

Lesson 3: Interactivity in Visual Analytics

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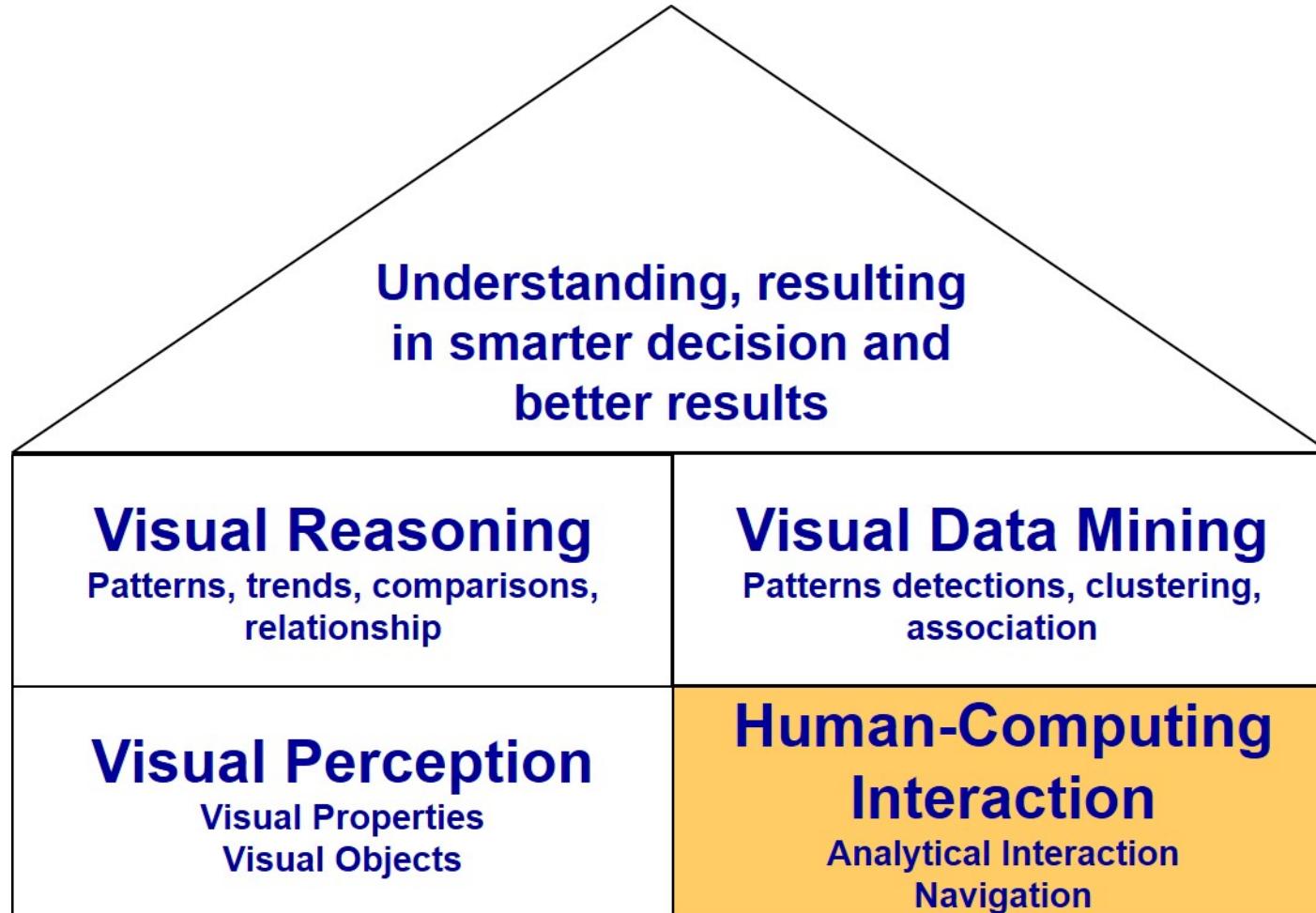
**School of Computing and Information Systems,
Singapore Management University**

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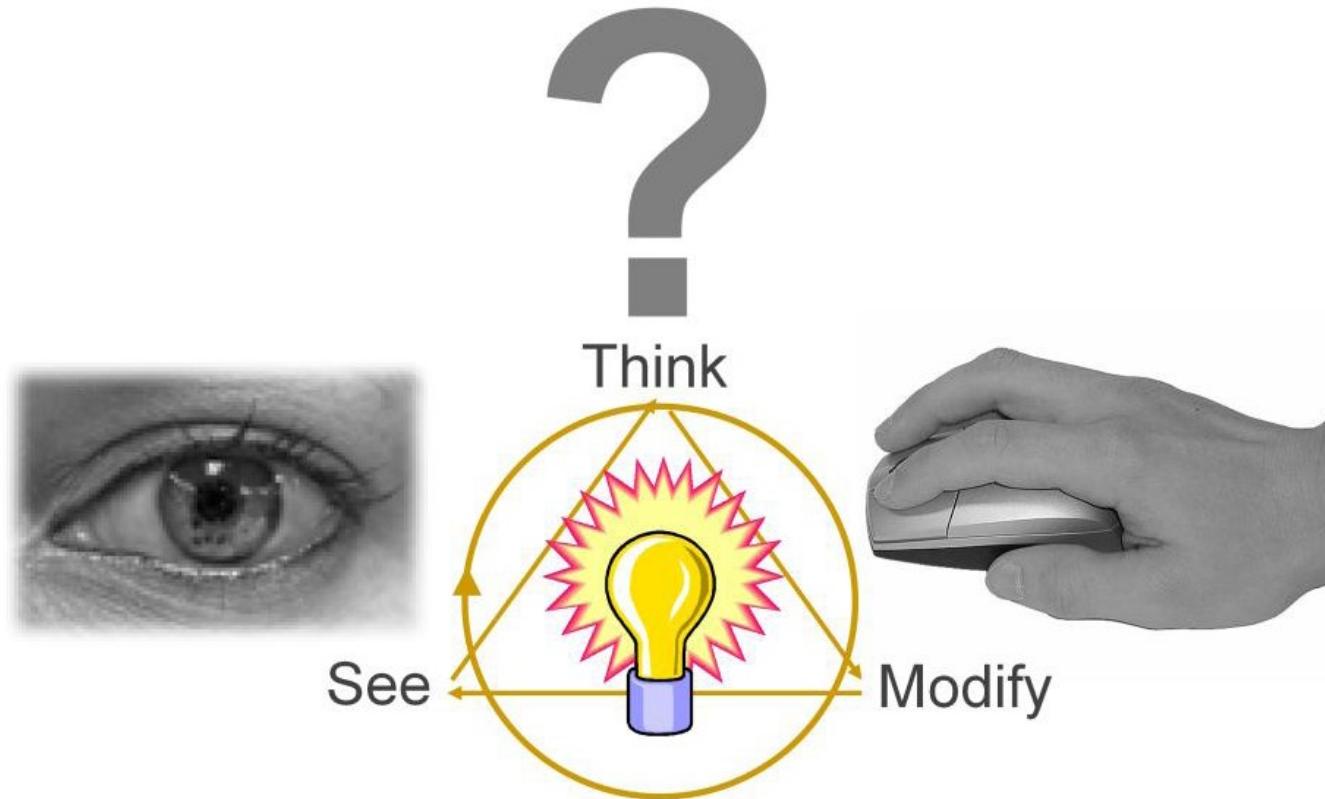
What will you learn from this lesson?

- Typology of Interactive Techniques
 - Data & view specification
 - View Manipulation
 - Process and Provenance
- Interactive Design Primitive
- Animation: Principles and Best Practices

Building Block of Visual Analytics



Revisiting Visual Analytics Framework



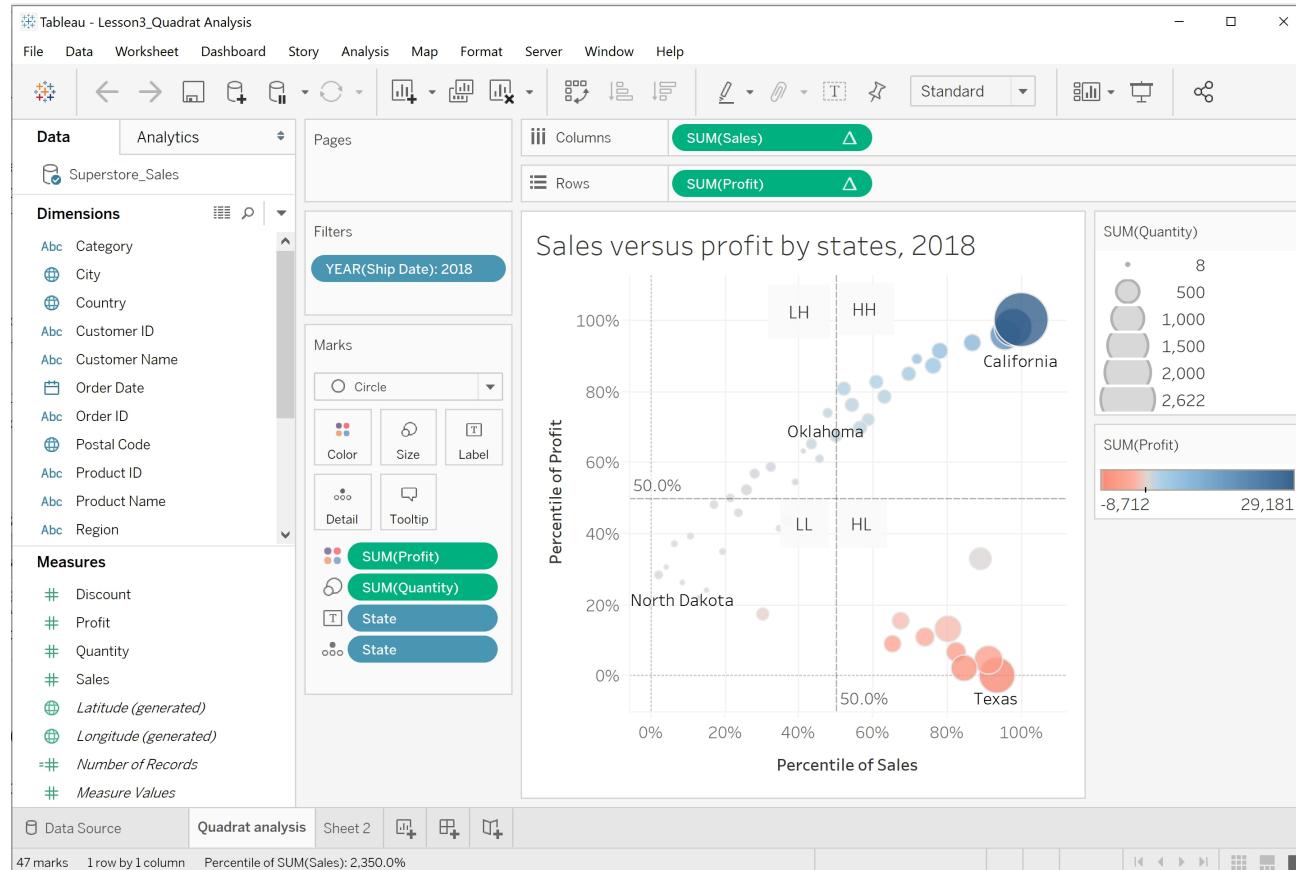
Taxonomy of Interactive Dynamics

Data and View Specification	Visualize data by choosing visual encodings. Filter out data to focus on relevant items. Sort items to expose patterns. Derive values or models from source data.
View Manipulation	Select items to highlight, filter, or manipulate them. Navigate to examine high-level patterns and low-level detail. Coordinate views for linked, multidimensional exploration. Organize multiple windows and workspaces.
Process and Provenance	Record analysis histories for revisit, review, and sharing. Annotate patterns to document findings. Share views and annotations to enable collaboration. Guide users through analysis tasks or stories.

Source: Heer, J. & Shneiderman, B. (2012) "Interactive Dynamics for Visual Analytics" *ACM Queue*, Vol. 55, No. 4, pp 45-54.

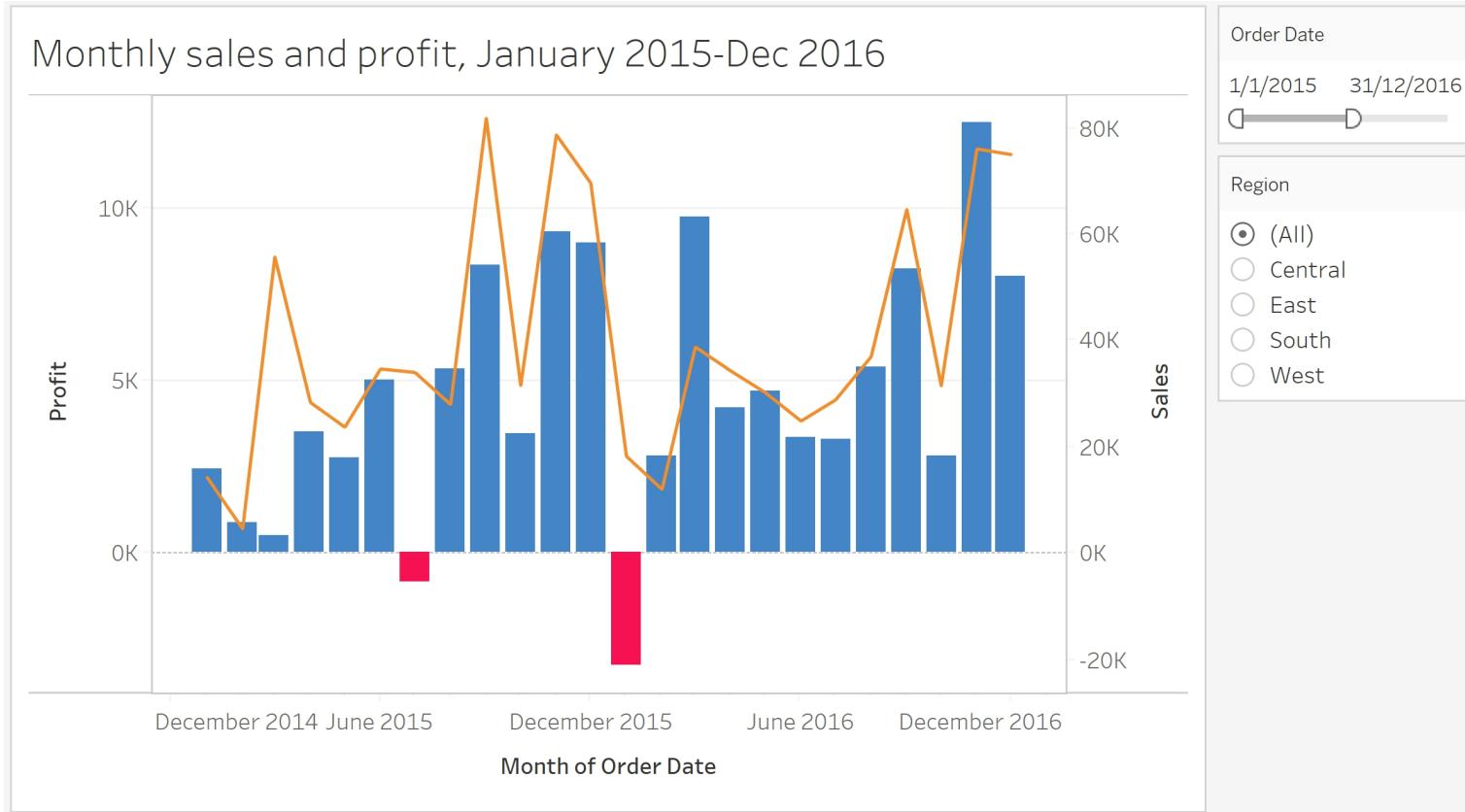
Data & view specification

- **Visualise** data by choosing visual encodings.
- **Polaris** of Tableau



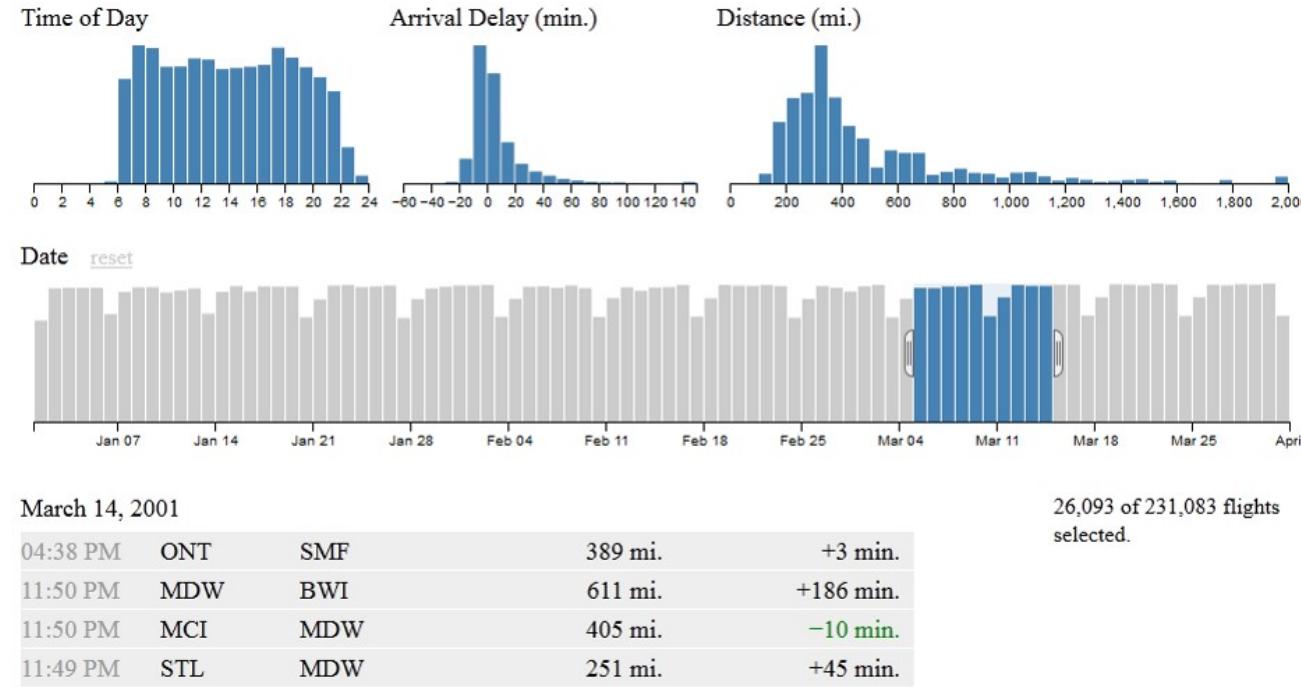
Data & view specification

- **Filter** out data to focus on relevant items.



Data & view specification

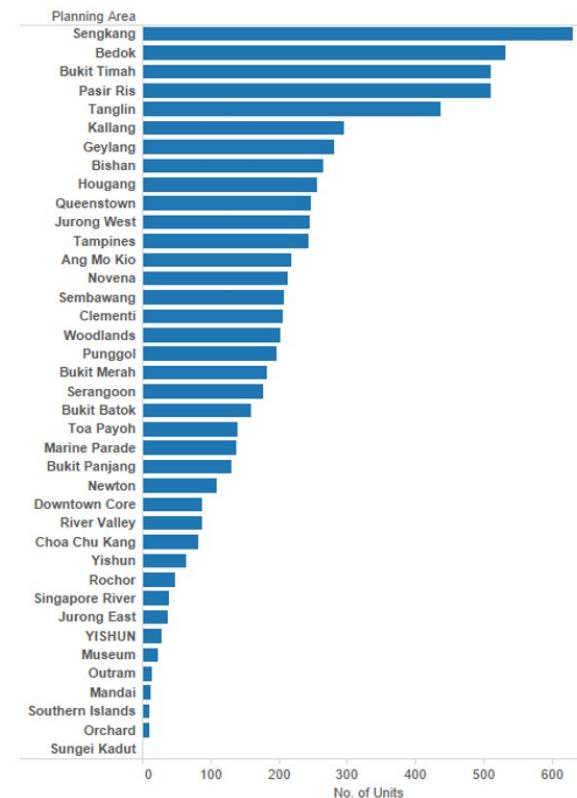
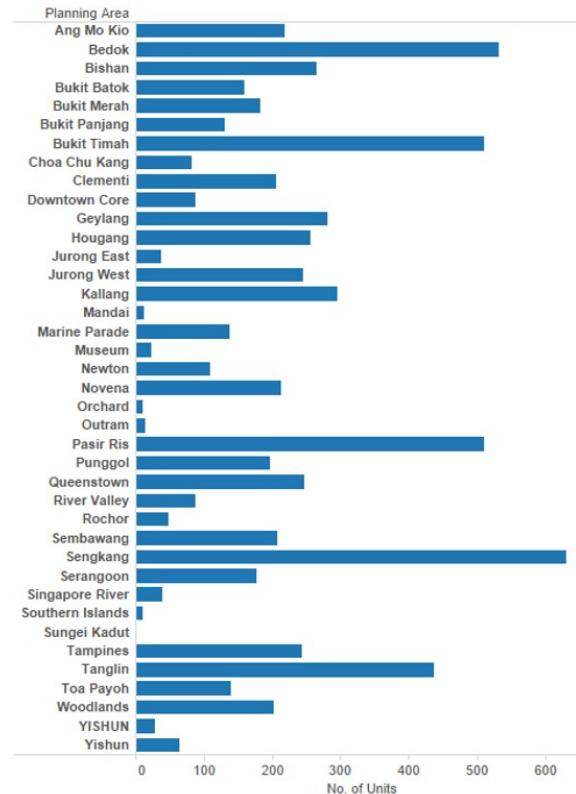
- **Slicer** is an axis-parallel selection tool, which selects a range along an axis, where the end-point of the interval can be modified dynamically.



Source: <https://square.github.io/crossfilter/>

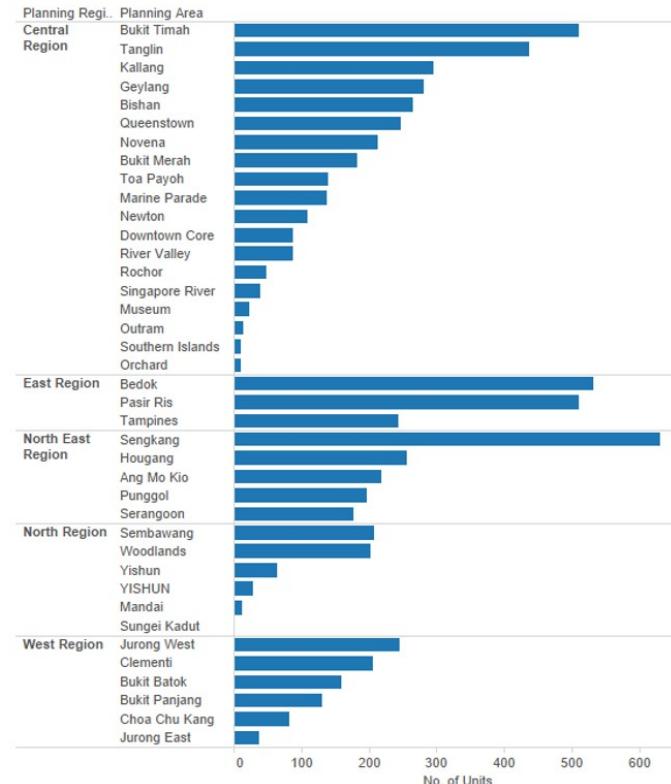
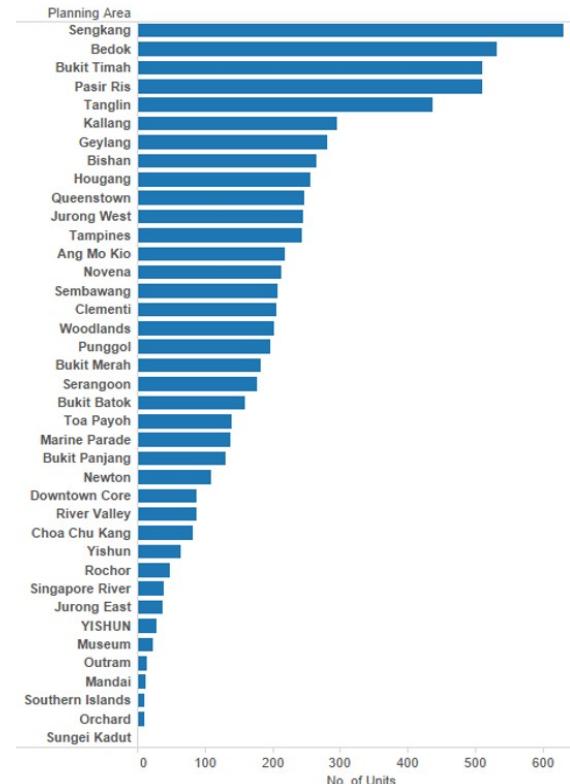
Data & view specification

- Sort items to expose patterns.



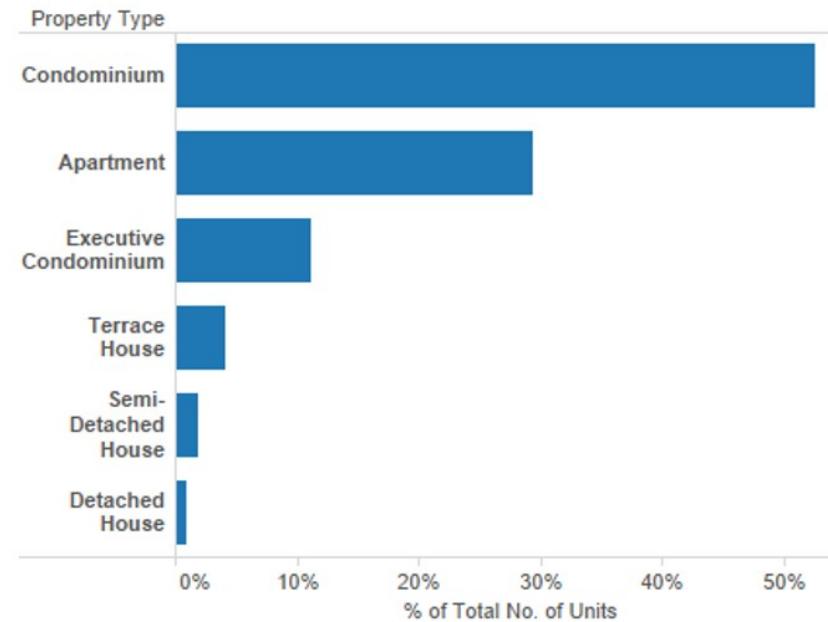
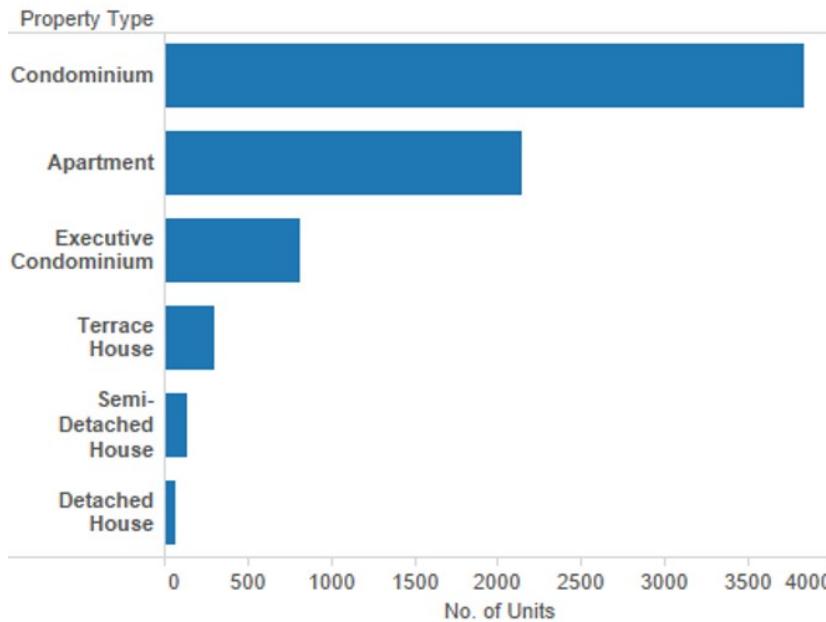
Data & view specification

- Hierarchical sorting



Data & view specification

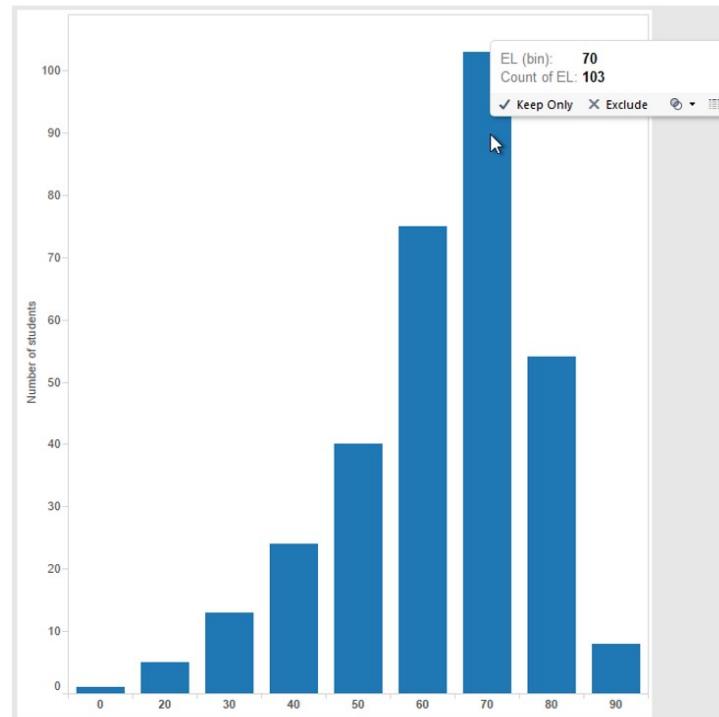
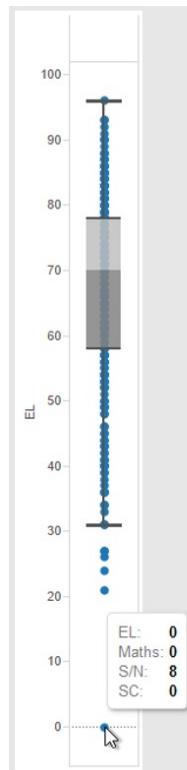
- Derive values or models from source data.



View Manipulation

Selection functions

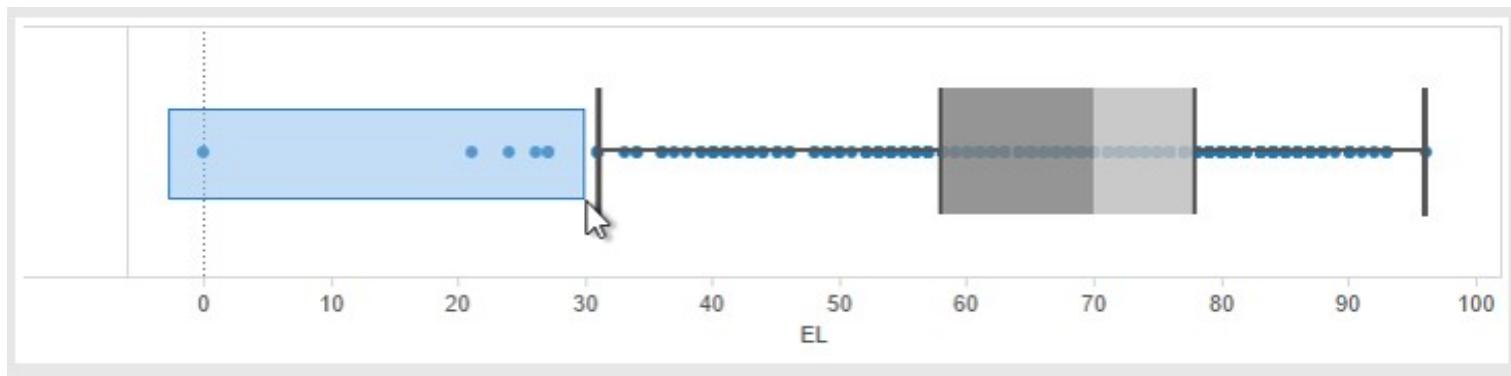
- **Pointer** selects a single object in a plot.



View Manipulation

Selection functions

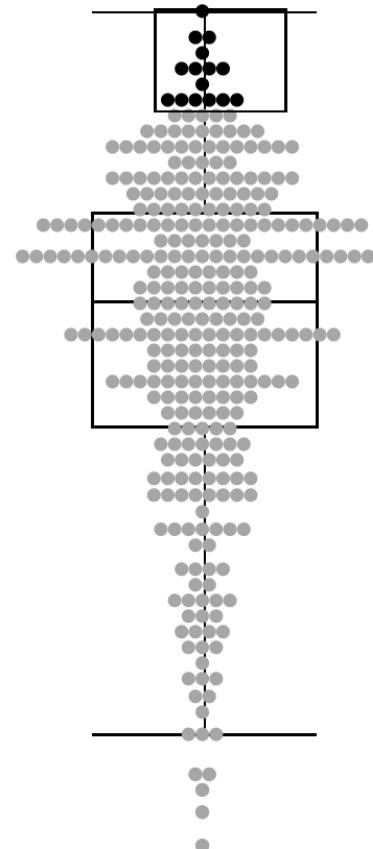
- **Drag-box** selects a rectangular region in a box.



View Manipulation

Selection functions

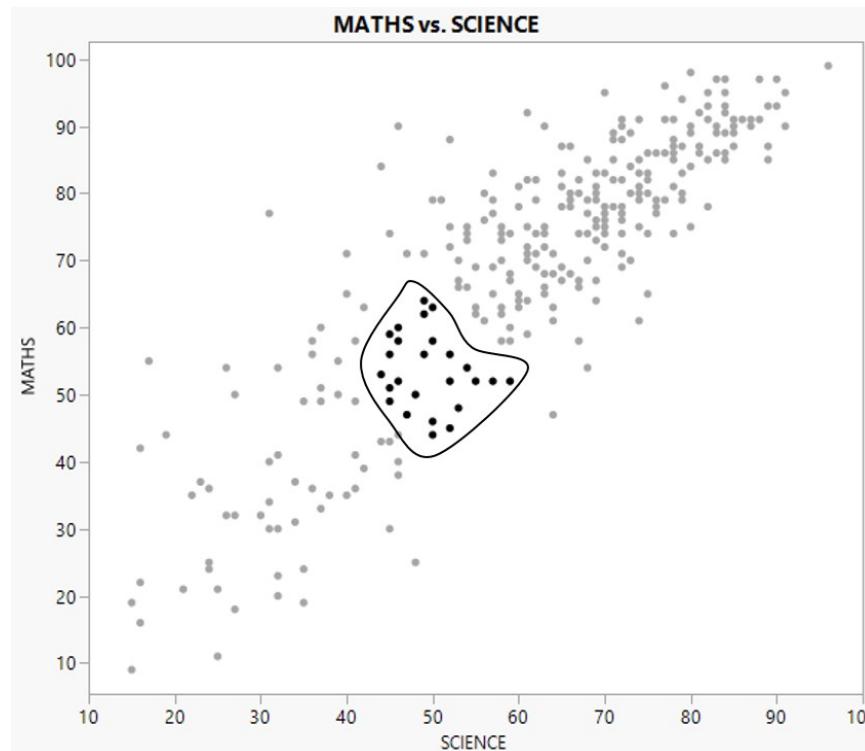
- **Brush** is a generalisation of the drag-box. Once a rectangular region is define, the brush allows users to move that region across a plot and thus dynamically change the selected subset.



View Manipulation

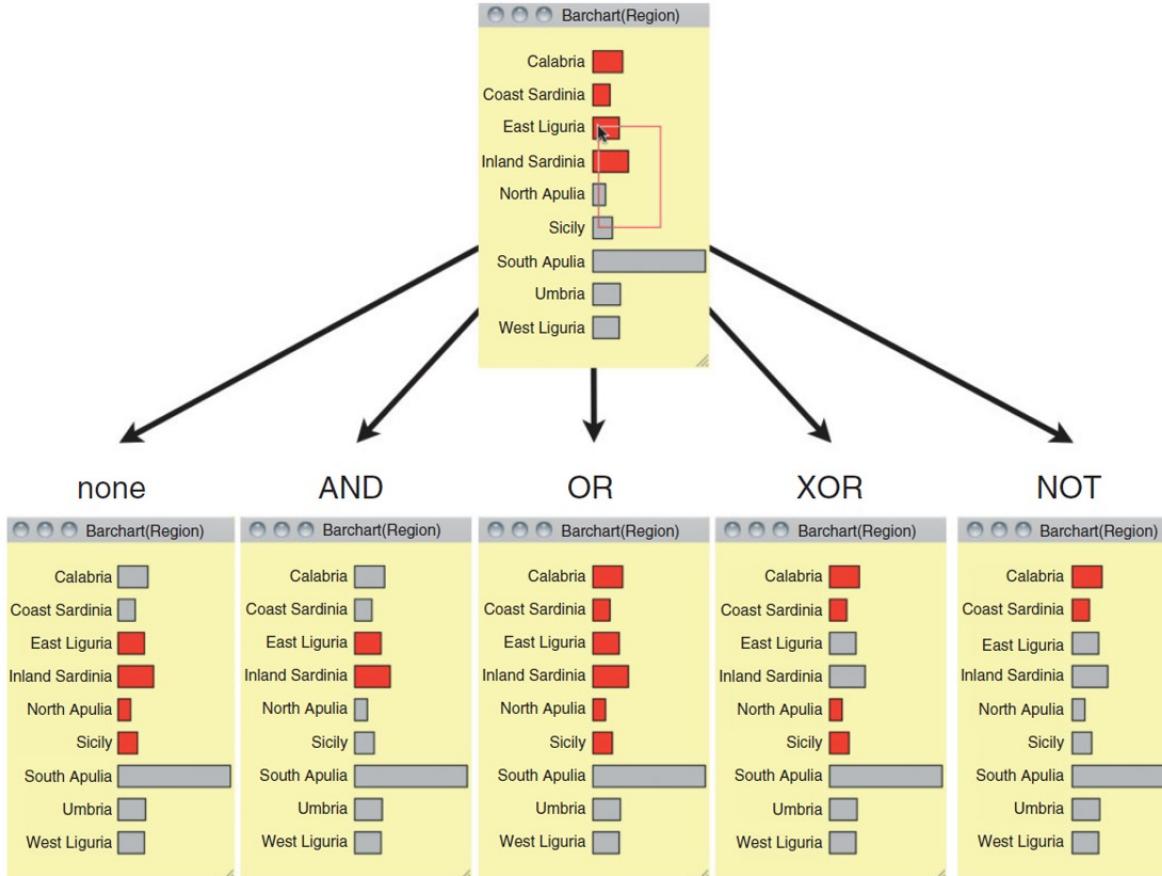
Selection functions

- **Lasso** allows users to define an arbitrary contiguous shape to select data.



View Manipulation

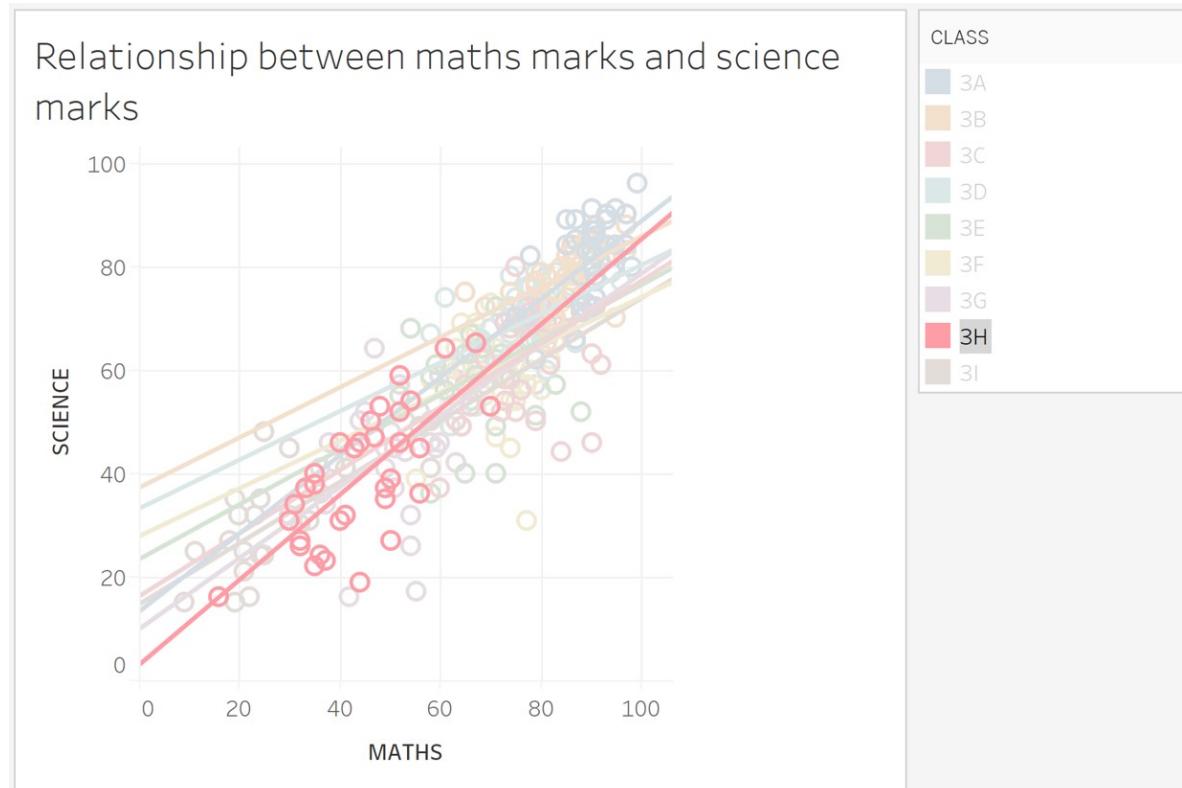
Selection modes



View Manipulation

Highlighting

- Selected records are highlighted.



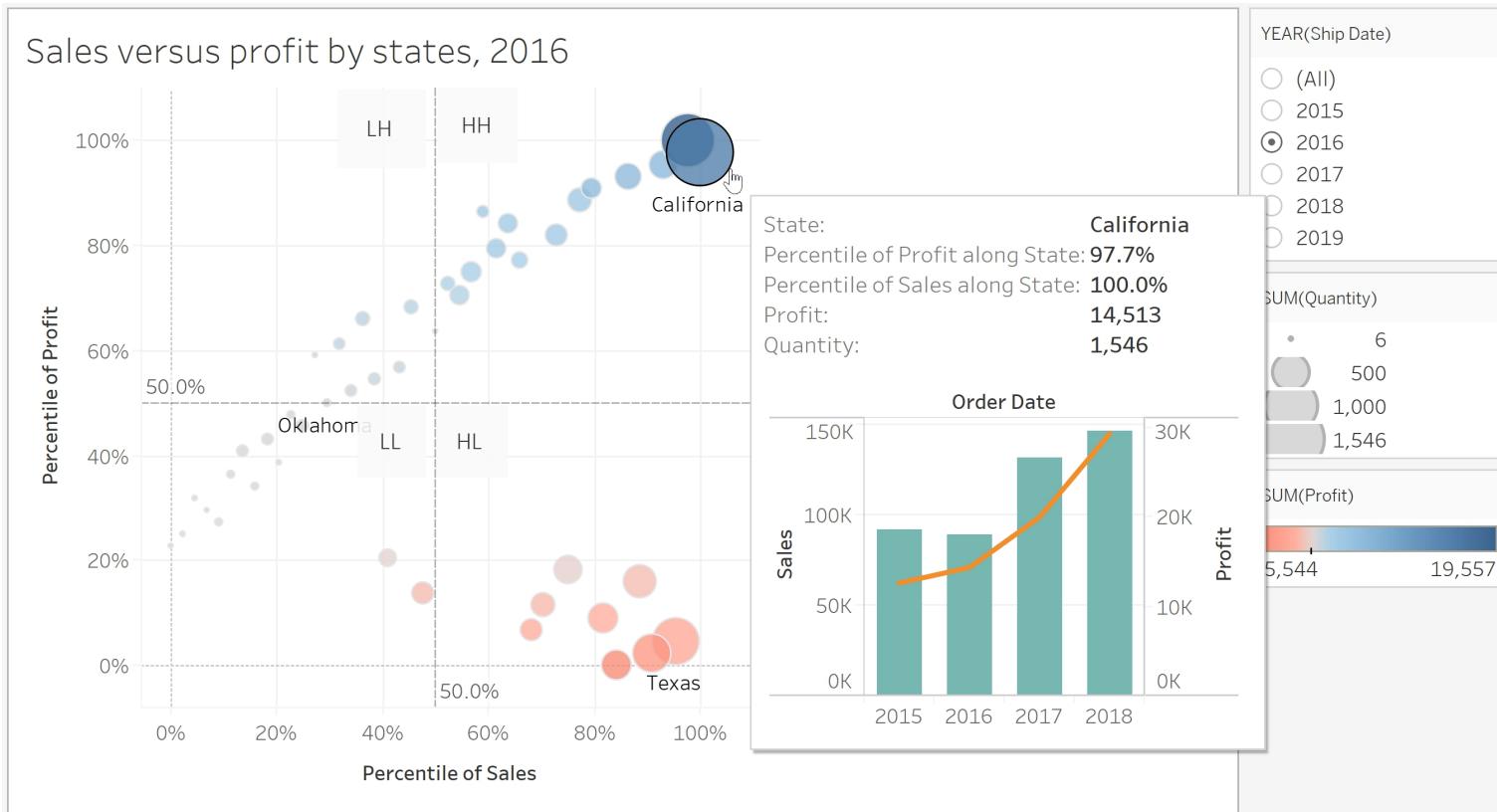
View Manipulation

- **Navigate** to examine high-level patterns and low-level detail.
- Shneiderman's mantra

**“Overview first,
zoom and filter,
then details-on-demand”**

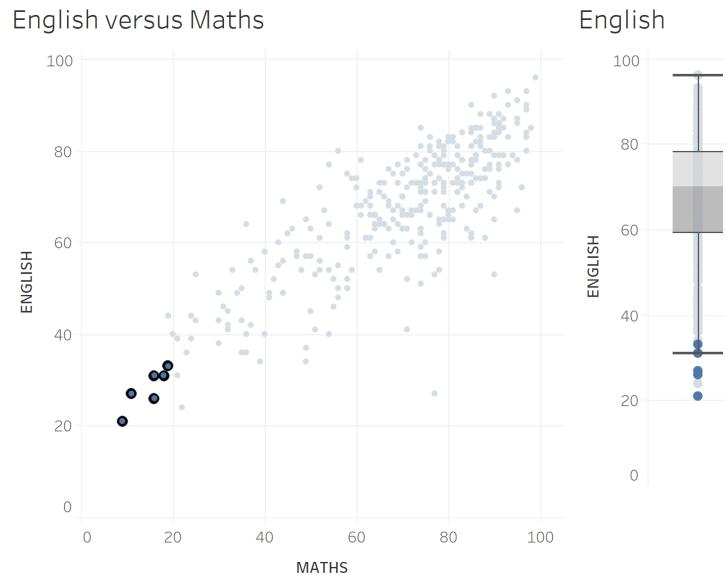
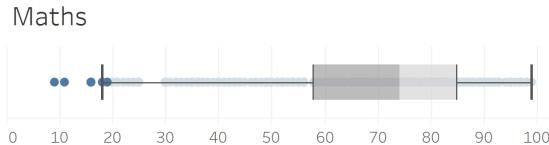
View Manipulation

- The scatter plot provides an overview and the bar and line graphs provide detail sales and profits trends overtime.



View Manipulation

- **Coordinate** views for linked, multi-dimensional exploration



Scatterplot with marginal boxplot

View Manipulation

- **Organise** multiple windows and workspaces

The screenshot shows a Tableau public dashboard titled "2017 VAST CHALLENGE". The dashboard has a header with navigation links: GALLERY, AUTHORS, BLOG, RESOURCES, ACTIVITY, SIGN UP, SIGN IN, and a search icon. Below the header is a breadcrumb trail: Yifei - Profile. The main content area features a banner for the "2017 VAST CHALLENGE" with a nature-themed illustration. The dashboard is organized into several sections:

- The Problem:** A text block describing a study at Mistford College about Rose-Crested Blue Pipls.
- The Tasks:** A text block detailing the analysis of traffic through the Boonlong Lekagul Nature Preserve to validate hypotheses about bird nesting.
- Demystifying with Visual Analytics:** A section listing five tasks with corresponding icons:
 - 1. Activity Overview: Hourly & daily traffic size at various checkpoints in the reserve
 - 2. Pattern Analysis: Gantt bars and heatmaps to visualize daily and longer period patterns of life in the reserve
 - 3. Path Analysis: Heatmap and animated map to visualize the most frequently travelled paths
 - 4. Movement Anomaly: Gantt chart and heatmap to discover unusual movements in the reserve
 - 5. Duration Anomaly: Scatter plot and heatmap to discover outliers in reserve stay durations
- Type of Visitors:** A table showing visitor segments based on vehicle and activity patterns.

Visitor Type	Is Ranger?	Entrance to entrance only?	Aisle Truck?	Visited Camp?	>1 day stay?	No of Cars	% of Total	
Day Camper	No	No	No	Yes	Yes	3,139	83.9%	
Extended Campers	No	No	No	Yes	No	6,521	99.66%	
Pass-by	No	Yes	No	No	Yes	16	8.79%	
			Yes	No	Yes	Yes	1,337	19.10%
			Yes	Yes	No	Yes	225	18.4%
Ranger	Yes	No	No	No	375	5.36%		
Sightseeing	No	No	No	No	601	16.07%		
Service Trucks	No	No	Yes	No	166	91.21%		
				Yes	5,287	75.54%		
				No	23	92.00%		
				Yes	994	81.54%		
- Type of Visitors by Car Type:** A stacked bar chart showing the distribution of visitors by car type across zip codes 1 through 21. The legend includes Day Camper (orange), Extended Campers (green), Pass-by (teal), Ranger (dark grey), Service Trucks (yellow), and Sightseeing (pink). The data is as follows:

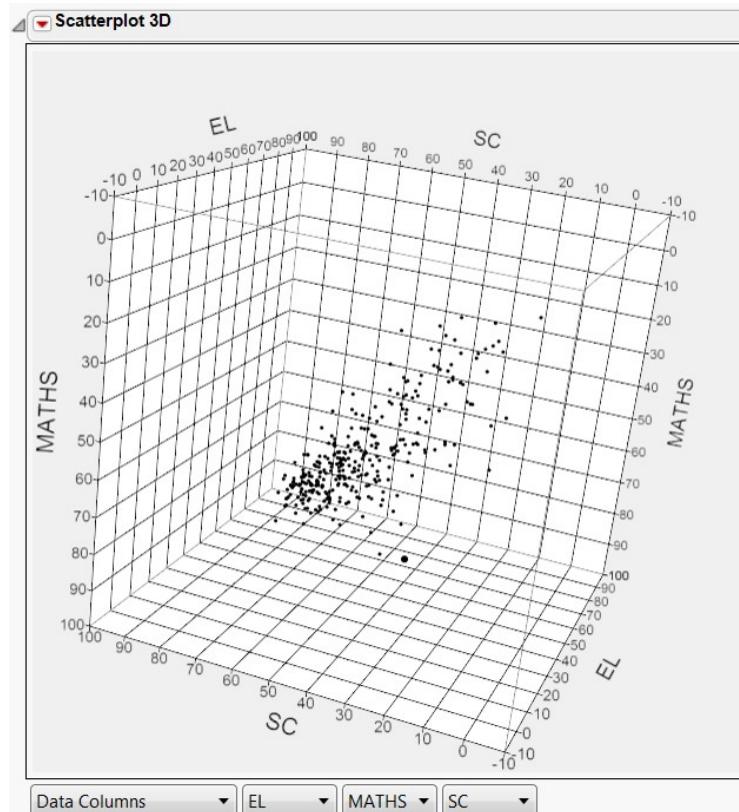
Zip Code	Day Camper	Extended Campers	Pass-by	Ranger	Service Trucks	Sightseeing
1	24.34%	44.04%	8.63%	34.58%	25.19%	0%
2	14.44%	34.58%	42.36%	0%	0%	0%
3	20.93%	30.80%	40.34%	0%	0%	0%
4	18.25%	0%	81.75%	0%	0%	0%
5	0%	0%	0%	82.13%	0%	0%
6	0%	0%	0%	0%	81.03%	0%
21	0%	0%	0%	0%	0%	100.00%

Source: <https://public.tableau.com/profile/yifei2012#/vizhome/Updated1/VASTChallenge2017MC1>

View Manipulation

Rotating

- Touring view with JMP's 3D scatterplot

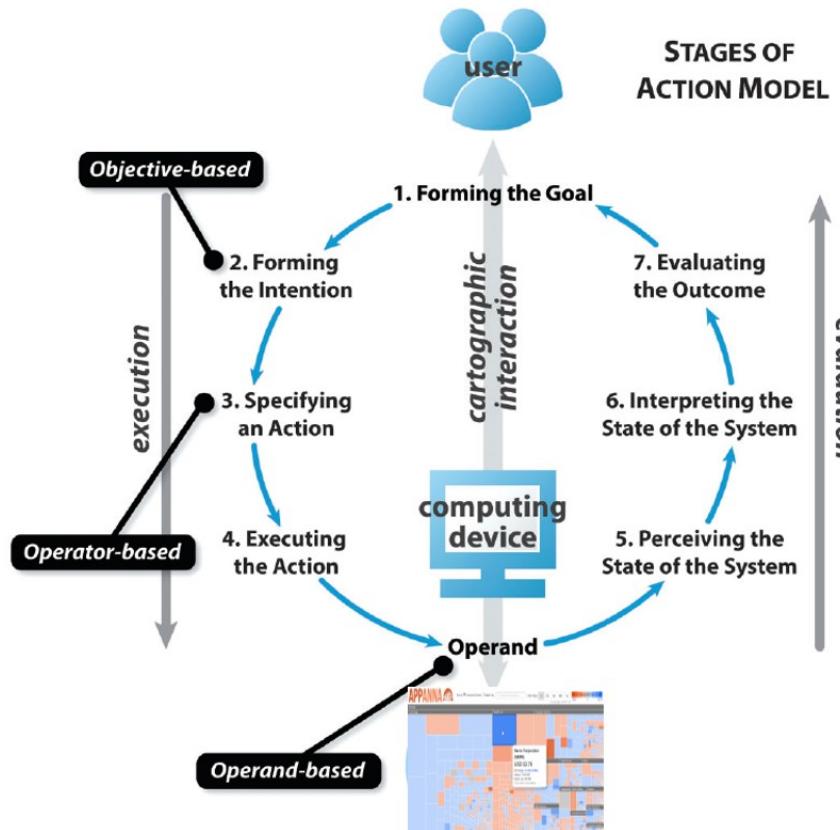


Process and Provenance

- **Record** analysis histories for revisit, review and sharing.
- **Annotate** patterns to determine findings.
- **Share** views and annotations to enable collaboration.
- **Guide** users through analysis tasks or stories.

Interactive Design Primitive

A framework for effective interactive design in visual analytics application.



Source: Roth, R.E. (2012) "Cartographic Interaction Primitive: Framework and Synthesis". The Cartographic Journal, Vol. 49, No. 4 pp. 376-395.

Interactive Design Primitive

Visual Analytics Objective Primitives

objectives | geographic insight

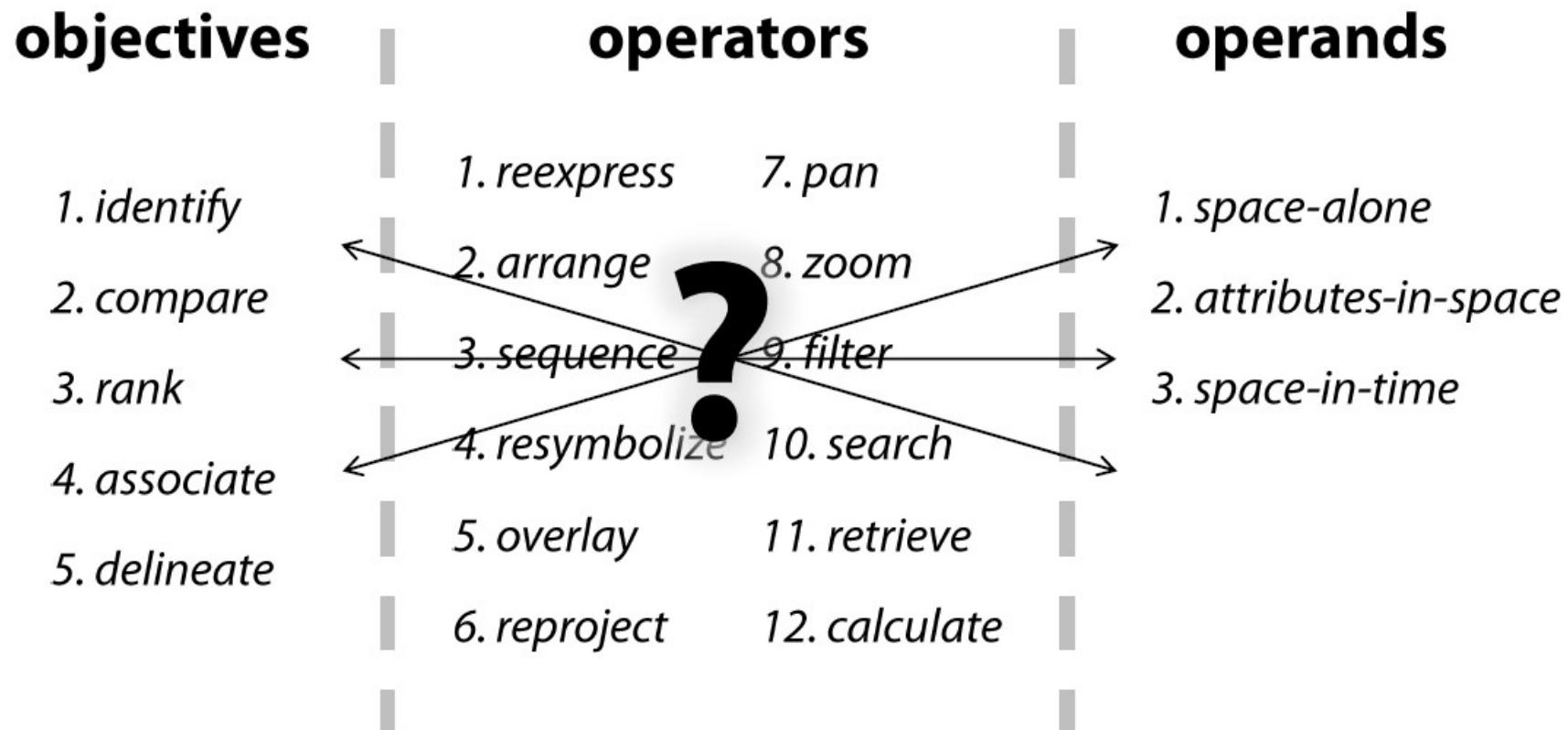
1. identify → e.g., ID, locate
2. compare → e.g., difference, change
3. rank → e.g., anomaly, outlier
4. associate → e.g., correlation, trend, cause-effect
5. delineate → e.g., cluster, hotspot, spike

Interactive Analytics Operator Primitives

operators

- | | |
|------------------------------|-----------------------------|
| 1. <i>reexpress</i> | 7. <i>pan</i> |
| 2. <i>arrange</i> | 8. <i>zoom</i> |
| 3. <i>sequence</i> | 9. <i>filter</i> |
| 4. <i>resymbolize</i> | 10. <i>search</i> |
| 5. <i>overlay</i> | 11. <i>retrieve</i> |
| 6. <i>reproject</i> | 12. <i>calculate</i> |

Interactive Design Primitive



Animation in Visual Analytics

- The purpose of animation is to facilitate perception of changes when transitioning between related data graphics
- Do not confine to time-series data only

The Original Design

The New York Times recently published an interactive graphic for exploring different types of American households. [Go check it out.](#)



Source: <http://worrydream.com/HowManyHouseholds/>

Why using Animation in Visual Analytics

- Motion is highly effective at attracting attention.
- Animation facilitates object constancy for changing objects.
- Animated behaviours can give rise to perceptions of causality and intentionality, communicating cause-and-effect relationships and establishing narrative.
- Animation can be emotionally engaging, engendering increased interest or enjoyment.

Principles of Animation

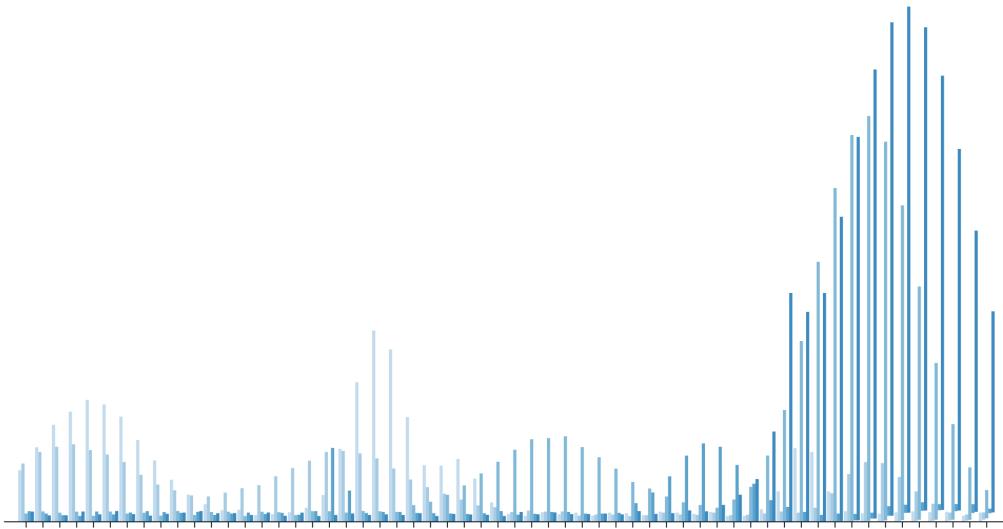
- **Congruence** principle states that the structure and content of the external representation should correspond to the desired and content of the internal representation.
- Maintain valid data graphics during transitions
- Use consistent semantic-syntactic mappings
- Respect semantic correspondence
- Avoid ambiguity
- **Apprehension** principle states that the structure and content of the external representation should be readily and accurately perceived and comprehended.
 - Group similar transitions
 - Minimise occlusion
 - Maximise predictability
 - Use simple transitions
 - Use staging for complex transitions
 - Make transitions as long as needed, but no longer

Source: Heer, J and Robertson G. (2007) [Animated Transitions in Statistical data Graphics](#), IEEE Transactions on Visualization and Computer Graphics, Vol. 13, No. 6, 1240-1247 and the [video](#).

Animation in Action

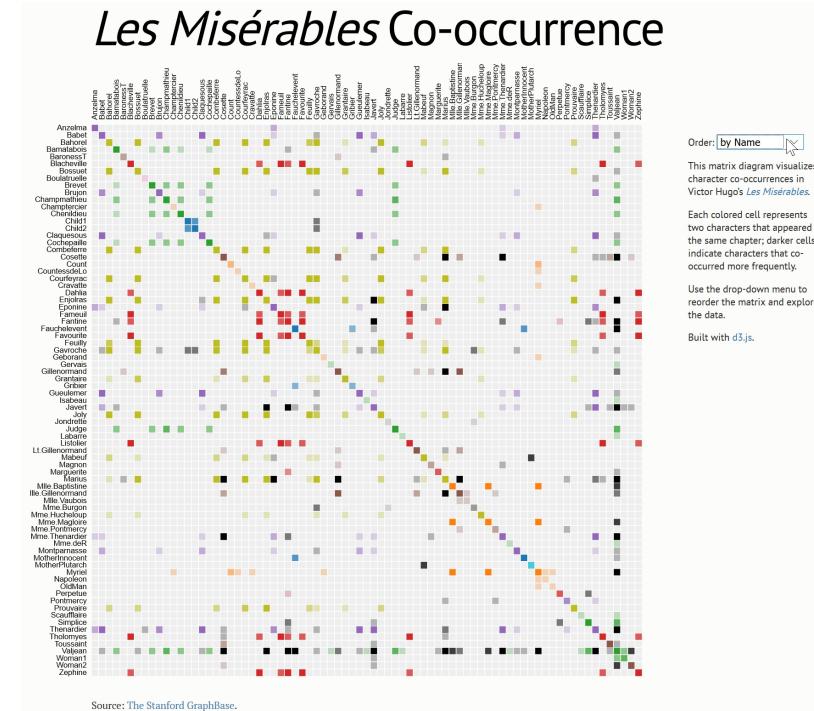
Stacked-to-Grouped Bars

○ Stacked ● Grouped



Source: <https://observablehq.com/@d3/stacked-to-grouped-bars>

Animated Co-occurrence matrix



Source: <https://bost.ocks.org/mike/miserables/>

References

- Dynamics for Visual Analysis
- [Animated Transitions in Statistical Data Graphics](#), IEEE Transactions on Visualization and Computer Graphics, Vol. 13, No. 6, 1240-1247 and the [video](#)
- Coordinated Highlighting in Context
- Cartographic Interaction Primitive: Framework and Synthesis