

Data Exploration & Visualization

Module 7

Interaction

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Interaction

- Two main components in a data visualization
 - Representation
 - Interaction
- Very challenging to come up with innovative, new visual representations
- But can do interesting work with how user interacts with the view or views
 - It's what distinguishes data visualization from static visual representations on paper
- A picture is worth a thousand words.
An interface is worth a thousand pictures.

- Ben Shneiderman

Interaction

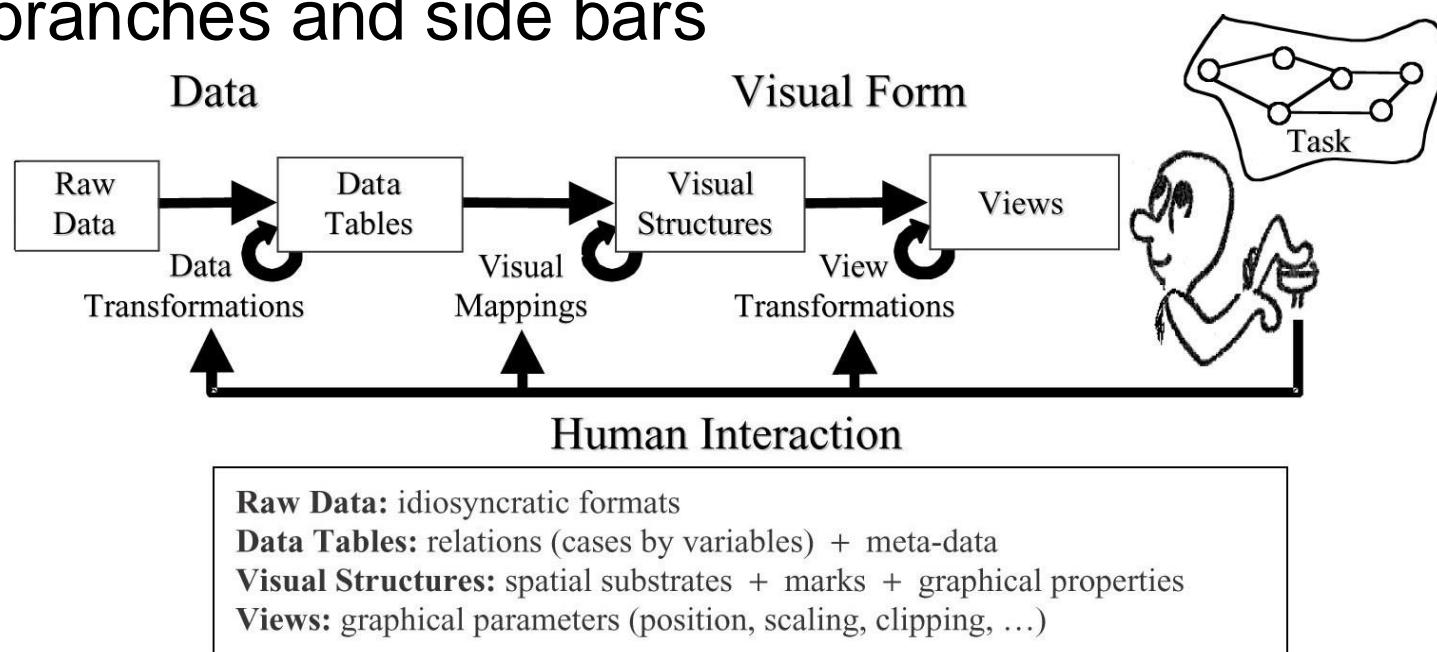
- Two main components in a data visualization
 - Representation
 - Interaction

“The effectiveness of information visualization hinges on two things: its ability to **clearly and accurately represent information** and our **ability to interact with it** to figure out what the information means.”

- S. Few, *Now you see it*

Interaction helps analysis

- Analysis is a process, often iterative with branches and side bars

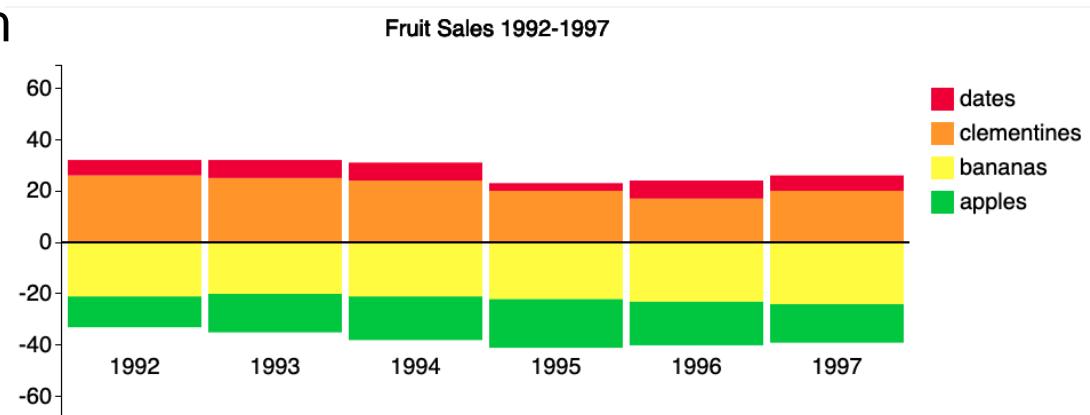


- For larger data, there is simply too much to show in a coherent manner

Example

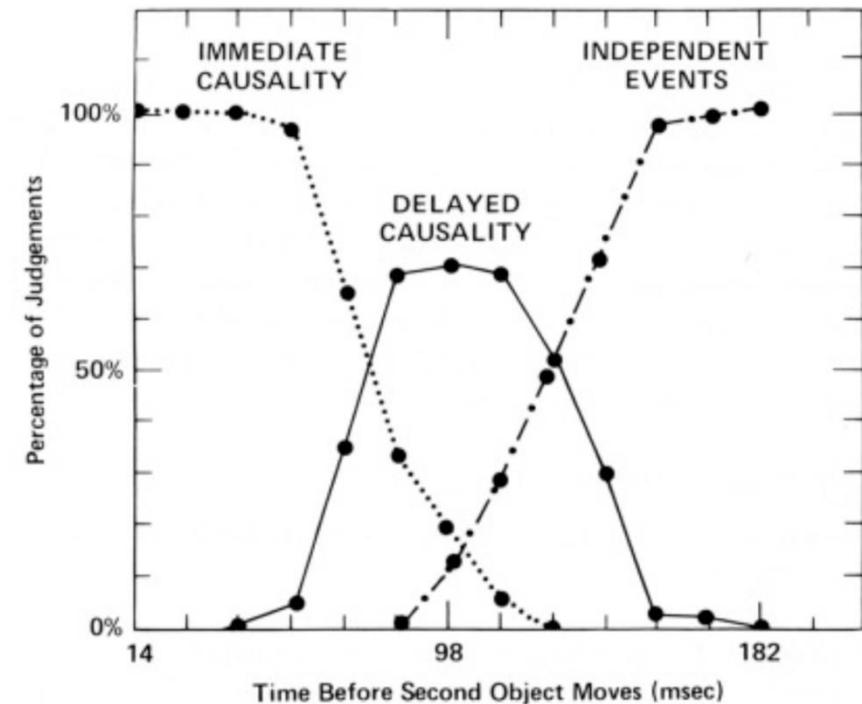
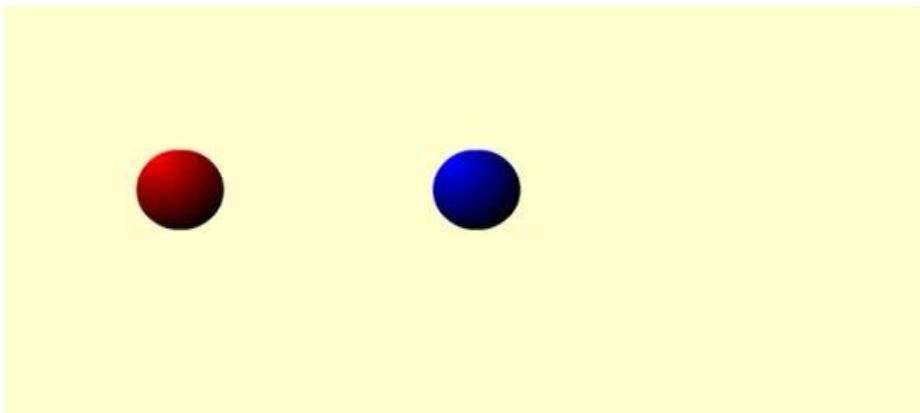
- Adding interactivity can help resolve many of the trade-offs inherent in static visualizations
 - by allowing multiple options to be available
 - most importantly to be interactively related
- Even simple interaction can be quite powerful
 - Dancing histogram

http://bl.ocks.org/marc_dhansen/1ace92ea6344aa05bbac



Interaction levels

- Response Time
 - 0.1 sec.: animation, visual continuity, sliders
 - 1.0 sec.: system response, conversation break
 - 10 sec.: cognitive response
- Big concern for designing visual exploration system
 - Aiming for real-time performance.



Data Exploration & Visualization

Module 7: Interaction

- Interaction taxonomy
 - Select, explore, reconfigure, encode, abstract / elaborate, filter, connect
- Beyond the desktop
 - New interaction and visualization devices
 - Challenges and solutions

Interaction taxonomy

- Dix and Ellis (AVI '98) propose
 - Highlighting and focus
 - Accessing extra info – drill down and hyperlinks
 - Overview and context – zooming and fisheyes
 - Same representation, changing parameters
 - Linking representations – temporal fusion

Interaction taxonomy

- Keim's taxonomy (TVCG '02) includes
 - **Projection:** dynamically change the projections in order to explore a multidimensional data set.
 - **Filtering:** a direct selection of the desired subset (browsing) or by a specification of properties of the desired subset (querying).
 - **Zooming:** present the data in a highly compressed form to provide an overview of the data, but, at the same time, allow a variable display of the data on different resolutions.
 - **Distortion:** show portions of the data with a high level of detail while others are shown with a lower level of detail.
 - **Linked brushing:** combine different visualization methods to overcome the shortcomings of single techniques.

Interaction taxonomy

- Operator
 - Navigation, selection, manipulation, distortion, filtering
- Space of interaction
 - screen, data value, data structure, attribute, object, visualization structure
- Parameters of the interaction operator
 - focus, extents, transformation, blender

Interaction taxonomy

- The role of interaction in information visualization
 - Select
 - Explore
 - Reconfigure
 - Encode
 - Abstract/Elaborate
 - Filter
 - Connect

Yi et al., 2007.

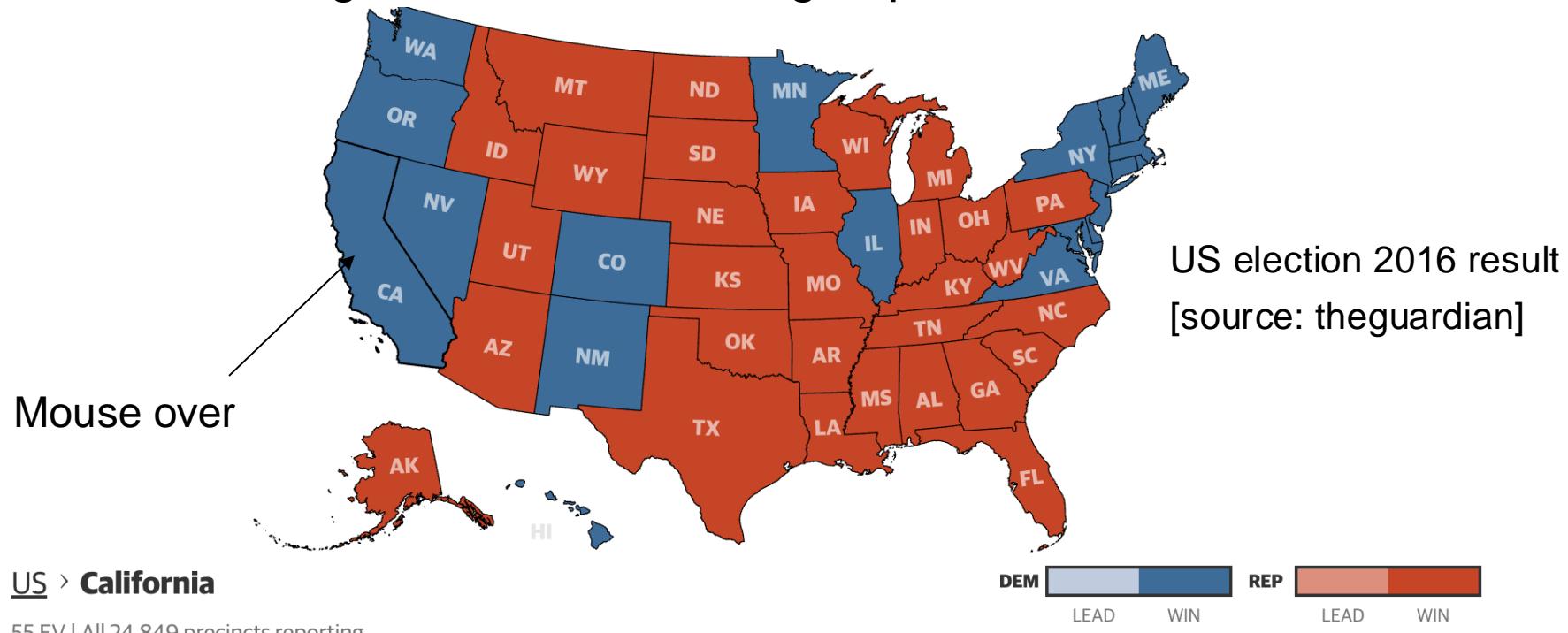
1. Select

“Mark something as interesting”

- Mark items of interest to keep track
- Using pointer (typically) to select or identify an element
 - Often leads to drill-down for more details
- Seems to often work as a preceding action to subsequent operations.

1. Select

- Pop-up Tooltips
 - hovering mouse cursor brings up details of item



2. Explore

“Show me something different”

- Enable users to examine a different subset of data
- Overcome the limitation of display size
- Example: direct link
 - Linkages between cases
 - Exploring one may lead to another
 - Following hyperlinks on web pages

2. Explore

Thinkmap Visual Thesaurus - An online thesaurus and dictionary of over 145,000 words that you explore using an interactive map. - Mozilla Firefox

File Edit View History Bookmarks Tools Help

<http://eantoine.visualthesaurus.com/>

Google

Thinkmap Visual Thesaurus - An online t... +

HOME HOW IT WORKS STORE PRAISE INSTITUTIONAL SALES EDUCATORS SUPPORT

Welcome: Edward A. My Profile My Account Sign Out

THINKMAP VISUAL THESAURUS

Look up a Word:

home

Search History Random Word Language: English

FRESH INK

BLOG EXCERPTS

What's the Most Beautiful Word?

July 12, 2011

What is the most beautiful word in the English language? This question was recently posed on GalleyCat, the Mediabistro blog covering the publishing industry. GalleyCat has its own suggestions, and recommends that readers use the Visual Thesaurus to map out their own favorite words. [Continue reading...](#)

Article Topics: [Blogs](#), [Words](#), [Writing](#)

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source
rootage
root
origin
beginning
base
plate
home plate
home base
dwelling house
habitation
abode
domicile
place
away
family
menage
nursing home
rest home
return
interior
internal
national

Visual Thesaurus Word of the Day

minion Tuesday, July 12th

Step and Fetch It Word of the Day:

There are some things that you can just never have too many of, and if your needs are great and your time limited, *minions* are surely one of them. A *minion* is a servile dependent or follower. The word's origin, Middle French *mignon* ("darling"), suggests that summoning servants by endearing names can be an effective way of getting their attention.

PREVIOUS NEXT

MY WORD LISTS CREATE NEW WORD LIST

Featured Word Lists

Science: Evolution & Genetics (96 words) ★★★★☆

By Sarah L.

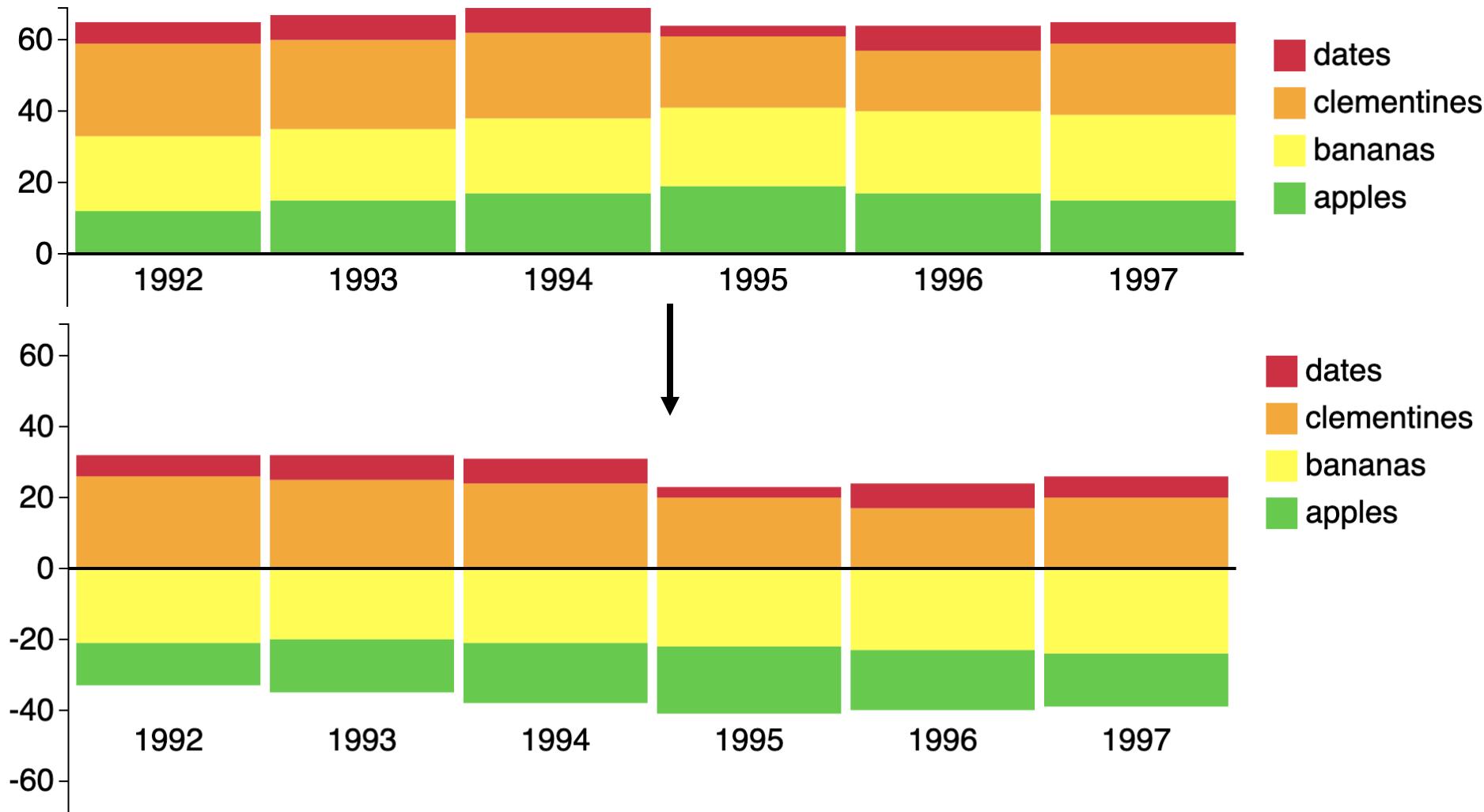
Click here to read more articles from Blog Excerpts.

3. Reconfigure

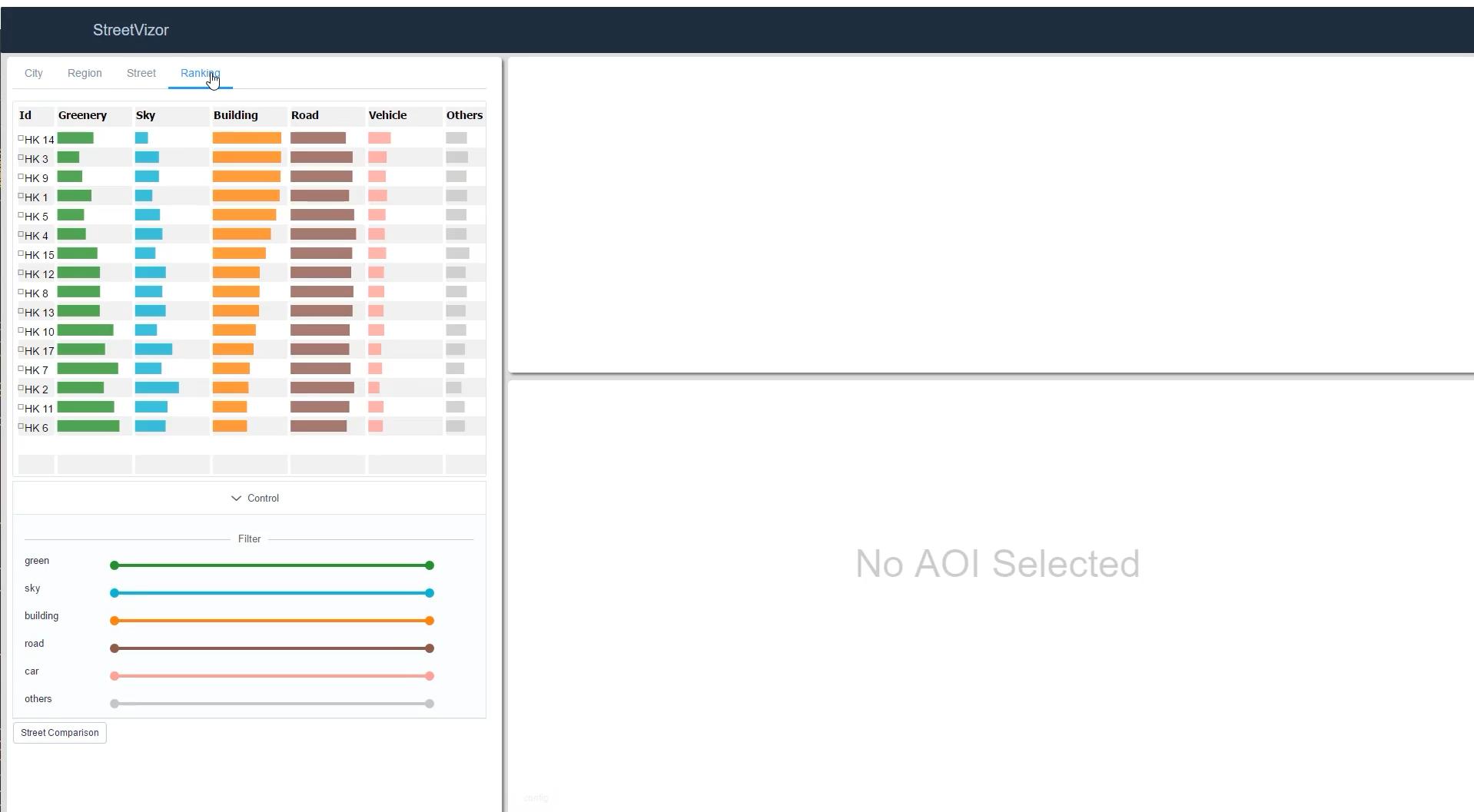
“Show me a different arrangement”

- Provide different perspectives by changing the spatial arrangement of representation
- Rearrange view: Keep same fundamental representation and what data is being shown, but rearrange elements
 - Alter positioning
 - Sort

3. Reconfigure: alter position



3. Reconfigure: sort



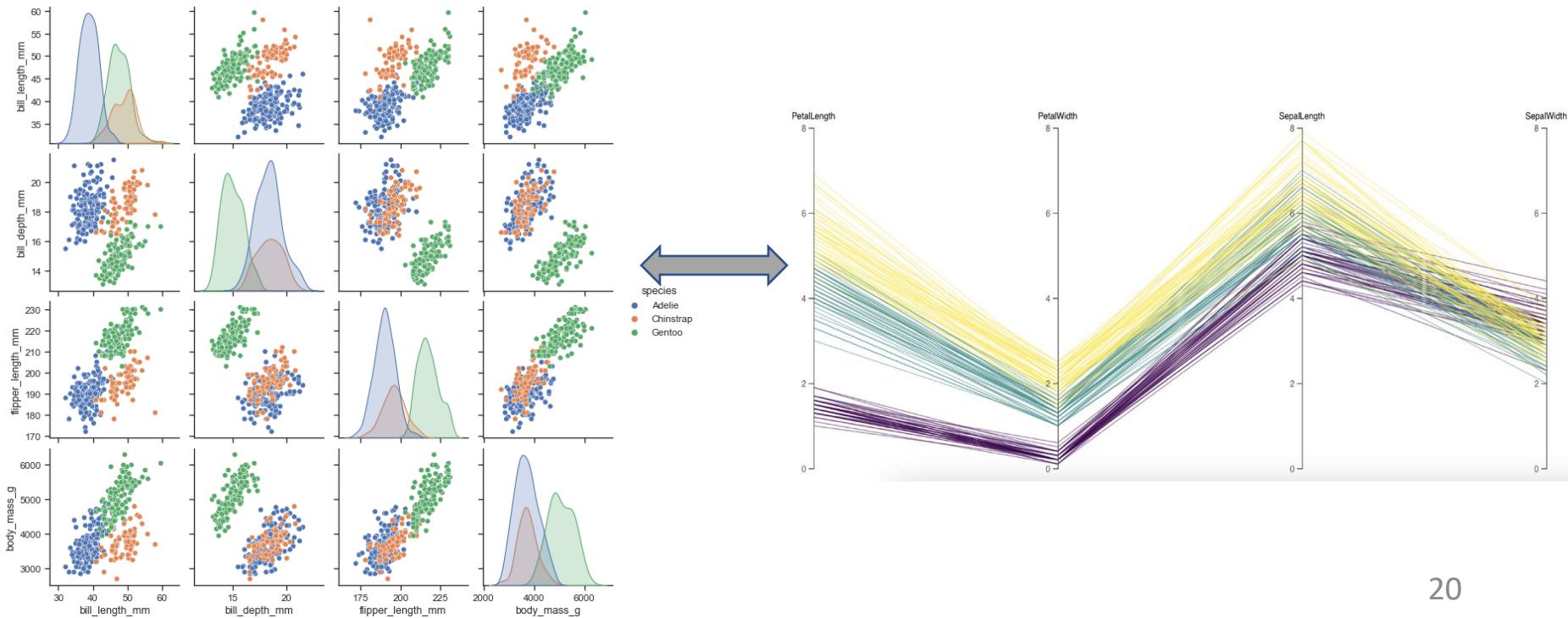
4. Encode

“Show me a different representation”

- Change visual appearances
 - Looking for new perspective
 - Limited screen space may force change

4. Encode

- Change visual appearances
 - Scatterplot matrix \rightleftharpoons parallel coordinates
 - Consider the pros and cons of alternative visualizations



5. Abstract/Elaborate

- **Fundamental Problem:** Many data sets are too large to visualize on one screen
 - Too many cases or too many variables
- You can just buy more pixels

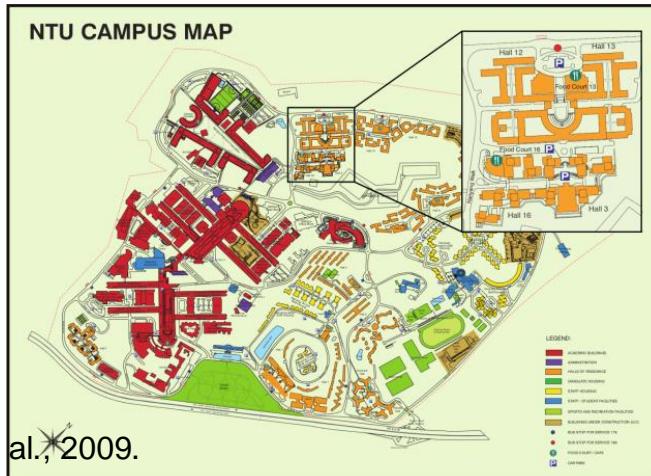


Problem: You'll always eventually run out of pixels

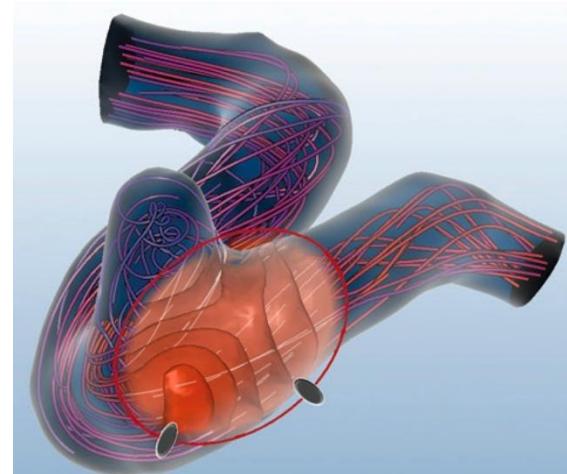
5. Abstract/Elaborate

“Show me more or less detail”

- Adjust the level of abstraction between focused and contextual views, including
 - **Overview + detail:** spatial separation
 - **Focus + context:** minimize the seam between views by displaying the focus within the context
 - **Zooming:** temporal separation



Cockburn et al., 2009.



Overview + detail

- Providing an overview of the data set can be extremely valuable
 - Helps present overall patterns
 - Assists user with navigation and search
 - Orients activities
- Generally start with overview
 - Information visualization mantra: overview first

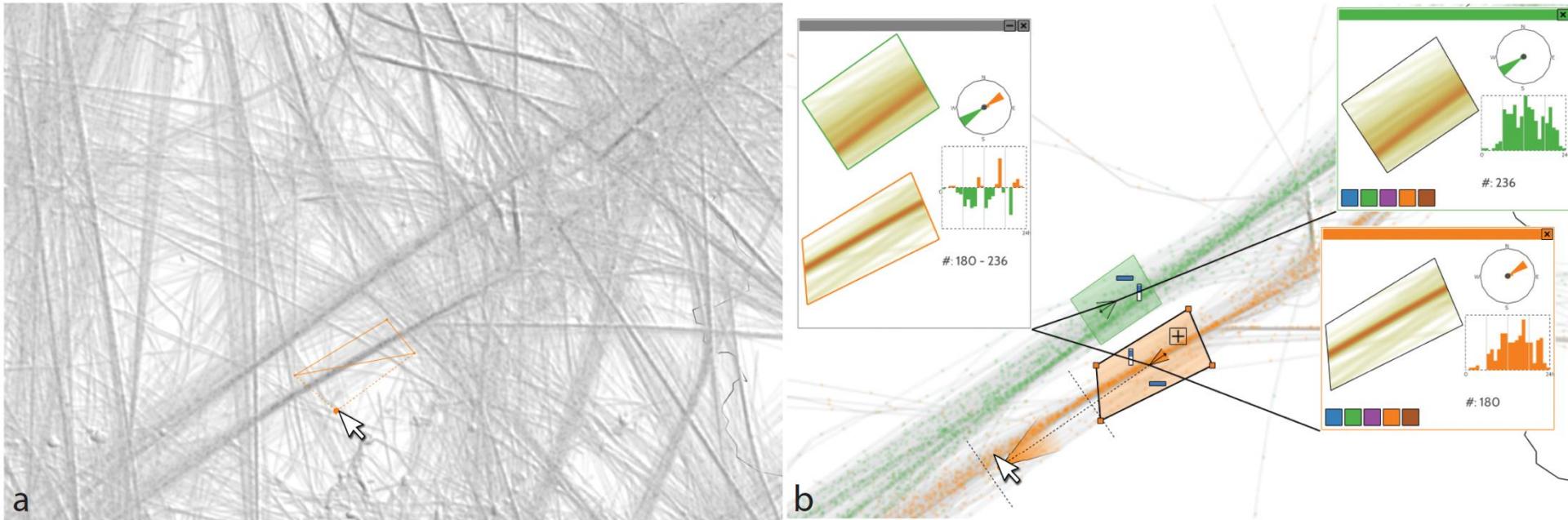
Overview + detail

- Viewers also will want to examine details, individual cases and variables - **details on demand**
 - May be moving from aggregation view to individual view
 - May not be showing all the data due to scale problem
- Very common in games



Overview + detail

- Pros: generally preferred (more effective) over other techniques
- Cons:
 - Additional use of screen real estate
 - Mental effort and time required to integrate the distinct views



Focus+context

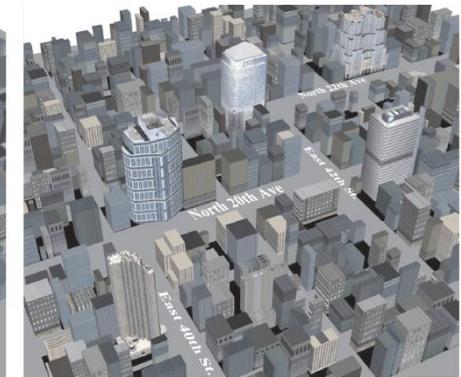
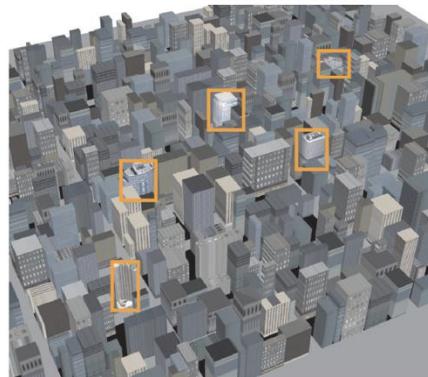
- Provide overview and orientation by means of *simultaneous* representation of information in the **focus** and in the **context** (environment).
- An example is fisheye view

$$DOI(x) = API(x) - d(x, y)$$

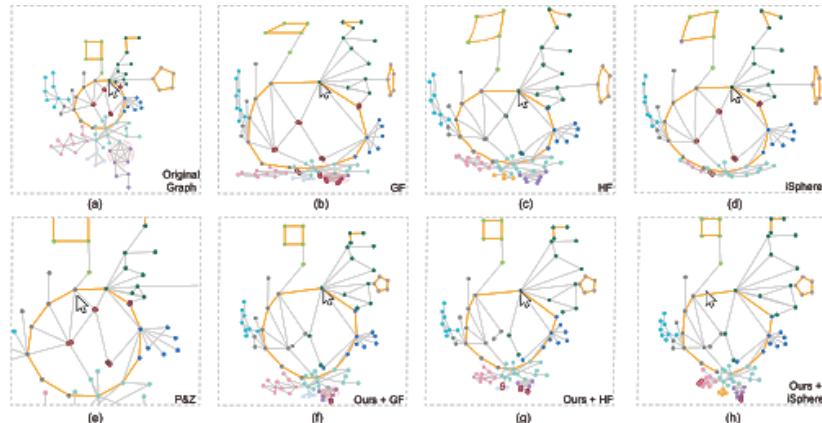
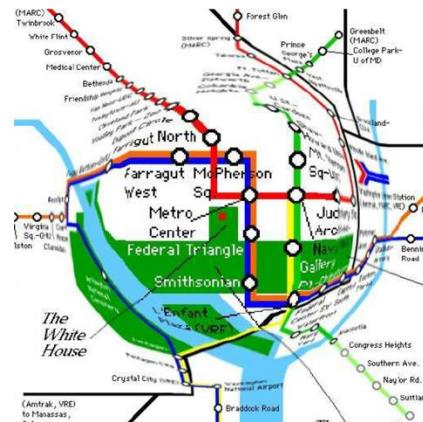
- DOI: degree of interest of a point x
- API: the global a priori importance of x
- $d(x, y)$: distance between x and the current point y

Focus+context

- Widely applied in (geo-)spatial data visualization

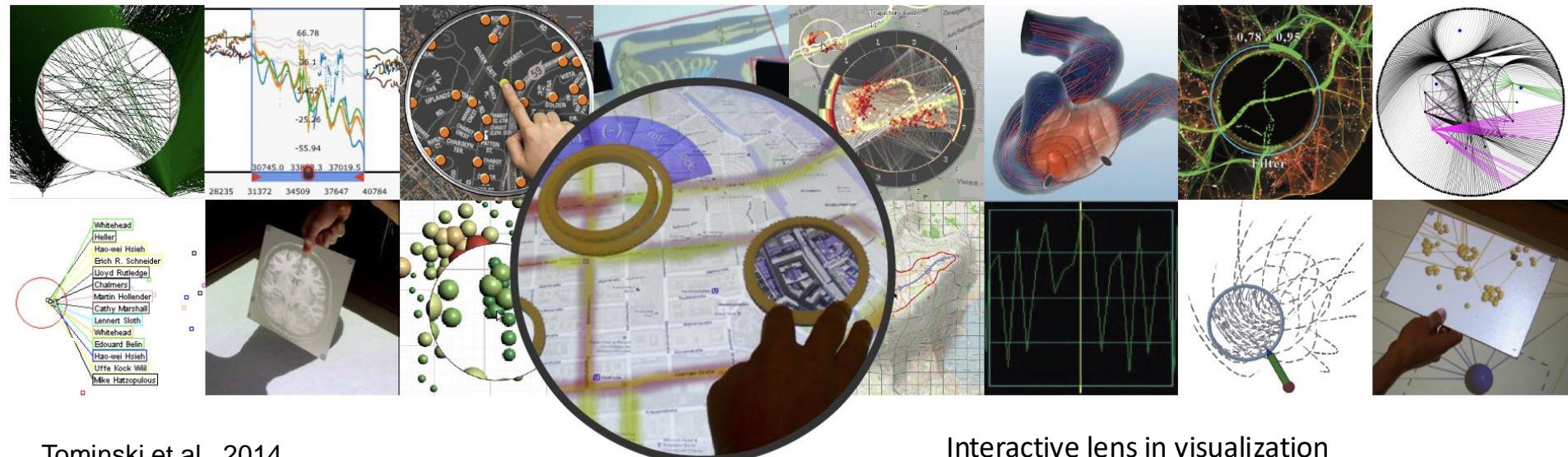


- Also applicable to abstract data visualization



Focus + context

- Pros:
 - gain a rapid overview of the data space
 - quickly follow graph representations that have a clear structure
- Cons:
 - impair the user's ability to make relative spatial judgments
 - cause target acquisition problems



Zooming

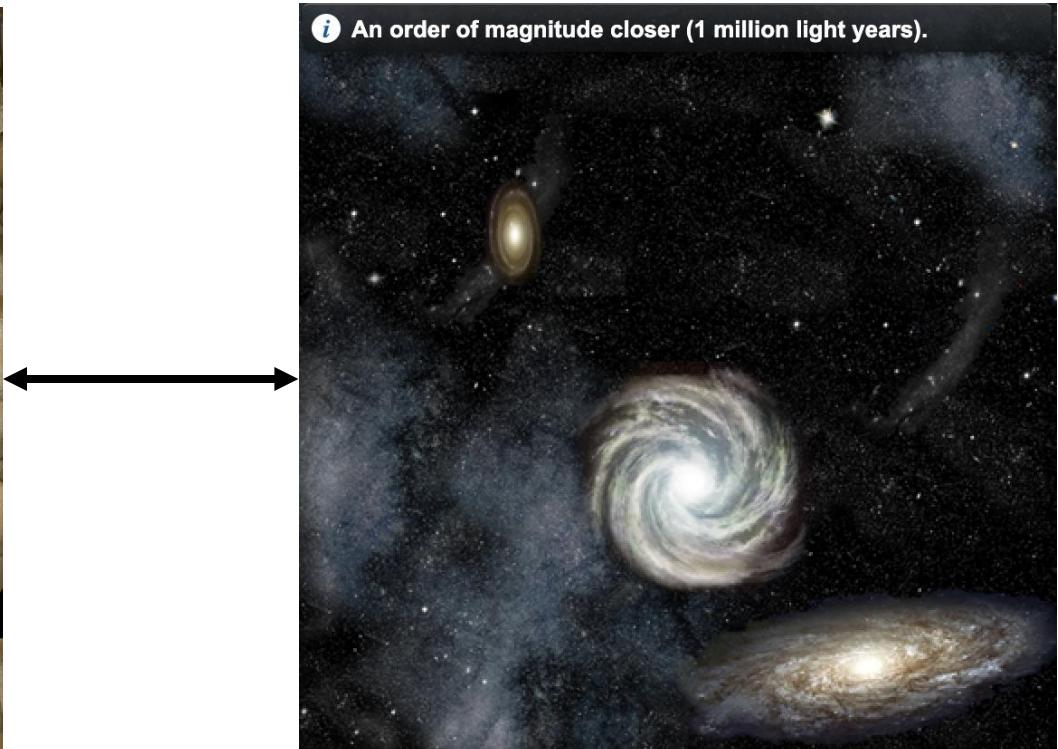
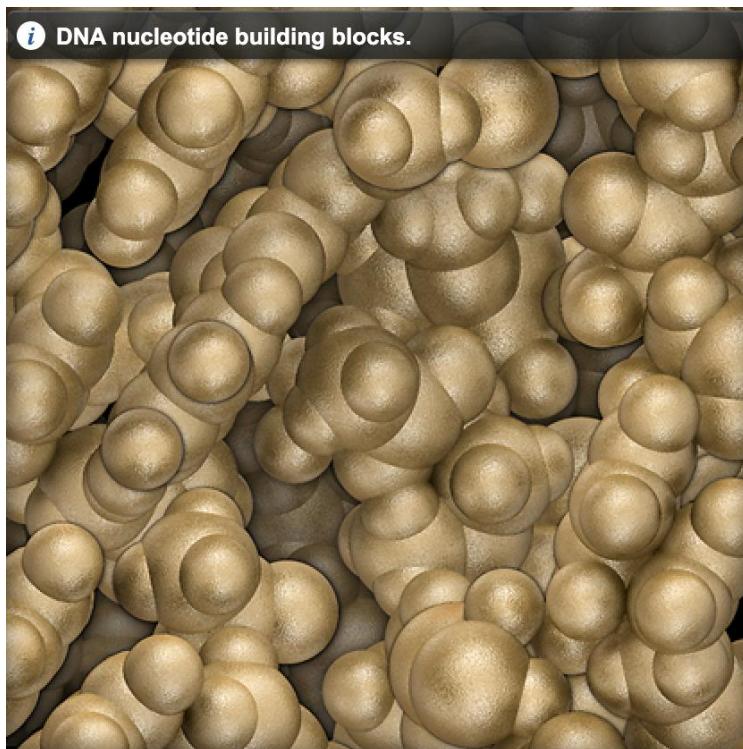
- Develop visualization and interface techniques to show viewers both overview + detail, and allow flexible alternation between each
- One common solution: **Pan/Scroll**
 - Provide a larger, virtual screen by allowing user to move to different areas
 - <https://observablehq.com/@d3/focus-context>
- Problems?
 - Still not a true overview
 - Clunky interaction

Powers of ten

<https://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html>

Zooming

- Zoom out shows an overview of data space
- Zoom in allows viewer to examine details



Critical issue

- What is the “best” way to go from one zoomed view to another?
 - Imaging to switch map view from HKUST to TianAnMen



- Research highlight: smooth zoom transitions
- Solution: differential equation to the rescue

Smooth zoom and pan

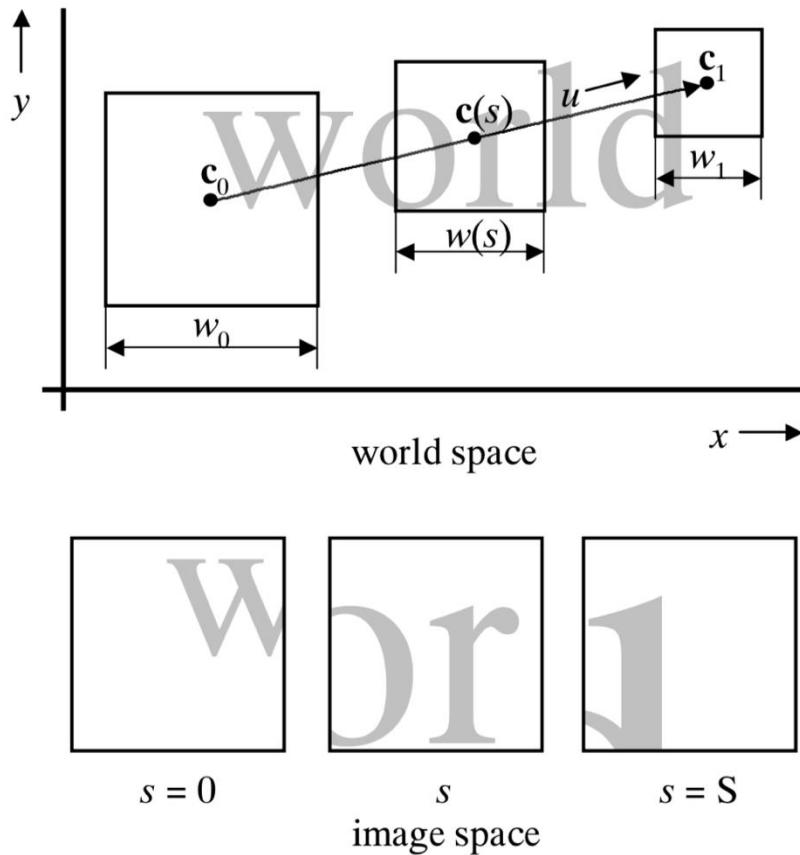


Figure 1: World space and image space

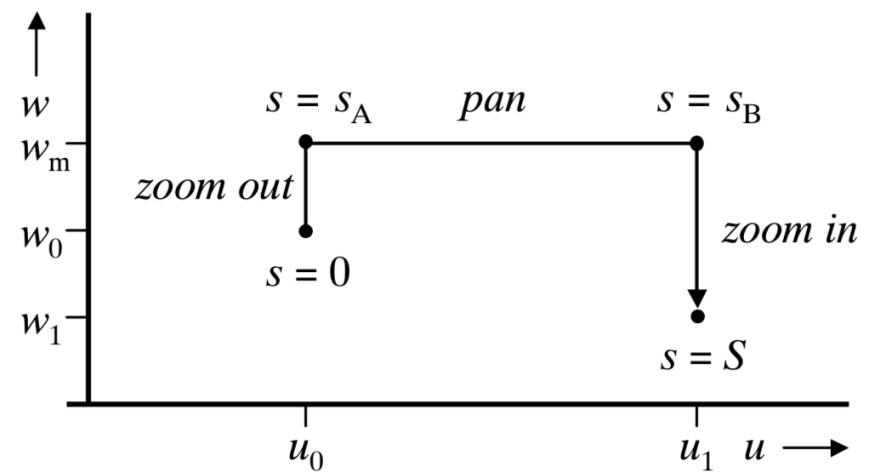


Figure 4: Zoom out, pan, zoom in

Smooth zoom and pan

Zooming

- Pros:
 - Supported by most desktop applications (but may not discovered)
 - CTRL + scroll wheel in Microsoft Office
 - Animation can attract attention
- Cons: easy to do badly
 - Easily create substantial cognitive load in assimilating the relationship between pre- and post-zoom states.
 - Animating the transition can dramatically reduce the cognitive load, but duration of animation is important.

6. Filter

“Show me something conditionally”

- Choose a rule, hide elements that don't match that rule
 - Change the set of data items being presented based on some specific conditions.
- The more complex the rule, the better you will be able to find patterns in the data - **More focus**
- The more complex the rule, the less transparent it is, so user doesn't know what the filtering is doing
 - **Less context**

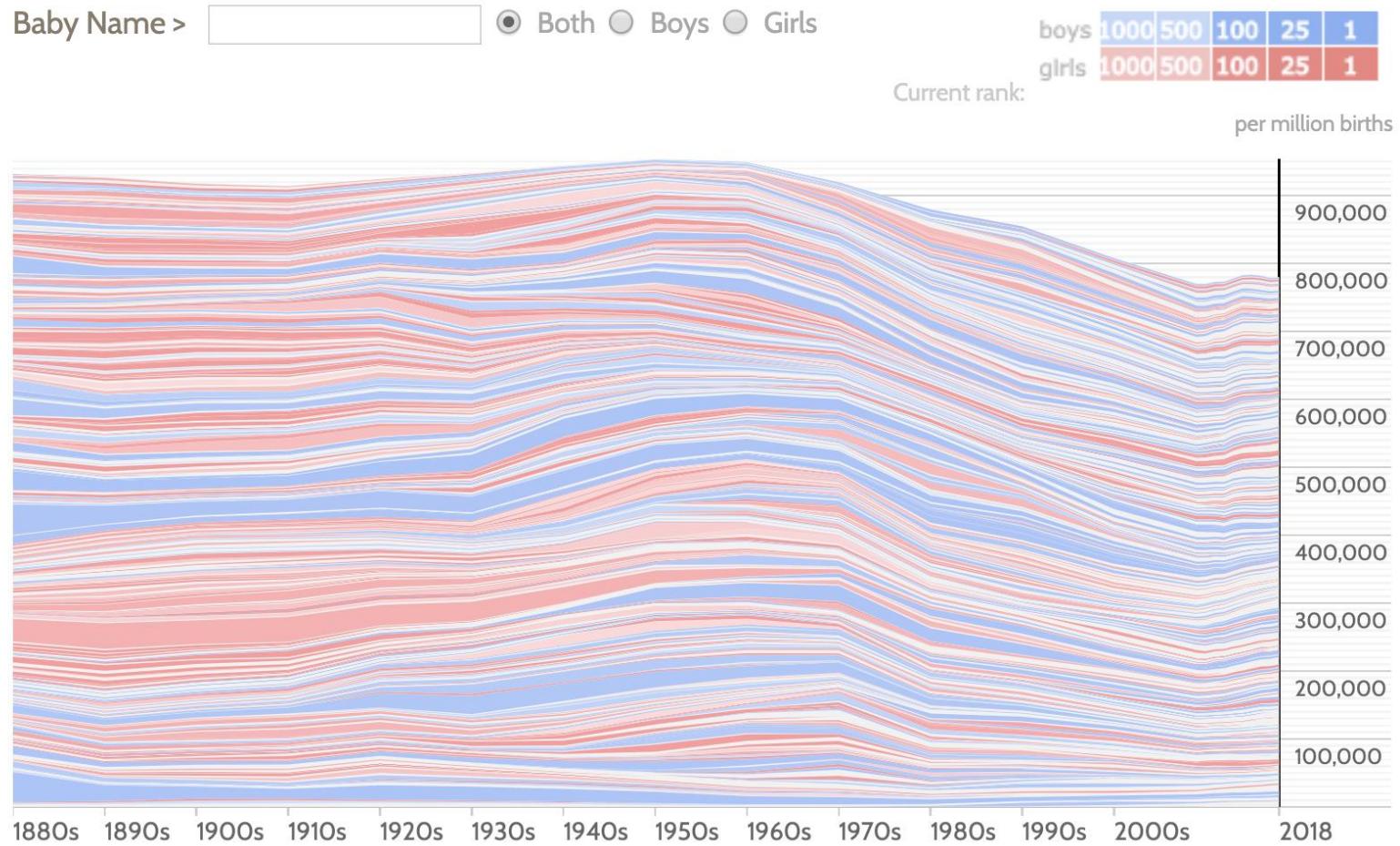
6. Filter

- Fundamental interactive operation in visualization is changing the set of data cases being presented
 - Focusing
 - Narrowing/widening
- Example
 - <https://benfry.com/zipdecode/>
 - <https://namerology.com/baby-name-grapher/>

6. Filter

- NameVoyager

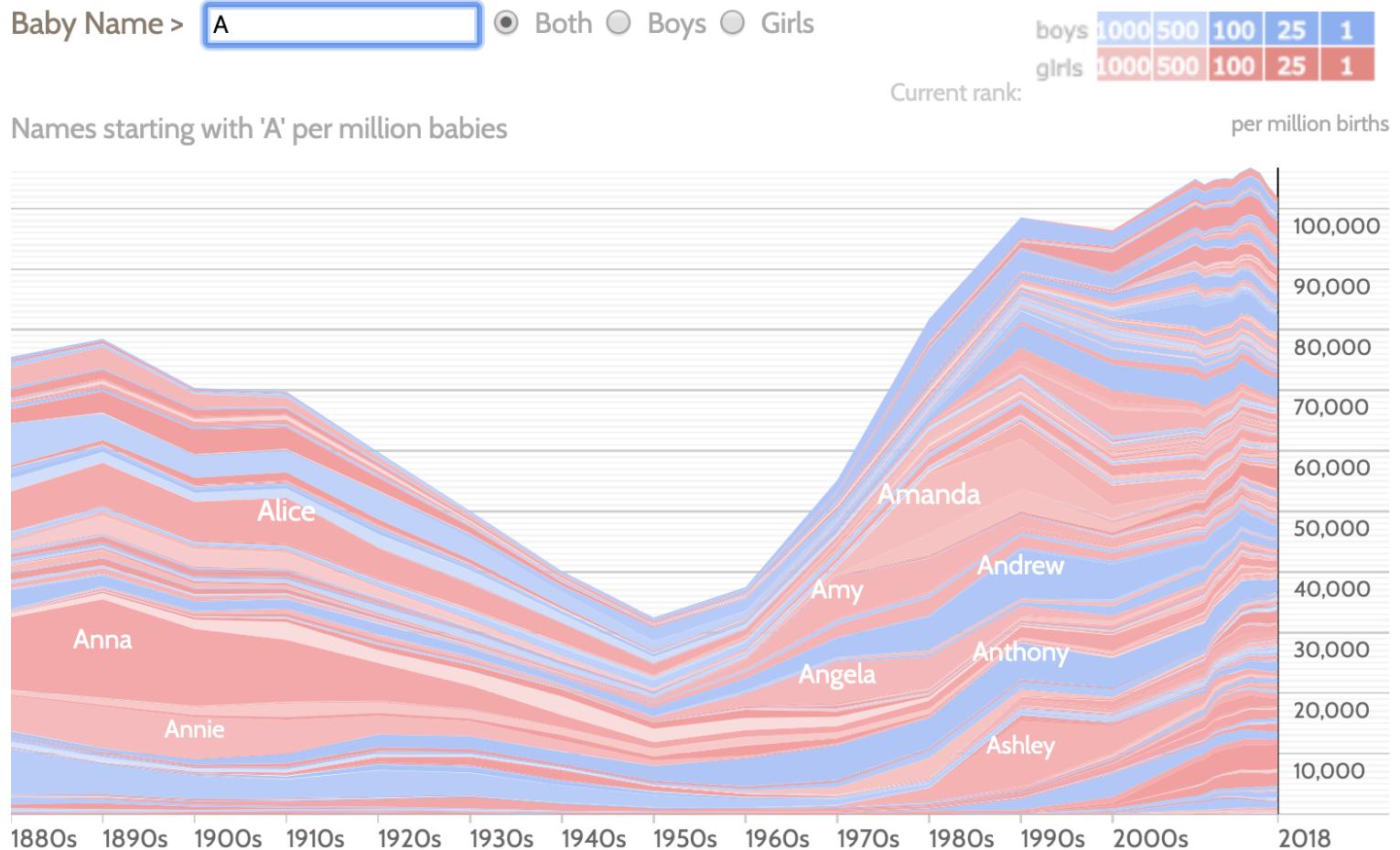
NameVoyager: Explore baby names and name trends letter by letter



6. Filter

- NameVoyager

NameVoyager: Explore baby names and name trends letter by letter



6. Filter

- NameVoyager

NameVoyager: Explore baby names and name trends letter by letter

Baby Name > Am

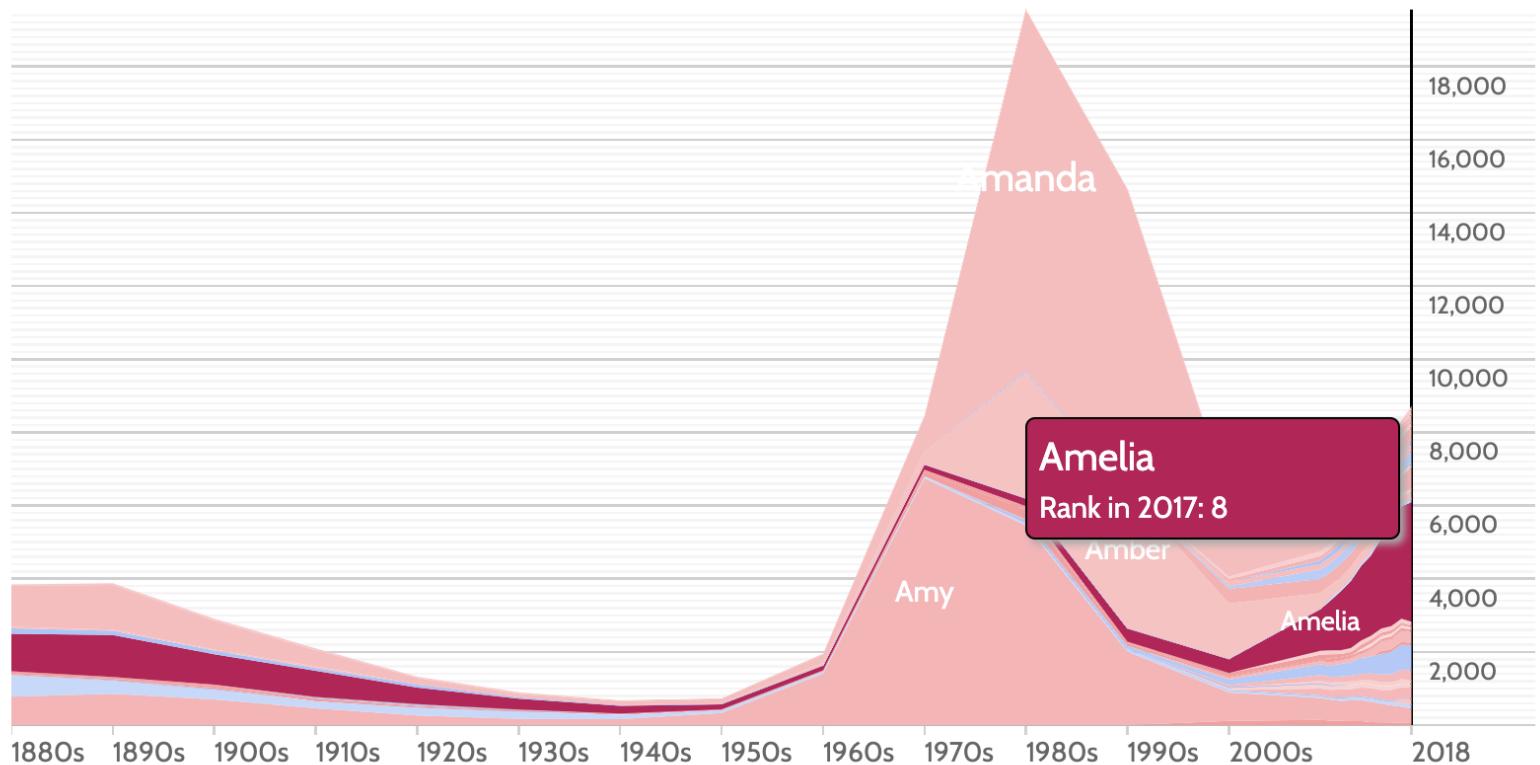
Both Boys Girls

boys	1000	500	100	25	1
girls	1000	500	100	25	1

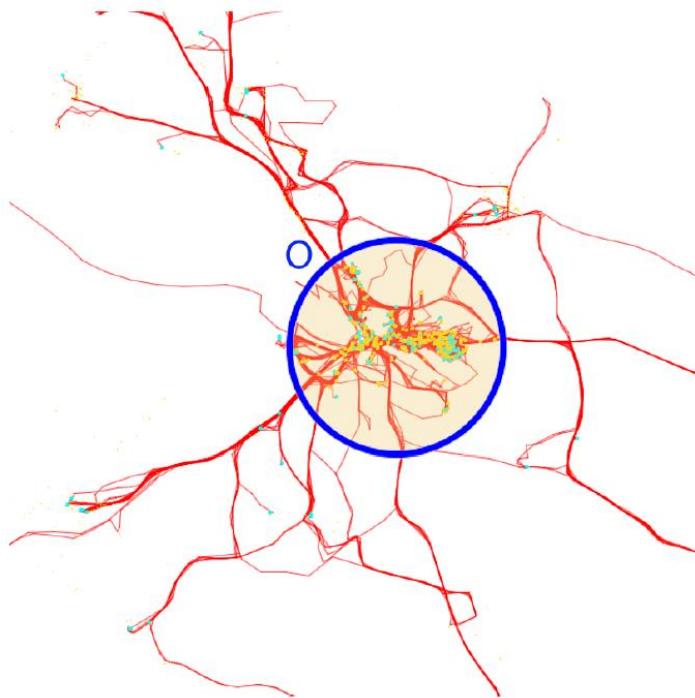
Current rank:

per million births

Names starting with 'AM' per million babies

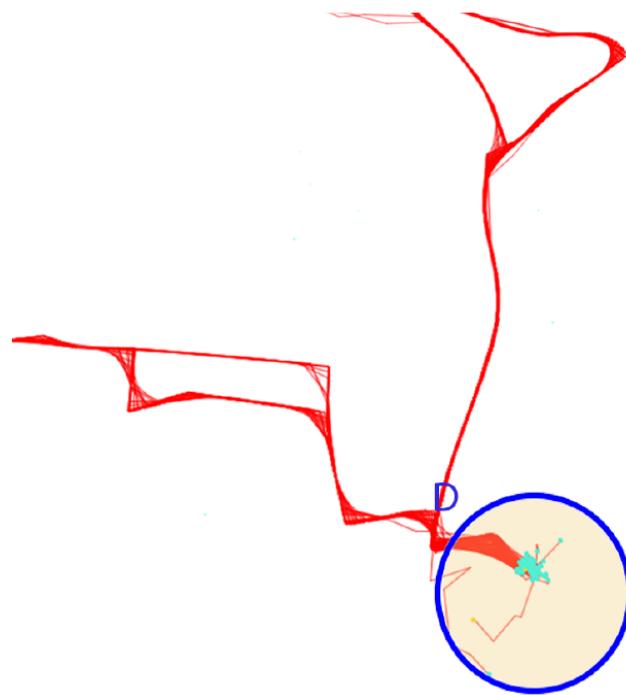


6. Filter



Origin lens:

query trajectories starting from
the area



Destination lens:

query trajectories ending at
the area

DB query vs. visual query

- DB query syntax:
 - **SELECT** *column1, column2, ...*
 - FROM** *table_name*
 - WHERE** *condition1 and condition2...*
- Pros:
 - Powerful, flexible
- Cons?

DB query vs. visual query

- Cons of DB query
 - Must learn language
 - Only shows exact matches
 - Don't know magnitude of results
 - No helpful context is shown
 - Reformulating to a new query can be slow
 - ...

DB query vs. visual query

- Pros of visual query
 - Specifying a query brings immediate display of results
 - “Fly through the data”, promote exploration, make it a much more “live” experience
 - Timesharing vs. batch
 - Visual representation of world of action including both the objects and actions
 - Rapid, incremental and reversible actions
 - Selection by pointing (not typing)
 - Immediate and continuous display of results

7. Connect

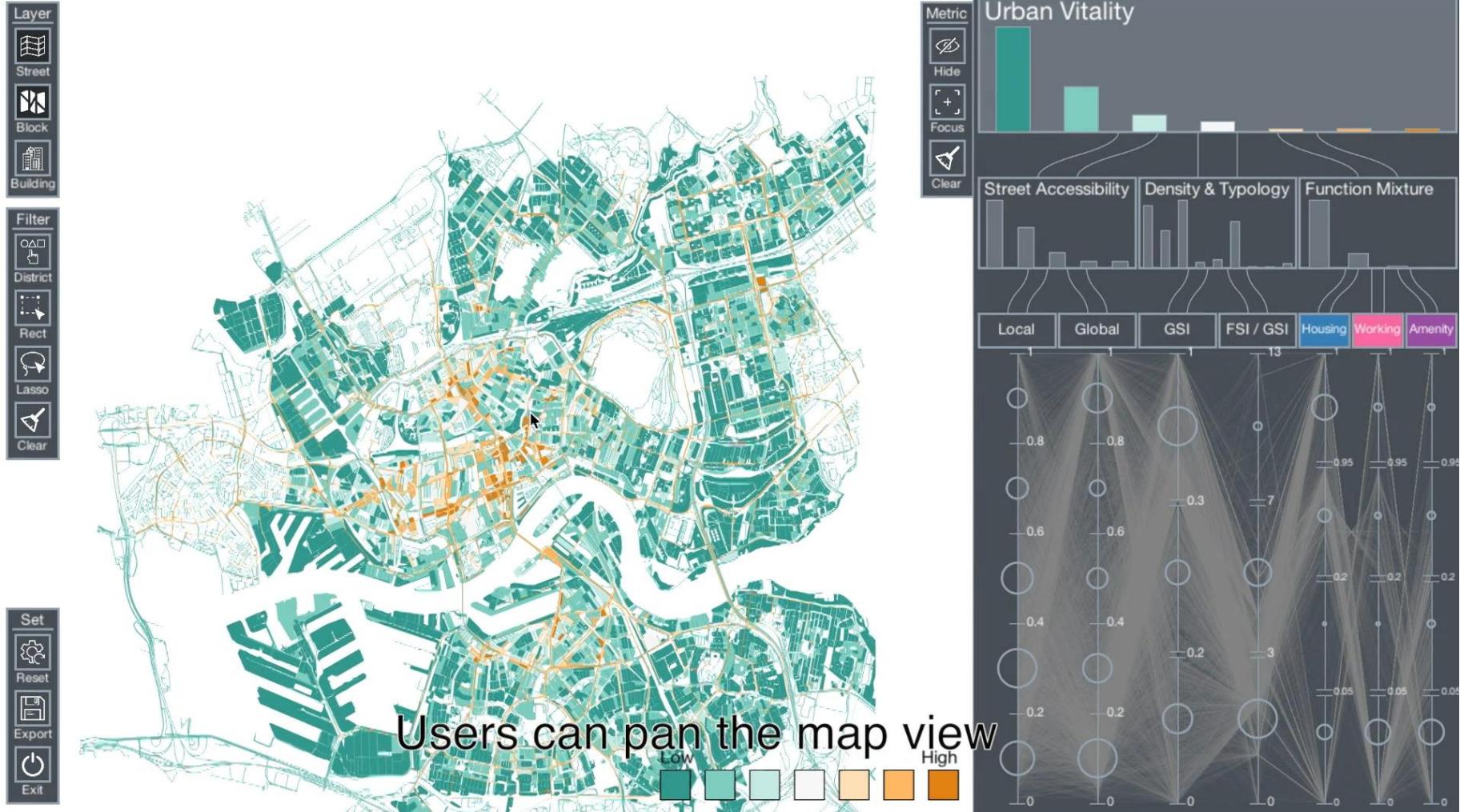
“Show me related items”

- Highlight associations and relationships
- Show hidden data items that are relevant to a specified item

Linked brushing

- Multiple views
 - Viewer may wish to examine different attributes of a data case simultaneously
 - Alternatively, viewer may wish to view data case under different perspectives or representations
 - But need to keep straight where the data case is
- Selecting or highlighting a case in one view generates highlighting the case in the other views

Linked brushing



Interaction taxonomy

- The role of interaction in information visualization
 - Select: Mark something as interesting
 - Explore: Show me something different
 - Reconfigure: Show me a different arrangement
 - Encode: Show me a different representation
 - Abstract/Elaborate: Show me more or less detail
 - Filter: Show me something conditionally
 - Connect: Show me related items

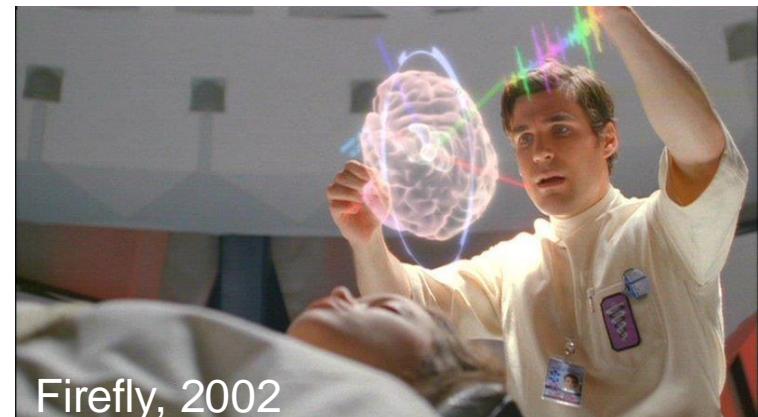
Data Exploration & Visualization

Module 7: Interaction

- Interaction taxonomy
 - Select, explore, reconfigure, encode, abstract / elaborate, filter, connect
- Beyond the desktop
 - New interaction and visualization devices
 - Challenges and solutions

Beyond the Desktop

- WIMP (windows, icons, menus, pointer) metaphor on desktops assumes certain input devices
 - Keyboard and mouse centric
- Other input devices
 - Direct vs. Indirect
 - Linear vs. Rotary
 - Dimensions (1-3D)

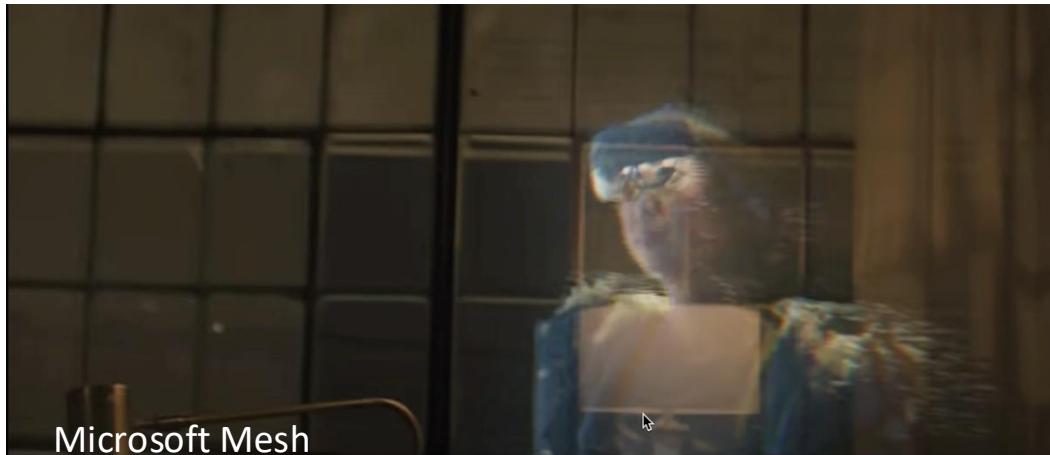


Beyond the Desktop

- Emerging interaction and visualization devices
 - AR, VR & MR
 - Small smartwatches, tablets
 - Big video wall...
 - ...



Zeng et al., TIP 2020



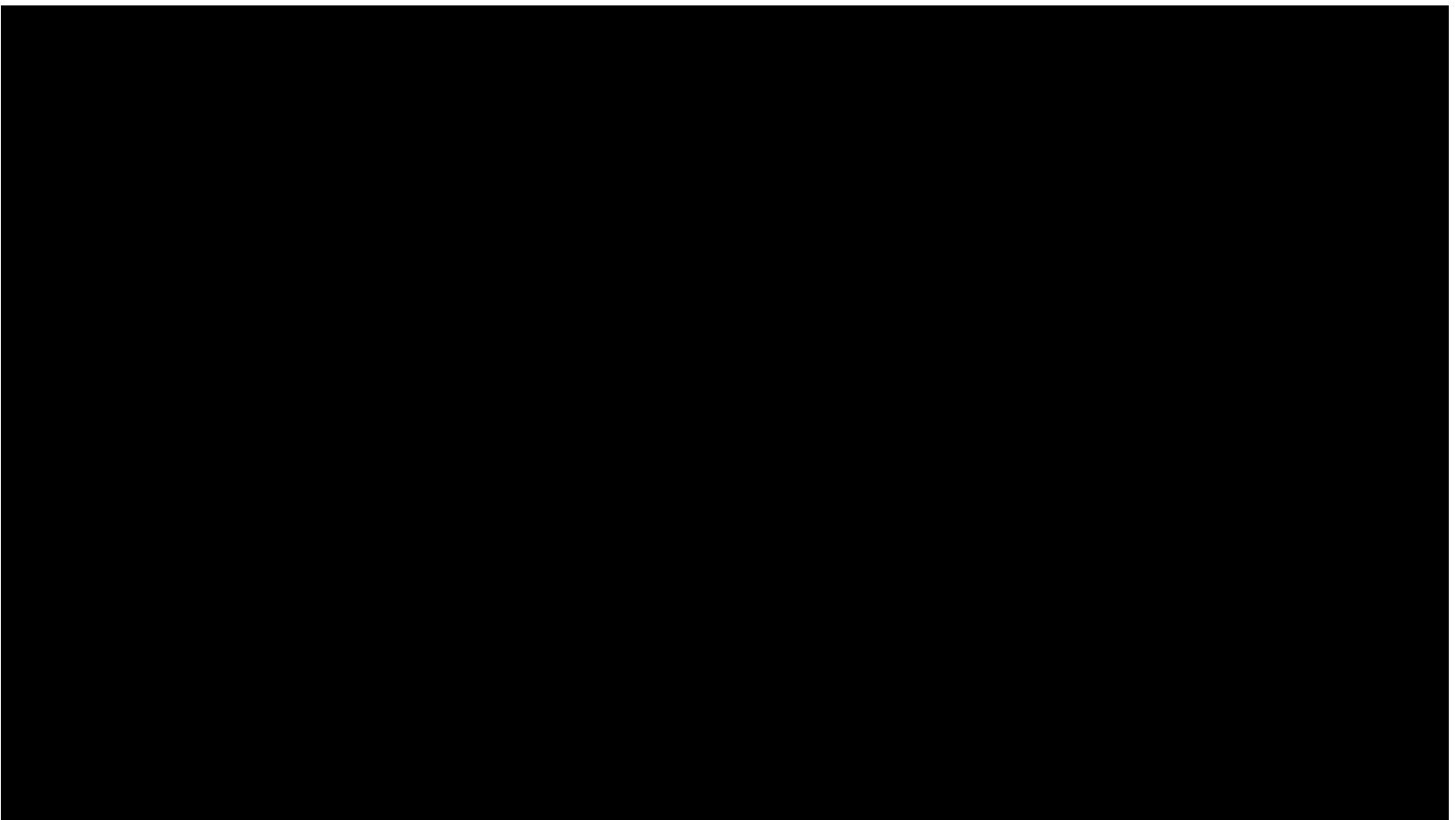
Microsoft Mesh



Langner et al., TVCG 2019

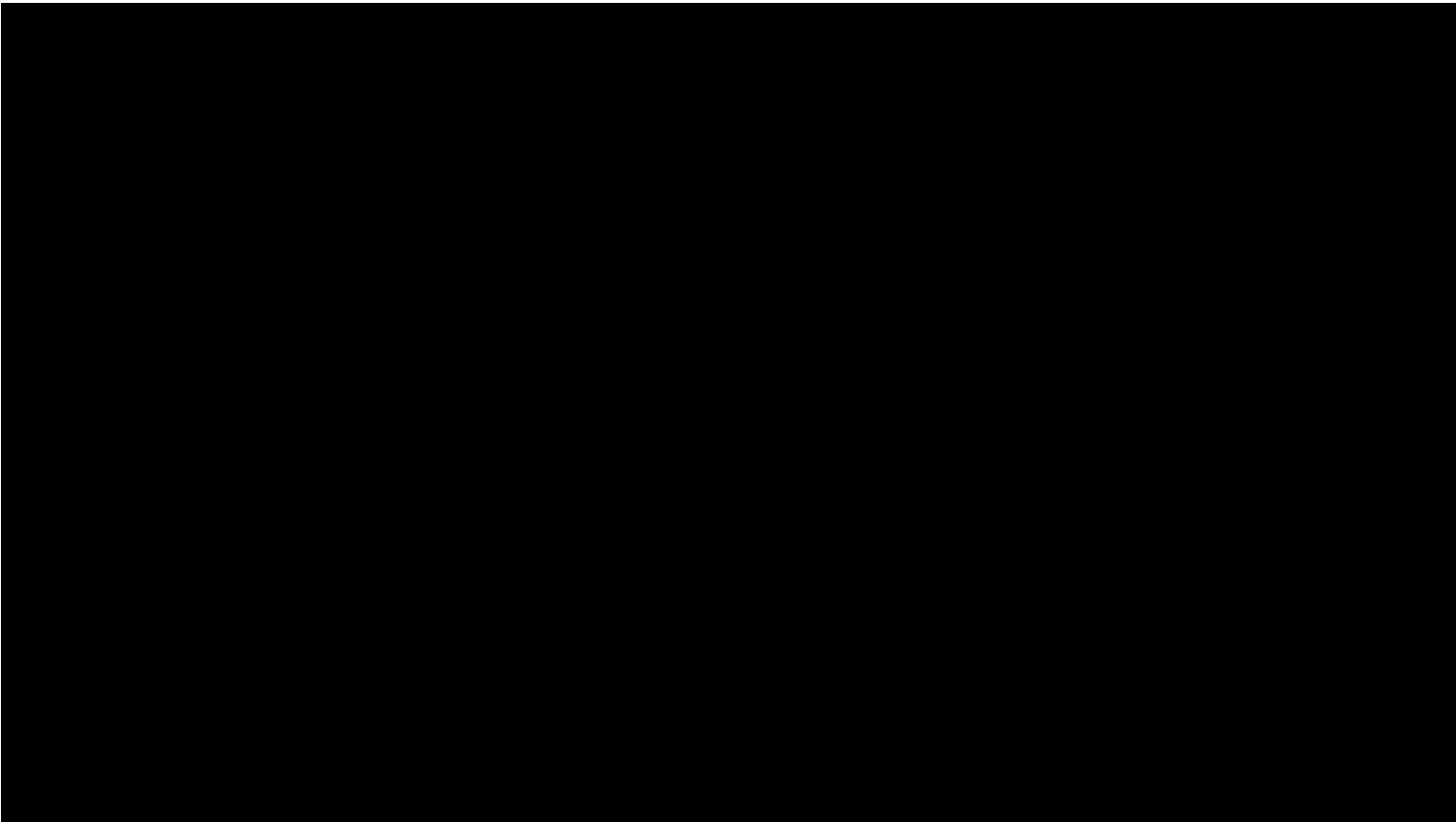
Beyond the Desktop

- Examples – augmented reality
 - Projections of reality

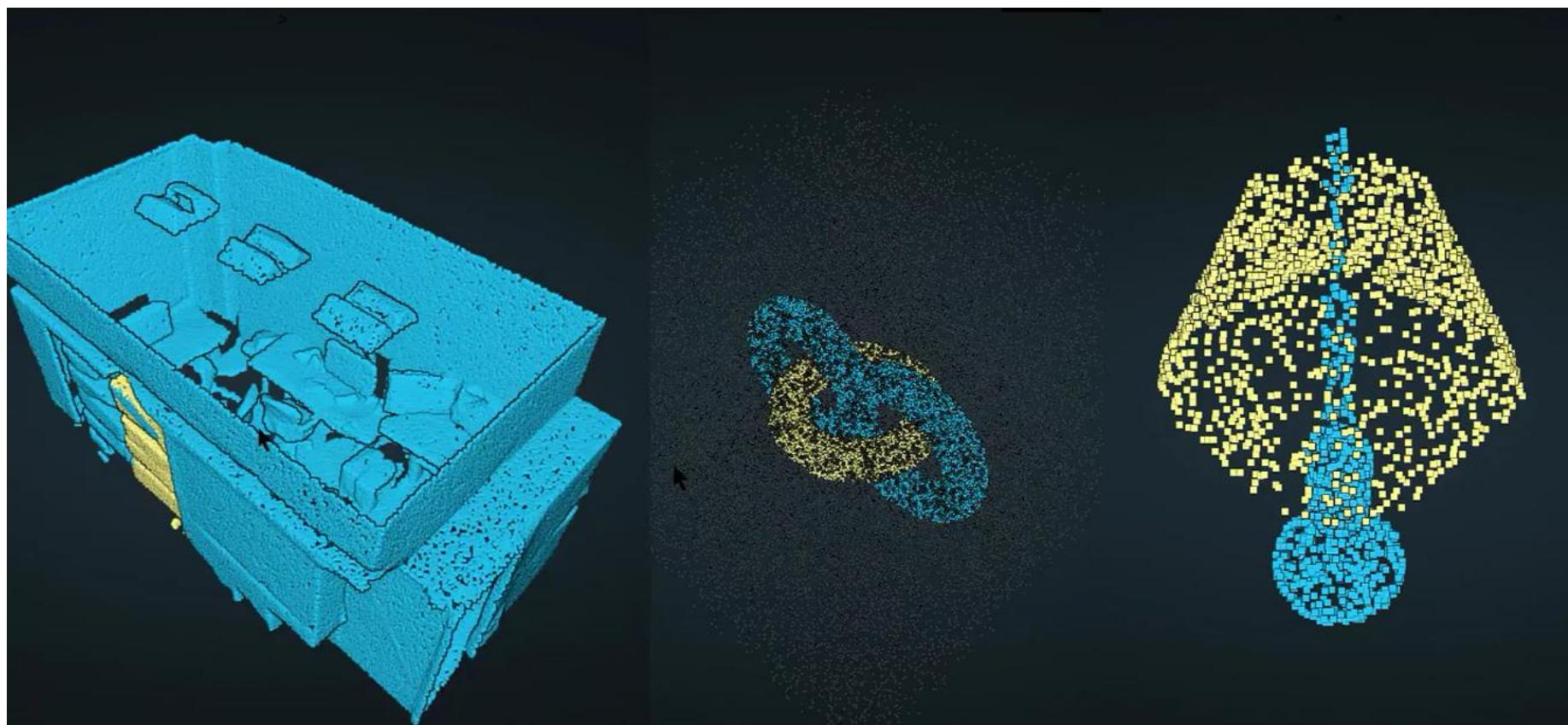


Gesture interactions?

- Gesture interactions are fascinating, but not easy
 - Hand gestures are inaccurate and implicit
 - Machines shall understand our intentions



Deep learning for interaction



Exploratory analysis of point clouds is important in many applications.

LLM for interaction

***VirtuWander*: Enhancing Seamless Multi-modal Interaction
for Virtual Tour Guidance through Large Language Models**

Zhan Wang, Lin-Ping Yuan, Liangwei Wang, Bingchuan Jiang, Wei Zeng

Natural Interface

CSIG-VIS

February 23/24, 2022

Designing Flexible and Natural Interfaces for Human-Data Interaction

John Stasko

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