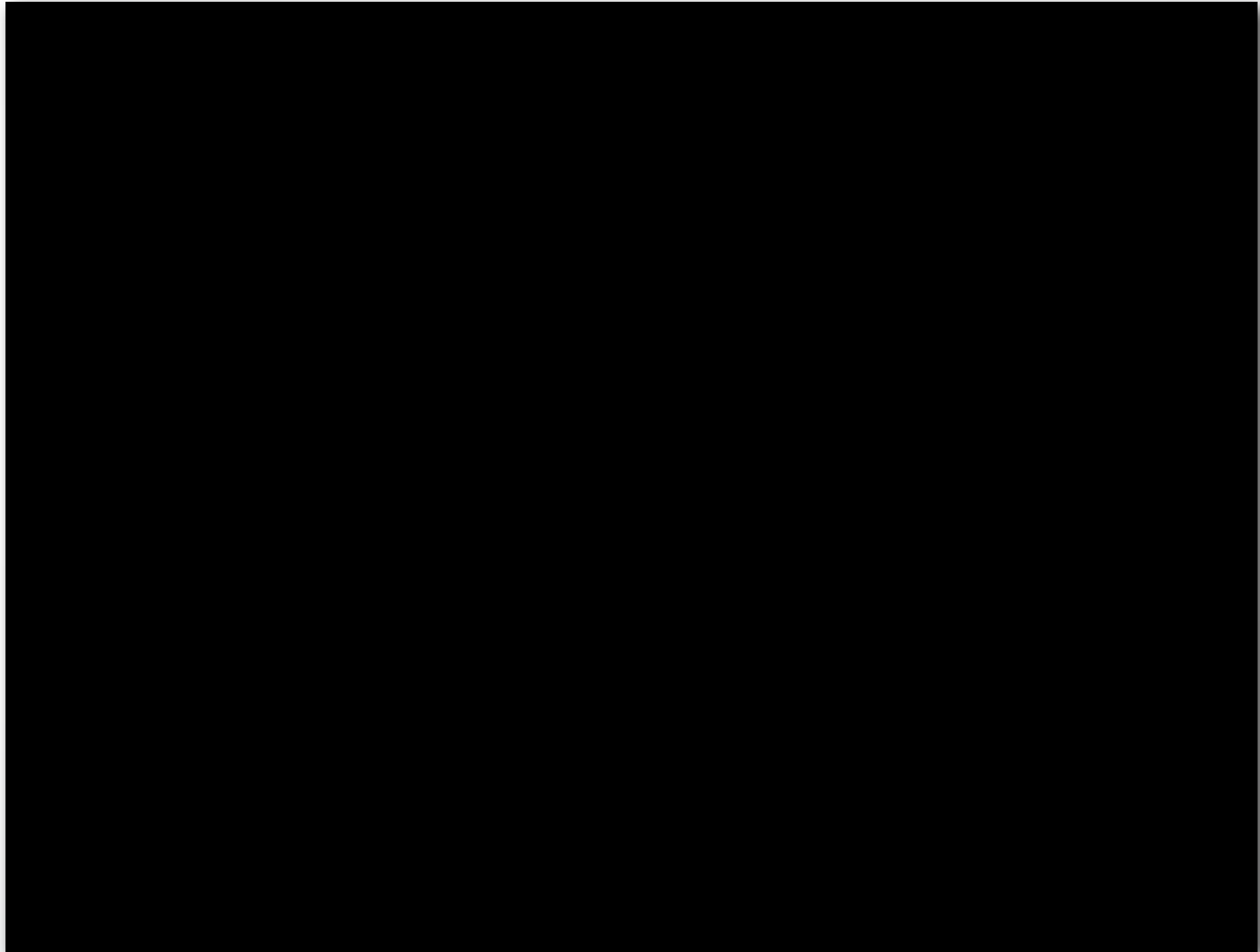
Render Pass of Shadows
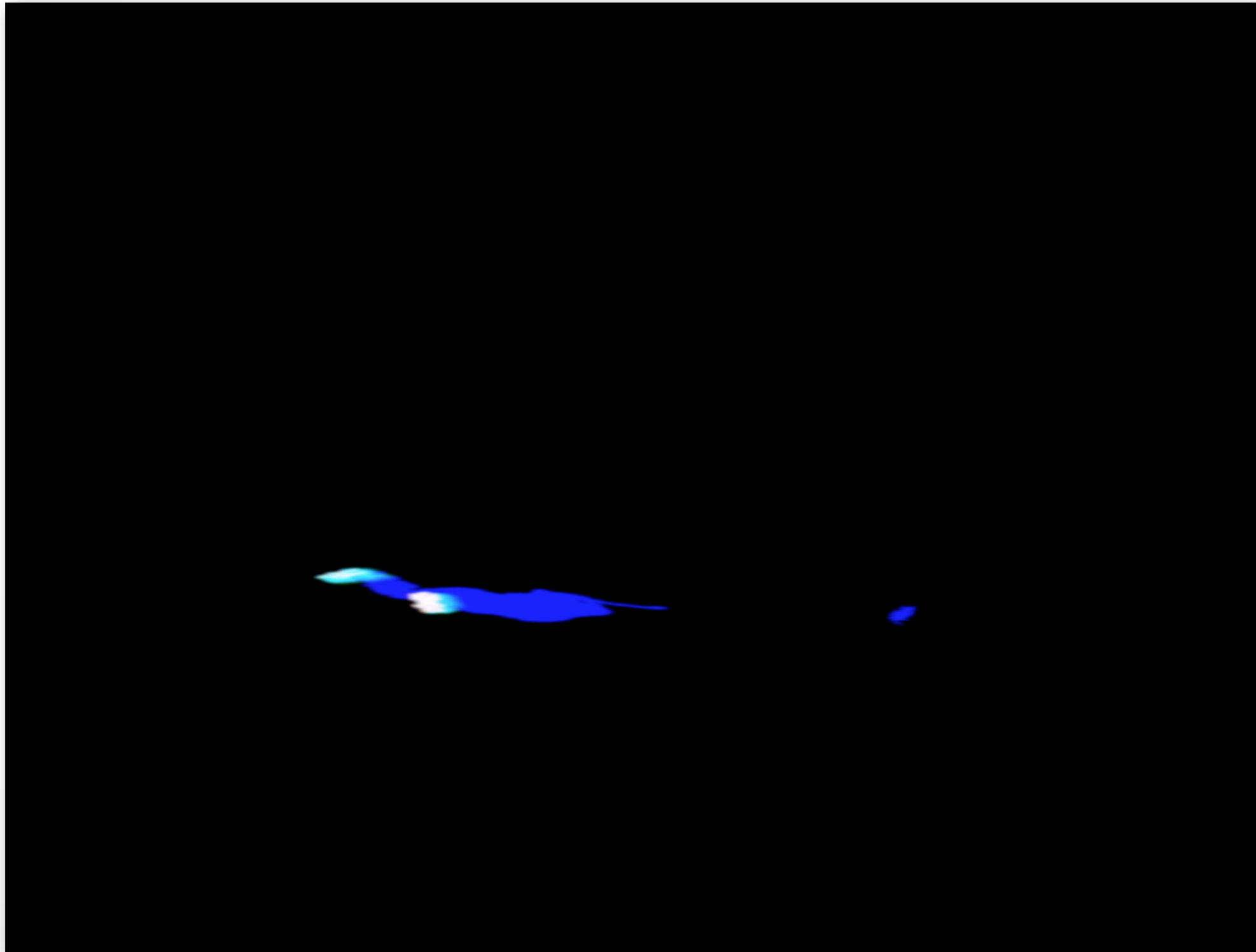
# Lighting & Rendering

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**



Final Color

# Animation Production
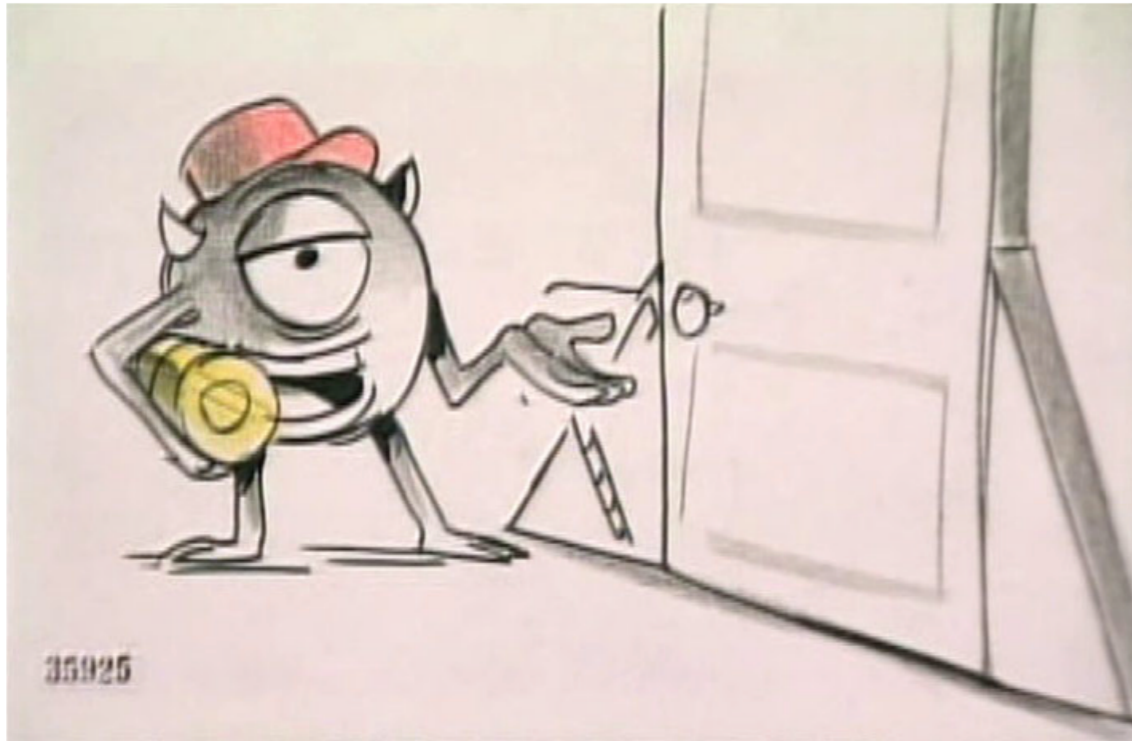


Story



Layout
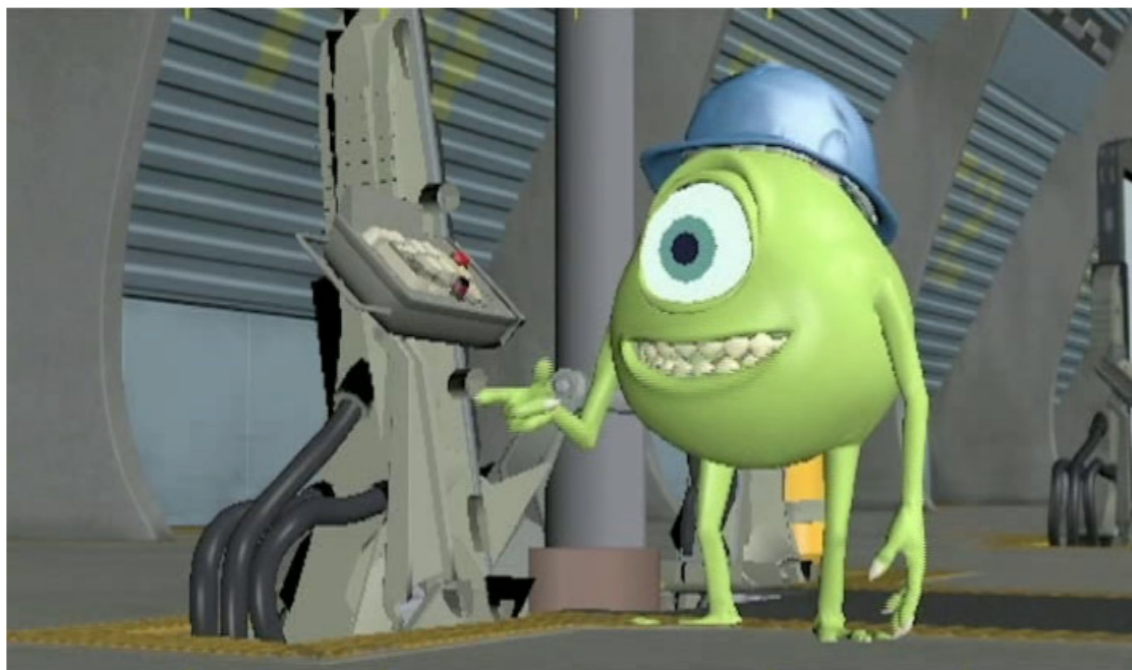


Animation



Final Rendering

## 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
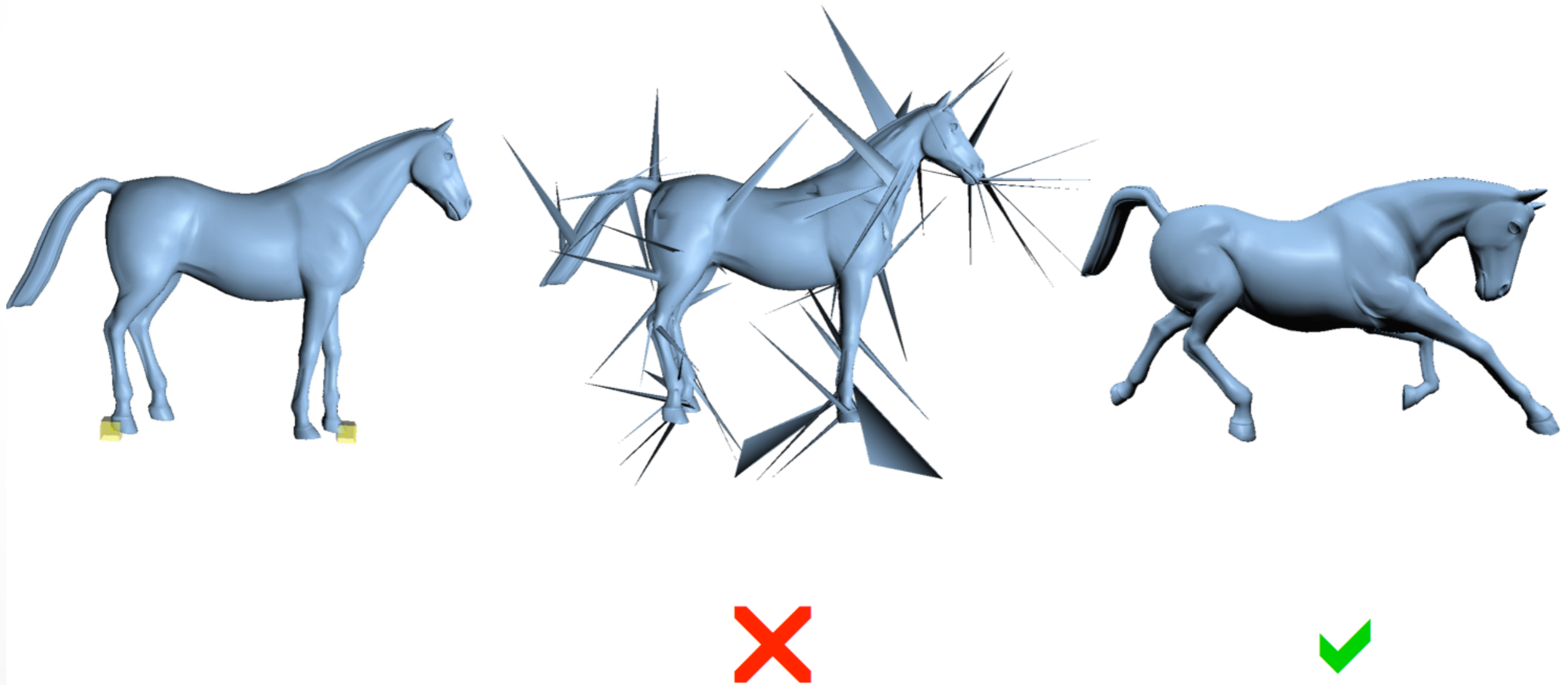
# Rigging

- 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



scripted pose file system
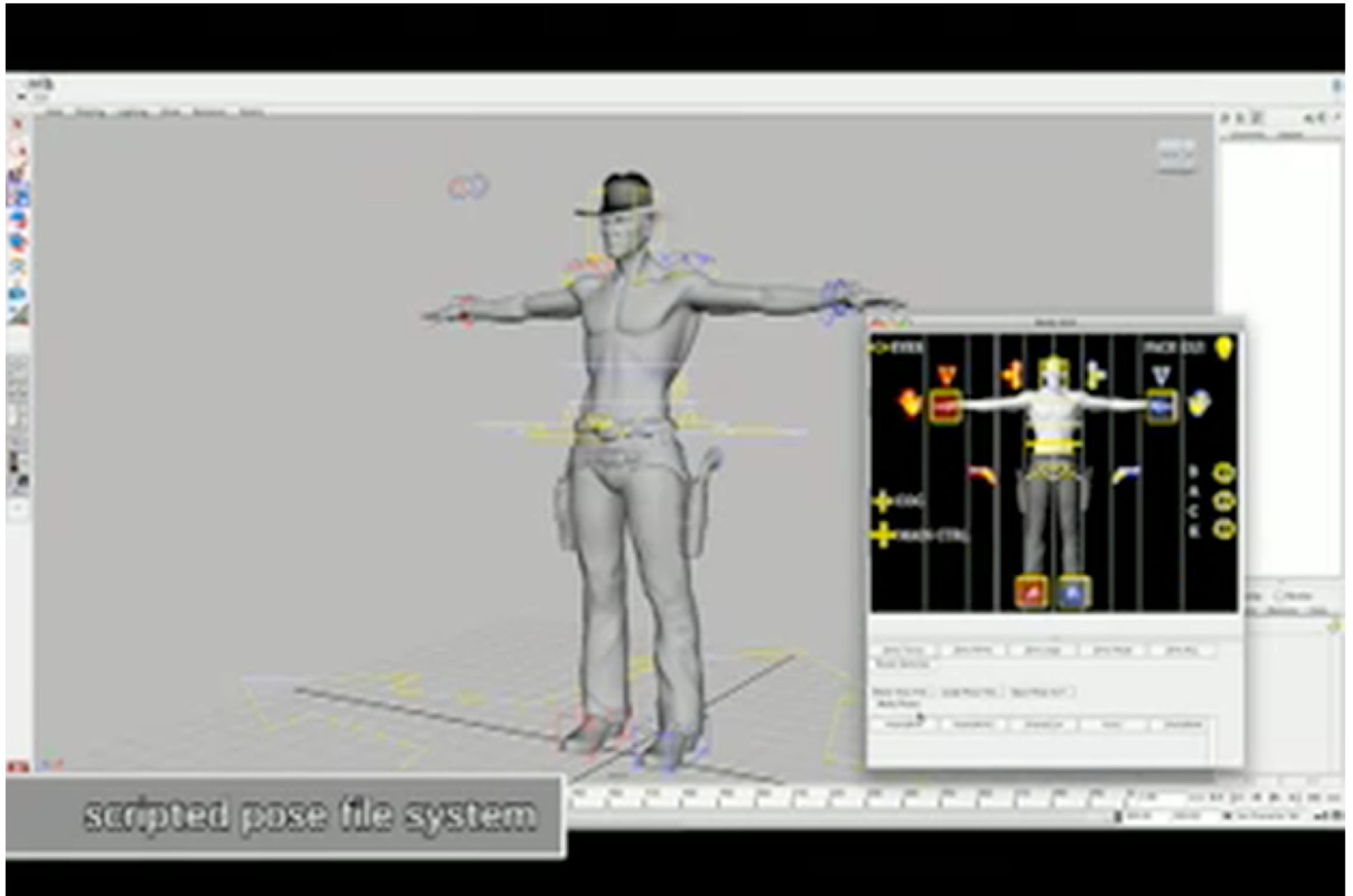
# Types of Rigging

- Procedural Rigging

- Skeletal Rigging

- Anatomical Rigging
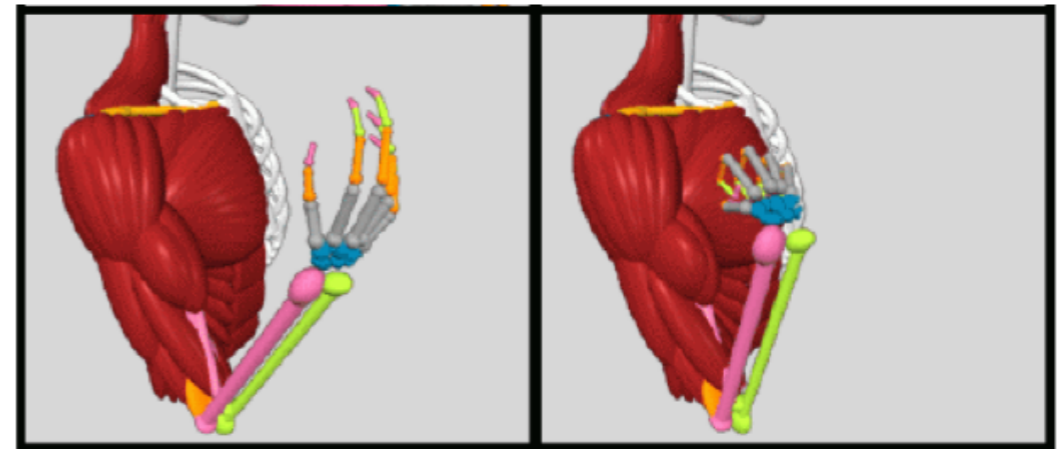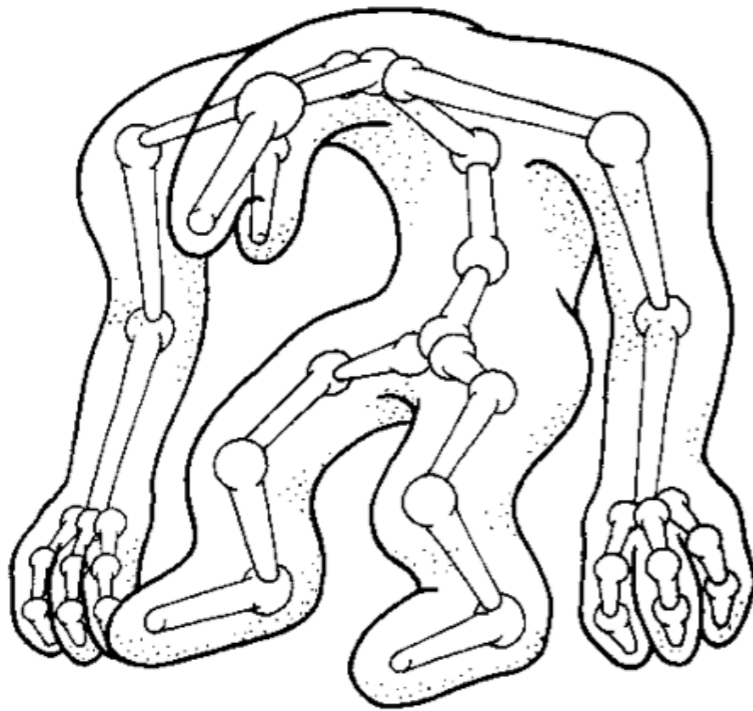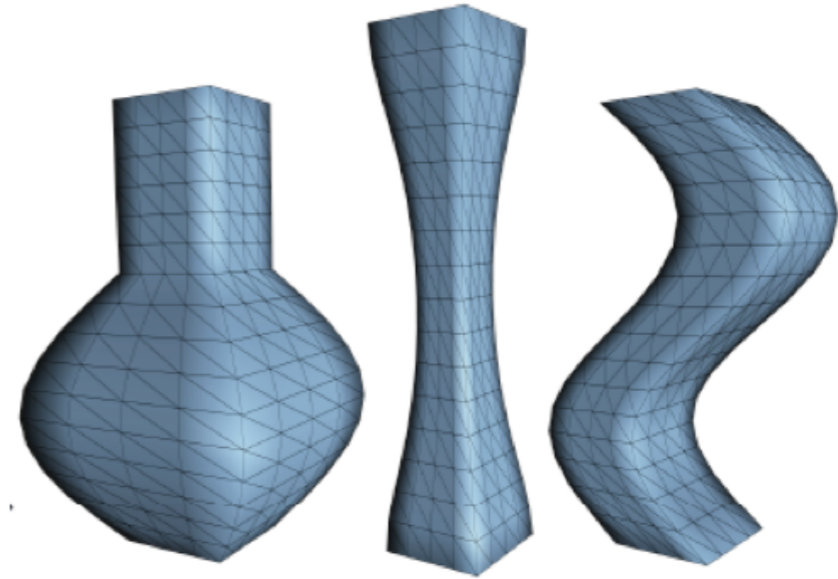
# Non-Linear Deformation

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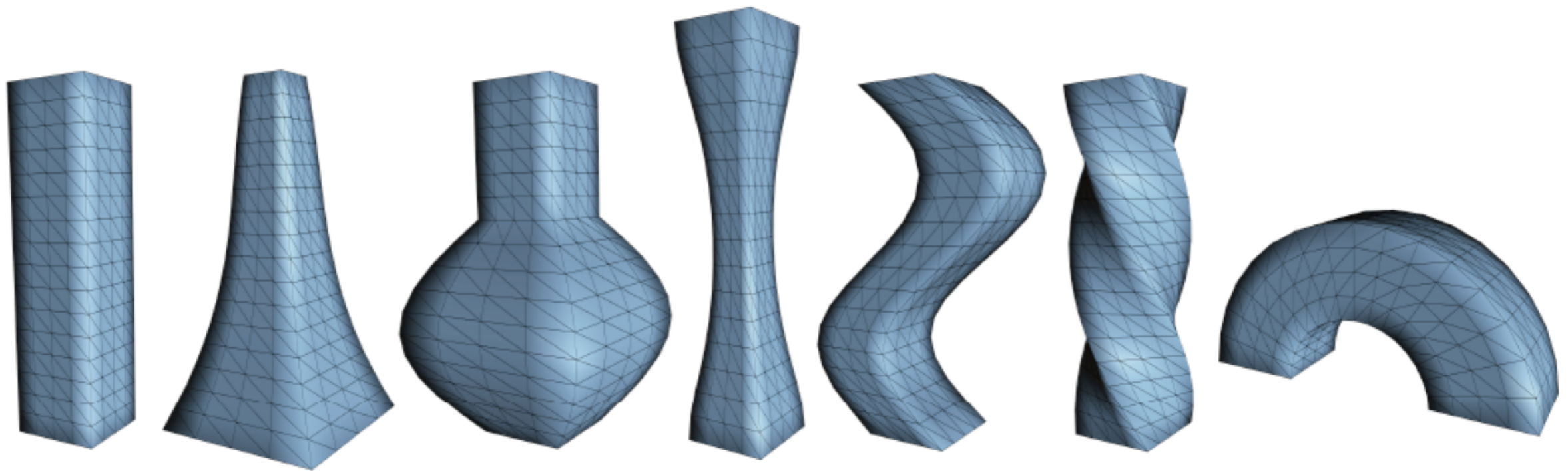


Al Barr. Global and Local Deformations of Solid Primitives. SIGGRAPH 1984.

# Non-Linear Deformation

"Squash and stretch"
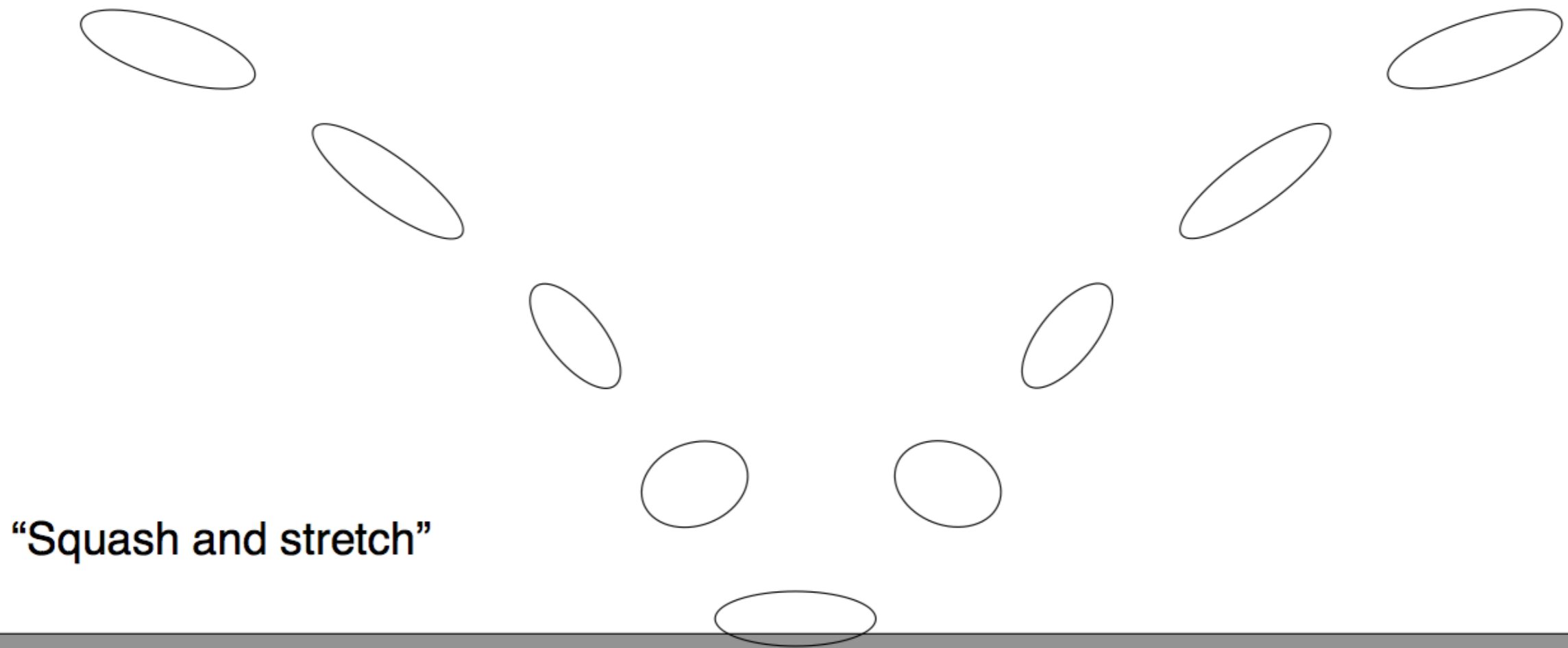
# Skeletal Rigging

- Parameterize character deformation with a skeleton.

- Approximate actual skeleton of the character.
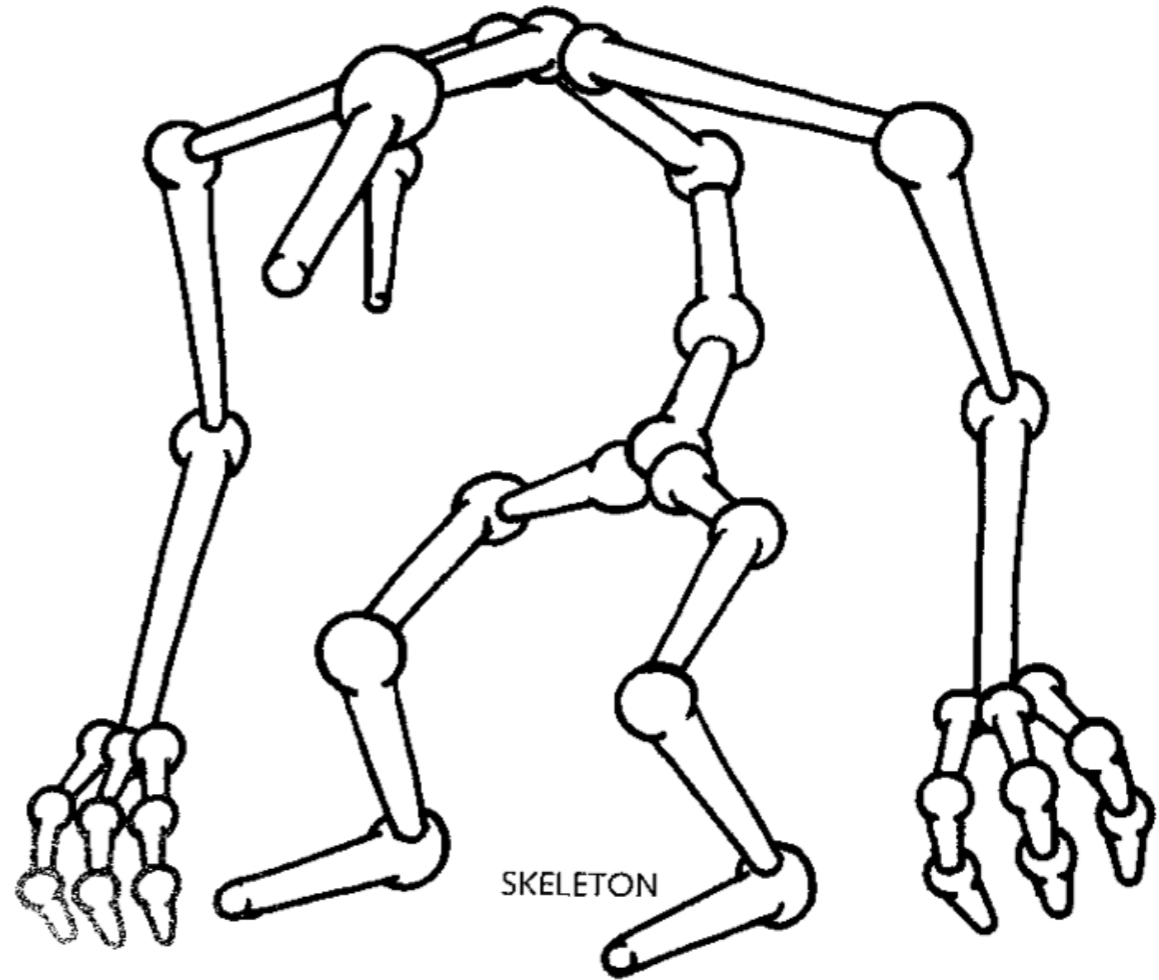
SKELETON

# Skeletal Rigging

- Then add skin on top.
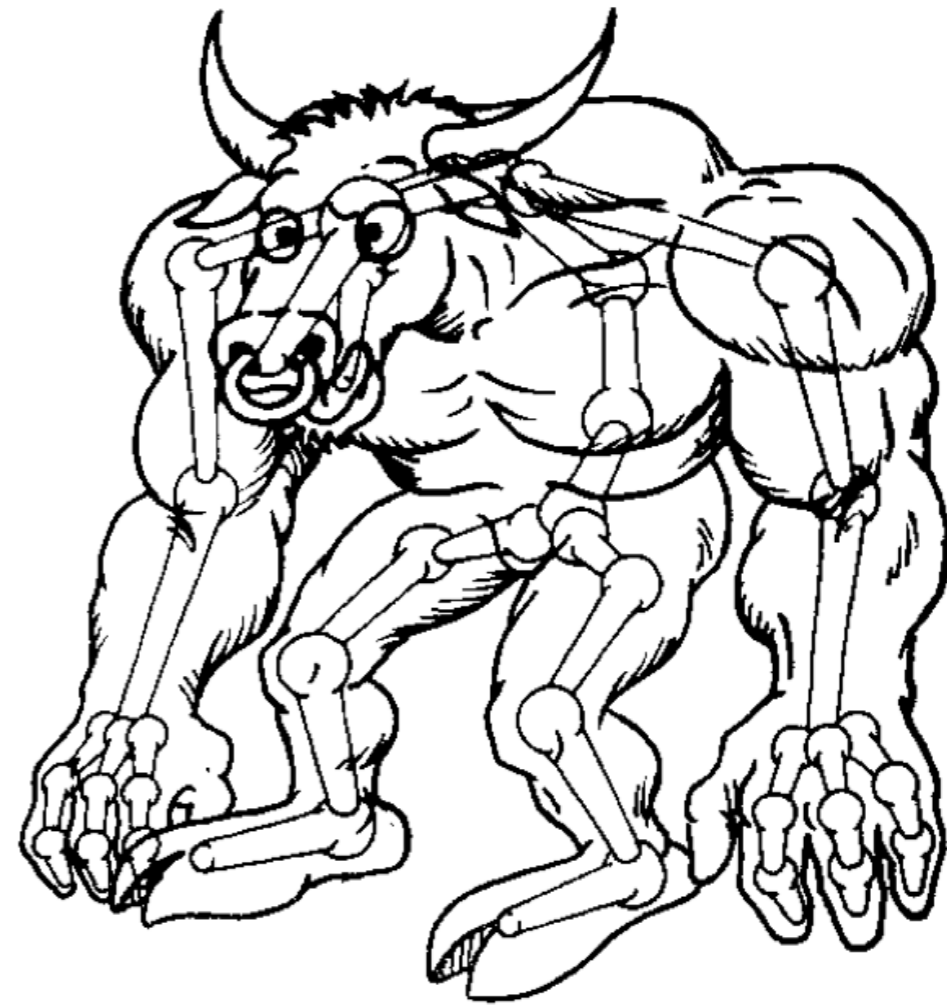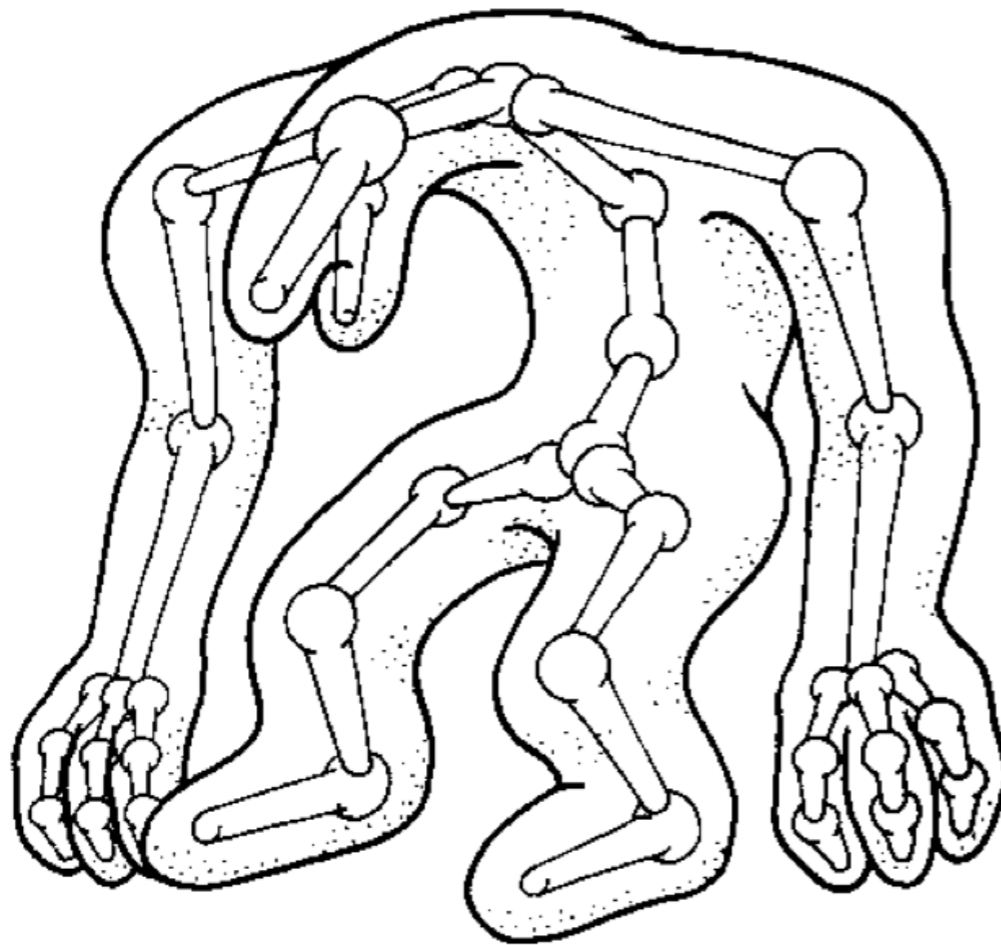
# Anatomical Models

- 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
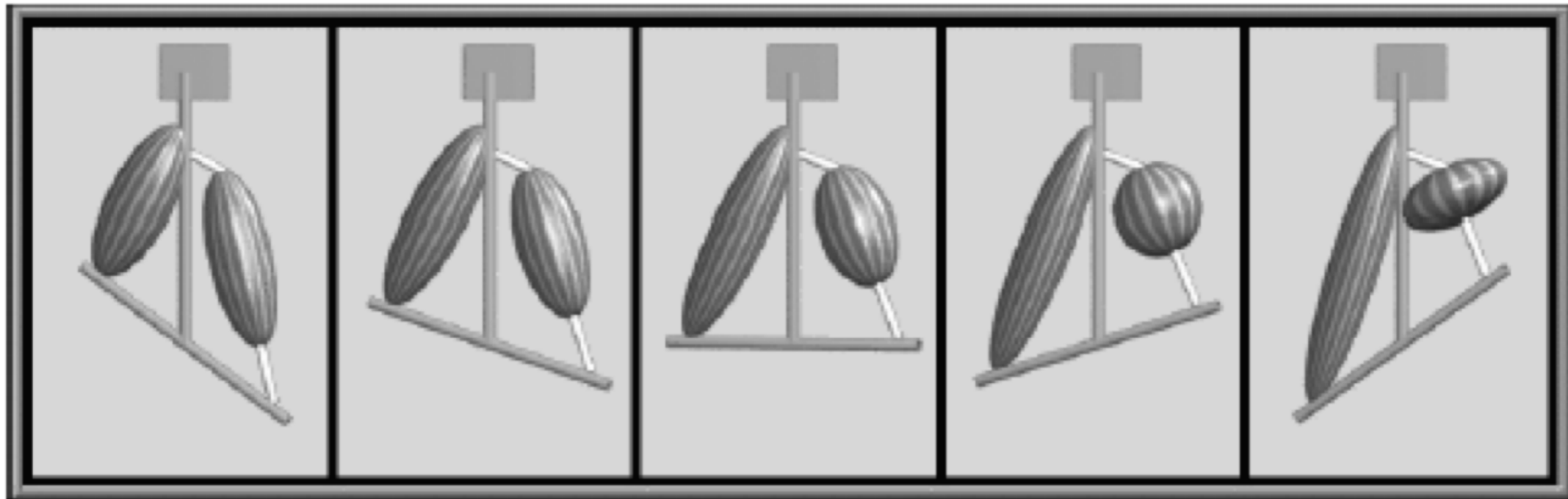
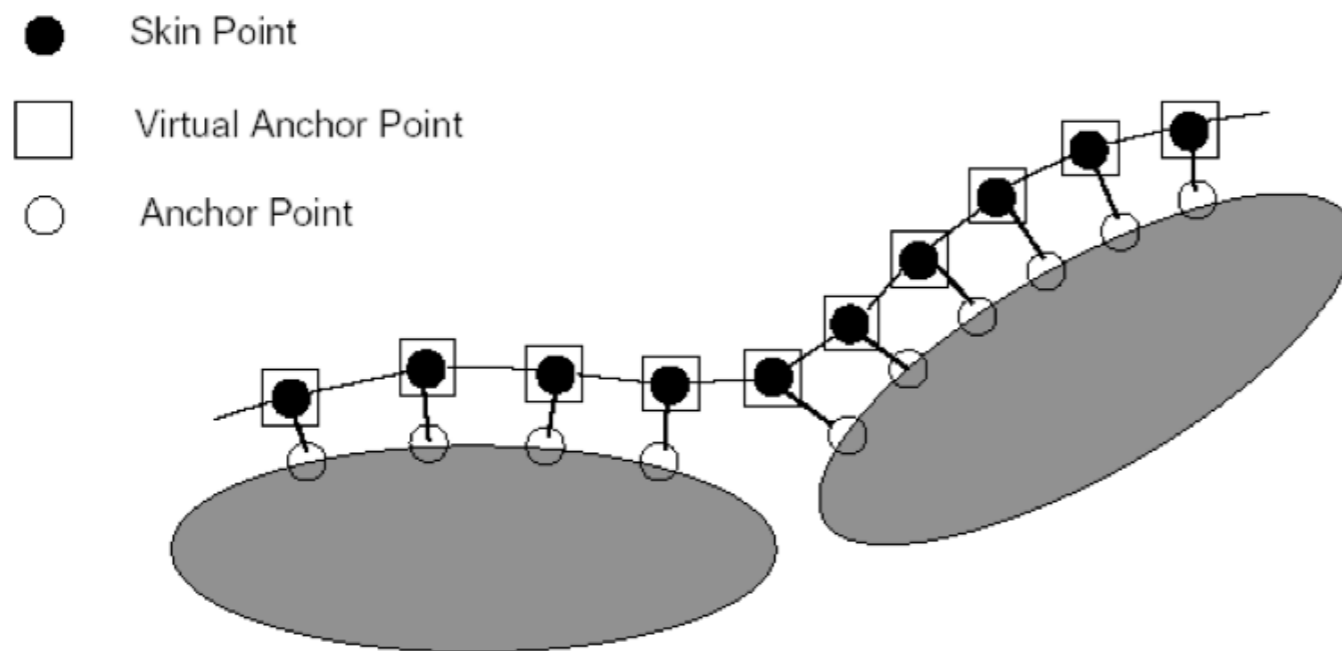# Anatomical Models

Complex musculature built up from lots of simple primitives.
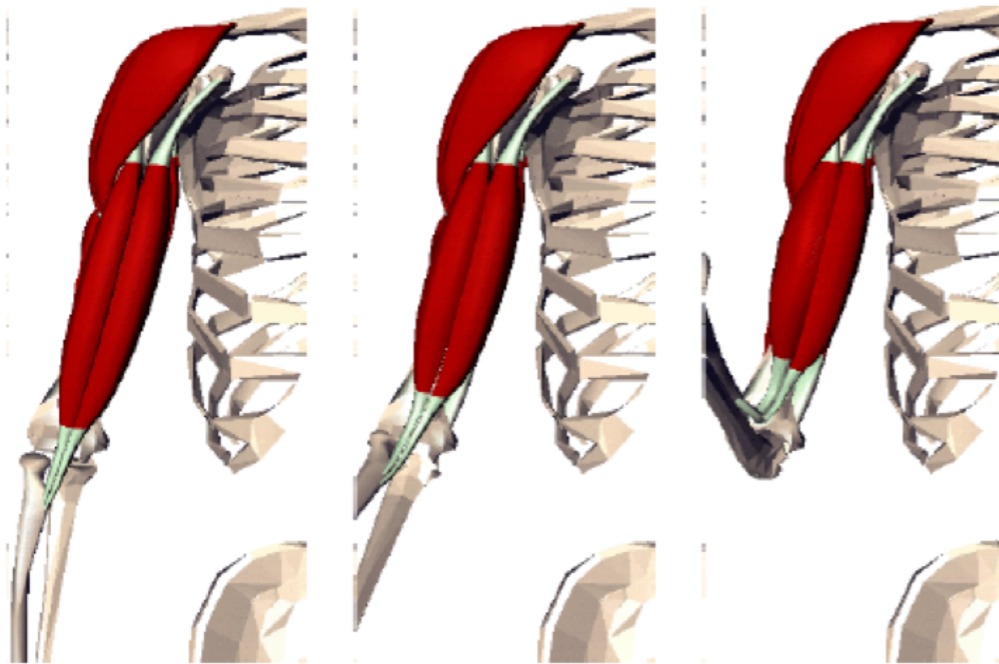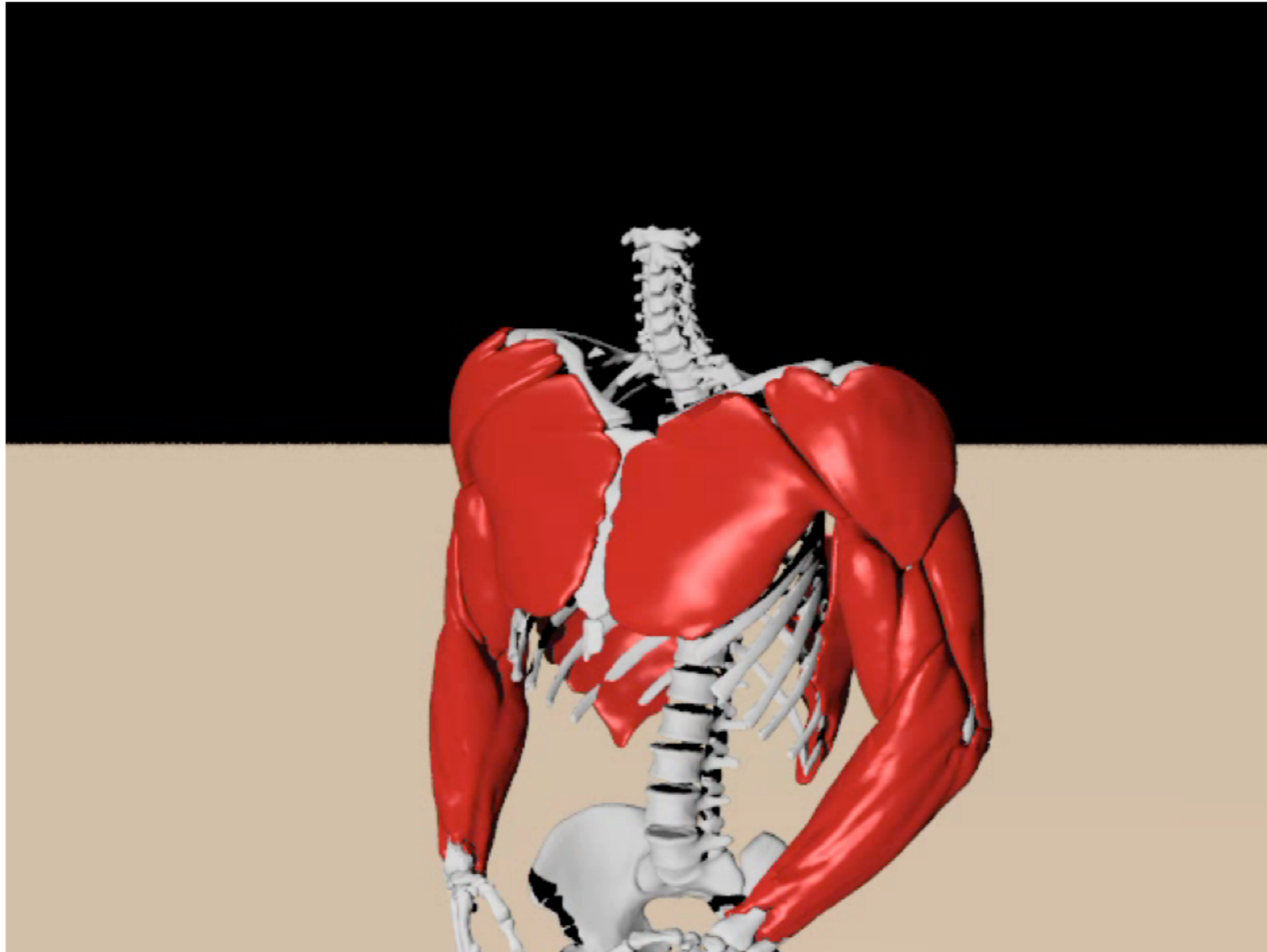
Anatomy-Based Modeling of the Human Musculature. Scheepers et al. SIGGRAPH 1997.
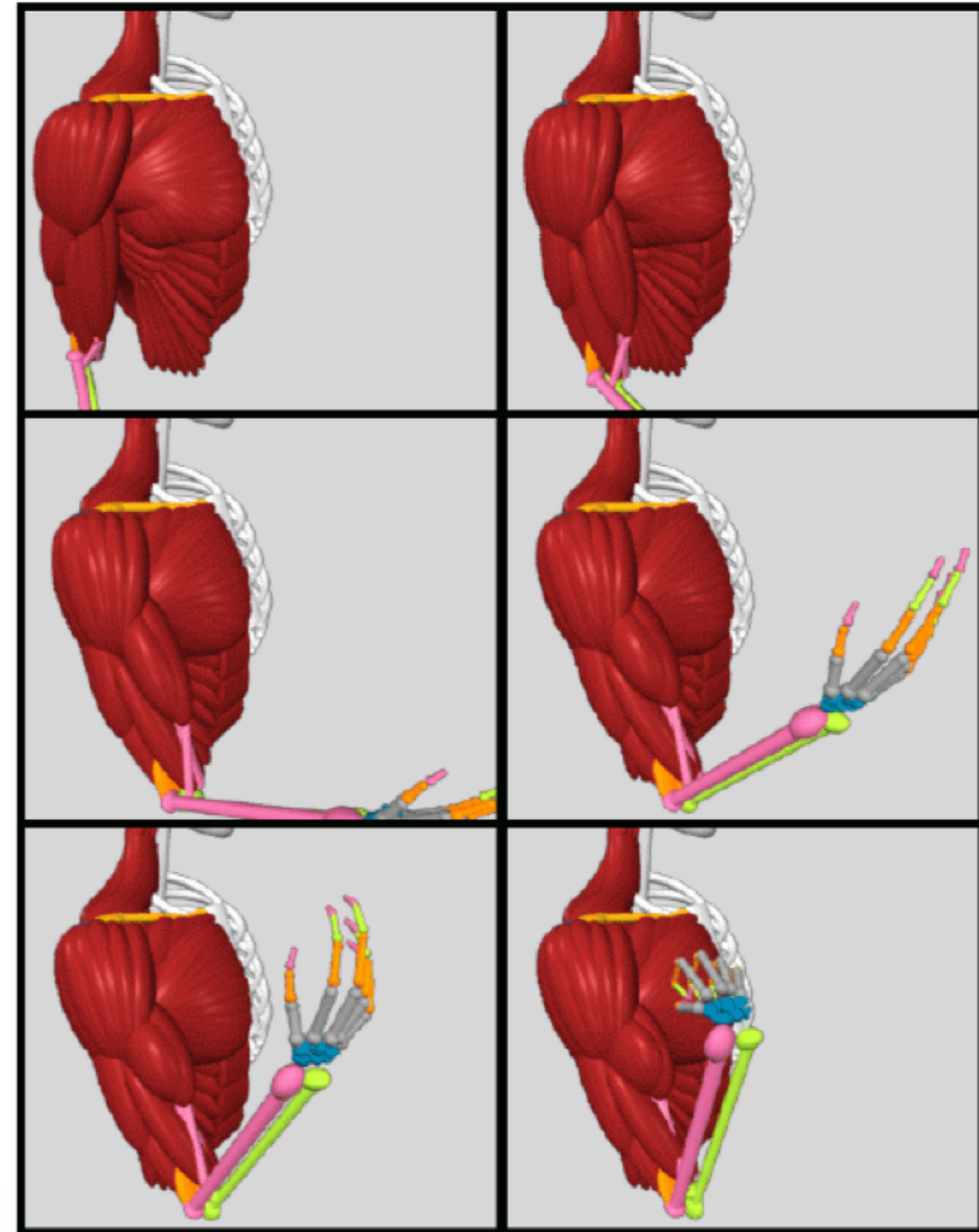
# Anatomical Models

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



● Skin Point

☐ Virtual Anchor Point

○ Anchor Point

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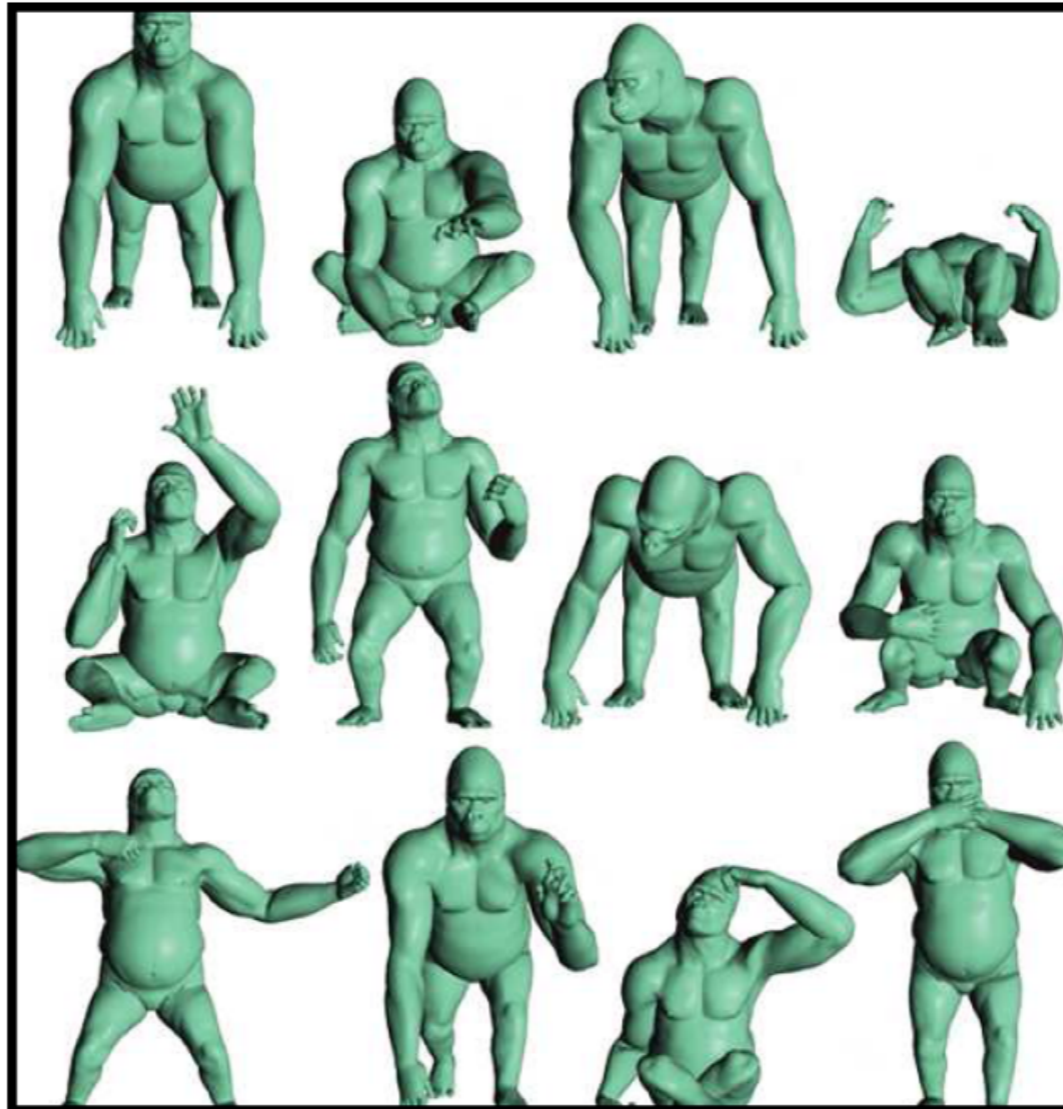
- Given the joint angles, find the position of the "end effector" (ie, hand)

- Problem: unintuitive



SKELETON
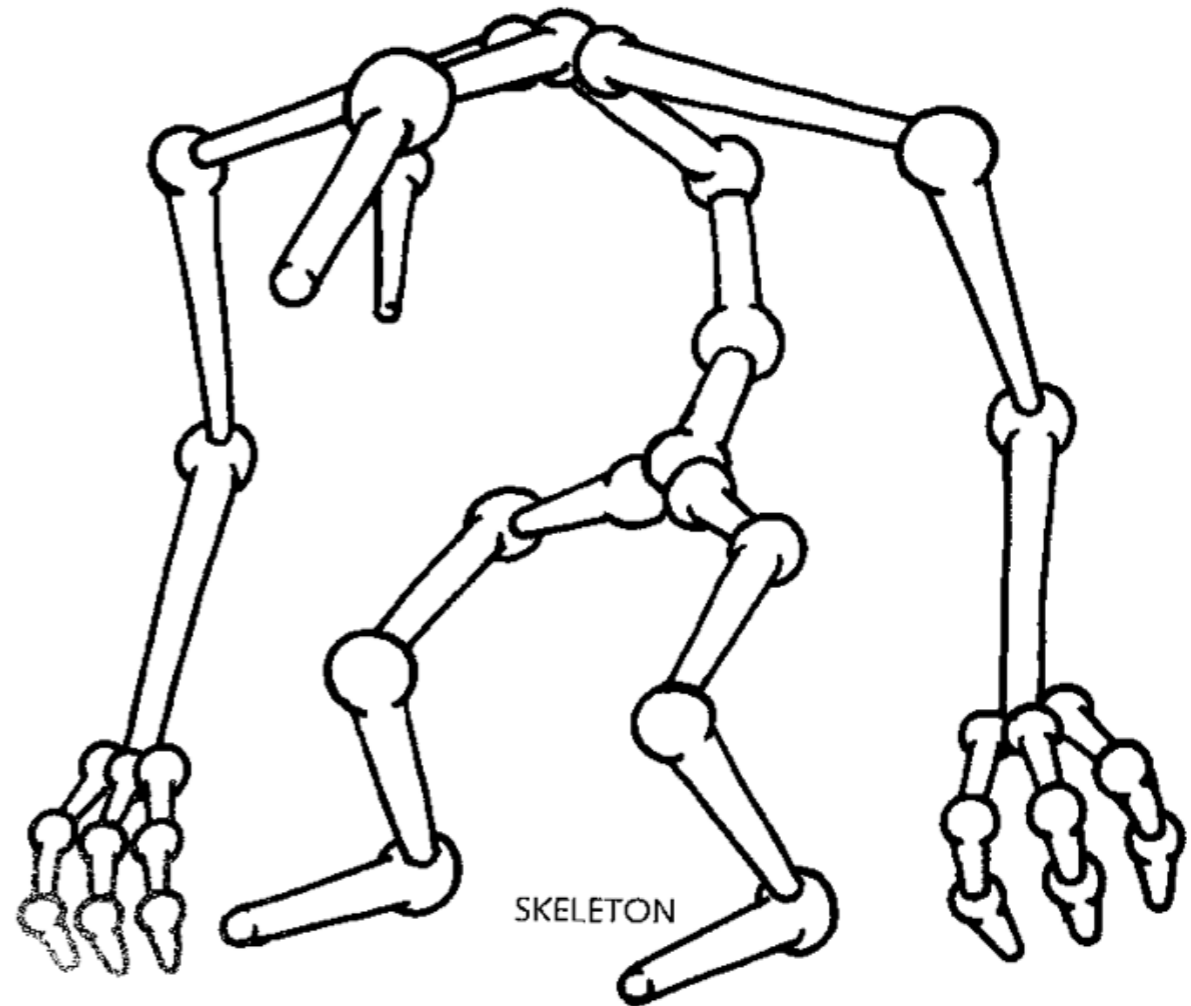
# Inverse Kinematics

- 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)

- Can be solved with trigonometry
  - Extra parameter for choice of solution
  - Joint limits
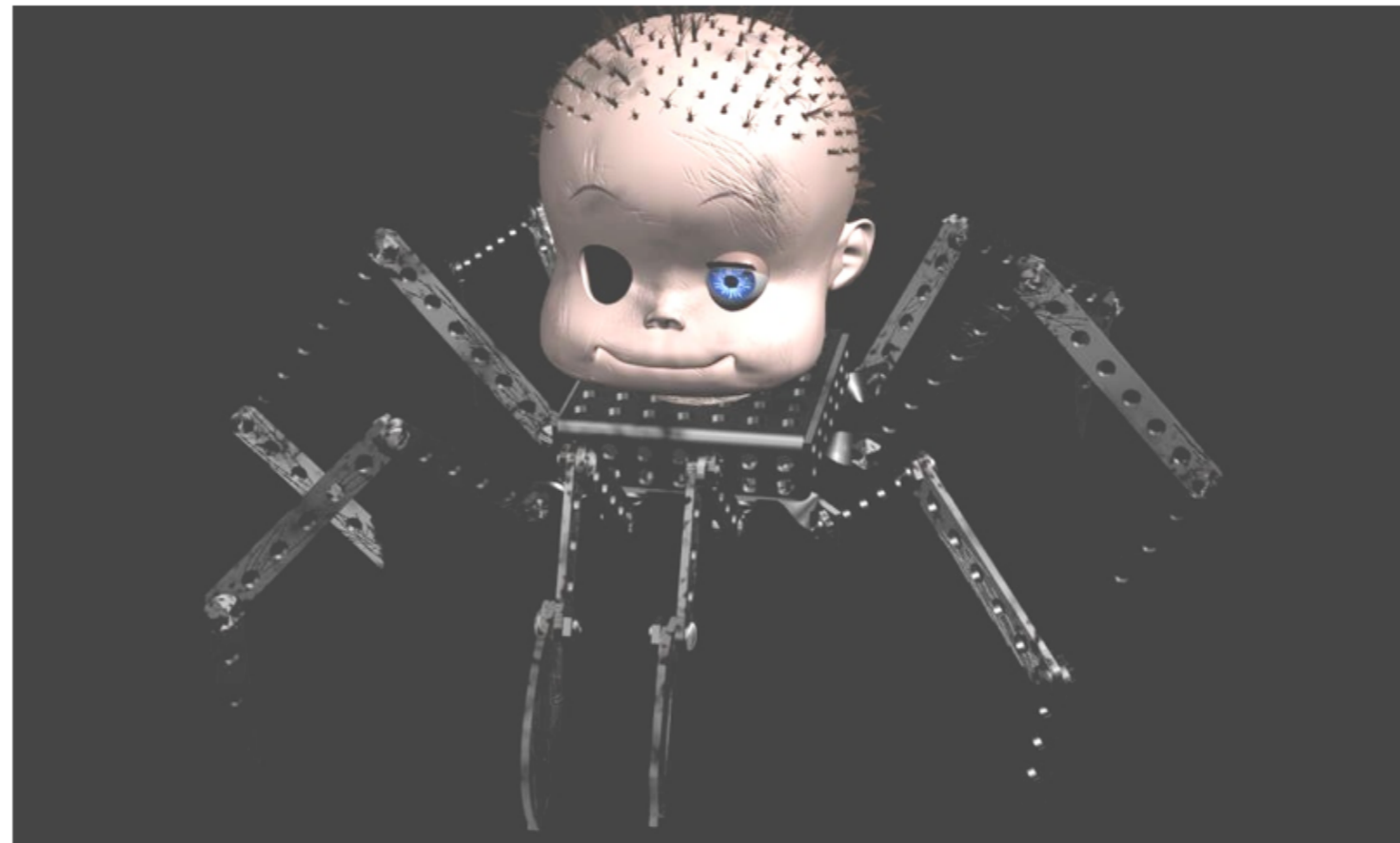
# General N-link IK
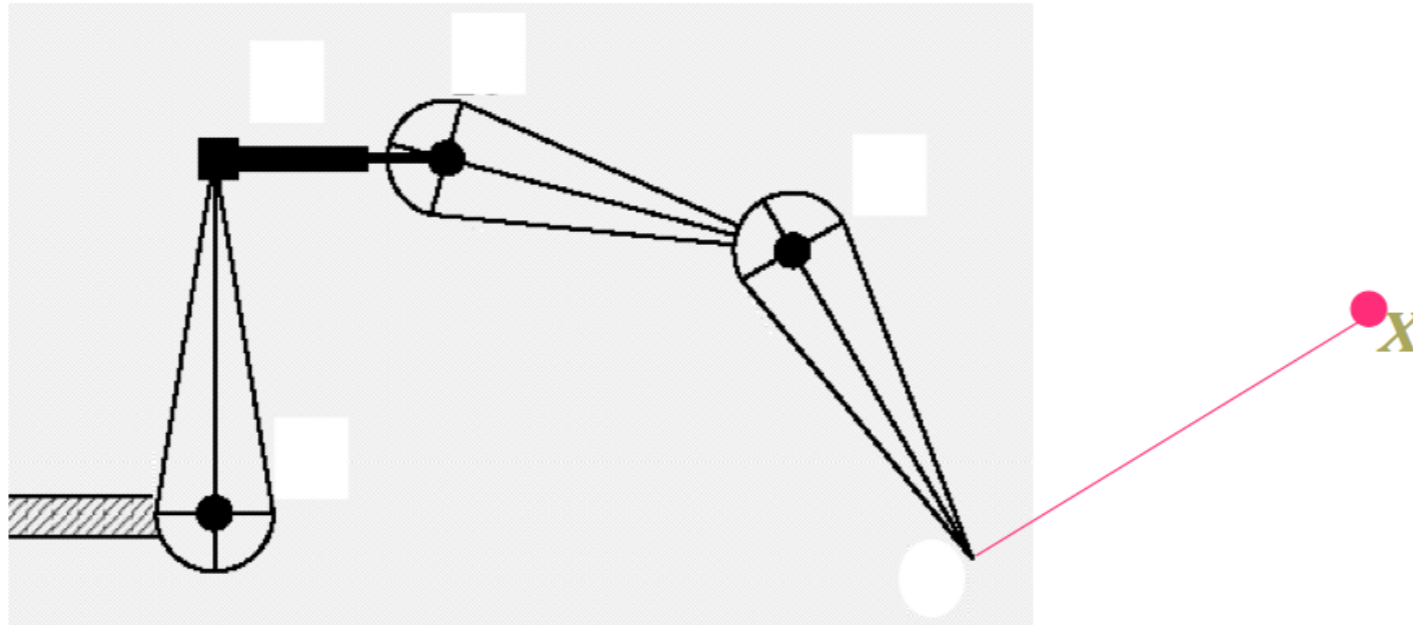


– want $f(\theta) = X$

- $\theta$ is a vector of N link parameters (angles, extensions)
- $f(\theta)$ is the position of the endpoint (2D coordinates)
- X is the position of the target (2D coords)

– Given X, find $\theta$

# Style-Based IK
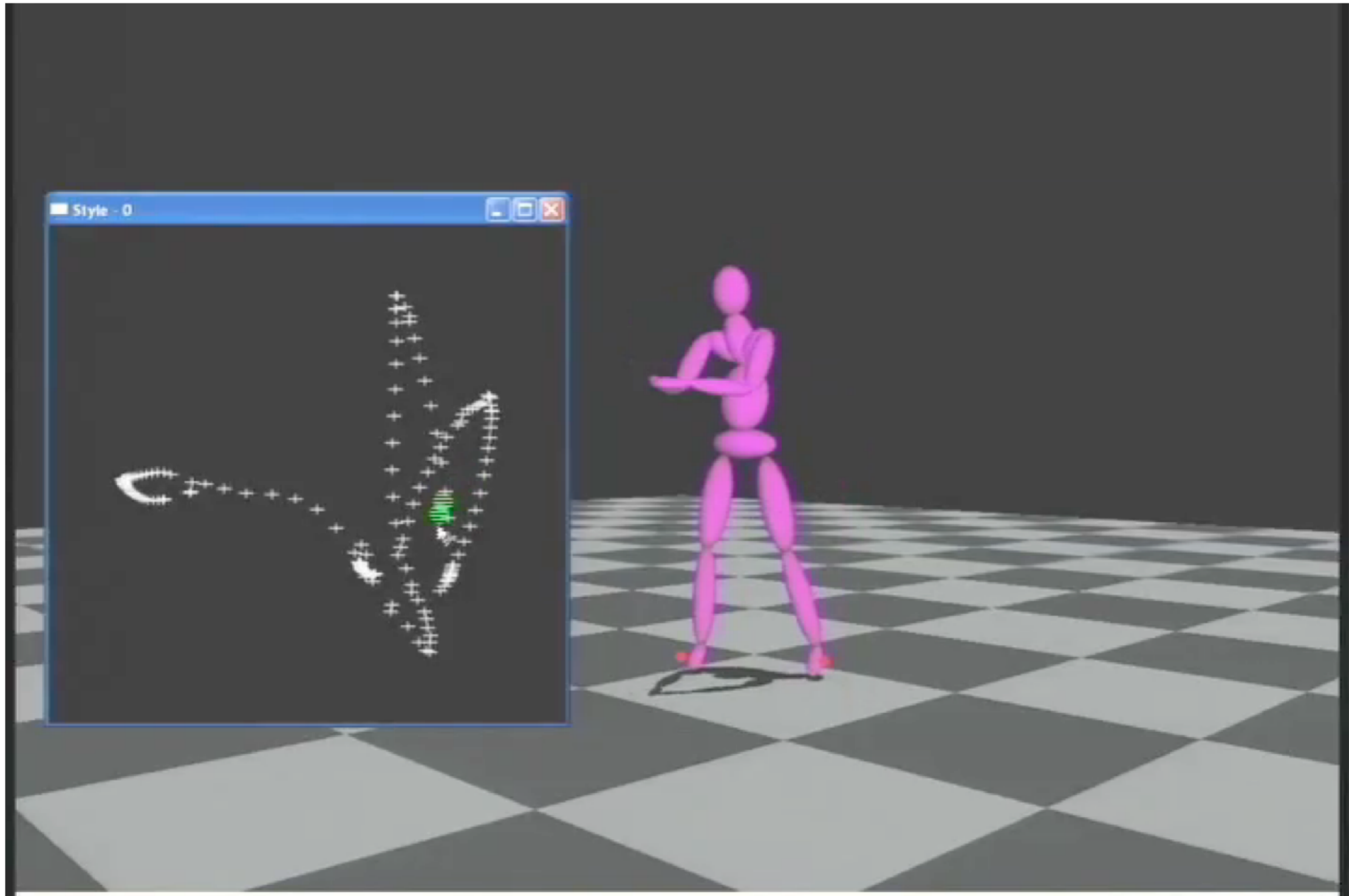
## Animation Production

## 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.
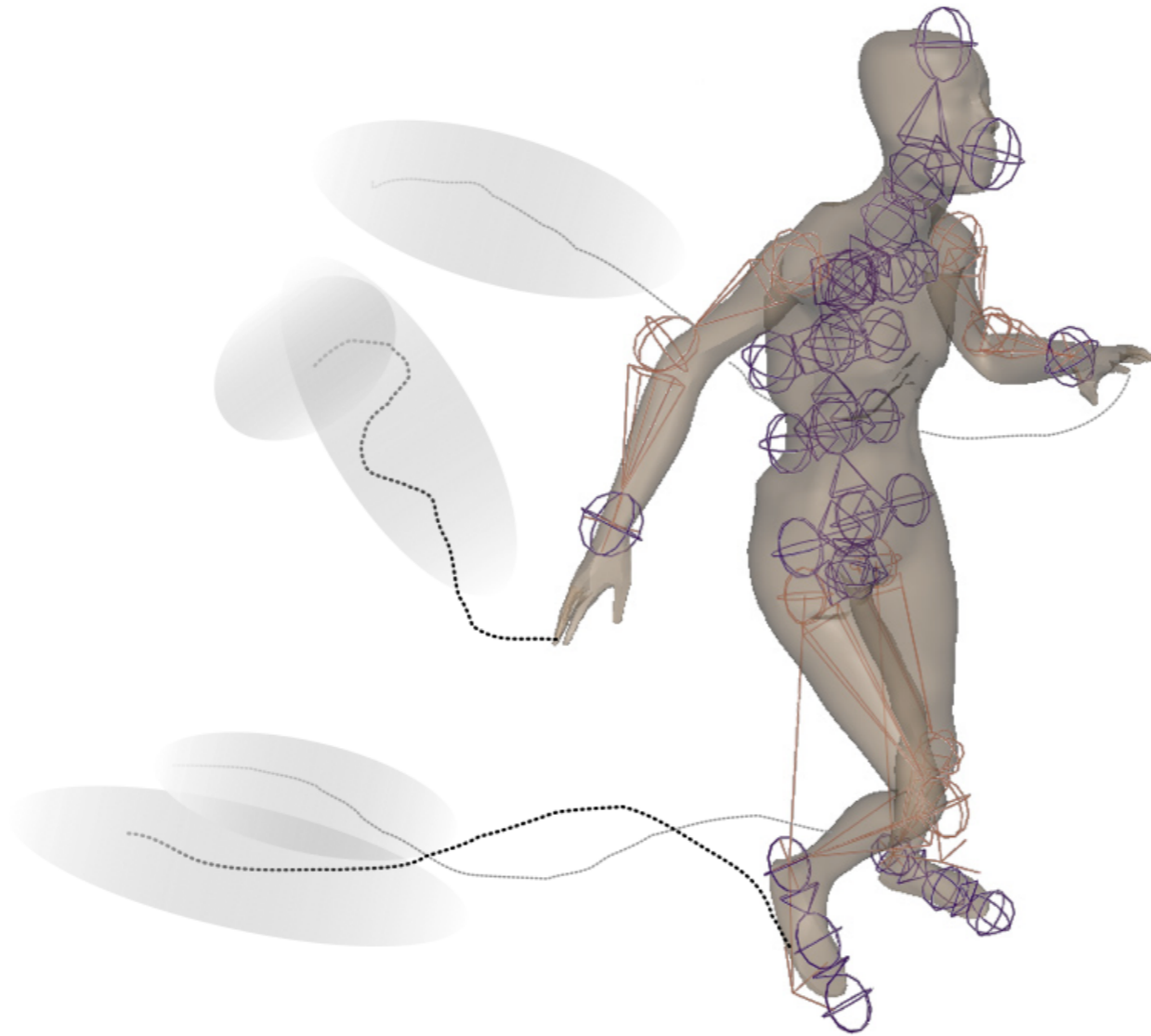
# Keyframe Animation

- Traditionally, animator draws character at "extreme" poses

- Fill in in-betweens

- Textbook "Illusion of Life"

# Keyframe Animation

1

2

3
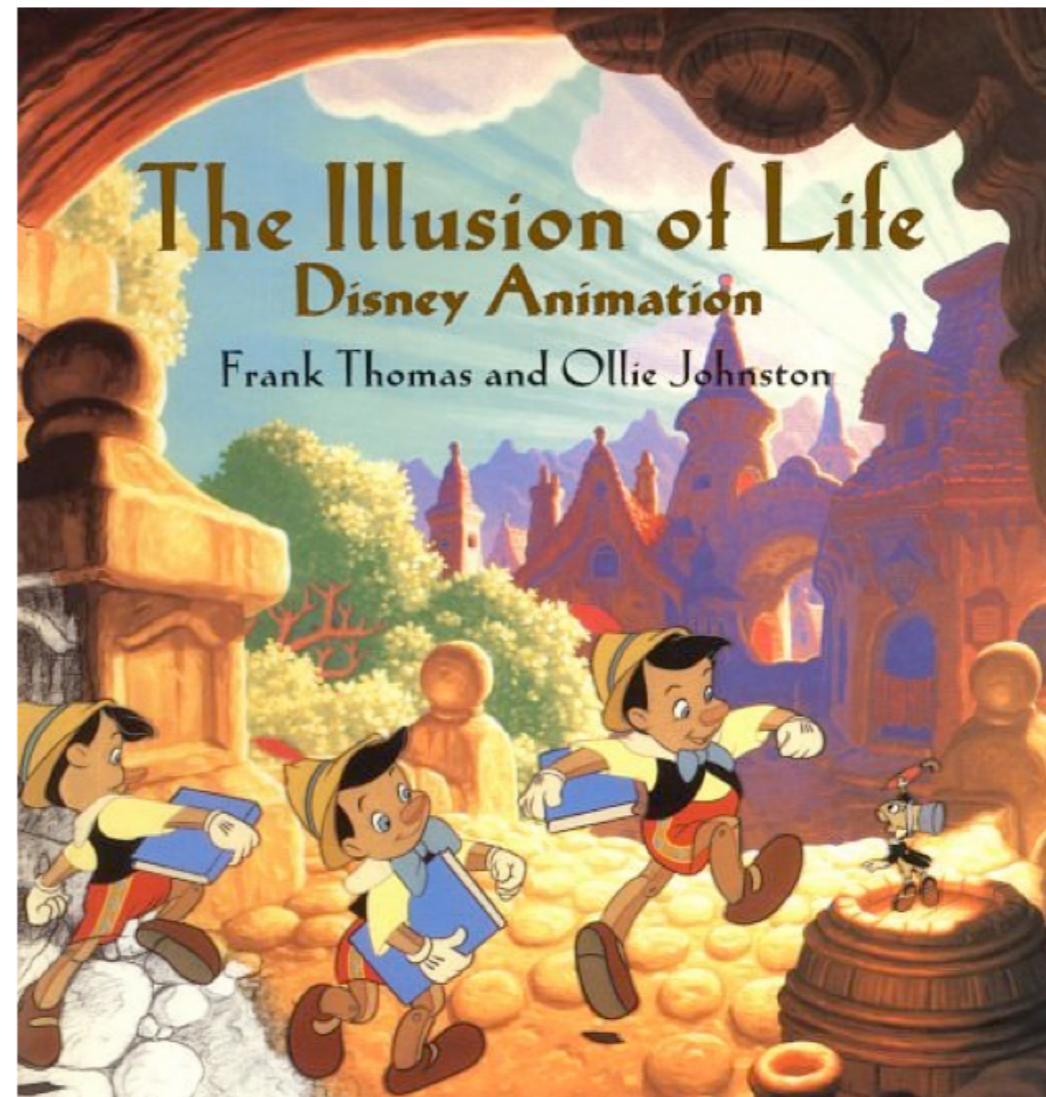
Keyframes
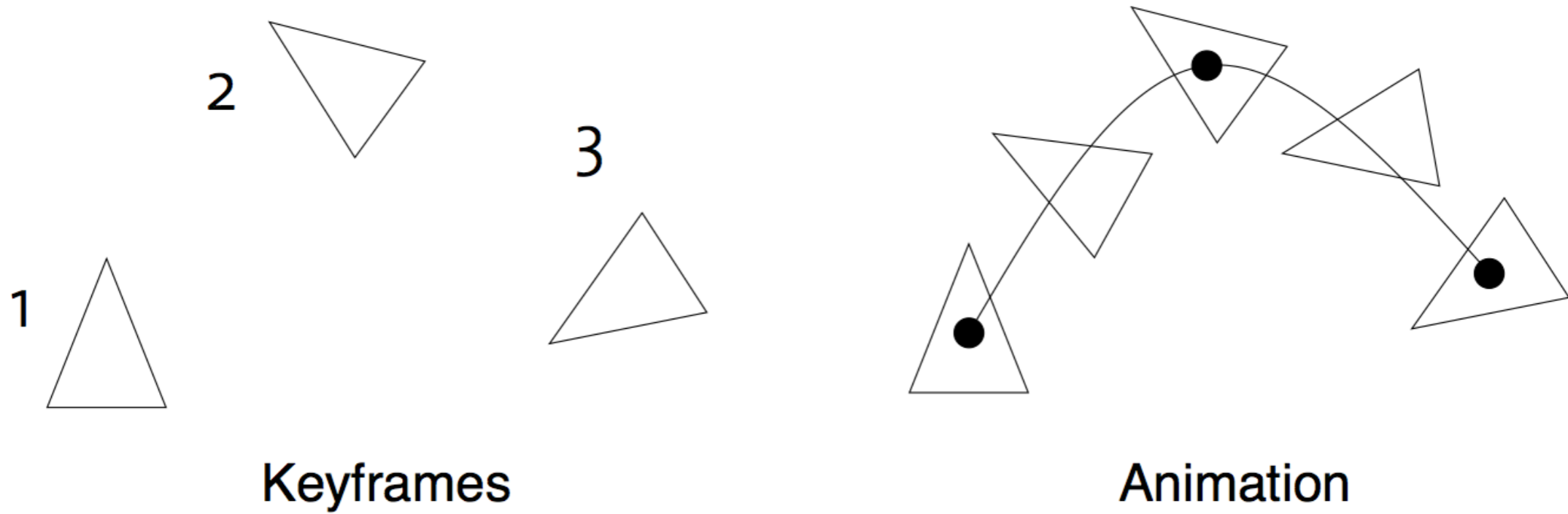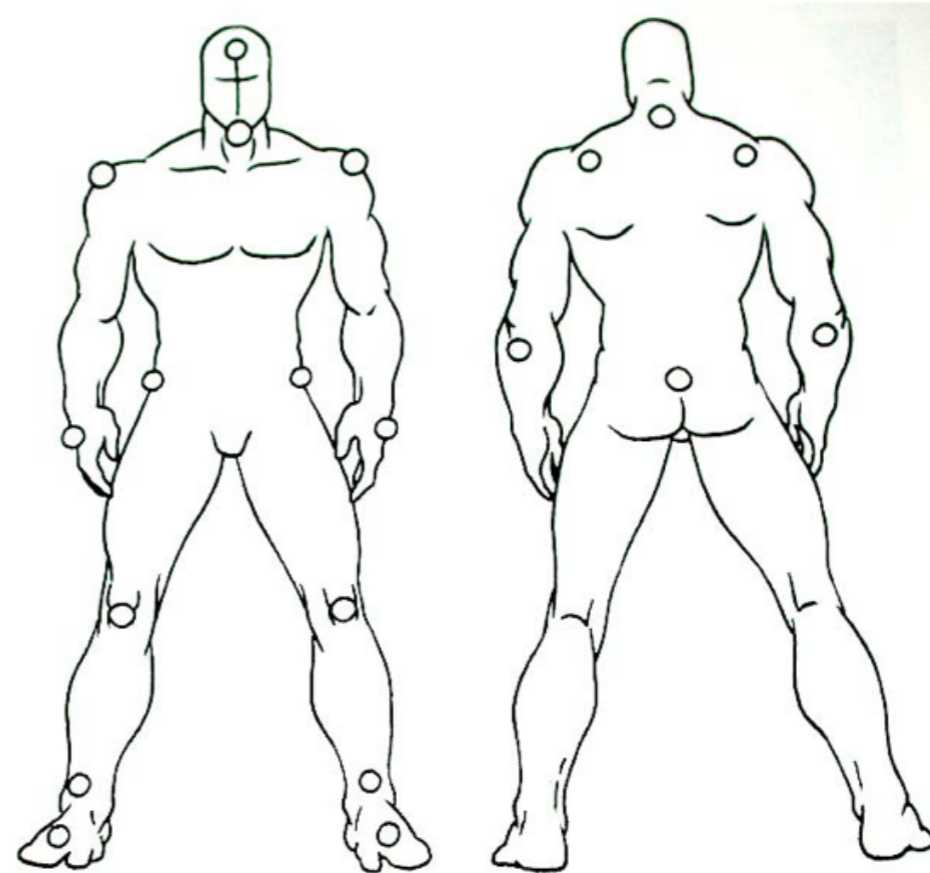
Animation

# Keyframe Animation
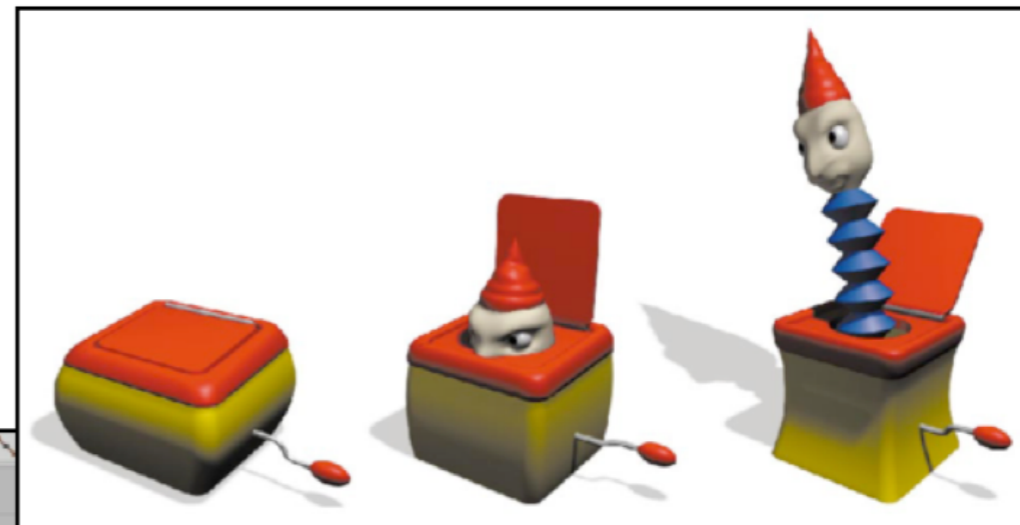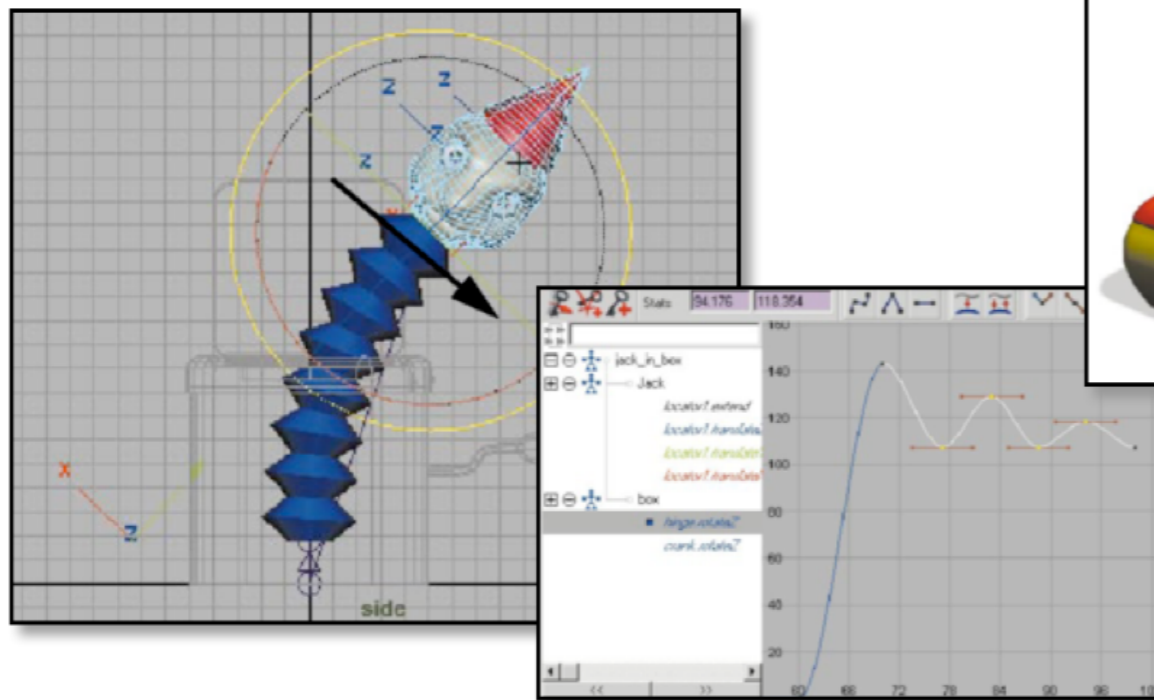


From *Learning Maya 2.0*

# 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

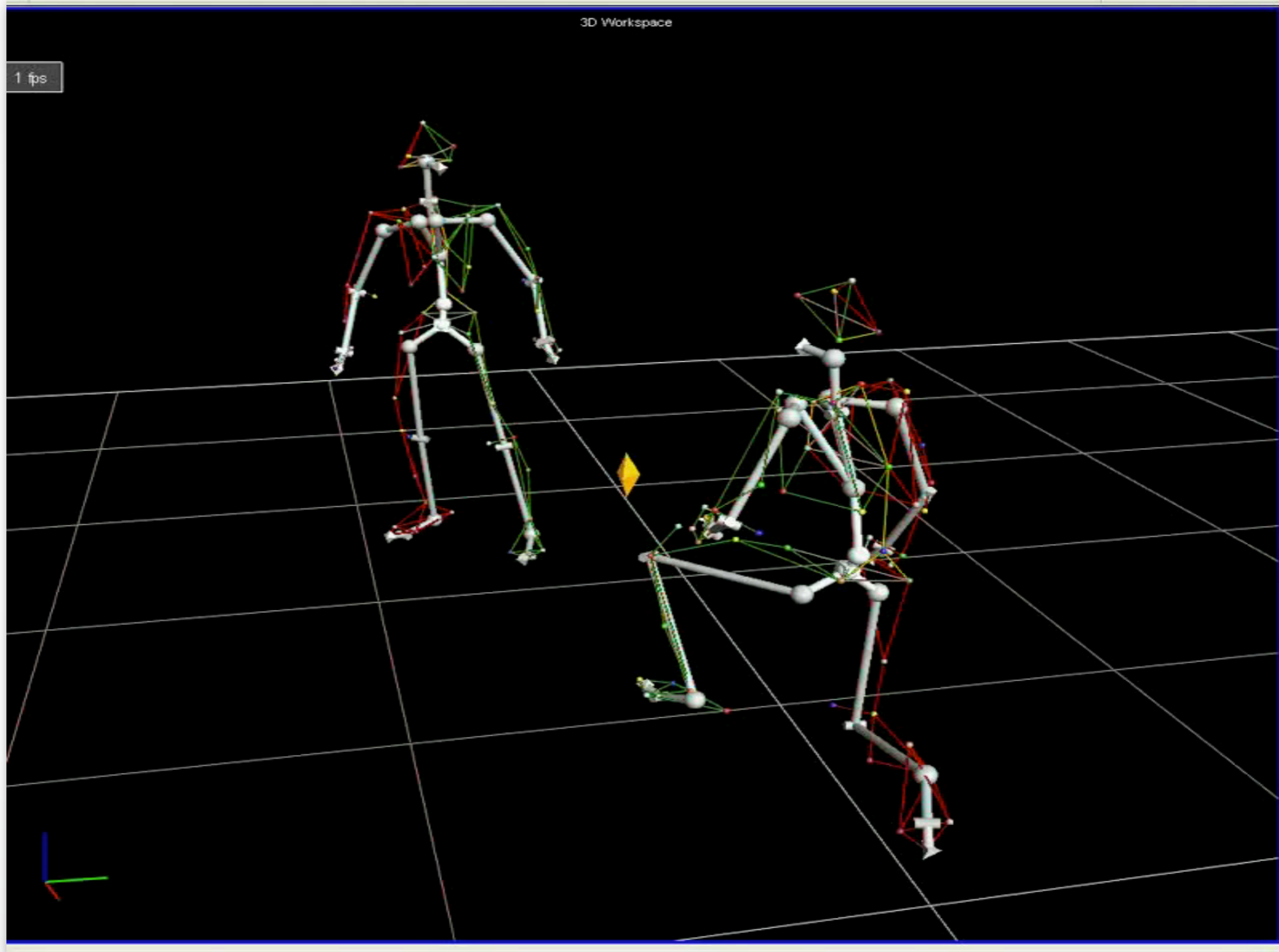- Record live action

# Optical



[Images from NYU and UW]
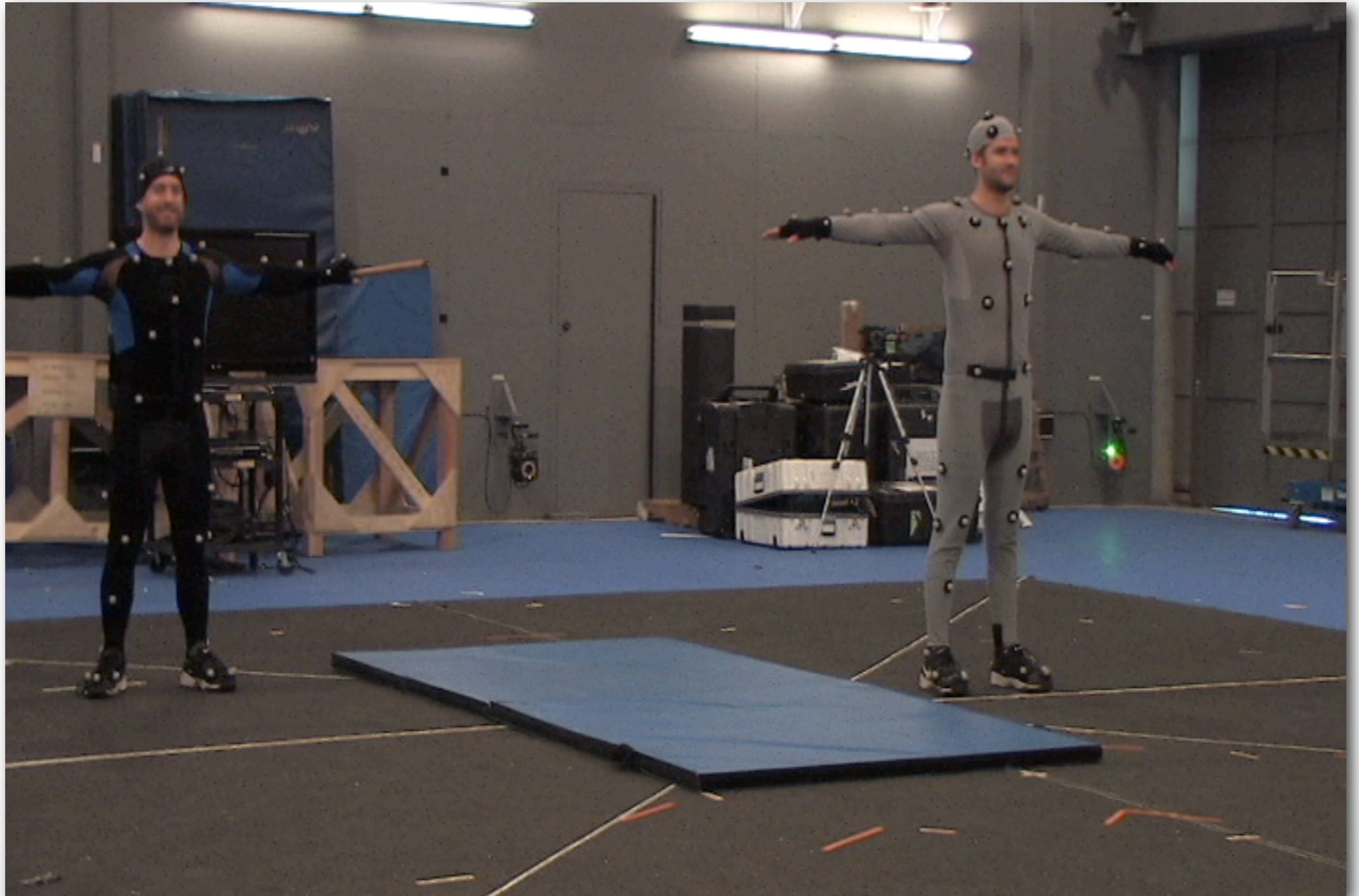
# Motion Capture



... becomes Mocap Data

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

# IMocap



114_NG_210_v24308          ILM          03-20-08

mclemens          48
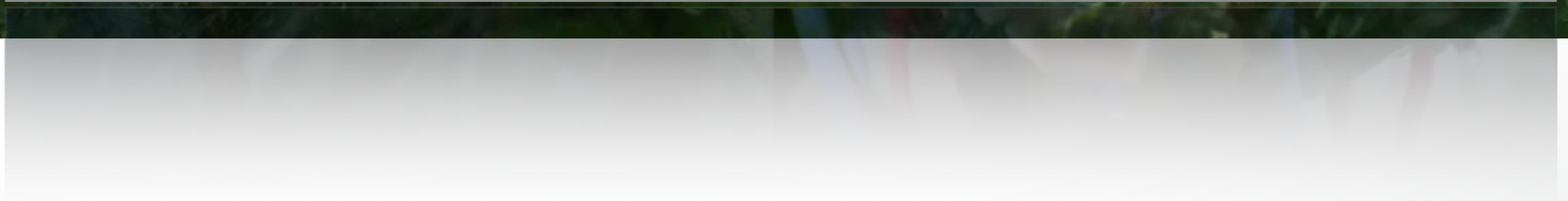
# Head-Mounted Camera



input performance

input video
with markers

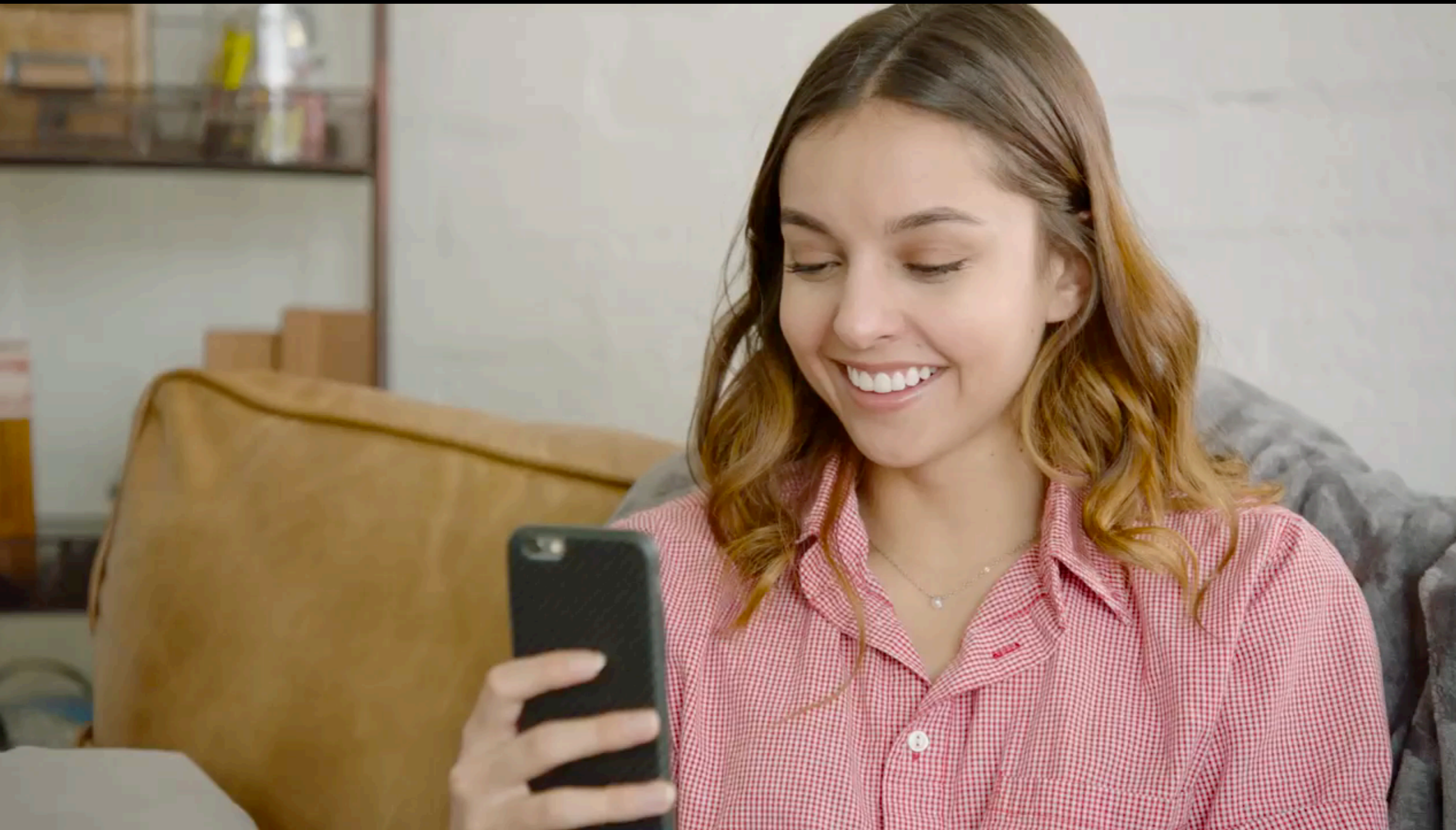tracking

retargeting

**Bhat et al. (2013)**

# Back in 2009

Weise et al. (2009)
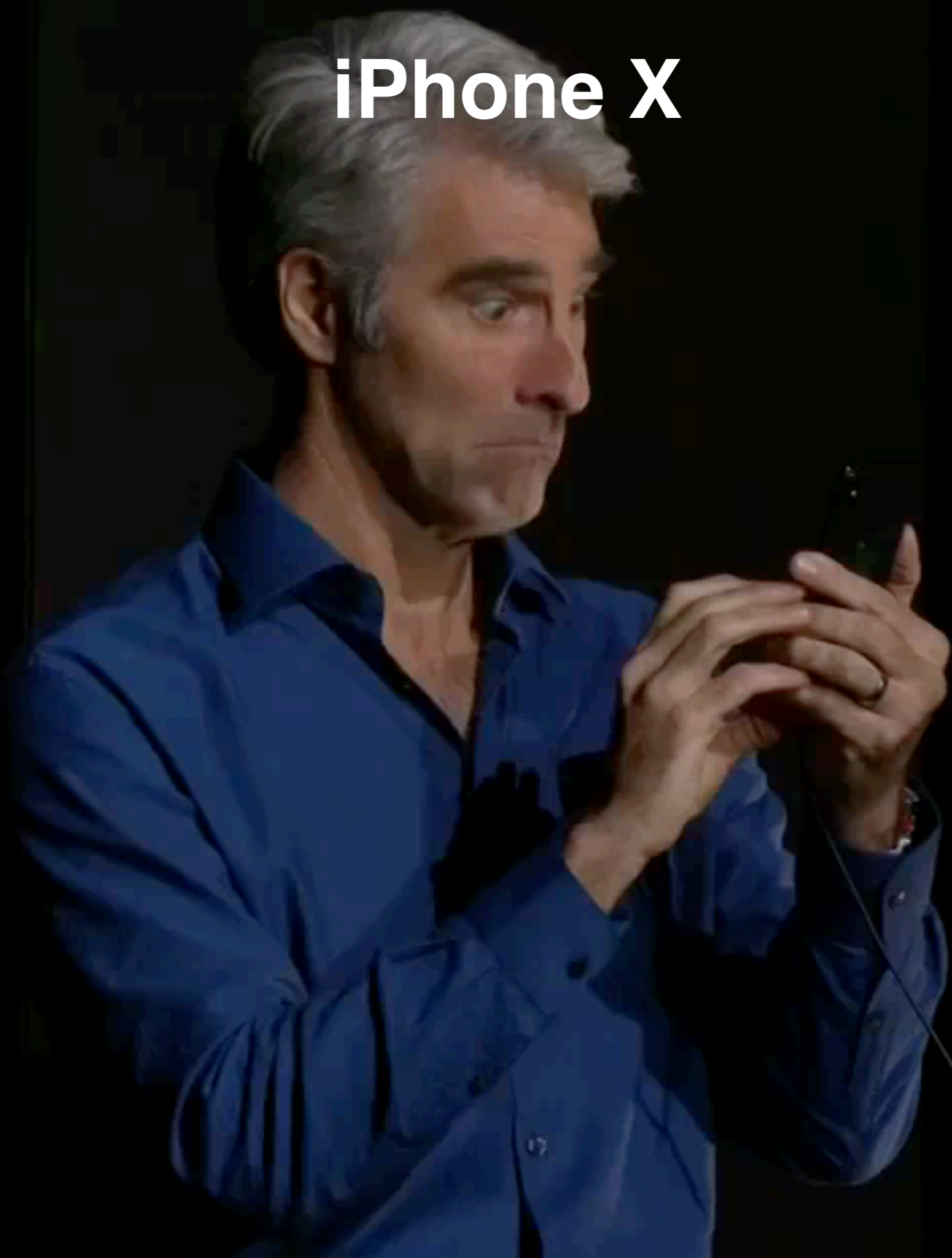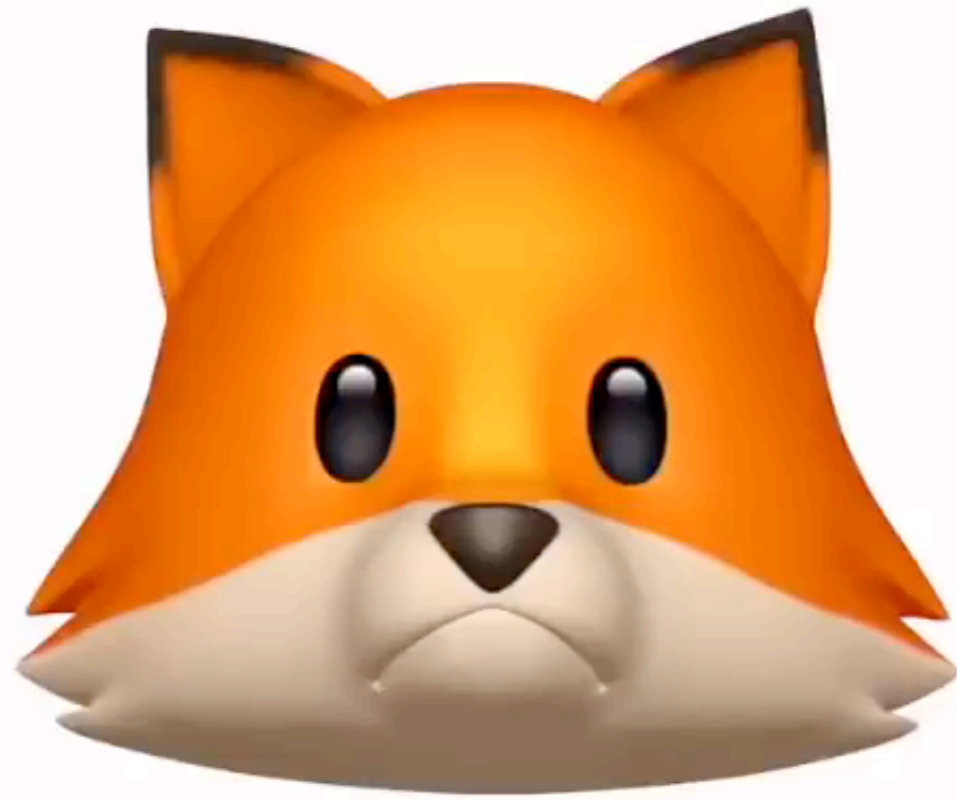
Li et al. (2013)

Snapchat

# We can capture these…

# Motion Capture???

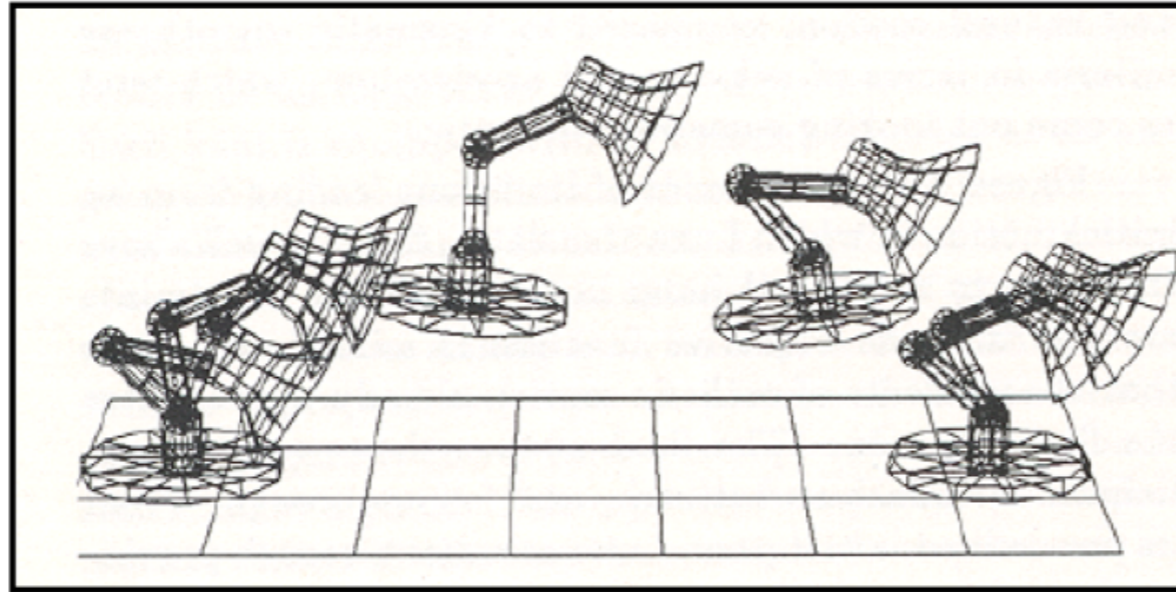# Physics-Based Character Animation
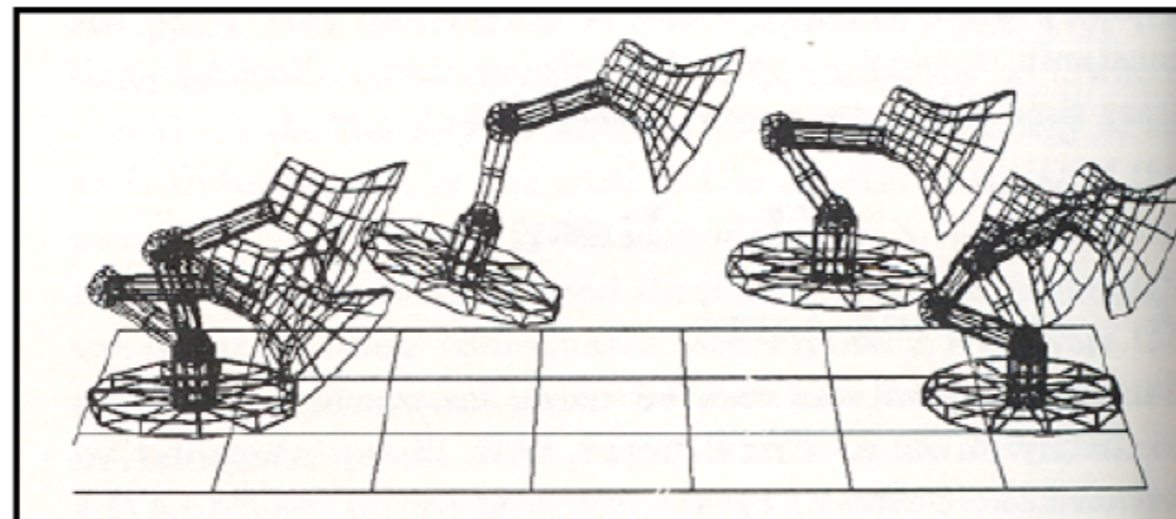


Olympic Running

# Physics-Based Character Animation



Vaulting, Cycling and Running
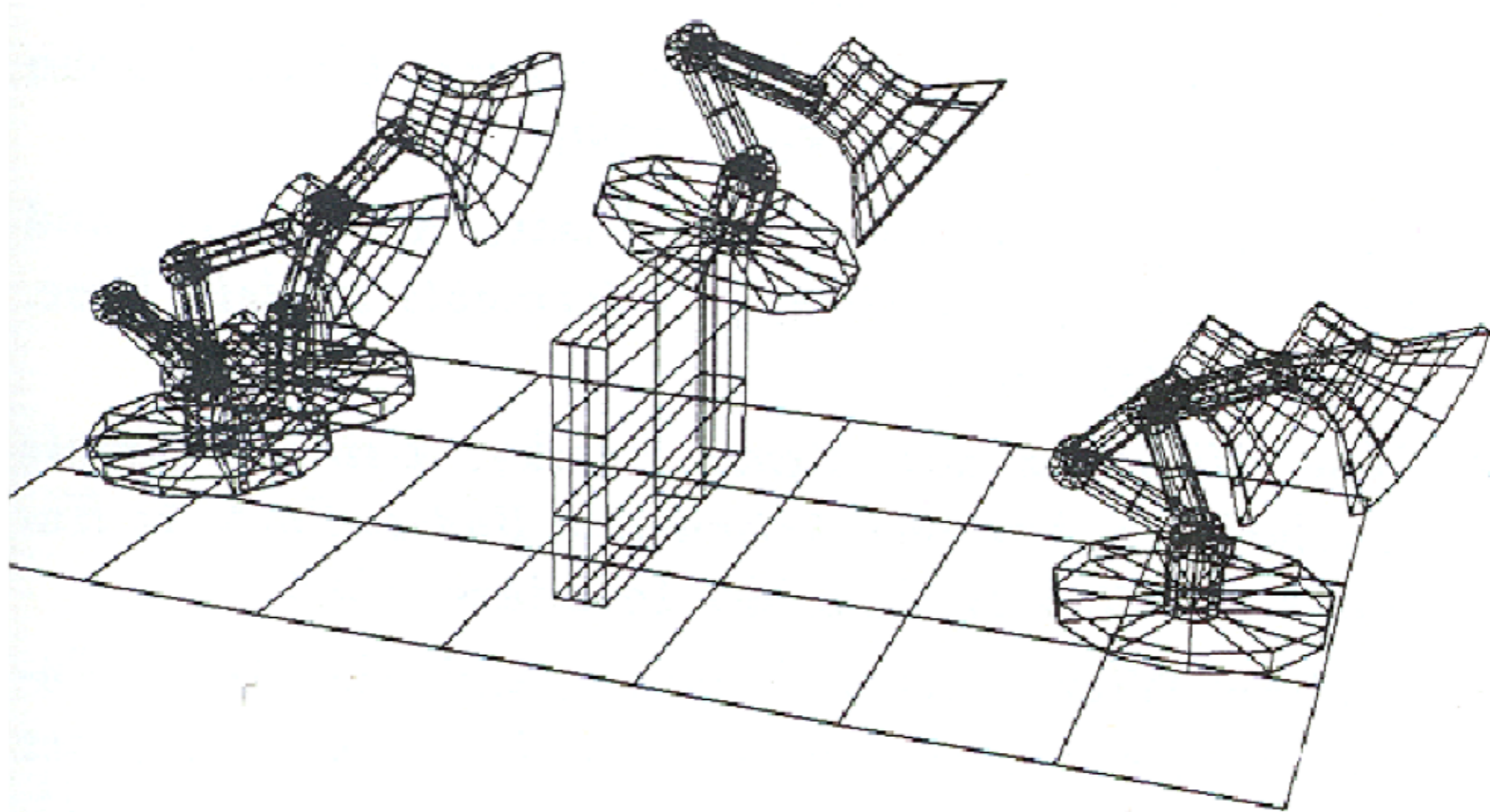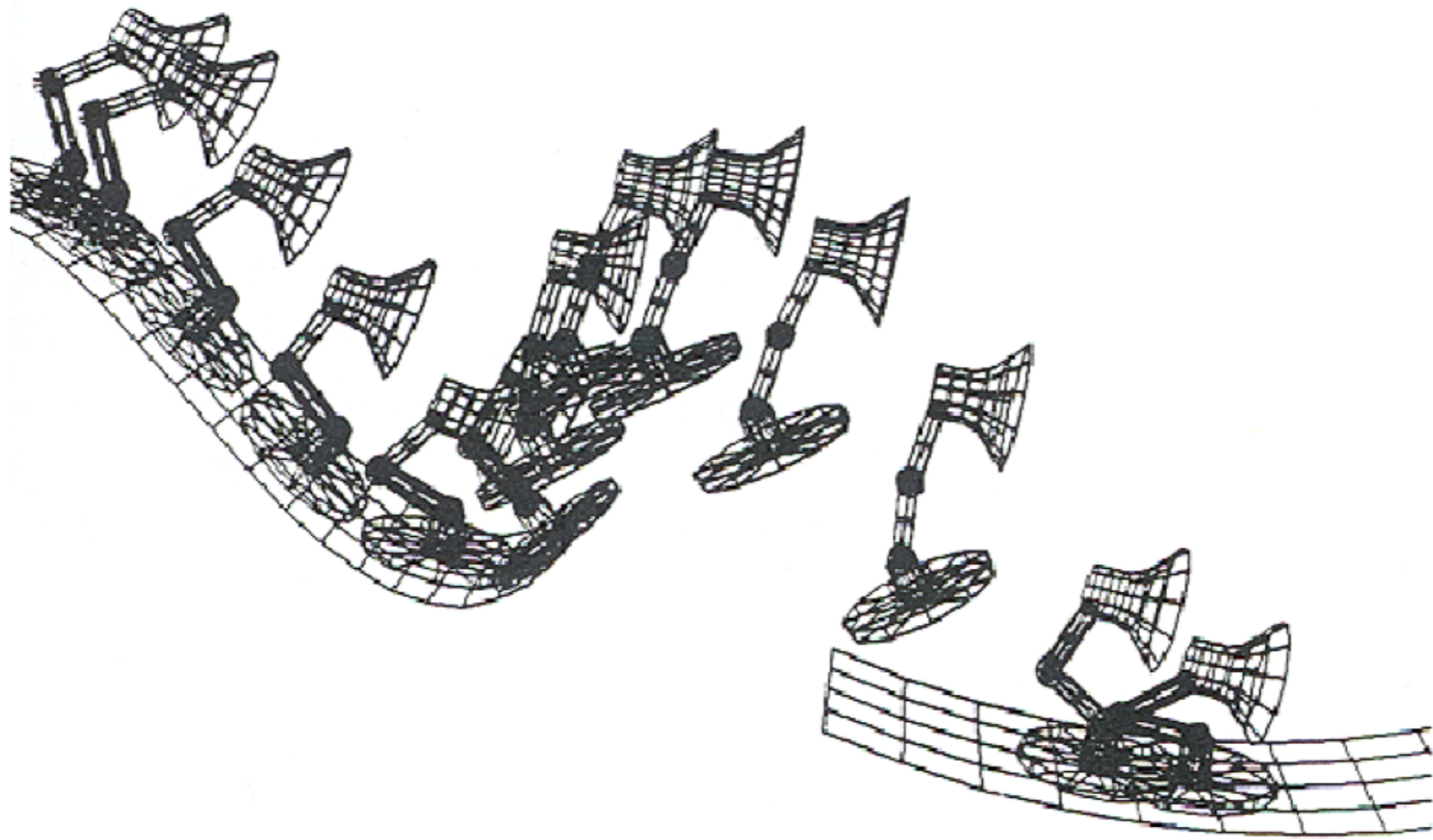
# Space Time Constraints



Original Jump

Heavier Base

# Space Time Constraints



Hurdle

Ski Jump

http://cs420.hao-li.com

# Thanks!