Computer Graphics

CSC 418/2504

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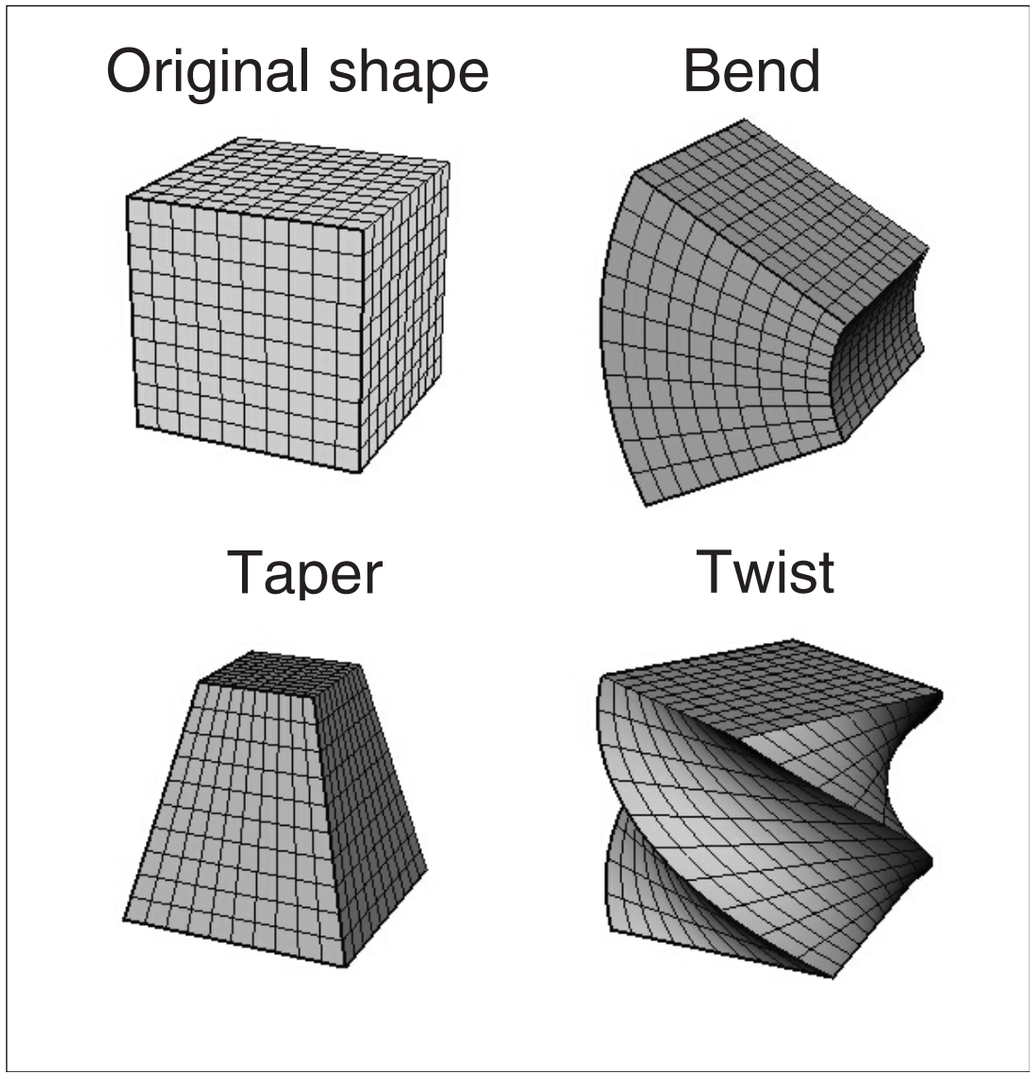
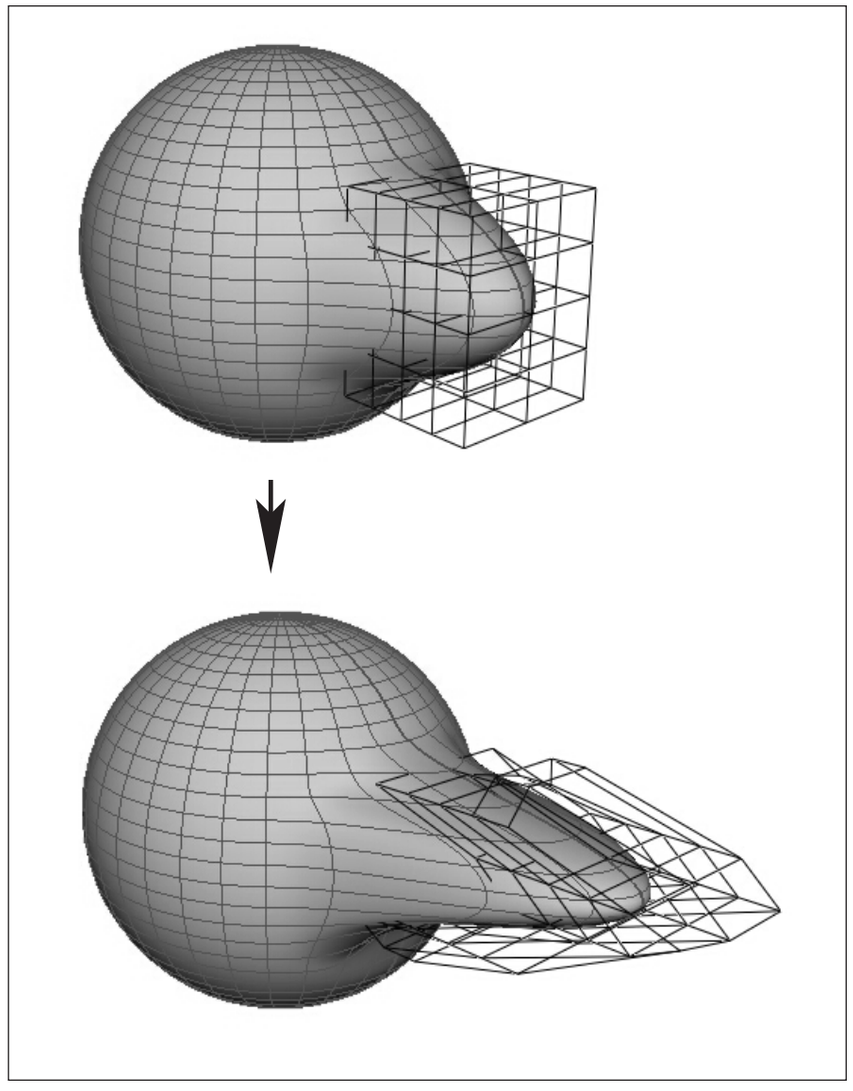
Some figures courtesy of Peter Shirley,
"Fundamentals of Computer Graphics", 2nd Ed.

Topics

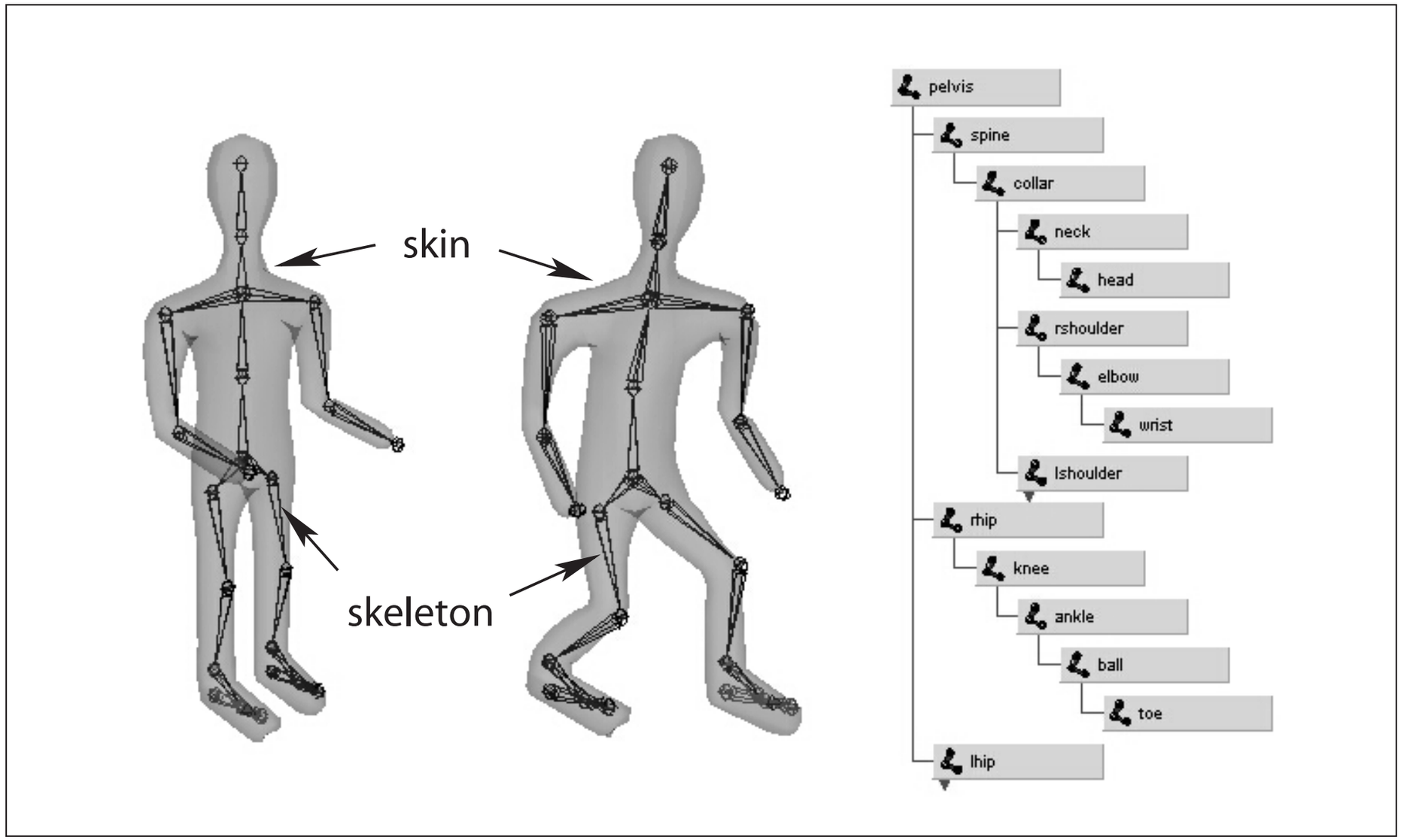
- Free form deformations
- Skeletal animation, forward and inverse kinematics
- Facial animation: blend shapes
- Motion capture
- Physical simulation
- AI-based behavior
- Particle systems

Free form deformation

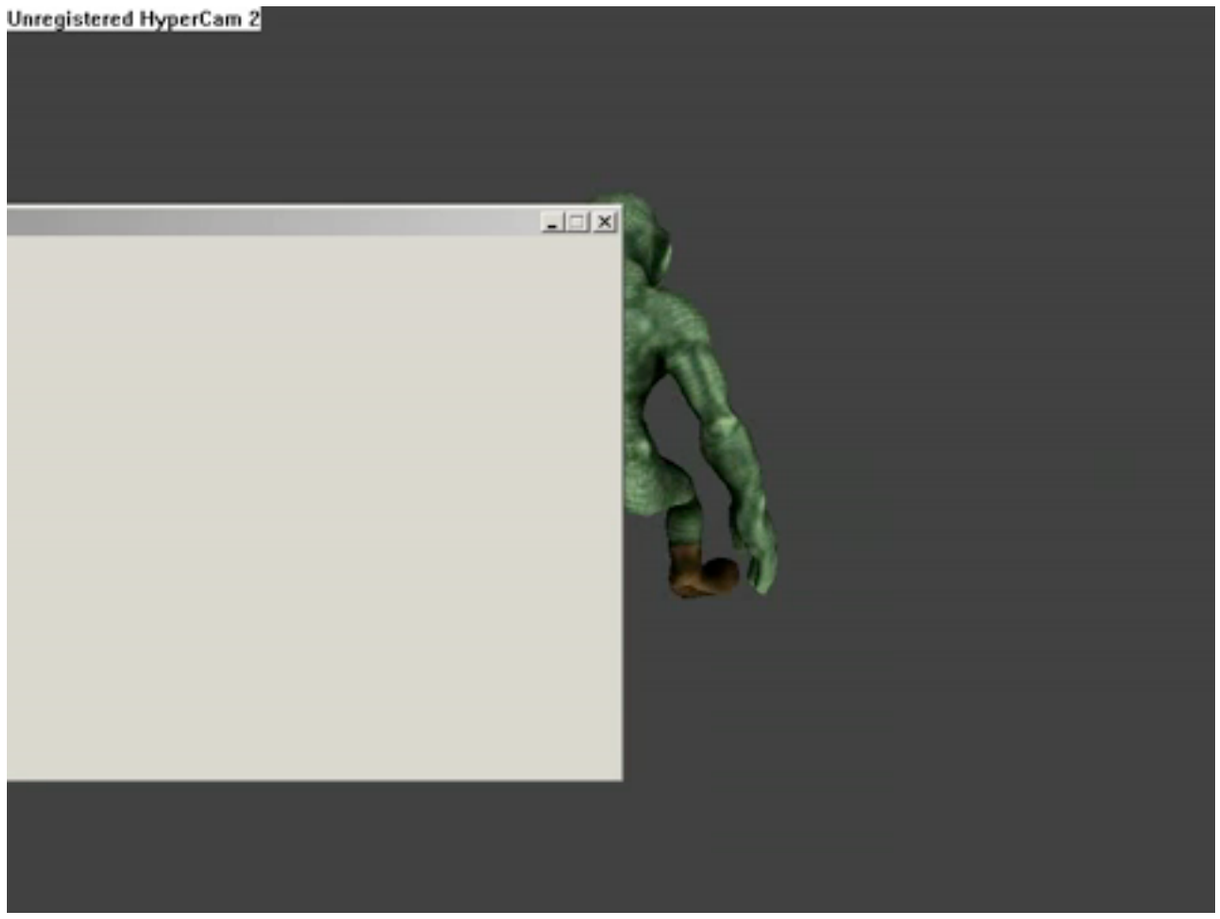




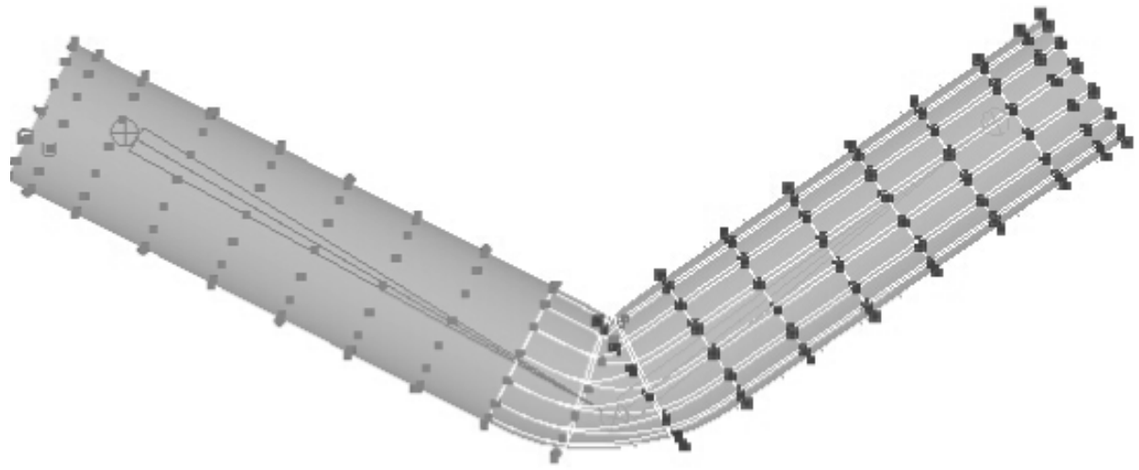
Skeletal animation



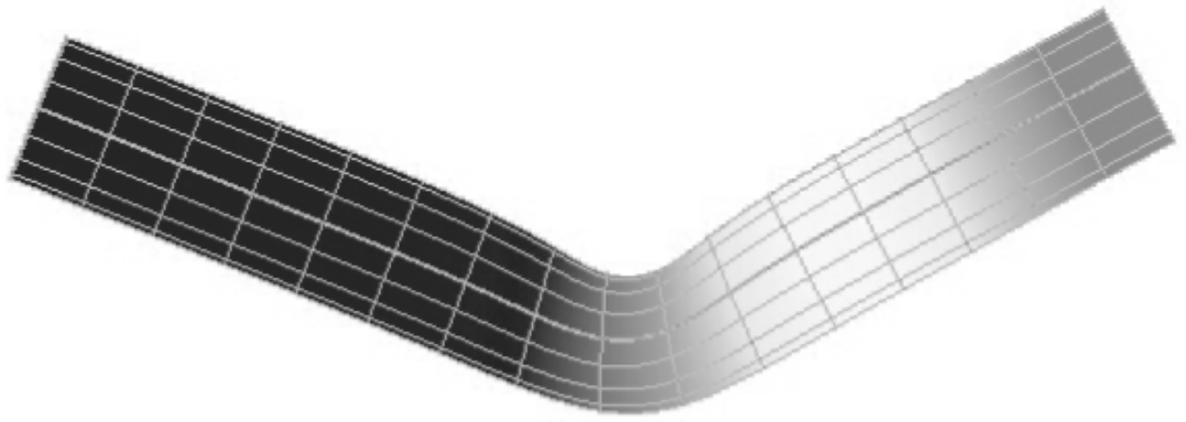
Skeletal animation



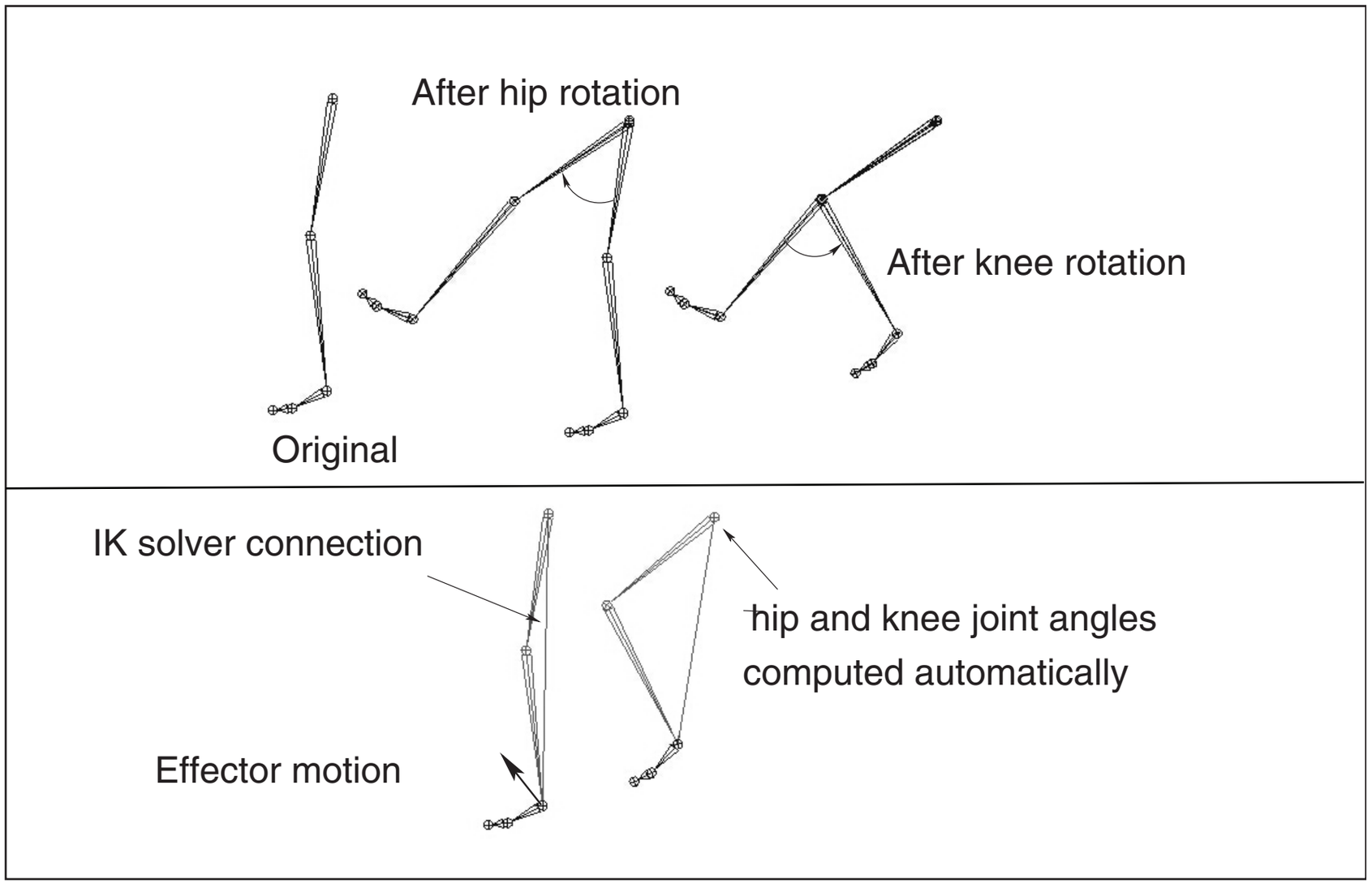
Rigid skinning:
verts assigned to
only one joint



Soft skinning:
blend the influence
of several joints

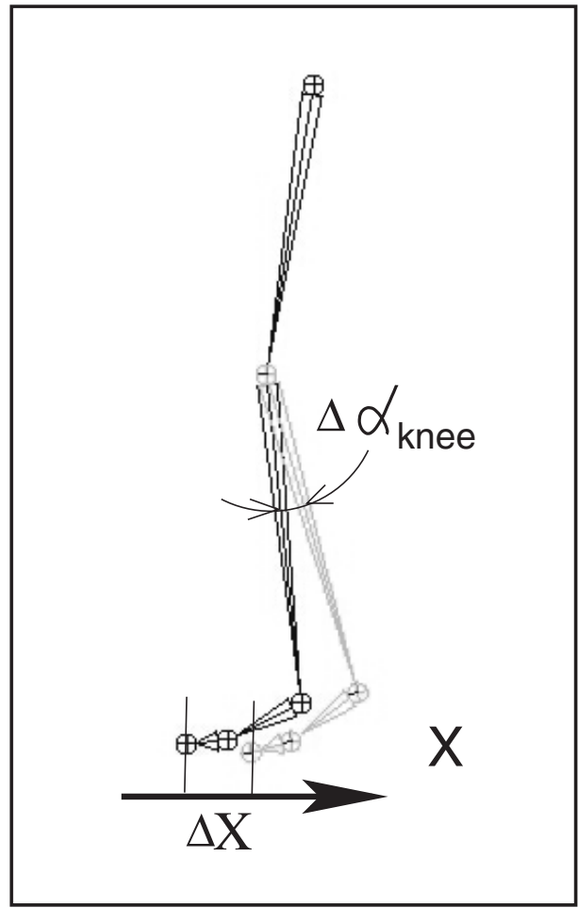


Forward vs inverse kinematics

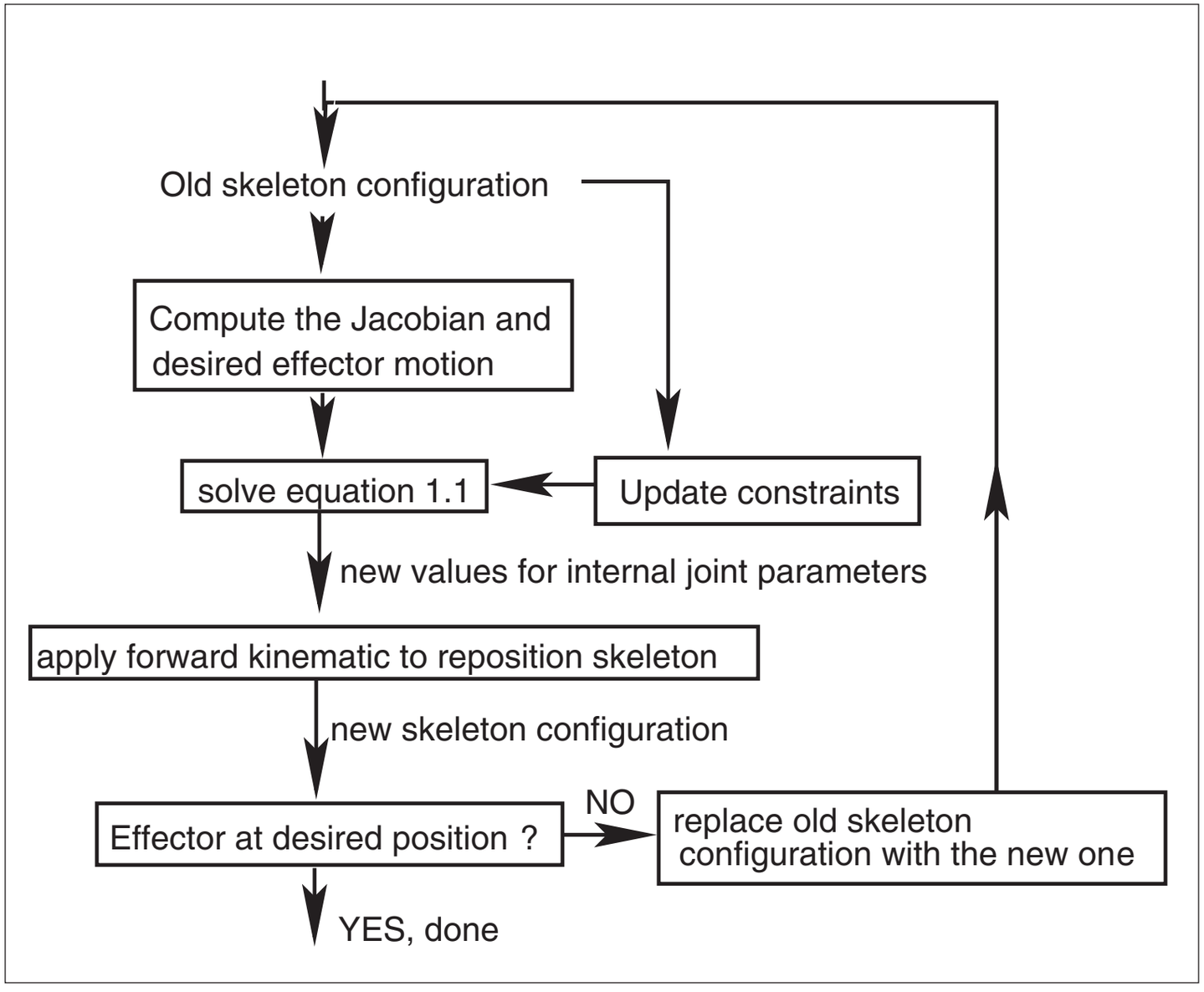


Inverse kinematics

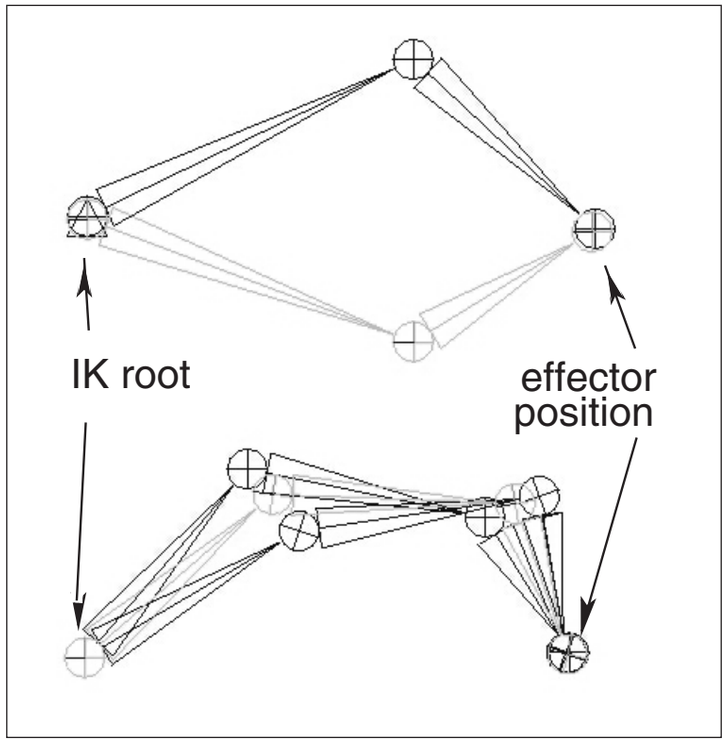
- Position of the end effector is set by the animator.
- Automatically solve for joint angles that will result in that effector position.
- Solution is not usually "closed form", iteratively solved by optimizer.



Inverse kinematics



Inverse kinematics



Typically underconstrained:
Multiple configurations of internal joints can result in the same effector position

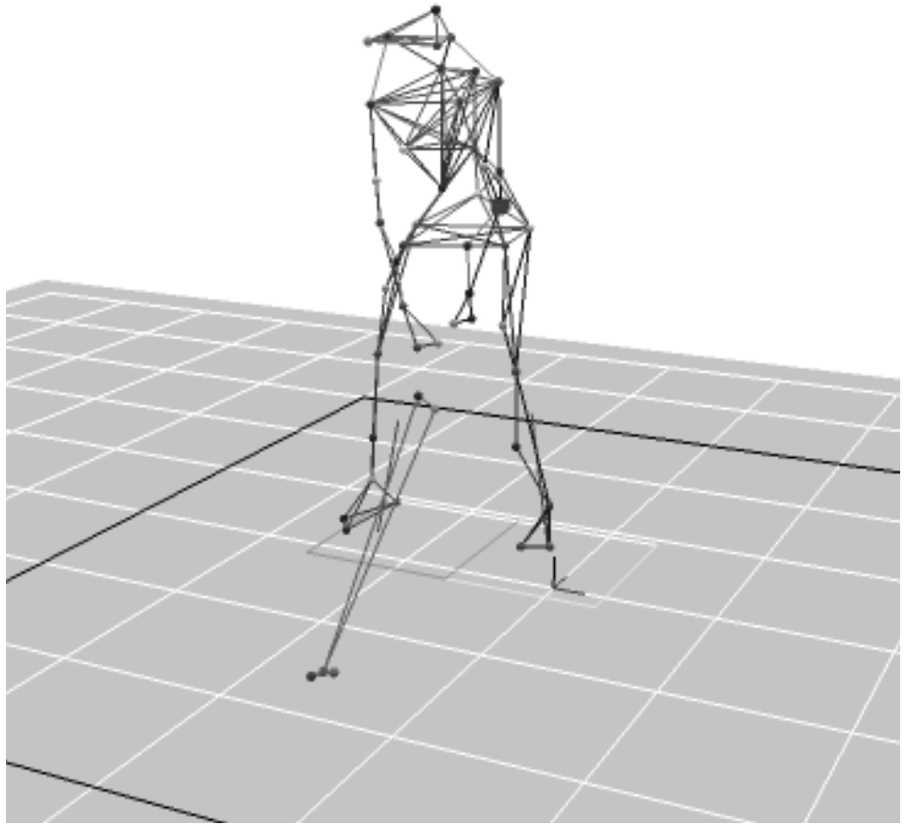
Facial animation

Blend shapes

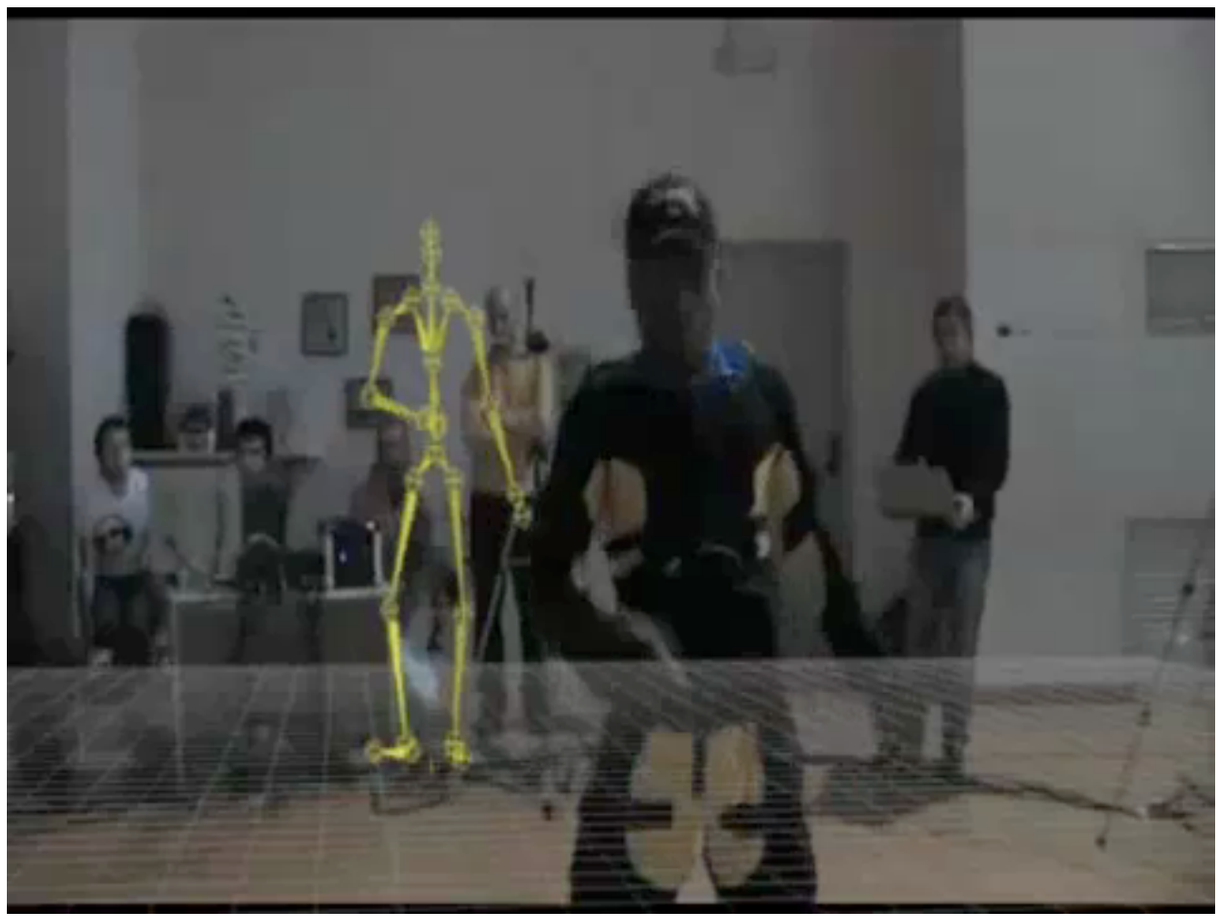
- Artist deforms a "base" face model into key facial expressions involving parts of the face
- e.g., eyes: wide, squint, blink; mouth: smile, frown, snear, *etc*.
- For speech: mouth to phoneme mapping
- Key faces have one-to-one vertex correspondence with each other and base
- Sliders allow the "blending" (interpolation) between the different expressions

Facial animation

Motion capture



Motion capture



Motion capture

Motion capture

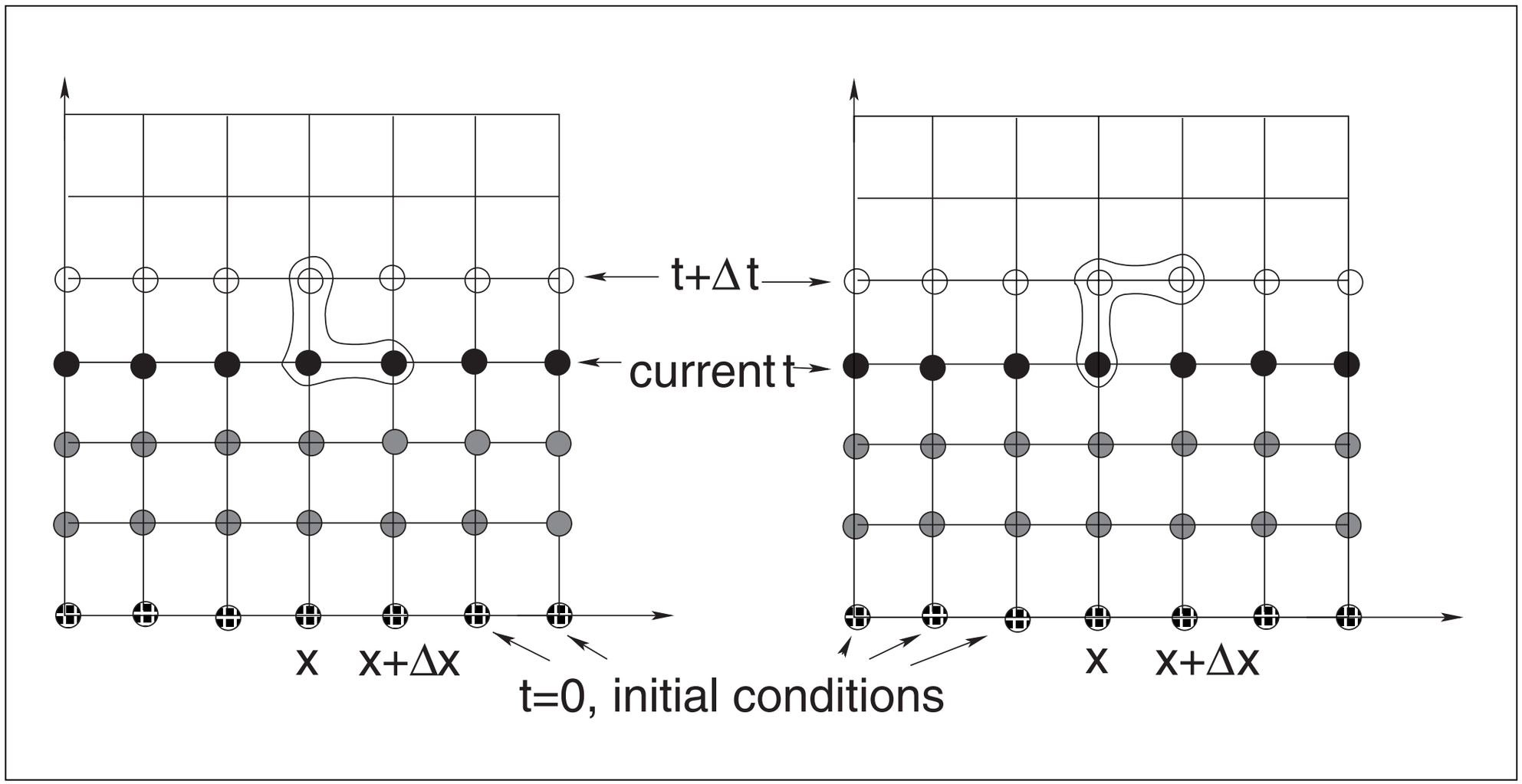
Motion capture

- Markers can be occluded. Use multiple cameras and interpolate where needed.
- Noise can cause limbs to loose contact with ground or other objects. Use redundant markers to reduce noise. Correct with Inverse Kinematics.
- Retargeting: applying recorded motion to different characters.

Physics-based animation

- Mathematically model real-world motion
- Animate via simulation
- Smoke, fire, clouds, fluids, cloth, rigid bodies, elastic objects.

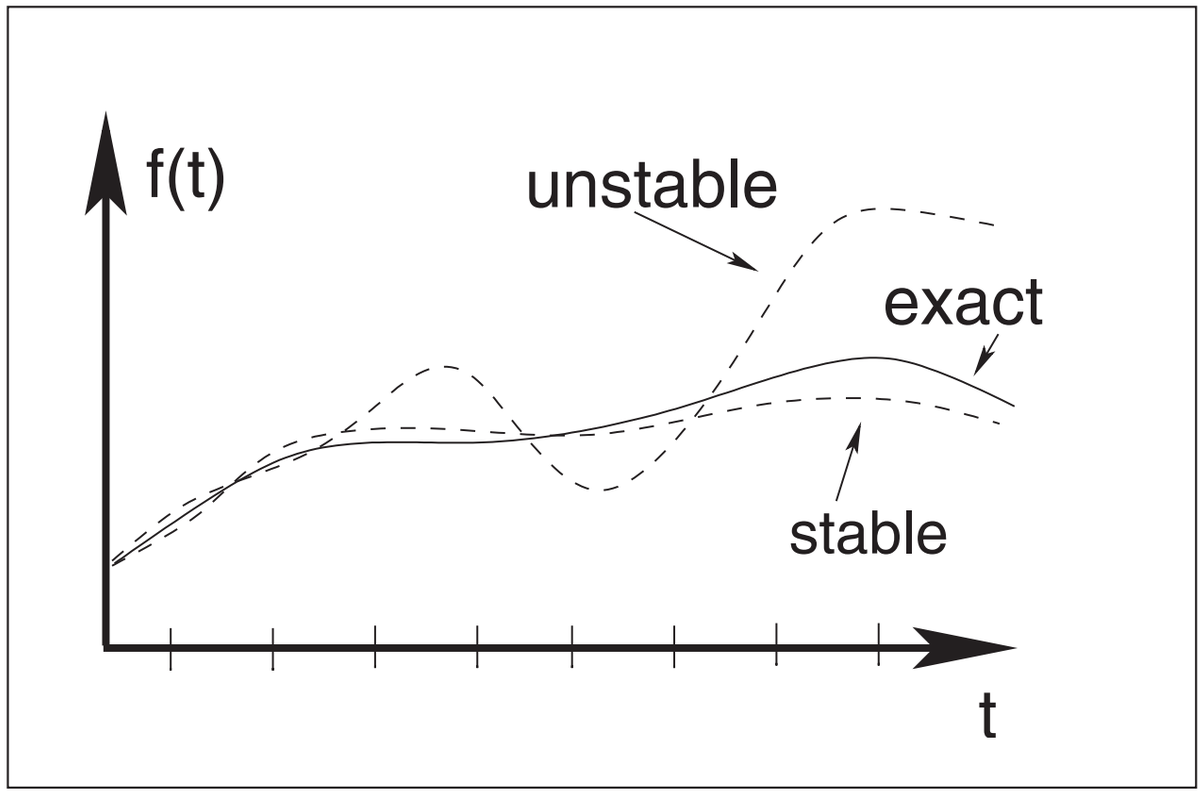
Finite differences



Explicit

Implicit

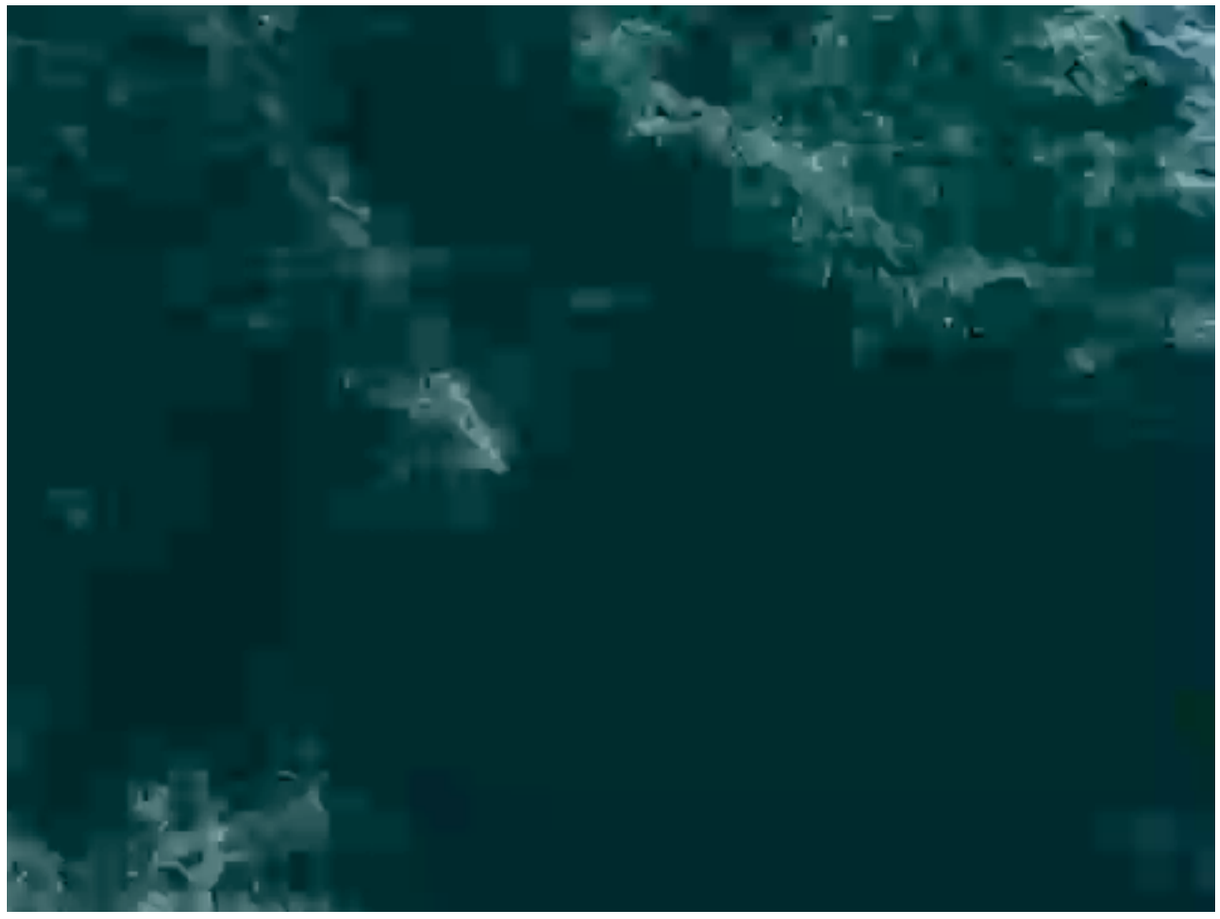
Stability



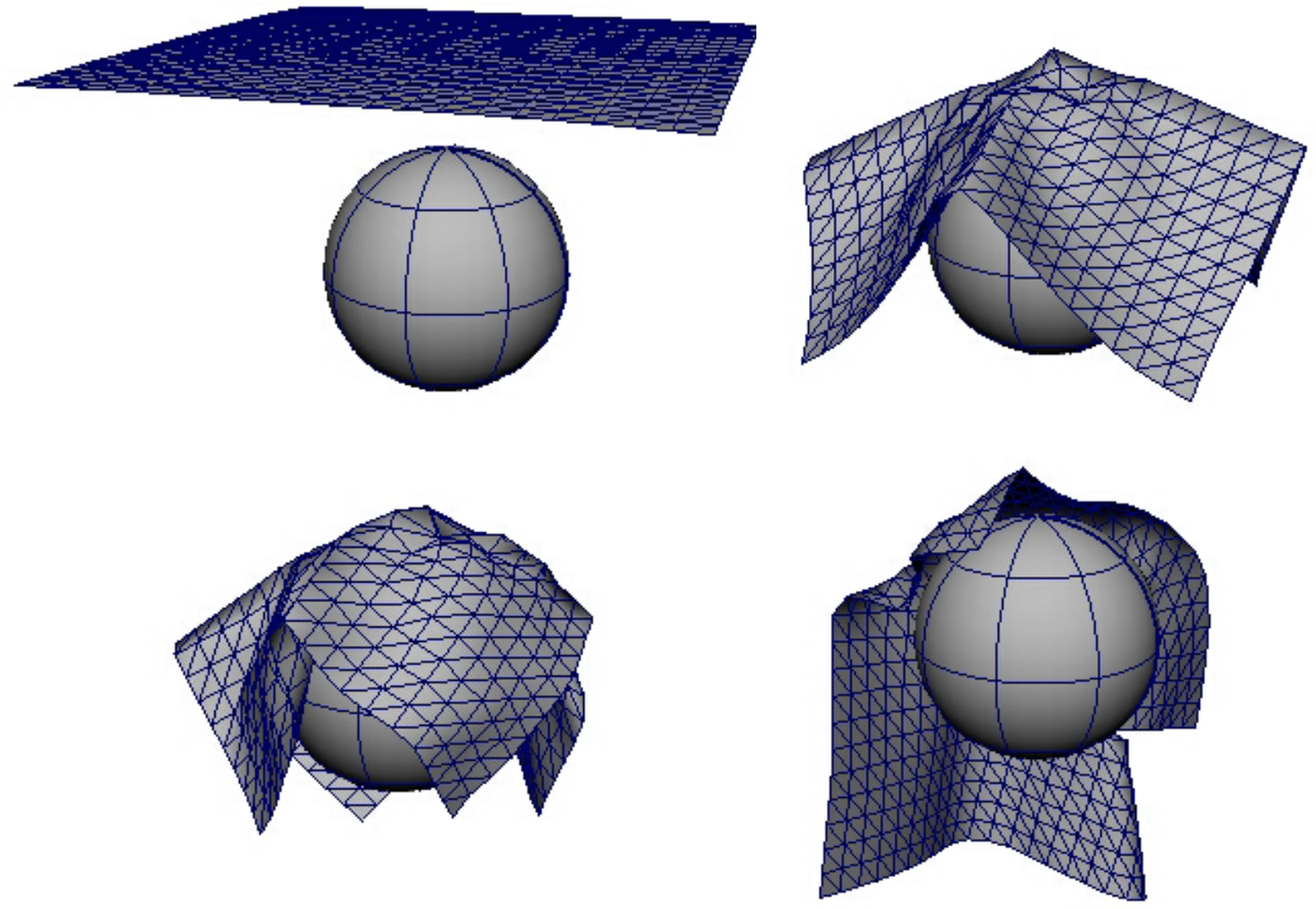
Explicit: less expensive but can become unstable

Implicit: more expensive but stable

Fluids



Cloth simulation

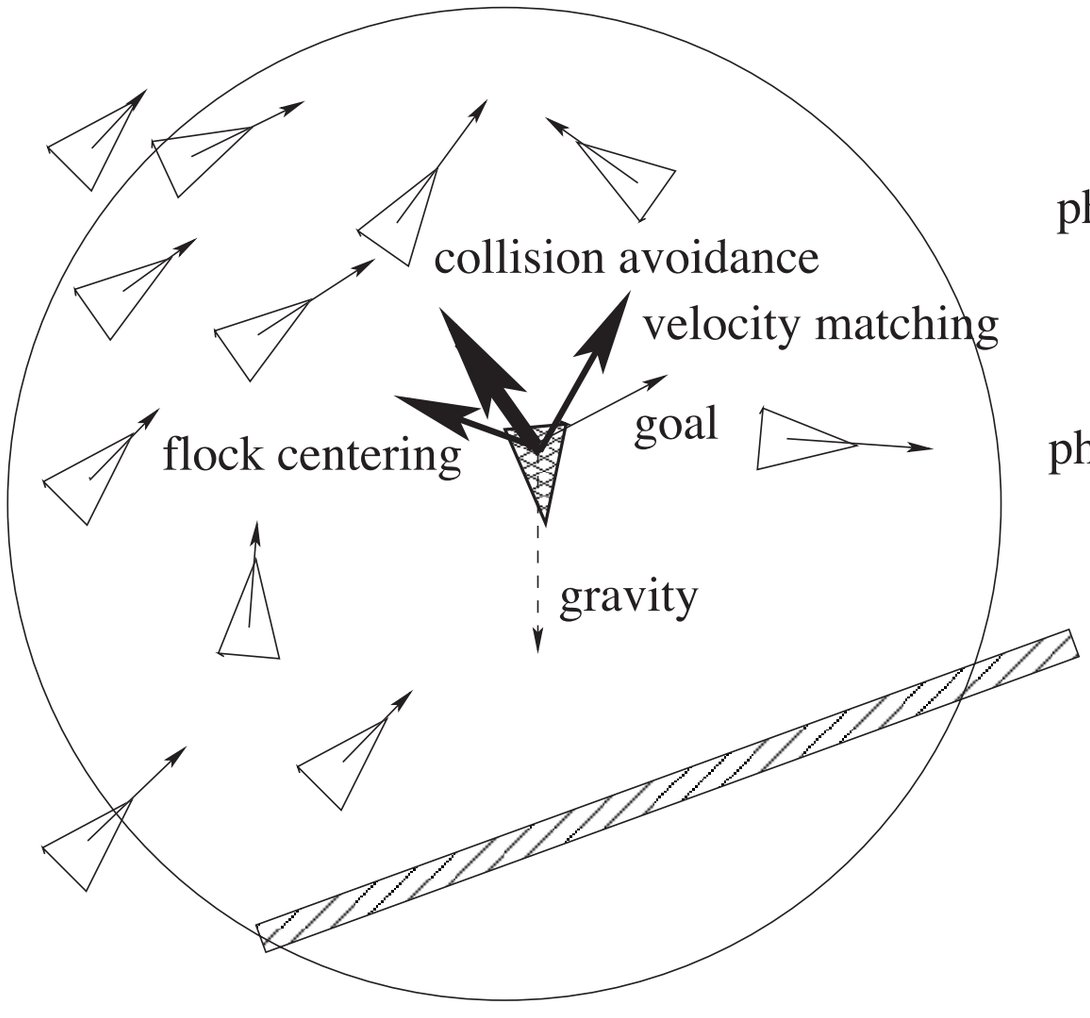


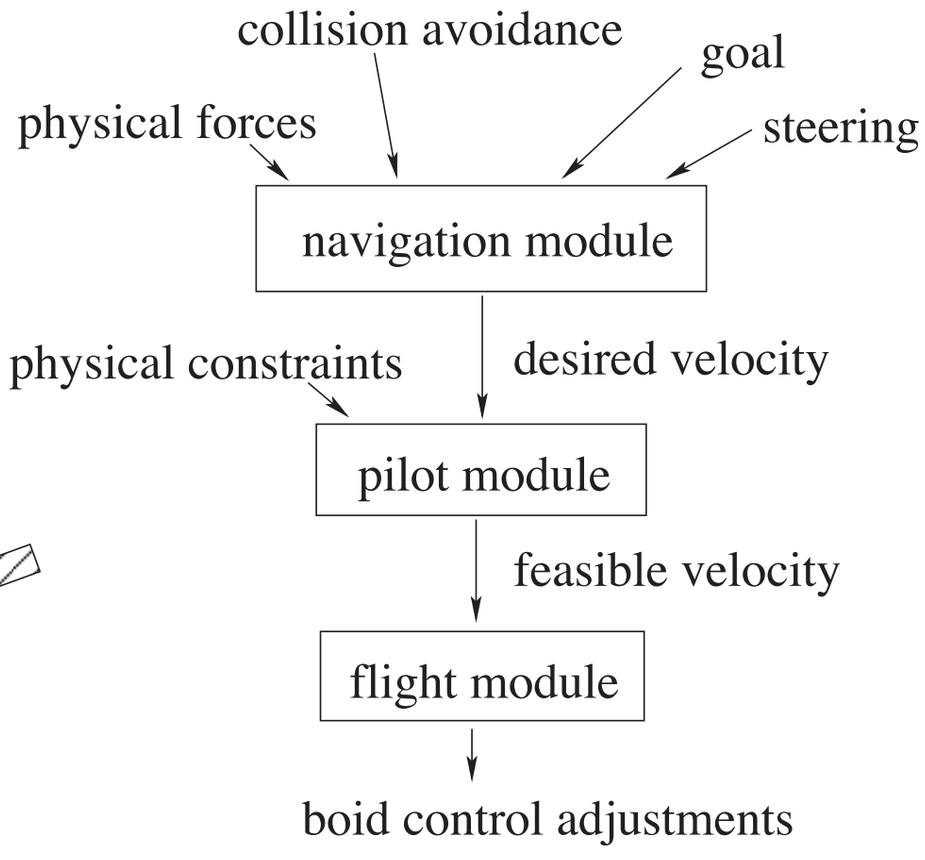
Cloth simulation

AI animation

- Flocks of birds
- Schools of fish
- Herds of animals
- Large crowds of people
- Armies of orcs...

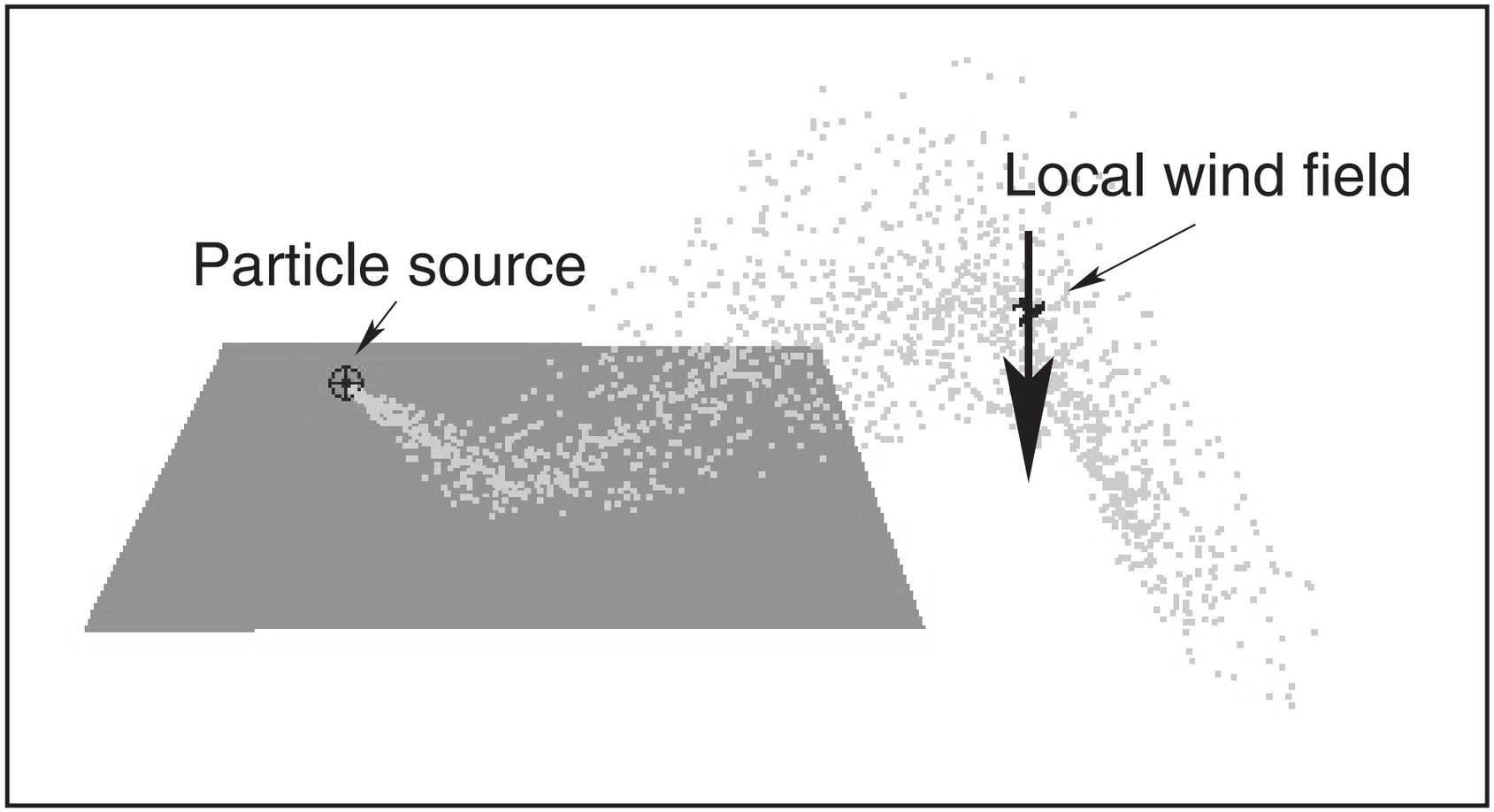
AI animation





Flocking

Particle systems



Particle systems

- Completely independent of each other.
- Interact with environment only: external forces and collisions.
- At each step: create new particles with initial parameters, terminate old ones, compute necessary forces, update remaining particles. Randomness.
- Specialized rendering (transparency, blending, *etc*.)
- Applications: fireworks, explosions, spraying liquid, smoke and fire, *etc*.

Particle systems