Animation as a Visualization Aid

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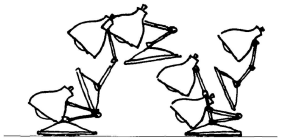
What is animation?

Consider computer graphics that change over time.



Animation sequence from *Luxo Jr.*, (Pixar, 1986)

Core Reading List

[1] Principles of Traditional Animation Applied to Computer Animation John Lasseter, Proceedings of SIGGRAPH 87, Computer Graphics, 21(4), pp. 35-44, July 1987.

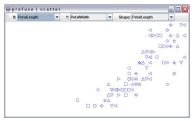
[2] Animation: Can It Facilitate? Barbara Tversky, Julie Morrison, Mireille Betrancourt. International Journal of Human Computer Studies 57:4, pp 247-262, 2002.

[3] Animated Transitions in Statistical Data Graphics Jeffrey Heer, George Robertson. Proc. IEEE Information Visualization (InfoVis) 2007.

[4] User-controlled animated diagrams: the solution for learning dynamic content?. Richard Lowe. Diagrammatic Representation and Inference. Lecture Notes in Computer Science, Springer-Verlag, 2004.

How is animation helpful?

Notion of visual encodings to take advantage of perceptual channels, e.g.:



Colour

Shape

Position

Can motion be used as a separate visual encoding?

Is animation good for displaying data with a temporal component?

Perceiving motion

The "Flying Gallop" Question

Le derby d'Epsom, (Théodore Géricault, 1821)

The Horse in Motion, (Muybridge, 1878)

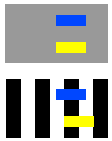
Perceiving motion

Benham's Top

Fechner Colours or pattern induced flicker colors

"Stepping Feet" Illusion

Is colour used by the visual system to detect motion?



Many more examples at http://www.michaelbach.de/ot/index.html

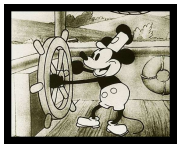
Principles of Animation

Animation pre-dates computer graphics.

Walt Disney: interest in realism of animated films.

Is this knowledge relevant?

Steamboat Willie, (Disney and Iwerks, 1928)



Principles of Animation

Principles enumerated in *"Principles of Traditional Animation Applied to Computer Animation"*:

- Squash and Stretch
- Timing
- Anticipation
- Staging
- Follow through and overlapping action
- Straight ahead and pose-to-pose action
- Slow in and out
- Arcs
- Exaggeration
- Secondary Action
- Appeal

Discussed in the context of computer animation, not InfoVis specifically.

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- **Slow in and out / Anticipation**
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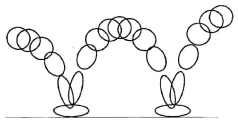
Squash and Stretch

Form changes, volume remains constant.



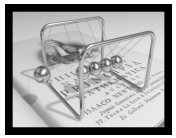
No change in shape implies rigidity.

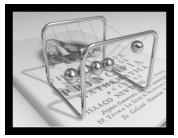
Timing

Humans infer object properties and causal relationships from timing [5]:

http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/principles/timing.htm

Example of "Newton's Cradle". See http://en.wikipedia.org/wiki/Newton's_cradle





Staging

Break animations into steps. Only show one step at a time (more or less).

Slow in and out / Anticipation

Abrupt movement can seem unnatural.

Prediction is helpful and reduces cognitive load.[2][3]

Second and third order continuity in animation?

Provide cues to the viewer so they know where to look.

Appeal

Want to create an animation that the audience enjoys watching. [7]

Normally animation that is appealing is simple, elegant, and clearly communicates a desired message.

Summary of principles

Humans are better at understanding realistic animations.

...so use techniques like squash and stretch.

Carefully manage the viewer's attention. Viewers do a poor job of attending to multiple moving objects at once. However, viewers can detect motion well in their visual periphery. [3]

Qualities of an animation can affect how viewers perceive qualities of the *objects* depicted.

Animation: Can it Facilitate?

Tversky and Morrisson present a skeptical view of animation's role in facilitating understanding of visualizations.

Sometimes, simpler graphics are easier to understand than complex graphics.

There is a lot of enthusiasm for animation, but does it help in an objective way or is it just more clutter?

Animation: Can it Facilitate?

Congruence Principle:

Natural cognitive correspondances should exist between a visualization and the data being modeled.

Example: Use of horizontal lines for graphs, with increases going up.

Claim that there is congruence between temporal and spatial relations.

Animation: Can it Facilitate?

Analysis of previous animation work:

- Most comparisons confound animation itself with content.
  - However, part of the argument is that animation may allow for the delivery of more content.
  - Is it reasonable to show one second or *30 frames* of animation statically?
  - It is very hard to avoid "straw man" comparisons.

Animation: Can it Facilitate?

Benefits due to interactivity or prediction instead of animation?

- Animation and interactivity go hand in hand.

Animation: Can it Facilitate?

Apprehension Principle:

- Structure and content of visualization should be readily and accurately perceived and comprehended.

Many examples of perculiarities in perception of motion.

Need to take into account princples of effective animation.

Animation: Can it Facilitate?

Summary

- Apprehension principle: slow, clear animation.
  - Schematic instead of realistic (animation principles?).
- Congruence principle: natural correspondance between change over time and the information being conveyed.

Tversky and Morrison: using animation to convey real-time changes and reorientations seems promising.

- This is coming up next.

Animated Transitions

Covered in "Animated Transitions in Statistical Data Graphics".

Problem:

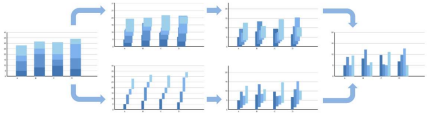
- Often want to change mapping between visual encodings and data attributes.
- Would like to facilitate understanding of these changes.

Solution:

- Animate the transitions, bearing in mind principles of good animation.
- Implemented in the DynaVis system.

Animated Transitions

Animated transitions between states.



Animation principles used: Staging, Slow in and out

Many other kinds of transitions such as view transformations, filtering, ordering...

Animated Transitions

Attempt to maintain valid data graphics during animations.

Attempt to minimize occlusion.

Timing is very important.

- Too slow and the viewer is bored.
- Too fast and the viewer misses details.

Animated Transitions

DynaVis was evaluated through a user study.

Two experiments:

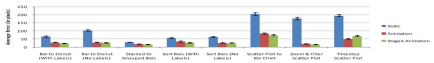
1)Object tracking task.

2)Change estimation task.

Animated Transitions

Results

- Animation improved performance in all cases.
- Staging generally improved performance further.
- Higher accuracy of change estimation for smaller marks (donut chart?).
- Users felt animation made transitions fun, engaging, and easier to understand.



Animated Transitions

Comments

- Appeal to users often has little to do with measurable performance.
- Very limited task that may be a bit contrived.
- Staging was effective but only when paced appropriately.
- When is fading appropriate?

User-Controllable Animated Diagrams

"User-controlled animated diagrams: the solution for learning dynamic content?"

Investigated how users interacted with a controllable animated diagram in order to extract information.

28-frame weather map with video-like controls used to make meteorological predictions. One frame sampled every six hours.

User-Controllable Animated Diagrams

Results:

- Multiple feature-by-feature interrogations of the weather map.
- Users made mostly short "sweeps" and spent large amounts of time looking at single frames.
- The fastest sweeps were made backwards.

Comments:

- According to [2], this is a poor way to use animation.
- The users picked out superficial features, but they were novices.
- Was the six hour granularity appropriate?

Recap: Animation

Key points to consider...

1)Human perception of motion is quirky. Naively treating motion as a visual variable is unlikely to produce desirable results.

2)Reproducing features of real-world motion can help, and ignoring these features can lead to false assumptions and confusion. [1]

3)Apprehension and congruence principles. [2]

4)Examples of good applications of animation include animated transitions. [3] Open-ended animations that work like video are often sub-optimal. [4]

References

[1] Principles of Traditional Animation Applied to Computer Animation John Lasseter, Proceedings of SIGGRAPH 87, Computer Graphics, 21(4), pp. 35-44, July 1987.

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[4] User-controlled animated diagrams: the solution for learning dynamic content? Richard Lowe. Diagrammatic Representation and Inference. Lecture Notes in Computer Science, Springer-Verlag, 2004.

[5] The perception of causality: feature binding in interacting objects. Kruschke, J. K., & Fragassi, M. M. Proceedings of the 18th annual conference of the Cognitive Science Society 1996, pp. 441–446. Hillsdale, NJ: Erlbaum.

[6] Animated Exploration of Graphs with Radial Layout Ka-Ping Yee, Danyel Fisher, Rachna Dhamija, and Marti Hearst, Proc InfoVis 2001.

[7] Emotion & design: Attractive things work better. Norman, D.A. (2002). ACM Interactions, 9(4), 36-42.