Animation and Interaction
CS148, Summer 2010

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Motion from Sequence of Still Frames

Eadweard Muybridge, 1887

Video: Luxo Jr. (Pixar, 1986)

Basics of Animation: Keyframes

- **Keyframe**: significant pose of an animated object
- Artist/computer interpolates between successive keyframes to generate intermediate poses
-Splines can provide smooth transitions!

Video Compression with Keyframes

- Store a complete new image (keyframe) only when the scene substantially changes
- For intermediate frames, store only the difference from the previous frame
- Difference images are mostly zero, so compress better

Kinematics

- Study of motion of objects without considering what causes that motion (i.e. forces)
- **Forward kinematics**:
  - Describe transformation of object as function of time
  - Advance in small steps to generate frames
- **Inverse kinematics**:
  - Describe motion of some parts of the object
  - Automatically infer motion of remaining parts, respecting object constraints
  - Such constraints might look like: keep some points fixed, and move the parts as little as possible
Inverse Kinematics

Constraints

These motions are automatically inferred

“UTPoser”, Yamane and Nakamura, 2003

Video: Combining Path Planning with IK

Synthesizing Animations of Human Manipulation (Yamane, Kuffner and Hodgins, 2004)

Physically-Based Animation

- **Dynamics**: Study of motion as a product of the stimuli/forces that cause it
- Simulate the evolution of a system as forces are applied to it
- Typically:
  - Model the system as a collection of differential equations
  - Set boundary conditions (constraints)
  - Numerically solve the equations for trajectories

Video: Solid-Fluid Coupling

Coupling Water and Smoke to Thin Deformable and Rigid Shells (Gundelman, Selle, Losasso and Fedkiw, 2005)

Video: Multiple Interacting Fluids

Multiple Interacting Liquids (Losasso, Shinar, Selle and Fedkiw, 2006)

Smooth Animation: Motion Blur

- A frame is not an instant but an *interval* in time
- For smooth transitions from the frame to the next, the frame should *integrate* all positions of the object during the interval
- This is naturally captured by longer exposures on film, and can be simulated on a computer

(Eadweard Muybridge)
Smooth Animation: Motion Blur

"1984", using distribution ray tracing (Cook, Porter and Carpenter, SIGGRAPH 1984)

Smooth Animation: Double-Buffering

- **Problem**: Screen flicker and tearing, when
  - display is cleared between frames, or
  - display refresh is not synced to redraw rate
- **Solution**: Maintain two framebuffers, one for the display and one for drawing
  - Display device reads display buffer, renderer draws on drawing buffer
  - Once the frame is drawn and the next display refresh is due, the buffers are quickly swapped
    - Just the pointers are swapped, no memory is copied
- **Demo**: Single- vs double-buffering

Video: Ivan Sutherland’s Sketchpad, 1962

(Presented by Alan Kay, 1987)

Interaction

- Detecting input:
  - **Polling**: I periodically query the system
  - **Interrupts**: OS notifies me asynchronously
- **Picking**: Finding the nearest object (e.g. window, button, jetpack…) at the pointer location
  - Picking = raycasting!
  - Can do in object space, or via the framebuffer
- Input events trigger responses/actions
  - e.g. a widget’s onClick() callback is called when the widget is clicked

Events

- Operating system responds to interrupt
- Creates timestamped event record and places in an event queue
  - Queues are first-in first-out (FIFO)
  - May store state of other devices at time of event
    - e.g. polled devices like the mouse
- Callback manager
  - Reorder events based on priority
    - e.g. keyboard has priority over PostRedisplay
  - Event coalescing
  - Combine mouse motions for current position

Simple Game Control

```
forever:
  readInputDevices()
  updateAI()
  processMovement()
  handleCollisions()
  draw()
```
Animation Graphs

- Crouch
- Crawl → Slide
- Stand
- Walk → Run → Sprint
- Skid

Filtering/Smoothing Input

- We don’t really want characters to respond instantaneously, so we take a little time to converge to the desired state.

Interaction: Things to Remember

- Flow from input to events to method invocation
- Inputs cause interrupts which generate events
- Events are routed to objects
- Pointer events require “hit testing”
- Interaction “building blocks” for GUIs, games
  - State machines
  - Filtering/smoothing
  - Clicking, dragging
  - Character movement

(‘Classic Super Mario 64 Third-Person Control and Animation’, Steve Rabin)