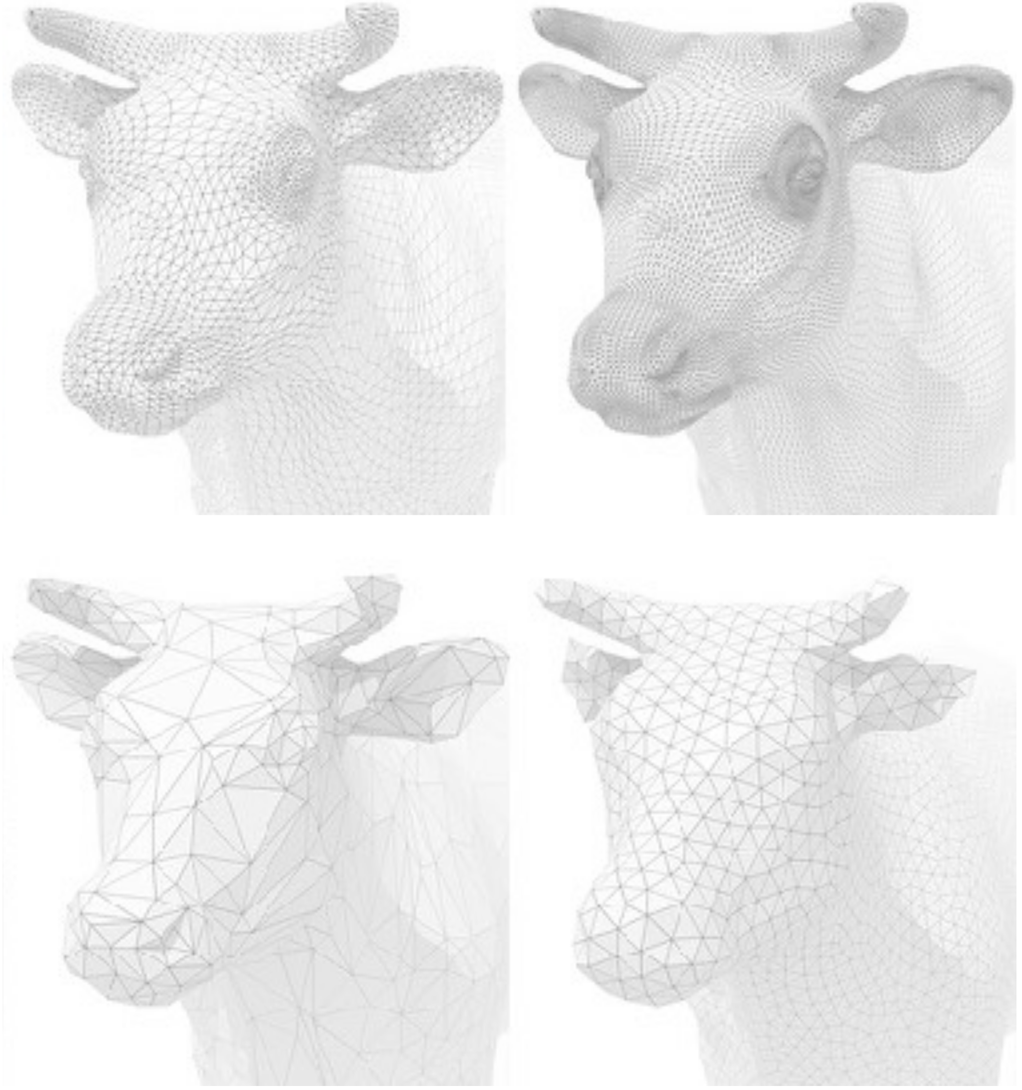
COL781: Computer Graphics

30. Introduction to Animation

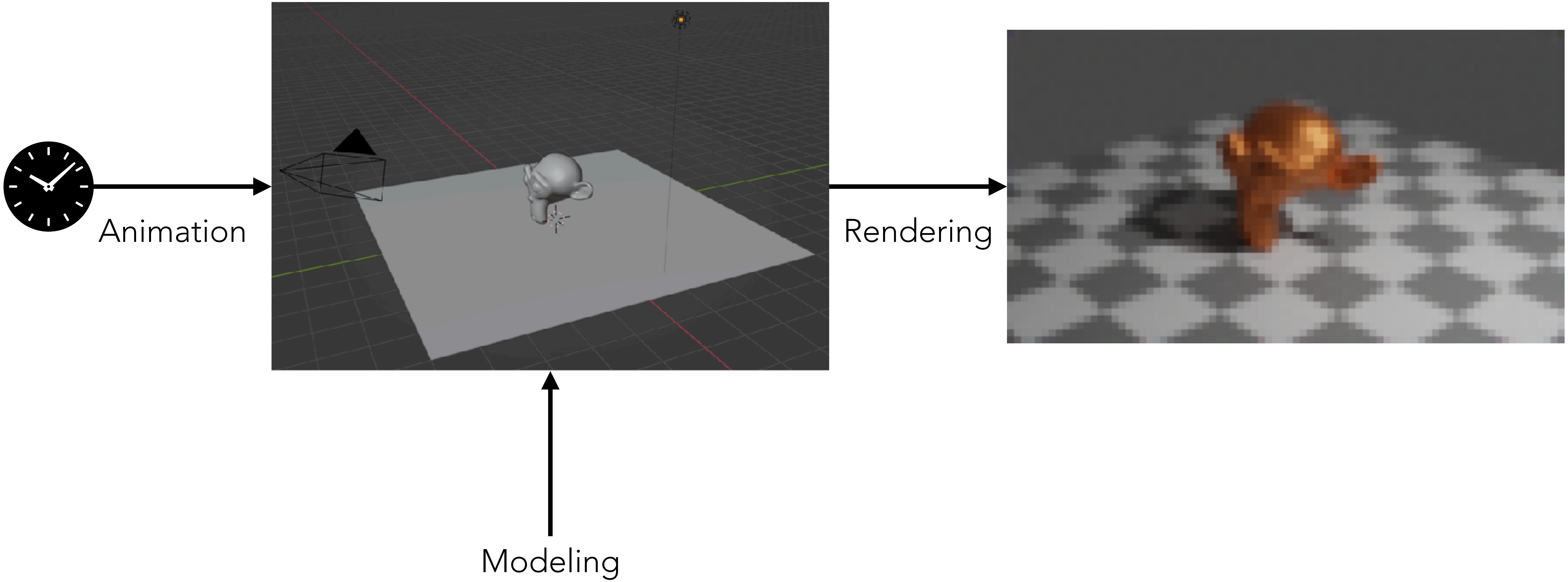
Course content



Modeling

Rendering

Animation



Animation

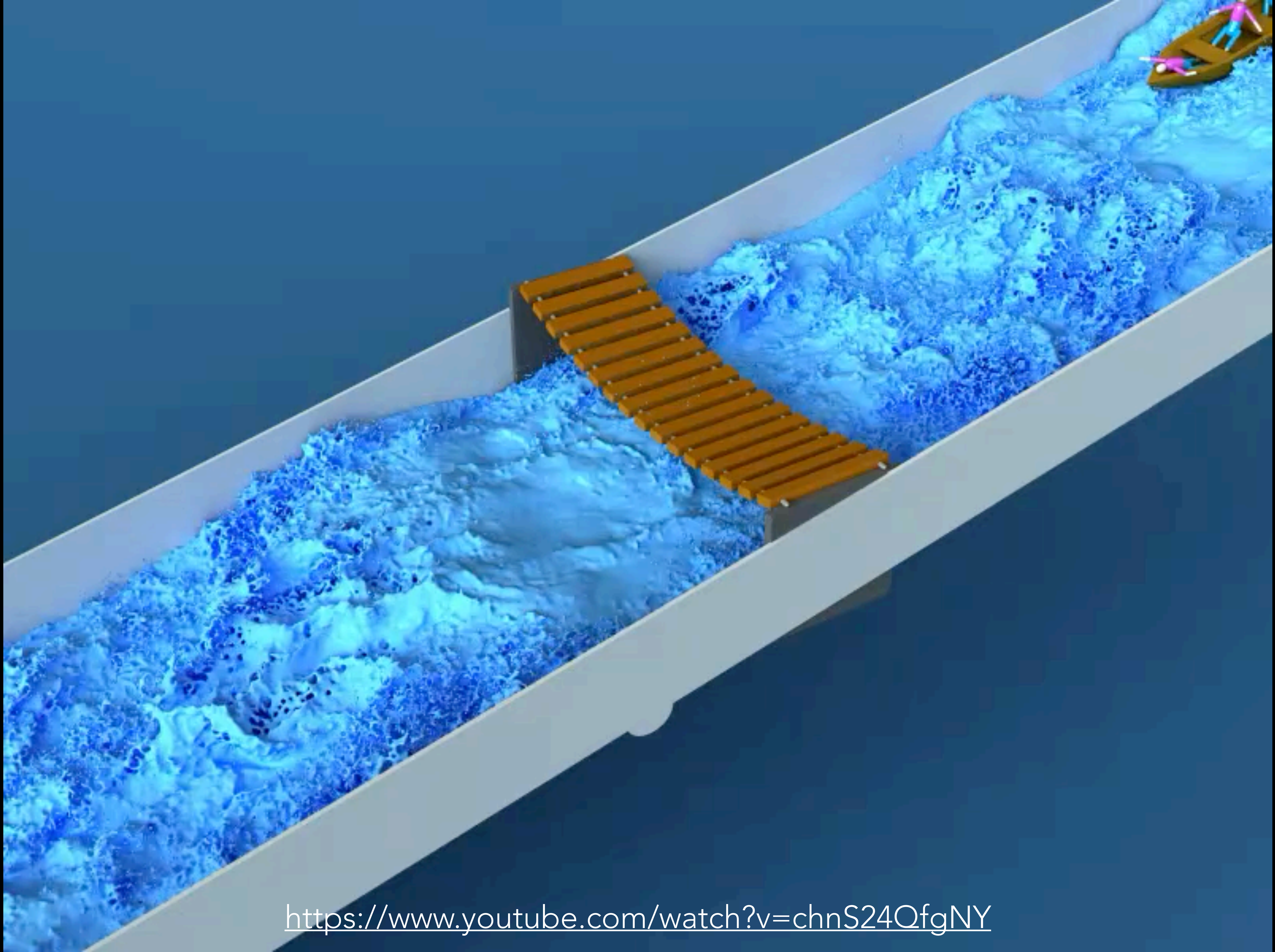
Rendering

Modeling

Dynamic Result

https://www.youtube.com/watch?v=KDvfFzFIruQ

McAdams et al. 2011



https://www.youtube.com/watch?v=chnS24QfgNY

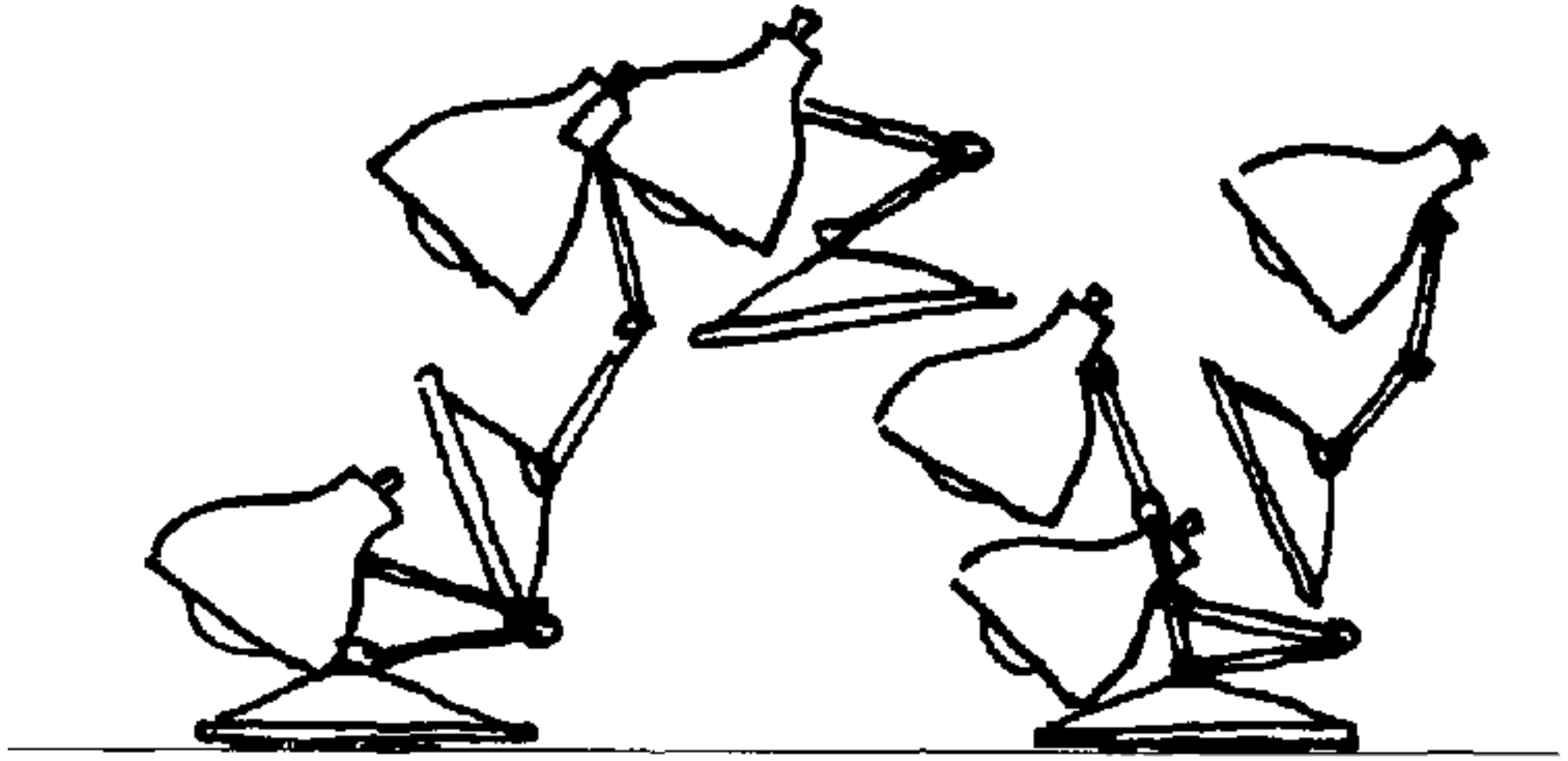
Akinci et al. 2012

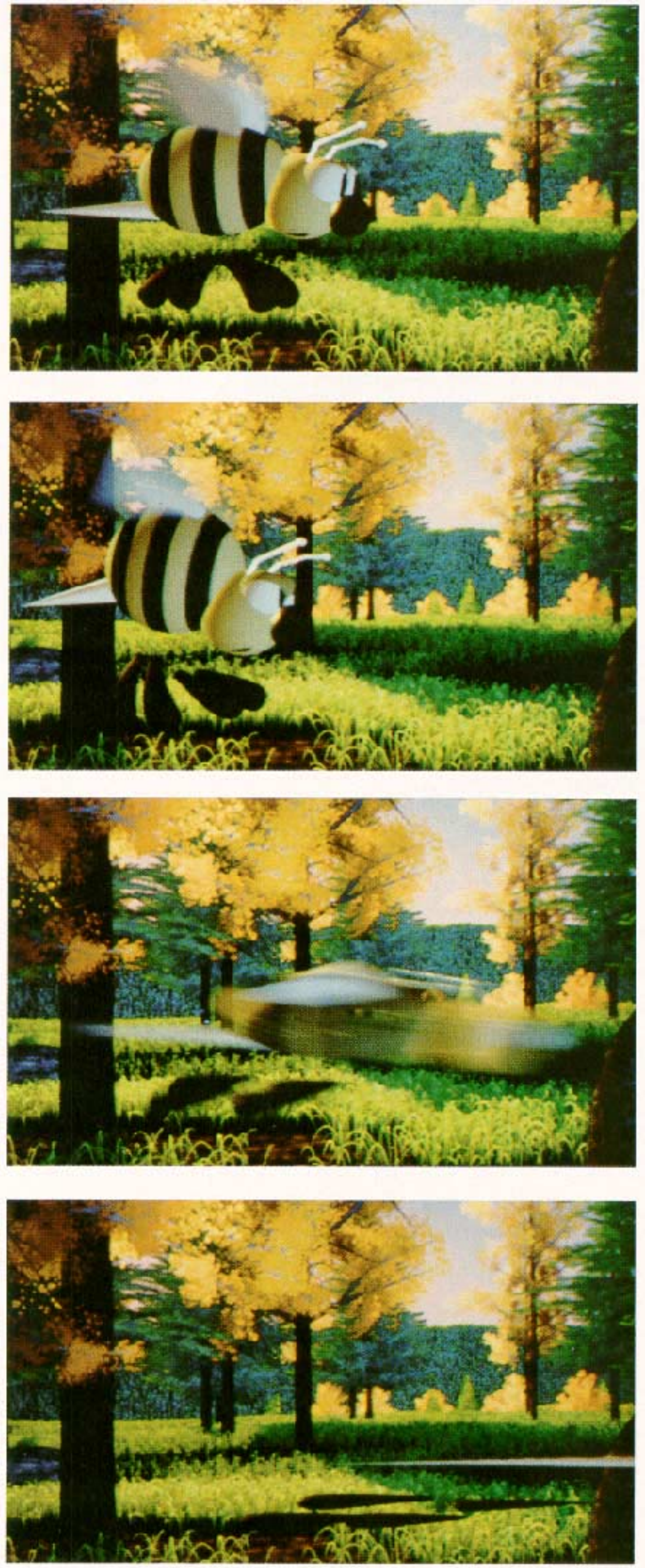
Character animation

What makes the motion of a character look real?

"Fundamental principles of [character] animation"
(cf. Lasseter 1987)

- Squash and stretch
- Anticipation
- Follow-through and overlapping action
- …

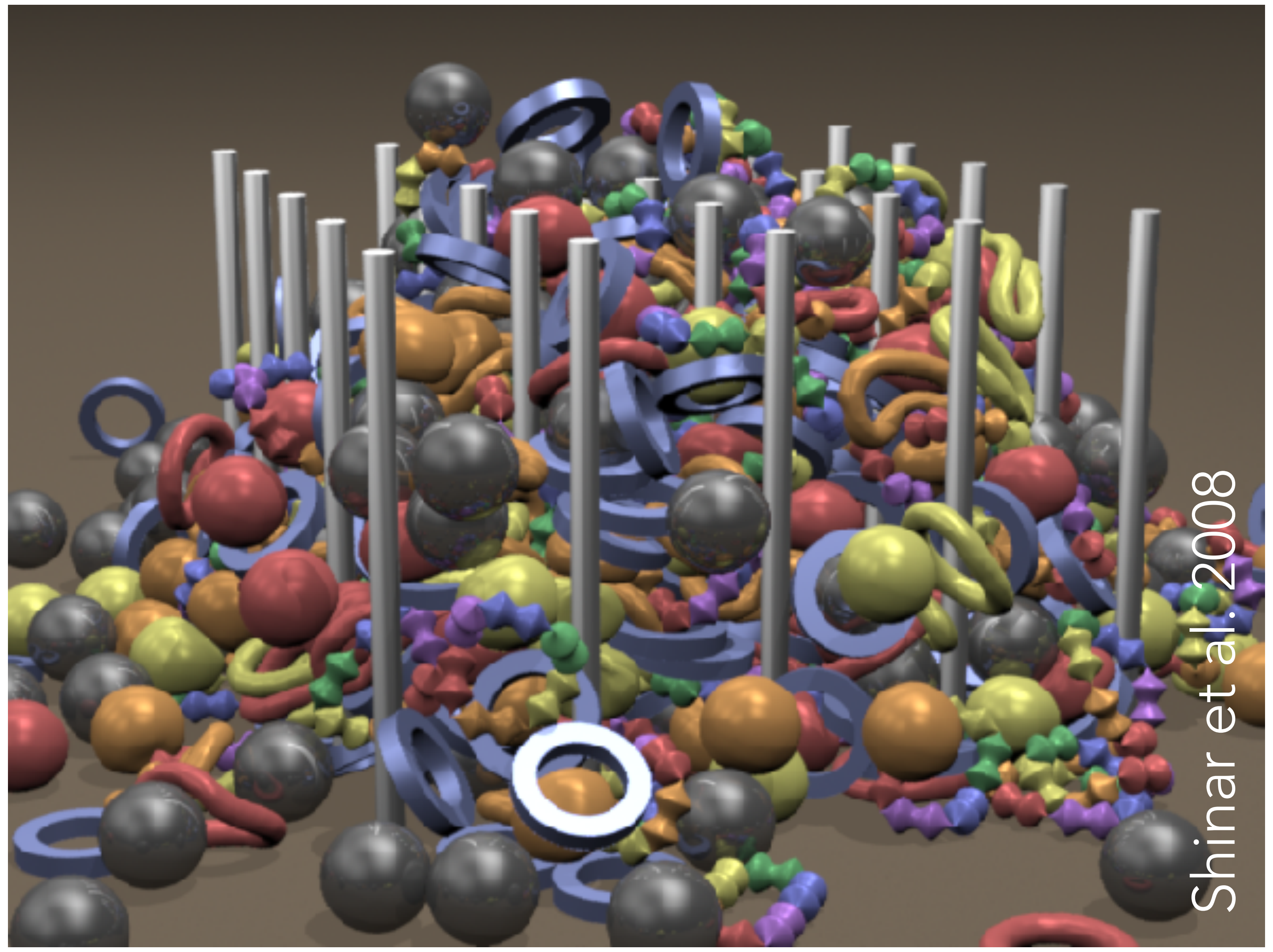




Physics-based animation

What makes the motion of a physical object look real?

$$\mathbf{F} = ma$$



Shinar et al. 2008

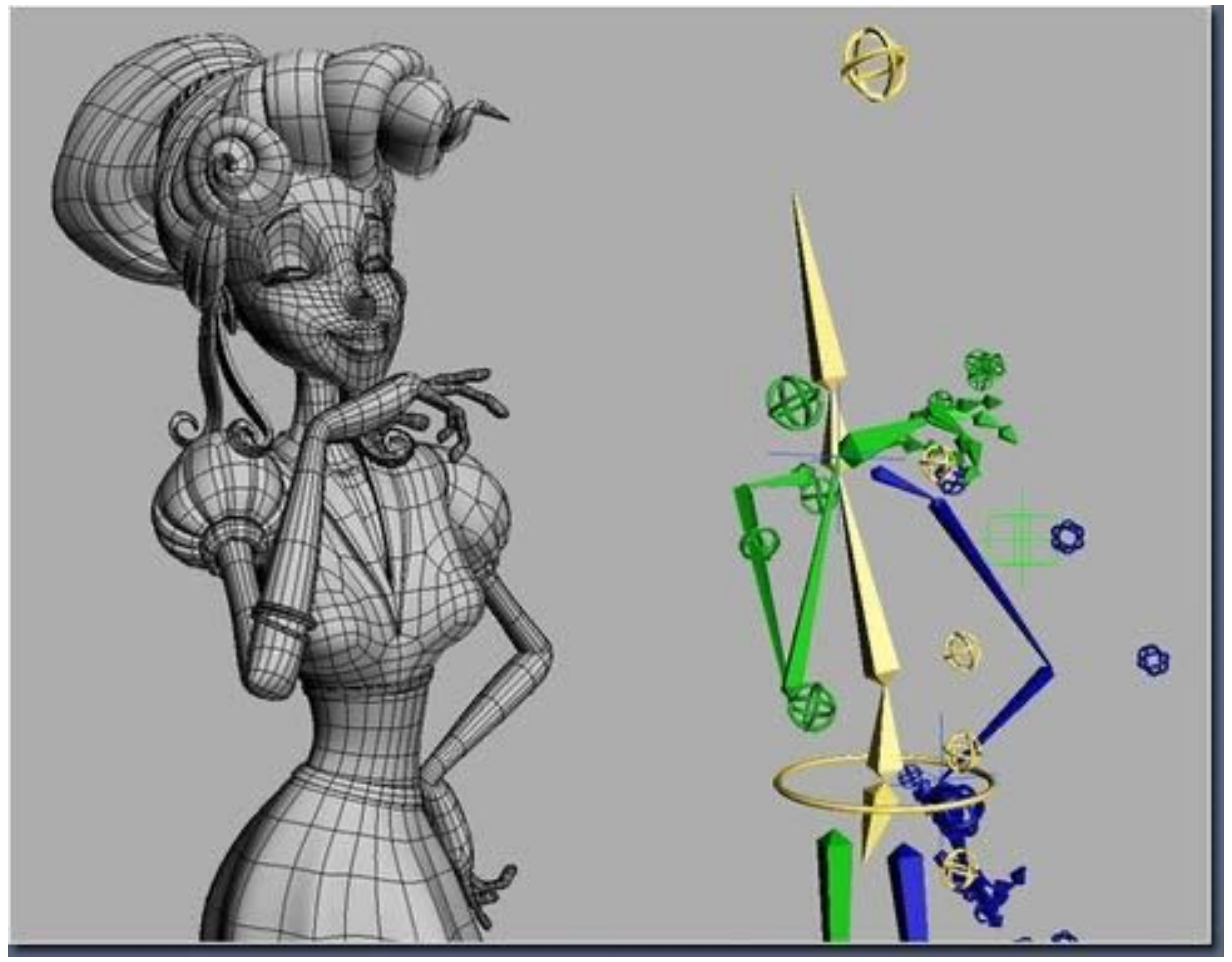
Feng et al. 2022

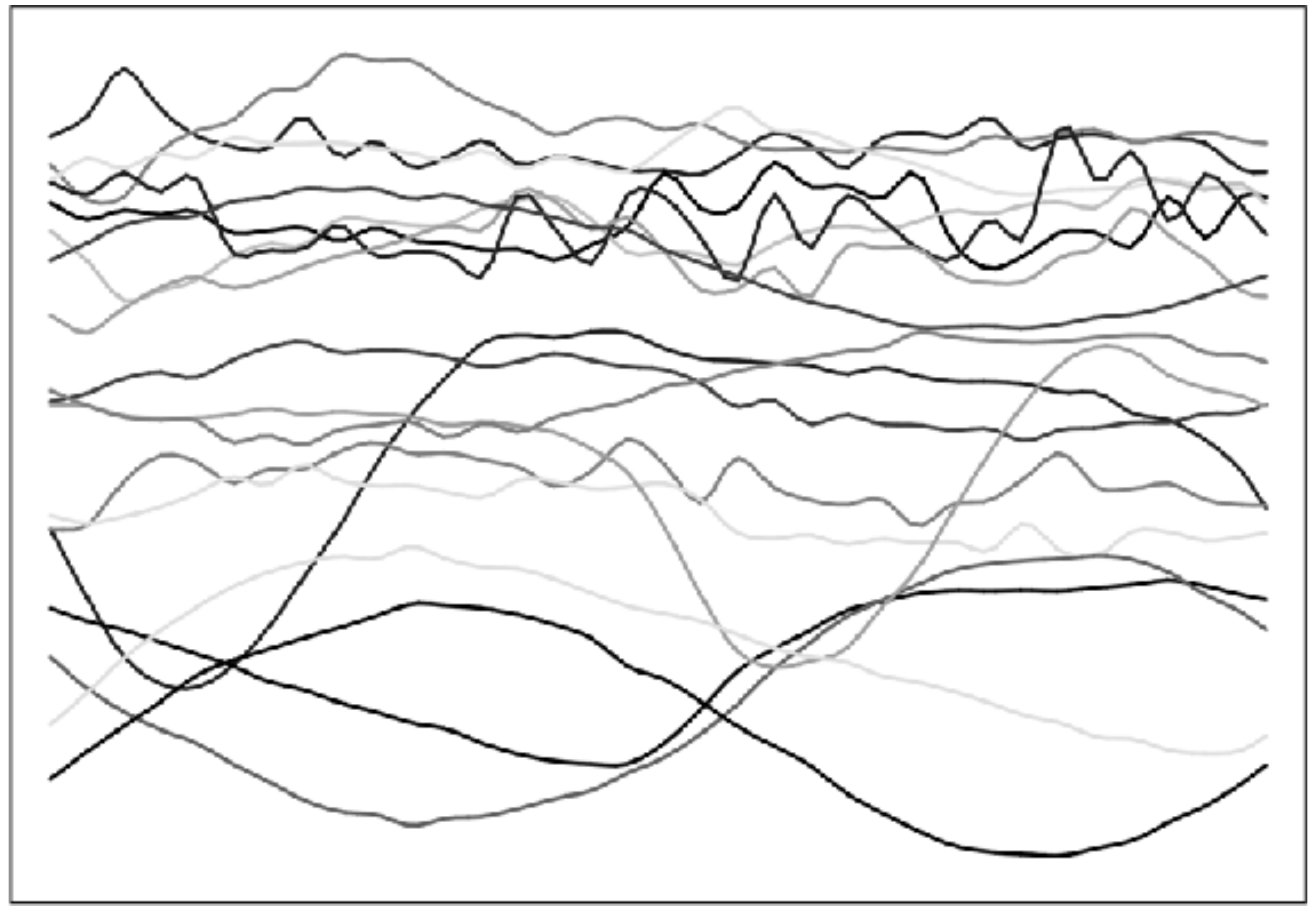
Thürey et al. 2010

Animation is defined through a set of **animation controls** (degrees of freedom) whose values vary with time

For example:

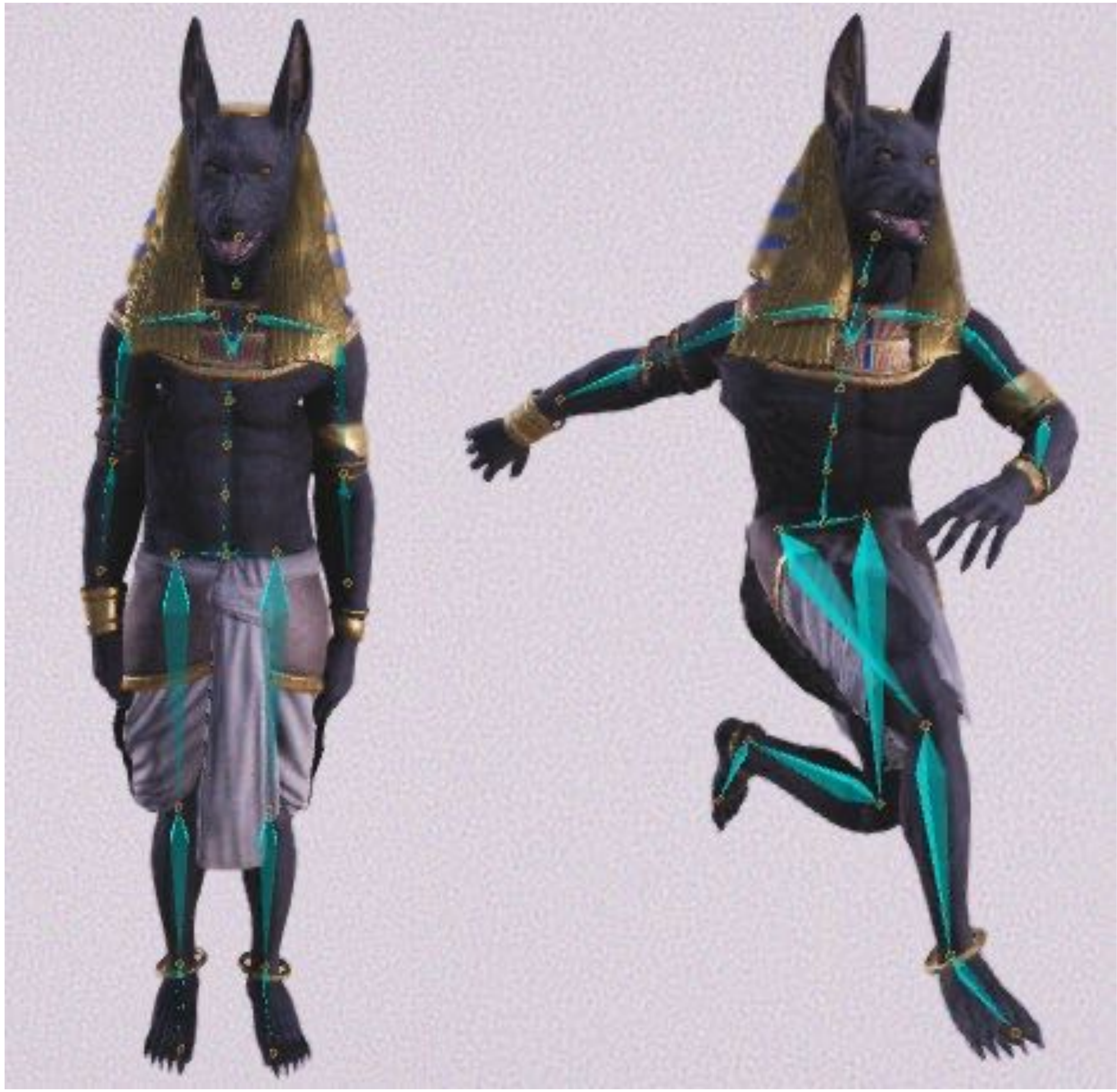
- Character: joint angles, etc.
- Rigid body: translation and rotation
- Liquid: position/velocity of all particles(!)





For an articulated character, we define the skeleton and control its pose over time: **skeletal animation**

The skin deforms following the movement of the skeleton: **skinning deformation**

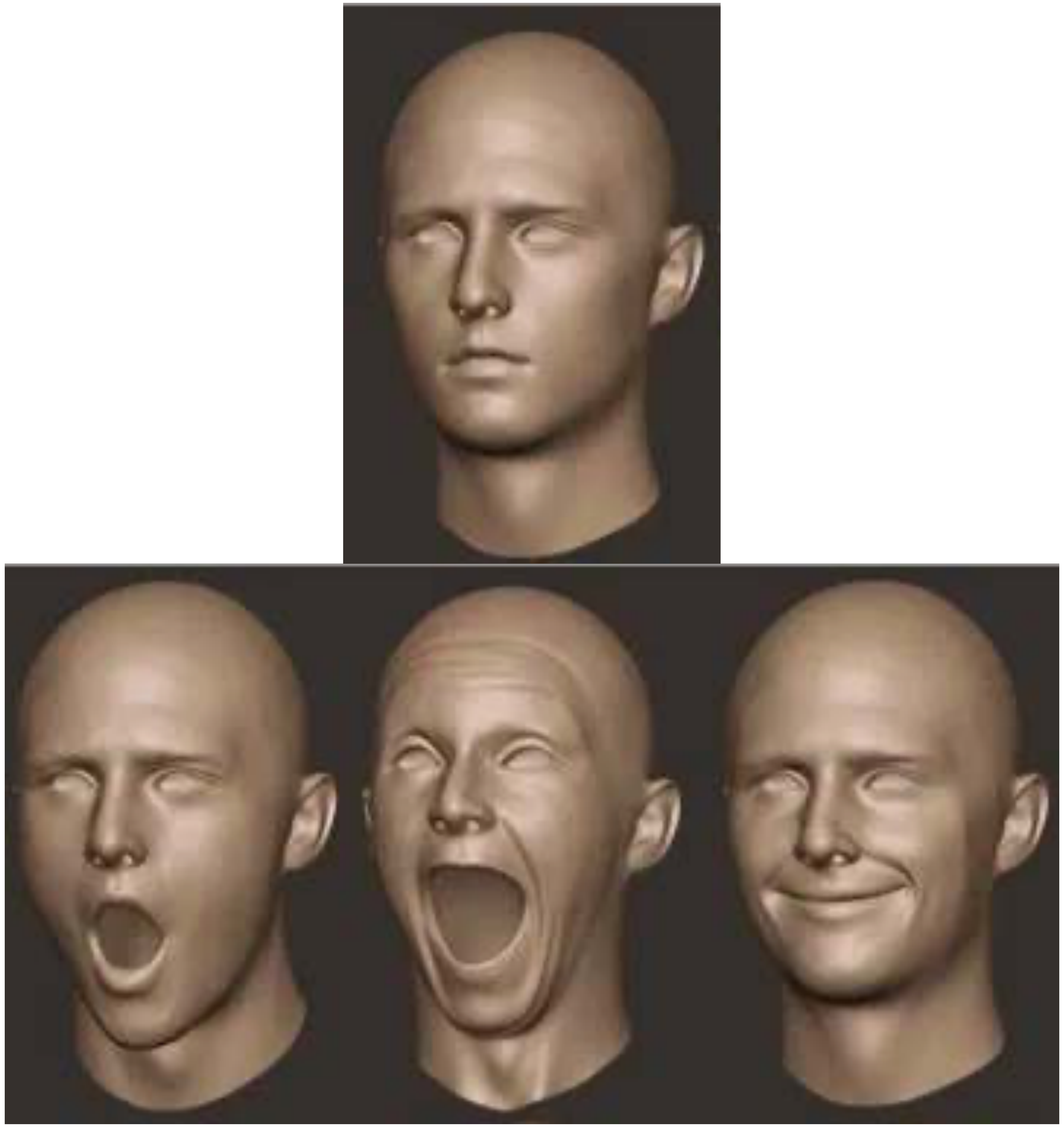


Not all deformations are from bones.

Define rest shape and set of deformations stored as vertex offsets: **blend shapes**

Can create new shapes by mixing:

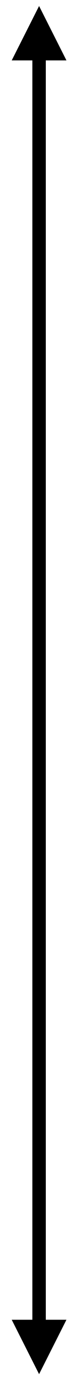
$$\mathbf{V} = \mathbf{V}_0 + \sum c_i \Delta \mathbf{V}_i$$



Types of animation techniques

- Artist-specified (e.g. keyframing)
- Data-driven (e.g. motion capture)
- Procedural (e.g. simulation)

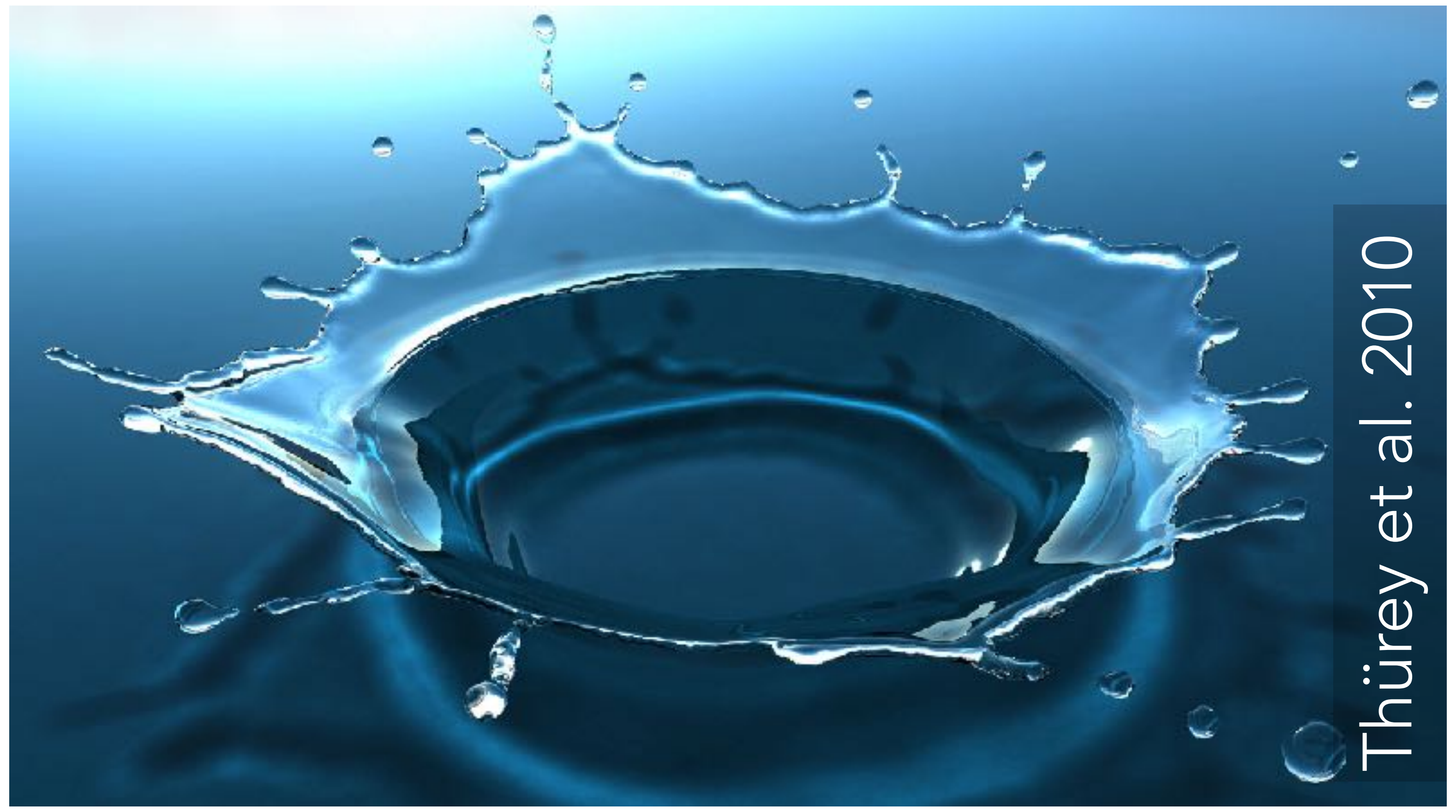
More artistic control



Less manual effort

Matthew Lailler

Andy Serkis as Gollum in *The Two Towers*

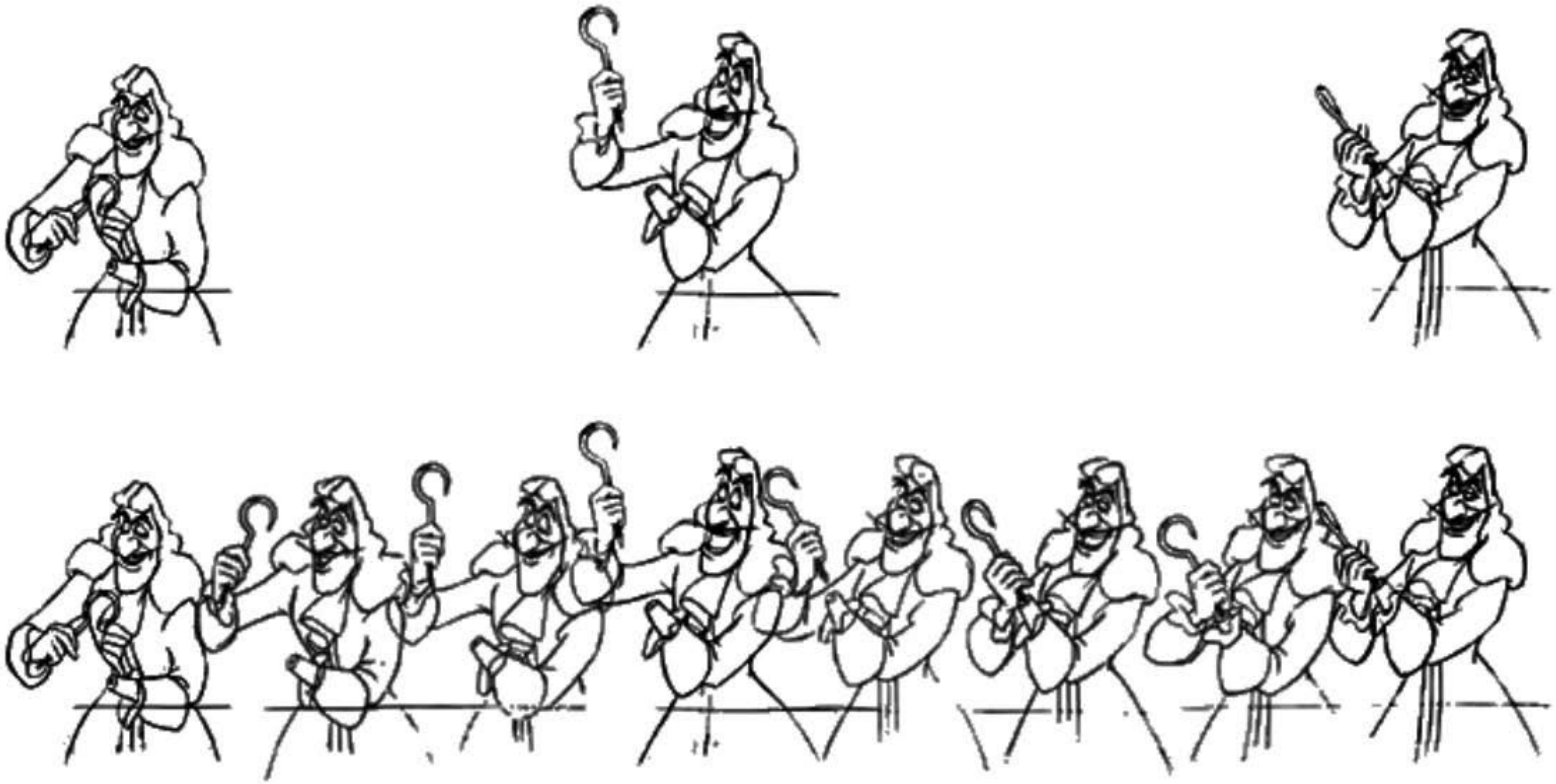


Thürey et al. 2010

Keyframe animation

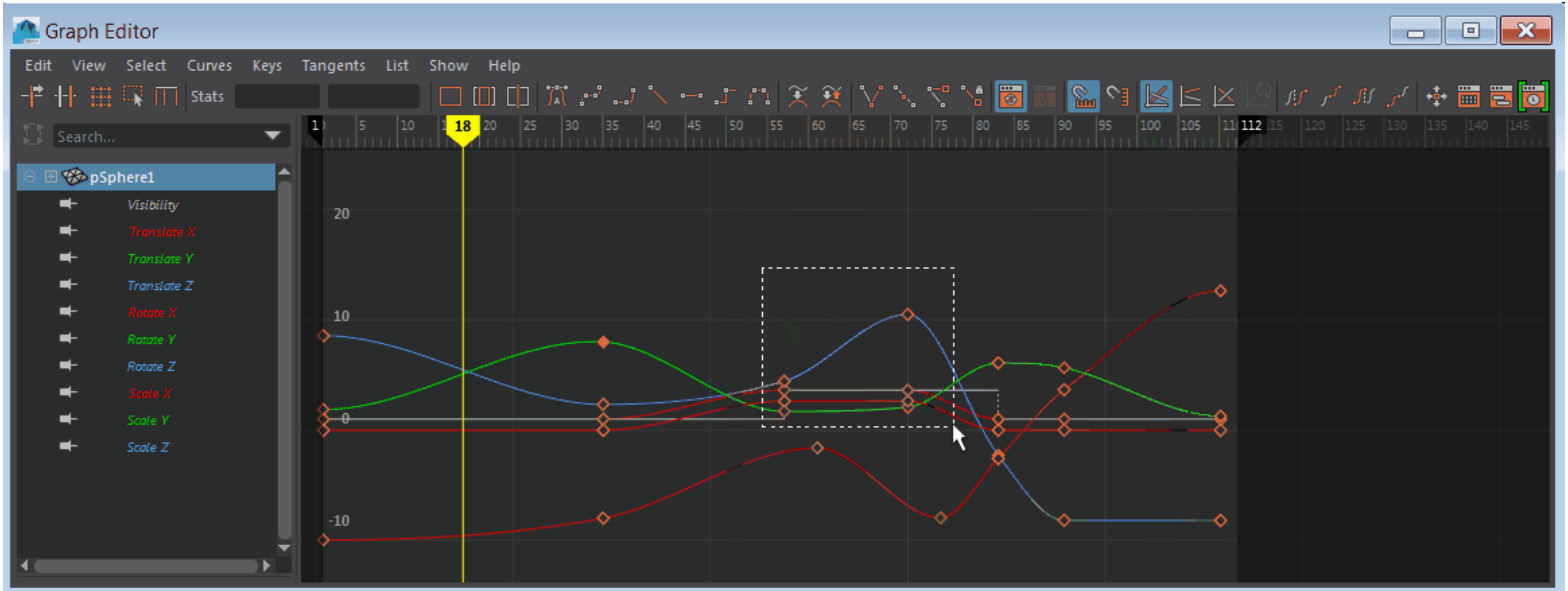
In traditional (hand-drawn animation:

- Lead animator creates **keyframes**
- Assistant creates in-between frames ("**tweening**")



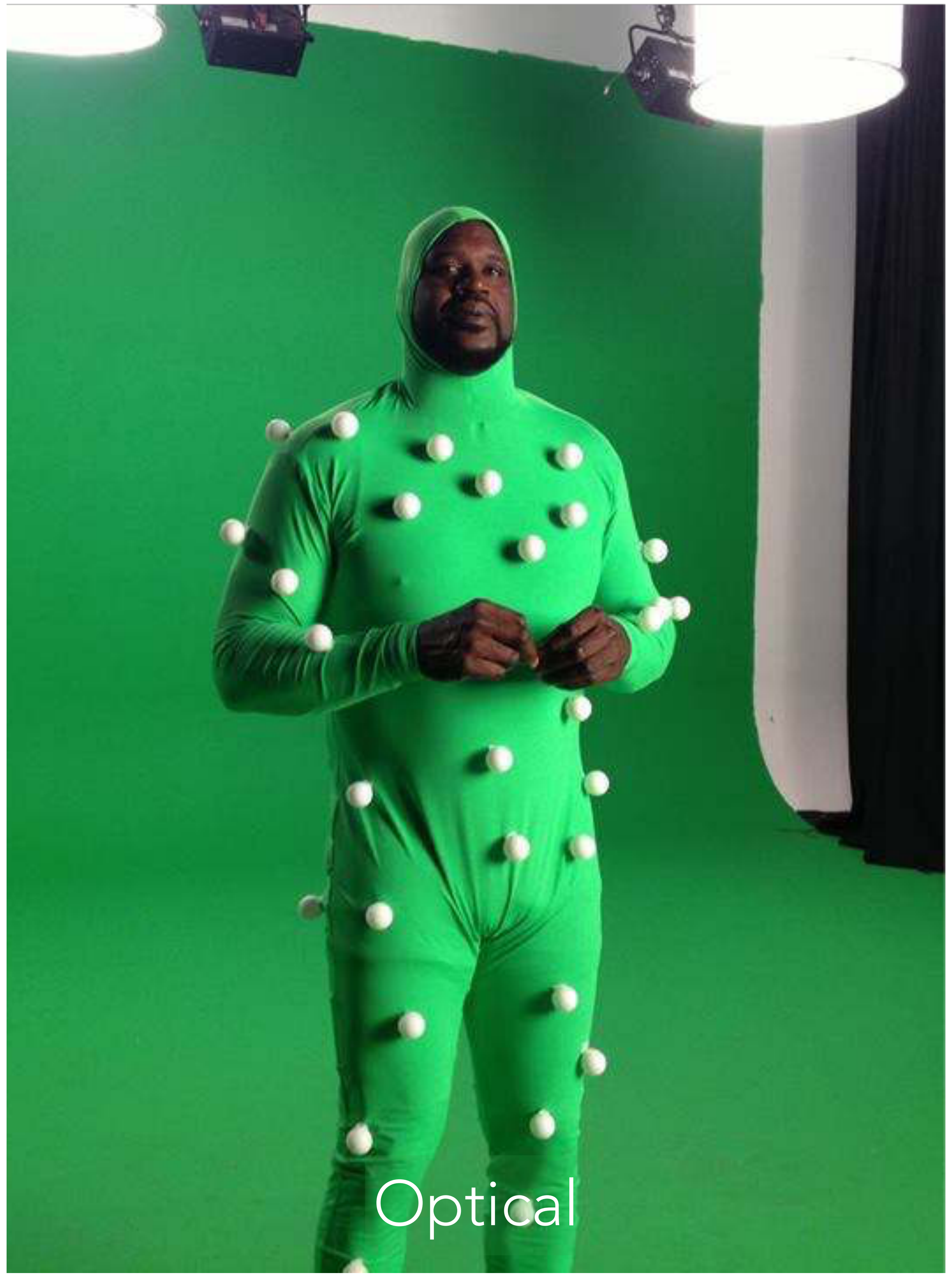
Thomas & Johnston, *The Illusion of Life*

In computer animation, keyframes = control points, tweening = splines!

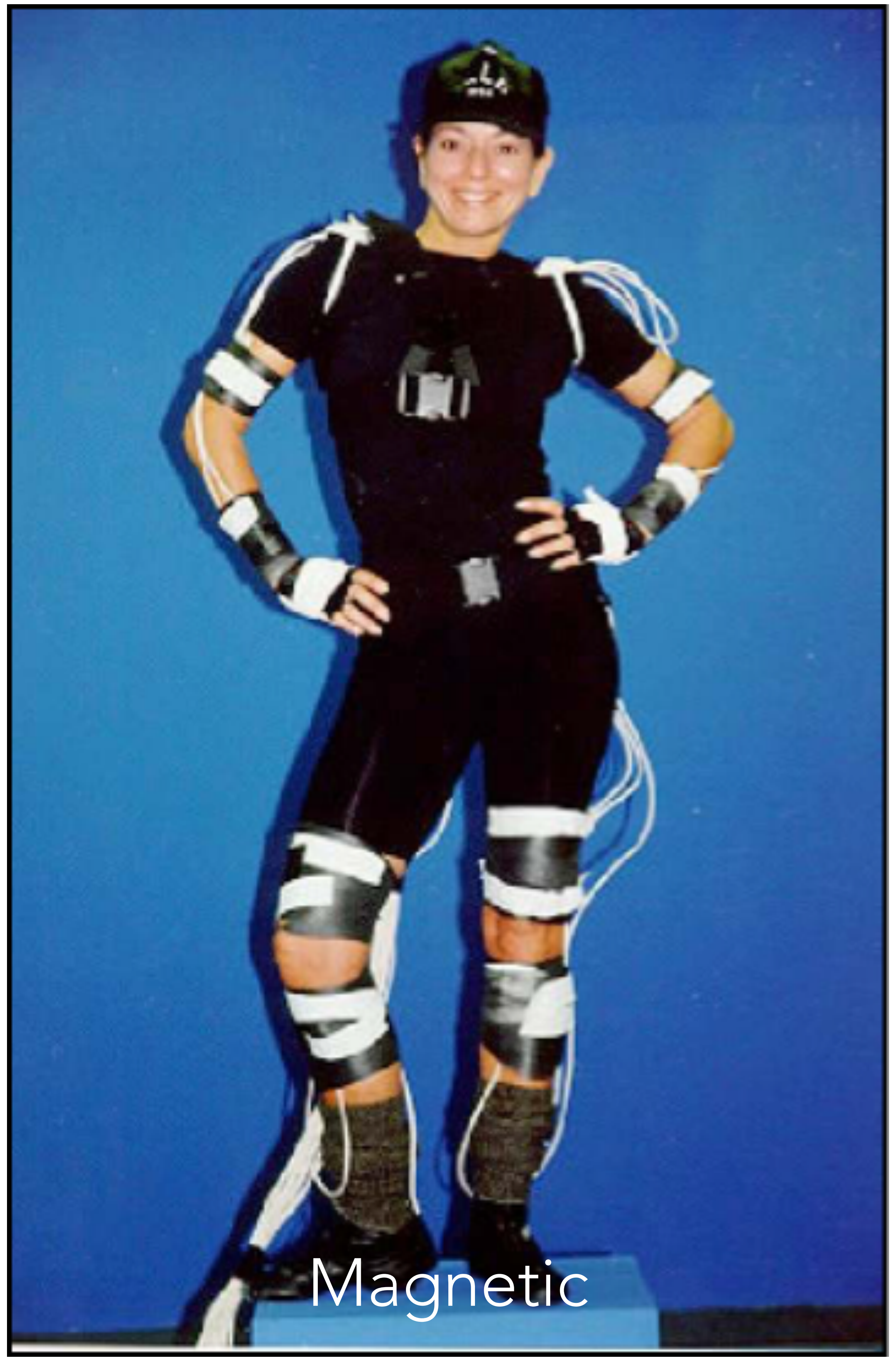


Autodesk Maya's Graph Editor

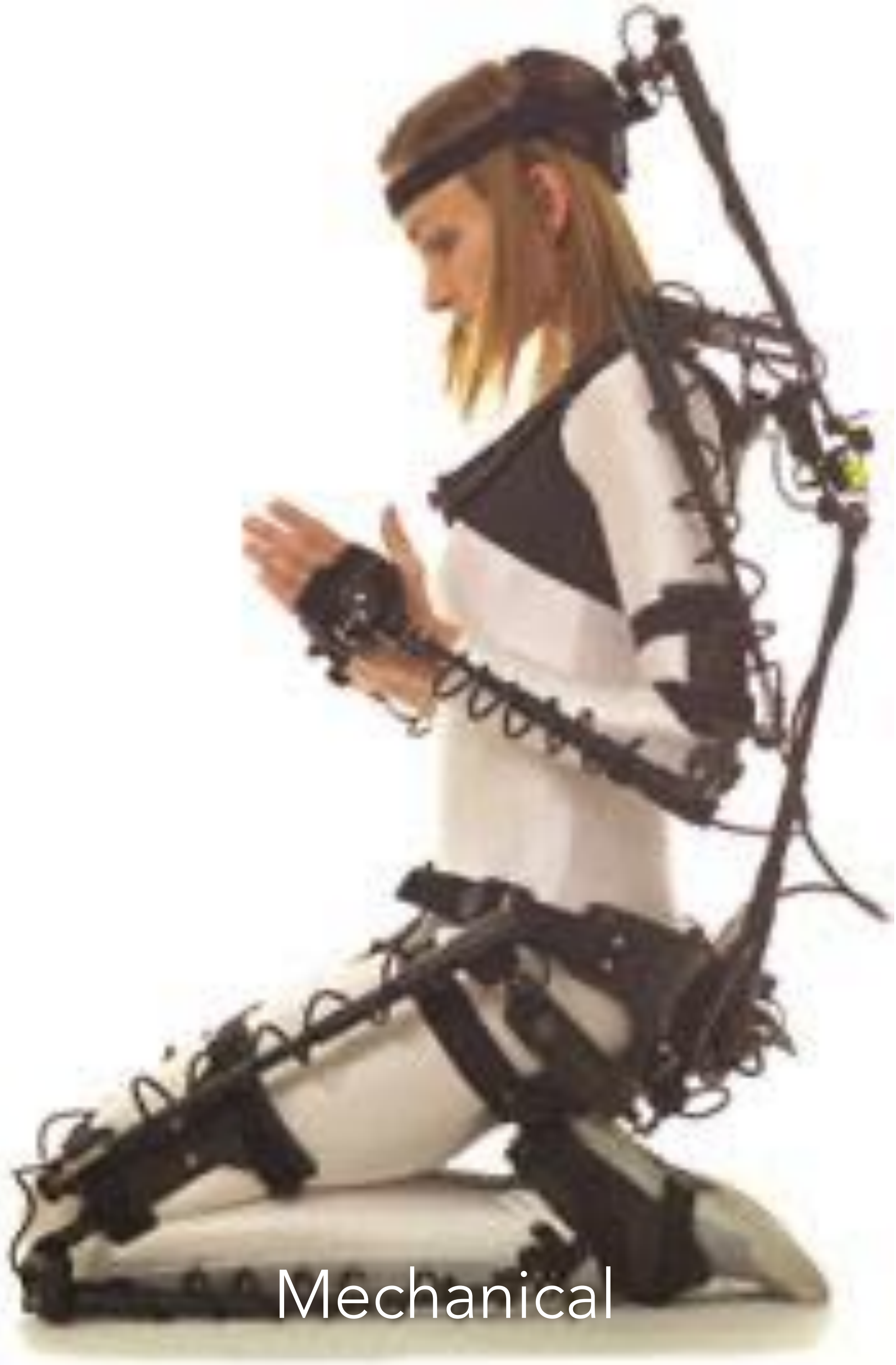
Motion capture



Optical



Magnetic

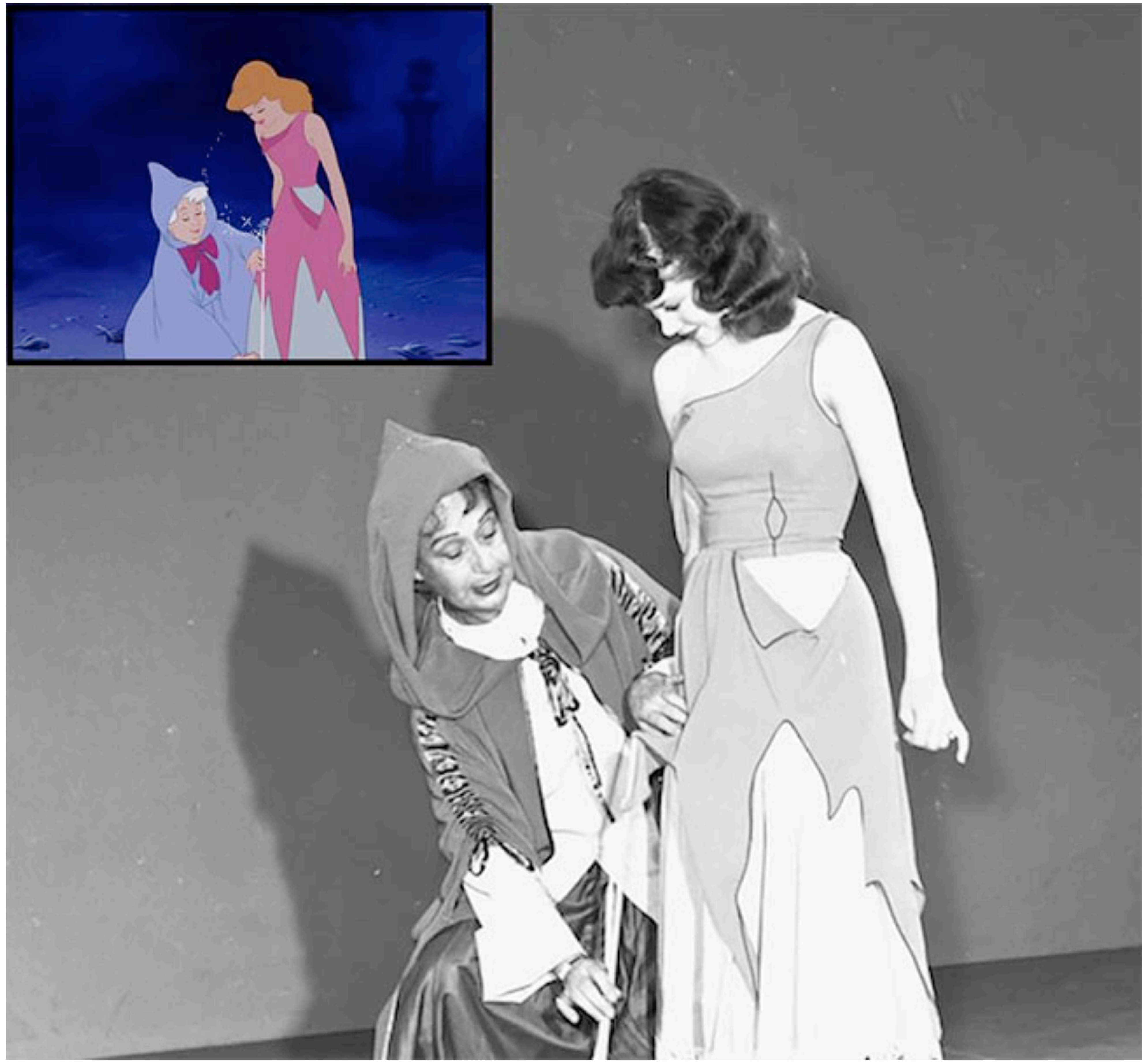


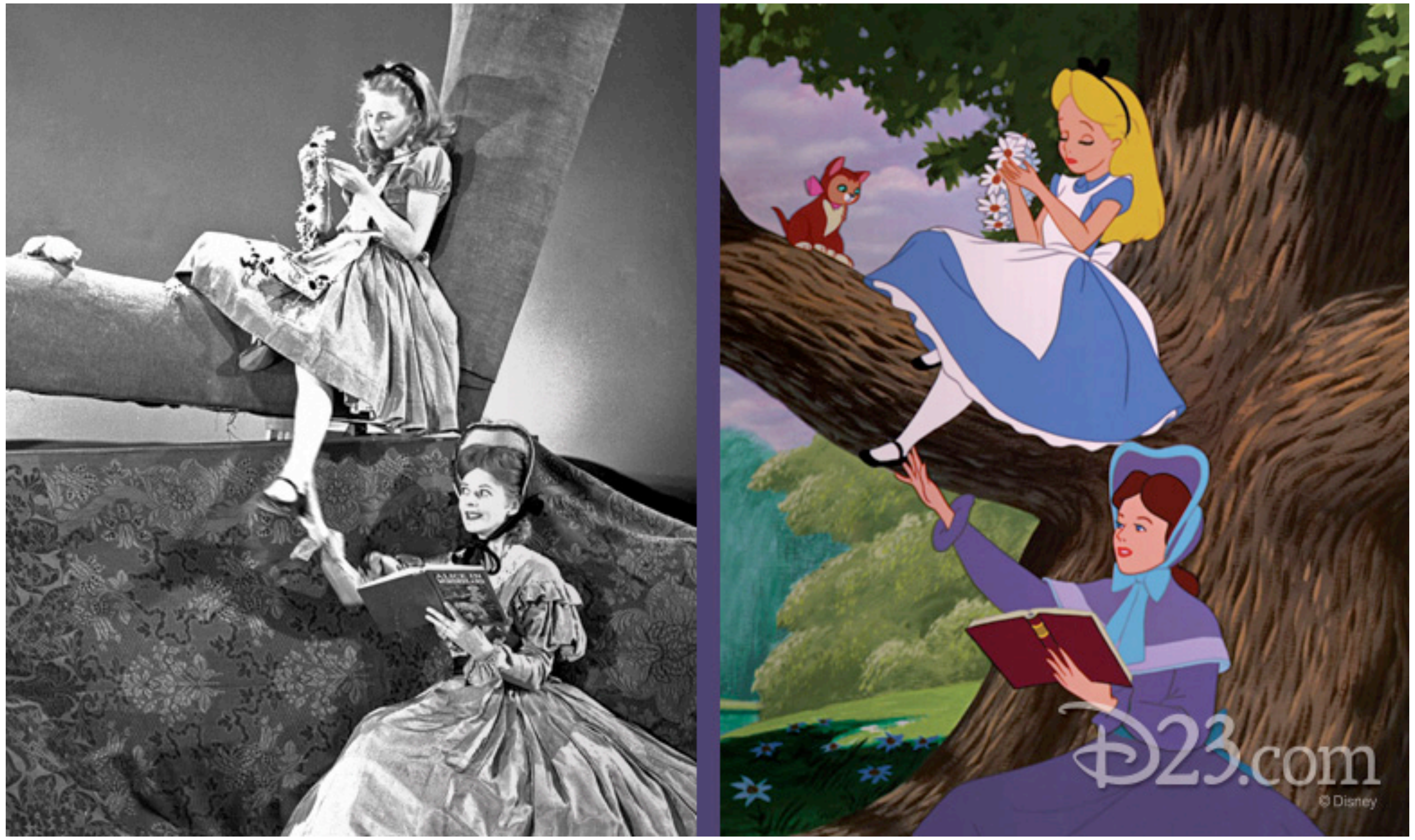
Mechanical

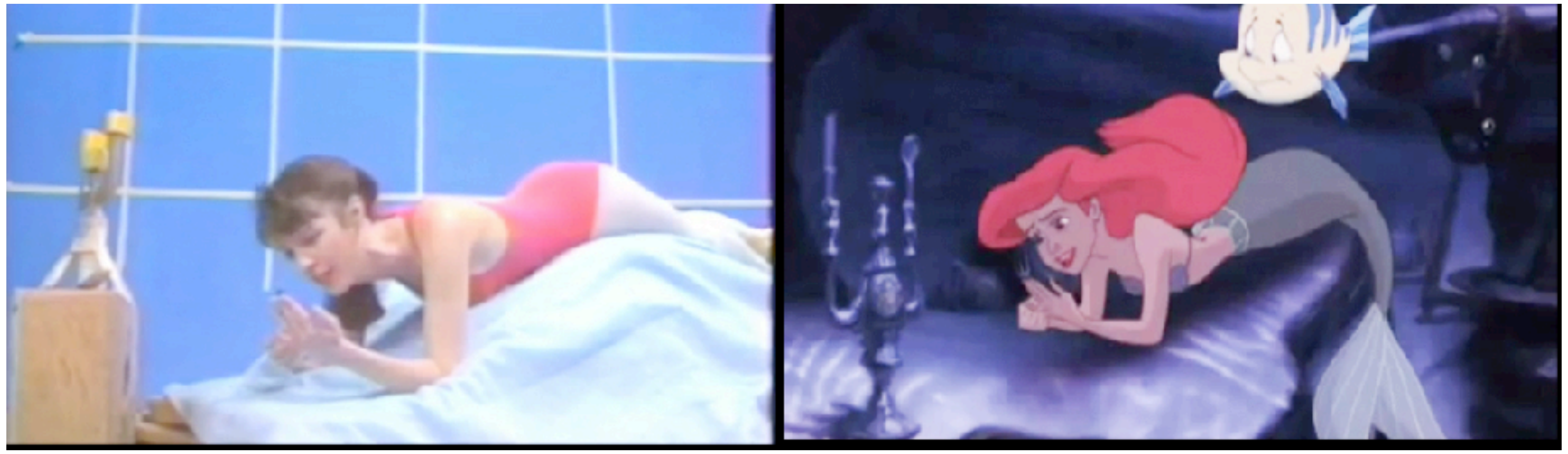
CAESAR

https://www.youtube.com/watch?v=4NU9ikjqjC0

“Motion capture” (live action reference) in traditional animation :)





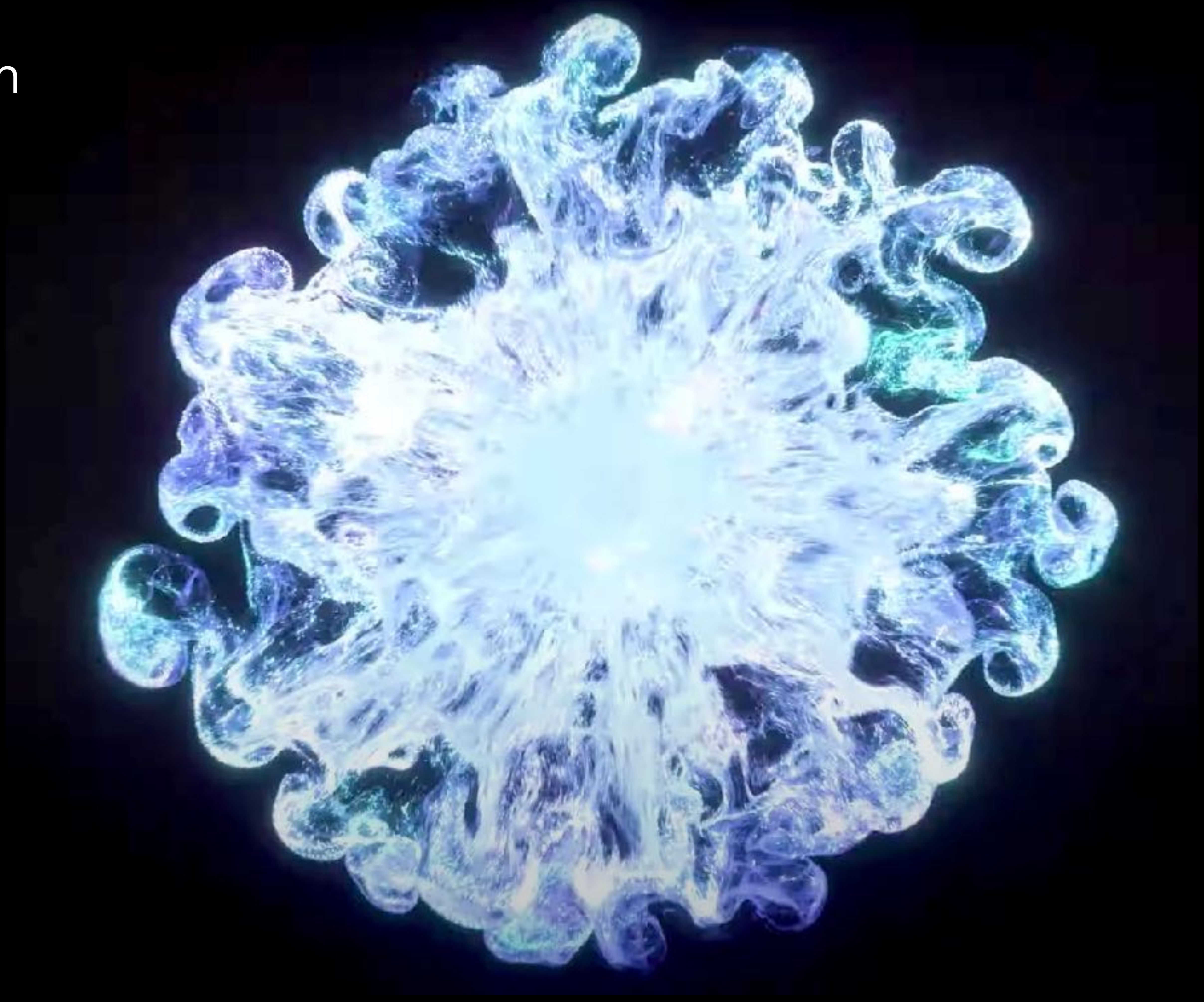


Procedural animation

Motion is defined entirely by some algorithm

e.g. particle systems: update particles' positions based on some chosen rules, e.g.

- directly: $\mathbf{x} = \mathbf{x}(t)$
- using velocity field: $\dot{\mathbf{x}} = \mathbf{v}(\mathbf{x}, t)$
- using forces: $\ddot{\mathbf{x}} = \mathbf{f}(\mathbf{x}, \mathbf{v}, t)$



Star Trek II: The Wrath of Khan

https://www.youtube.com/watch?v=52XlyMbxxh8

Physics-based animation (a.k.a. simulation)

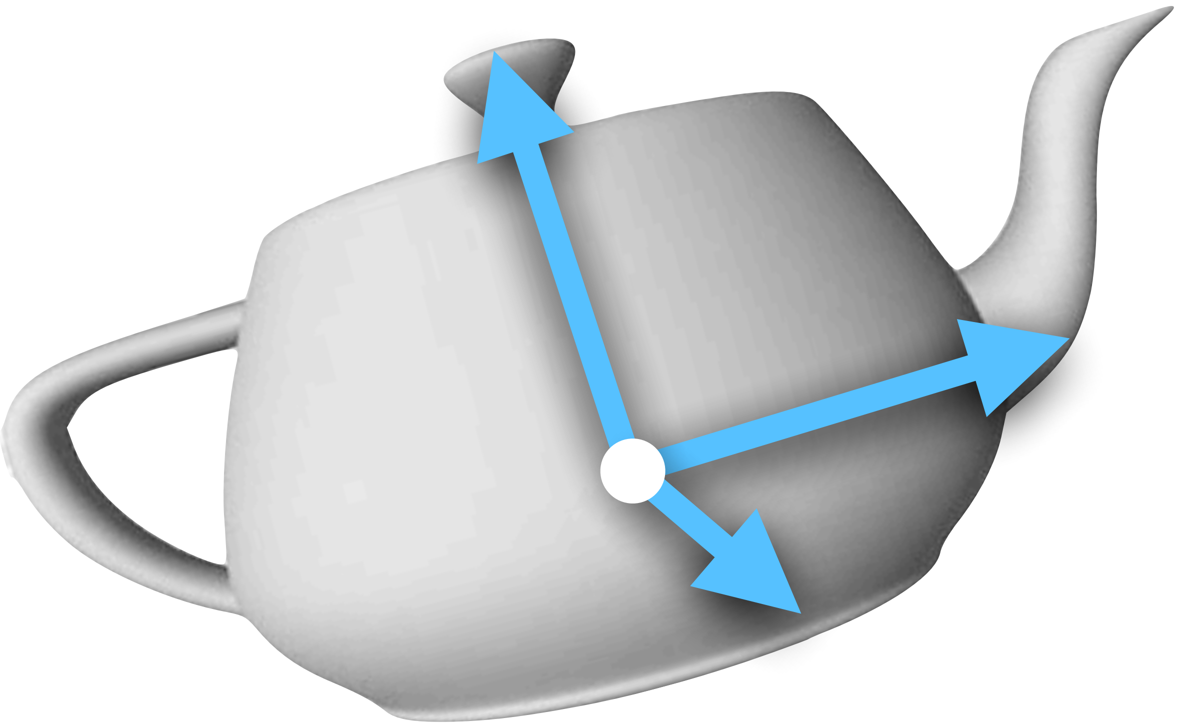
Solve the equations of motion to automatically get physically realistic motion.

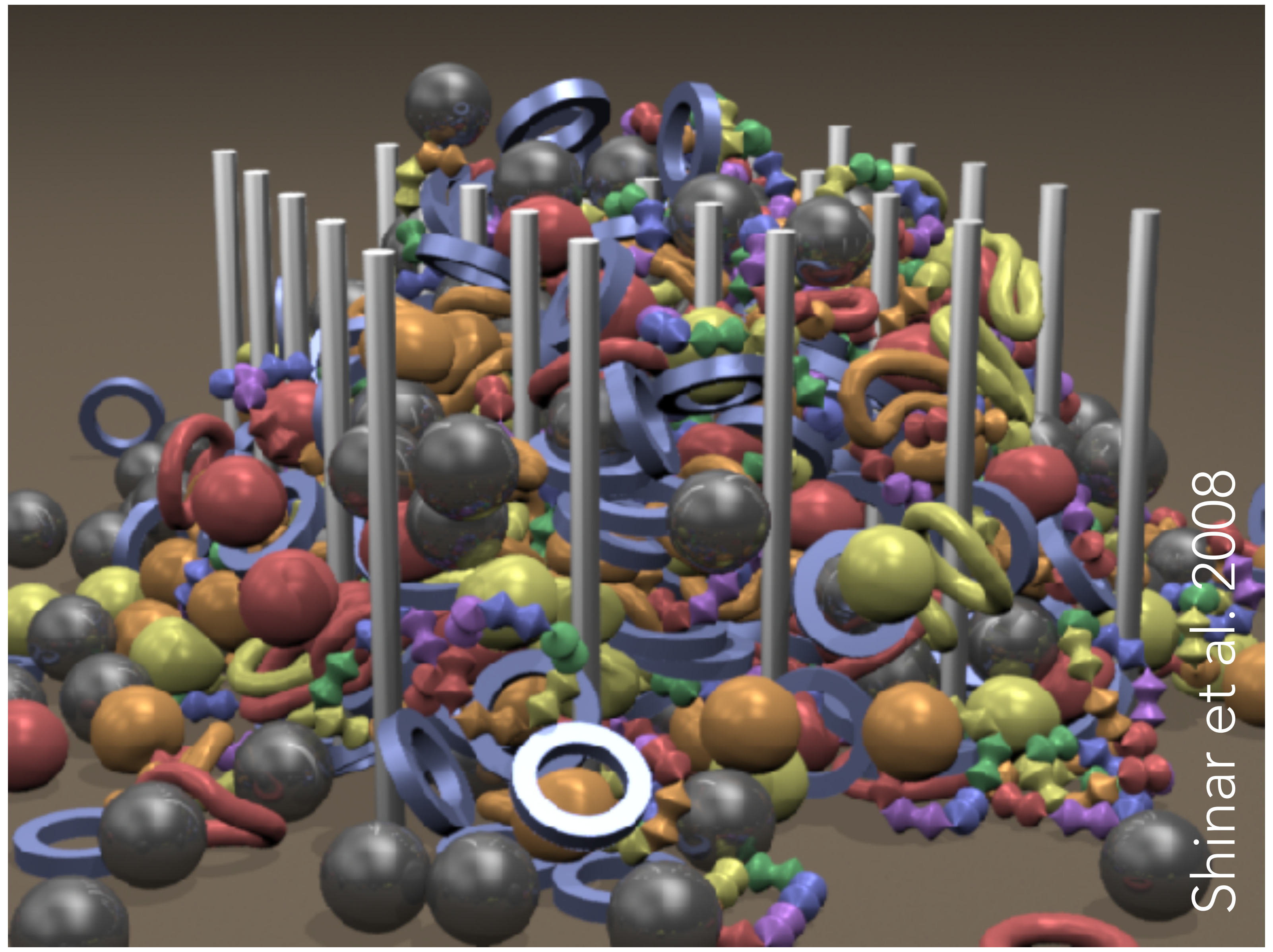
e.g. Rigid bodies

- Degrees of freedom: position, rotation

$$\frac{\mathrm{d}^2\mathbf{x}}{\mathrm{d}t^2} = \mathbf{f}_{\text{ext}}/m$$

$$\frac{\mathrm{d}^2\mathbf{R}}{\mathrm{d}t^2} = \cdots$$



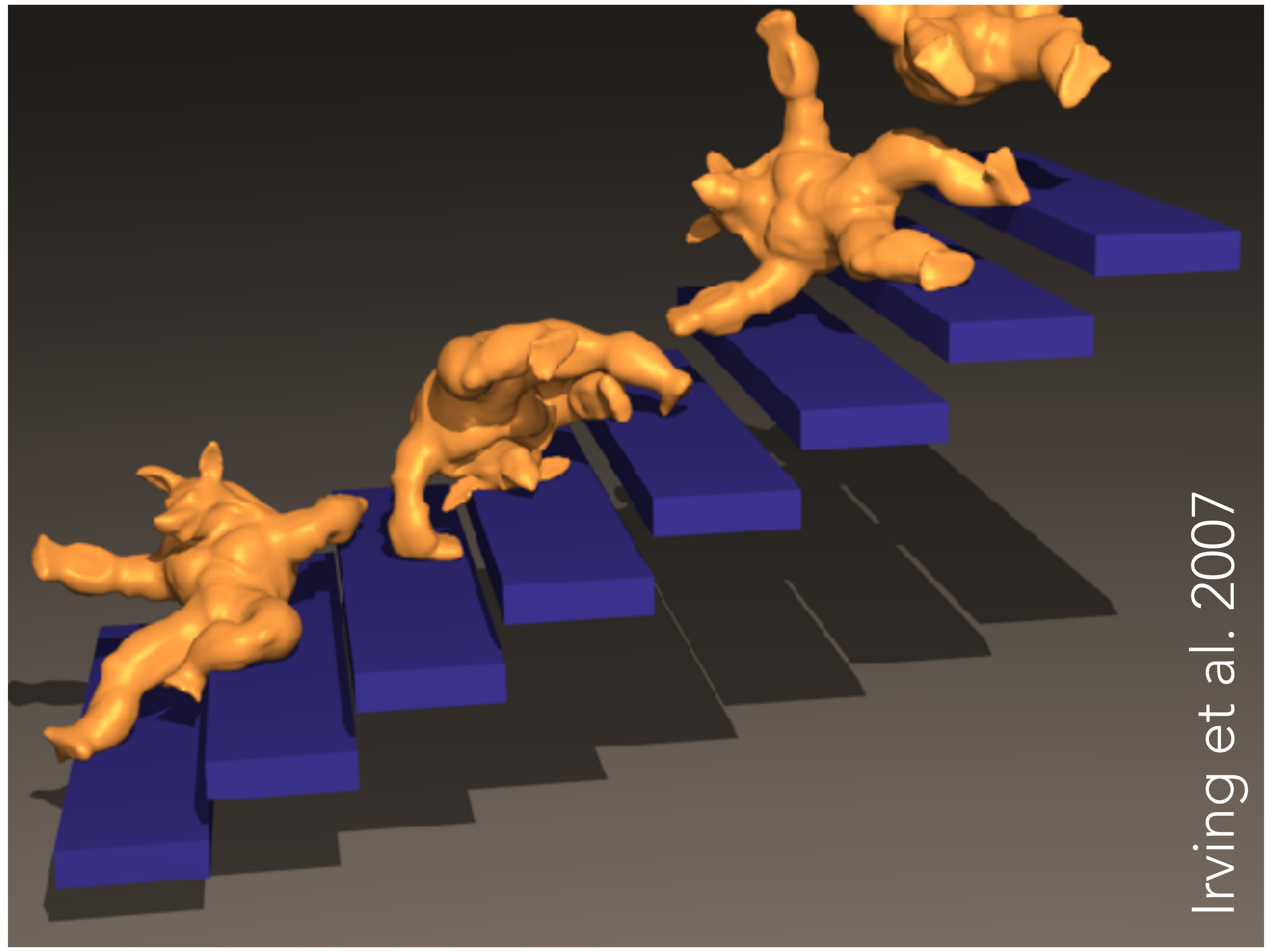

Shinar et al. 2008

- Challenges: collisions, frictional contact, stacking

Deformable bodies, cloth, etc.

Every vertex can move independently! But deformation causes internal elastic forces

- Physically accurate: **finite element method**
- Cheap approximation: **mass-spring systems** (just a bunch of particles and 1D springs)



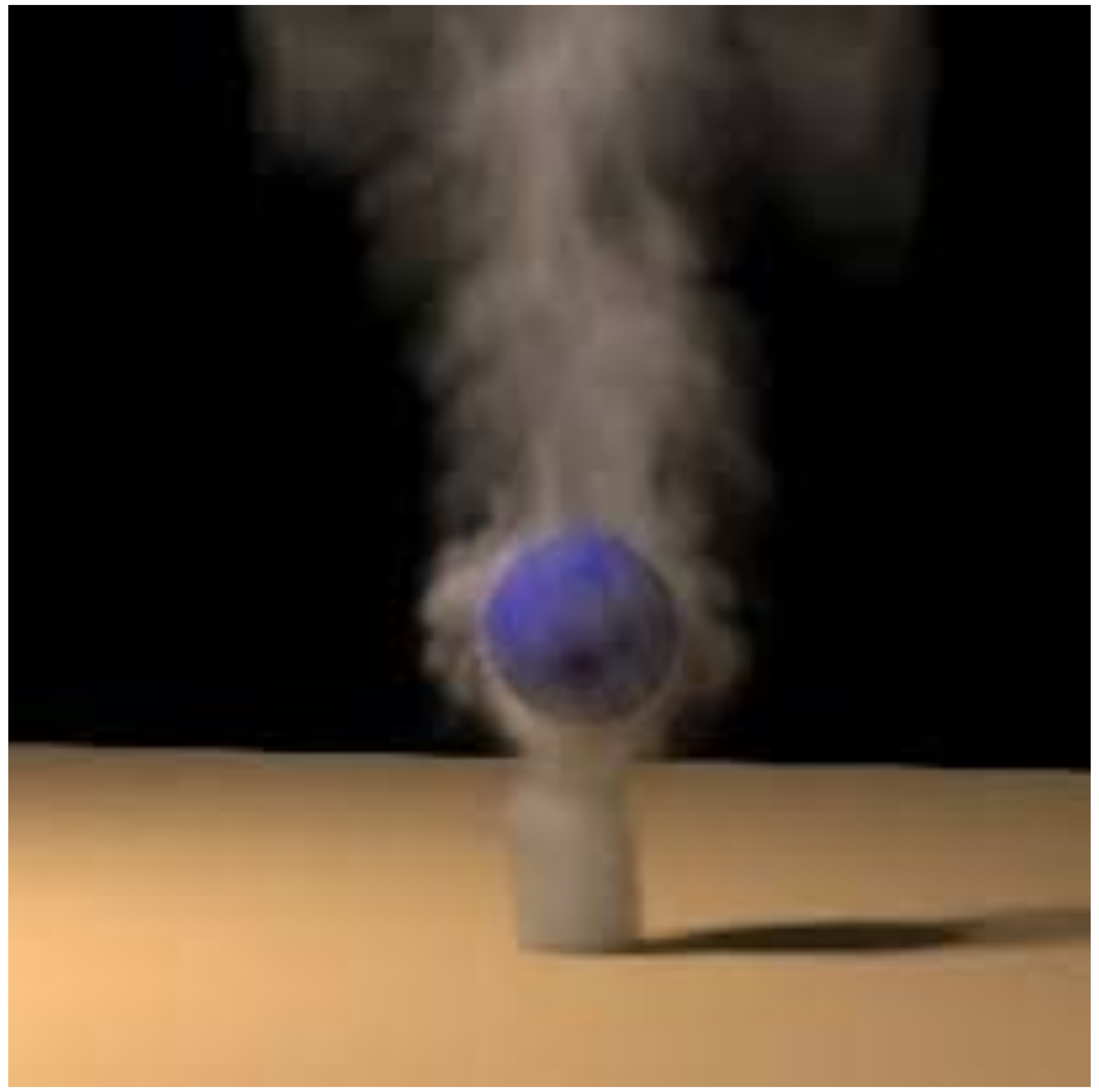
Irving et al. 2007

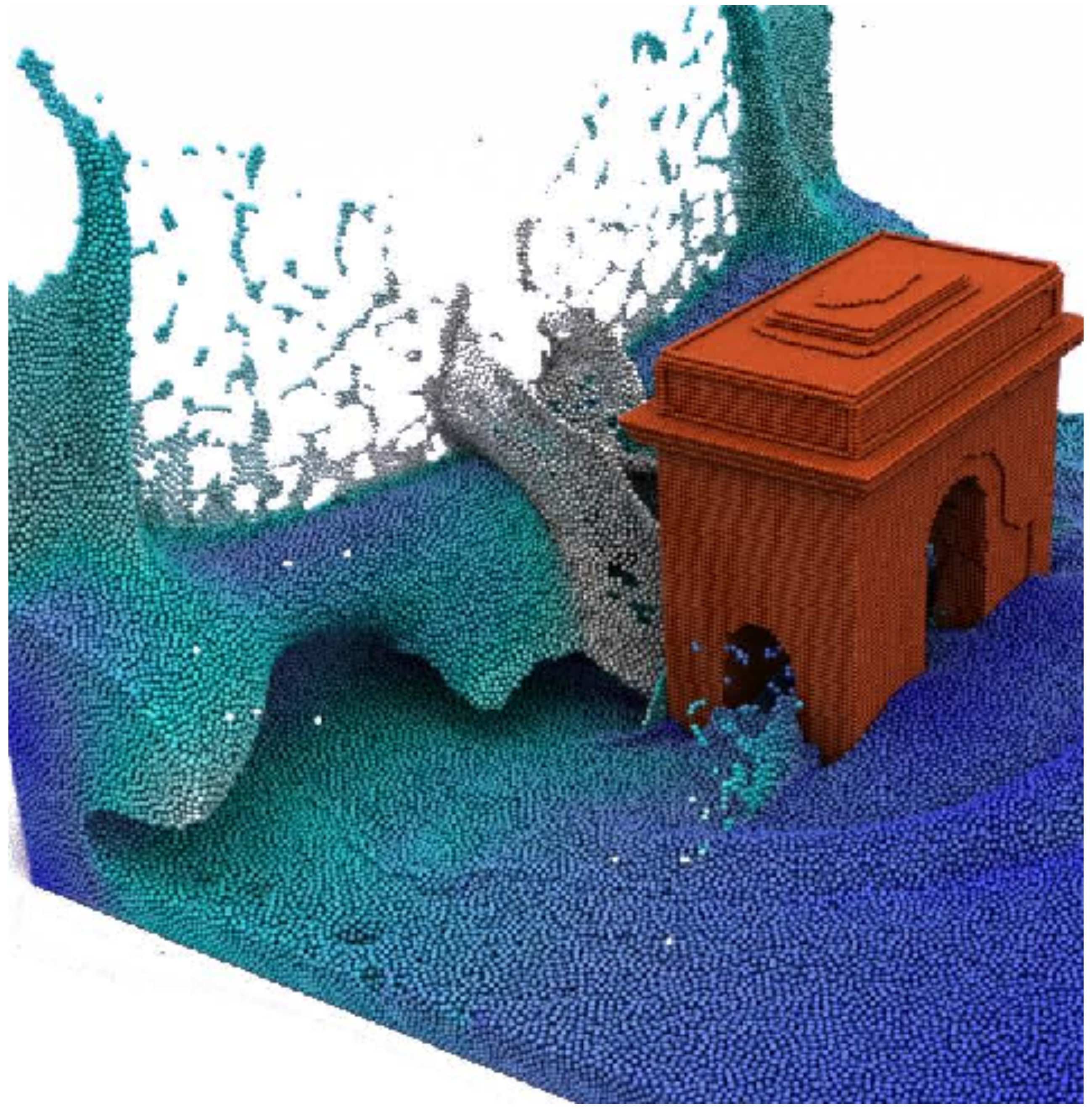
Feng et al. 2022

Fluids (smoke, water, fire, etc.)

Described by the Navier-Stokes equations (system of partial differential equations)

Velocity field **v**(**x**): every point has its own velocity!





Physics in character animation

https://vimeo.com/245424174

Smith et al. 2018