Visualization Tools

DSC 106: Data Visualization

Sam Lau

UC San Diego

Announcements

Lab 6 (Mapbox) out, due Friday

Project 3 due Friday

Lecture on Thurs is Project 3 feedback session

FAQs:

1. Help, I can't get data into my Svelte project! See Ed #307. Sam will also walk through.
2. How do I get a Svelte project into GitHub pages? See Ed #303. Sam will also walk through.

Demo: Exporting your project into GitHub pages

Demo: Getting data into your Svelte Project

What's your status for Project 3?

What are your roadblocks?

Join at

slido.com

#1060

How do people create visualizations?

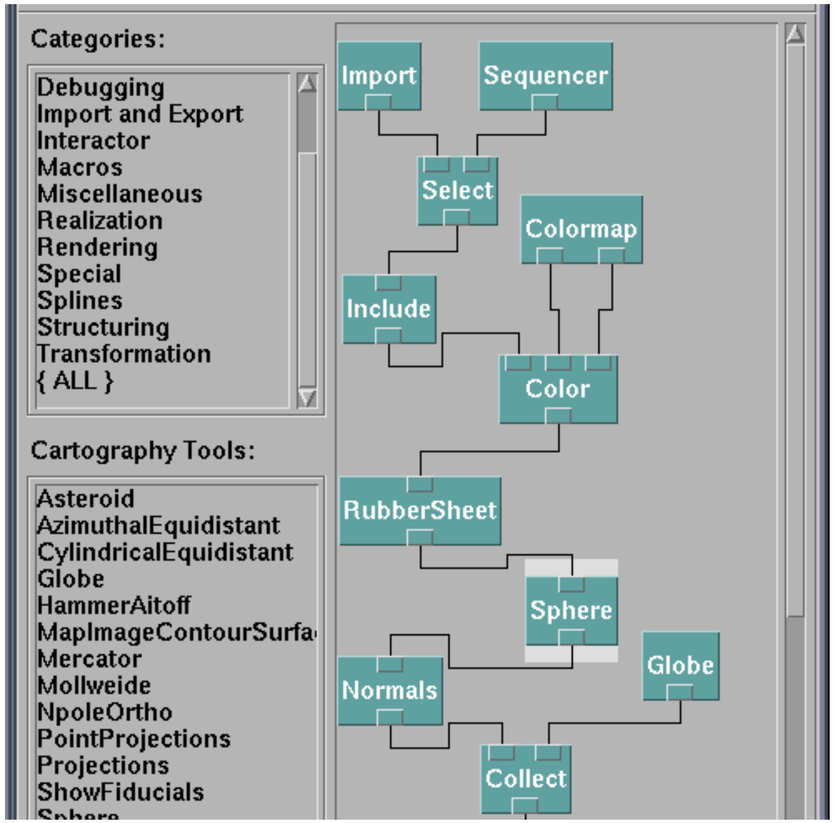


Chart Typology

Pick from a stock of templates
Easy-to-use but limited expressiveness
Prohibits novel designs, new data types

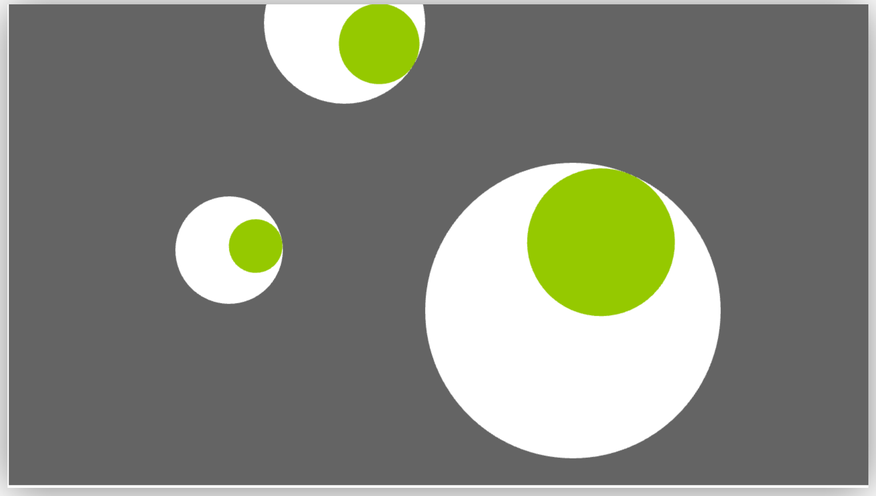
Component Architecture

Permits more combinatorial possibilities
Novel views require new operators,
which requires software engineering

Graphics APIs

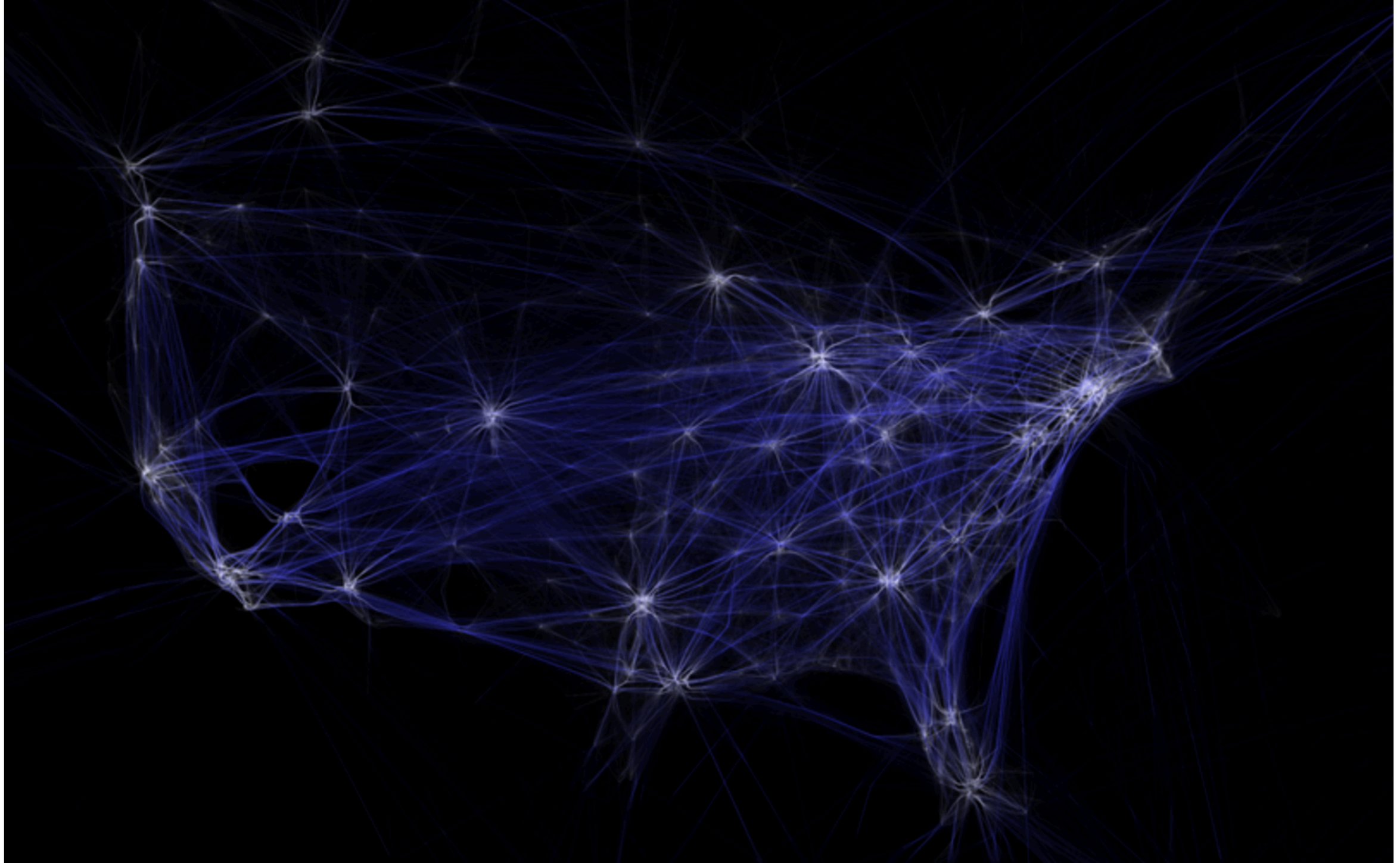
Canvas, OpenGL, Processing, SVG

```
class Eye {
  int x, y;
  int size;
  float angle = 0.0;

  Eye(int tx, int ty, int ts) {
    x = tx;
    y = ty;
    size = ts;
 }

  void update(int mx, int my) {
    angle = atan2(my-y, mx-x);
  }

  void display() {
    pushMatrix();
    translate(x, y);
    fill(255);
    ellipse(0, 0, size, size);
    rotate(angle);
    fill(153, 204, 0);
    ellipse(size/4, 0, size/2, size/2);
    popMatrix();
  }
}
```



https://processing.org/

User needs to draw individual shapes



Graphics APIs

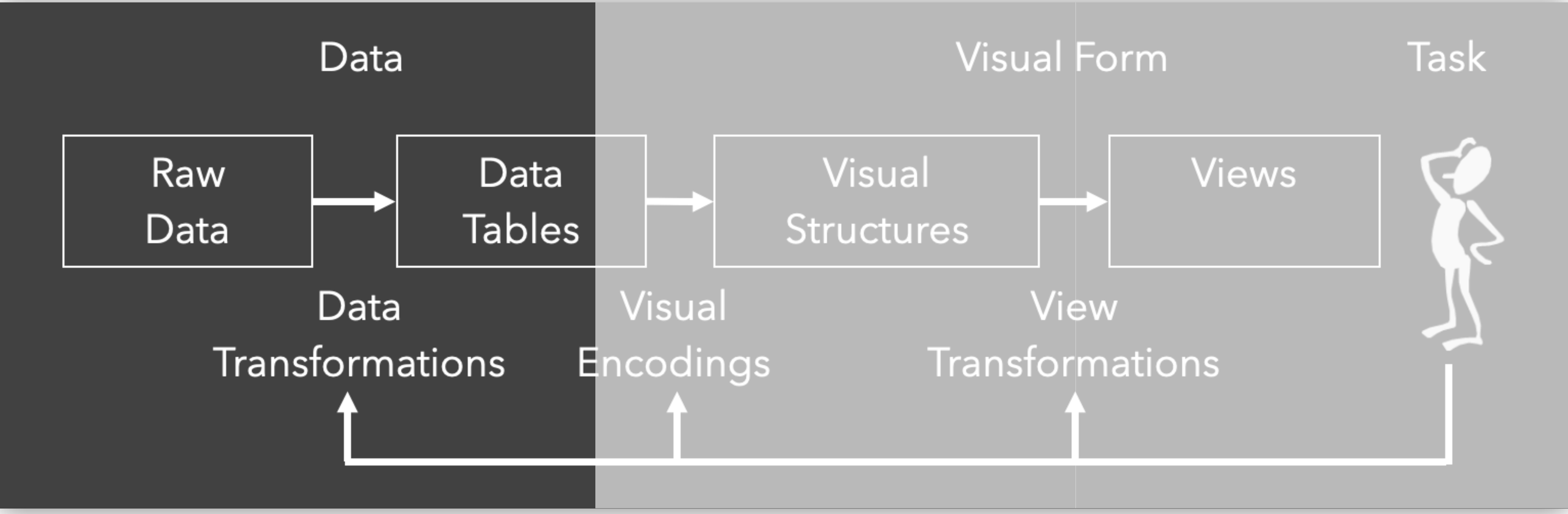
Canvas, OpenGL, Processing, SVG

Component Architectures

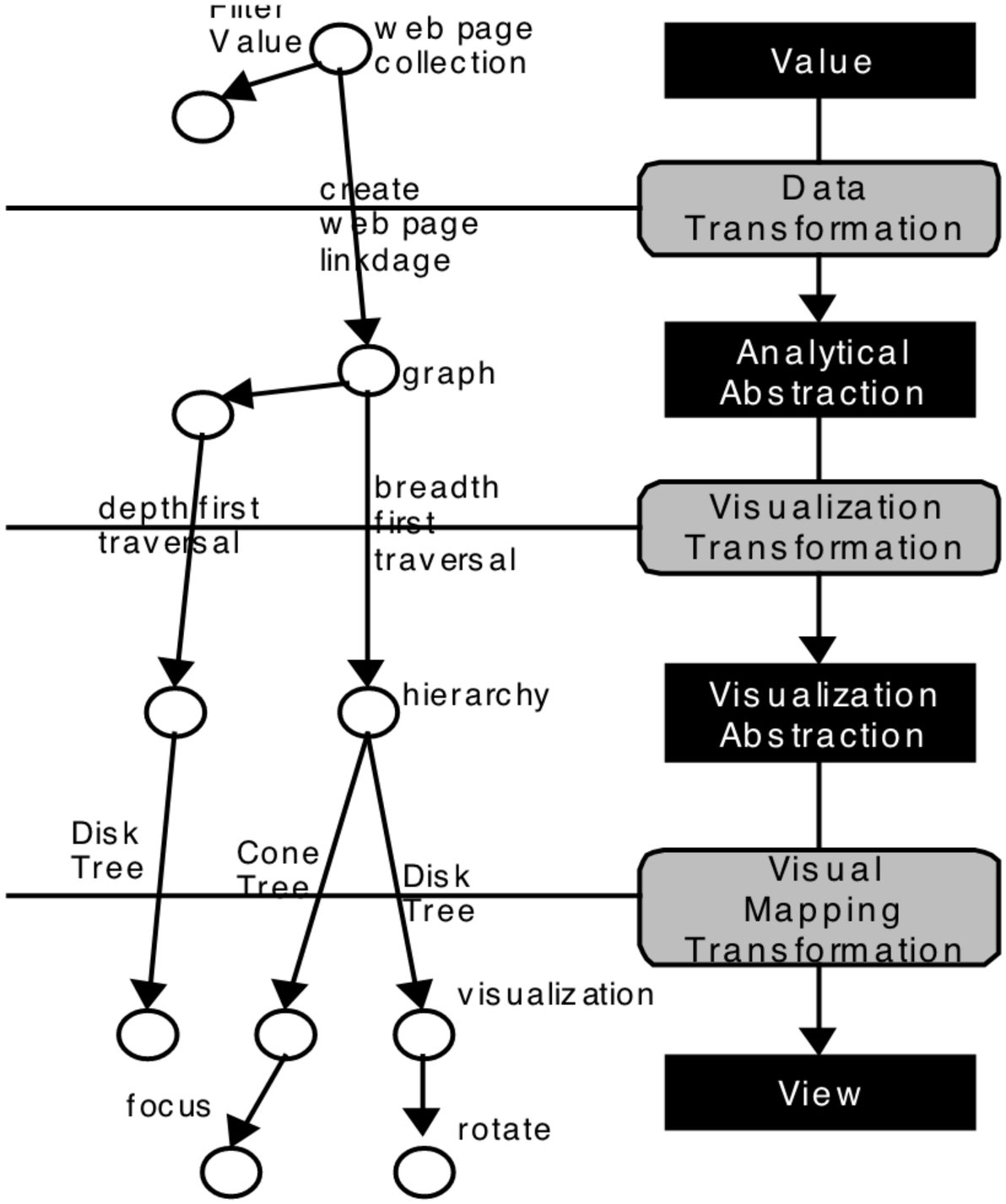
Prefuse, Flare, Improvise, VTK

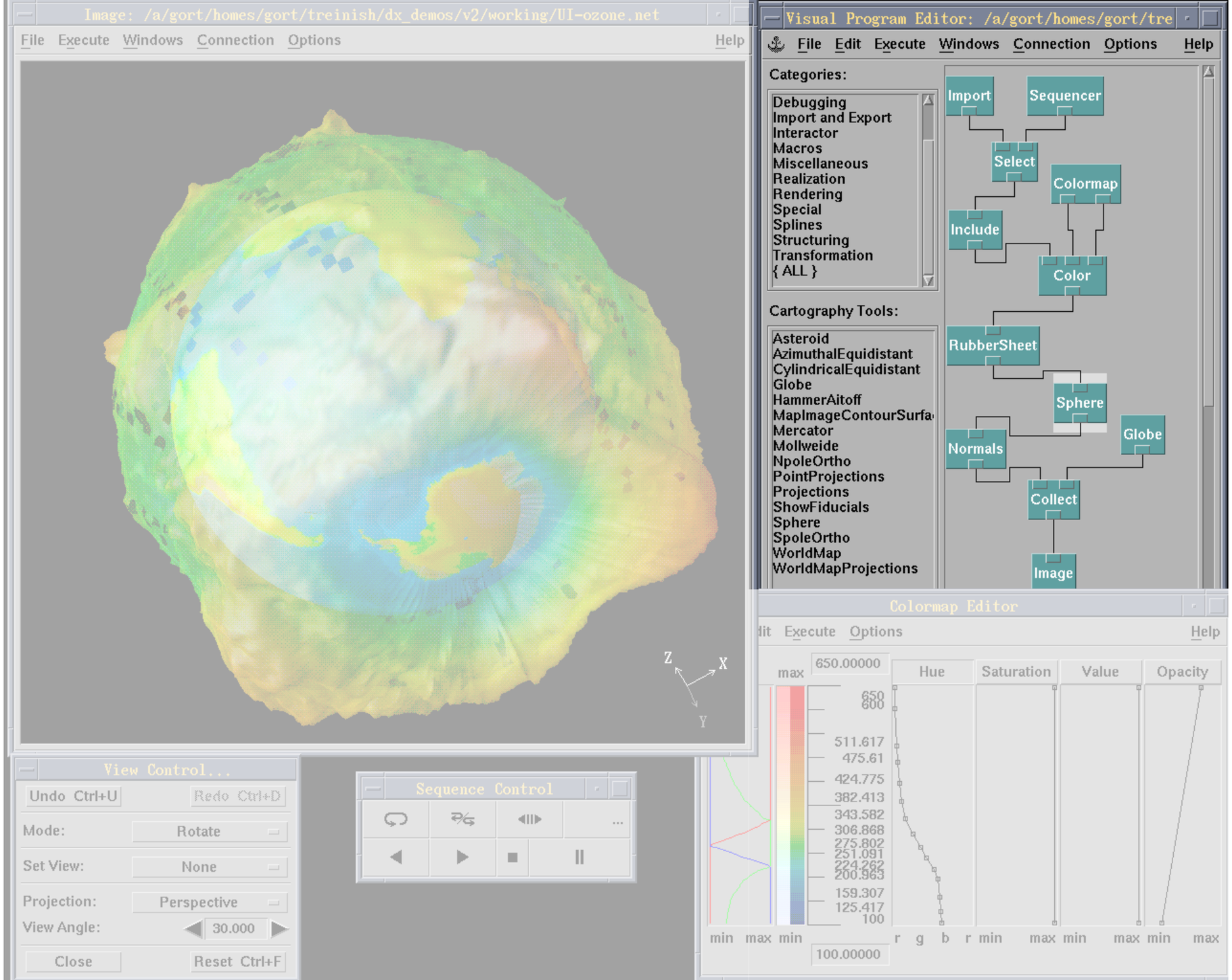
Graphics APIs

Canvas, OpenGL, Processing, SVG


Data
Visual Form
Task
Raw Data
Data Tables
Visual Structures
Views
Data Transformations
Visual Encodings
View Transformations

Data State Model
[Chi 98]

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File Execute Windows Connection Options Help
Visual Program Editor: /a/gort/homes/gort/tre
File Edit Execute Windows Connection Options Help
Categories:
Debugging
Import and Export
Interactor
Macros
Miscellaneous
Realization
Rendering
Special
Splines
Structuring
Transformation
{ ALL }
Cartography Tools:
Asteroid
AzimuthalEquidistant
CylindricalEquidistant
Globe
HammerAitoff
MapImageContourSurfa
Mercator
Mollweide
NpoleOrtho
PointProjections
Projections
ShowFiducials
Sphere
SpoleOrtho
WorldMap
WorldMapProjections
Import
Sequencer
Select
Colormap
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Color
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Sphere
Globe
Normals
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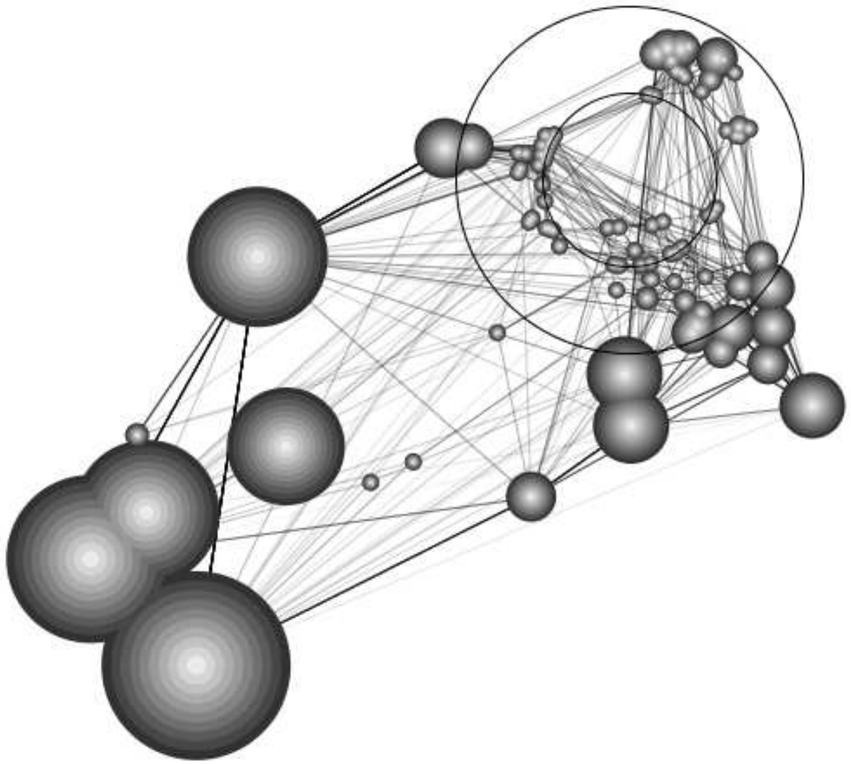
Sequence Control

Prefuse & Flare

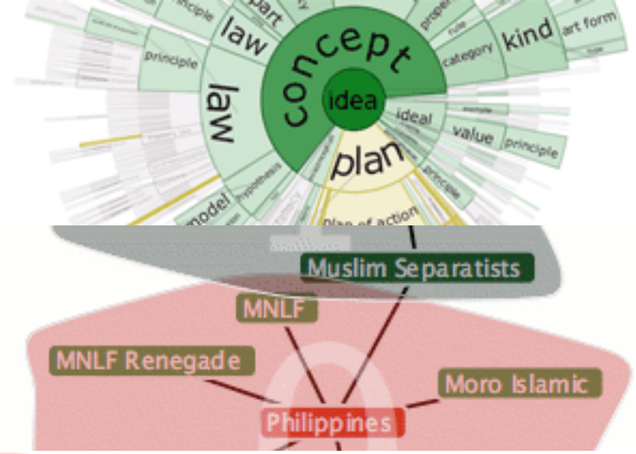
Operator-based toolkits for visualization design
Vis = (Input Data -> Visual Objects) + Operators



```
// initialize action lists
ActionList layout = new ActionList(registry);
layout.add(new TreeFilter(true));
layout.add(new RadialTreeLayout());
layout.add(new ColorFunction());
```

Users can define their own layouts, etc.

Heer, Jeffrey, Stuart K. Card, and James A. Landay. "Prefuse: a toolkit for interactive information visualization." *2005*


concept
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MNLF Renegade
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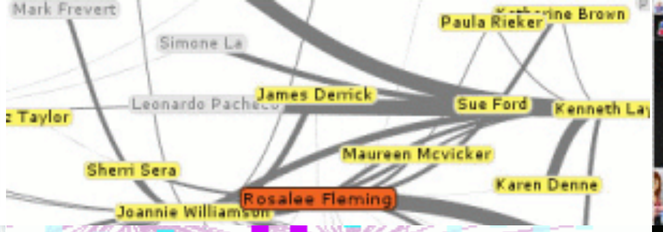
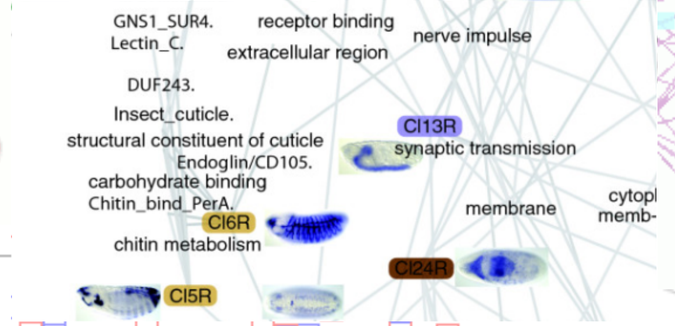

Mark Frevert
Paula Rieker
Simone La
James Derrick
Sue Ford
Leonardo Pacheco
Maureen Mcvicker
Shemi Sera
Karen Denne
Rosalee Fleming
Joannie Williamson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Insect_cuticle.
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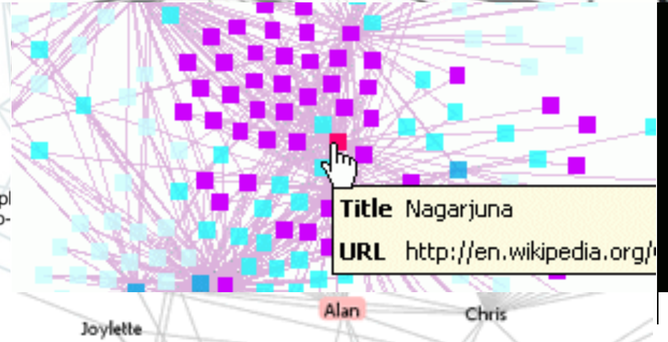
Chitin_bind_PerA.
CI13R
synaptic transmission
membrane
CI6R
chitin metabolism
CI24R
CI5R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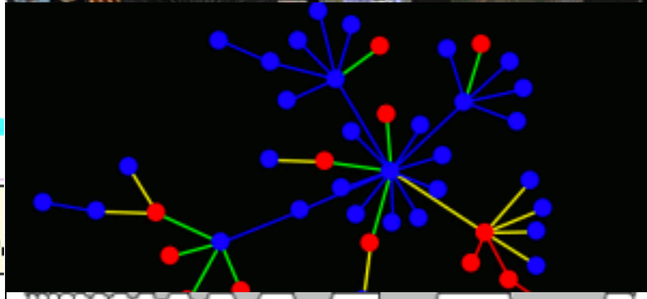
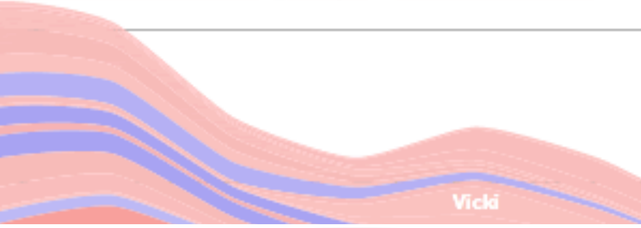
URL http://en.wikipedia.org/
Alan
Chris
Joylette




Vicki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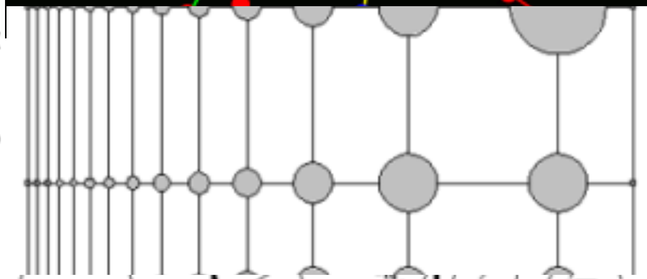
Amanda
Shane
Rikard
David
Justin
Shane
Micaela
Steven
Matt
Fernando

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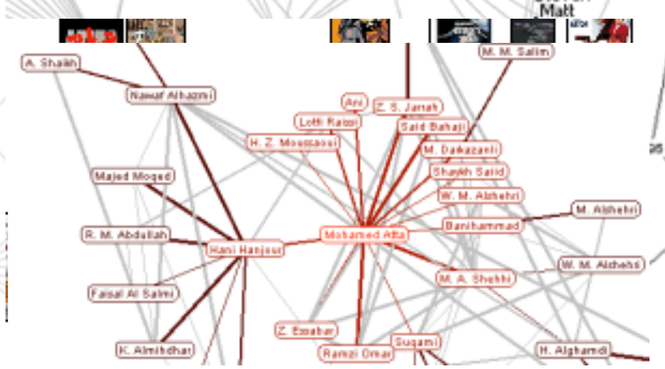
CA


Ideology
Science
Humanities
Technology
Recurring
Knowledge
Historical
The Millennium
Events
Generic
Civilizations
Individuals
People
S. People
Organizations
Categories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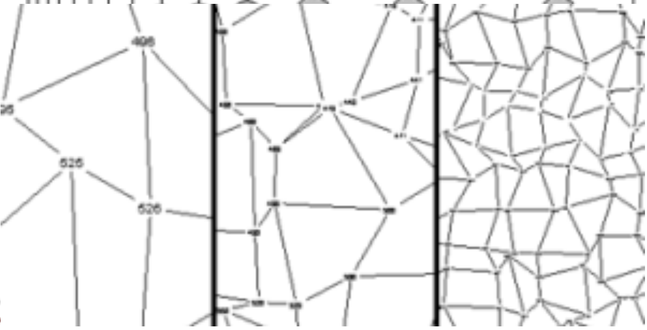
Nawaf Alhazmi
Majed Moged
R. M. Abdullah
Faisal Al Salmi
K. Almilidhar
Hani Hanjour
Mohamed Atta
Ziad Jarrah
Said Bahaji
Marwan Al-Shehhi
Ramzi Omar
Z. Essabar
H. Alghamdi
M. M. Salim
M. Alshehri
W. M. Alshehri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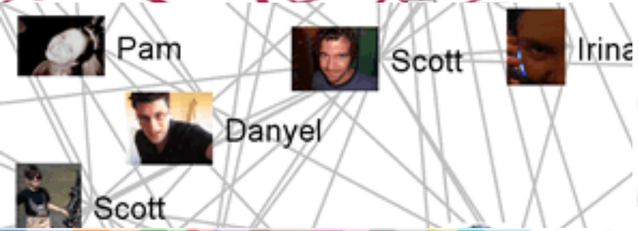
526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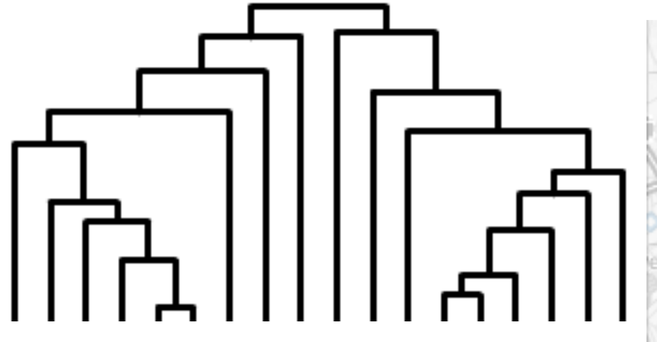
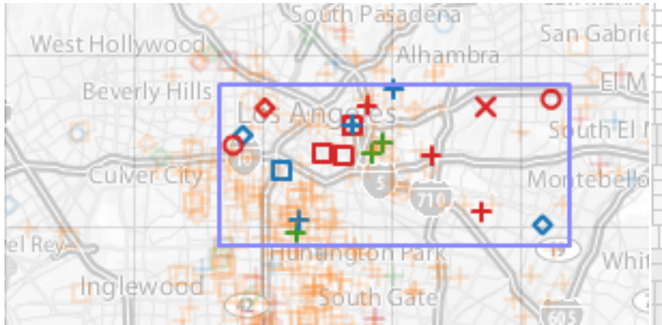
Scott
Irina
Danyel
Scott

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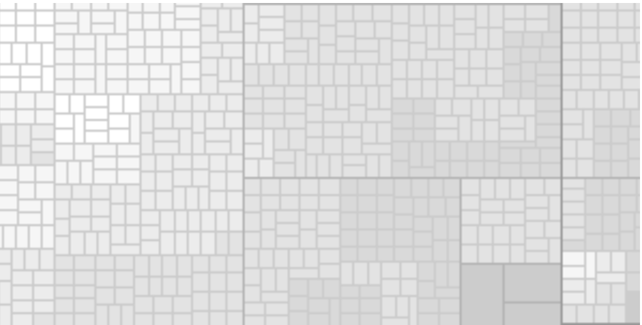
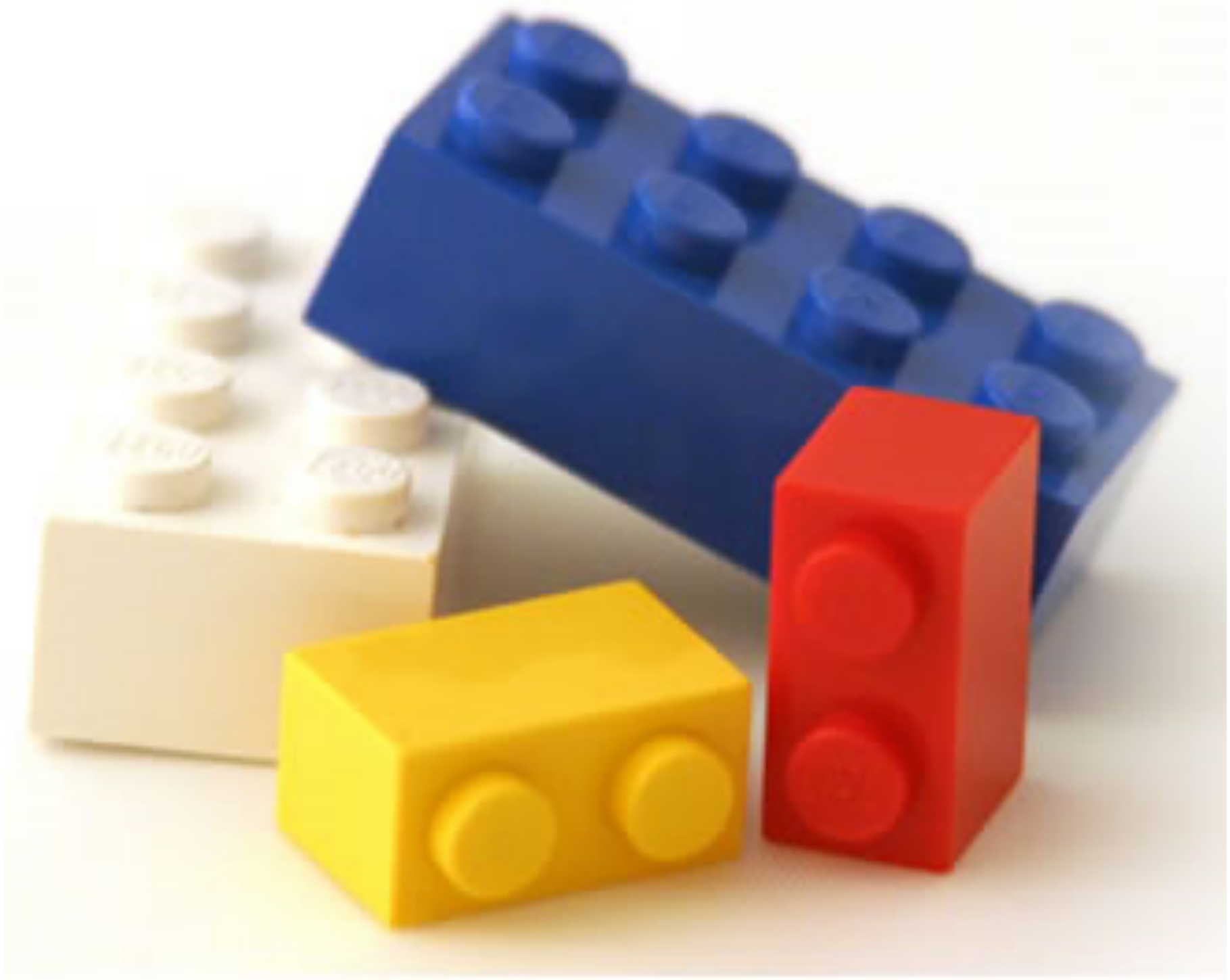
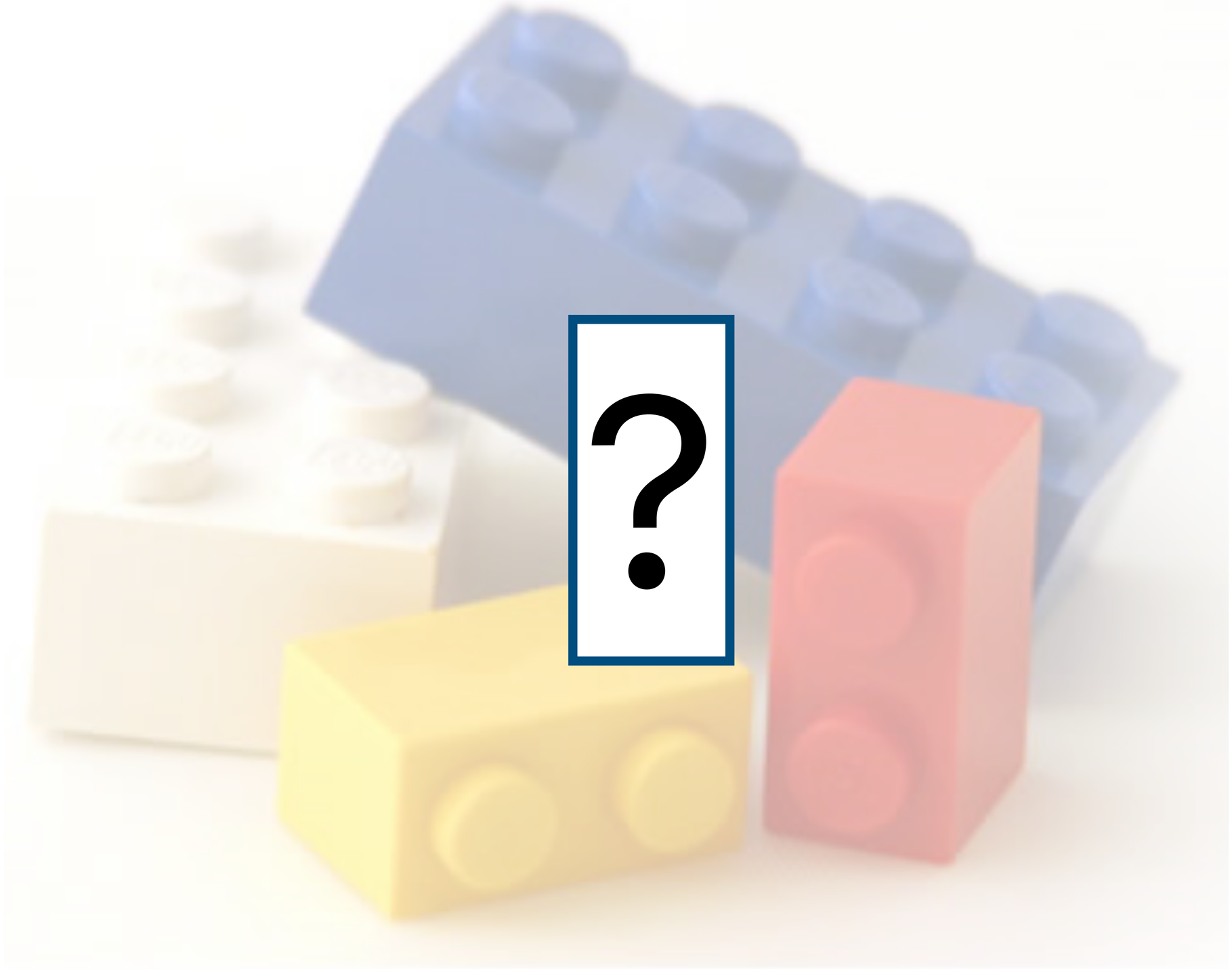
West Hollywood
Alhambra
Beverly Hills
Los Angeles
Culver City
Montebello
Huntington Park
Inglewood
South Gate







Component Architectures

Prefuse, Flare, Improvise, VTK

Graphics APIs

Canvas, OpenGL, Processing, SVG

Chart Typologies

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2D
3D
Interactive

Data Sets : State Quick Facts

Uploaded By: zinggoat
Data Source: US Census Bureau
Description:
Tags: people census

Created at: Friday May 18, 3:08 PM

view as text | edit data set

	People QuickFacts	Population 2005 estimate	Population percent change April 1 2000 to July 1 2005	Population 2000	Population percent change 1990 to 2000	Persons under 5 years old percent 2004	Persons under 18 years old percent 2004	Persons 65 years old and over percent 2004
1	Alabama	4557808	0.03	4447100	0.1	0.07	0.24	0.13
2	Alaska	663661	0.06	626932	0.14	0.08	0.29	0.06
3	Arizona	5939292	0.16	5130632	0.4	0.08	0.27	0.13
4	Arkansas	2779154	0.04	2673400	0.14	0.07	0.25	0.14
5	California	36132147	0.07	33871648	0.14	0.07	0.27	0.11
6	Colorado	4665177	0.08	4301261	0.31	0.07	0.26	0.1
7	Connecticut	3510297	0.03	3405565	0.04	0.06	0.24	0.14
8	Delaware	843524	0.08	783600	0.18	0.07	0.23	0.13
9	Florida	17789864	0.11	15982378	0.24	0.06	0.23	0.17
10	Georgia	9072576	0.11	8186453	0.26	0.08	0.26	0.1
11	Hawaii	1275194	0.05	1211537	0.09	0.07	0.24	0.14
12	Idaho	1429096	0.1	1293953	0.29	0.07	0.27	0.11
13	Illinois	12763371	0.03	12419293	0.09	0.07	0.26	0.12
14	Indiana	6271973	0.03	6080485	0.1	0.07	0.26	0.12
...	...	...	...	...	...	...	...	...

Choosing a visualization type for State Quick Facts

Analyze a text

Tag Cloud

How are you using your words? This enhanced tag cloud will show you the words popularity in the given set of text.

Learn more

Wordle

Wordle is a toy for generating "word clouds" from text that you provide. The clouds give greater prominence to words that appear more frequently in the source text.

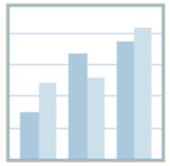
Learn more

Word Tree

See a branching view of how a word or phrase is used in a text. Navigate the text by zooming and clicking.

Learn more

Compare a set of values



Bar Chart

How do the items in your data set stack up? A bar chart is a simple and recognizable way to compare values. You can display several sets of bars for multivariate comparisons.

Learn more

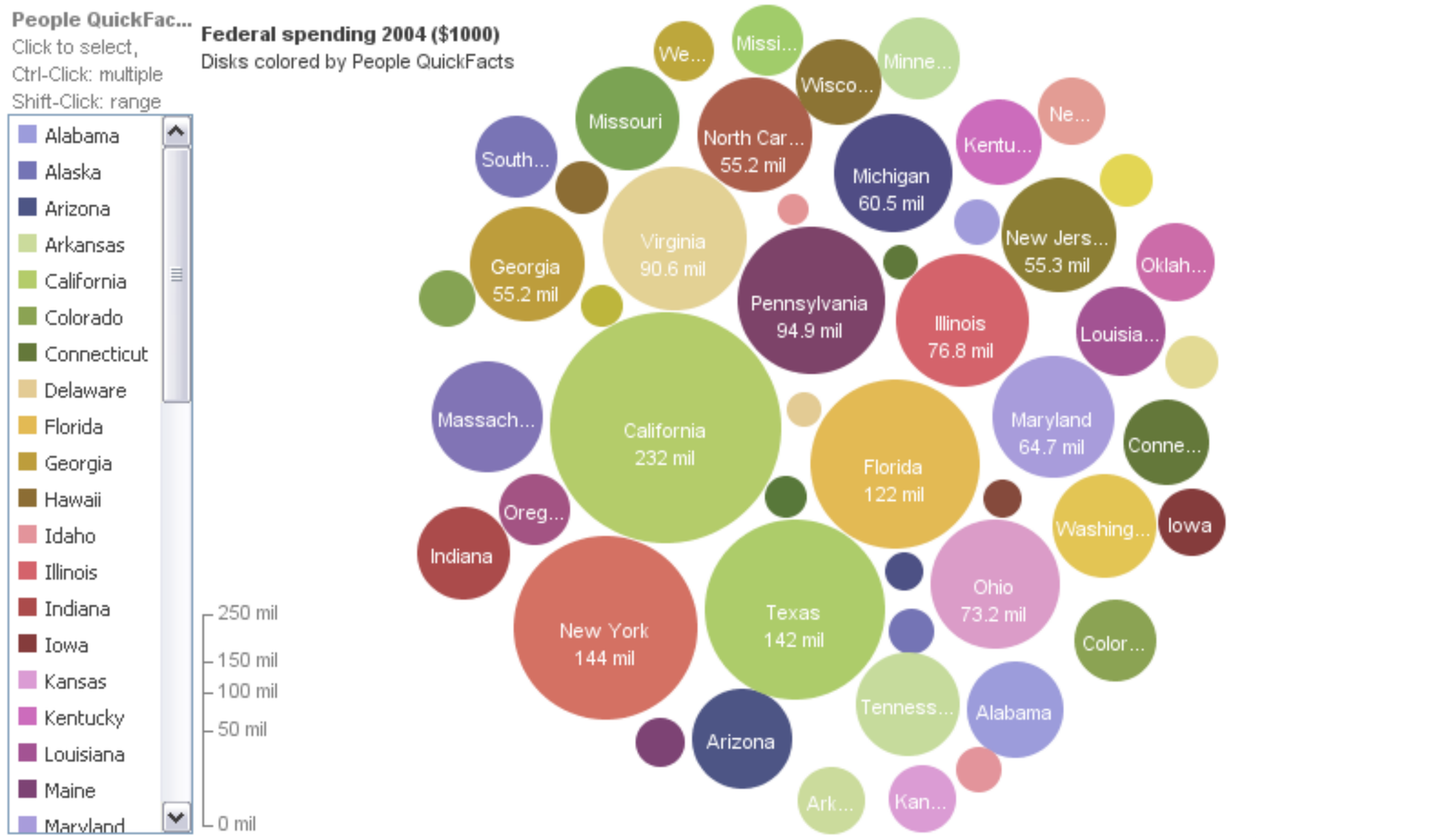
Block Histogram

This versatile chart lets you get a quick sense of how a single set of data is distributed. Each item in the data is an individually identifiable block.

Learn more

Visualizations : Federal Spending by State, 2004

Creator: Anonymous
Tags: census people



MAD LIBS®

MY MUSIC LESSON

Every Wednesday, when I get home from school, I have a piano lesson. My teacher is a very strict house (NOUN). Her name is Hillary Clinton (CELEBRITY (FEMALE)). Our piano is a Steinway Concert tree (NOUN) and it has 88 cups (PLURAL NOUN). It also has a soft pedal and a/an Smily (ADJECTIVE) pedal. When I have a lesson, I sit down on the piano AIBERTO (NOUN) and play for 16 Minuts (PERIOD OF TIME). I do scales to exercise my cats (PLURAL NOUN), and then I usually play a minuet by Johann Sebastian Washington (CELEBRITY (LAST NAME)). Teacher says I am a natural Haunted House (NOUN) and have a good musical leg (PART OF THE BODY). Perhaps when I get better I will become a concert vet (PROFESSION) and give a recital at Carnegie hospital (TYPE OF BUILDING).

[M]ost charting packages channel user requests into a rigid array of chart types. To atone for this lack of flexibility, they offer a kit of post-creation editing tools to return the image to what the user originally envisioned. **They give the user an impression of having explored data rather than the experience.**

Leland Wilkinson
The Grammar of Graphics, 1999

Chart Typologies

Excel, Google Charts

Component Architectures

Prefuse, Flare, Improvise, VTK

Graphics APIs

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Visual Analysis Grammars
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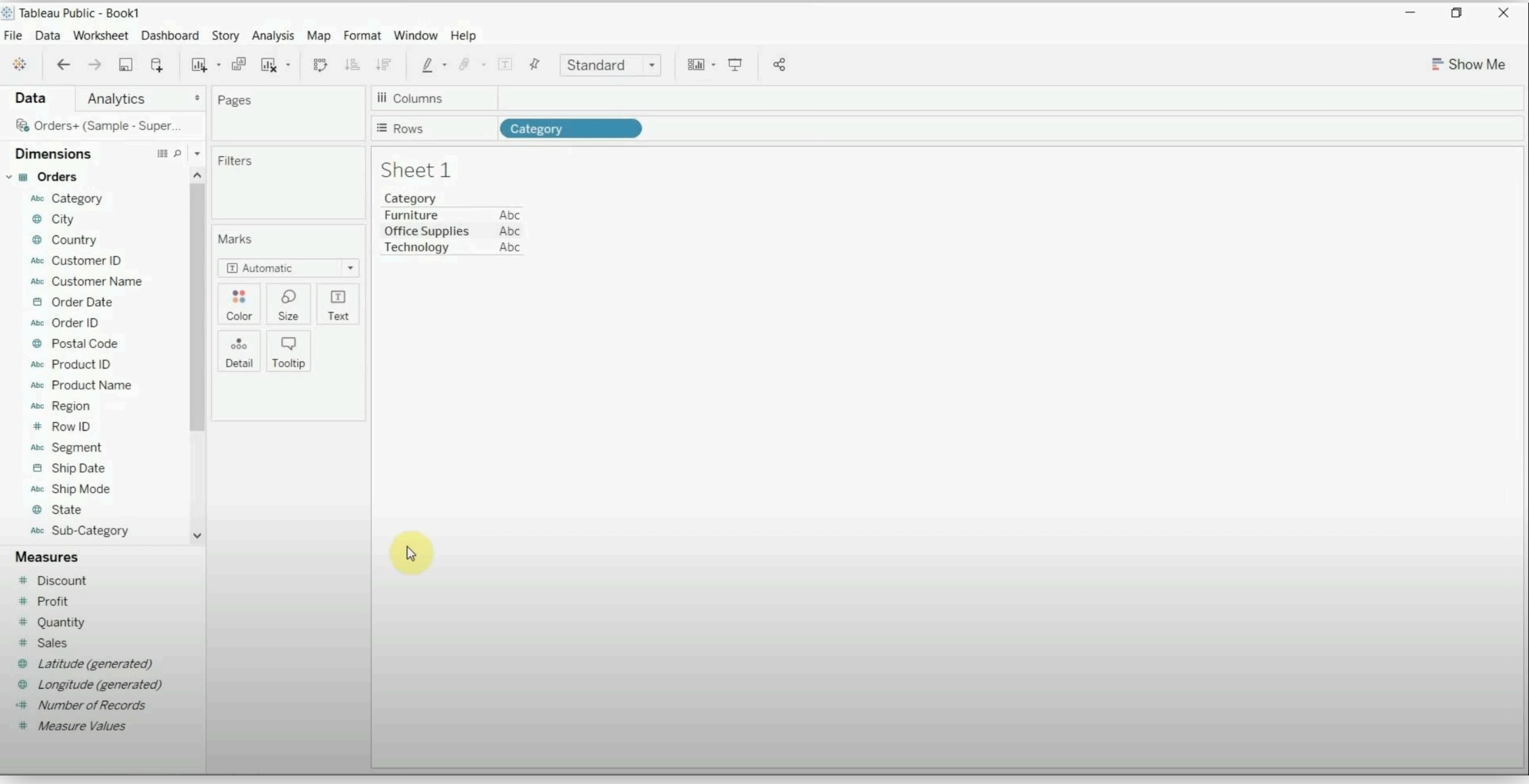
Tableau Public - Book1
File Data Worksheet Dashboard Story Analysis Map Format Window Help
Standard
Show Me
Data
Analytics
Orders+ (Sample - Super...
Dimensions
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Category
City
Country
Customer ID
Customer Name
Order Date
Order ID
Postal Code
Product ID
Product Name
Region
Row ID
Segment
Ship Date
Ship Mode
State
Sub-Category
Measures
Discount
Profit
Quantity
Sales
Latitude (generated)
Longitude (generated)
Number of Records
Measure Values
Pages
Filters
Marks
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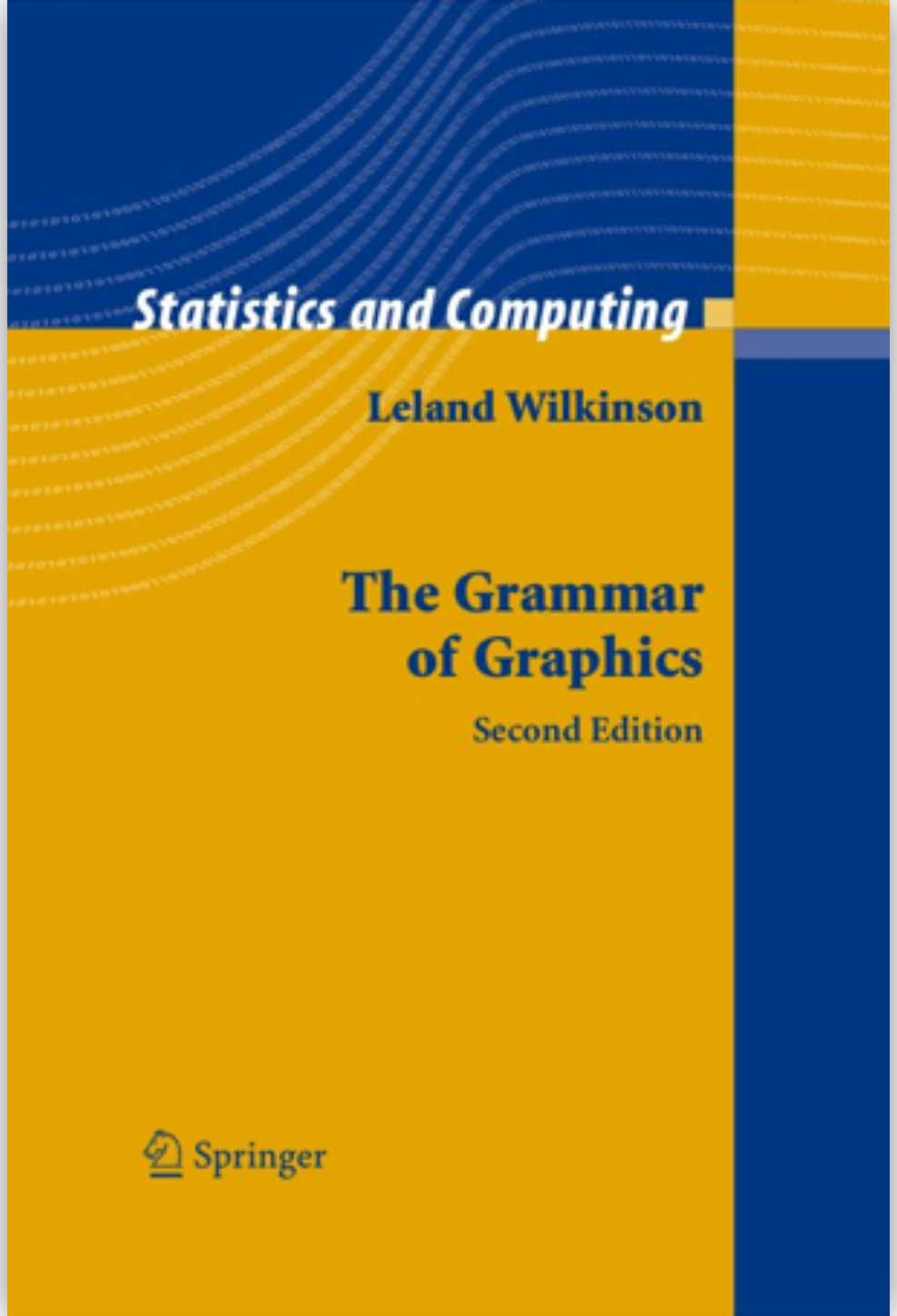
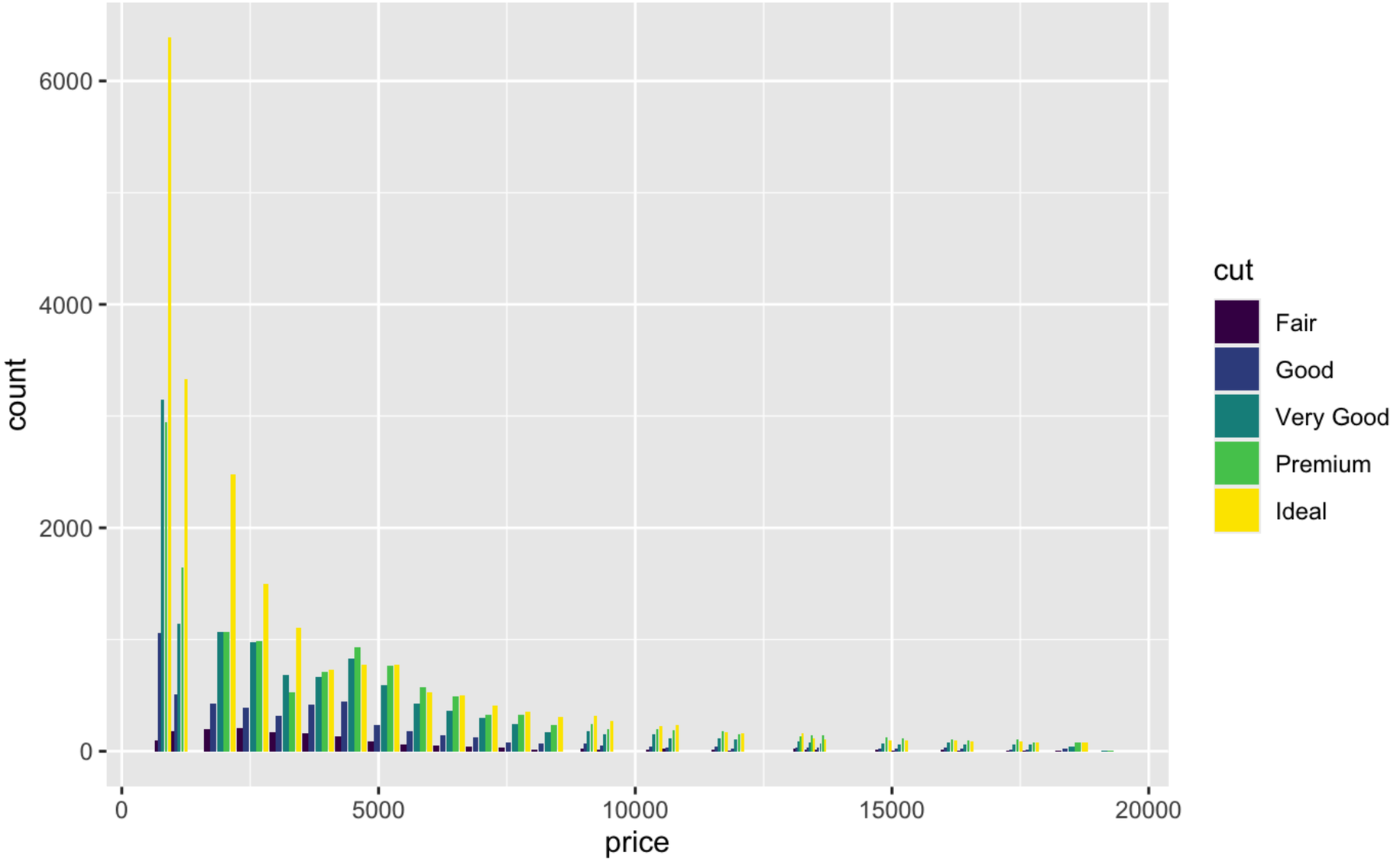
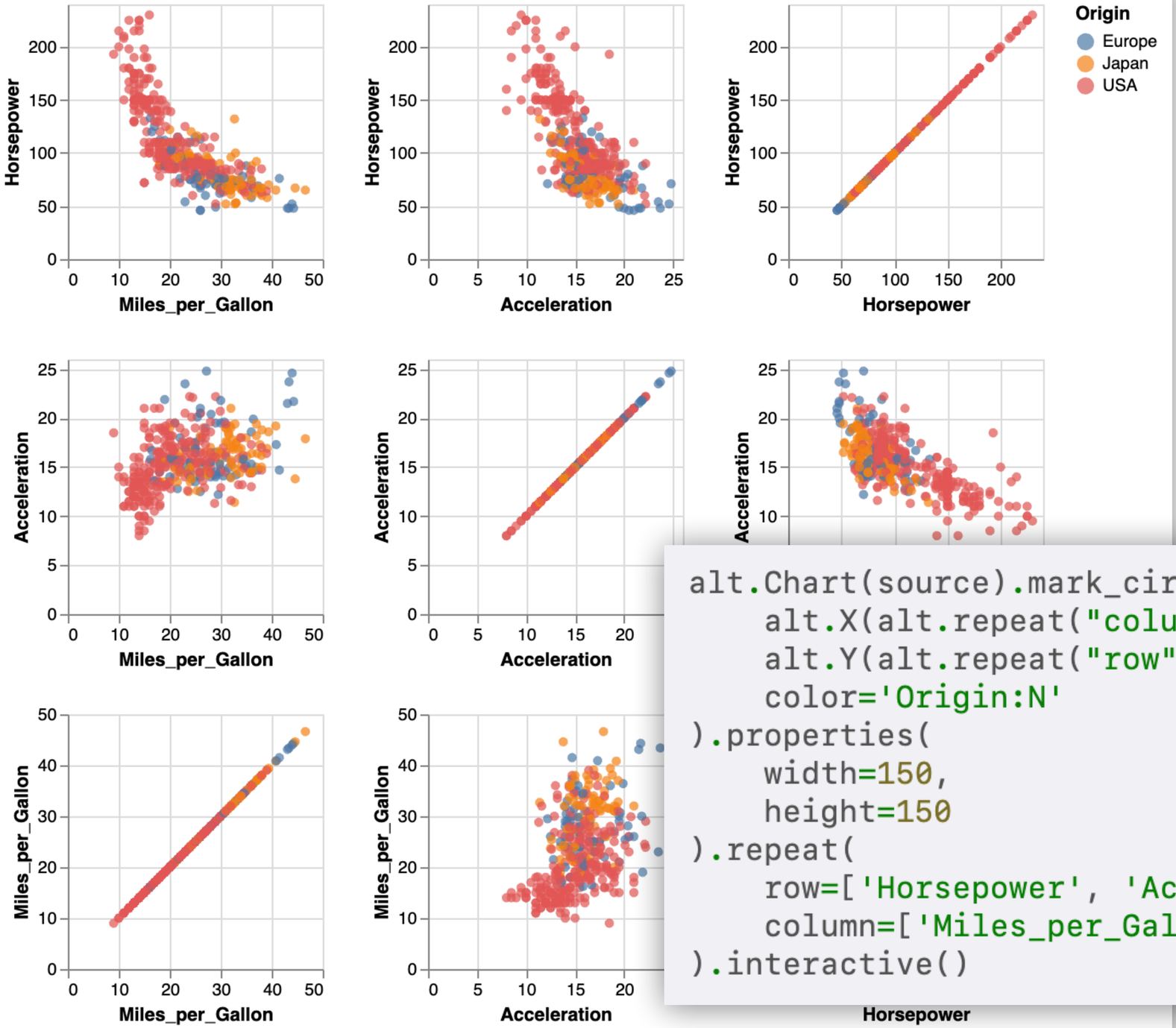
Detail
Tooltip
Columns
Rows
Category
Sheet 1
Category
Furniture Abc
Office Supplies Abc
Technology Abc


Statistics and Computing
Leland Wilkinson
The Grammar of Graphics
Second Edition
Springer




```
ggplot(diamonds, aes(x=price, fill=cut))
+ geom_bar(position="dodge")
```




```
alt.Chart(source).mark_circle().encode(
    alt.X(alt.repeat("column"), type='quantitative'),
    alt.Y(alt.repeat("row"), type='quantitative'),
    color='Origin:N'
).properties(
    width=150,
    height=150
).repeat(
    row=['Horsepower', 'Acceleration', 'Miles_per_Gallon'],
    column=['Miles_per_Gallon', 'Acceleration', 'Horsepower']
).interactive()
```

Chart Typologies
Excel, Google Charts

Visual Analysis Grammars
VizQL, ggplot2, Vega-Lite, Altair

Component Architectures
Prefuse, Flare, Improvise, VTK

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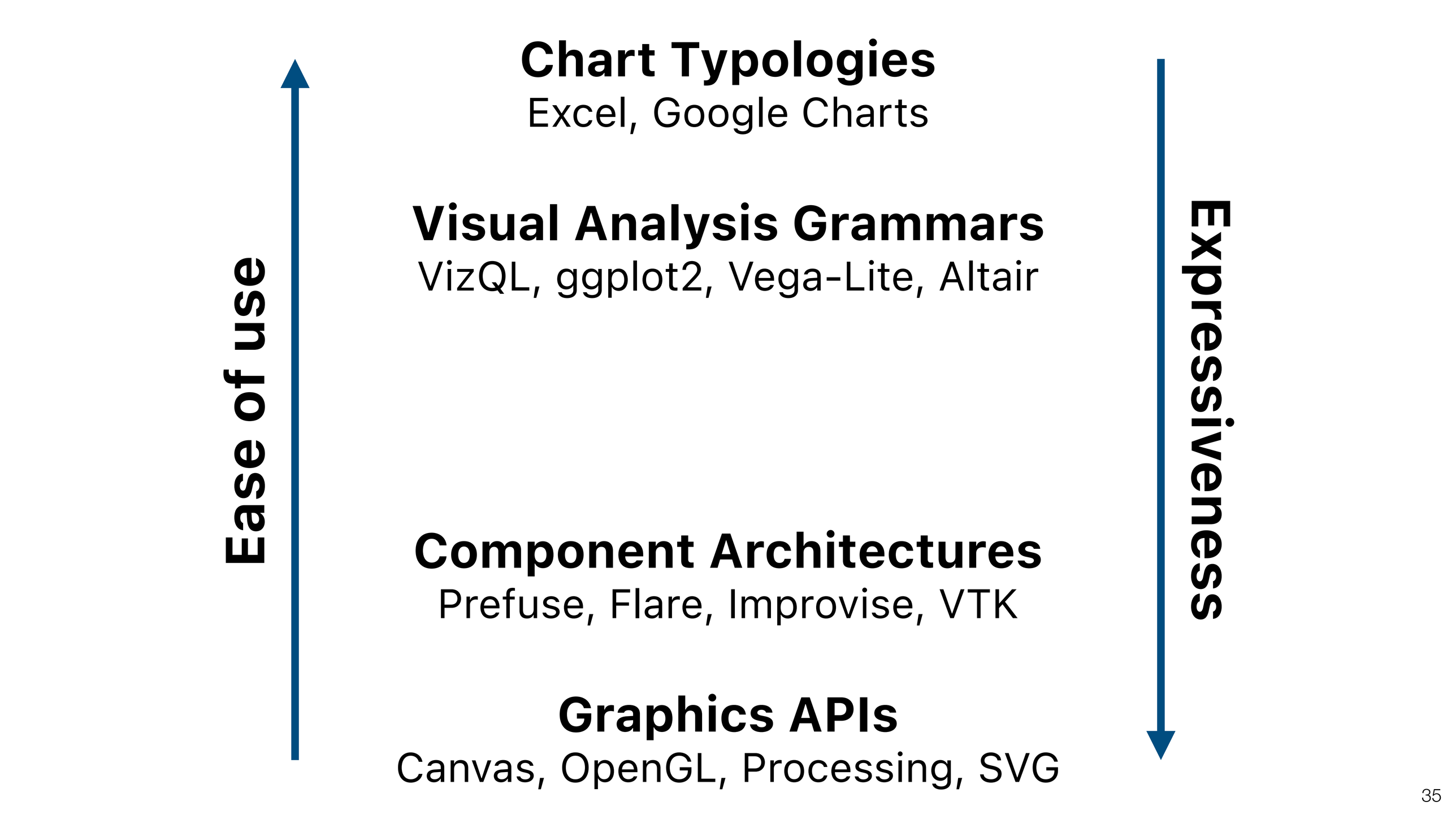
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Graphics APIs
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Ease of use
Expressiveness

Chart Typologies
Excel, Google Charts

Visual Analysis Grammars
VizQL, ggplot2, Vega-Lite, Altair

?

Component Architectures
Prefuse, Flare, Improvise, VTK

Graphics APIs
Canvas, OpenGL, Processing, SVG

What's going well for you in the course?
What could be improved?

Anonymous answers

Join at
slido.com
#1060

Do you have any feedback for Sam + the course staff?

Anonymous answers

Join at

slido.com

#1060

Chart Typologies
Excel, Google Charts

Visual Analysis Grammars
VizQL, ggplot2, Vega-Lite, Altair

Visualization Grammars
Protovis, D3.js, Vega

Component Architectures
Prefuse, Flare, Improvise, VTK

Graphics APIs
Canvas, OpenGL, Processing, SVG

Visualization Grammar

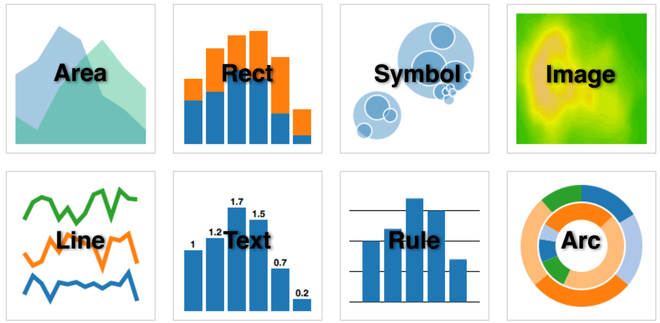
Data Input data to visualize

Transforms Group, aggregate, layout

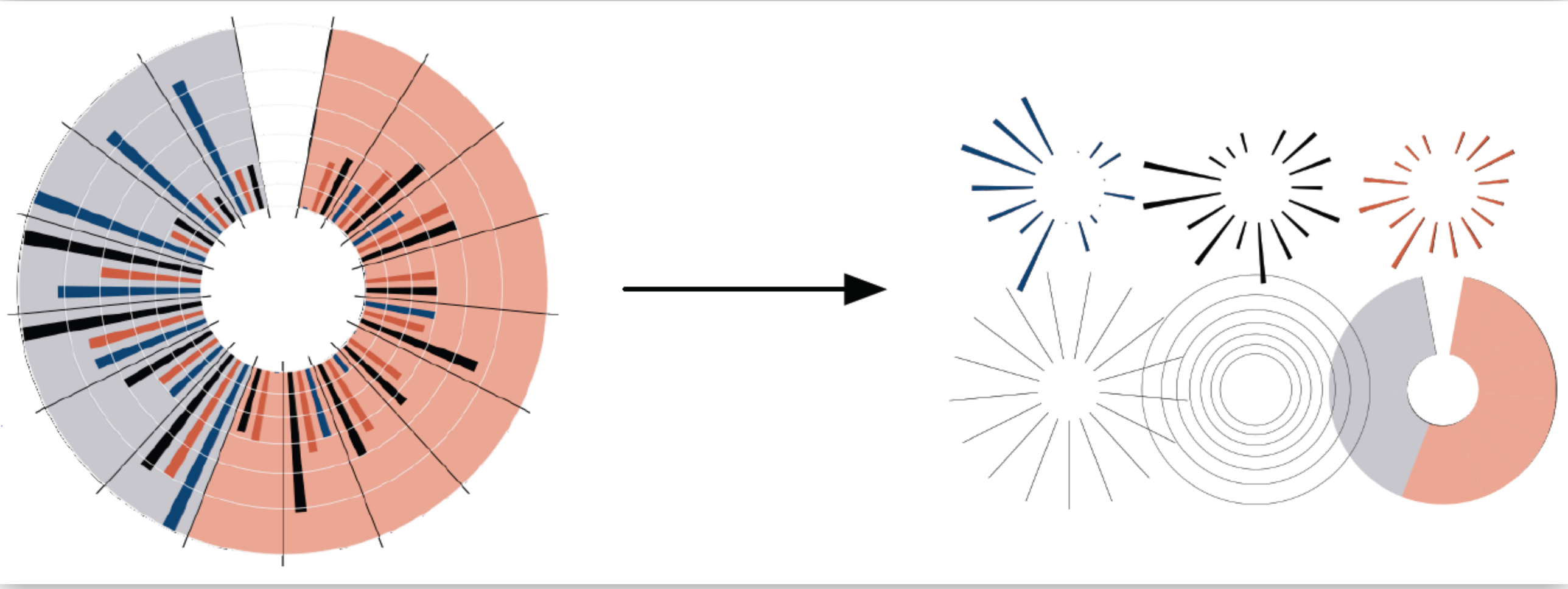
Scales Map data values to visual values

Guides Axes & legends

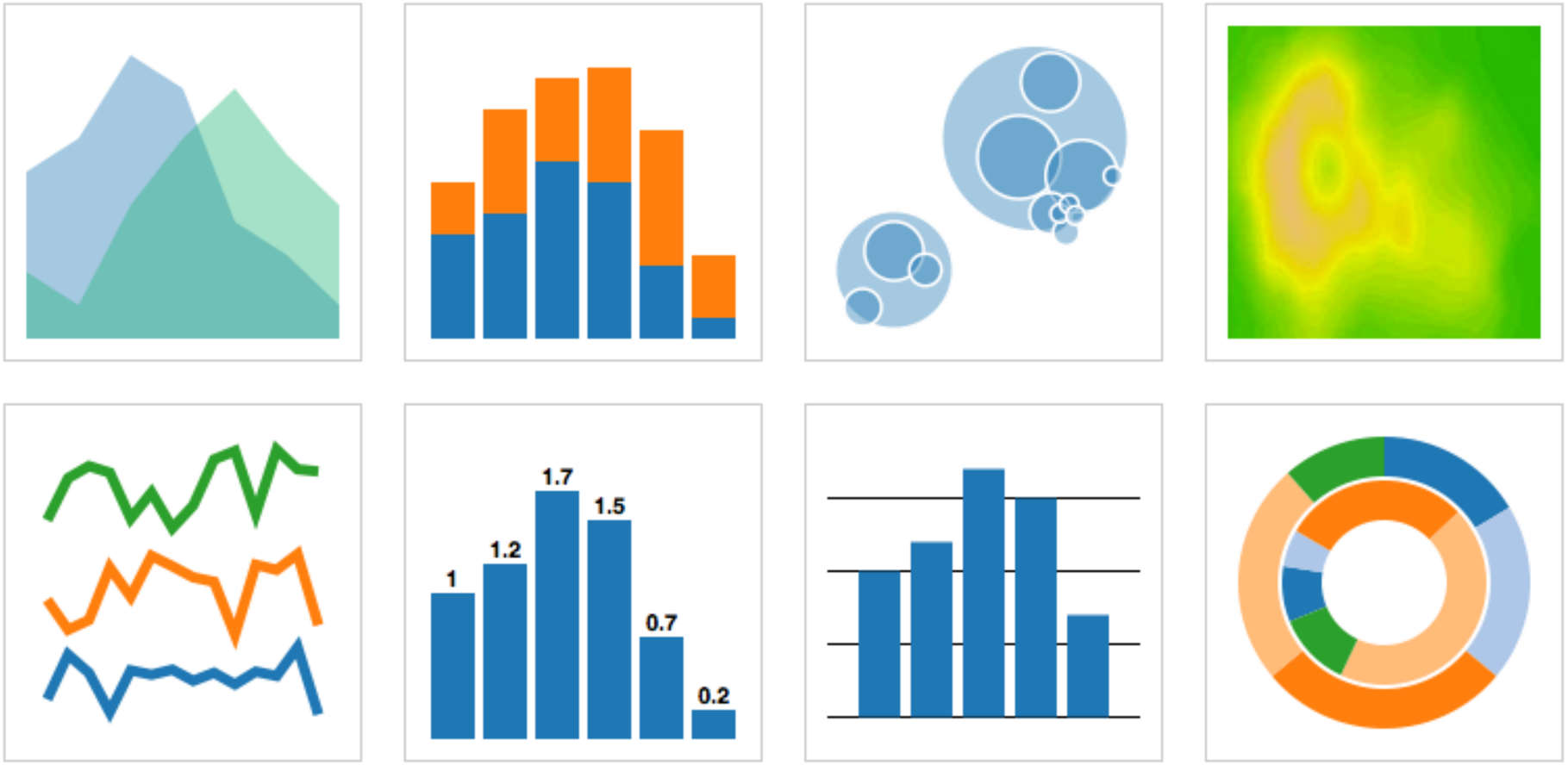
Marks Data-representative graphics



Protovis (D3 predecessor)



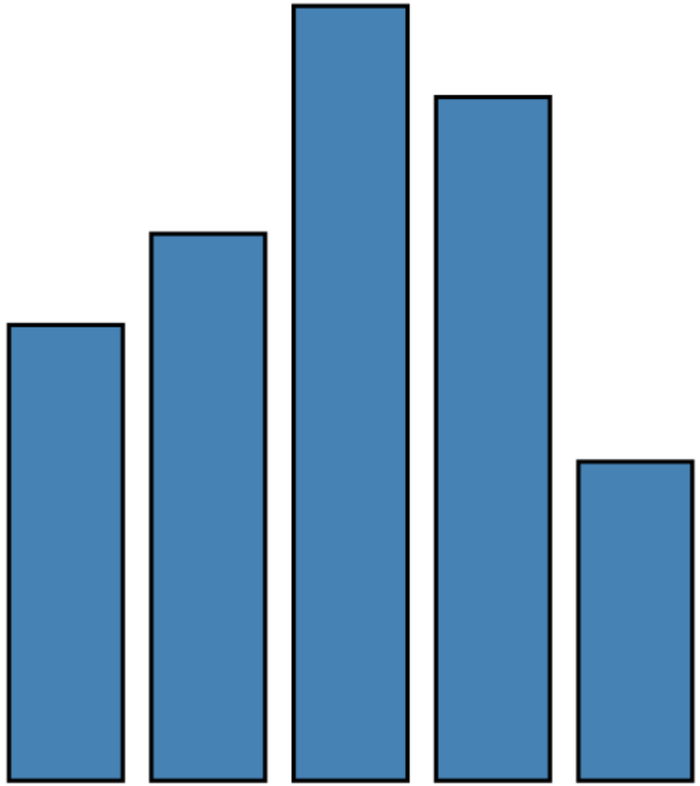
Bostock, Michael, and Jeffrey Heer. "Protovis: A graphical toolkit for visualization." 2009



Marks

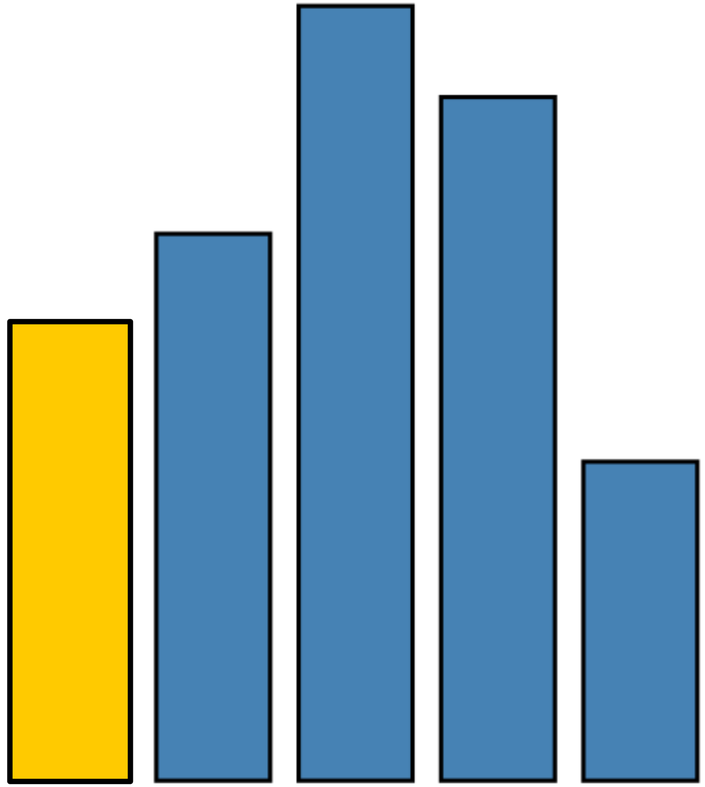
MARK	$\lambda : D \rightarrow R$
data	λ
visible	λ
left	λ
bottom	λ
width	λ
height	λ
fillStyle	λ
strokeStyle	λ
lineWidth	λ
...	λ

RECT	$\lambda : D \rightarrow R$				
data	1	1.2	1.7	1.5	0.7
visible	true				
left	λ: index * 25				
bottom	0				
width	20				
height	λ: datum * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



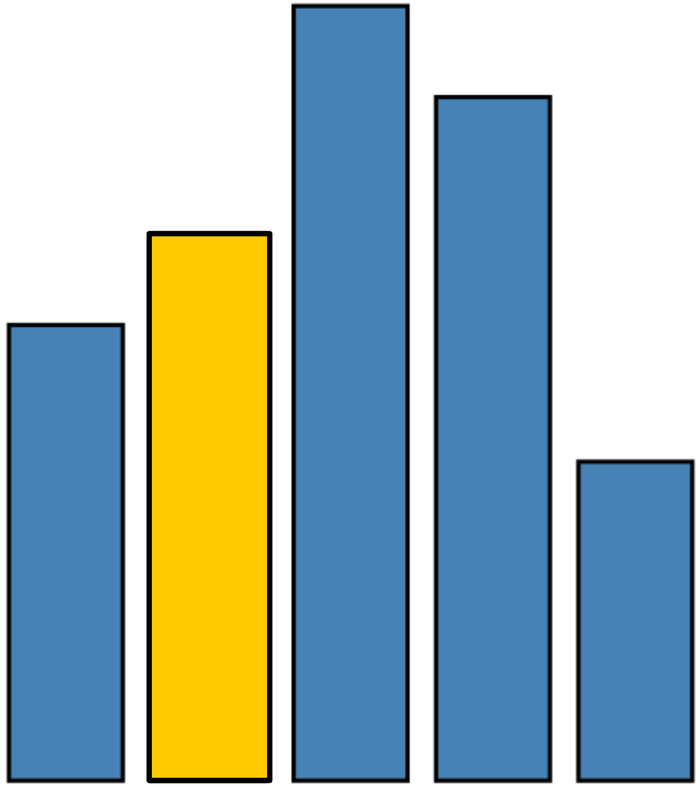
RECT $\lambda : D \rightarrow R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	0 * 25				
bottom	0				
width	20				
height	1 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



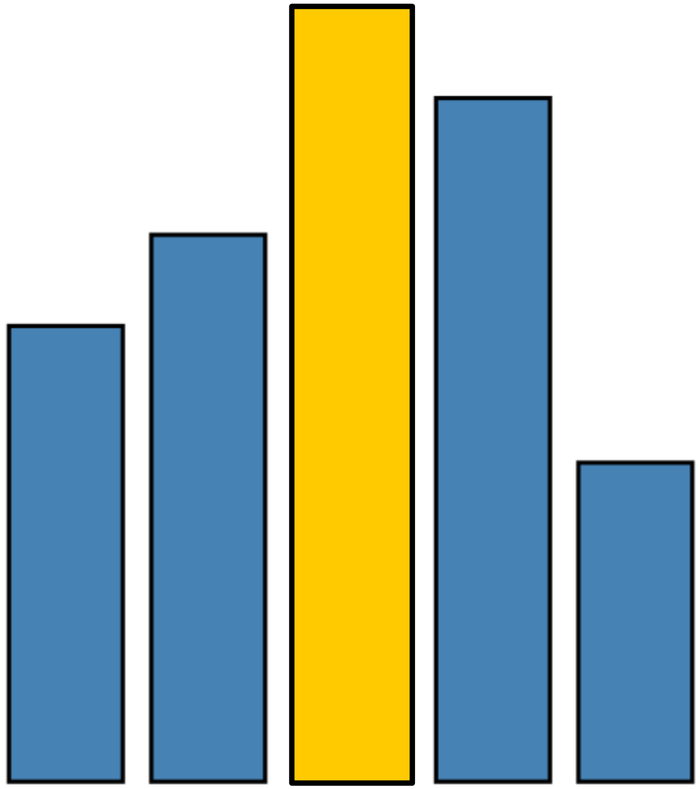
RECT $\lambda : D \rightarrow R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	1 * 25				
bottom	0				
width	20				
height	1.2 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



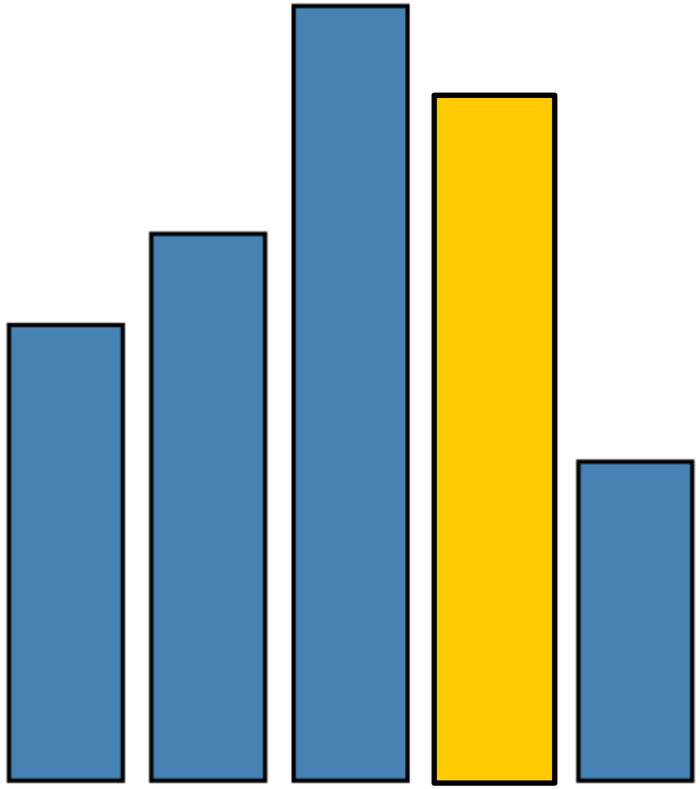
RECT $\lambda : D \rightarrow R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	2 * 25				
bottom	0				
width	20				
height	1.7 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



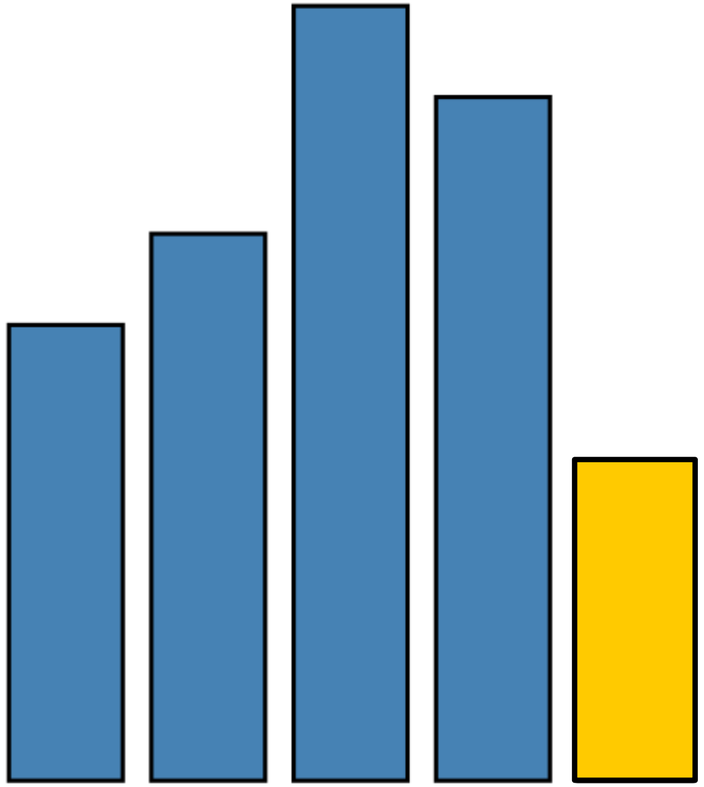
RECT $\lambda : D \rightarrow R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	3 * 25				
bottom	0				
width	20				
height	1.5 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				

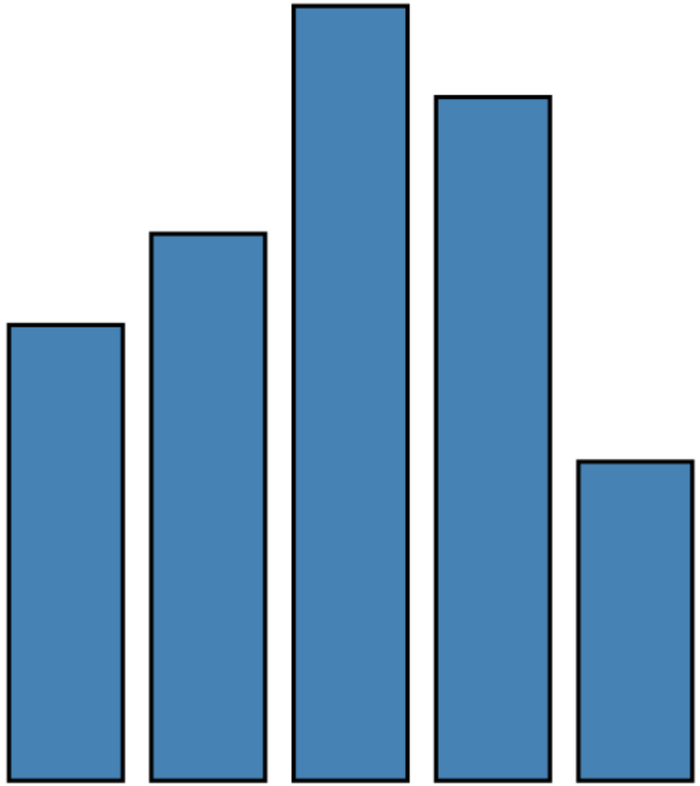


RECT $\lambda : D \rightarrow R$

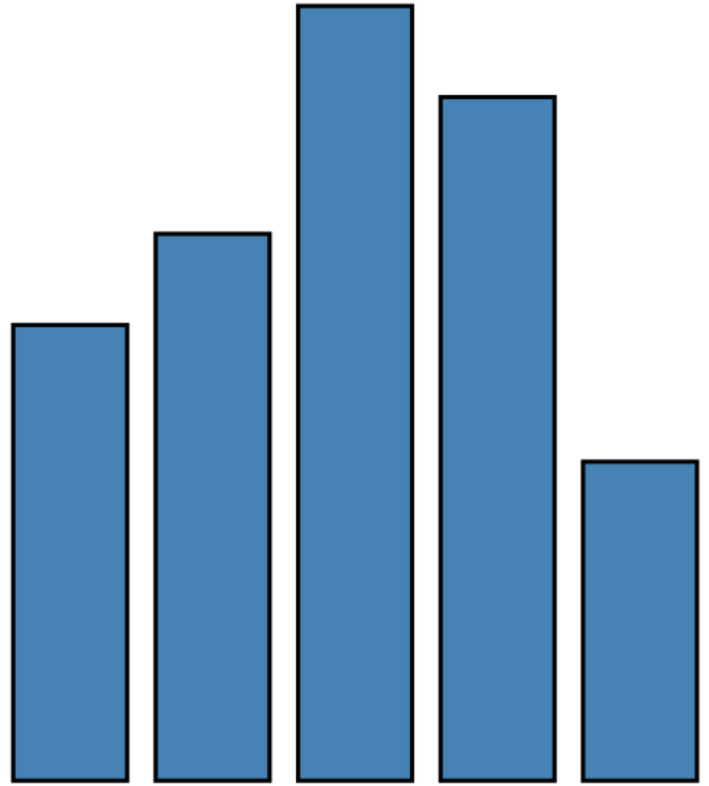
data	1	1.2	1.7	1.5	0.7
visible	true				
left	4 * 25				
bottom	0				
width	20				
height	0.7 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				

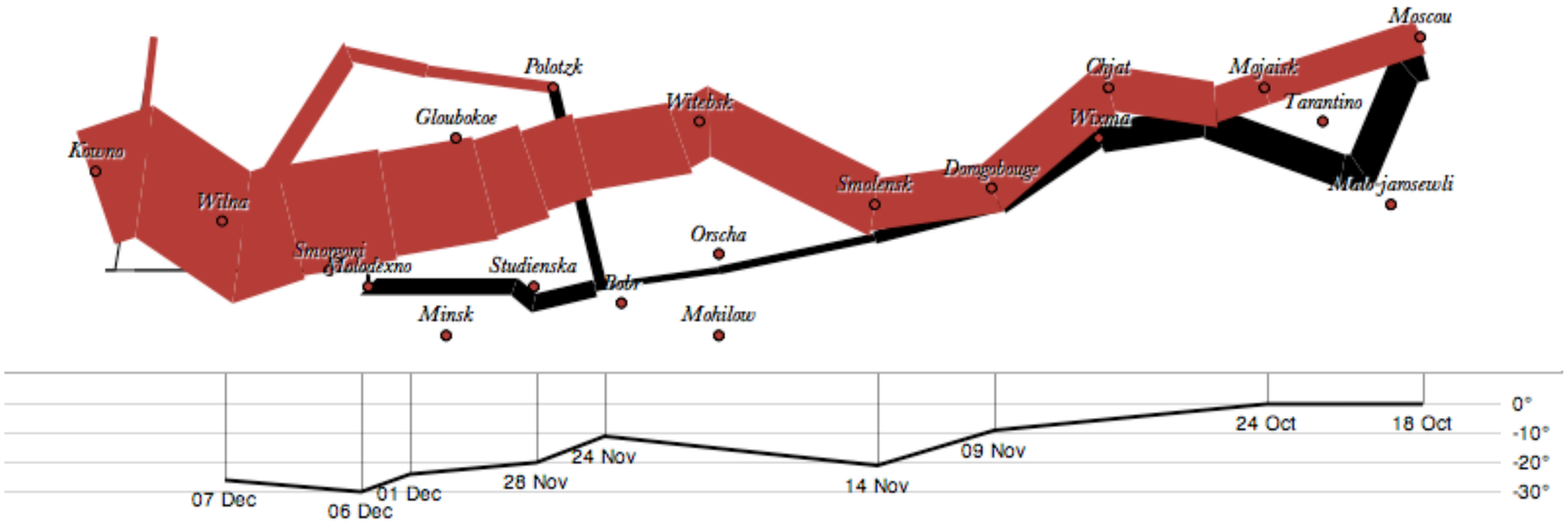


RECT	**λ : *D* → *R***				
data	1	1.2	1.7	1.5	0.7
visible	true				
left	λ: index * 25				
bottom	0				
width	20				
height	λ: datum * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



```
var vis = new pv.Panel();
vis.add(pv.Bar)
  .data([1, 1.2, 1.7, 1.5, 0.7])
  .visible(true)
  .left((d) => this.index * 25);
  .bottom(0)
  .width(20)
  .height((d) => d * 80)
  .fillStyle(“blue”)
  .strokeStyle(“black”)
```





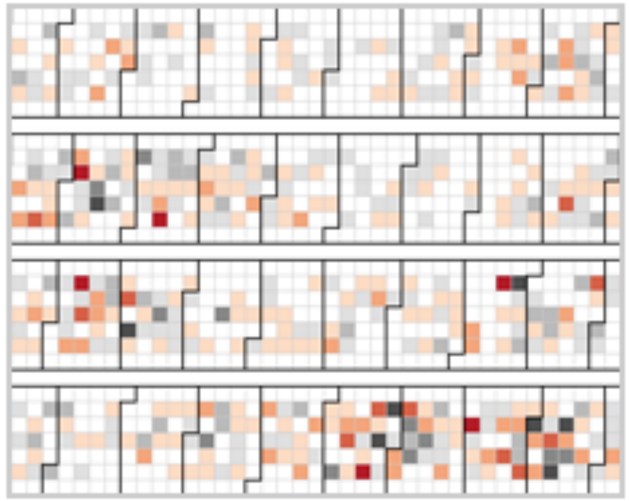

```
var army = pv.nest(napoleon.army, "dir",
"group“);
var vis = new pv.Panel();

var lines = vis.add(pv.Panel).data(army);
lines.add(pv.Line)
  .data(() => army[this.idx])
  .left(lon).top(lat).size((d) => d.size/
   8000)
  .strokeStyle(() => color[army[paneIndex]
   [0].dir]);

vis.add(pv.Label).data(napoleon.cities)
  .left(lon).top(lat)
  .text((d) => d.city).font("italic 10px
   Georgia")
  .textAlign("center").textBaseline("middle
   ");
```

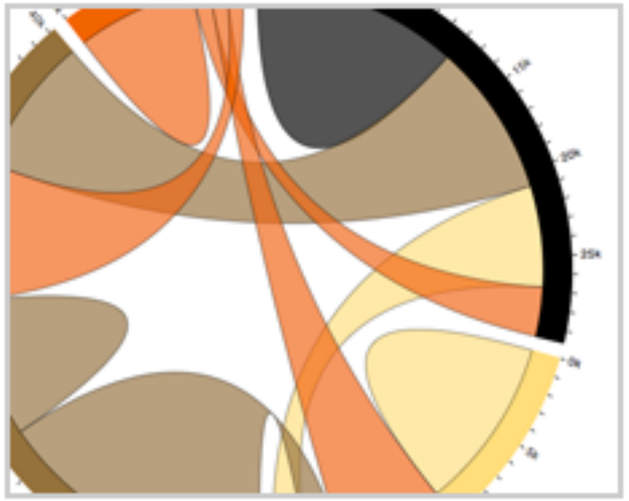
```
vis.add(pv.Rule).data([0,-10,-20,-30])
   .top((d) => 300 - 2*d -
   0.5).left(200).right(150)
   .lineWidth(1).strokeStyle("#ccc")
   .anchor("right").add(pv.Label)
```

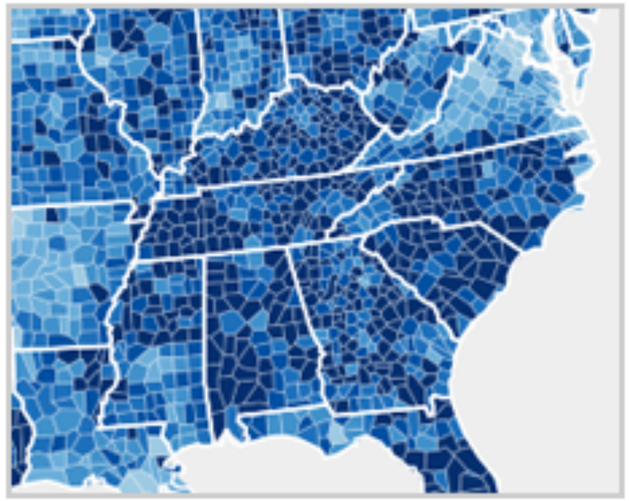
Create axes manually

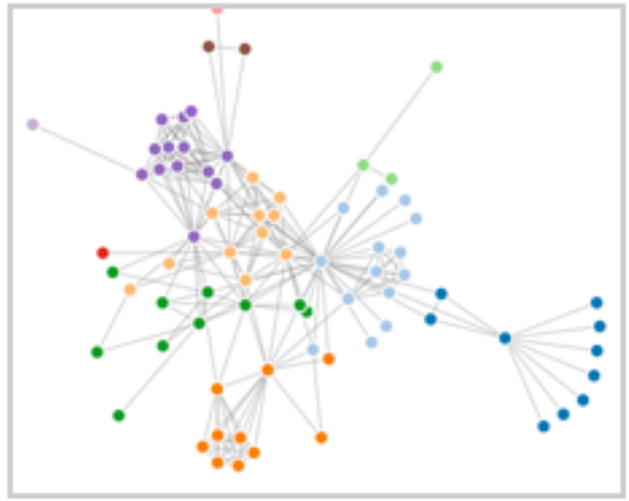
```
vis.add(pv.Line).data(napoleon.temp)
   .left(lon).top(tmp) .strokeStyle("#0")
  .add(pv.Label)
    .top((d) => 5 + tmp(d))
    .text((d) => d.temp+"°
   "+d.date.substr(0,6))
    .textBaseline("top").font("italic 10px
   Georgia");
```

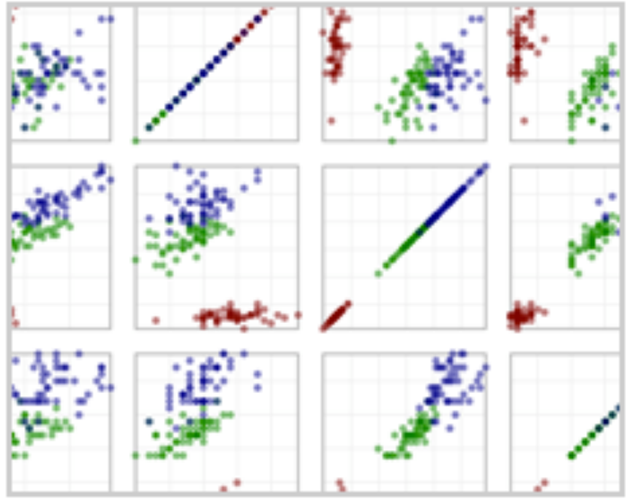
d3.js: Data-Driven Documents

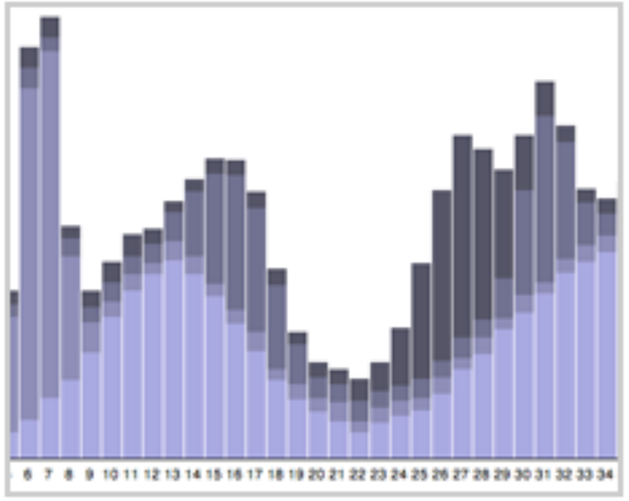


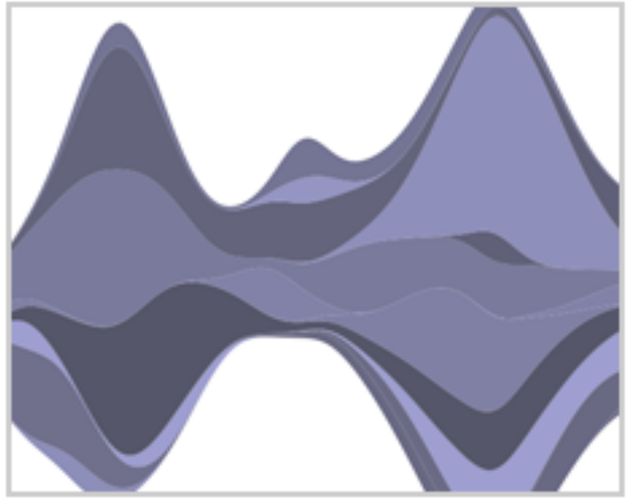


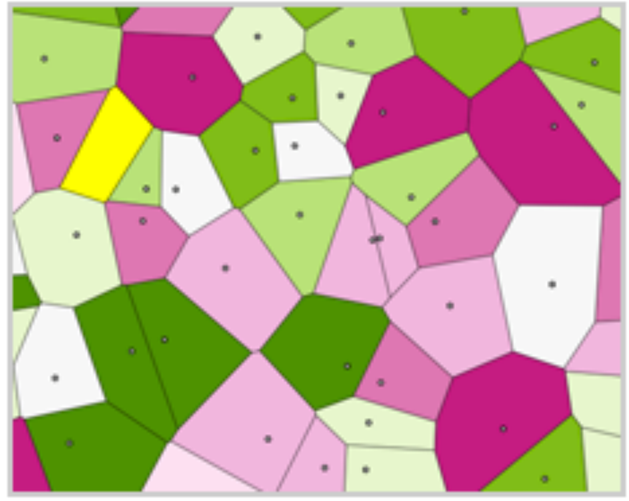












M Bostock, V Ogievetsky, J Heer. D³ data-driven documents. 2011

Protovis

Specialized mark types

✅ Streamlined design

- Limits expressiveness
- More overhead (slower)
- Harder to debug
- Self-contained model

Specify a scene (nouns)

✅ Quick for static vis

- Delayed evaluation
- Animation, interaction are more cumbersome

D3

Bind data to DOM

✅ Exposes SVG/CSS/…

✅ Less overhead (faster)

✅ Debug in browser

✅ Use with other tools

Transform a scene (verbs)

- More complex model

✅ Immediate evaluation

✅ Dynamic data, anim, and interaction natural

```
// Add a layer of dots.
svg.append("g")
    .attr("stroke", "steelblue")
    .attr("stroke-width", 1.5)
    .attr("fill", "none")
  .selectAll("circle")
  .data(cars)
  .join("circle")
    .attr("cx", d => x(d.m
    .attr("cy", d => y(d.h
    .attr("r", 3);
```

Bind one <circle> for every element in cars.

If <circle> doesn't exist, create.
If <circle> exists, update.
If data doesn't exist, remove <circle>.

D3 Modules

Data Parsing / Formatting	(JSON, CSV, …)
Shape Helpers	(arcs, curves, areas, symbols, …)
Scale Transforms	(linear, log, ordinal, …)
Color Spaces	(RGB, HSL, LAB, …)
Animated Transitions	(tweening, easing, …)
Geographic Mapping	(projections, clipping, …)
Layout Algorithms	(stack, pie, force, trees, …)
Interactive Behaviors	(brush, zoom, drag, …)

Chart Typologies
Excel, Google Charts

Visual Analysis Grammars
VizQL, ggplot2, Vega-Lite, Altair

Visualization Grammars
Protovis, D3.js, Vega

Component Architectures
Prefuse, Flare, Improvise, VTK

Graphics APIs
Canvas, OpenGL, Processing, SVG