CSE 512 - Data Visualization

Animation

Jeffrey Heer  University of Washington
Why Use Motion?

Visual variable to encode data
Direct attention
Understand system dynamics
Understand state transition
Increase engagement
Cone Trees [Robertson 91]
Volume Rendering [Lacroute 95]
The Baby Name Wizard's NameVoyager

To begin, type in a name.
Topics

Motion perception
Principles for animation
Animated transitions in visualizations
Motion Perception
Perceiving Animation

Under what conditions does a sequence of static images give rise to motion perception?

Smooth motion perceived at \(~10\) frames/sec \((100\ \text{ms})\).

http://www1.psych.purdue.edu/Magniphi/PhIsNotBeta/phi2.html
Motion as Visual Cue

Pre-attentive, stronger than color, shape, …
More sensitive to motion at periphery
Similar motions perceived as a group
Motion parallax provide 3D cue (like stereopsis)
How many dots can we simultaneously track?
Tracking Multiple Targets

How many dots can we simultaneously track?
~4-6. Difficulty increases sig. at 6. [Yantis 92, Pylyshn 88, Cavanagh 05]
Segment by Common Fate

http://dragon.uml.edu/psych/commfate.html

http://www.singlecell.org/july/index.html
Dots moving together are grouped

http://coe.sdsu.edu/eet/articles/visualperc1/start.htm
Grouping of Biological Motion

http://www.lifesci.sussex.ac.uk/home/George_Mather/Motion/WALK.MOV

[Johansson 73]
Motions Show Transitions

See change from one state to next

start
Motions Show Transitions

See change from one state to next

end
Motions Show Transitions

See change from one state to next

- Shows transition better, but
- Still may be too fast, or too slow
- Too many objects may move at once

start   end
Velocity Perception

What is perceived as smooth, uniform motion?

Velocity perception can be affected by:

- Path curvature
- Size / depth perception
- Luminance contrast

(DEMO)
Constructing Narratives

http://anthropomorphism.org/img/Heider_Flash.swf
 Attribution of Causality  [Michotte 46]

Michotte demonstration 1. What do you see? Most observers report that "the red ball hit the blue ball." The blue ball moved "because the red ball hit it." Thus, the red ball is perceived to "cause" the blue ball to move, even though the balls are nothing more than color disks on your screen that move according to a programme.

http://cogweb.ucla.edu/Discourse/Narrative/michotte-demo.swf
Attribution of Causality [Michotte 46]

[Reprint from Ware 04]
<table>
<thead>
<tr>
<th>Animation</th>
<th>Helps?</th>
<th>Hurts?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attention</td>
<td>direct attention</td>
<td>distraction</td>
</tr>
<tr>
<td>Constancy</td>
<td>change tracking</td>
<td>false relations</td>
</tr>
<tr>
<td>Causality</td>
<td>cause and effect</td>
<td>false agency</td>
</tr>
<tr>
<td>Engagement</td>
<td>increase interest</td>
<td>“chart junk”</td>
</tr>
<tr>
<td>Calibration</td>
<td></td>
<td>too slow: boring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>too fast: errors</td>
</tr>
</tbody>
</table>
Animation Principles
Principles for Animation

Character Animation
(Johnston & Thomas ’81, Lasseter ’87)

Squash and stretch
Exaggeration
Anticipation, Follow-through
Staging, Overlapping Action
Slow-in / Slow-out
Squash & Stretch

Defines rigidity of material

Should maintain constant volume

Smothes fast motion, similar to motion blur
Staging

Clear presentation of one idea at a time

Highlight important actions

Lead viewers’ eyes to the action

Motion in still scene, stillness in busy scene

Motion clearest at silhouette
Anticipation

Show preparation for an action
Follow-Through

Emphasize termination of action
Slow-In, Slow-Out

Space in-betweens to provide slow-in and out

Linear interpolation is less pleasing
Example: Andre and Wally B.
Example: Andre and Wally B.
Example: Andre and Wally B.
Example: Andre and Wally B.
Animated Presentations
(Zongker & Salesin ’03)

Make all movement meaningful
Avoid squash-and-stretch, exaggeration
Use anticipation and staging

*Do one thing at a time*
Principles for Animation

Congruence
The structure and content of the external representation should correspond to the desired structure and content of the internal representation.

Apprehension
The structure and content of the external representation should be readily and accurately perceived and comprehended.

Expressiveness
Effectiveness

[from Tversky 02]
Problems with Animation [Tversky]

Difficult to estimate paths and trajectories
Motion is fleeting and transient
Cannot simultaneously attend to multiple motions
Parse motion into events, actions and behaviors
Misunderstanding and wrongly inferring causality
Anthropomorphizing physical motion may cause confusion or lead to incorrect conclusions
Administrivia
Create an interactive visualization application. Choose a data domain and an appropriate visualization technique.

1. Choose a data set and storyboard your interface
2. Implement the interface using tools of your choice
3. Submit your application and produce a final write-up

You should work in groups of 2-3.

Due by 5pm on Monday, May 4
Animated Transitions
Cone Trees [Robertson 91]
Polyarchies [Robertson 02]

Animate pivots across intersecting hierarchies.
Tested a number of animation parameters.
Best duration: ~1 sec
Rotational movement degraded performance, translation preferred.
Degree-of-Interest Trees [Heer 04]

Animation of expanding/collapsing branches
Break animated transitions into discrete stages
Radial Graph Layout

Optimize animation to aid comprehension

http://people.ischool.berkeley.edu/~rachna/gtv/
Animation in Radial Graph Layout

Help maintain context of nodes and general orientation of user during refocus.

Transition Paths
Linear interpolation of polar coordinates
Node moves in an arc, not straight lines
Moves along circle if not changing levels
When changing levels, spirals to next ring
Animation in Radial Graph Layout

Transition constraints
Minimize rotational travel (move former parent away from new focus in same orientation)
Avoid cross-over of edges
Retain Edge Orientation
Retain Neighbor Order
Animated Transitions in Statistical Graphics
Log Transform
Sorting
Filtering
Month 1
Month 2
Change Encodings
Change Data Dimensions
Change Data Dimensions
Change Encodings + Axis Scales
Data Graphics & Transitions

<table>
<thead>
<tr>
<th>Category</th>
<th>Sales</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>B</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>D</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Visual Encoding

Animation to communicate changes?

Change selected data dimensions or encodings
During analysis and presentation it is common to transition between related data graphics.

Can animation help?
How does this impact perception?
Principles for Animation

Congruence
The structure and content of the external representation should correspond to the desired structure and content of the internal representation.

Apprehension
The structure and content of the external representation should be readily and accurately perceived and comprehended.

[from Tversky 02]
Principles for Animation

Congruence
Maintain valid data graphics during transitions
Use consistent syntactic/semantic mappings
Respect semantic correspondence
Avoid ambiguity

Apprehension
Group similar transitions
Minimize occlusion
Maximize predictability
Use simple transitions
Use staging for complex transitions
Make transitions as long as needed, but no longer
Principles for Animation

**Congruence**
Maintain valid data graphics during transitions
Use consistent syntactic/semantic mappings
Respect semantic correspondence
Avoid ambiguity

**Apprehension**
Group similar transitions
Minimize occlusion
Maximize predictability
Use simple transitions
Use staging for complex transitions
Make transitions as long as needed, but no longer

Visual marks should always represent the same data tuple.
Principles for Animation

**Congruence**
Maintain valid data graphics during transitions
Use consistent syntactic/semantic mappings
Respect semantic correspondence
Avoid ambiguity

**Apprehension**
Group similar transitions
Minimize occlusion
Maximize predictability
Use simple transitions
Use staging for complex transitions
Make transitions as long as needed, but no longer

Different operators should have distinct animations.
Principles for Animation

**Congruence**
Maintain valid data graphics during transitions
Use consistent syntactic/semantic mappings
Respect semantic correspondence
Avoid ambiguity

**Apprehension**
Group similar transitions
Minimize occlusion
Maximize predictability
Use simple transitions
Use staging for complex transitions
Make transitions as long as needed, but no longer

Objects are harder to track when occluded.
Principles for Animation

**Congruence**
Maintain valid data graphics during transitions
Use consistent syntactic/semantic mappings
Respect semantic correspondence
Avoid ambiguity

**Apprehension**
Group similar transitions
Minimize occlusion
Maximize predictability
Use simple transitions
Use staging for complex transitions
Make transitions as long as needed, but no longer

Keep animation as simple as possible. If complicated, break into simple stages.
Study Conclusions

Appropriate animation improves graphical perception

Simple transitions beat “do one thing at a time”

Simple staging was preferred and showed benefits
  *but* timing important and in need of study

Axis re-scaling hampers perception
  Avoid if possible (use common scale)
  Maintain landmarks better (delay fade out of lines)

Subjects preferred animated transitions
Animation in Trend Visualization

Heer & Robertson study found that animated transitions are better than static transitions for estimating changing values.

How does animation fare vs. static time-series depictions (as opposed to static transitions)?

Experiments by Robertson et al, InfoVis 2008
Select two countries with decreasing InfantMortality, but little change in life expectancy.

Ctrl-Click on a country (in chart) to set an answer.

Answers set: 0/2

Click on "Next" when finished (or "Give Up" if you cannot find all the answers).

Give Up  Next
Select two countries whose InfantMortality dropped first, then increased later.

Ctrl-Click on a country (in chart) to set an answer.

Answers set: 0/2

Next

Click on "Next" when finished (or "Give Up" if you cannot find all the answers)

Give Up  Next
Study: Analysis & Presentation

Subjects asked comprehension questions. Presentation condition included narration.

Multiples 10% more accurate than animation

Presentation: Anim. 60% faster than multiples
Analysis: Animation 82% slower than multiples

User preferences favor animation
Summary

Animation is a salient visual phenomenon
Attention, object constancy, causality, timing
Design with care: congruence & apprehension

For processes, **static images** may be preferable

For transitions, animation has demonstrated benefits, but **consider task and timing**