6.859: Interactive Data Visualization

Animation

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Two-cylinder Stirling Engine
http://www.animatedengines.com/vstirling.html
Two-cylinder Stirling Engine: In Static Steps

http://www.animatedengines.com/vstirling.html

1 Expansion
Most of the gas in the system has just been driven into the hot cylinder. The gas heats and expands driving both pistons inward.

2 Transfer
The gas has expanded (about 3 times in this example). Most of the gas (about 2/3) is still located in the hot cylinder. Flywheel momentum carries the crankshaft the next 90 degrees, transferring the bulk of the gas to the cool cylinder.

3 Contraction
The majority of the expanded gas has shifted to the cool cylinder. It cools and contracts, drawing both pistons outward.

4 Transfer
The contracted gas is still located in the cool cylinder. Flywheel momentum carries the crank another 90 degrees, transferring the gas back to the hot cylinder to complete the cycle.
Animation Goals

- Direct Attention
- Increase Engagement
- Explain a Process
- Understand a State Transition
Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition
Animation Goals

Direct Attention

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Motion as a visual cue

Smooth motion is perceived at ~10 frames/sec (1 frame every 100ms).
15 fps
30 fps
Animation Goals

Direct Attention
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Motion as a visual cue

Smooth motion is perceived at ~10 frames/sec (1 frame every 100ms).
Pre-attentive, stronger than color, shape, etc.
More sensitive to motion at our periphery.
Similar motions perceived as a group (gestalt principle of common fate).
Animation Goals

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Animation Goals

Direct Attention
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**Explain a Process**

Understand a State Transition

[Heider and Simmel 1944]

Constructing narratives & anthropomorphizing
[Michotte 1946]
[Michotte 1946]
[Michotte 1946]
[Michotte 1946]
Animation Goals

Direct Attention

Increase Engagement

**Explain a Process** – the perception (or attribution) of causality.

Understand a State Transition
Animation Goals

- Direct Attention
- Increase Engagement
- **Explain a Process**
- Understand a State Transition

Attrition of Causality.

[Reprint from Ware 2004]
Animation Goals

Direct Attention
Increase Engagement
Explain a Process

Understand a State Transition

Start
End
Animation Goals

Direct Attention
Increase Engagement
Explain a Process

Understand a State Transition

Start
End
Animation Goals

Direct Attention
Increase Engagement
Explain a Process

Understand a State Transition
Animation can show transition better, but...
May be too fast or too slow.
Too many objects may move at once.
Animation Goals

Direct Attention
Increase Engagement
Explain a Process

Understand a State Transition
  Animation can show transition better, but...
    May be too fast or too slow.
    Too many objects may move at once.

How many dots can we track at once?
Animation Goals

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Animation can show transition better, but...

May be too fast or too slow.

Too many objects may move at once.

How many dots can we track at once?

~4-6. Difficulty increases significantly at 6.
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
Animated Scatterplot

[Robertson et al. 2008]
Traces

[Robertson et al. 2008]
Small Multiples

[Robertson et al. 2008]
Study Conclusions

Subjects asked comprehension questions. Presentation condition included narration.

Animated Scatterplot vs. Static Traces vs. Small Multiples

In which condition would participants:
- be most accurate?
- be faster?
- prefer?

Post in the chat
Raise your hand
Subjects asked comprehension questions. Presentation condition included narration.

Small multiples 10% more accurate than animation.

**Presentation:** Animation 60% faster than small multiples.

**Analysis:** Animation 82% slower than small multiples.

User preferences favor animation (even though less accurate and slower for analysis!).
Animation Goals

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Use to encode data

[Hullman et al. 2015]
Implementing Animation

Frame-Based Animation

Redraw the scene at regular intervals (e.g., 16ms).
Developer defines the redraw function (e.g., Processing, p5.js)
Implementing Animation

Frame-Based Animation

Redraw the scene at regular intervals (e.g., 16ms).
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Implementing Animation

circle(10, 10)
circle(15, 15)
circle(20, 20)
circle(25, 25)
clear()
clear()
clear()
clear()
Implementing Animation

circle(10, 10)
circle(15, 15)
circle(20, 20)
circle(25, 25)
Implementing Animation

Frame-Based Animation
Redraw the scene at regular intervals (e.g., 16ms).
Developer defines the redraw function (e.g., Processing, p5.js)

Transition-Based Animation [Hudson & Stasko, 1993]
Specify a property value, duration, and an “easing” function.
Also called tweening (for “in-betweens”).
Steps computed via interpolation
   \[
   \text{step (fraction)} \{ \text{val}_{\text{now}} = \text{val}_{\text{start}} + \text{fraction} \times (\text{val}_{\text{end}} - \text{val}_{\text{start}}); \}
   \]
Timing & redraw managed by UI toolkit.
Implementing Animation

From: (10, 10).
To: (25, 25).
Duration: 3 seconds.

System handles the frame-by-frame updates!

\[ dx = 25 - 10 \]
\[ x = 10 + \frac{0}{3} \times dx \]
\[ x = 10 + \frac{1}{3} \times dx \]
\[ x = 10 + \frac{2}{3} \times dx \]
\[ x = 10 + \frac{3}{3} \times dx \]
**Easing/Pacing Functions**

**Goals:** Stylize animation, improve perception.

Basic idea is to **warp time**: as *duration* goes from start (0%) to end (100%), dynamically adjust the *interpolation fraction* using an easing function.

\[
\text{ease}(x) = x \\
\text{(linear, no warp)}
\]

\[
\text{ease}(x) = s\text{-curve}(x) \\
\text{(slow-in, slow-out)}
\]
Easing functions specify the rate of change of a parameter over time. Objects in real life don't...

When we open a drawer, on the floor, and it will first...

This page helps you choose the right easing function.

https://easings.net

Help translate site to your language

Andrey Sitnik and Ivan Solovev