CIS 4930/6930-002
DATA VISUALIZATION

TASKS & INTERACTION

Paul Rosen
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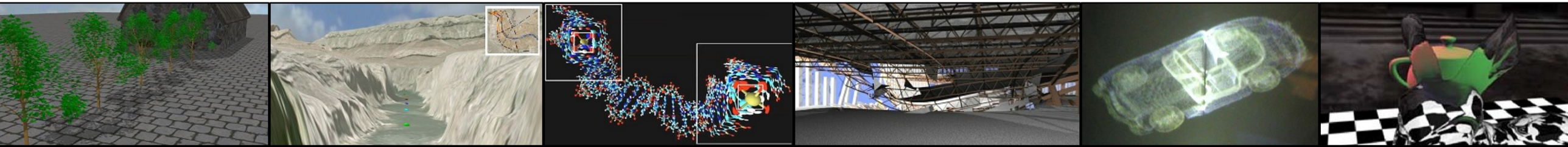
University of South Florida

slides credits Miriah Meyer (U of Utah)



REMINDERS

2/14/2018 – Project 3 Peer Reviews

2/19/2018 – Project 4 due

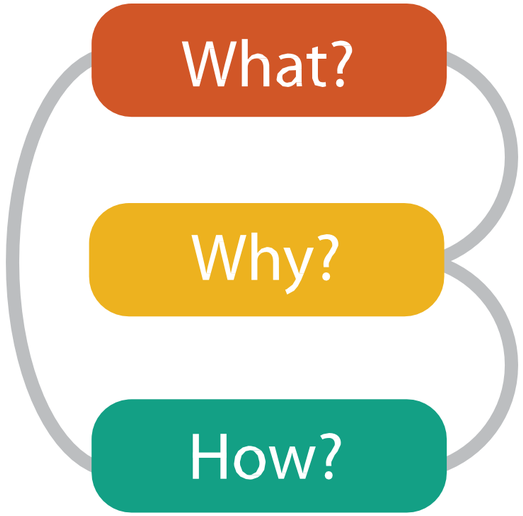
2/21/2018 – Paper Review 2 Due

ANALYSIS: WHAT, WHY, AND HOW

what is shown?

why is the user looking at it?

how is it shown?



abstract vocabulary avoids domain-specific terms

what-why-how analysis framework as scaffold to think systematically about design space

DATA ABSTRACTION

What?

Why?

How?

VISUAL ENCODING

How?

Encode

Arrange
- Express
- Separate
- Order
- Align
- Use

Map
from categorical and ordered attributes
- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion
  Direction, Rate, Frequency, ...

Manipulate

Change

Select

Navigate

Facet

Juxtapose

Partition

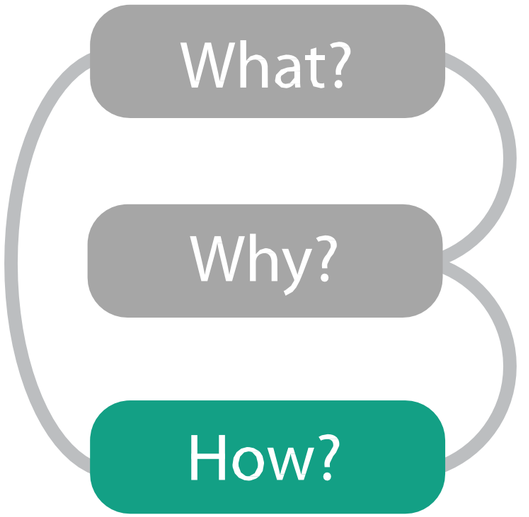
Superimpose

Reduce

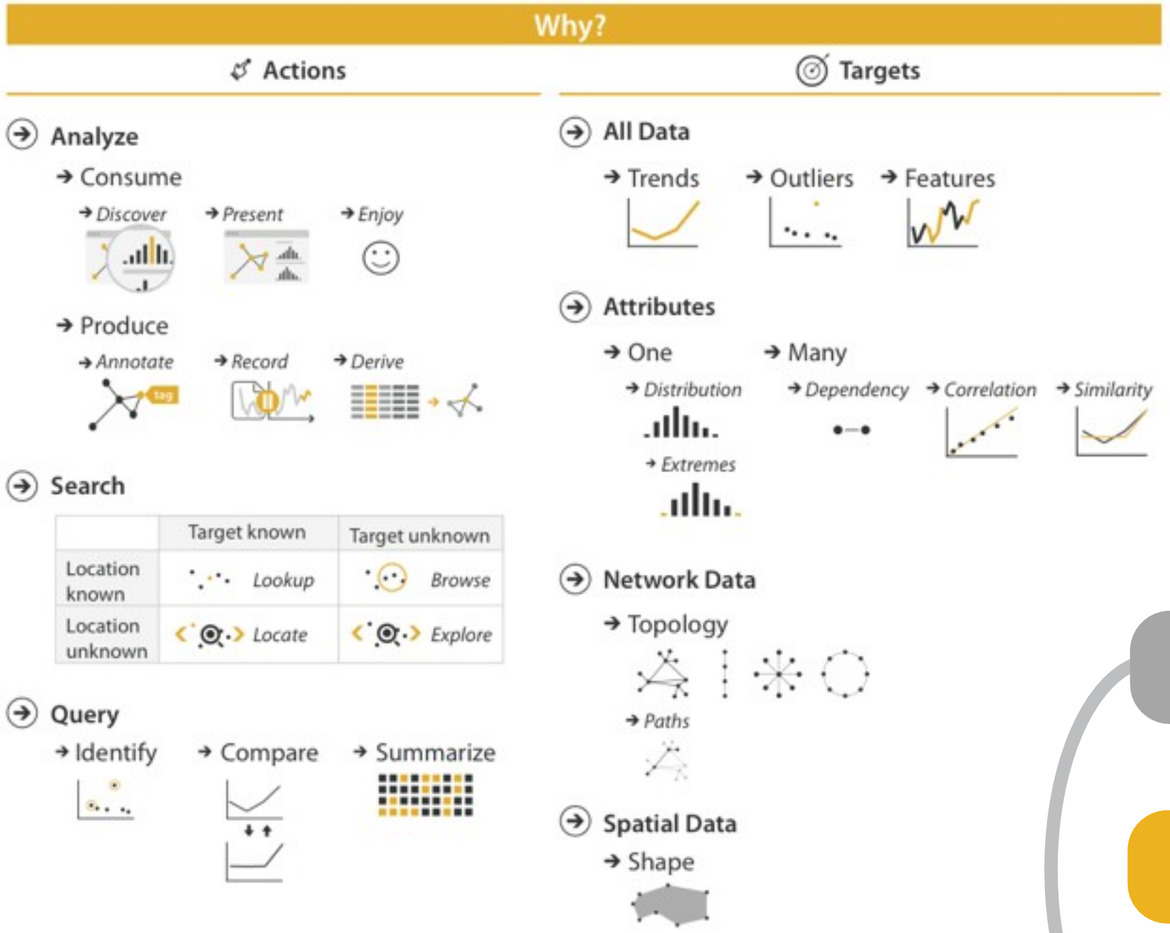
Filter

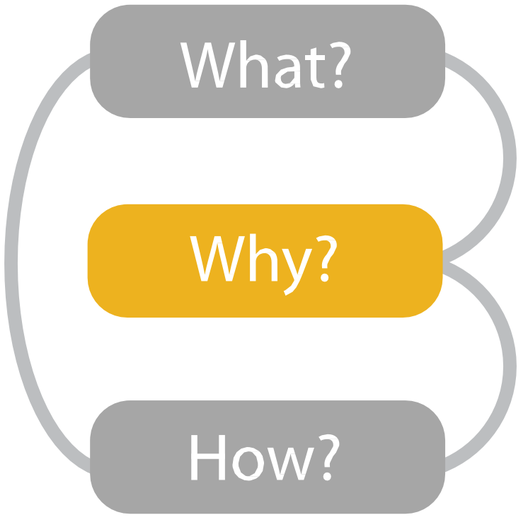
Aggregate

Embed



TASK ABSTRACTION





{ACTION, *TARGET*} PAIRS

discover distribution

compare trends

locate outliers

browse topology

Analyze

{**ACTION**, TARGET}

Search

Query

Analyze

→ Consume

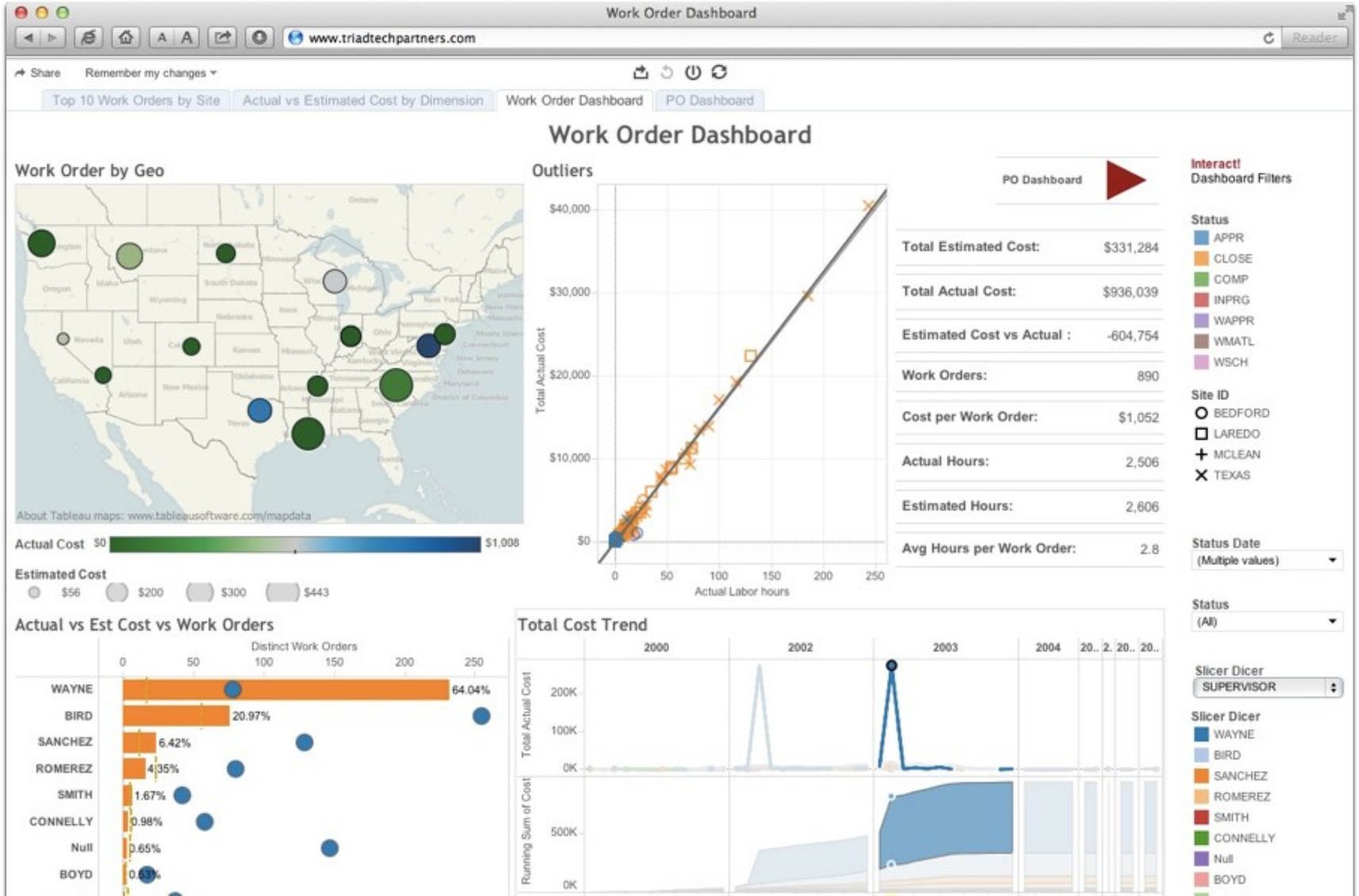
→ *Discover* → *Present* → *Enjoy*

{**ACTION**, TARGET}

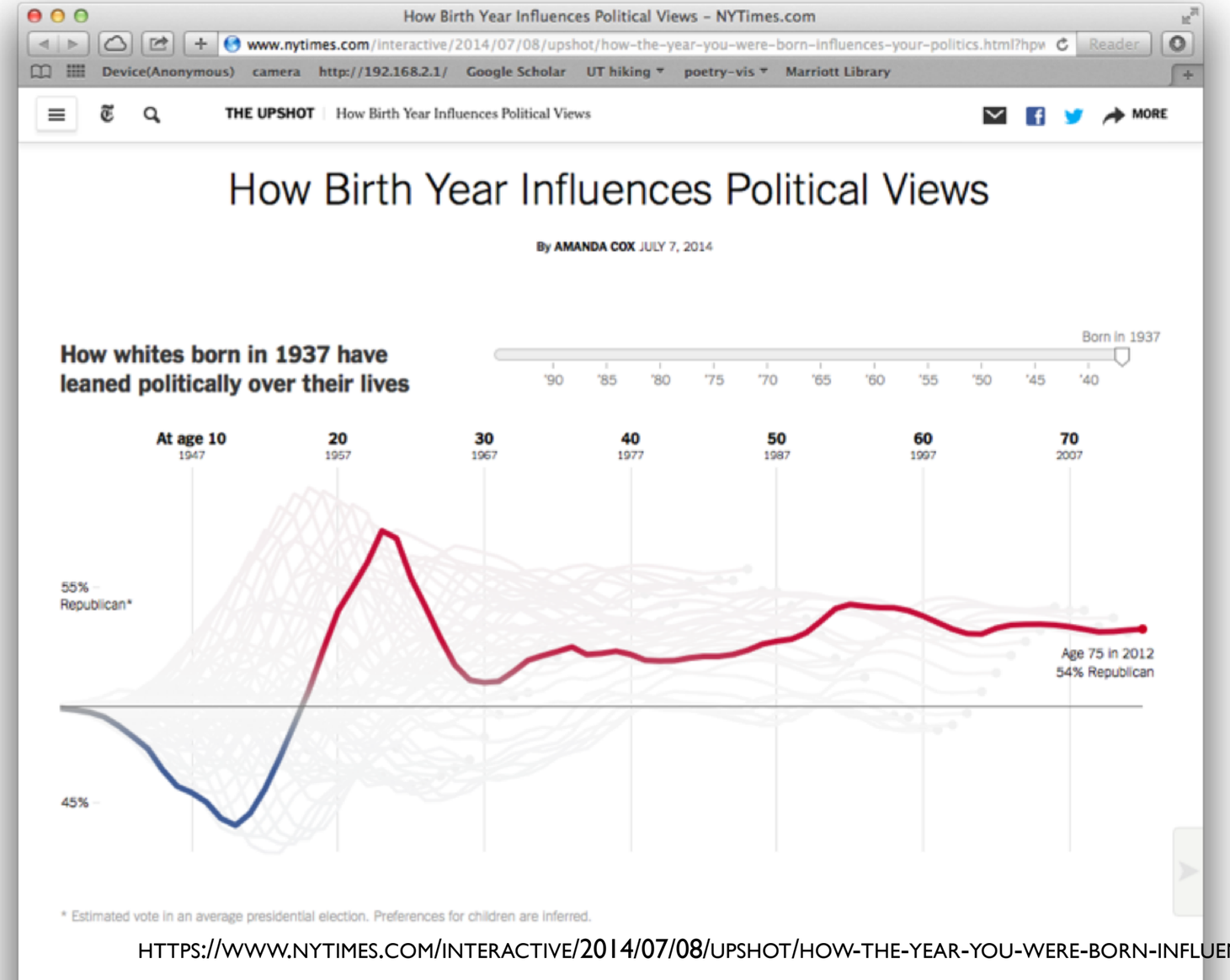
Search

Query

DISCOVER


Work Order Dashboard
www.triadtechpartners.com
Reader
Share
Remember my changes
Top 10 Work Orders by Site
Actual vs Estimated Cost by Dimension
Work Order Dashboard
PO Dashboard
Work Order Dashboard
Work Order by Geo
About Tableau maps: www.tableausoftware.com/mapdata
Actual Cost $0 $1,008
Estimated Cost
$56 $200 $300 $443
Outliers
Total Actual Cost
$40,000
$30,000
$20,000
$10,000
$0
0 50 100 150 200 250
Actual Labor hours
PO Dashboard
Total Estimated Cost: $331,284
Total Actual Cost: $936,039
Estimated Cost vs Actual : -604,754
Work Orders: 890
Cost per Work Order: $1,052
Actual Hours: 2,506
Estimated Hours: 2,606
Avg Hours per Work Order: 2.8
Interact!
Dashboard Filters
Status
APPR
CLOSE
COMP
INPRG
WAPPR
WMATL
WSCH
Site ID
BEDFORD
LAREDO
MCLEAN
TEXAS
Status Date
(Multiple values)
Status
(All)
Slicer Dicer
SUPERVISOR
Slicer Dicer
WAYNE
BIRD
SANCHEZ
ROMEREZ
SMITH
CONNELLY
Null
BOYD
Actual vs Est Cost vs Work Orders
Distinct Work Orders
0 50 100 150 200 250
WAYNE 64.04%
BIRD 20.97%
SANCHEZ 6.42%
ROMEREZ 4.35%
SMITH 1.67%
CONNELLY 0.98%
Null 0.65%
BOYD 0.63%
Total Cost Trend
2000 2002 2003 2004 20.. 2.. 20.. 20..
Total Actual Cost
200K
100K
0K
Running Sum of Cost
500K
0K

PRESENT



HTTPS://WWW.NYTIMES.COM/INTERACTIVE/2014/07/08/UPSHOT/HOW-THE-YEAR-YOU-WERE-BORN-INFLUENCES-YOUR-POLITICS.HTML

ENJOY

HTTP://HINT.FM/WIND/

{**ACTION**, TARGET}

- **Analyze**
  - Consume
    - *Discover*
    - *Present*
    - *Enjoy*

  - Produce
    - *Annotate*
    - *Record*
    - *Derive*

- **Search**
- **Query**

ANNOTATE & RECORD

HTTP://VIS.STANFORD.EDU/FILES/SENSE.US/

{**ACTION**, TARGET}

Analyze

Consume

→ *Discover* → *Present* → *Enjoy*

Produce

→ *Annotate* → *Record* → *Derive*

Search

	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

Query

{**ACTION**, TARGET}

Analyze

Consume

- *Discover*
- *Present*
- *Enjoy*

Produce

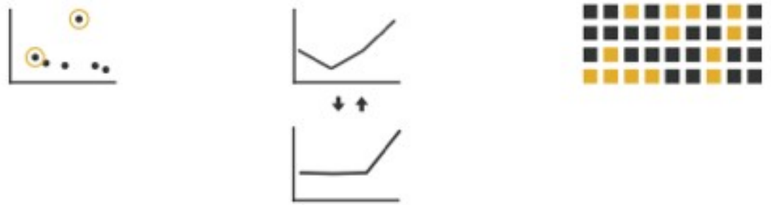
- *Annotate*
- *Record*
- *Derive*

Search

	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

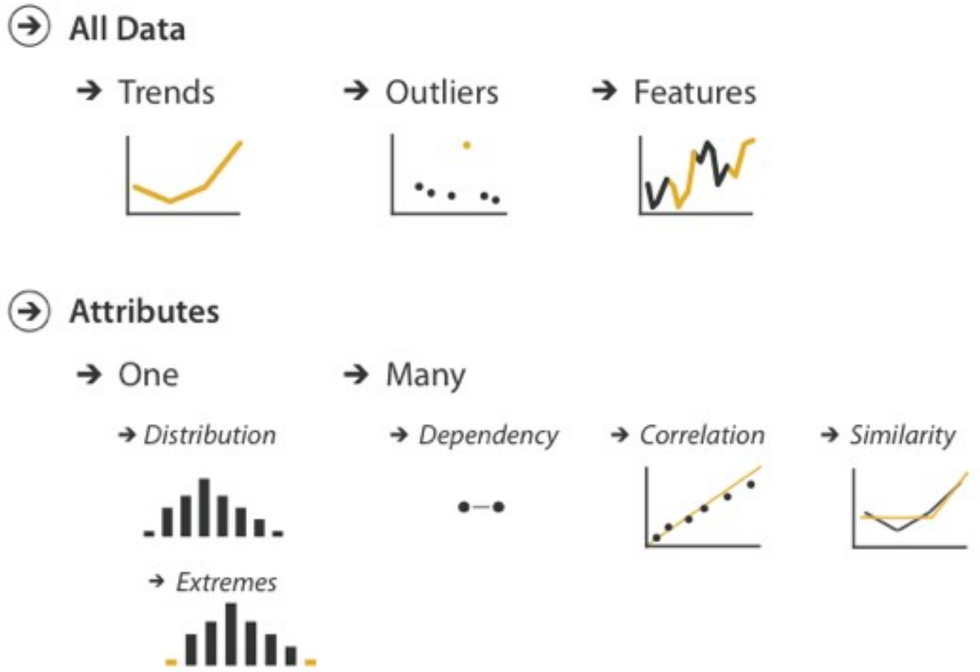
Query

- Identify
- Compare
- Summarize



{ACTION, **TARGET**}

{ACTION, **TARGET**}



{ACTION, **TARGET**}

- **All Data**
  - Trends
  - Outliers
  - Features

- **Attributes**
  - One
    - *Distribution*
    - *Extremes*
  - Many
    - *Dependency*
    - *Correlation*
    - *Similarity*

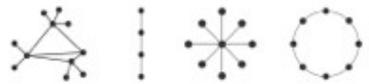
- **Network Data**
  - Topology
  - *Paths*

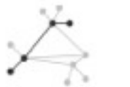
{ACTION, **TARGET**}

- All Data
  - Trends
  - Outliers
  - Features

- Attributes
  - One
    - *Distribution*
    - *Extremes*
  - Many
    - *Dependency*
    - *Correlation*
    - *Similarity*

- Network Data
  - Topology
  - *Paths*





- Spatial Data
  - Shape

WHY DOES THIS MATTER?

A Design Space of Visualization Tasks

Hans-Jörg Schulz, Thomas Nocke, Magnus Heitzler, and Heidrun Schumann

Abstract—Knowledge about visualization tasks plays an important role in choosing or building suitable visual representations to pursue them. Yet, tasks are a multi-faceted concept and it is thus not surprising that the many existing task taxonomies and models all describe different aspects of tasks, depending on what these task descriptions aim to capture. This results in a clear need to bring these different aspects together under the common hood of a general design space of visualization tasks, which we propose in this paper. Our design space consists of five design dimensions that characterize the main aspects of tasks and that have so far been distributed across different task descriptions. We exemplify its concrete use by applying our design space in the domain of climate impact research. To this end, we propose interfaces to our design space for different user roles (developers, authors, and end users) that allow users of different levels of expertise to work with it.

Index Terms—Task taxonomy, design space, climate impact research, visualization recommendation

1 Introduction

As the field of information visualization matures, a phase of consolidation sets in that aims to pull together multiple individual works of research under a common conceptual hood. This hood can take on different shapes and forms, one of which is the *design space*. Such a design space realizes a descriptive generalization that permits to specify a concrete instance – be it a layout [8], a visualization [46], or a combination of visualizations [28] – by making design choices along a number of independent design dimensions. Even last year's InfoVis conference recognized the increasing importance of design spaces by dedicating an entire session to them.

Yet, information visualization is more than the visual representation alone. It also takes into account the tasks the user wishes to pursue with the visual representation. The literature contains a wealth of classifications, taxonomies, and frameworks that describe these tasks: lists of verbal task descriptions, mathematical task models, domain-specific task collections, and procedural task combinations into workflows. All of these serve the respective purpose well for which they have been developed. However, the research question of how to consolidate them under the hood of one common design space is still open, even though it has been shown on a smaller scale that such a combination into a common framework can be a useful endeavor [9, 21].

In this paper, we aim to give a first answer to this research question by contributing such a design space for visualization tasks. This contribution is twofold. First, it derives an abstract design space that brings together the different aspects of the existing task taxonomies and models. It serves to clarify the somewhat fuzzy notion of visual

a visualization task design space for climate impact research based on structured interviews with eight domain experts and two visualization developers. This design space is then utilized to recommend visualizations that are suitable to pursue a given task in that field.

The remainder of this paper is organized as follows: The related work is summarized in Section 2 and from its discussion, we derive our task design space in Section 3. We then debate its properties, limitations, and applications in Section 4. This also includes examples of how some of the existing task taxonomies can be expressed as parts of our design space. After this conceptual part, Section 5 details the use case example of how to apply the general design space to the application domain of climate impact research and how to draw concrete benefits from it. With this example, we aim to show a feasible way for the adaptation of the design space that can be transferred to other application domains as well. We conclude this paper by briefly sharing our personal experience from working with the design space and pointing out directions for future work in Section 6.

2 Related Work

The concept of *tasks* exhibits numerous facets that are also reflected in the existing body of research on that topic. Commonly, *visualization tasks* are understood as activities to be carried out interactively on a visual data representation for a particular reason. The investigation of visualization tasks has the aim to **establish recurring tasks** in order to use the knowledge about them for improving the **design and evaluation of visualizations**. Existing research for both of these aspects is

A Design Space of Visualization Tasks

Hans-Jörg Schulz, Thomas Nocke, Magnus Heitzler, and Heidrun Schumann

Abstract—Knowledge about visualization tasks plays an important role in choosing or building suitable visual representations to pursue them. Yet, tasks are a multi-faceted concept and it is thus not surprising that the many existing task taxonomies and models all describe different aspects of tasks, depending on what these task descriptions aim to capture. This results in a clear need to bring these different aspects together under the common hood of a general design space of visualization tasks, which we propose in this paper. Our design space consists of five design dimensions that characterize the main aspects of tasks and that have so far been distributed across different task descriptions. We exemplify its concrete use by applying our design space in the domain of climate impact research. To this end, we propose interfaces to our design space for different user roles (developers, authors, and end users) that allow users of different levels of expertise to work with it.

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1 Introduction

As the field of information visualization matures, a phase of consoli-

a visualization task design space for climate impact research based on structured interviews with eight domain experts and two visualization

- WHY is a task pursued? This specifies the task's **goal**.
- HOW is a task carried out? This specifies the task's **means**.
- WHAT does a task seek? This specifies the data **characteristics**.
- WHERE in the data does a task operate? This specifies the **target**, as well as the **cardinality** of data entities within that target.
- WHEN is a task performed? This specifies the order of tasks.
- WHO is executing a task? This specifies the (type of) user.

brings together the different aspects of the existing task taxonomies and models. It serves to clarify the somewhat fuzzy notion of visual-

to use the knowledge about them for improving the **design and evaluation of visualizations**. Existing research for both of these aspects is

Using Interaction

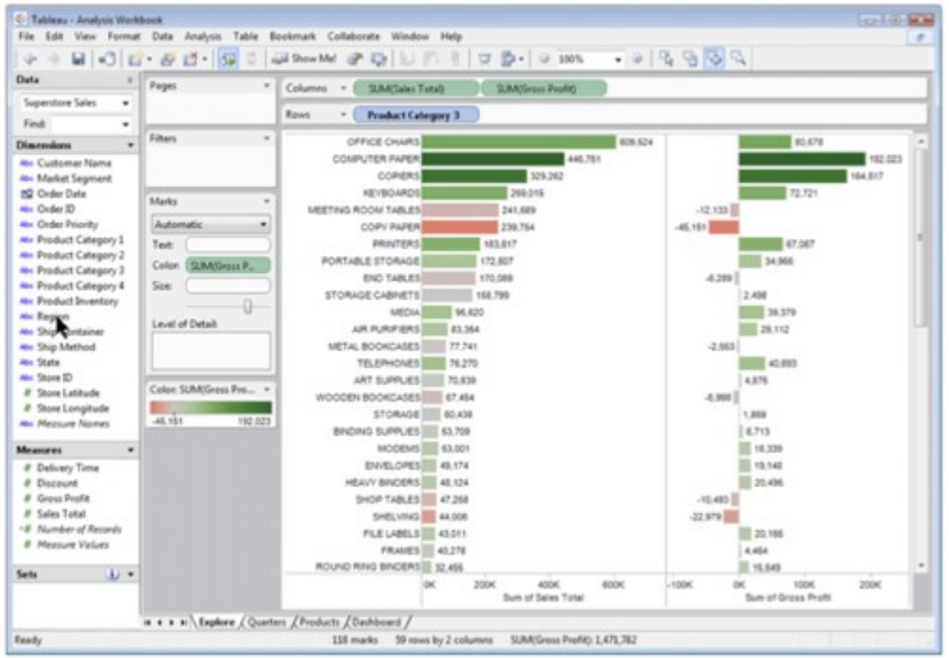
change over time

selection

highlighting

navigation

CHANGE OVER TIME



CHANGE ENCODING

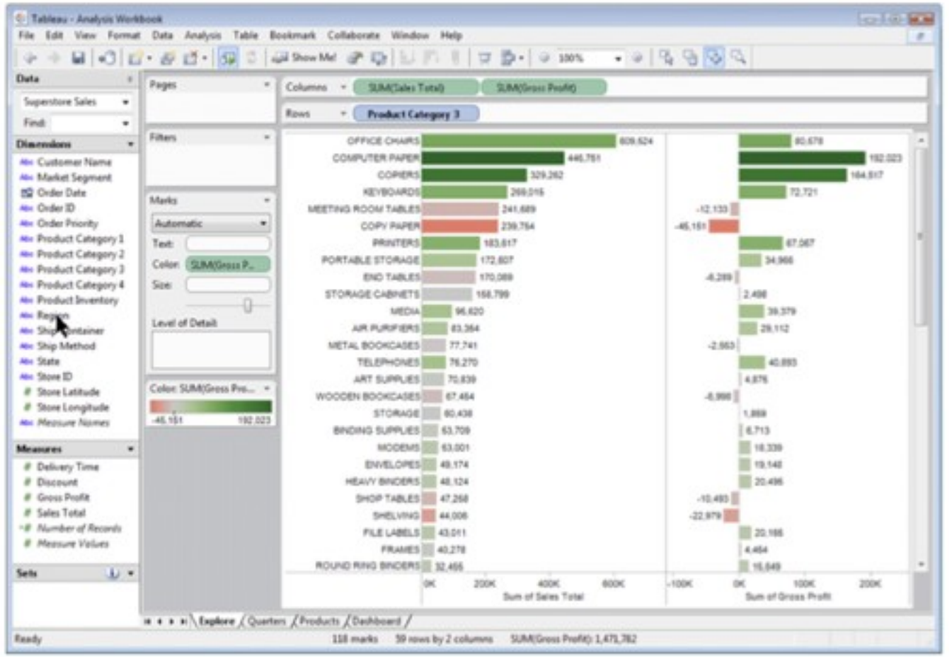


Tableau - Analysis Workbook
File Edit View Format Data Analysis Table Bookmark Collaborate Window Help
Data
Superstore Sales
Dimensions
Customer Name
Market Segment
Order Date
Order ID
Order Priority
Product Category 1
Product Category 2
Product Category 3
Product Category 4
Product Inventory
Region
Ship Container
Ship Method
State
Store ID
Store Latitude
Store Longitude
Measure Names
Measures
Delivery Time
Discount
Gross Profit
Sales Total
Number of Records
Measure Values
Sets
Pages
Filters
Marks
Automatic
Text
Color SUM(Gross P...
Size
Level of Detail
Color: SUM(Gross Pro...
-46,151
192,023
Columns SUM(Sales Total) SUM(Gross Profit)
Rows Product Category 3
OFFICE CHAIRS 609,524 80,678
COMPUTER PAPER 446,751 192,023
COPIERS 329,262 164,817
KEYBOARDS 269,016 72,721
MEETING ROOM TABLES 241,689 -12,133
COPY PAPER 239,754 -46,151
PRINTERS 183,617 67,067
PORTABLE STORAGE 172,807 34,966
END TABLES 170,089 -6,289
STORAGE CABINETS 168,799 2,498
MEDIA 96,620 39,379
AIR PURIFIERS 83,364 29,112
METAL BOOKCASES 77,741 -2,553
TELEPHONES 76,270 40,893
ART SUPPLIES 70,839 4,876
WOODEN BOOKCASES 67,484 -8,998
STORAGE 60,438 1,869
BINDING SUPPLIES 53,709 6,713
MODEMS 53,001 18,339
ENVELOPES 49,174 19,148
HEAVY BINDERS 48,124 20,496
SHOP TABLES 47,268 -10,483
SHELVING 44,006 -22,979
FILE LABELS 43,011 20,166
FRAMES 40,278 4,464
ROUND RING BINDERS 32,456 15,649
0K 200K 400K 600K
Sum of Sales Total
-100K 0K 100K 200K
Sum of Gross Profit
Explore Quarters Products Dashboard
Ready
118 marks 39 rows by 2 columns SUM(Gross Profit): 1,471,782

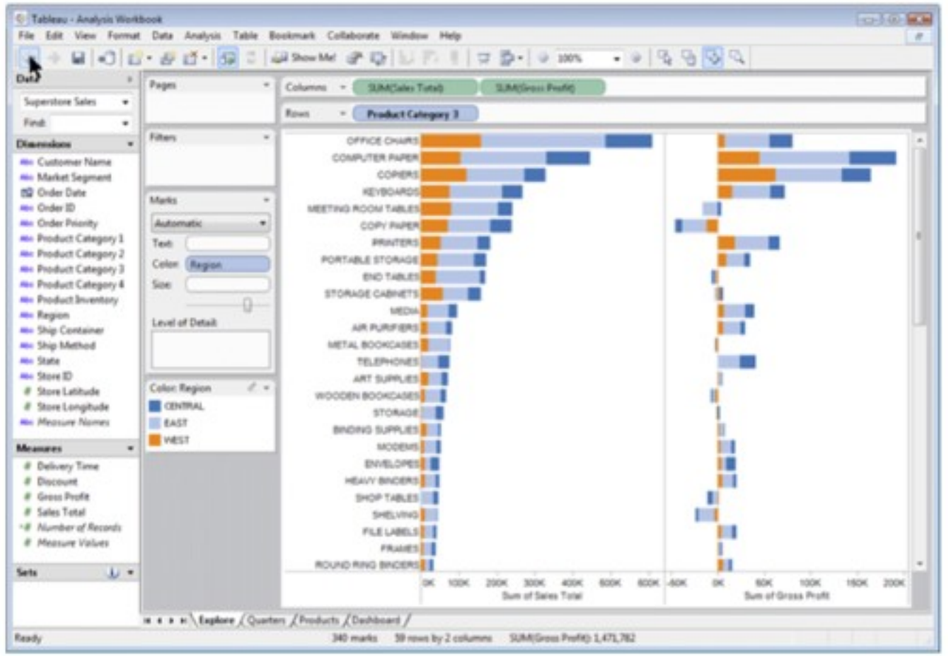


Tableau - Analysis Workbook
File Edit View Format Data Analysis Table Bookmark Collaborate Window Help
Data
Superstore Sales
Dimensions
Customer Name
Market Segment
Order Date
Order ID
Order Priority
Product Category 1
Product Category 2
Product Category 3
Product Category 4
Product Inventory
Region
Ship Container
Ship Method
State
Store ID
Store Latitude
Store Longitude
Measure Names
Measures
Delivery Time
Discount
Gross Profit
Sales Total
Number of Records
Measure Values
Sets
Pages
Filters
Marks
Automatic
Text
Color Region
Size
Level of Detail
Color: Region
CENTRAL
EAST
WEST
Columns SUM(Sales Total) SUM(Gross Profit)
Rows Product Category 3
OFFICE CHAIRS
COMPUTER PAPER
COPIERS
KEYBOARDS
MEETING ROOM TABLES
COPY PAPER
PRINTERS
PORTABLE STORAGE
END TABLES
STORAGE CABINETS
MEDIA
AIR PURIFIERS
METAL BOOKCASES
TELEPHONES
ART SUPPLIES
WOODEN BOOKCASES
STORAGE
BINDING SUPPLIES
MODEMS
ENVELOPES
HEAVY BINDERS
SHOP TABLES
SHELVING
FILE LABELS
FRAMES
ROUND RING BINDERS
0K 100K 200K 300K 400K 500K 600K
Sum of Sales Total
-60K 0K 60K 100K 150K 200K
Sum of Gross Profit
Explore Quarters Products Dashboard
Ready
340 marks 39 rows by 2 columns SUM(Gross Profit): 1,471,782

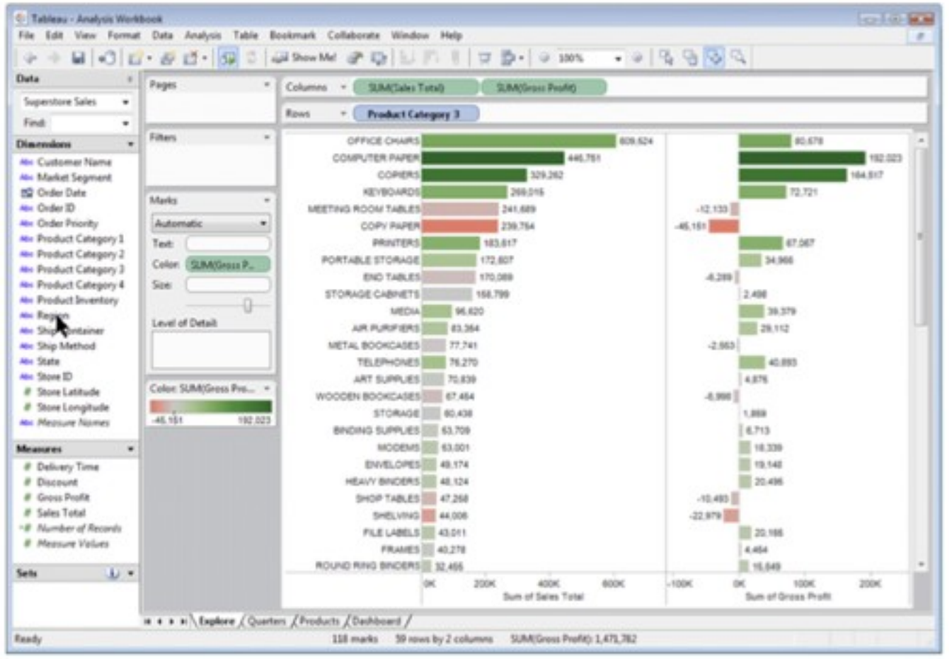


Tableau - Analysis Workbook
Product Category 3
Sum of Sales Total
Sum of Gross Profit

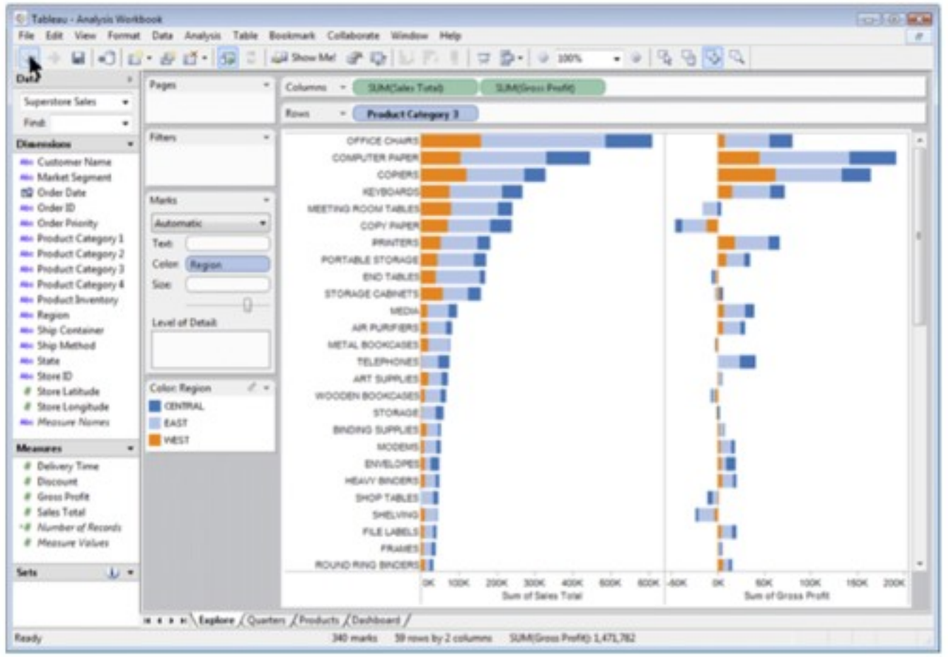


Tableau - Analysis Workbook
Product Category 3
Color: Region
CENTRAL
EAST
WEST
Sum of Sales Total
Sum of Gross Profit

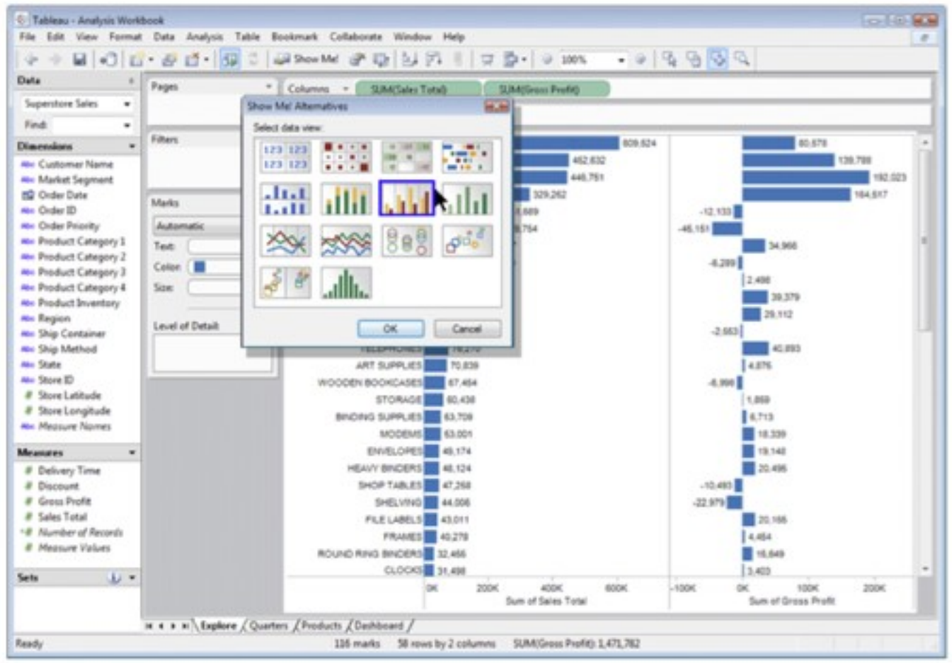


Tableau - Analysis Workbook
Show Me! Alternatives
Select data view:
OK
Cancel
Sum of Sales Total
Sum of Gross Profit

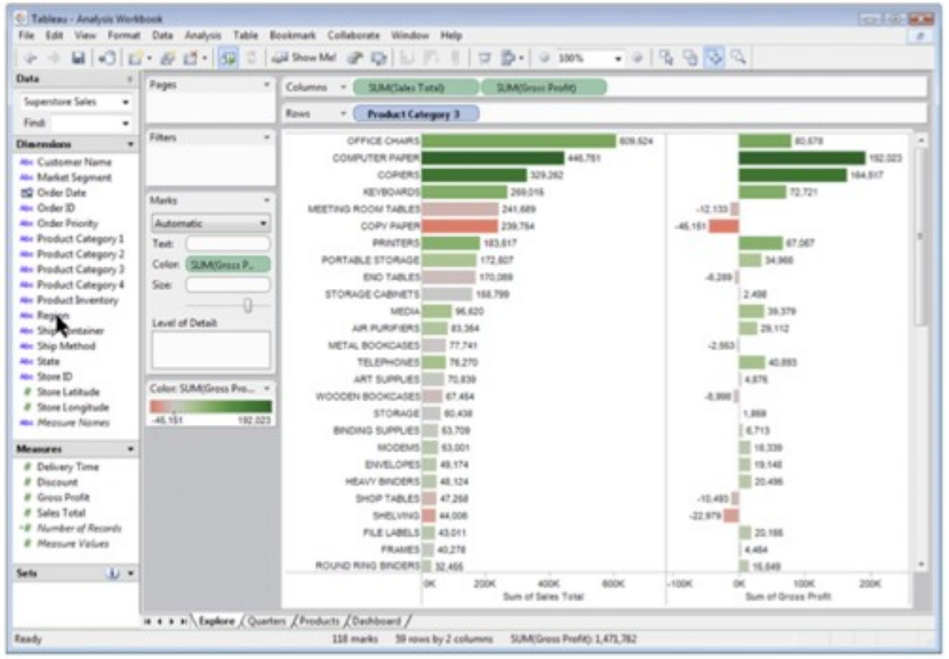


Tableau - Analysis Workbook
Product Category 3
SUM(Sales Total)
SUM(Gross Profit)
Sum of Sales Total
Sum of Gross Profit

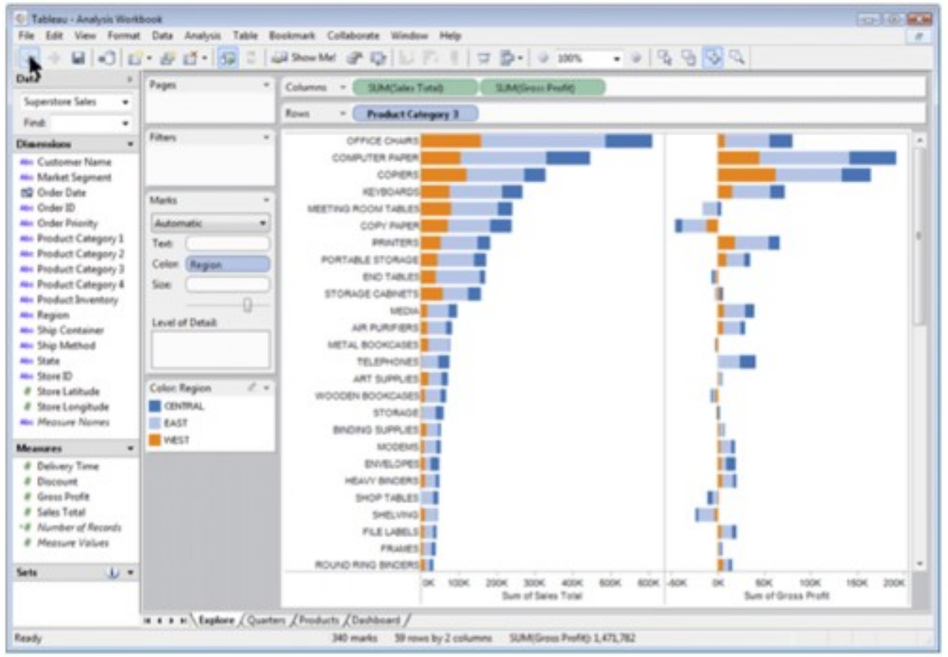


Tableau - Analysis Workbook
Product Category 3
Color: Region
CENTRAL
EAST
WEST
Sum of Sales Total
Sum of Gross Profit

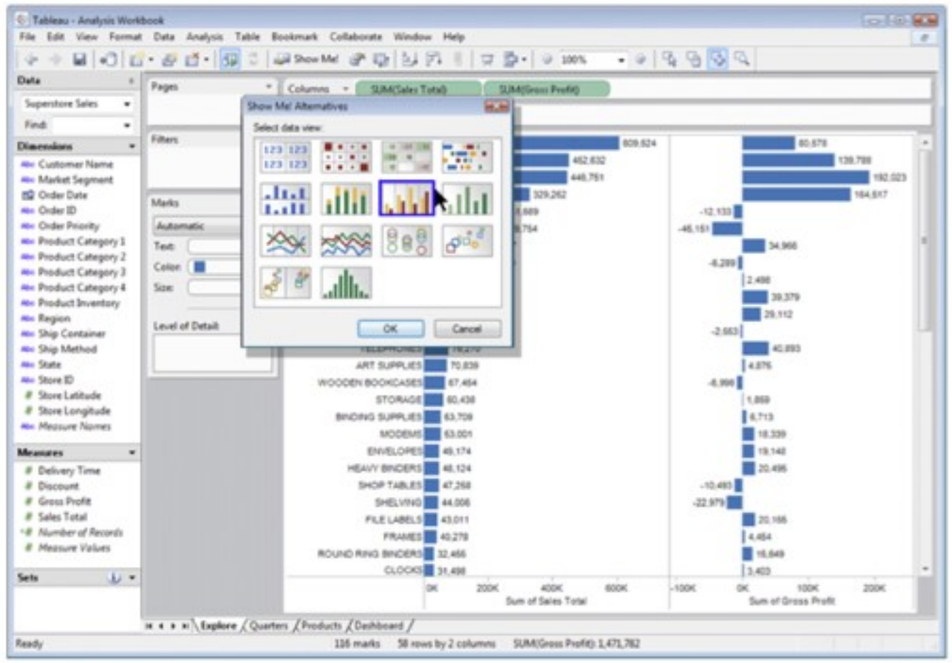


Tableau - Analysis Workbook
Show Me! Alternatives
Select data view:
OK
Cancel
Sum of Sales Total
Sum of Gross Profit

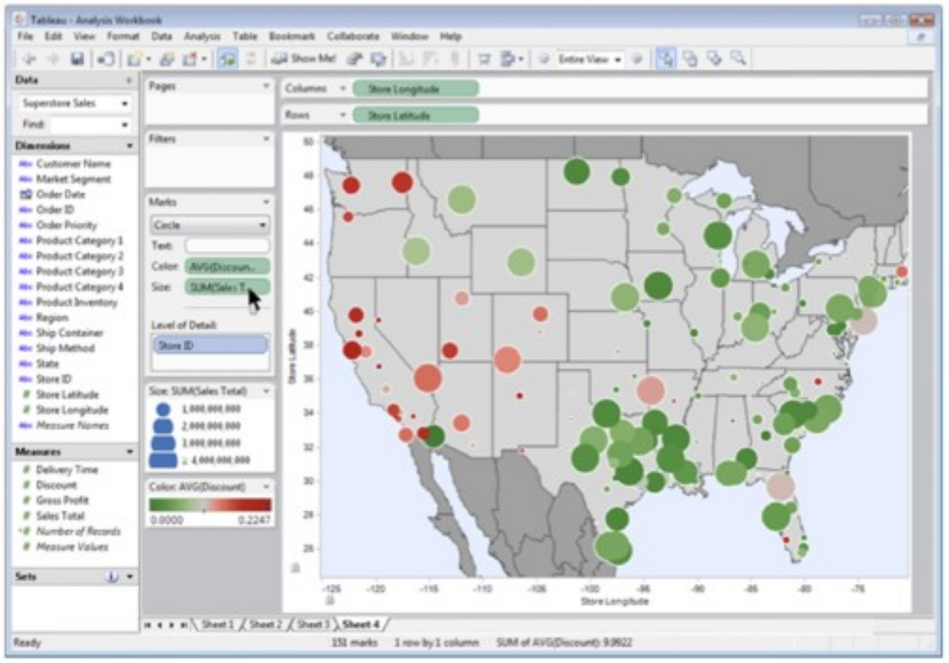
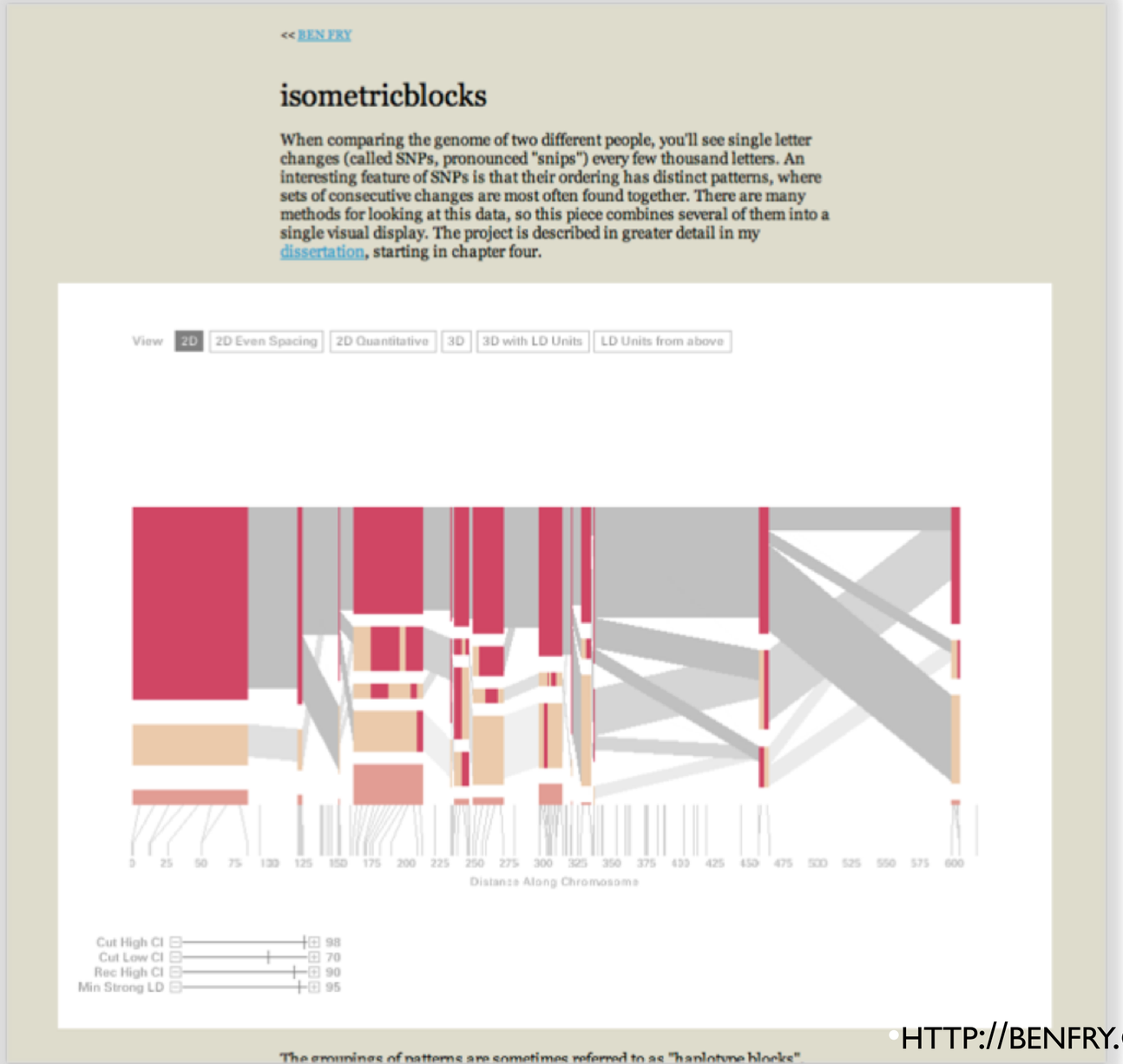


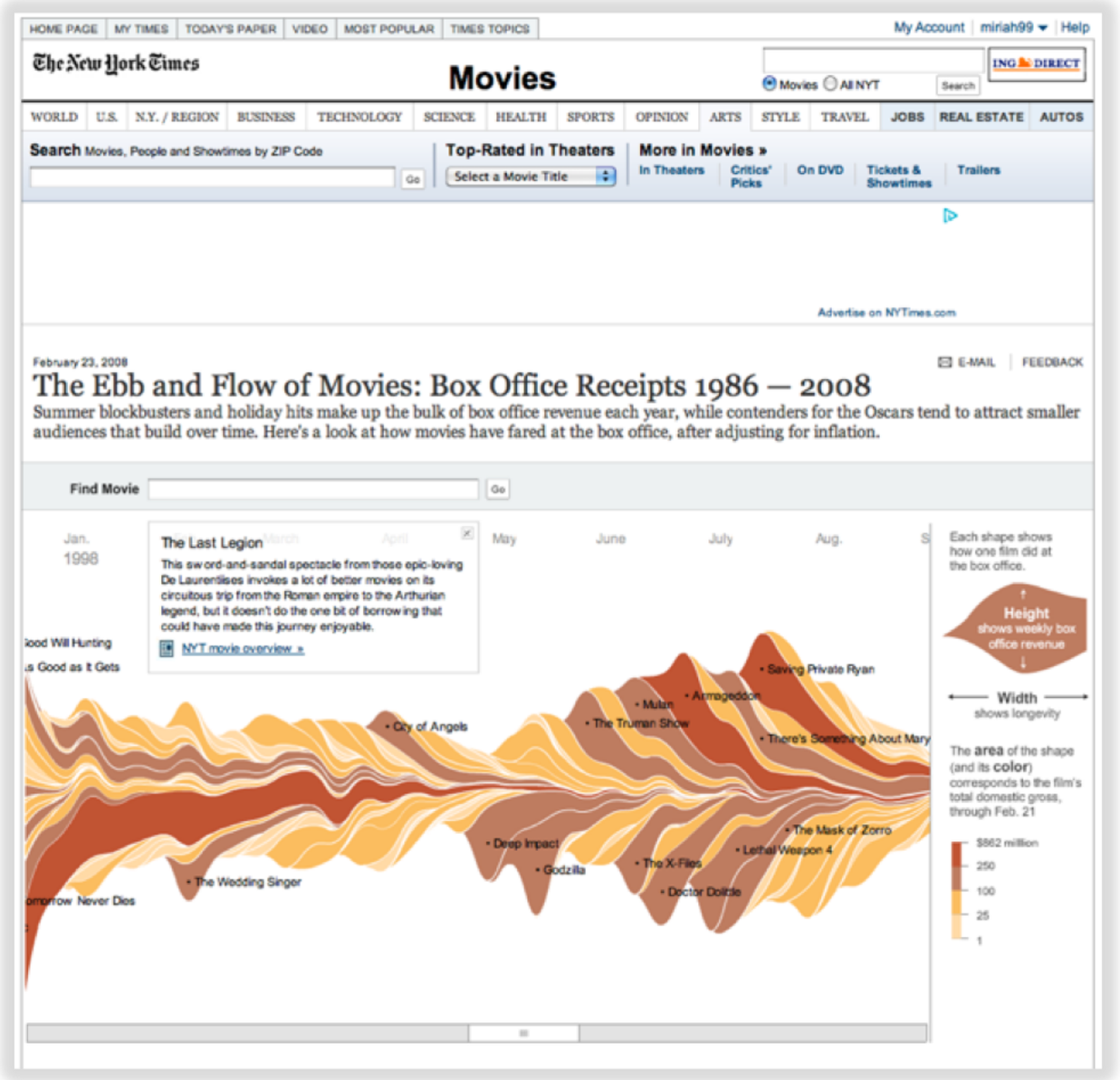
Tableau - Analysis Workbook
Store Longitude
Store Latitude
Size: SUM(Sales Total)
Color: AVG(Discount)
Store Longitude
Store Latitude

ANIMATED TRANSITIONS



HTTP://BENFRY.COM/ISOMETRICBLOCKS/

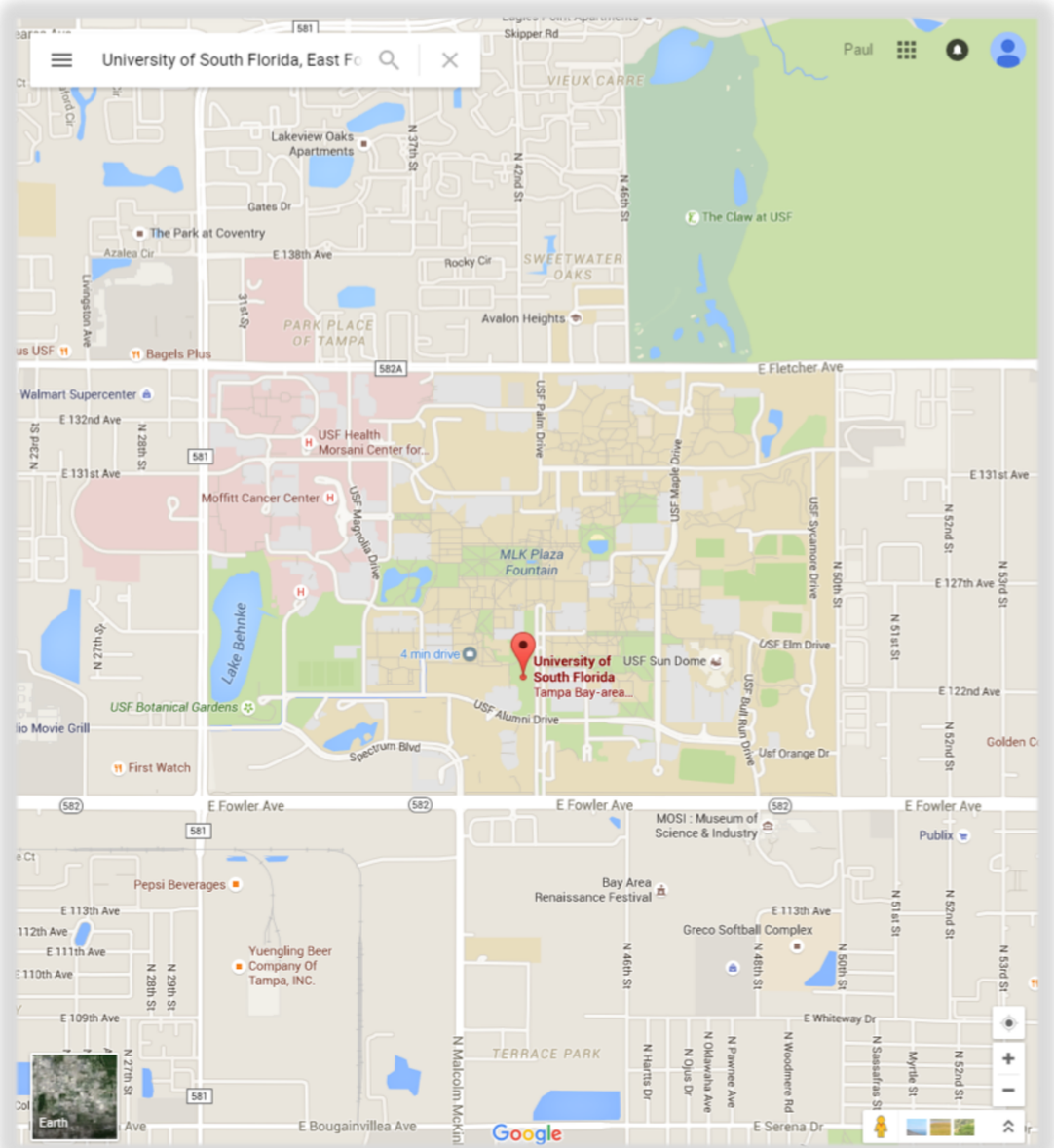
SELECTION & HIGHLIGHTING



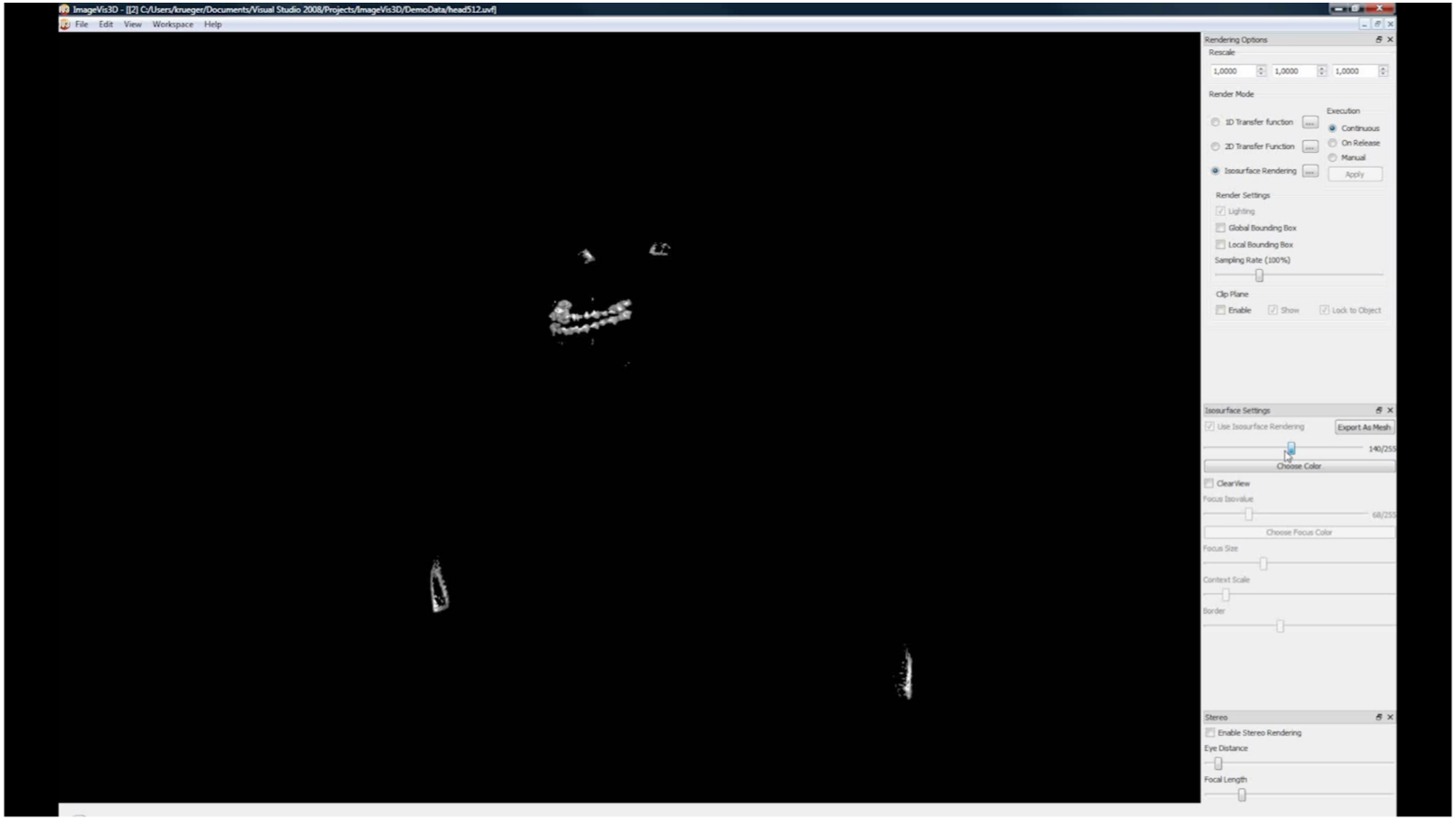
HTTP://WWW.NYTIMES.COM/INTERACTIVE/2008/02/23/MOVIES/20080223_REVENUE_GRAPHIC.HTML

NAVIGATION

PAN (AND TRANSLATE)



ROTATE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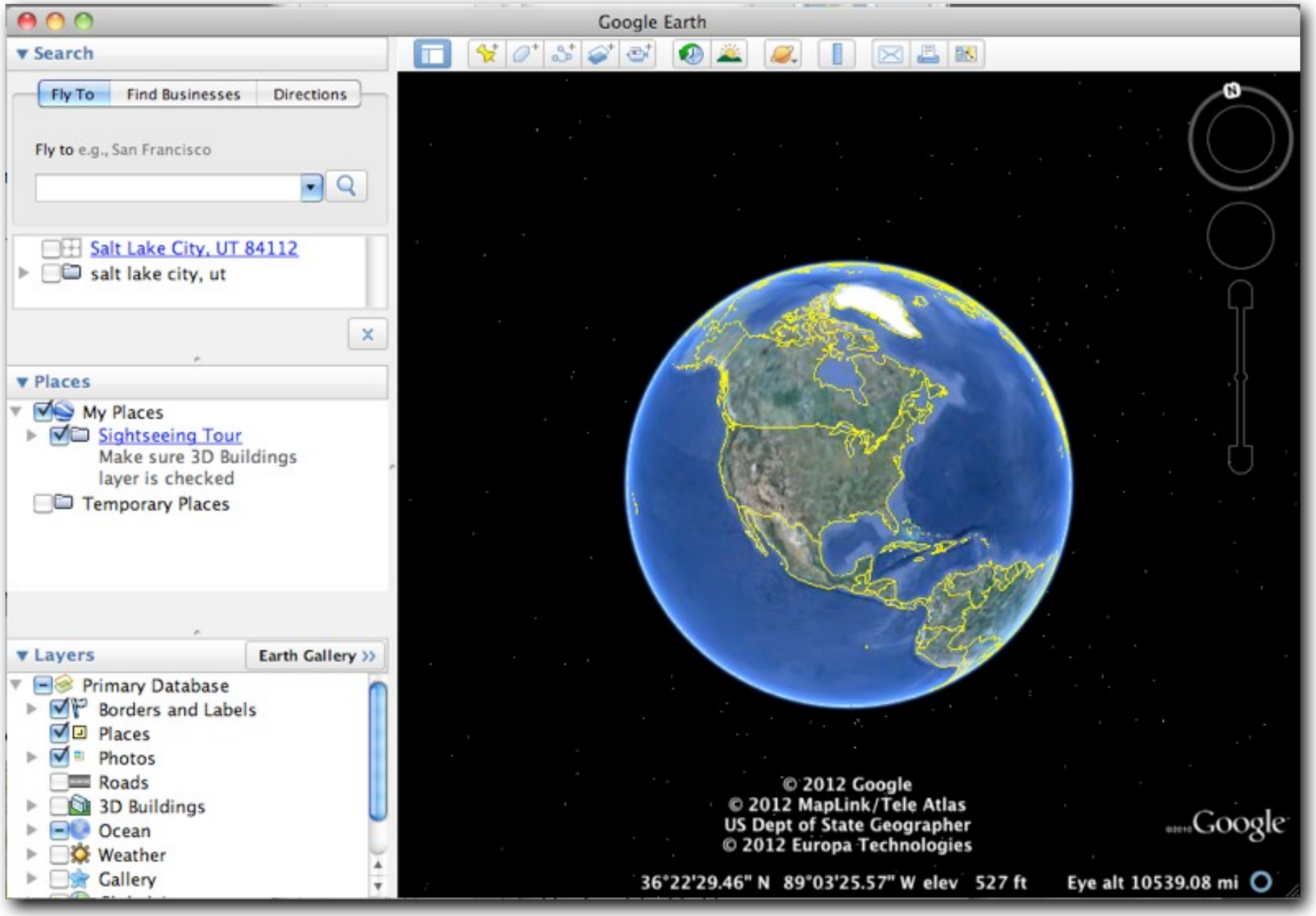
File Edit View Workspace Help
Rendering Options
Rescale
1,0000 1,0000 1,0000
Render Mode
1D Transfer function
2D Transfer Function
Isosurface Rendering
Execution
Continuous
On Release
Manual
Apply
Render Settings
Lighting
Global Bounding Box
Local Bounding Box
Sampling Rate (100%)
Clip Plane
Enable
Show
Lock to Object
Isosurface Settings
Use Isosurface Rendering
Export As Mesh
140/255
Choose Color
ClearView
Focus Isovalue
68/255
Choose Focus Color
Focus Size
Context Scale
Border
Stereo
Enable Stereo Rendering
Eye Distance
Focal Length

GEOMETRIC vs SEMANTIC ZOOMING

GEOMETRIC

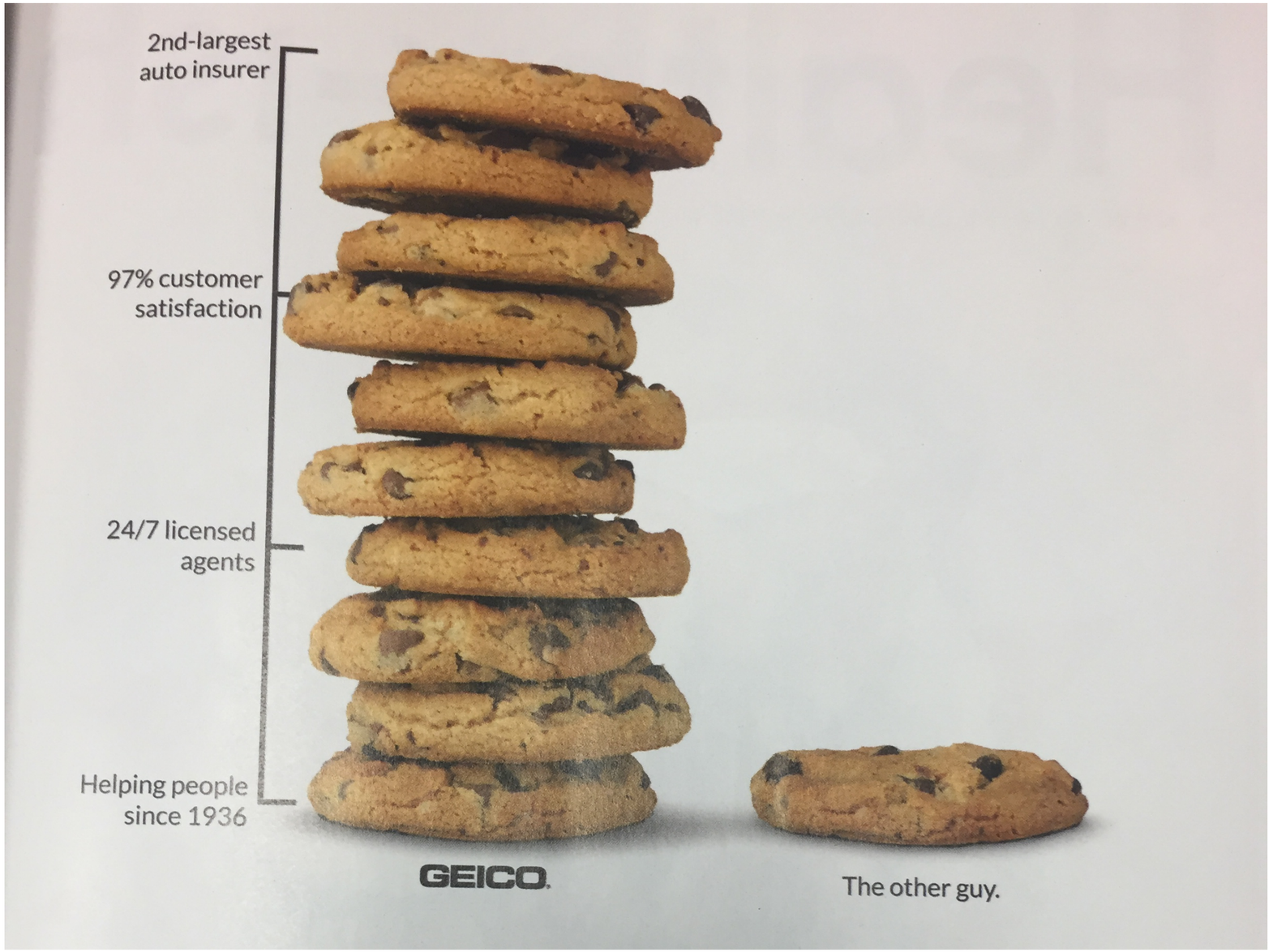

Google Earth
Search
Fly To
Find Businesses
Directions
Fly to e.g., San Francisco
Salt Lake City, UT 84112
salt lake city, ut
Places
My Places
Sightseeing Tour
Make sure 3D Buildings layer is checked
Temporary Places
Layers
Earth Gallery
Primary Database
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
© 2012 Google
© 2012 MapLink/Tele Atlas
US Dept of State Geographer
© 2012 Europa Technologies
Google
36°22'29.46" N 89°03'25.57" W elev 527 ft
Eye alt 10539.08 mi

SEMANTIC

SEMANTIC

LiveRAC: Interactive Visual Exploration of System Management Time-Series Data

Let's Critique Some More Visualizations!



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D = 2.0, A = PI
D = 1.6, A = 0.65*PI

A Ratio = 0.65 (67%/43.5%)
D Ratio = 0.8 (67%/53.6%)

D = 1.05, A = 0.28*PI
D = 0.8, A = 0.16*PI

A Ratio = 0.57 (16%/9.1%)
D Ratio = 0.76 (16%/12.1%)

D = 1.7, A = 0.73*PI
D = 0.8, A = 0.16*PI

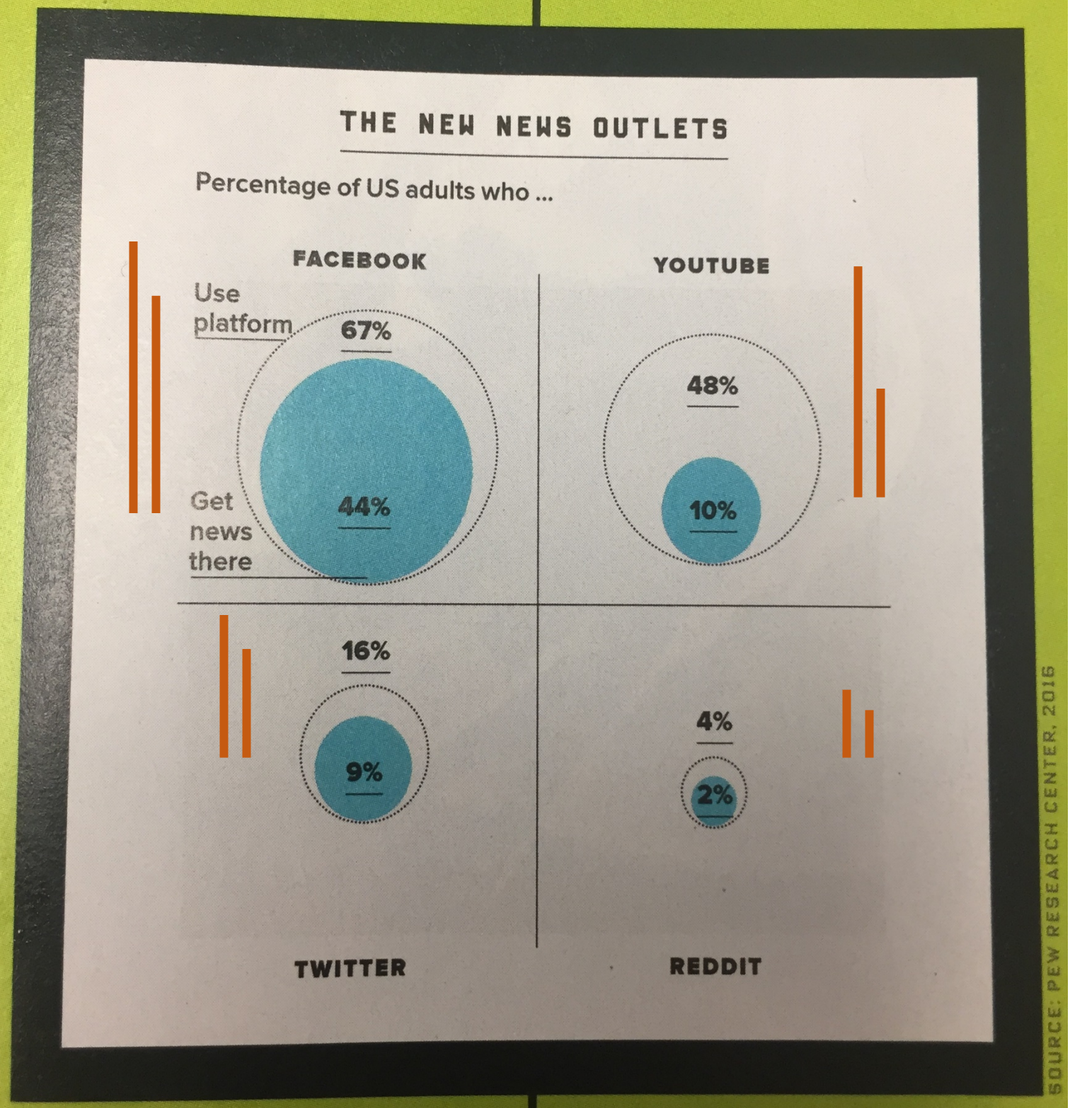
A Ratio = 0.21 (48%/10.1%)
D Ratio = 0.47 (48%/22.6%)

D = 0.5, A = 0.06*PI
D = 0.35, A = 0.03*PI

A Ratio = 0.5 (4%/2%)
D Ratio = 0.7 (4%/2.8%)

alone, or even primarily, for the rise of
abusive behavior. Traditional media—
—recklessly amplified nonsense this
layed shamelessly by Russia's email

for anyone to flag a post if it seems li
If a link that purports to be a news st
it's sent to a human Facebook team
where a group of external fact-che



carefully reported sources like *The*

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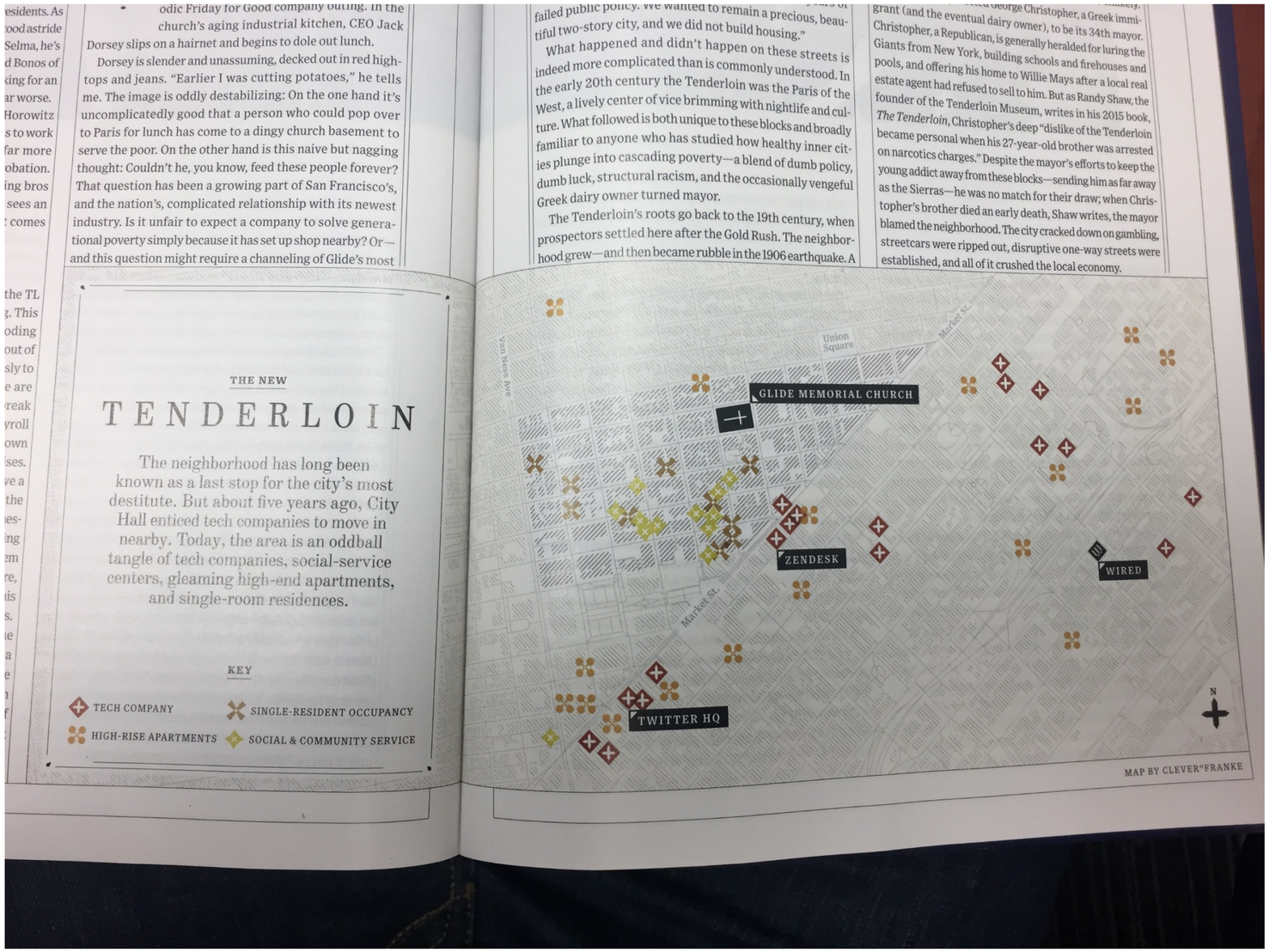

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Recommended Reading

Visualization Analysis & Design: Chapter 3 (pp. 42-65)