CSE 512 - Data Visualization

Narrative Visualization

Jeffrey Heer  University of Washington

(with material from Edward Segel & Jessica Hullman)
STORYTELLING
as ancient as mankind
STORYTELLING across various media

PEOPLE TELL STORIES
WORDS TELL STORIES
IMAGES TELL STORIES
COMICS TELL STORIES
MOVIES TELL STORIES
narrative (n): An account of a series of events, facts, etc., given in order and with the establishing of connections between them.

Effective story-telling “require[s] skills like those familiar to movie directors, beyond a technical expert’s knowledge of computer engineering and science.” - Gershon & Page ‘01
Generals Wary of Move to Cut Their Ranks

By GINGER THOMPSON and THOM SHANKER

WASHINGTON — Maj. Gen. Paul D. Eaton, a retired Army officer, is familiar with the perks and pitfalls of power, having commanded tens of thousands of troops at Fort Benning, Ga., managed budgets exceeding $2 billion in Iraq, and overseen layers upon layers of staff members who helped manage both his professional duties and his personal life.

He has experienced the full range of lifestyles that come with military leadership, living at one point in an elegant antebellum mansion, and at another, with eight other officers crowded in a marble bathhouse behind one of Saddam Hussein’s old palaces.

When he traveled, he was occasionally able to justify the use of military aircraft, but most times, he said, he flew coach. And today he lives on a pension worth 75 percent of his military salary, with health benefits that cover everything except dental and eye care for himself and his wife.

“We are well compensated, and we live very comfortable lives,” General Eaton said, referring to the military’s most senior leaders. “But when you look at all the things going on around a general, the nation is getting a very, very high return on its money.”

Not everyone at the Pentagon agrees. Two weeks ago, Defense Secretary Robert M. Gates announced a sweeping effort to improve efficiency that, among other things, takes aim at the military’s sacrosanct corps of generals and admirals, ordering his staff to cut at least 50 positions, and making clear that he would be happier if they cut more.
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August 26, 2010

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Topics

Narrative visualization design
Navigation in interactive documents
Chart sequence models
Automatic augmentation for communication
Collaborative visualization
Storytelling

... with data?
“to affect thro’ the Eyes what we fail to convey to the public through their word-proof ears”

1856 “Coxcomb” of Crimean War Deaths, Florence Nightingale
Obesity Map Vadim Ogievetsky
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Percentage of Chart Which Resembles Pac-man

http://www.boingboing.net/2006/11/02/hilarious-piechartvi.html
Lives of others

Jennifer Stodolsky, Canada's privacy commissioner, has clashed with Facebook in August over the social network's decision to share data. The company has agreed to change its privacy policy, which allowed it to send information to third parties.

Facebook and Google face a backlash from users and regulators alike over the way they have handled sensitive data.

For example, when Facebook changed its privacy policy, users were able to send information to third parties. This was seen as a violation of user privacy, and the company has since changed its policy to allow users to control what information is shared.

Privacy and the internet

Support
Budget Forecasts, Compared With Reality

Just two years ago, surpluses were predicted by 2012. How accurate have past White House budget forecasts been?

Latest forecast

Today, with a better understanding of the severity of the economic downturn, the deficit situation is much more dire.

Use the slider to isolate a single year's forecast.
Holograms?
Narrative Devices for Storytelling with Data
What devices communicate effectively?
... for which contexts and audiences?
Narrative Visualization
Design Space
58 CASE STUDIES

70% Journalism
20% Business
10% Research
Homer Pace After Age 34
If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.

**Aaron**
Actual homers slightly outpace projected homers for five seasons.

**Ruth**
Averaged 46.4 homers a season from age 30 to 34. Averaged 42.5 for next four seasons.

**Bonds**
From age 35 to 39, he averaged 14 more homers a season than projected.

**Note:** Ages as of July 1 of each season.
Steroids or Not, the Pursuit Is On

Barry Bonds is taking aim at the career home run record. He needs 60 in 2005 to tie Pete Rose and 47 to equal Hank Aaron. Bonds takes lead
Home runs after 16 seasons
Bonds 567
Aaron 554
Ruth 612

Hank Aaron 755 homers 23 seasons
Babe Ruth 714 homers 22 seasons
Barry Bonds 708 homers 20 seasons

According to allegations in a book about Bonds, he began taking steroids before the 1989 season, hit 14th in the league. Two seasons later, he hit 73 home runs, surpassing Aaron’s career pace.

Home Run Pace After Age 34
If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run pains for each player after age 34.

Homer Pace: Projected pace based on average of previous five seasons

Differing Paths to the Top of the Charts
The top seven players on the career home run list, along with a look at Griffey (12th), Rodriguez (37th) and Pujols (tied 257th).

Beginning
Middle
End
Epilogue
Budget 2010: reaction from around the UK
People in key constituencies around the country give their responses to Alistair Darling’s budget

Shilpa Wymer, 40, is managing director of two branches of Pitman Training Ltd, a training school specialising in secretarial and PA training.

Enquiries from individuals suddenly dropped off a cliff from October 2008 and in January last year we had to lay off a couple of people, though things have picked up since. The budget seems very positive and shows the government are thinking about small and medium sized businesses at last. I think the measures will help businesses be more confident, which will have a knock-on effect on us. It has turned my head and made me think about which way I will vote.

Constituency profile
MP: Greg Hands, Conservative. Majority: 5,029
Unemployment benefit claimants, Feb 2010: 3,281 (up 13% over last year)
Observe Narrative Devices

Visualization Description

Architecture and Justice (Brooklyn Crime Blocks)

Case Studies

- Virgin America Airplane Safety Video
- The Story of Stuff
- McDonald’s “Making Comics”
- How the Government Deals with Past Recession
- Afghanistan: Behind the front line
- Toys: A timeline: a company history
- UNDER HUMAN DEVELOPMENT
- Earthquakes: why they happen
- Nuclear program
- Shady White’s Double McIntosh
- Toy’s stick accelerator problem

- Oil: From Technical Terms to Tuts and Speed
- GDP Forecasts vs. Reality
- Macintosh Video
- Dell: Processor Cooling
- The Story of Stuff
- Virgin America Airplane Safety Video
Genres for Narrative Visualization (2010)

Missing “scrollly-telling” designs...
Genres + Interactivity + Messaging = DESIGN SPACE

Author Driven
- strong ordering
- heavy messaging
- limited interactivity

Reader Driven
- weak ordering
- light messaging
- free interactivity

STORYTELLING
- CLARITY
- SPEED

ASK QUESTIONS
- EXPLORE
- FIND

martini
glass

interactive slideshow

drill-down story
Interactive Documents: Steppers, Scrollers, ...
Budget Forecasts, Compared With Reality

Just two years ago, surpluses were predicted by 2012. How accurate have past White House budget forecasts been?

Today, with a better understanding of the severity of the economic downturn, the deficit situation is much more dire.

The 1995 forecast for 1999 did not predict a surplus ...

... but the 2008 forecast for 2012 did.

Use the slider to isolate a single year's forecast.
Ramadi: The Government Provides an Opening for ISIS

Tensions between this city’s residents, who are mostly Sunni, and the central government had been brewing here for at least a year. Then in December, Iraq’s prime minister, Nuri Kamal al-Maliki, ordered security forces to dismantle a protest camp — an outlet for disenchanted Sunnis angered at their treatment by the Shiite-dominated government. The action ignited days of violence and created the opening ISIS needed to seize parts of the city, the provincial capital.

Falluja: A Symbolic Fall

Just days after the raid on the camp in Ramadi, ISIS fighters destroyed the Police Headquarters and mayor’s office here, planted their flag on government buildings and declared the city to be theirs. Ten years earlier, American forces had captured this city from Qaeda-style insurgents at a considerable cost of American lives.
A visual introduction to machine learning

In machine learning, computers apply statistical learning techniques to automatically identify patterns in data. These techniques can be used to make highly accurate predictions.

*Keep scrolling.* Using a data set about homes, we will create a machine learning model to distinguish homes in New York from homes in San Francisco.
Discrete step vs. Continuous scroll

Different means for narrative navigation. A source of debate among practitioners!
Different means for narrative navigation. A source of debate among practitioners!

**Step:** sequential frames as in a slideshow

Simple and familiar, but less engaging?
Different means for narrative navigation. A source of debate among practitioners!

**Step:** sequential frames as in a slideshow
Simple and familiar, but less engaging?

**Scroll:** continuous navigation of page
Parameterize content by scroll position
May cause usability / scrolljacking issues
Discrete step vs. Continuous scroll

Different means for narrative navigation. A source of debate among practitioners!

**Step:** sequential frames as in a slideshow
Simple and familiar, but less engaging?

**Scroll:** continuous navigation of page
Parameterize content by scroll position
May cause usability / scrolljacking issues

**Hybrids:** scroller with discrete sections
Narrative Implementation

Do-It-Yourself
Monitor scroll position & element positions
Guidance: M. Bostock, J. Vallandingham

Third-Party Support
Idyll: Markup for Interactive Documents
Scrollly Helper Libraries
**Idyll**

A markup language for interactive documents.

**INPUT**

```
# Hello World
[val name="x" value=5 /]
The value of x is [Display value=x format="d" /].
[Range value=x min=0 max=10 /]
```

**OUTPUT**

**Hello World**

The value of x is 5.

---

**Try Idyll in your browser**

Idyll extends the ubiquitous Markdown format to enable the creation of dynamic, interactive narratives for the web. The language and toolchain aim to empower journalists, researchers, and technical experts to create compelling content using familiar tools and processes.

Idyll can be used to create explorable explanations, to power blog engines and content management systems, and to generate dynamic technical reports. The tool can generate standalone webpages or be embedded inside of your existing site.

Idyll is supported by the Interactive Data Lab at the University of Washington, and by Rhizome and the Eutopia Foundation. Show your support by buying a sticker.
Chart Sequence Models
Multiple Charts in Data Analysis
Multiple Charts in Story Telling

Copenhagen: Emissions, Treaties and Impacts

At the Copenhagen climate conference, discussions are likely to cover emissions levels, the legacy of the Kyoto Protocol and the risks of inaction on global warming. Explore each issue in the tabs below.

<table>
<thead>
<tr>
<th>Global Emissions</th>
<th>Lessons From Kyoto</th>
<th>Possible Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9 10 11 NEXT ▸</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Almost every country in the world signed and ratified the protocol. The treaty’s aim was to provide a starting point for reducing global carbon dioxide emissions.

Countries that ratified Kyoto

[Map of countries that ratified Kyoto]

By JAMES BRONZAN, AMANDA COX, XAQUÍN G.V. and KEVIN QUEALY | Send Feedback
In many cases, data is conveyed via a sequence of charts.
How might we evaluate different orderings of visualizations?
GraphScape: A Directed Graph Model

Nodes are Vega-Lite specifications. Edges represent edit operations, weighted by estimated transition costs.

[Kim, Wongsuphasawat, Hullman, Heer, CHI’17]
Design Alternatives

“Too many data points !”

Add Filter

Add Size(count)

Binned Scatter Plot

Bin

Random Sample
Path Elaboration

Heer, Jeffrey and George G. Robertson.  
Path Elaboration

Heer, Jeffrey and George G. Robertson.
Sequence Recommendation

<table>
<thead>
<tr>
<th>Region</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denver</td>
<td>10</td>
</tr>
<tr>
<td>Seattle</td>
<td>12</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>
Learning Edge Weights

Given a reference chart, what should come next?

Triplet judgments express inequalities among edits.

We encode these in a linear program. The solution gives us cost estimates for each edit operation type.

Asks the question: Is $\text{Drop Field}_y < \text{Add Field}_{\text{color}}$?
Sequence Cost Model

Chart Sequence \rightarrow Cost(S)
Sorted by
Sum of Transition Costs

Modify Filter
Year: 1976 → 1980
Modify Filter
Region: USA → Europe
Modify Filter
Year: 1980 → 1976
Remove Filter
Region: Europe
Modify Filter
Year: 1976 → 1980

USA Cars in 1976
→
USA Cars in 1980
→
European Cars in 1980
→
European Cars in 1976
→
Cars in 1976
→
Cars in 1980
Sequence Cost Model

Chart Sequence

\[ \text{Cost}(S) = \]

Transition (Edit Distance) Cost

\[ \sum_{i=1}^{\mid S \mid} T(S_{i-1}, S_i) \]
Sequence Cost Model

\[ \text{Cost}(S) = W(S) \cdot \left( \sum_{i=1}^{\left| S \right|} T(S_{i-1}, S_i) + F(S) \right) \]

- Chart Sequence
- Transition (Edit Distance) Cost
- Consistency Weight (Promote Parallelism)
- Filter Cost
Sorted by
Sum of Transition Costs

Modify Filter
Year: 1976 → 1980
Modify Filter
Region: USA → Europe
Modify Filter
Year: 1980 → 1976
Remove Filter
Region: Europe
Modify Filter
Year: 1976 → 1980

USA Cars in 1976
→
USA Cars in 1980
→
European Cars in 1980
→
European Cars in 1976
→
Cars in 1976
→
Cars in 1980
Sorted by
Sum of Transition Costs

Modify Filter
Year: 1976 → 1980
USA Cars in 1976

Modify Filter
Region: USA → Europe
USA Cars in 1980

Modify Filter
Year: 1980 → 1976
European Cars in 1980

Remove Filter
Region: Europe
European Cars in 1976

Modify Filter
Year: 1976 → 1980
Cars in 1976

Cars in 1980
Begin with the empty (null) chart
Account for interpretation of first chart
Sorted by
Sum of Transition Costs

Sorted by
Final Sequence Cost

1976 < 1980
Prioritize sorted filter criteria
Penalize unsorted orders
Find maximal repeating transition patterns
Determine fraction of transitions they cover
Weight overall score by this term
Sequence Cost Model

\[ \text{Cost}(S) = W(S) \cdot \left( \sum_{i=1}^{\lvert S \rvert} T(S_{i-1}, S_i) + F(S) \right) \]

- Chart Sequence
- Transition (Edit Distance) Cost
- Consistency Weight (Promote Parallelism)
- Filter Cost
Sequence Ratings

Evaluation with 55 subjects, recruited via Mechanical Turk.

Subjects rated quality and clarity on a 5-point Likert scale.

In all but one case, GraphScape’s top pick among highest-rated.

GraphScape correlates strongly with subject rankings ($\rho = 0.80, p < 0.001$) when both transition & sequence terms are included.
Previously we’ve discussed approaches for automatic design of a single visualization. GraphScape supports automated design methods for collections of visualizations. Plenty of future work to do here!
Automatic Augmentation of Charts for Communication
Given existing visualizations, can we adapt them to communicate more effectively?
Graphical Overlays [Kong et al. ‘12]

Add (interactive) reading aids to bitmap charts!
Graphical Overlays [Kong et al. ‘12]

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Add (interactive) reading aids to bitmap charts!
Apple Passes Microsoft as No. 1 in Tech

SAN FRANCISCO — Wall Street has called the end of an era and the beginning of the next one: The most important technology product no longer sits on your desk but rather fits in your hand.

The moment came Wednesday when Apple, the maker of iPods, iPhones and iPads, shot past Microsoft, the computer software giant, to become the world’s most valuable technology company.

This changing of the guard caps one of the most stunning turnarounds in business history for Apple, which had been given up for dead only a decade earlier. The rapidly rising value attached to Apple by investors also heralds an important cultural shift. Consumer tastes have overtaken the needs of business as the leading force shaping technology.

Microsoft, with its Windows and Office software franchises, has dominated the relationship most people had with their computers for almost two decades, and that was reflected in its stock market capitalization. But the click-deck of the keyboard has ceded ground to the swipe of a finger across a smartphone’s touch screen.
Can we produce an automated solution?
**Contextifier System** [Hullman et al.]

Input: news article about a company

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**Yahoo Decides to Friend Facebook**

By AMIR EFRATI

Yahoo Inc. [YHOO -1.34%] watched as social-networking website Facebook Inc. stole the attention of users and grabbed a major share of the online-advertising market.

Now the Internet pioneer is following an old mantra: If you can't beat 'em, join 'em.

After struggling for years to develop services that compete with the social network, Yahoo in recent months has installed tools such as Facebook's "Like" and "Share" buttons on its news and sports websites in order to help Yahoo users share articles with their contacts on Facebook, among other things.

Yahoo, like other content providers, is seeking to leverage Facebook's huge user base to draw more traffic back to Yahoo after readers click on the sharing buttons. The moves also are aimed at ensuring that links to Yahoo content appear in the search feature on Facebook's site. Yahoo is using similar approaches with Twitter Inc., the Internet messaging service, and Zynga Game Network Inc., which offers online social games.
Relevancy Feature

Do other articles that mention the company have relevant content?
Use Kullback-Leibler divergence to measure difference.
Prioritize dates with unusually high numbers of company articles.
Visual Saliency proxy via simple analyses on stock series.

\[ \max(t), \min(t) \]

\[ t_i - t_{i-1} \]
Public Visualization as Survey Instrument
Visualizations: Harry Potter is Freaking Popular

Number of Libraries Contained in

Creator: Alison
Tags:
Do you agree or disagree with the main goals of the Occupy Wall Street movement?

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Strongly Disagree" /></td>
<td><img src="image2" alt="Disagree" /></td>
<td><img src="image3" alt="Neutral" /></td>
<td><img src="image4" alt="Agree" /></td>
<td><img src="image5" alt="Strongly Agree" /></td>
</tr>
</tbody>
</table>

Do you support or oppose the methods of the protestors?
You Draw It: What Got Better or Worse During Obama’s Presidency

By LARRY BUCHANAN, HAEYOUN PARK and ADAM PEARCE  JAN. 15, 2017

Draw your guesses on the charts below to see if you’re as smart as you think you are.

Under President Obama, the unemployment rate ...

Draw the line for the Obama years.

Show me how I did.