CSE 442 - Data Visualization

Narrative Visualization

Matthew Conlen  University of Washington
(with material from Jeff Heer, Edward Segel, and Jessica Hullman)
STORYTELLING
as ancient as mankind
Going forward
I carried wax along the line, and laid it thick on their ears. *They tied me up,* then, plumb amidships, **back to the mast,** lashed to the mast, and took themselves again to rowing. Soon, as we came smartly within hailing distance, the two **Sirens,** noting our fast ship, off their point, **made ready, and they sang**…
STORYTELLING
across various media

PEOPLE TELL STORIES
WORDS TELL STORIES
IMAGES TELL STORIES
COMICS TELL STORIES
MOVIES TELL STORIES
Narrative Story-Telling

**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 ante-bellum 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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Topics

Narrative visualization design
Navigation in interactive documents
Tools for creating interactive documents
Evaluating Interactive documents
Chart sequence models
Storytelling
... with data?
Obesity Map Vadim Ogievetsky
Privacy and the Internet

Lives of others

Jennifer Stodard, Canada's privacy commissioner, spoke with The Economist in August 2012. The social networking site saw a deal, agreeing to change its policies within a year to comply with the country's privacy laws. But even today, the company appears to be changing its policies after years of dealing with privacy concerns.

Privacy is the concern of everyone, not just tech companies. It's about how our data is collected, used, and shared. In the digital age, our personal information is often accessed by third parties without our knowledge.

Facebook and Google face the details, from users and regulators alike, on how they handle sensitive data.

Facebook's and Google's practices raise concerns about how our data is handled. The companies have been known to share user data with third parties, raising privacy concerns.

Growth of social networks

Social networks have allowed us to connect with others, but they also come with risks. Privacy is an issue that needs to be addressed.

In conclusion, privacy is a fundamental human right, and social networks must take it seriously. We must ensure that our data is protected and that our privacy is respected.
SHENANIGANS

Change in teen shenanigans from 1993 to 2013. Showing % difference from 2003 levels.
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
Steroids or Not, the Pursuit Is On

Barry Bonds is taking aim at the career home run record. He needs only six more to tie Babe Ruth and 47 to equal Hank Aaron.

Lines are cumulative home runs.

Hank Aaron
755 home runs
23 seasons

Babe Ruth
714 home runs
22 seasons

Barry Bonds
708 home runs
20 seasons

Bonds takes lead
Home runs after 16 seasons
Ruth 516
Aaron 554
Bonds 567

Bonds was injured last season. He played 14 games and hit 5 homers.

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

PROJECTED PACE BASED ON AVERAGE OF PREVIOUS FIVE SEASONS

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 41 more homers a season than projected.

Note: Ages as of July 1 of each season.

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).

Hank Aaron 755
15 times hit 30 or more (M.L. most).
Hit only 20 over first five seasons.
Averaged 52 from 2000 to 2004.
No one hit more from 1950-69.
Three 60-homer seasons is record.

Babe Ruth 714
1920s (28)
Hit in 13 straight years.
1930s (17)
Averaged 52.3 from 1950-69.
1940s (23)
Triple Crown '66 (49, 122, 316).
1950s (21)
First to hit 70 in a season.

Barry Bonds 708
2000s (1)
Only McGwire had more in the 90's.
2010s (1)
Youngest to reach 400 home runs.

Willie Mays 660
1950s (22)
Hit 40 in 6 straight seasons.
1960s (12)
No one hit more from 1950-69.
1970s (3)
Triple Crown '66 (49, 122, 316).

Sandy Sosa 593
1990s (13)
No one hit more from 1950-69.
2000s (6)
First to hit 70 in a season.

Frank Robinson 586
1950s (22)
Hit in 13 straight years.
1960s (11)
Averaged 52.3 from 1950-69.
1970s (12)
Triple Crown '66 (49, 122, 316).

Mark McGwire 536
1980s (13)
No one hit more from 1950-69.
1990s (1)
Only McGwire had more in the 90's.

Ken Griffey Jr. 536
1980s (13)
No one hit more from 1950-69.
2000s (1)
Only McGwire had more in the 90's.

Alex Rodriguez 429
1990s (11)
No one hit more from 1950-69.
2000s (6)
Youngest to reach 400 home runs.

Albert Pujols 257
2000s (13)
No one hit more from 1950-69.
2000s (6)
Youngest to reach 400 home runs.

Grab attention with image and position

Matching on content

Visual prominence

Reduced visual priority
Steroids or Not, the Pursuit Is On

Barry Bonds, taking aim at the career home run record. He needs 756 to break Hank Aaron's record of 755, set in 1976. Bonds was injured last season. He played 14 games and hit 5 home runs.

Hank Aaron
755 home runs
23 seasons

Babe Ruth
714 home runs
22 seasons

Barry Bonds
708 home runs
20 seasons

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

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 homors a season than projected.

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):

- Hank Aaron
  - 755 home runs
- Babe Ruth
  - 714 home runs
- Barry Bonds
  - 708 home runs
- Willie Mays
  - 660
- Sammy Sosa
  - 586
- Frank Robinson
  - 586
- Mark McGwire
  - 583
- Ken Griffey Jr.
  - 536
- Alex Rodriguez
  - 429
- Albert Pujols
  - 261

On his way to 755 home runs, Bonds hit 536 in 2001-2002. The only other 500-number club member since 1970 is Ken Griffey Jr., who has 536 home runs since 1989.

Ken Griffey Jr.
Many thought he would be the first to catch Ruth and Aaron until injuries limited his output.
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)
Gun Deaths In America

By Ben Casselman, Matthew Conlen and Rouben Fischer-Baum

CLICK to advance

Explore the data for yourself »
How 2 M.T.A. Decisions Pushed the Subway Into Crisis

By ADAM PEARCE  MAY 9, 2018

40% of trains delayed

Delayed trains

Source: M.T.A. on-time performance data

By now, New York City commuters are familiar with the wait. We descend from the bitter cold or the stifling heat to find subway platforms teeming with other bodies trying to make it to work on time. Delays ripple through the system, so there’s barely room to squeeze into the next train that
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Observed Narrative Devices

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Architecture and Justice (Brooklyn Crime Blocks)
John Snow’s chart of deaths from cholera
Politicians abuse their free-mailing privileges before elections
Football (soccer) drawings
Pedestrians crossing the street
The Climate Agenda
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<td>Police &amp; Crime: A Global Olympic Medals Chart</td>
<td>Visualization Description</td>
</tr>
<tr>
<td>Police &amp; Crime: All Aboard! (Little Parts)</td>
<td>Bar, Side, or Full Page</td>
</tr>
<tr>
<td>Police &amp; Crime: Bonds Visualization (Objective)</td>
<td>Visualization Description</td>
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<tr>
<td>Police &amp; Crime: The Bless Rate for FedEx (Objective)</td>
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Genres for Narrative Visualization (2010)
Missing “scrolly-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

For some families at Camp T1 unit type a window and 50

Percentages shares year on year using the index

Budget measures vs. Compulsory Reality

Housing Unit
Other techniques: simulation, games, rhetorical, draw the trend
Watch how the measles outbreak spreads when kids get vaccinated – and when they don't

- **Vaccinated**
- **Susceptible**
- **Vaccinated but susceptible**
- **Infected**
- **Contact with an infected person**

---

**NOT PROTECTED**
- 10.0% vax rate

**NOT PROTECTED**
- 30.0% vax rate

**50.0% vax rate**

**58.5% vax rate, similar to Okanagan County, WA**

**68.9% vax rate, similar to Thurston County, WA**

**74.4% vax rate, similar to Island County, WA**

**83.8% vax rate, similar to Santa Cruz County, CA**

**86.0% vax rate, similar to Los Angeles County, CA**

**90.0% vax rate, similar to Orange County, CA**

**99.7% vax rate, similar to Gadsden County, FL**
Who Should Get Parole?

Even the best risk assessments yield probabilities, not certainties. That means they label as “high risk” some people who won’t commit another crime and label as “low risk” some people who will. This simulation lets you sort offenders into risk categories based on the results of an assessment. Think we should rarely lock up anyone who wouldn’t reoffend? Set the “low risk” threshold high and the “high risk” threshold even higher. Have little tolerance for recidivism? Try the opposite. In the real world, policymakers have to strike a balance. Read more »

1

The prisoners in this simulation are up for parole. Some will reoffend if released and some won’t. They each take an assessment, which estimates the chance they will reoffend.

2

Prisoners are placed in one of three categories based on these estimates. Move the slider to change the cutoffs for each category. “Low risk” prisoners will be awarded parole. “High risk” prisoners will be denied.

3

Some people you let out reoffended. Some people you left in prison wouldn’t have. Are you OK with the results?

AWARDED PAROLE

18%
AWARDED PAROLE AND THEN REOFFENDED

DENIED PAROLE

14%
DENIED PAROLE BUT WOULDN’T HAVE REOFFENDED
99% 1% 23 years
Died so far
Still alive
Age of death
9 years old,
Currently 23 years old.
I am female, white, and currently
live.
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.
If job growth were actually steady over the last 12 months... …the jobs report could look like this:
If job growth **had** been accelerating...

...the jobs report could look like this:
Why Momentum Really Works

We often think of Momentum as a means of dampening oscillations and speeding up the iterations, leading to faster convergence. But it
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.
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 decreed 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!

**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
Helper Libraries
Interactive Document Formats: Idyll
A toolkit for creating data-driven stories and explorable explanations.
Overview

Document model for interactive articles
Overview

Document model for interactive articles

Markdown-based specification language

[var name:"x" value:5 /]

# Hello World

The value of x is

[Display value:x format:"d" /].
Overview

Document model for interactive articles

Markdown-based specification language

Component library supporting common needs
Overview

Document model for interactive articles
Markdown-based specification language
Component library supporting common needs
Suite of build, runtime, and deployment tools
In action...

[section]
# A Sad Guitar.

Take a second and strum the guitar. It doesn't sound so good, does it?

We've just taken it out of storage and it's all out of tune... *
[/section]

[section onEnterViewFully:'guitarState = 'headstock'; playScale = false;']

# Electric Tuner to the Rescue.

Tune the guitar using the tuner. Click and drag the tuning knobs on the right to tighten and loosen the strings.
// Need a reward state to let them know when a string is in tune

[Tuner selectedString:targetString currFreq:currentFrequency /]

[conditional if:isInTune]
Great work, scroll on.
[/conditional]
[/section]
Document Model

Data and state variables

[var name:“x” value:10 /]
[data name:“y” source:“data.csv” /]
Document Model

Data and state variables

Components that affect layout and render content

```
[var name:“x” value:10 /
[data name:“y” source:“data.csv” /]

[Table
data:y
onEnterView:`x += 1` /]
```
Document Model

Data and state variables

Components that affect layout and render content
Implementation

[var name:"x" value:5 ]

# Hello World

The value of x is
[Display value:x format:"d "].

[Range value:x min:0 max:10 ]
Implementation

class Range extends Component {

handleChange(event) {
    updateProps({
        value: +event.target.value
    });
}

[Range value:x min:0 max:10 /]

Hello World

The value of x is 5.
Idyll Components

28 components included

Input
- Check
- Button
- Select
- Radio
- Range
- Select
- Text input

Presentation
- Chart
- Conditional
- Display
- Equation
- Embed
- Inline
- Link
- SVG

Layout
- Aside
- FullWidth
- Fixed
- Float
- Inline

Helpers
- Analytics
- Meta
- Preload
Idyll Components 28 components included

- Action
- Boolean
- Button
- Dynamic
- Select
- Text Input
- Range
- Select
- Text Input

Input

Layout
Idyll Components

28 components included

Input

Layout
Build and Deploy

Abstracts away the need to use complex build tools
Build and Deploy

Abstracts away the need to use complex build tools

JavaScript best practices are included by default (minification, server side rendering, bundling, transpilation)
Build and Deploy

Abstracts away the need to use complex build tools
JavaScript best practices are included by default (minification, server side rendering, bundling, transpilation)
Evaluation

*Is it expressive?*

*Is it an improvement over raw JS/HTML?*

*Can technical and editorial colleagues collaborate?*
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild

Based on existing workflow model Lee et al. 2015
Informal interviews with 13 experts (journalism, scientific publishing,
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild

>120k page views of documentation and examples

>30k downloads of the command line tool
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild

Undergraduate students
19 groups, 4 students each
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild

Undergraduate students

- Custom
- Markdown
- HTML
- Standard lib.
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild

Folo Media
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild
Evaluation

Iterative Design
Open-source release
Pilot Studies

**Usage in the wild**

Used by programmers, researchers on personal blogs

Accepted as a submission format at VisXAI workshop at IEEE Vis
Evaluation

Iterative Design
Open-source release
Pilot Studies
Usage in the wild

Demand for more blog/book oriented tooling
Popular with educators
Integration with tools,
Evaluating Interactive Articles

Research from education and journalism suggests interactives are effective for conveying complex topics to a wide audience.

But more data needed!
Evaluating Interactive Articles

Instrumented articles created with Idyll, recorded >50k user sessions
Evaluating Interactive Articles

Embedding data in two dimensions

The same brightness features can be used to position the artworks in 2D space instead of 1D. The pieces have more room to spread out.

On the right you see a simple 2-dimensional embedding based on image brightness, but this isn’t the only way to position the artworks. In fact, there are many, and some projections are more useful than others.

Use the slider to vary the influence that the brightness and artwork age have in determining the embedding positions. As you move the slider from brightness to artwork age, the embedding changes from highlighting bright and dark images, and starts to cluster recent/modern-day images in the bottom left corner whereas older artworks are moved farther away (hover over images to see their data).

Artwork Age
Brightness

The embedding you see here is actually a linear 1D embedding, whose resulting scalar is then mapped on a space-filling Hilbert curve to give the illusion of a 2D embedding.
Evaluating Interactive Articles

Embedding data in two dimensions

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Artwork Age — Brightness

The embedding you see here is actually a linear 1D embedding, whose resulting scalar is then mapped on a space-filling Hilbert curve. To give the illusion of a 2D
Evaluating Interactive Articles

Embedding data in two dimensions

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Artwork Age

The embedding you see here is actually a linear 1D embedding, whose resulting scalar is then mapped on a space-filling Hilbert curve. To give the illusion of a 2D embedding, the 2D coordinates are calculated from the 1D embedding values.
Chart Sequence Models
Multiple Charts in Data Analysis
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.

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
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]
"Too many data points!"
Design Alternatives

“Too many data points!”
Design Alternatives

"Too many data points!"

Add Filter

Binned Scatter Plot

Add Size(count)
Design Alternatives

“Too many data points!”

Add Filter

Binned Scatter Plot

Add Size(count)

Bin

Random Sample

...
Sequence Recommendation
Sequence Recommendation
Sequence Recommendation

Sequence

Cost

: 10

: 12

: 13

...
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>13</td>
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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!