Data Visualization (CSCI 490/680)

Multiple Views & Filtering

Dr. David Koop





Interaction Overview





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[Munzner (ill. Maguire), 2014]



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Sorting & Slope Graphs: LineUp

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27.	University of Pittsburgh	United States							ŀ

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[Gratzl et al., 2013]









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Animated Transitions









Animated Transitions











• User Preferences: Staged animation > animation > static transitions



- Animation improves graphical perception
- Staging is better (do axis rescaling before value changes)
- Avoid axis rescaling when possible











Selection

- Selection is often used to initiate other changes
- User needs to select something to drive the next change
- What can be a selection target?
 - Items, links, attributes, (views)
- How?
 - mouse click, mouse hover, touch
 - keyboard modifiers, right/left mouse click, force
- Selection modes:
 - Single, multiple
 - Contiguous?





Highlighting

- Selection is the user action
- Feedback is important!
- How? Change selected item's visual encoding
 - Change color: want to achieve visual popout
 - Add outline mark: allows original color to be preserved

_ _ _ _

- Change size (line width)
- Add motion: marching ants

(1)	Contacts
- 60	Dashboard
Aa	Dictionary
- 83	Dropbox
8	DVD Player
3	Emacs
-0	FaceTime
Æ	FileZilla
2	Firefox









Highlighting

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Interaction Latency

- The Effects of Interactive Latency on Exploratory Visual Analysis, Z. Liu and J. Heer, 2014
- Brush & link, select, pan, zoom



- 500ms added latency causes significant cost - decreases user activity and dataset coverage - reduces rate of observations, generalizations, and hypotheses







Navigation

→ Item Reduction



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→ Attribute Reduction



→ Cut

→ Slice



→ Project



[Munzner (ill. Maguire), 2014]



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Geometric vs. Semantic Zooming

- Geometric zoom: like a camera



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• Semantic zoom: visual appearance of objects can change at different scales







Project Design

- Work on turning your visualization ideas into designs
- Turn in:
 - Three Designs Sketches
 - Progress on Implementation
- Options:
 - Try vastly different options
 - Refine an initial idea
- Due Monday, Nov. 11





Assignment 5

- Farming data with multiple views & interaction
- Add Crop Sales Information





Design Space of Composite Visualization

- Composite visualization views (CVVs)
 - Includes Coordinated multiple views (CMV)
 - + More!
- Design Patterns:
 - Juxtaposition: side-by-side
 - Superimposition: layers
 - Overloading: vis meshed with another
 - Nesting: vis inside a vis (recursive vis)
 - Integration: "merge" views + links

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[W. Javed and N. Elmqvist, 2012]



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Juxtaposition



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Juxtaposition



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Juxtaposition Guidelines

- Benefits:
 - without interference
 - Easy to implement
- Drawbacks:
 - objects are selected
- combined.

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- The component visualizations are independent and can be composed

- Implicit visual linking is not always easy to see, particularly when multiple

- Space is divided between the views, yielding less space for each view

• Applications: Use for heterogeneous datasets consisting of many different types of data, or for where different independent visualizations need to be

[W. Javed and N. Elmqvist, 2012]





Integration



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Integration



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[VisLink, Collins and Carpendale, 2007]





Integration



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Integration Guidelines

- Benefits:
 - components
 - separate
- Drawbacks:
 - Extra visual clutter added to the overall view
 - Display space is split between the views
- Applications: Use for heterogeneous datasets where correlation and comparisons between views is particularly important.

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- Easy to perceive one-to-one and one-to-many relations between items in

- Visualizations are less independent compared to juxtaposed views, but still

- Some dependencies exist between views to allow for the visual linking



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Superimposition



is composed of:

Ireland

Portugal

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Superimposition



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[GeoSpace, I. Lokuge and S. Ishizaki, 1995]









Superimposition Guidelines

- Benefits:
 - Allows direct comparison in the same visual space.
- Drawbacks:
 - May cause occlusion and high visual clutter.
 - The client visualization must share the same spatial mapping as the host visualization.
- Applications: In settings where comparison is common, or where the component visualization views need to be as large as possible (potentially the entire available space).

[W. Javed and N. Elmqvist, 2012]









Overloading













Overloading



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[Links on Treemaps, J.-D. Fekete et al., 2003]









Overloading Guidelines

- Benefits:
 - as the host visualization
 - This also yield more flexibility and control over visual clutter
- Drawbacks:
 - Visual clutter is increased
 - Visual design dependencies between components are significant
- yield a compact (and complex) result.

- The client visualization does not have to share the same coordinate space

Applications: Situations where one visualization can be folded into another to

[W. Javed and N. Elmqvist, 2012]











Nesting

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Nesting



Nesting Guidlines

- Benefits:
 - Very compact representation
 - Easy correlation
- Drawbacks:
 - Limited space for the client visualizations
 - Clutter is high
 - Visual design dependencies are high
- Applications: Situations that call for augmenting a particular visual representation with additional mapping

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[W. Javed and N. Elmqvist, 2012]

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Design Space

- Visualizations: the techniques or idioms used
- Spatial relation: relationship between visual structures in display space
- Data relation: visual relationship between items in different views
 - None: No relation
 - Item-item: One-to-one
 - Item-group: One-to-many
 - Item-dimension: Item in one view is a scale in another

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[W. Javed and N. Elmqvist, 2012]

Summary

Technique	Visualization A	Visualization B	Spatial Relation	Data Relation
ComVis [24] (Figure 2)	any	any	juxtapose	none
Improvise [39] (Figure 3)	any	any	juxtapose	none
Jigsaw [36]	any	any	juxtapose	none
Snap-Together [30]	any	any	juxtapose	none
semantic substrates [34] (Figure 4)	node-link	node-link	juxtapose	item-item
VisLink [11] (Figure 5)	radial graph	node-link	juxtapose	item-item
Napoleon's March on Moscow [37]	time line view	area visualization	juxtapose	item-item
Mapgets [38] (Figure 6)	map	text	superimpose	item-item
GeoSpace [22] (Figure 7)	map	bar graph	superimpose	item-item
3D GIS [8]	map	glyphs	superimpose	item-item
Scatter Plots in Parallel Coordinates [45] (Figure 8)	parallel coordinate	scatterplot	overload	item-dimensior
Graph links on treemaps [14] (Figure 9)	treemap	node-link	overload	item-item
SparkClouds [21]	tag cloud	line graph	overload	item-item
ZAME [13] (Figure 10)	matrix	glyphs	nested	item-group
NodeTrix [17] (Figure 11)	node-link	matrix	nested	item-group
TimeMatrix [44]	matrix	glyphs	nested	item-group
GPUVis [25]	Scatterplot	glyphs	nested	item-group

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[W. Javed and N. Elmqvist, 2012]





Summary (Scatterplot + Bar Chart)



(a) Juxtaposed views.





(d) Overloaded views.



(b) Integrated views.



(c) Superimposed views.









- Facet (noun and verb)
 - particular aspect or feature of something
 - to split
- Partition visualization into views/layers
 - Either juxtapose (side-by-side), superimpose (layer), nest, etc.
 - Depends on data and encoding
 - Generally, superimposing does not scale as well
 - Multiple views eats display space (either large screens or small visualizations)







→ Share Encoding: Same/Different

→ Linked Highlighting



→ Share Data: All/Subset/None



Share Navigation



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[Munzner (ill. Maguire), 2014]











Multiform



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	Oceana MI	0.157	26873 14.00	02.66	Centre Hall Chesaning	PA Centre County 1079 MI Saginaw County 2548
	Ogemaw MI Ontonagon MI	0.168	7818 21.60	02.49 01.57	Dearborn	MI Wayne County 97775
	Osceola MI Osceola MI	0.167	23197 14.20 9418 20.20	02.53	Detroit	MI Wayne County 951270
	Otsego MI	0.155	23301 13.70	02.59	Ecorse Flat Rock	MI Wayne County 11229 MI Wayne County 8488
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Multiform Views

- The same data visualized in different ways
- Does not need to be a totally different encoding (all choices need not be disjoint), e.g. horizontal positions could be the same
- One view becomes cluttered with too many attributes
- Consumes more screen space
- Allows greater separability between channels







Small Multiples

• Same encoding, but different data in each view (e.g. SPLOM)











Interaction with Multiform & Small Multiples

- Key interaction with multiform and small multiples: brushing - also called linked highlighting
- views

• Want to understand correspondences between representation in the different





Brushing











Schneiderman's Mantra

- Visual Information-Seeking Mantra [B. Schneiderman, 1996]:
 - Overview first
 - Zoom and filter (Chapter 13)
 - Details on demand
- Goal of the overview is to summarize all of the data
- layer
 - May be permanent: side-by-side
 - May be a popup layer: often opaque or separated
- (see textbook Ch. 6.7)

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Want specific details about some aspect(s) of the data, need another view/





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Overview-Detail View



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Overview-Detail (Different Encoding)

EXPENDITURES BY FUNCTION (BAR & DONUT)



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FIVE-YEAR TREND











Overview-Detail (with Zoom-Filter)

- Detail involves some subset of the full dataset Involves user selection or filtering of some type
- How question: includes facet
- Examples:
 - Maps: partition into two views with same encoding, overview-detail
 - overview+detail of expenditures

- UC Trends: partition into multiple views, coordinated with linked highlighting,







Multiform & Small Multiples (Cerebral)









Navigation across multiple views

- Often navigation in one view updates navigation in another • Example: Maps: overview shifts as you move around in detail view Selections in one view may trigger selections in another





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Partition into Side-by-Side Views



Superimpose Layers



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Partitioned Views

- Split dataset into groups and visualize each group
- Extremes: one item per group, one group for all items
- Can be a hierarchy
 - Order: which splits are more "related"?
 - Which attributes are used to split? usually categorical

ize each group group for all items





Glyphs, Views, and Regions

- Glyphs are composed of multiple marks
- Views are a contiguous region of space
- A region is usually associated with a group of data
- Blurry lines of distinction between them







Example: Grouped Bar Chart



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65 Years and Over 45 to 64 Years 25 to 44 Years 18 to 24 Years 14 to 17 Years 5 to 13 Years Under 5 Years











Example: Small Multiples Bar Chart











Matrix Alignment & Recursive Subdivision

- Matrix Alignment:
 - regions are placed in a matrix alignment
 - splits go to rows and columns
 - main-effects ordering: use summary statistic to determine order of categorical attribute
- Recursive subdivision:
 - Designed for exploration
 - Involves hierarchy
 - User drives the ways data is broken down in recursive manner









Example: Trellis Matrix Alignment



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Barley Yield (bushels/acre)











Example: HiVE System







Example: HiVE System















Reducing Complexity







Reducing Complexity

- Too many items or attributes lead to visual clutter
- Interaction and Multiple Views can help, but often lose the ability to start understanding an entire dataset at first glance
- Reduction techniques show less data to reduce complexity
- Can reduce items or attributes (both are elements)
- Filtering: eliminate elements from the current view
 - "out of sight, out of mind"
- Aggregation: replace elements with a new element that represents the replaced elements
 - summarization is often challenging to design
- Another method is focus+context: show details in the context of an overview





Overview: Reducing Items & Attributes



→ Attributes

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→ Aggregate

→ Items



→ Attributes



[Munzner (ill. Maguire), 2014]



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Filtering

- Just don't show certain elements
- Item filtering: most common, eliminate marks for filtered items
- Attribute filtering:
 - attributes often mapped to different channels
 - if mapped to same channel, allows many attributes (e.g. parallel coordinates, star plots), can filter
- How to specify which elements?
 - Pre-defined rules
 - User selection









Filter vs. Query

- Queries start with an empty set of items and **add** items
- Filters start with all items and **remove** items









Example: NYC Health Dept. Restaurant Ratings



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Dynamic Filters

- Interaction need not be with the visualization itself
- Users interact with widgets that control which items are shown
 Sliders, Combo boxes, Text Fields
- Often tied to attribute values
- Examples:
 - All restaurants with an "A" Grade
 - All pizza places
 - All pizza places with an "A" Grade

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ualization itself Introl which items are shown





Scented Widgets









Scented Widgets





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on A	Name	Description	Example
on <u>B</u> on <u>C</u>	Hue	Varies the hue of the widget (or of a visualization embedded in it)	Option A
on <u>D</u> I rank	Saturation	Varies the saturation of the widget (or of a visualization embedded in it)	Option <u>A</u> Option <u>B</u>
	Opacity	Varies the saturation of the widget (or of a visualization embedded in it)	Option <u>A</u> Option <u>B</u>
	Text	Inserts one or more small text figures into the widget	(2) Option <u>A</u> (10) Option <u>B</u>
	lcon	Inserts one or more small icons into the widget.	 Option<u>A</u> Option<u>B</u>
or	Bar Chart	Inserts one or more small bar chart visualizations into the widget	Option <u>A</u> Option <u>B</u>
I	Line Chart	Inserts one or more small line chart visualizations into the widget	Option <u>A</u> Option <u>B</u>

[Willett et al., 2007]







Star Plots (aka Radar Charts)



Aberlour









Auchentoshan



Auchroisk













Star Plot / Radar Chart



- Compare variables
- Similarities/differences of items
- Locate outliers
- Considerations:
 - Order of axes
 - Too many axes cause problems








Attribute Filtering on Star Plots



(C)

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(d)











Attribute Filtering

- How to choose which attributes should be filtered?
 - User selection?
 - Statistics: similarity measures, attributes with low variance are not as interesting when comparing items
- Can be combined with item filtering









Aggregation

- Usually involves **derived** attributes
- Examples: mean, median, mode, min, max, count, sum
- Remember expressiveness principle: still want to avoid implying trends or similarities based on aggregation

						IV	
Х	У	Х	У	Х	У	Х	У
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.70
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.7
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.8
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.4
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.2
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.5
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.5
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.9
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.8







Aggregation

- Usually involves **derived** attributes
- Examples: mean, median, mode, min, max, count, sum
- Remember expressiveness principle: still want to avoid implying trends or similarities based on aggregation



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9	
11	
7.50	
4.122	
0.816	
4.122 0.816	

		II				IV	
Х	У	Х	У	Х	У	Х	У
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.5
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89







Anscombe's Quartet





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