Animation in the Interface

Reading assignment: This section based on 2 papers

- Bay-Wei Chang, David Ungar, "Animation: From Cartoons to the User Interface", *Proceedings of UIST' 93*, pp.45-55.
- http://www.acm.org/pubs/articles/proceedings/uist/168642/p45-chang/p45-chang.pdf

- Scott E. Hudson, John T. Stasko, "Animation Support in a User Interface Toolkit: Flexible, Robust and Reusable Abstractions", *Proceedings of UIST '93*, pp.57-67.
- http://www.acm.org/pubs/articles/proceedings/uist/168642/p57-hudson/p57-hudson.pdf

- Good related paper: John Lasseter, "Principles of traditional animation applied to 3D computer animation", Proceedings of SIGGRAPH '87, pp. 35 - 44

Animation is of increasing interest

- Perceptual advantages
- Just recently had enough spare horsepower (circa Win98)
- Now seeing this in the mainstream (Vista, MacOS X)

Why animation?

- Gives a feeling of reality and liveness
  - “animation” = “bring to life”
  - make inanimate object animate

Why animation?

- Provides visual continuity (and other effects) enhancing perception
  - particularly perception of change
    - hard to follow things that just flash into & out of existence
    - real world doesn't act this way

Why Animation?

- Can also be used to direct attention
  - movement draws attention
  - strong evolutionary reasons
    - therein lies a danger
    - overuse tends to demand too much attention
      - e.g., the dreaded paper clip

Why Animation?

- Used sparingly and understandingly, animation can enhance the interface

- Draw attention to important details
- Provide a sense of realism
- Provide important affordances and feedback to user actions

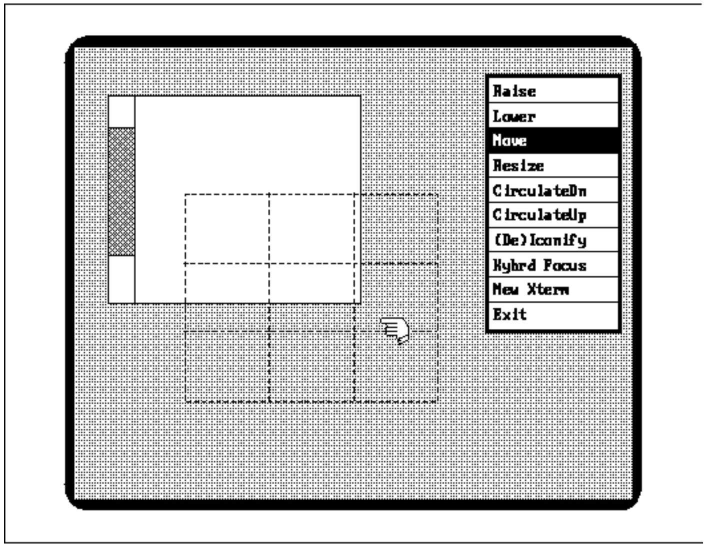
Three principles from traditional animation

- Not mutually exclusive:
- **Solidity**
  - make objects appear to be solid, have mass
- **Exaggeration**
  - exaggerate certain physical actions to enhance perception
  - paradoxically, increases realism (liveness) by being less literal
- **Reinforcement**
  - effects to drive home feeling of reality...often more subtle than the above

- We'll discuss a set of techniques that build on these... each technique may draw from multiple principles

Specific techniques drawn from these principles

- **Solid drawing**
  - Want objects to appear solid and appear to have mass
  - Solid (filled) drawing
    - now common place

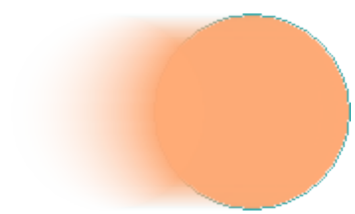


Specific techniques drawn from these principles

- **No teleportation**
  - objects must come from somewhere
    - not just "pop into existence"
  - nothing in the real world does this (things with mass can't do this)
  - E.g., OS X Dock
  - (new windows still materialize though)

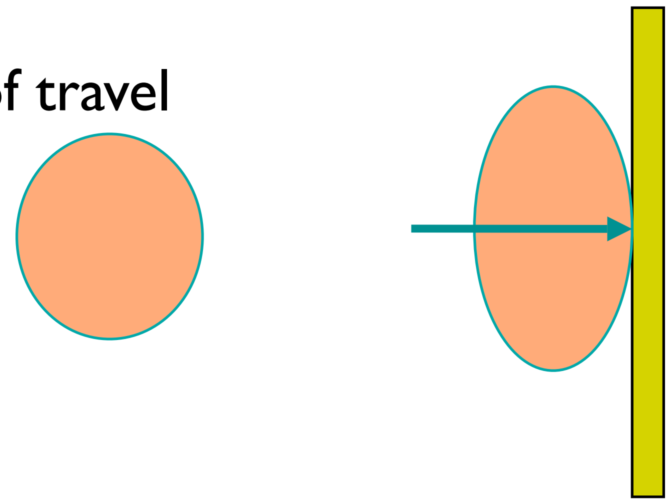
Specific techniques drawn from these principles

- **Motion blur**
  - if objects move more than their own length (some say 1/2 length) in one frame, motion blur should be used
  - matches real world perception of solid objects
  - makes movement look smoother
  - doesn't need to be realistic

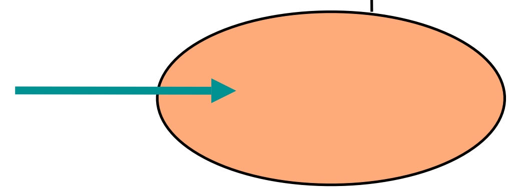


Specific techniques drawn from these principles

- **Squash and stretch**
  - Cartoon objects are typically designed to look "squishy"
  - When they stop, hit something, land, they tend to squash
    - like water balloon
    - compress in direction of travel



Specific techniques drawn from these principles



- Squash and stretch
  - Also stretch when they accelerate
    - opposite direction
  - Basically an approximation of inertia + conservation of volume (area)

Specific techniques drawn from these principles

- Squash and stretch
  - Conveys **solidity**
  - Although S&S makes things look "squishy" they **reinforce** solidity because they show mass
  - (This is tends to be **exaggerated**)

Specific techniques drawn from these principles

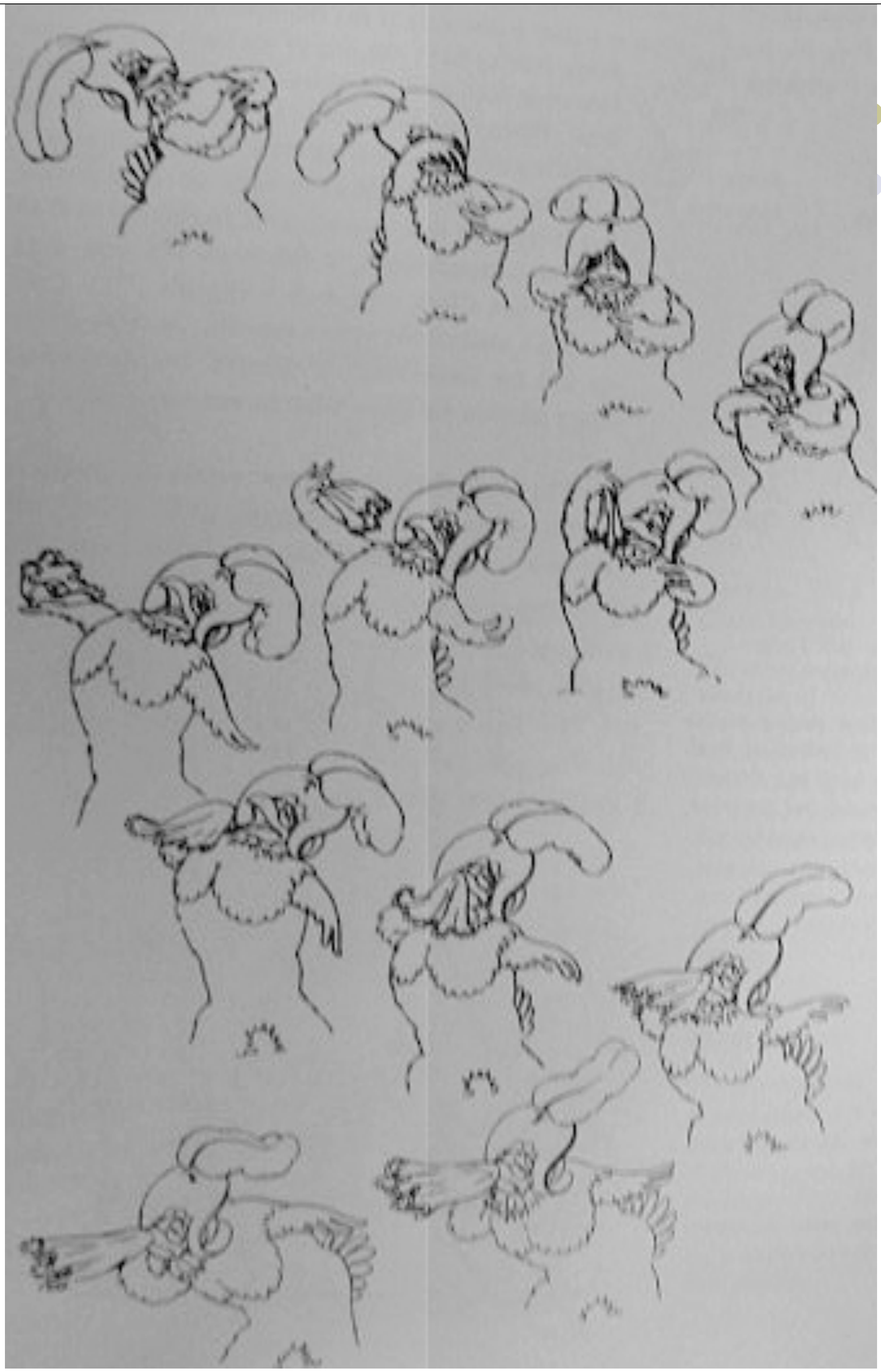
- **Follow through** (& secondary action)
  - Emphasize **termination** of an action
    - **Solid** objects don't just stop, they continue parts of the motion
      - e.g., clothes keep moving, body parts keep moving
    - **Reinforces** that object has mass via inertia
    - (also tends to be **exaggerated**)

Example of Follow Through

- Notice feather lags behind character

- Also S&S here

- From: Thomas & Johnston "The Illusion of Life: Disney Animation", Hyperion, 1981



Specific techniques drawn from these principles

- **Anticipation**
  - Example of **exaggeration** in the interface
  - small counter movement just prior to the main movement
  - this sets our attention on the object where the action is (or will be)
  - Contrast to follow-through (which is about termination of movement)... anticipation is about the **start** of movement

Specific techniques drawn from these principles

- **Slow-in / Slow-out**
  - Movement between two points starts slow, is fast in the middle, and ends slow
  - Two effects here
    - objects with mass must accelerate... thus **reinforces solidity**
    - interesting parts typically @ ends
      - tweaking perception to draw attention to most salient aspects of motion from a UI perspective

Specific techniques drawn from these principles

- **Movement in arcs**
  - Subtle reinforcement effect
  - Objects in the real world rarely move in a straight line
  - Animate objects to move in gently curving paths, not straight lines
  - Why?
    - Movements by <u>animate</u> objects are in arcs (due to mechanics of joints)
    - Most movements in gravity also in arcs

Recap

- Appearance of mass
  - solidity & conservation of volume
  - several ways to show inertia
- Tweak perception
  - direct attention to things that count
  - time on conceptually important parts
- Caricature of reality

Examples From Video

Reminder

- Animation can bring otherwise boring things to life, but…
- Its not a uniformly good thing
  - demands a lot of attention
  - can take time
- Needs to be used wisely (and probably sparingly)

Making animation happen in a toolkit

- Paper describes model in subArctic (and predecessor)
  - high to middle level model
  - robust to timing issues
- Primary abstraction: transition
  - models movement over time
    - arbitrary space of values (eg, color)
    - screen space is most common

Transition consists of

- Reference to obj being animated
  - passage of time modeled as events
- Time interval
  - period of time animation occurs
- Trajectory
  - path taken through value space
  - timing of changes through values

Trajectory has two parts

- Curve
  - set of values we pass through
  - typically in 2D space, but could be in any space of values (e.g., font size)
- Pacing function
  - mapping from time interval (0…1) to "parameter space" of curve (0…1)
  - determines pacing along curve
    - e.g., slow-in / slow-out

Mapping from time to value

- Time normalized with respect to animation interval (0...1)
- Normalized time is transformed by pacing function (0…1)
- Paced value is then fed to curve function to get final value

To get a movement

- Create and schedule a transition
  - several predefined types (i.e., linear)
  - scheduling can be done absolute
    - start stop at the following wall clock times
  - or relative
    - D seconds from now
    - D seconds from start / end of that

System action

- Transition will deliver time as input using animatable interface
  - transition_start()
  - transition_step()
  - transition_end()
- Each delivers:
  - trajectory object, relative time & value

Transition steps

- Steps represent intervals of time, not points in time
  - deliver start and end times & values
- Typical OS can't deliver uniform time intervals
  - Number of steps (delivery rate) is not fixed in advance (animation system sends as many as it can)

  - system delivers as many as it can

Recap

- Transition
  - Object to animate
  - Time interval to work over
    - Time ➡ (0…1)
  - Trajectory to pass through
    - Pacing function (0…1) ➡ (0… 1)
    - Curve (0...1) ➡ Value

Animation in Swing

- Unfortunately, no nice API custom built for animation
- Animation usually cobbled together using a grab bag of tricks
    - Separate thread to update positions or other attributes of animated components
    - Custom repaint code
    - Graphical trickery
    - Understanding/using the Swing threading model
- (Depending on what you want to do...)

Good Animation Examples

- Excellent book: *Swing Hacks*, Marinacci and Adamson, O'Reilly Press
  - Hack #8: Animated transitions between tabs
  - Hack #18: Animated fade-ins of JList selections
  - Hack #42: Animated dissolving JFrames
- Plus several others
- Most involve:
  - Subclassing existing components to override their painting behavior (overriding paintComponent() for example)
  - Capturing on-screen regions in an Image, and then:
    - Fiddle with the image
    - Blit it to the screen
    - Lather, rinse, repeat as necessary to do a transition
  - Simply using a thread to update existing properties on normal components

Using a Thread to Update Normal Component Properties

- If you want to do *simple* animation (just move a component on-screen, or change its size), you can do this pretty easily
  - No need for crazy custom paint code or imaging
- Figure out the two states you want to change between
  - Example: location is currently (0, 0); want to get to (100, 100)
- Figure out how often you want to do updates, and how long the total transition should take
  - Example, want the entire move to happen in .5 seconds; would like .1 seconds between updates, so ideally 5 "frames" in the animation
- Create a thread that sleeps for the interval, wakes up, and does the update

Threading and Swing

- Caution!
  - You cannot (should not) update or read any Swing property from a thread other than a Swing thread
  - Example: ok to update component properties in an event handler, as that code is running in the Swing event dispatch thread
  - Updating *outside* a Swing thread can yield unpredictable results
- See: http://java.sun.com/products/jfc/tsc/articles/threads/threads1.html

How to Run Code in the Swing Event Dispatch Thread?

- javax.swing.SwingUtilities
  - invokeLater(Runnable r) -- queue up a runnable to execute on the Swing event dispatch thread at some later time
  - invokeAndWait(Runnable r) -- caution: may lead to deadlock!
  - Useful for one-off updates to Swing state
- javax.swing.Timer
  - Fires one or more actions after a specified delay
  - Calls out to ActionListeners, whose code executes on the event dispatch thread

SwingUtilities.invokeLater Example

```
SwingUtilities.invokeLater(new Runnable() {
    public void run() {
        someComponent.setLocation(50, 50);
    }
});
```

- Take care -- don't loop in run() or you'll tie up the event dispatch thread

SwingUtilities.Timer Example

```
public final static int TENTH_OF_A_SECOND = 100;
public int numIterations = 0;
timer = new Timer(TENTH_OF_A_SECOND, new ActionListener() {
    public void actionPerformed(ActionEvent ev) {
        if (numIterations++ >= 5) {
            timer.stop();
        } else {
            someComponent.setLocation(startX + numIterations * (endX - startX)/5,
                                      startY + numIterations * (endY - startY)/5);
        }
    }
});
timer.start();
```

- (Be sure to distinguish from non-Swing java.util.Timers, which *aren't* smart with respect to the event dispatch thread)

Gotchas

- Don't forget that some updates may conflict with other ongoing processes in Swing
- Example:
  - Changing a component's layout may not "take" if you're using a LayoutManager in the parent of that component