Computers in Film Making

Snow White (1937)

Snow White - Disney's Folly

Original Budget	$250,000
Production Cost	$1,488,422
Frames	127,000
Production time	3.5 years

but

Gross revenue	$184,925,486

Moral:

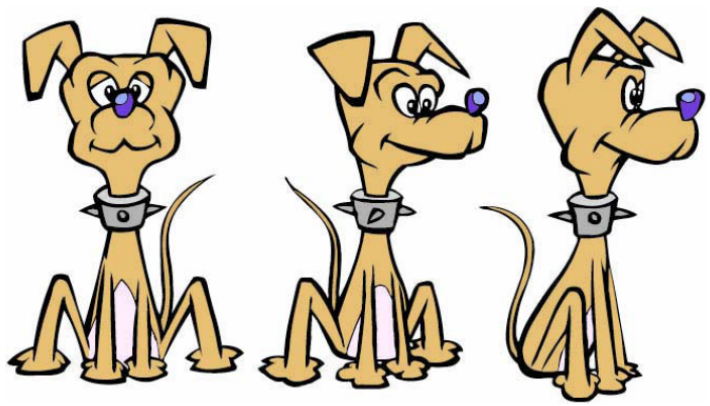
- Animated films are high risk, but very profitable
- Creation of these films required enormous human input

Computers:

- Could automate some of the human tasks

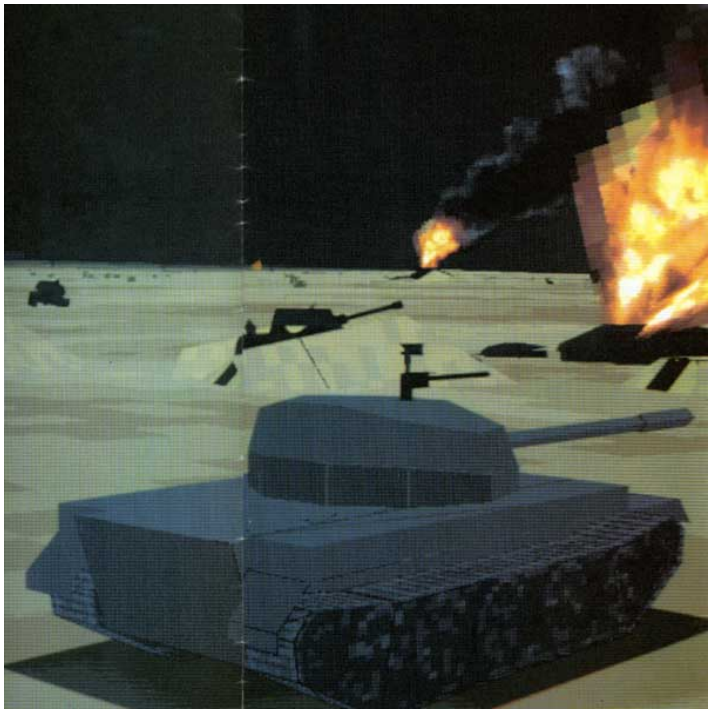
$2\frac{1}{2}$D Graphics - Tweening

By the 1970s computers were sufficiently powerful to help with drawing cartoons, and assembling "cell based" animation.



Some work was done to support "tweening" - drawing the frames that go between two keyframes - but this proved hard to automate.

3D Animation - Polygon rendering

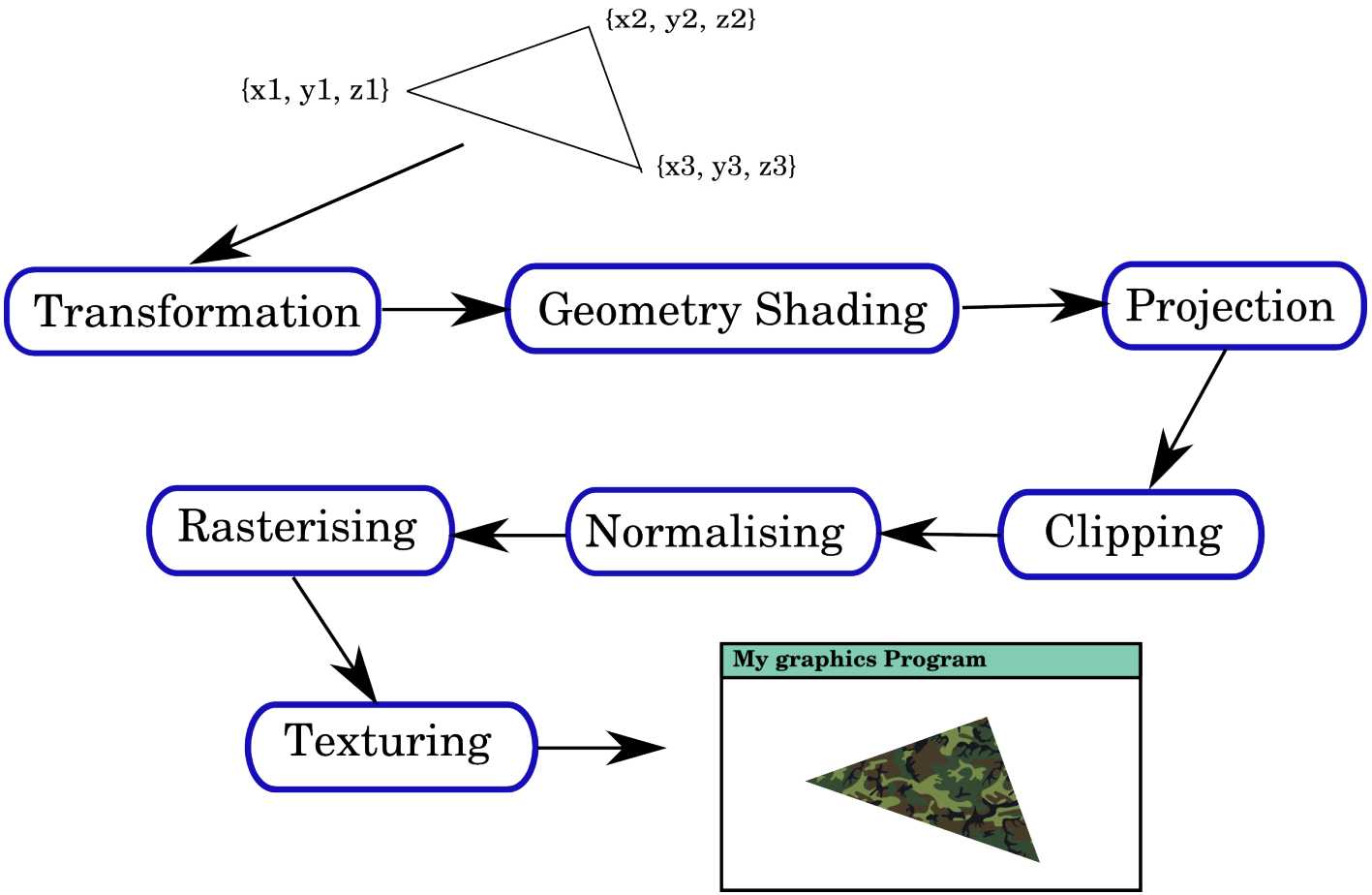


Military simulator circa 1990

Early computer animation systems (flight/military simulators) used planar polygons to create 3D worlds.

Costs were high and the quality was too low for film.

The Graphics Pipeline: 1980



Silicon Graphics Reality Engine (1992)

Special purpose hardware for interactive graphics

OpenGL: General purpose design language

Nowadays you can buy a far more powerful Graphics Processing Unit to plug into your PC.

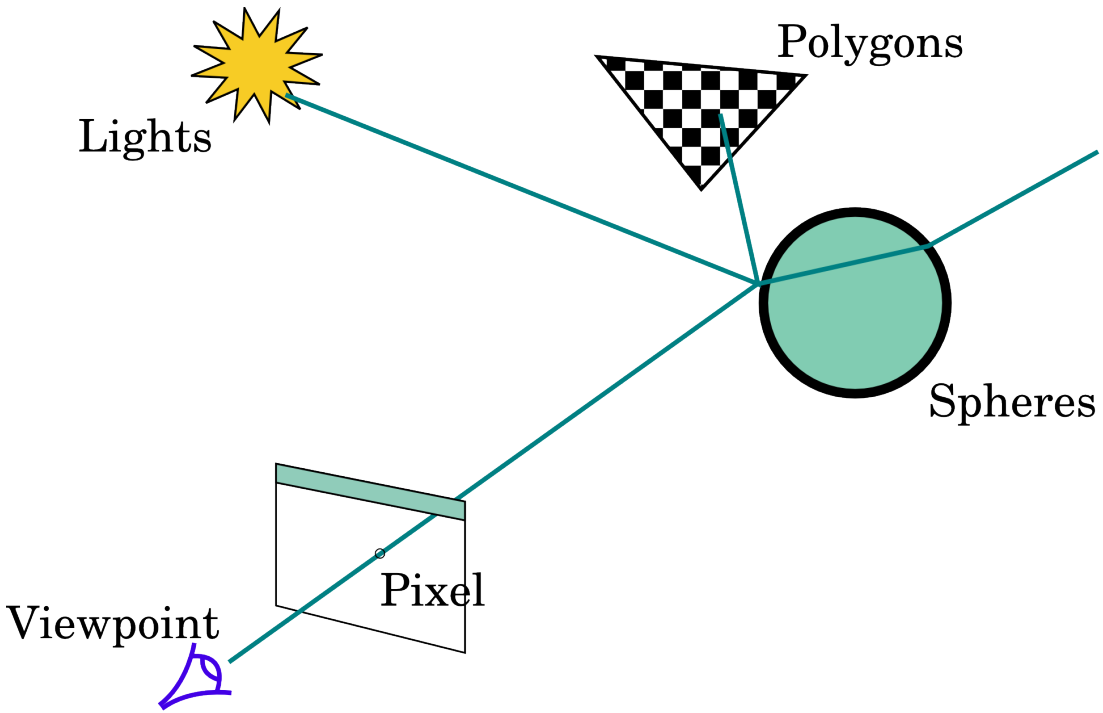
Polygon Rendering in films

Toy Story (1995)

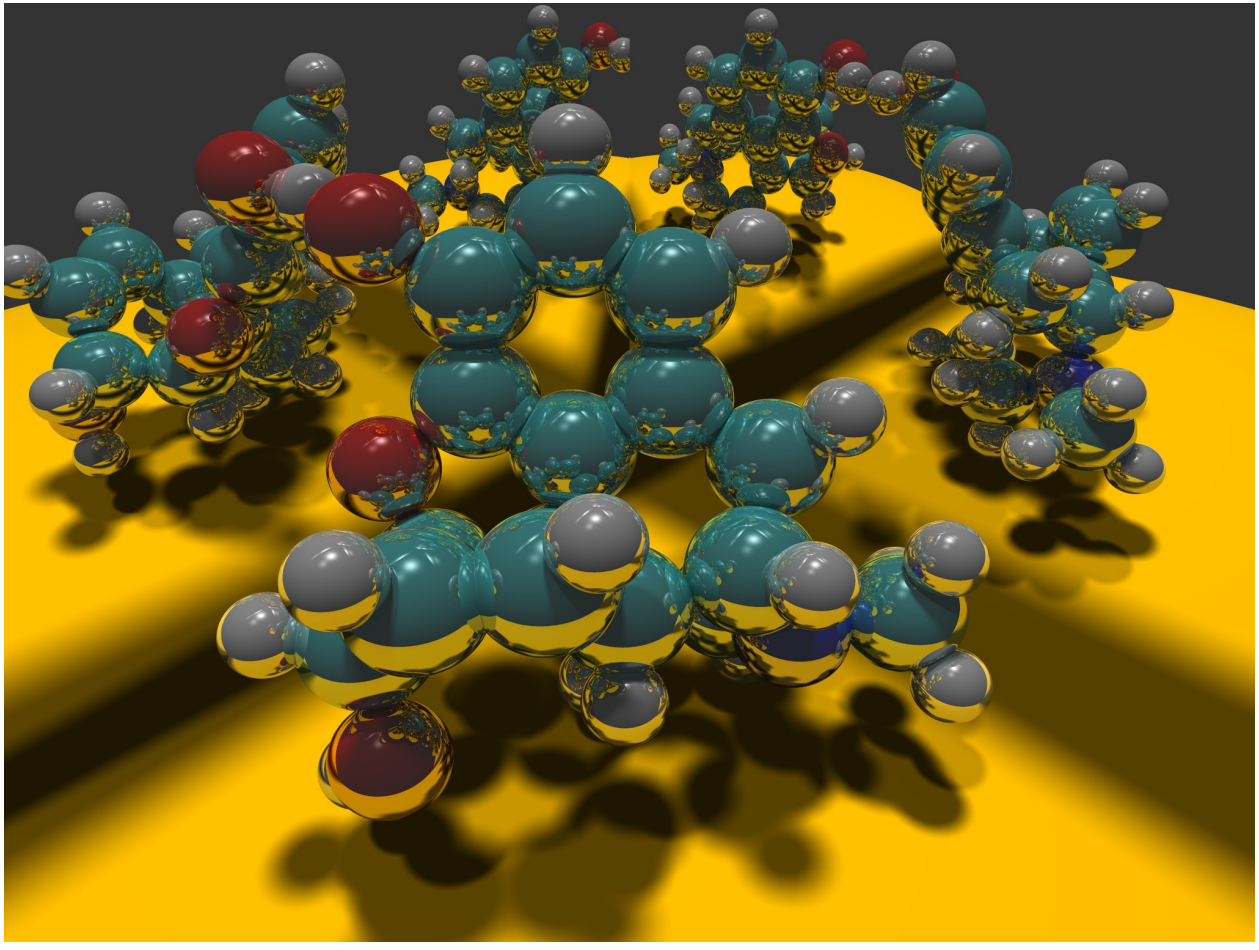
Ray Tracing (1980)

Each pixel of the image is computed independently

Reflections and refractions can be created.



Ray Tracing Examples

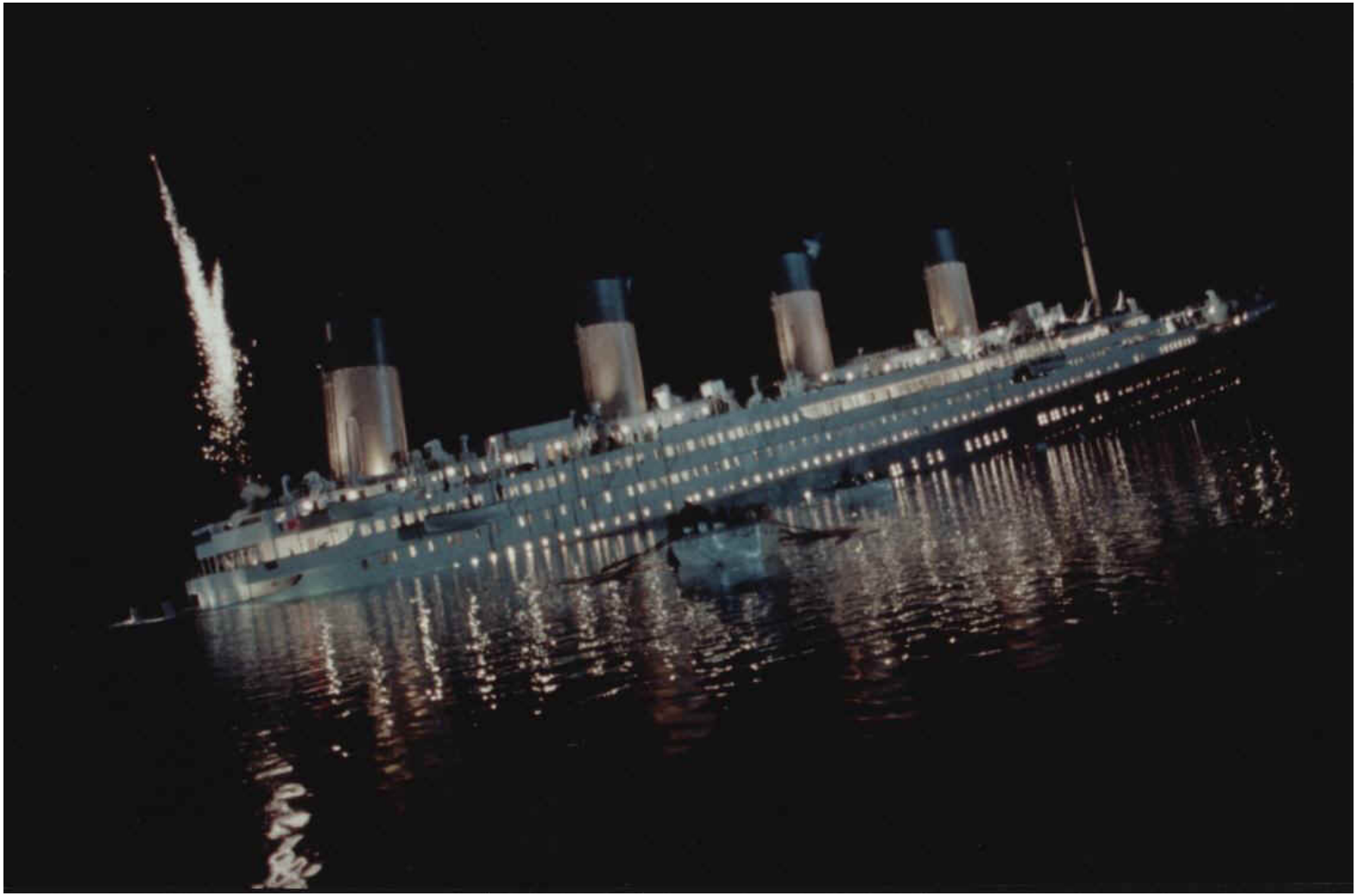


morphine molecule (1983)

Ray Tracing Examples

Street Scene (2011)

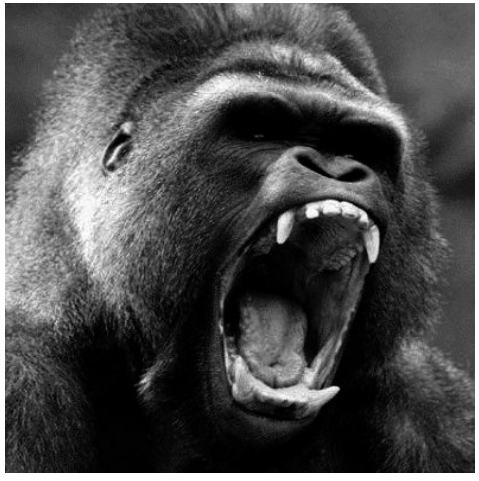
Ray Tracing Examples



Titanic (1997)

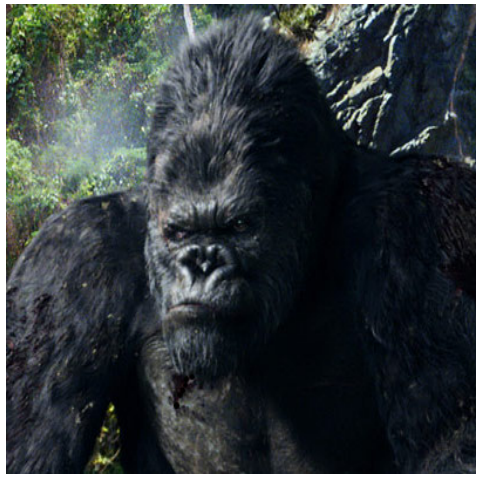
Gorilla Filmstars - are they Computer Generated?






Gorilla Filmstars - are they Computer Generated?

King Kong 1976



King Kong 2005

Real Gorilla

Real Gorilla

King Kong 1933

Trading Places 1989

Motion Capture

One approach to create realistic movement is to use motion capture - for example Gollum in the Lord of the Rings films.

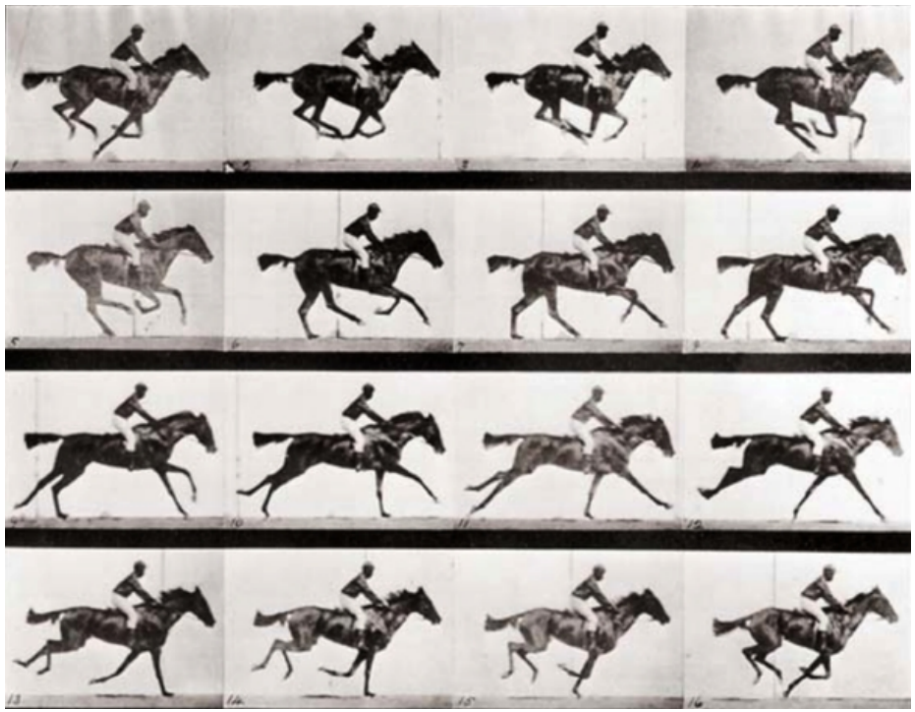
The actor's movements are filmed and turned into 3D movements, then mapped to the avatar.

The Fellowship of the Rings 2001

Complexities of Motion

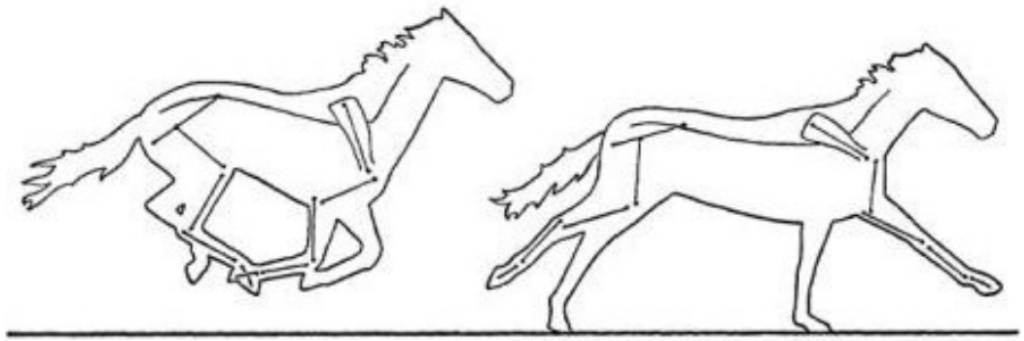
Natural motions are complex, as shown by Eadweard Muybridge's horse photographs of (1878).

Both the geometric motion and the dynamics (velocity and acceleration) are difficult to describe.

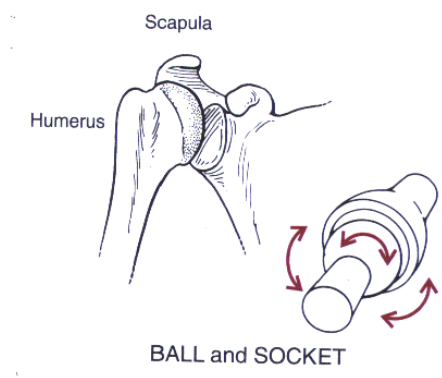


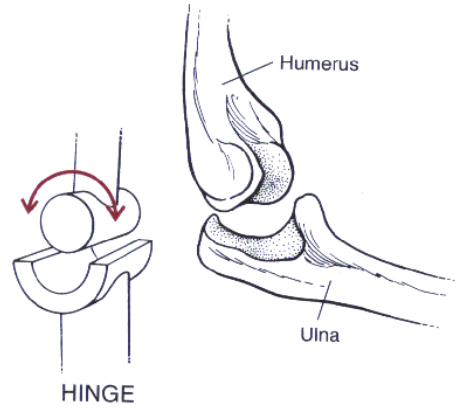
Skeleton based Animation

The skeleton geometry is well defined and constrains the motion.



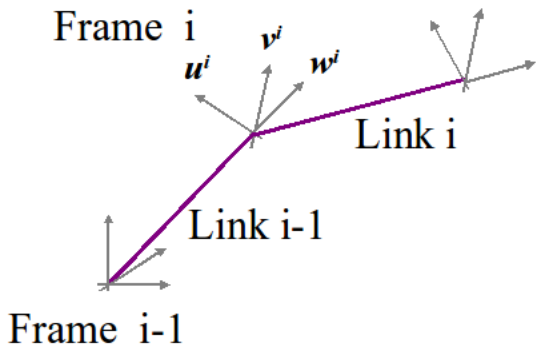
However there are many different types of joints.





Inverse Kinematics

One approach to moving a skeleton is to specify how the extema (hands feet) move, and calculate the positions of the other joints. Each link is specified in the coordinate system of its predecessor



However there is no unique solution, so there is an open research question - How do we constrain the solution to achieve natural movement?

Amorphous Objects

A major challenge for the computer scientist was (and still is) creating amorphous moving objects such as fire, smoke clouds and water.

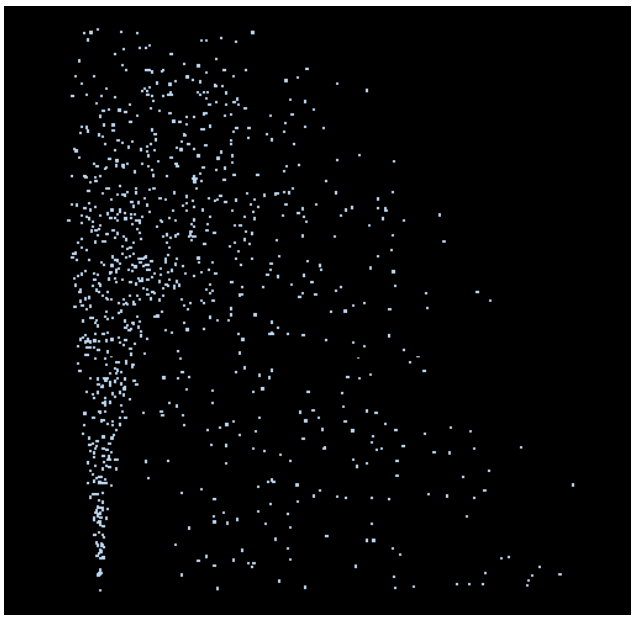
The problem has two aspects:

- modelling
- rendering

Particle Systems

One modelling method is to approximate amorphous objects by a discrete set of small particles. Particles can have:

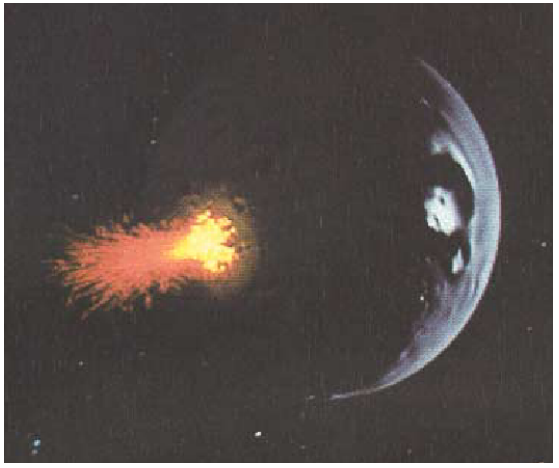
- Mass
- Position
- Velocity
- Temperature
- Shape
- Lifetime

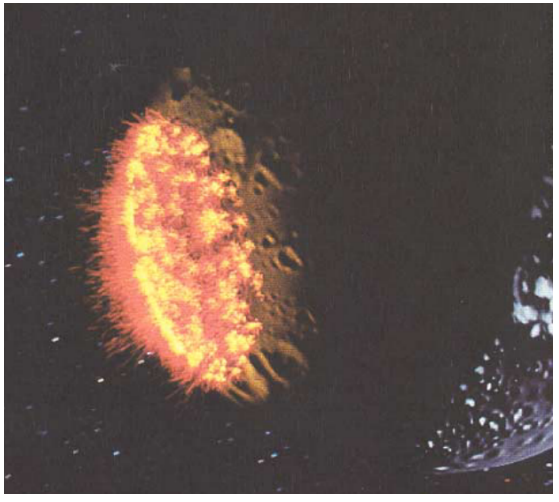


Particle Fountain

Particle Fires - The Wrath of Khan (1983)

Particle systems were first used in film to create fire in the film "The Wrath of Khan".





The Genesis Bomb:

- A special bomb is dropped on a baren planet
- The bomb and fire create life on the planet

(Doesn't sound very likely to me)

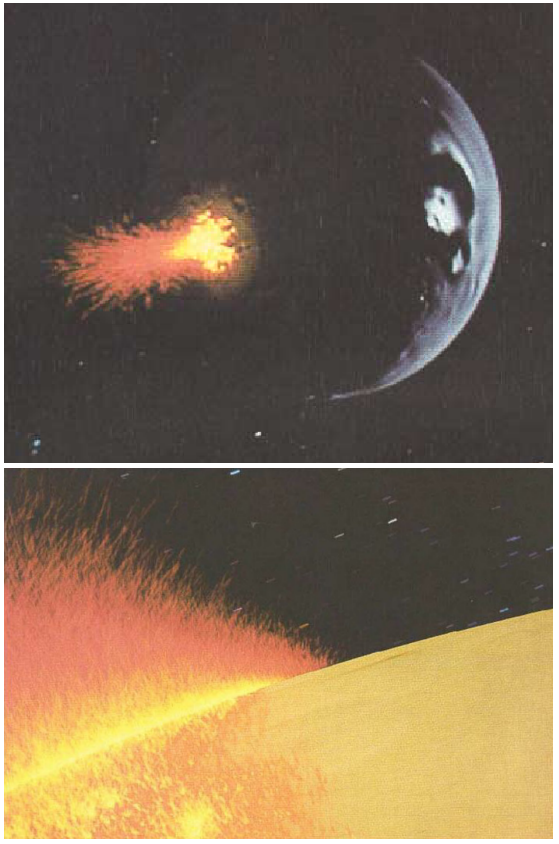
Rendering Particle Fires

The Wrath of Khan rendered each particle by drawing a line showing its path during each frame.

The line was temperature coloured:

- Yellow -very hot
- Red -hot
- &c.

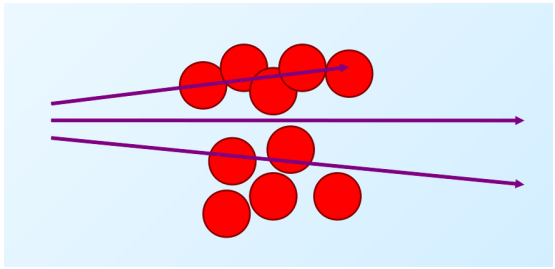
This worked well in long shots but poorly in close up.



Ray Tracing Particles

More realistic rendering, including translucency, can be done by ray tracing the particles

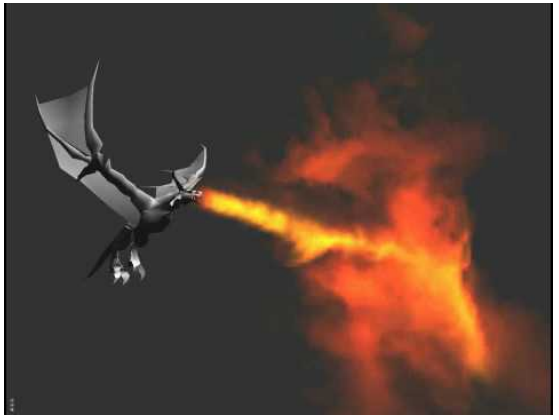
- Particles are given a radius
- As the ray passes through a particle sphere it takes on some of its colour.
- Rays that miss all the particles take on the background colour
- Rays that pass through a few particles mix their colour with the background



Fluid Fires

More realistic modelling can be achieved by treating the fire as a fluid in motion.

- Flames are incandescent gasses in motion
- Fluid motion is described by a differential equation named the Navier-Stokes Equation
- Numerical solutions can be used to find a velocity field
- Particles move at the velocities defined in the field



Ocean Waves

Another fluid modelling problem is how to create ocean waves.

Surface tension and driving forces need to be modelled.

A current research problem is how to make them break

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In Summary

- Computers have been a major force in film making for forty years.
- Computer Scientists contribute to the industry in many ways:
  - Analysis of 3D geometry
  - Specialised Hardware Design (GPU)
  - Describing and constraining behaviour
  - &c
- The challenges to computer scientists are:
  - Achieving Visual Realism
  - Creating Natural Movements for Avatars
  - Modelling and Rendering Amorphous Objects
- There are many small hi-tech companies in the field wanting excellent computer science graduates.