Forward Kinematics: Transformation Hierarchies

Determine Object Locations?

Ground

Inverse Kinematics (IK)

Things Need to Move to a Particular Location – What Parameters Will Make Them Do That?

Of course, there will always be target locations that can never be reached. Think about that spot in the middle of your back that you can never scratch.

Inverse Kinematics (IK) solves the problem "If I know where I want the end of the chain to be \((X^*, Y^*)\), what transformation parameters will put it there?"
Particle Systems: A Cross Between Modeling and Animation?

The basic process is:

1. Emit
2. Random Number Generator
3. Display
4. Update

Particle Systems Examples

Particle Systems Examples

The Lion King (2019) -- Disney
A Particle System to Simulate Colliding Galaxies in Cosmic Voyage

Particles Don't Actually Have to Be “Particles”

Animating using Rigid-body Physics

Newton’s first law: 
force = mass * acceleration 
or 
acceleration = force / mass

In order to make this work, you need to supply physical properties such as mass, center of mass, moment of inertia, coefficients of friction, coefficients of restitution, etc.

Animating using Fluid Physics

Animating using Physics

D = unloaded spring length

\[ (D - D_0) = \frac{F}{k} \]

k = spring stiffness in Newtons/meter or pounds/inch

Or, if you know the displacement, the force exerted by the spring is:

\[ F = k (D - D_0) \]

This is known as Hooke’s law

Animating using the Physics of a Mesh of Springs

“Lumped Masses”
Cloth Example

Functional Animation: Make the Object Want to Move Towards a Goal Position

\[ m\ddot{x} + c\dot{x} + kx = 0 \]

Functional Animation: While Making it Want to Move Away from all other Objects

\[ m\ddot{x} = \sum F_{\text{repulsive}} \]

Total Goal – Make the Free Body Move Towards its Final Position While Being Repelled by the Other Bodies

\[ m\ddot{x} + c\dot{x} + kx = \sum F \]

Increasing the Stiffness

Increasing the Repulsion Coefficient

Stiffness = 3

Stiffness = 6

Stiffness = 9

Repulse = 10

Repulse = 30
Functional Animation

Motion Capture as an Input for Animation

Motion Capture is for Faces Too

Tron I –
Probably should have used physics, but didn’t

Card Trick

Pixar Animated Shorts