Advanced Computer Graphics

Lecture 11:
Animation I – Animation Principles

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Overview

- Introduction
- Principles of (Traditional) Animation
- Types of Animation Systems

More Information
M. Comet (1999): Character Animation: Principles and Practice
  http://www.comet-cartoons.com/3ddocs/charanim/
  http://www.siggraph.org/education/materials/HyperGraph/animation
Animation

„To animate means to give life to”
Illusion of movement through consecutive rendering of single frames
Perception:
- Eye/brain interprets fast state changes as motion
- Rate varies with environment conditions (light, distance, etc.)
- TV: 30 Hz
- playback rate vs. sampling (capturing) rate

2 Hz 10 Hz 12 Hz – typical rate for animated cartoons
Traditional Animation

- 1800s: flipbooks
- 1906: first cartoon
- 1910: John Bray: overlayed translucent celluloids
- 1915: Max Fleischer: rotoscope
- ca 1920: Otto Mesmer / Pat Sullivan: first animated character drawing movie audiences, John Bray: first colored animation
- ca. 1930: Walt Disney: storyboard, keyframing, sound, color, characters, analysis of real life motion
- ...
Video: Luxo Jr.

Principles of Animation

Many of the principles of traditional animation were developed in the 1930’s at the Walt Disney studios. These principles were developed to make animation, especially character animation, more realistic and entertaining. These principles can and should be applied to 3D computer animation.


see also:
M. Comet (1999): Character Animation: Principles and Practice
http://www.comet-cartoons.com/3ddocs/charanim/
Principles of Animation (Lasseter, 1987)

1. Squash and Stretch
2. Timing and Motion
3. Anticipation
4. Staging
5. Follow Through and Overlapping Action
6. Straight Ahead Action and Pose-to-Pose Action
7. Slow In and Out
8. Arcs
9. Exaggeration
10. Secondary Action
11. Appeal

Timing

- Animation too slow: loss of viewer’s attention
- Animation too fast: viewer does not understand events

- Timing and Perception of Mass
  - E.g. which of the two sphere is heavy, which one light?

- Heavy objects accelerate more slowly
- Big objects are typically heavier than smaller ones, should be animated slower
- Lifting of heavy objects by an animated figure should be slower than lifting of light objects
Principles of Animation (Lasseter, 1987)

Timing

- Timing and Emotional State
  - e.g. turning one’s head
  - ultra fast: head hit by an object
  - fast: nervousness
  - intermediate speed: following an object with the eyes; giving instructions
  - slow: person watches something pleasant
  - very slow: thinking
  - very very slow: stretching of neck muscles

Principles of Animation (Lasseter, 1987)

Squash and Stretch

- Objects deform during an action
  - e.g. ball deforms when hitting the ground
- Degree of deformation provides hint of the object’s physical properties
- In keyframe-based animations, squash-and-stretch can be accomplished by scaling (the object’s volume should approximately remain constant)
- For articulated objects, ‘squash and stretch’ can also be accomplished without deformation
  - e.g. Luxo Jr
**Principles of Animation (Lasseter, 1987)**

**Anticipation**

- 3 phases of an action:
  - the preparation for the action (anticipation)
  - the action
  - the termination of the action

- Anticipation can be the anatomical preparation for the action
  - e.g., retracting a foot before kicking a ball

- Anticipation can also be a device to attract the viewer's attention to the proper screen area and to prepare them for the action
  - e.g., raising the arms and staring at something before picking it up, or staring off-screen at something and then reacting to it before the action moves on-screen

- Anticipation can further create the perception of weight or mass,
  - e.g., a heavy person might put their arms on a chair before they rise, whereas a smaller person might just stand up.

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**Follow-Through and Overlapping Action**

- **Follow-Through** (termination part of an action)
  - E.g., throwing a ball - the hand continues to move after the ball is released.
  - In the movement of a complex object different parts of the object move at different times and different rates.
    - Example: in walking, the hip leads, followed by the leg and then the foot. As the lead part stops, the lagging parts continue in motion.
  - Heavier parts lag farther and stop slower
    - E.g. antennae of an insect

- **Overlapping Action**
  - Start a second action before the first action has completely finished
  - Keeps the interest of the viewer, as there is no dead time between actions

> "It is not necessary for an animator to take a character to one point, complete that action completely, and then turn to the following action as if he had never given it a thought until after completing the first action. When a character knows what he is going to do he doesn't have to stop before each individual action and think to do it. He has it planned in advance in his mind." (Walt Disney)
Principles of Animation (Lasseter, 1987)
Secondary Action

- Secondary Action: an action that directly results from another action
- e.g. the trailing electrical cord of Luxo, Jr
- e.g. a moving ball that hits a second object that may or may not move as a result
- secondary action can create the perception of mass
- secondary action can be used to increase the complexity and interest in a scene
- secondary action should always be subordinate to and not compete with the primary action in the scene

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Principles of Animation (Lasseter, 1987)
Slow in & Slow Out, Arcs

- **Slow in & slow out (or ease-in ease out)**: the spacing of the in-between frames to achieve subtlety of timing and movement
  - an object isn't moving 100% and then in one frame comes to a complete stop
  - e.g. a **bouncing ball** tends to have a lot of ease in and out when at the top of its bounce
  - in character animation, use ease in and out for most movements
    - e.g. **Arm - Bad, No Ease** - Very robotic / computer-generated looking
    - e.g. **Arm - Good, With Ease** - Much more natural and fluid

- **Arcs**: the visual path of action for natural movement
Principles of Animation (Lasseter, 1987)

Further Principles

- Staging: presenting an idea so that it is unmistakably clear

- Exaggeration: Accentuating the essence of an idea via the design and the action

- Appeal: creating a design or an action that the audience enjoys watching

Types of Animation Systems

- Computer animation: Computer graphics + motion control

- One way to classify animation techniques is by the level of abstraction in the motion control techniques:
  - low-level methods: direct specification of all motion parameters
  - high-level methods: general, abstract motion specification, automatic generation of low-level parameters
    - e.g. human >240 DOF per frame at 30 fps
    - e.g. animating an entire flock of birds
Types of Animation Systems

Scripting Systems

- Earliest type of motion control systems
- Animator writes a script in the animation language
- The user must learn this language and the system is not interactive
- E.g. ASAS (Actor Script Animation Language)
  - C. Reynolds, 1982
  - Syntax similar to LISP
  - Actor: a complex object which has its own animation rules.
  - Actors can communicate with other actors by sending messages and so can synchronize their movements.
  - e.g. used in Tron
- Today
  - 3DS Max: MaxScript, scripting language similar to C
  - Blender: Python scripting

Procedural Animation

- Use of procedures that define movement over time
  - procedures based on the laws of physics (physically-based modeling)
  - animator generated methods
  - E.g. a motion that is the result of some other action (this is called a "secondary action"), for example throwing a ball which hits another object and causes the second object to move.
Types of Animation Systems

Representational Animation

- This technique allows an object to change its shape during the animation.
  - no separation of modeling and animation

Three subcategories:
- Animation of articulated objects, i.e., complex objects composed of connected rigid segments.
- Soft object animation used for deforming and animating the deformation of objects, e.g. skin over a body or facial muscles.
- Morphing = changing of one shape into another quite different shape (2D or 3D).

Types of Animation Systems

Stochastic and Behavioral Animation

- **Stochastic Animation**
  - This uses stochastic processes to control groups of objects, such as in *particle systems*.
  - E.g. fireworks, fire, water falls, hair, etc.

- **Behavioral Animation**
  - Objects or "actors" are given rules about how they react to their environment.
  - E.g. schools of fish or flocks of birds where each individual behaves according to a set of rules defined by the animator

http://www.cs.unc.edu/~davemc/Particle/
"One thing you will see is much more sophisticated artificial intelligence," said David Zucker, the CEO of Chicago-based Midway Games. "The artificial intelligence, it's the way in which the world works. When you walk up to an individual in the world, he reacts one way if you punch him. If you say hello to him, he does something else. It's how objects work when acted upon."

The Xbox 360 makes these possibilities available en masse.

In Microsoft's new fantasy game Kameo, players can ride a horse into an army of 3,500 ogres. Amazingly, each ogre has its own intelligence and reacts to the player independent of the thousands of ogres around it.

### Types of Animation Systems

#### Performance Animation

- **Motion capture:** measurement and recording of the direct actions of an actor for immediate or delayed analysis and playback
- **Capturing systems:**
  - Mechanical: joystick, mouse, data glove
  - Optical: at least two cameras + reflective markers
  - Magnetic: centrally located transmitter + set of receivers strapped on to various parts of the performer’s body
- **Mapping of raw data sets to motion of digital character**

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*News report on upcoming Xbox 360, May 2005*
Motion Capture

source: http://www.ptphoenix.com/

Motion Capture File Formats

- Many contenders
  - e.g. Biovision .BVA, Biovision .BVH, Acclaim Skeleton format .ASF
  - E.g. .BVA
    - translation, rotation, scale for each segment and frame of the animation

Sample Biovision .BVA file

.BVA file hierarchy
Types of Animation Systems
Performance Animation

- Performance Capture
  - motion capture + facial expression capture

Softimage Face Robot
http://www.softimage.com/products/face_robot/

Types of Animation Systems
Classification by Funge

[Diagram of classification by Funge]
Dancing Baby
www.dbaby.com