Computer Graphics 1

Chapter 8 (June 24th, 2010, 2-4pm):
Animation
The 3D rendering pipeline (our version for this class)

3D models in model coordinates → 3D models in world coordinates → 2D Polygons in camera coordinates → Pixels in image coordinates

- Scene graph
- Camera
- Rasterization

Animation, Interaction

Lights
Animation == bring to life

• Generally any kind of **moving** graphics
  – flipbooks
  – cartoon films
  – computer animation

• Sequence of single images
  – Movie: 24, TV: 30, Comp.: up to >100/sec.

• Impression of movement >6 fps (???)

• 3D animation most often at video frame rates
Creating a classic cartoon animation

- idea > treatment > story board, sound
- draw keyframes (expensive)
  - important or tricky phases of motion
- interpolate between keyframes (cheap)
  - easy and straightforward phases
- color and film the single frames
Creating 3D computer animation

• idea > treatment > story board
• describe keyframes explicitly
  – complete description of the 3D world state
• interpolate between keyframes
  – calculate state of the world for each frame
• render and display/store single frames

Some ways to animate in 3D

- key framing
- bone animation
- motion capturing
- physics simulation
- scripting and AI

- this is not a comprehensive list
- can be combined (e.g., bones with keyframing)
Keyframing

• define certain parameters of the scene for certain frames
• not all in every keyframe
• also known from Flash

Keyframing the Position
Linear interpolation

\[ x = x_0 + \frac{t - t_0}{t_1 - t_0} (x_1 - x_0), \quad y = y_0 + \frac{t - t_0}{t_1 - t_0} (y_1 - y_0) \]
Spline interpolation

- still only define key frames as control points of the spline
- interpolate in a smooth curve
- risk of overshooting when controlling the splines
Keyframing the Orientation

• Choose rotation axis
• interpolate angle about this axis
• or: shortest path on the unit sphere
Keyframing the Size
Keyframing mesh deformation

- grab a control point
- keyframe its position
- deform the polygon mesh accordingly
Keyframing the Color

• Can be done in RGB or HSV color space
Keyframing the virtual camera

- Position
- Orientation
- Field of view
- Depth of field
Keyframing the light setup

- directional light
- positional light
- ambient light
- spotlight
- area light

- position
- direction
- beam angle
Other things to keyframe

• levels of detail
• visibility
• transparency, shininess
• texture / bump maps
• shading parameters
• rendering method
Bone animation

• also: skeletal animation

• define a skeleton for a polygon mesh
  – topology/structure of the model

• move only the bones of this skeleton
  – by keyframing joint angles
  – by motion capture data
  – by inverse kinematics

• polygon mesh follows and deforms
  – connection between bone and mesh is not rigid
  – mesh stays closed and smooth

http://www.3dluvr.com/clisk3d/anim.htm
Motion Capture

• tracking position and/or orientation of
  – limbs of an actor
  – feature points of a face
  – optical markers on a suit

• Define a relation between tracked feature points and 3D scene points

• Move the mesh exactly along the tracked data

• Still gives the most realistic results
Physics simulation

• Physics engine is often an integral part of 3D games
  – calculations can be done efficiently on GPUs, for example
  – can handle large numbers of objects

• Not all aspects of physics need to be simulated

• 2 examples
  – inverse kinematics
  – particle systems

mass m,
gravitation g,
fell: \( v = g \times t, \)
\( y = y_0 - \frac{1}{2} g \times t^2 \)
jump: \( v_2 = -c \times v_1 \)
Inverse kinematics

- kinematics describes how an object moves
- forward kinematics: how does the object move, given the joint angles
- inverse kinematics: what are the joint angles, given the object motion

- Mainly a way to save work in keyframing
Particle systems

• used for various phenomena
  – dust, explosions
  – fire
  – grass, hair, fur

• generates a large number of objects
• moves them with simple physics
• handle collisions etc..

• no detailed influence on single objects
• parameters of creation and motion can be controlled
AI example: flocks, herds, schools

• A classic example of a simulation of a natural phenomenon (1987)

• Each bird/fish has 3 simple control principles

  – Separation: steer to avoid crowding local flockmates

  – Alignment: steer towards the average heading of local flockmates

  – Cohesion: steer to move toward the average position of local flockmates
Stanley & Stella in Breaking the Ice (1987)
Animation principles

• known by cell animators for a long time
• will make your animations look appealing
• often have to do with exaggeration
  – support our perception of a character/motion

• Examples here from tutorials at
  • http://www.comet-cartoons.com/toons/3ddocs/charanim/
  • http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/principles/prin_trad_anim.htm
  • http://billysalisbury.com/tutorials_principles.htm
Timing

• The exact same motion can express entirely different things at different speeds
• Generally: slow timing conveys calm, fast timing conveys hectic
• "The difference between the right timing and the almost right timing, is the difference between lightning and a lightning bug."
Ease In and Out (or Slow In and Out)

- All motions in nature start slowly and accelerate
- Due to physics (inertia of mass)
- Heavy objects generally accelerate slower
- Light objects accelerate faster
- Can be combined with object deformations
Arcs

• Many motions in nature happen in arcs.
• Linear motions only in machines
• Motion in arcs look more natural on characters
Anticipation

- Motions in nature never start abruptly.
- There is always a phase before the actual motion, when the character already knows he wants to move.
- Is used with much exaggeration in cartoons.
Exaggeration

- Motions come across more pointedly when exaggerated
- Light exagg. = only emphasizing the motion
- Strong exagg. = cartoon-like appearance
Squash and Stretch

• Soft objects are squashed when they hit an obstacle and stretch when released.
• All objects are soft to *some* extent
• Again: exaggeration creates a cartoon-like appearance
Secondary Action

- Secondary story/character/movement in the background
- Should not outpower main action
- Creates a counterpoint to the main action
- Can be used for running gags, Eastereggs
- Can create ironic side notes
- Can emphasize atmosphere
- Example:
  - fingers on the table
  - Figure in the background
Follow Through and Overlapping Action

• Same as anticipation, but at the end of an action
• Object goes past its resting point and then comes back to where it would normally be.
• Again: exaggeration creates a cartoon-like appearance
Staging

• Make action and objects understandable
• Show actions one at a time
• Position objects to maximize silhouette
• Combine effects to convey a consistent message
Non-symmetrical Posing and Performing

- Asymmetrical compositions are more interesting
- Nature is almost never *perfectly* symmetric
- Image diagonal can convey atmosphere
Snap

- Quick and abrupt motions
- Only a few frames long
- Convey something that happens abruptly
- Can be emphasized by sound
Weight

- Imitate physical behavior to convey the weight of objects
- Heavy objects accelerate slowly
- Light objects bounce higher
- Heavy objects push light ones aside
Line crossing error

• Camera must not cross the line of motion
• Otherwise will be perceived as 2 different motions
• Fix: cut a different scene in between

• not particular to 3D animation!
Appeal, Personality

- Appeal is anything the audience likes to see
- Can be quality of charm, design, simplicity, movements, communication
- Create believable personalities
  - Consistency in pose, facial expression, communication, behavior

- Image from "ferdinand the bull"
- Disney, 1938.

http://www.ultimatedisney.com/images/w-z/wdac-v6-03.jpg
Pixar: For the Birds (2008)