

INTERACTION FOR VISUALIZATION

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UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

INTERACTION
DATAVIS FALL 2025 | HANS-JÖRG SCHULZ
ASSOCIATE PROFESSOR



1. INTRODUCTION

2. VISUAL ENCODING

3. BASIC CHART TYPES

4. INTERACTION

5. VISUALIZATION DESIGN

6. DATA PREPROCESSING

7. RECAP 1st Half

8. MULTIVARIATE DATAVIS

9. TEMPORAL DATAVIS

10. GEOSPATIAL DATAVIS

11. GRAPH DATAVIS

12. 3D DATAVIS

13. VISUAL ANALYTICS

14. RECAP 2nd Half

Basics

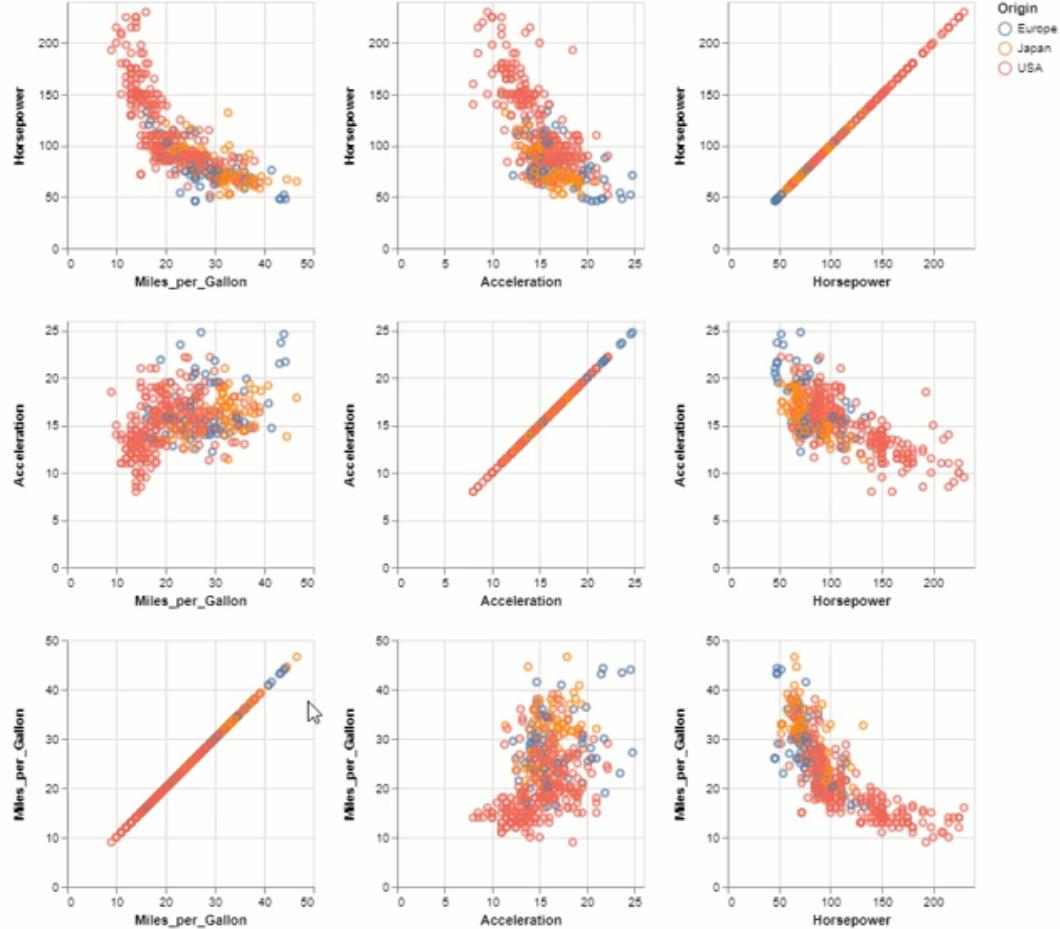
Visualization
Building Blocks
& Processes

Visualization
Techniques

Visualization
Applications



WHY TALK ABOUT INTERACTION?



- **Possibility of adjusting the visualization**
-> from viewing to exploring
- **Possibility for issuing visual queries**
-> from typing to selecting or sketching
- **Possibility for enhancing the visualization**
-> from screenshot to annotated animation
- **Possibility to cater to diverse users & tasks**
-> from one-size-fits-all to tailored vis



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OVERVIEW

- Visual Information Seeking:
 - Overview & Detail and Zoom & Pan
 - Focus & Context and Interactive Lenses
- Multiple Coordinated Views and Brushing & Linking
- Tangible Interaction for Data Visualization



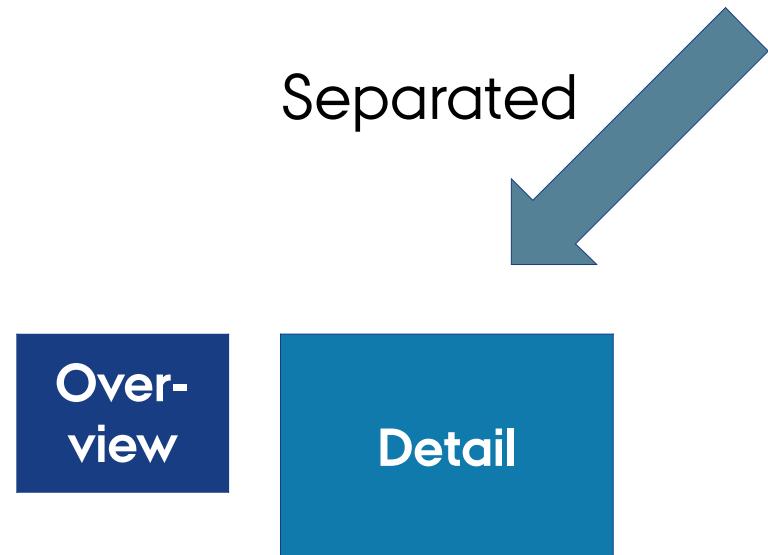
VISUAL INFORMATION SEEKING - OVERVIEW & DETAIL

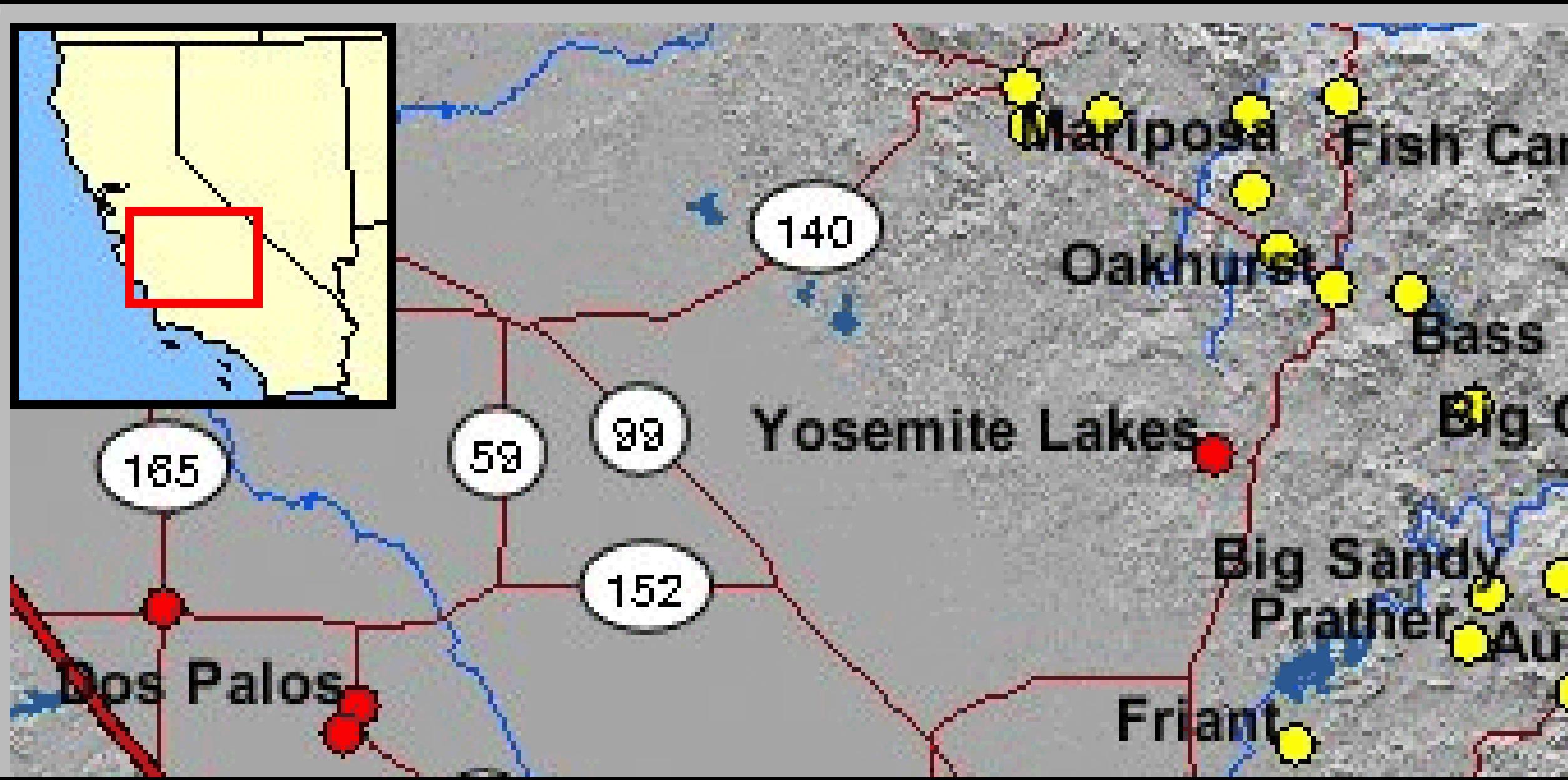


VISUAL INFORMATION SEEKING MANTRA

'Overview first, zoom and filter, then details-on-demand'

Ben Shneiderman, 1996

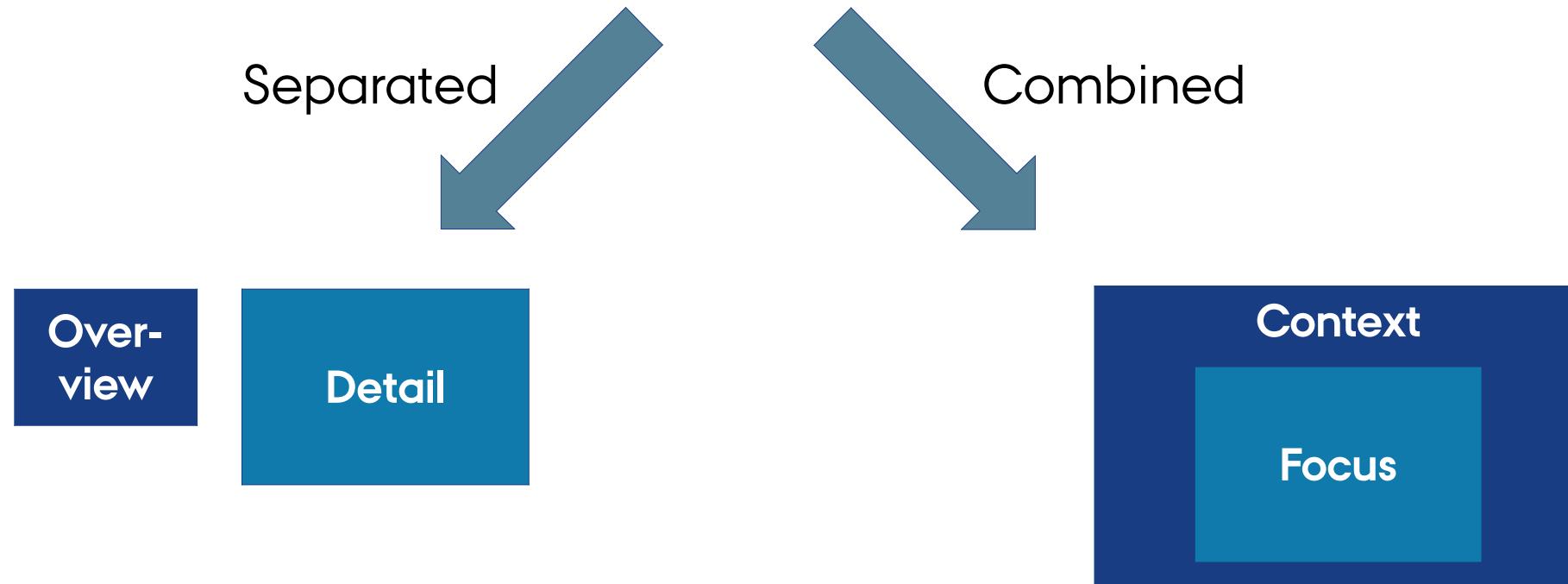


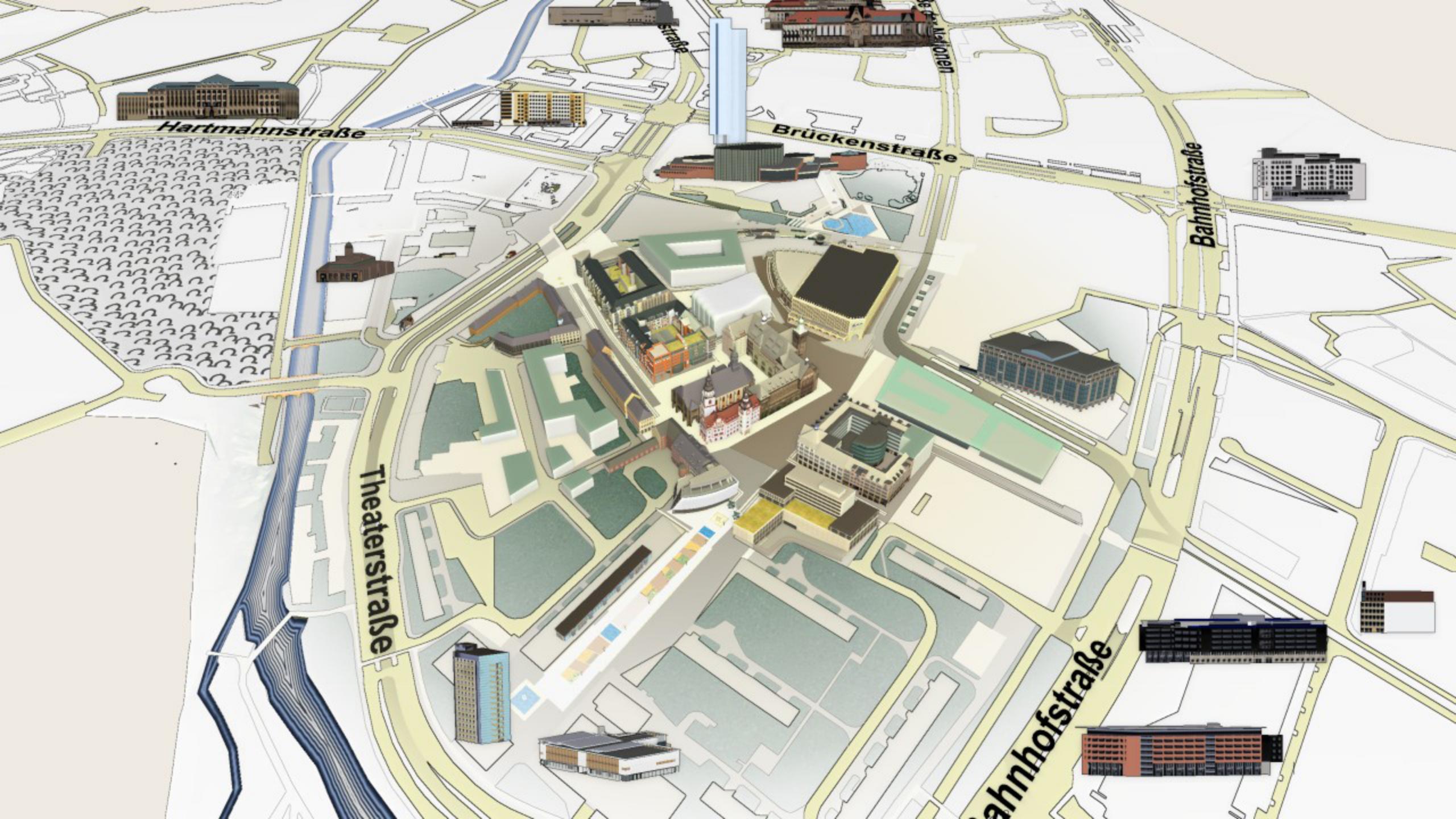


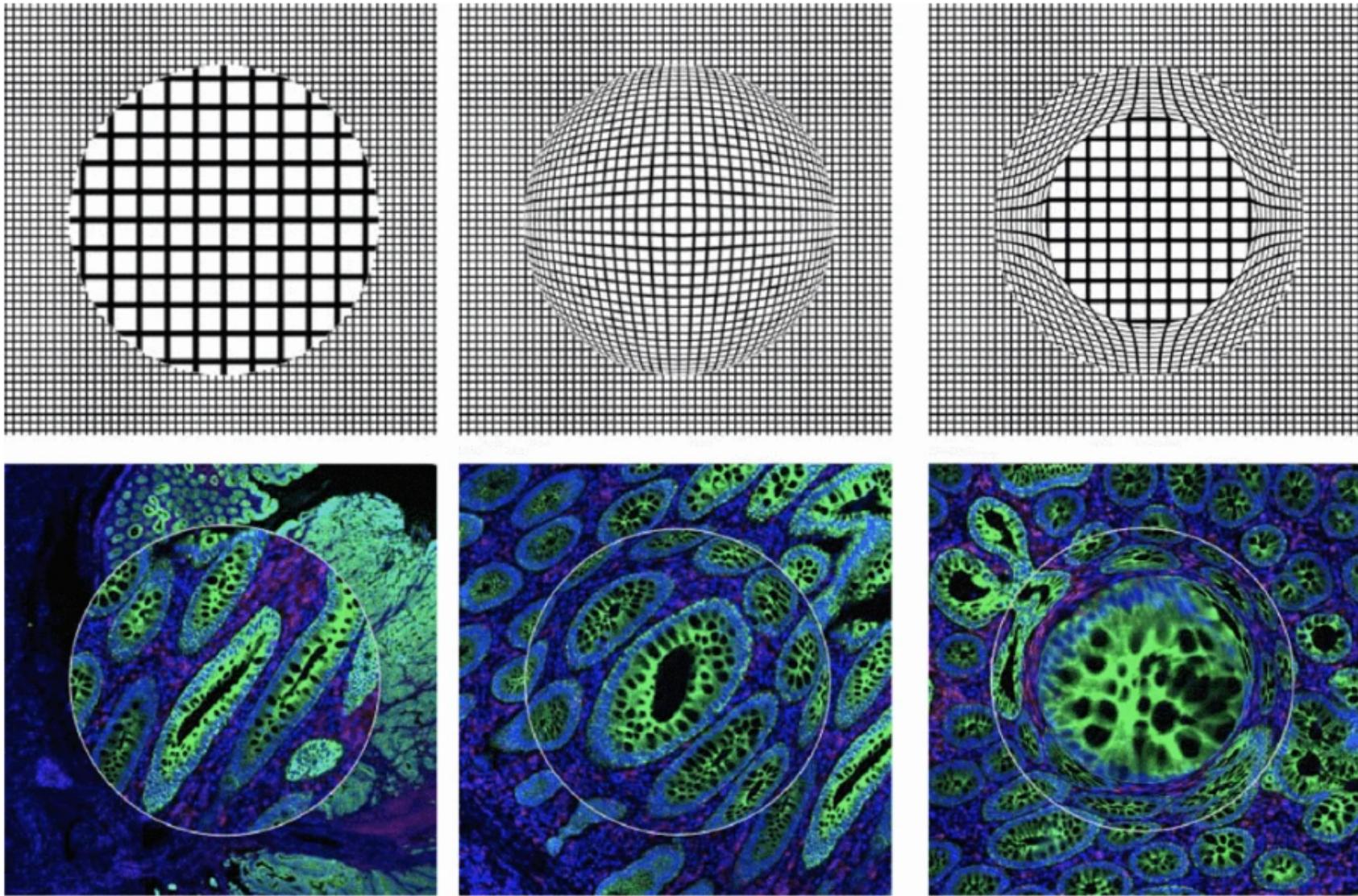
VISUAL INFORMATION SEEKING MANTRA

‘Overview first, zoom and filter, then details-on-demand’

Ben Shneiderman, 1996







(A) Magnification

(B) Fisheye

(C) Plateau

[doi:10.1109/TVCG.2021.3114786]



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OVERVIEW + DETAIL TECHNIQUES

Separation can be

- **Spatial:** Overview & Detail in separate views (e.g., Minimap)





Templafy

Clipboard

Slides

Font

Paragraph

Drawing

Editing

Create and Share

Adobe PDF

Dictate

Design Ideas

Voice

Designer

VISUAL INFORMATION SEEKING MANTRA

Overview first, zoom and filter, then details on-demand

Ben Shneiderman, 1996

Separated

Combined

Over-view

Detail

Context
Focus



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DAVI - INTERACTION
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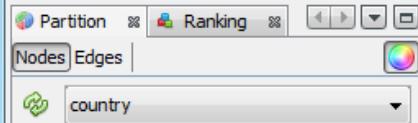




Overview

Data Laboratory

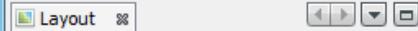
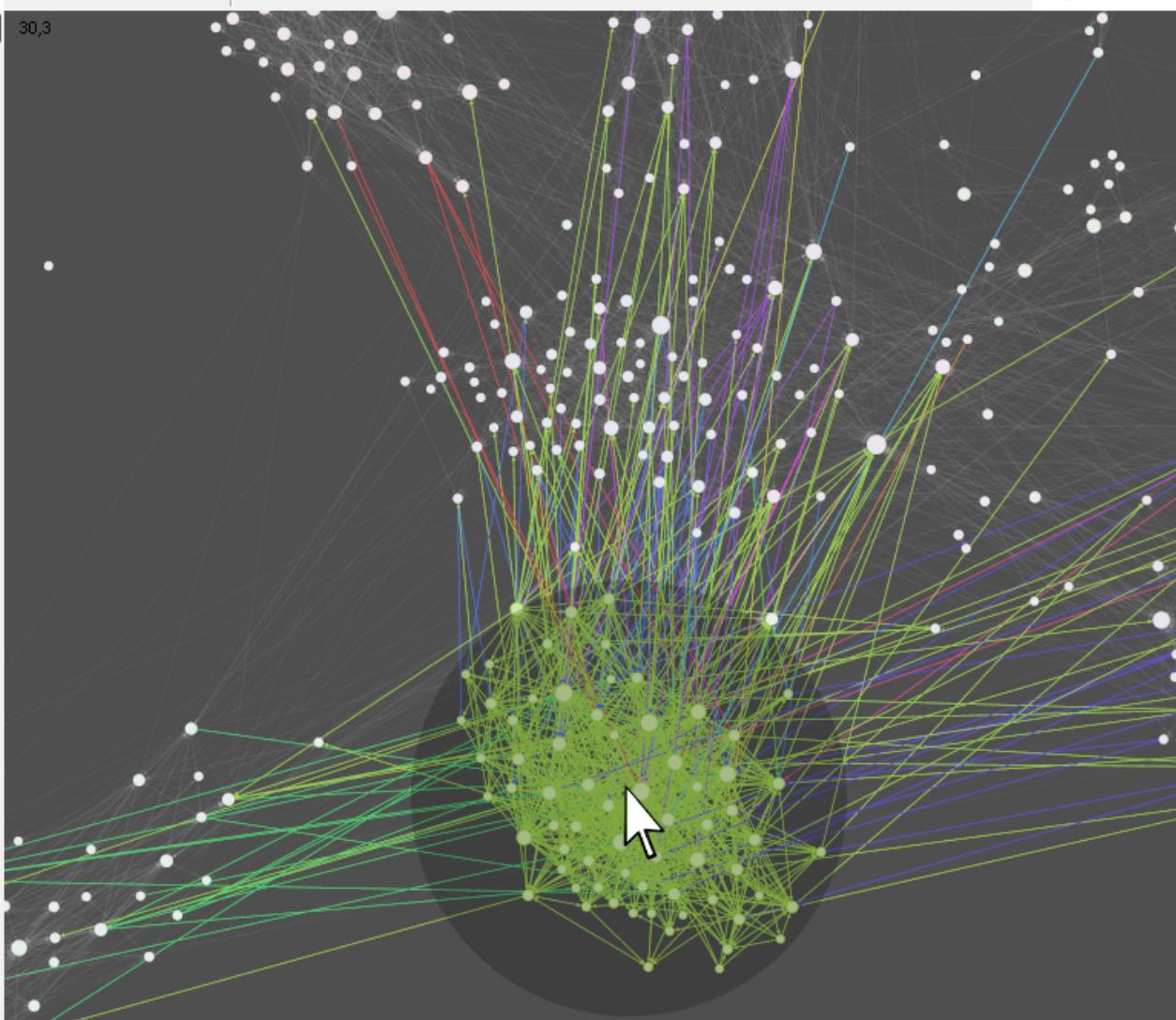
Preview



Mouse selection

30,3

Hierarchy



Run

Force Atlas

Inertia	0.1
Repulsion strength	115.0
Attraction strength	10.0
Maximum displacement	10.0
Auto stabilize function	<input checked="" type="checkbox"/>
Autostab Strength	80.0
Autostab sensibility	0.2
Gravity	15.0
Attraction Distrib.	<input type="checkbox"/>
Adjust by Sizes	<input checked="" type="checkbox"/>
Speed	1.0

Presets... Reset



A Arial Gras, 20



Context

Nodes: 677 (52,68 %)

Edges: 6120 (81,34 %)

Directed Graph

Statistics

Filters

Reset

Library

- + Attributes
- + Dynamic
- + Edge
- + Operator
- + Topology
- Saved queries

Queries

Degree Range

Degree Range Settings



Select

Filter

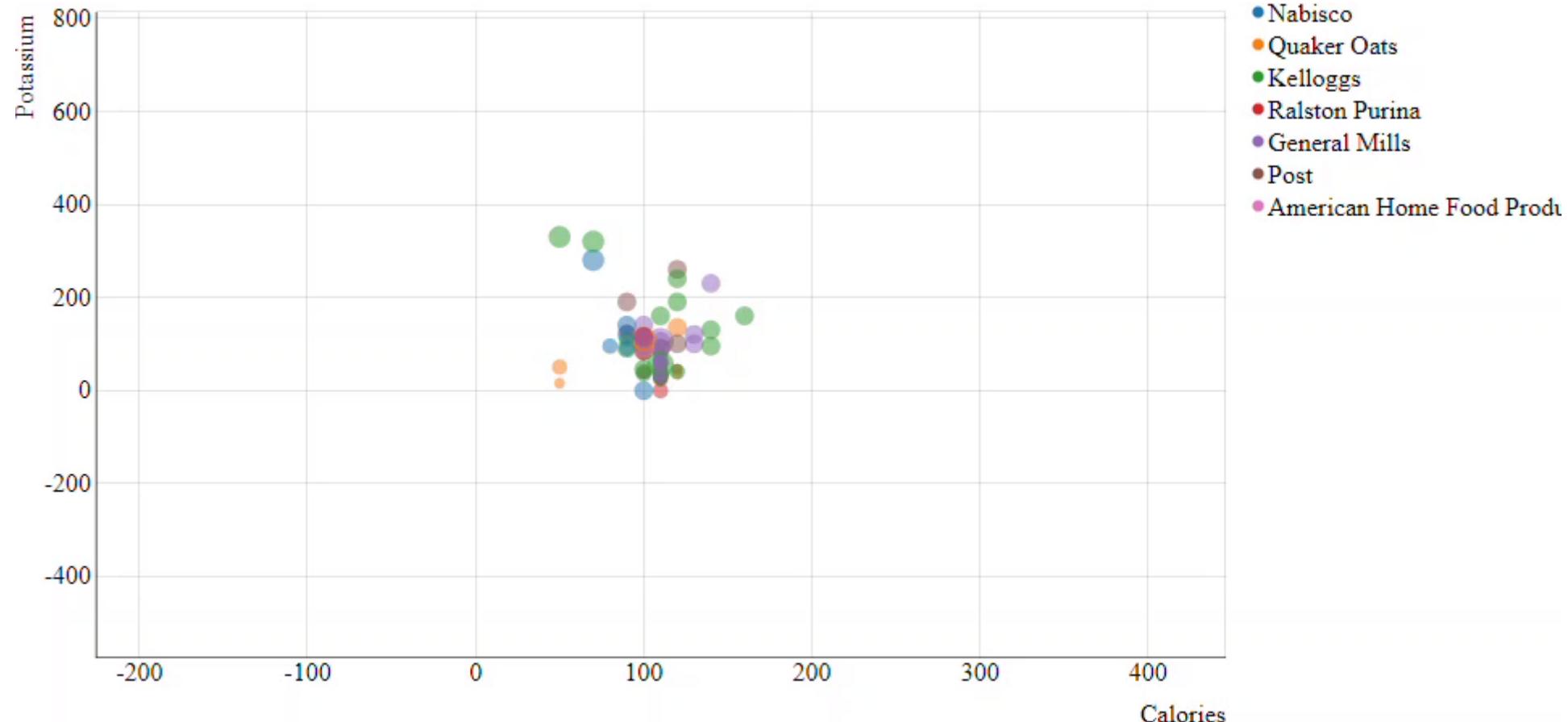
Workspace 1

OVERVIEW + DETAIL TECHNIQUES

Separation can be

- **Spatial:** Overview & Detail in separate views (e.g., Minimap)
- **Temporal:** Overview & Detail are shown one after the other (e.g., Zoom)

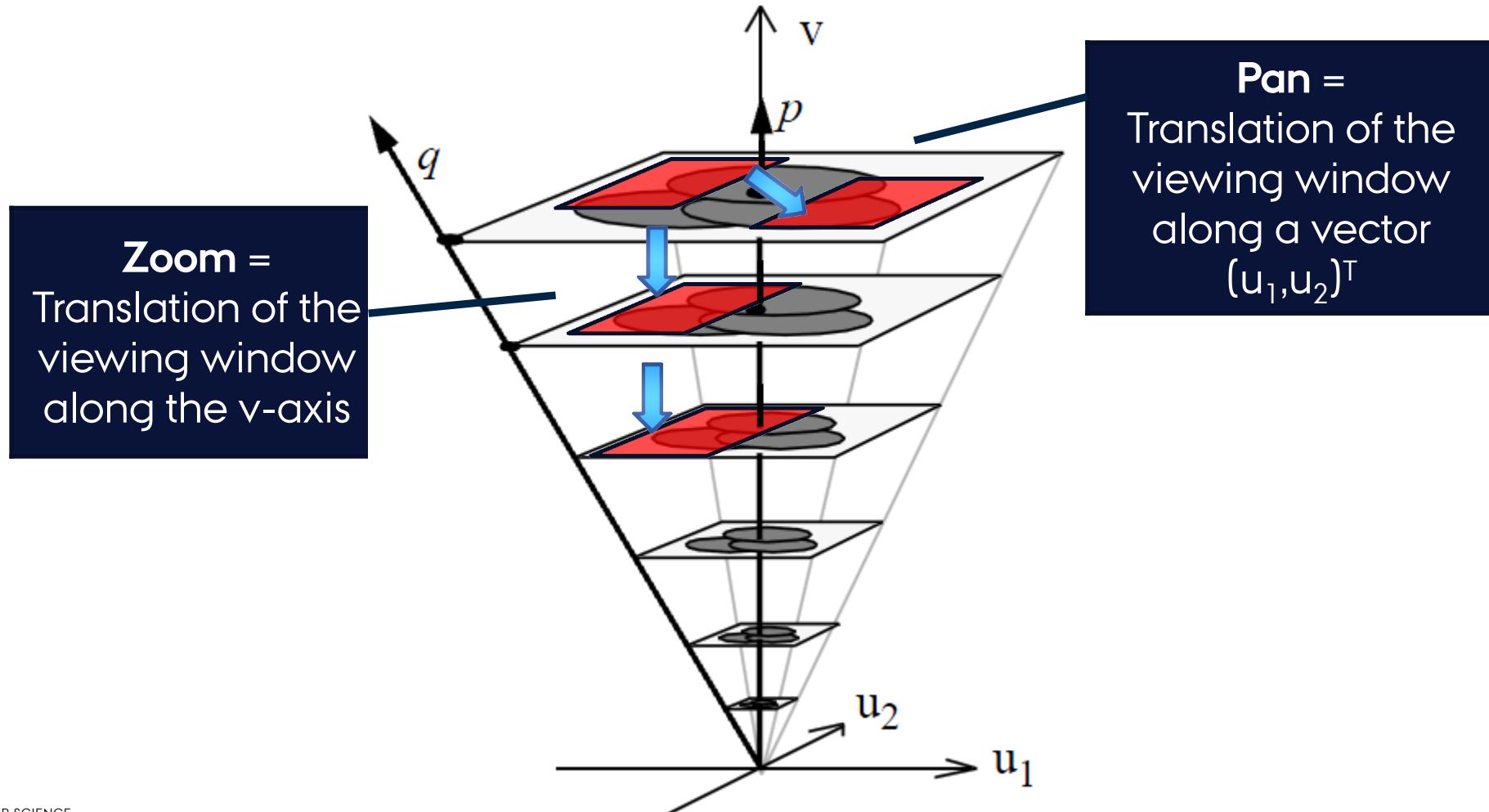
ZOOM-IN/OUT



Jonas Petterson's
D3 Zoomable Scatterplot

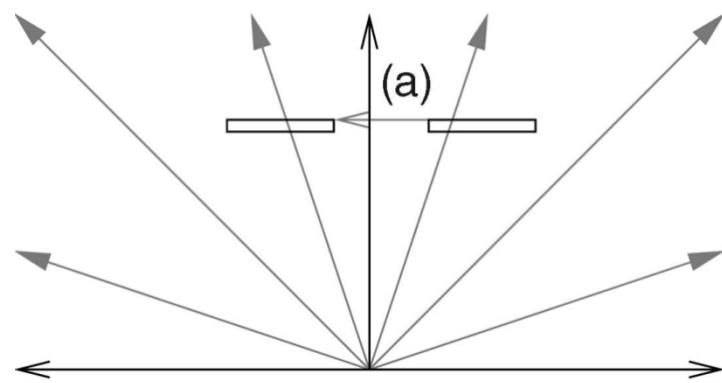
A CONCEPTUAL SPACE OF ZOOM & PAN

Space-Scale-Diagrams [Furnas, Bederson 1995]:

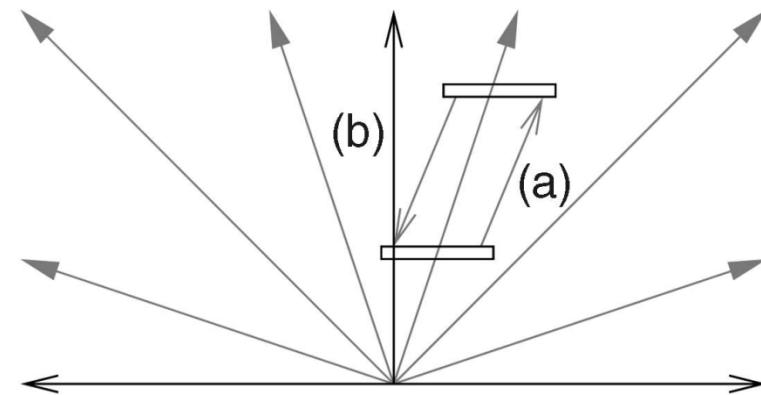


A CONCEPTUAL SPACE OF ZOOM & PAN

Abstraction into 2D diagrams:



Pan

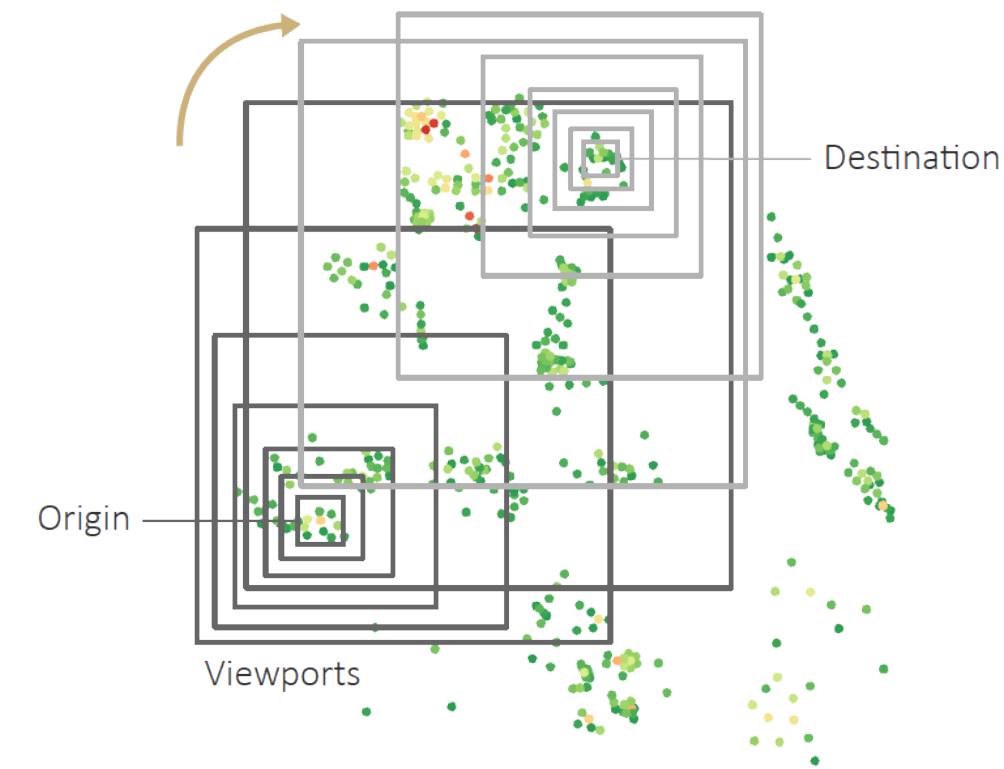
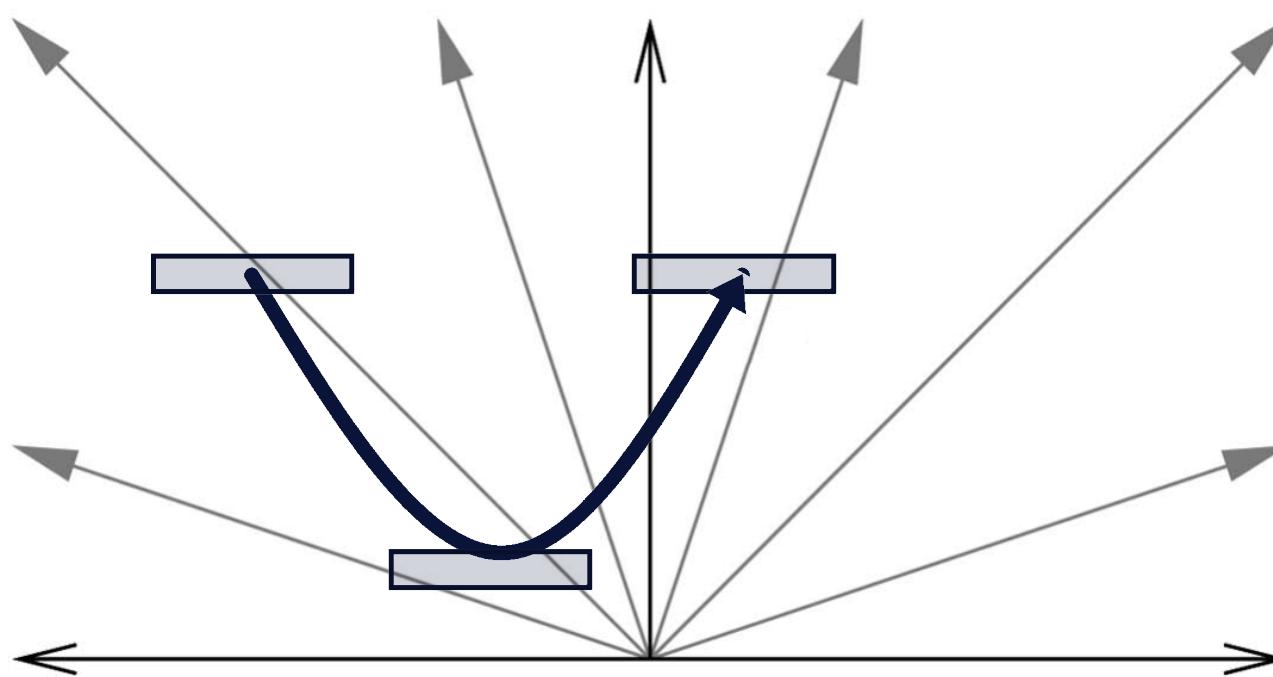


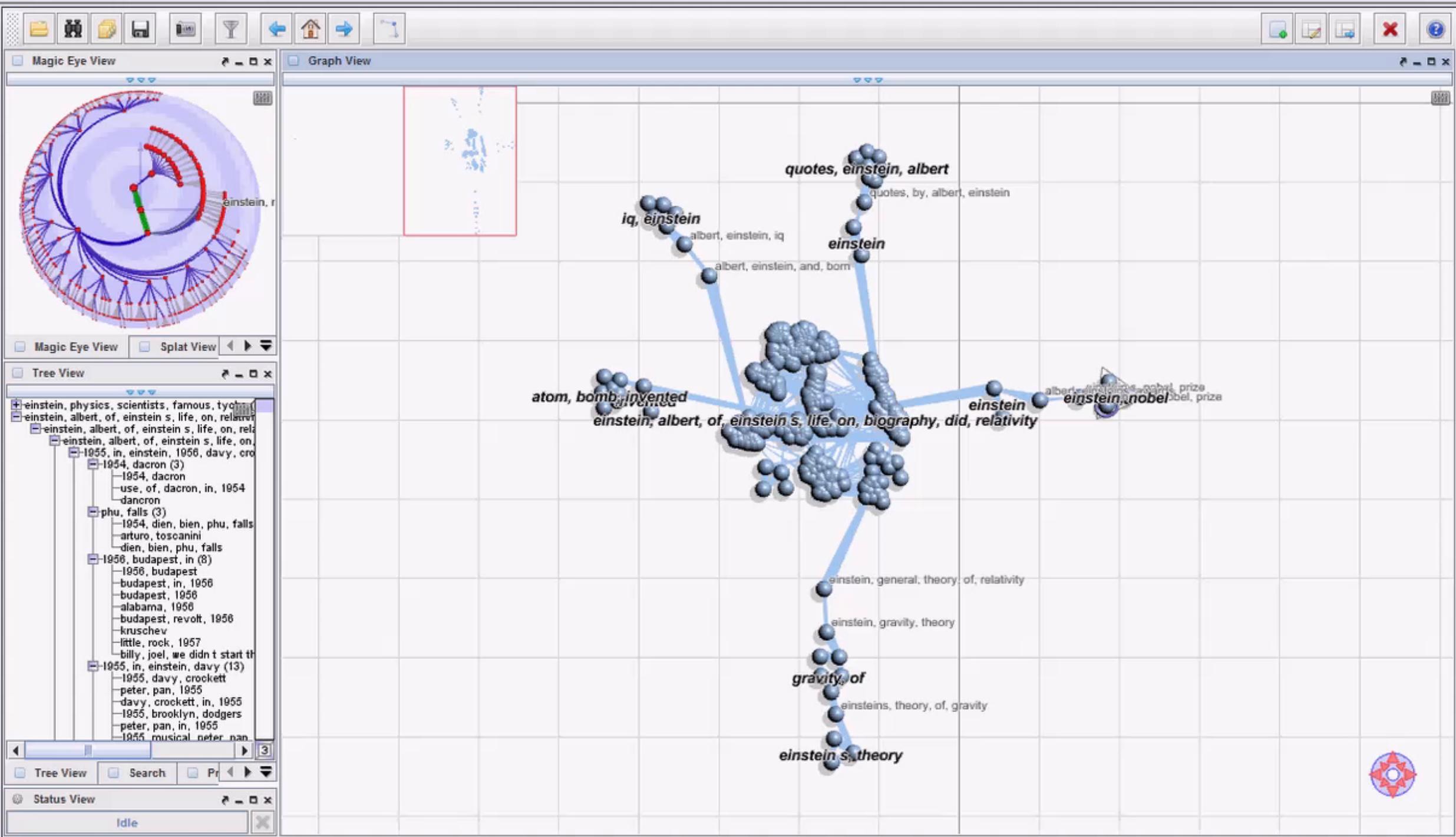
Zoom

EXAMPLE: SMOOTH NAVIGATION

[v.Wijk, Nuij 2004]

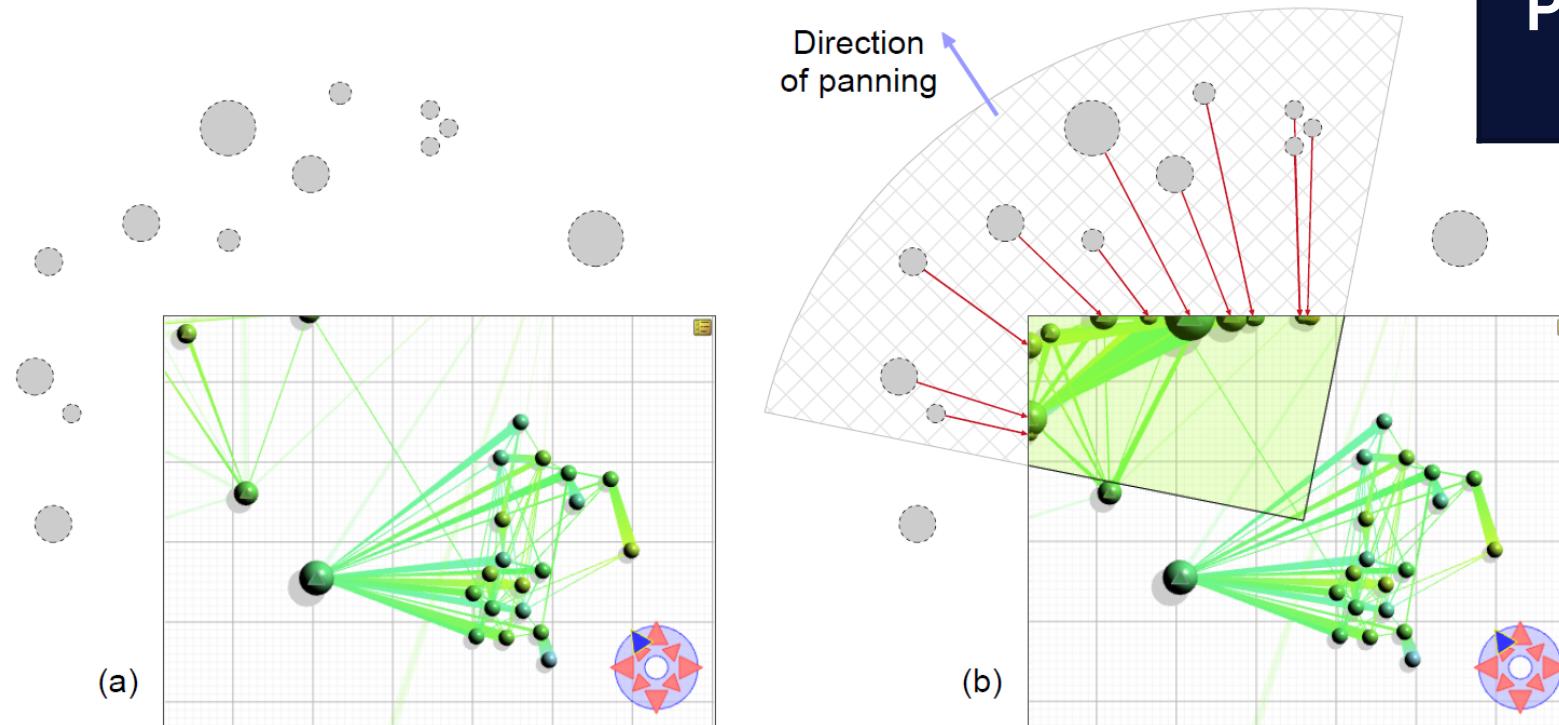
- > Interpolate between Zoom-out, Pan, and Zoom-in to maintain the mental map of the user





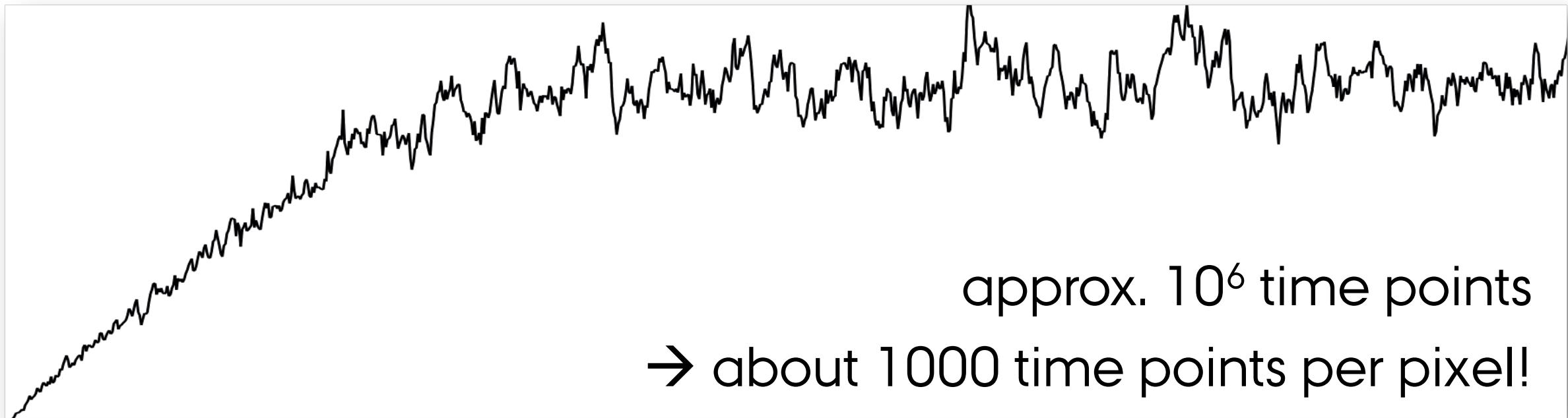
NAVIGATIONAL CUES: PANNING

Radar View for Foresighted Panning [Tominski et al. 2009]



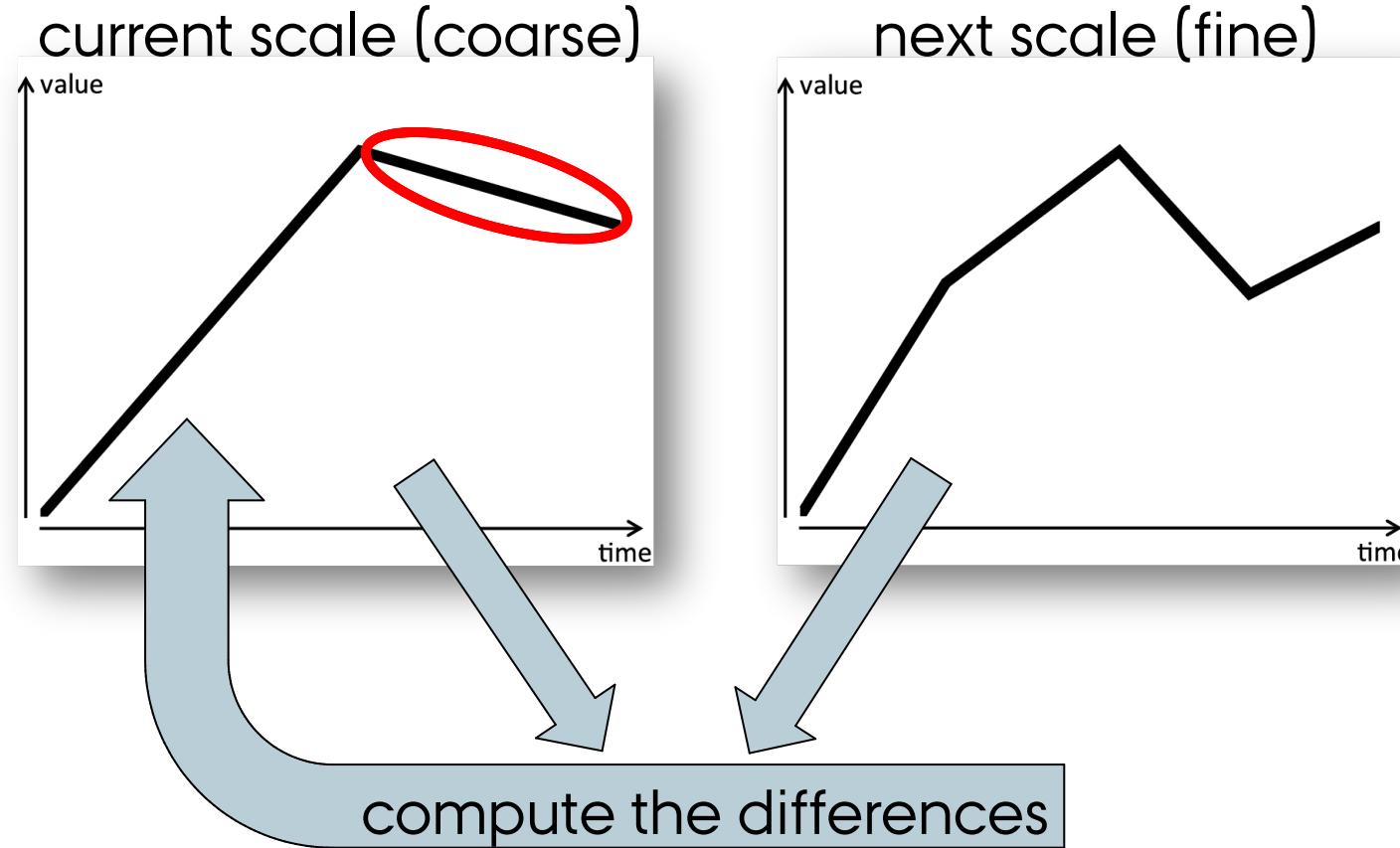
NAVIGATIONAL CUES: ZOOMING

[Luboschik et al. 2012]



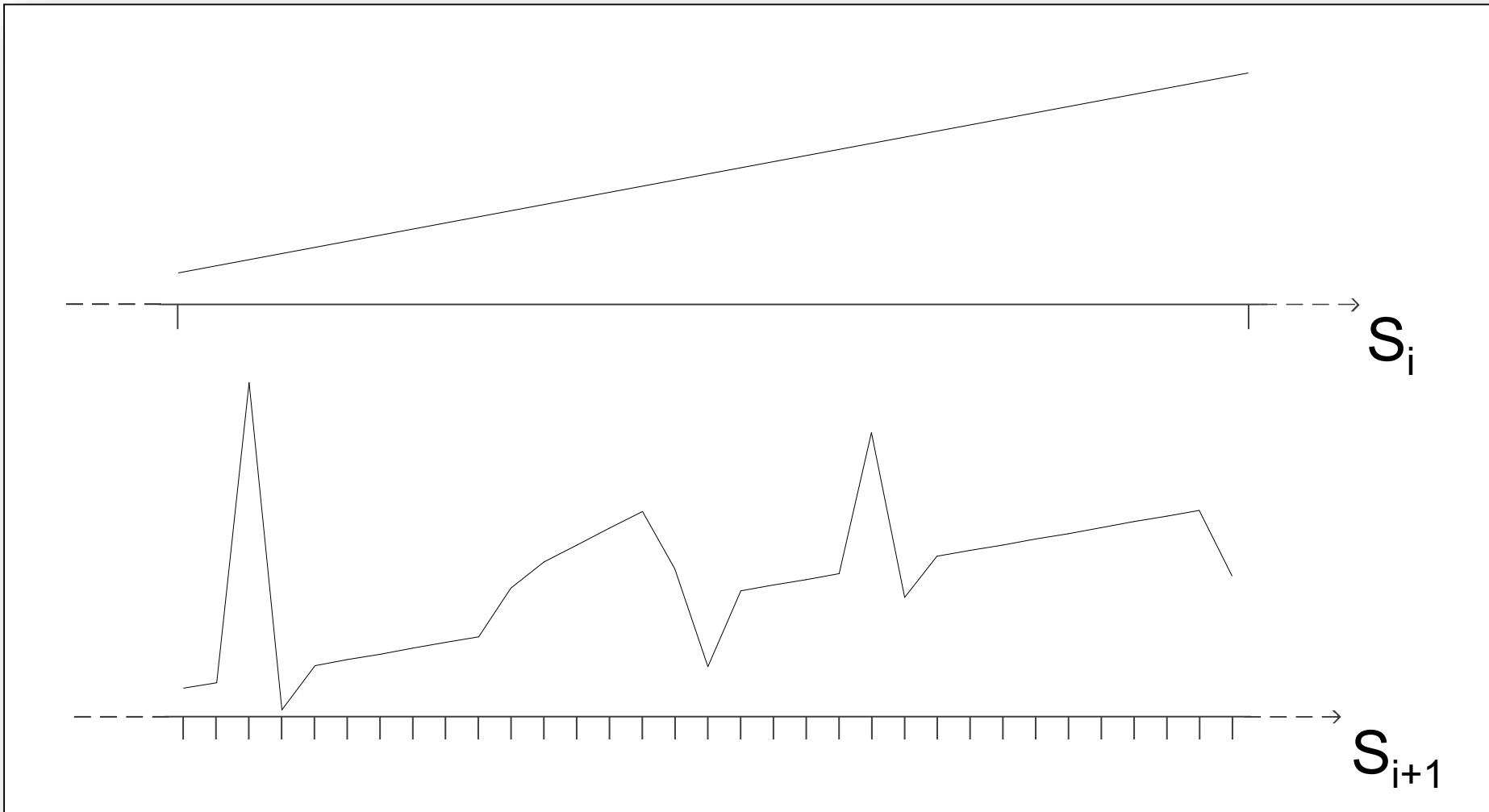
NAVIGATIONAL CUES: ZOOMING

[Luboschik et al. 2012]



1. DETERMINE WHERE TO COMPARE

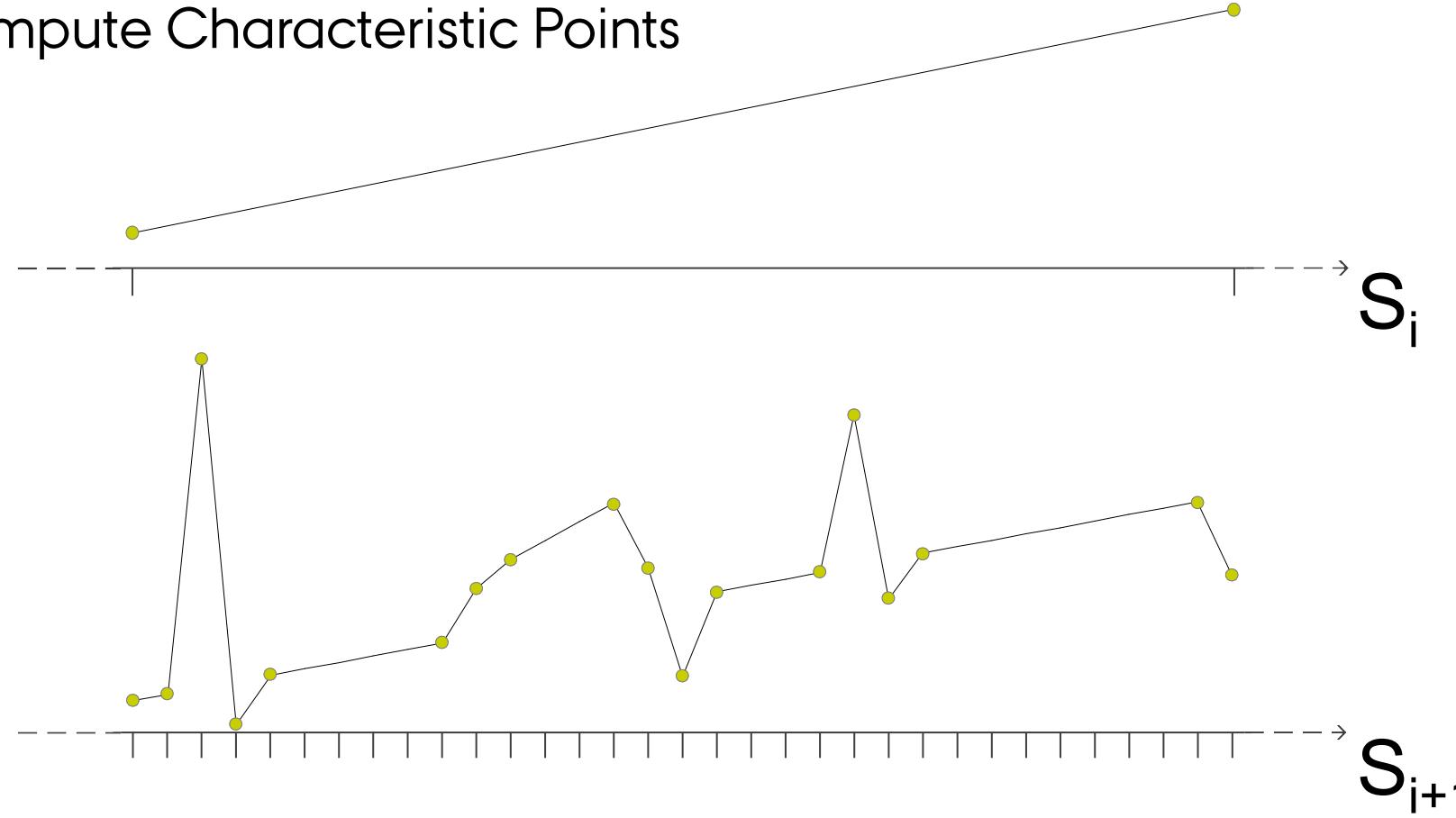
[Luboschik et al. 2012]



1. DETERMINE WHERE TO COMPARE

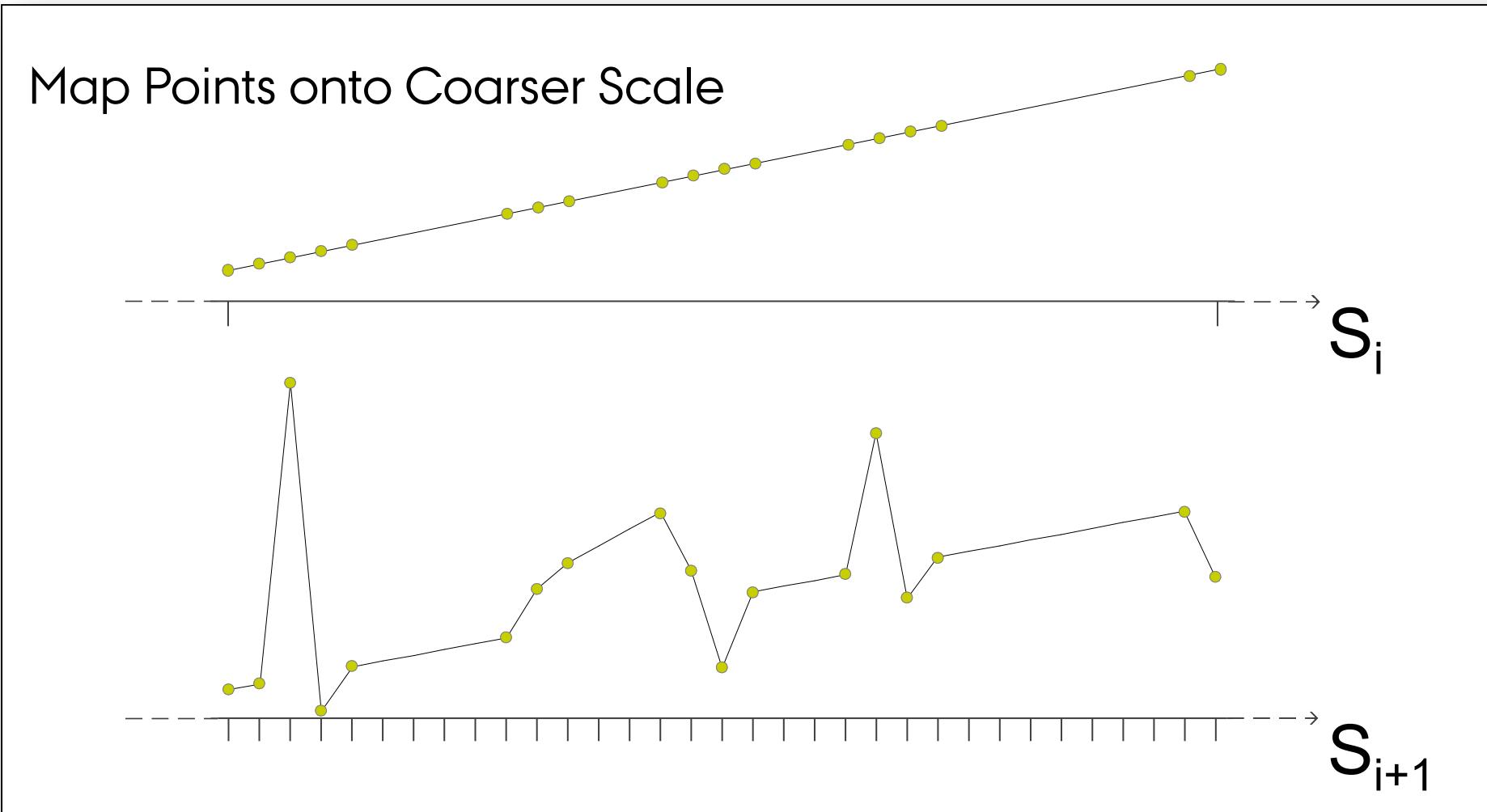
[Luboschik et al. 2012]

Compute Characteristic Points



1. DETERMINE WHERE TO COMPARE

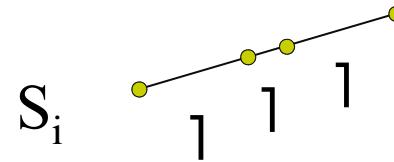
[Luboschik et al. 2012]



2. CALCULATE DIFFERENCE AT THESE POINTS

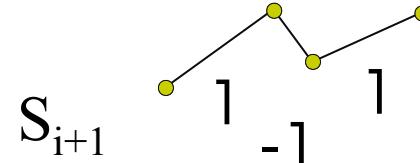
[Luboschik et al. 2012]

symbolic representation of the slope



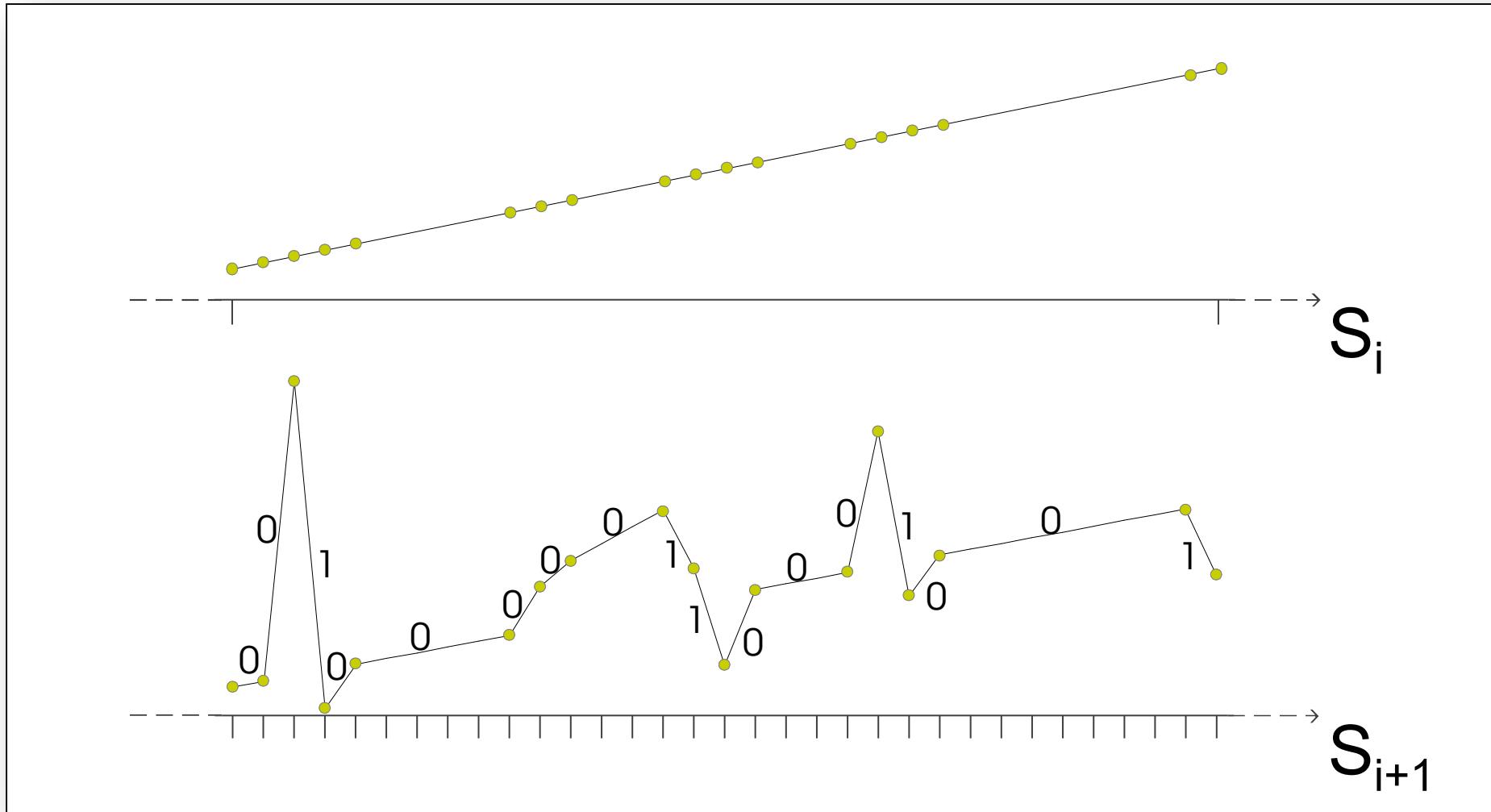
Difference in sign

0 1 0



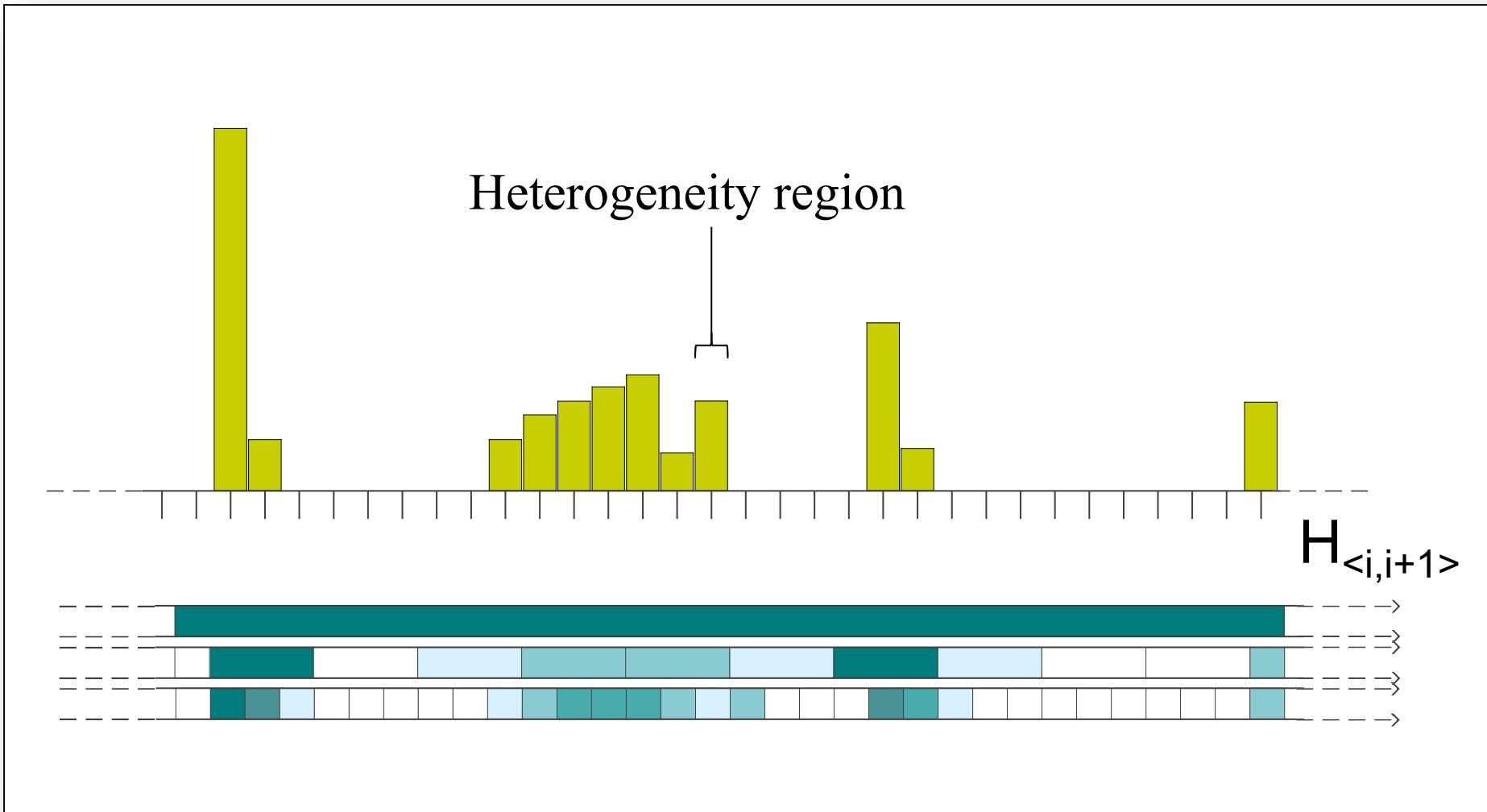
2. CALCULATE DIFFERENCE AT THESE POINTS

[Luboschik et al. 2012]



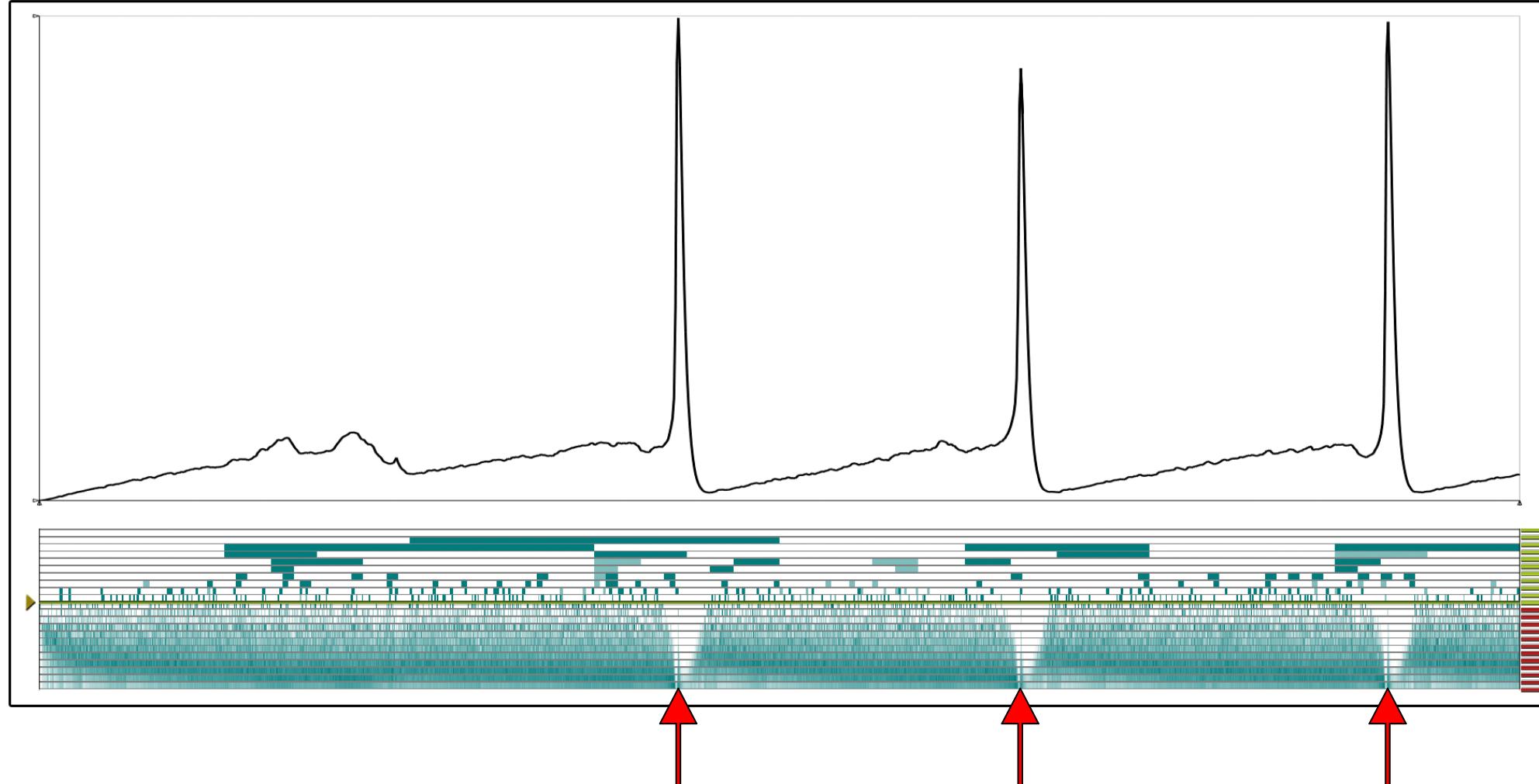
3. AGGREGATE AND VISUALIZE DIFFERENCES

[Luboschik et al. 2012]



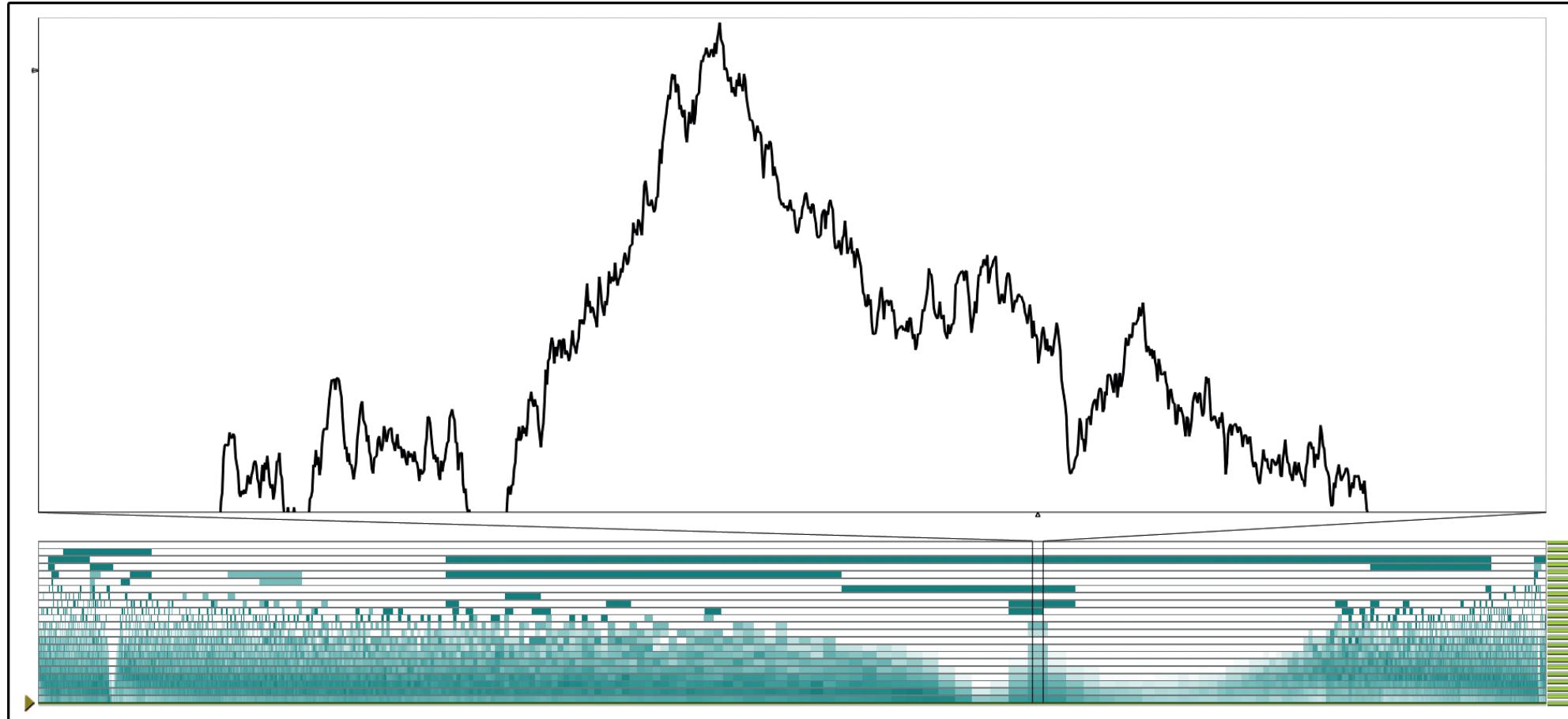
NAVIGATIONAL CUES: ZOOMING

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NAVIGATIONAL CUES: ZOOMING

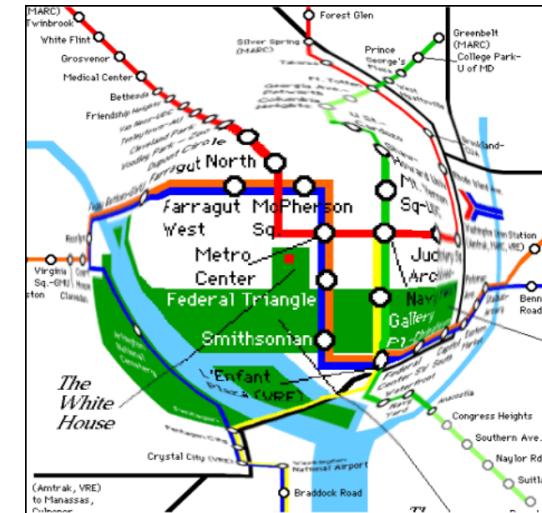
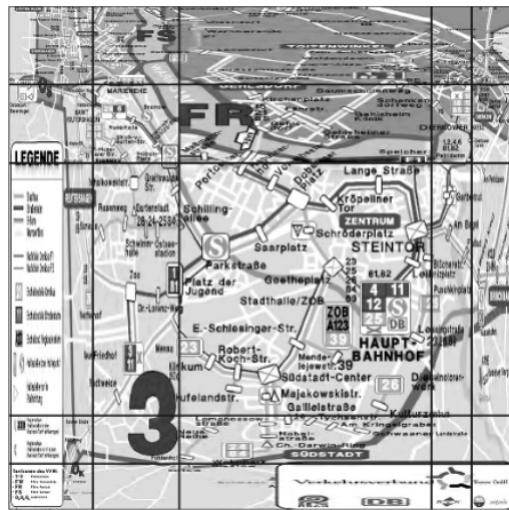
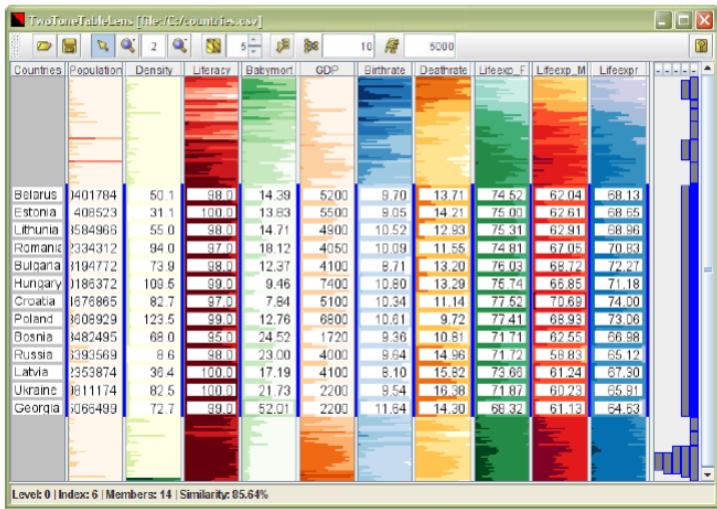
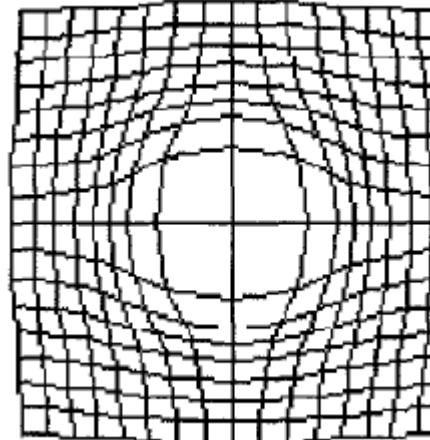
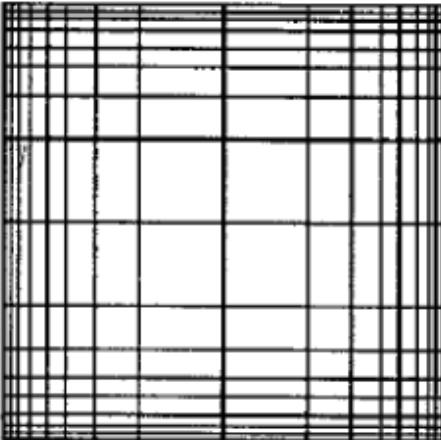
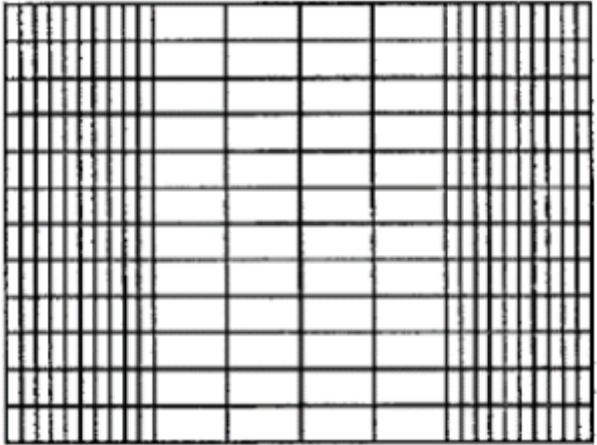
[Luboschik et al. 2012]



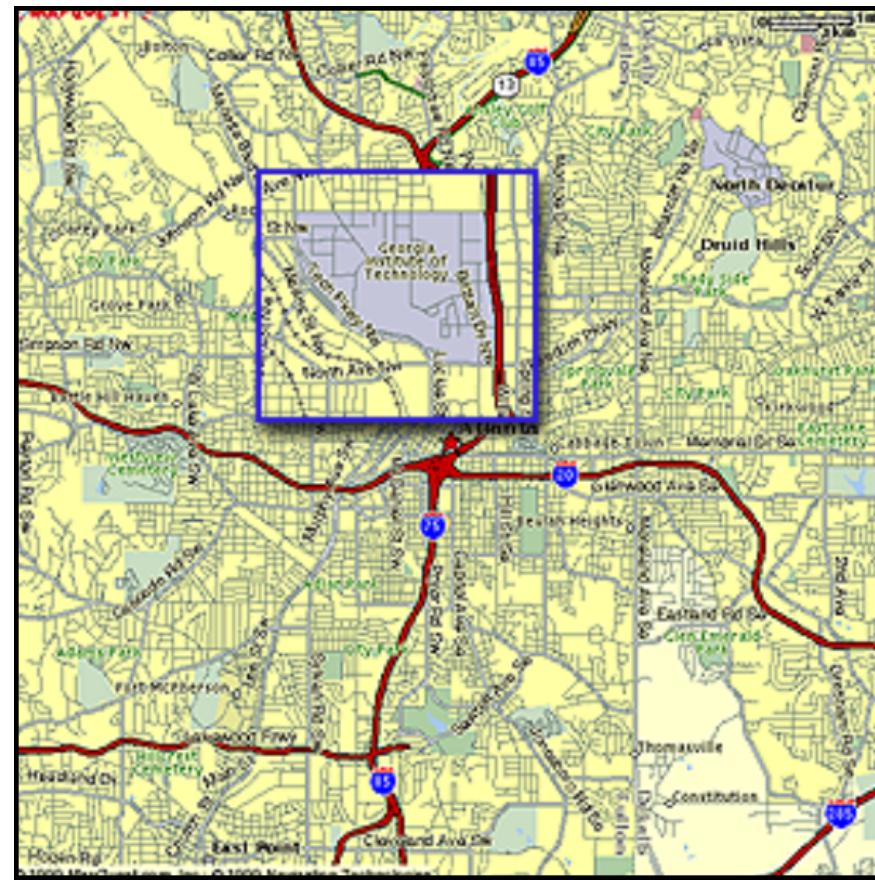
VISUAL INFORMATION SEEKING - FOCUS & CONTEXT



FOCUS + CONTEXT



OVERVIEW + DETAIL VS. FOCUS + CONTEXT

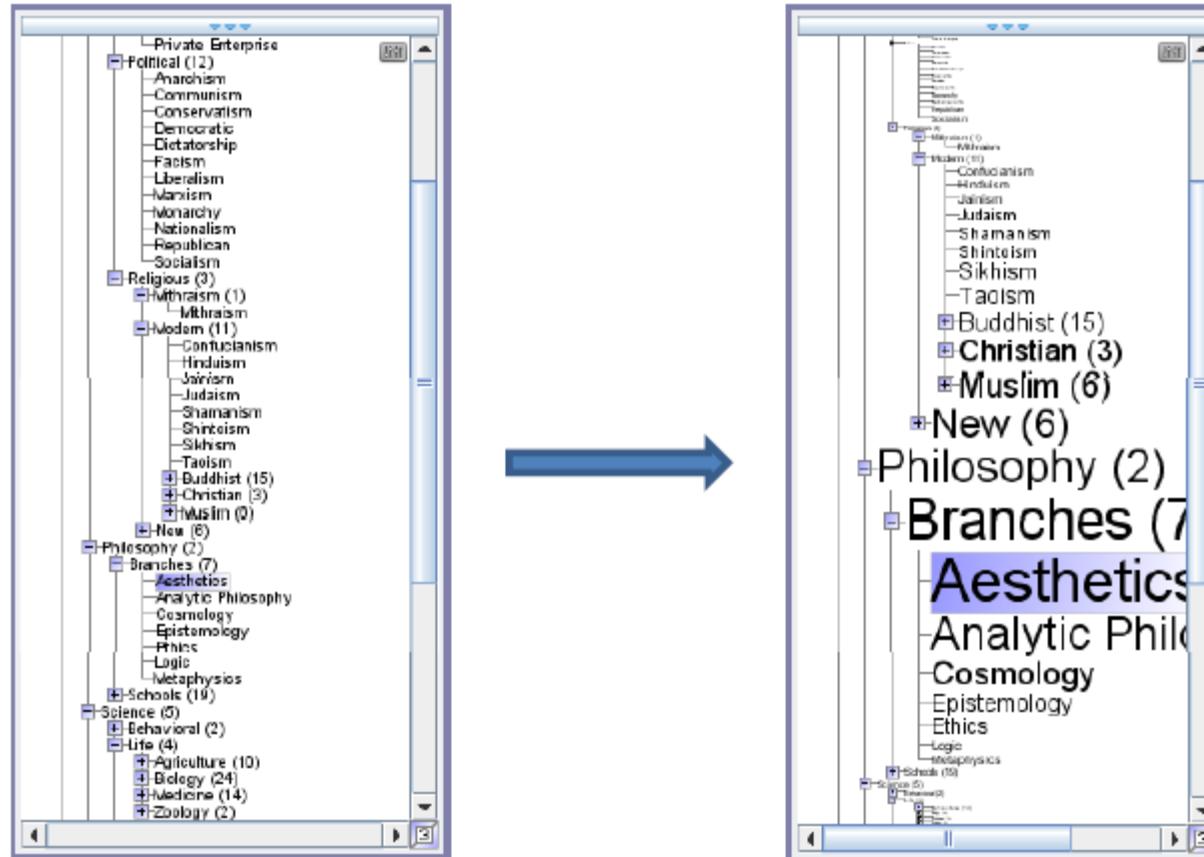


Source: Carsten Görg 2008



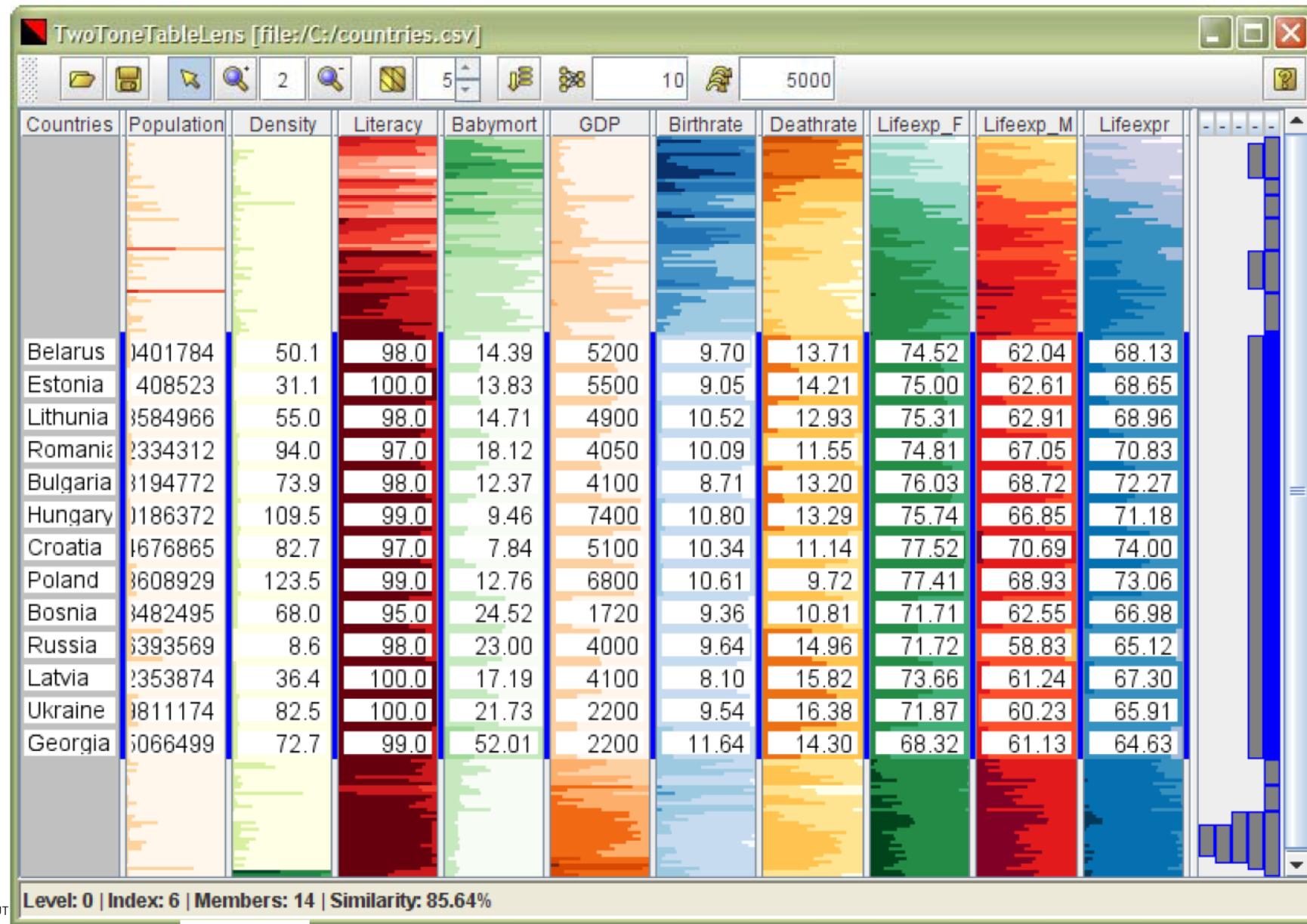
EXAMPLE: FISHEYE TREEVIEWS

[Tominski et al. 2006]



EXAMPLE: TABLE LENS

[Rao+Card 1994, John et al. 2008]



INTERACTIVE LENSES

[Tominski et al. 2017]

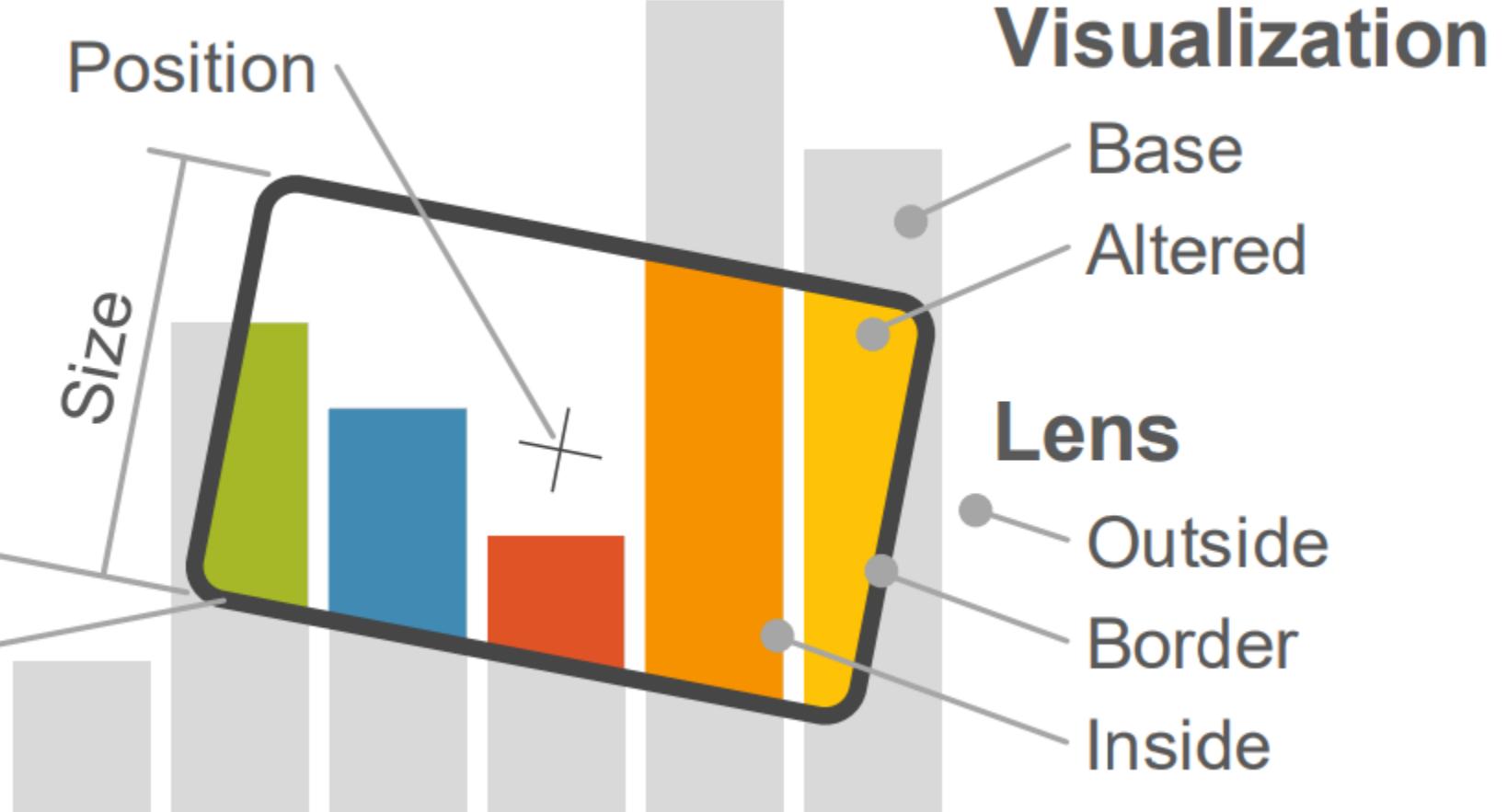
Properties

Orientation

Shape

Position

Size



Visualization

Base

Altered

Lens

Outside

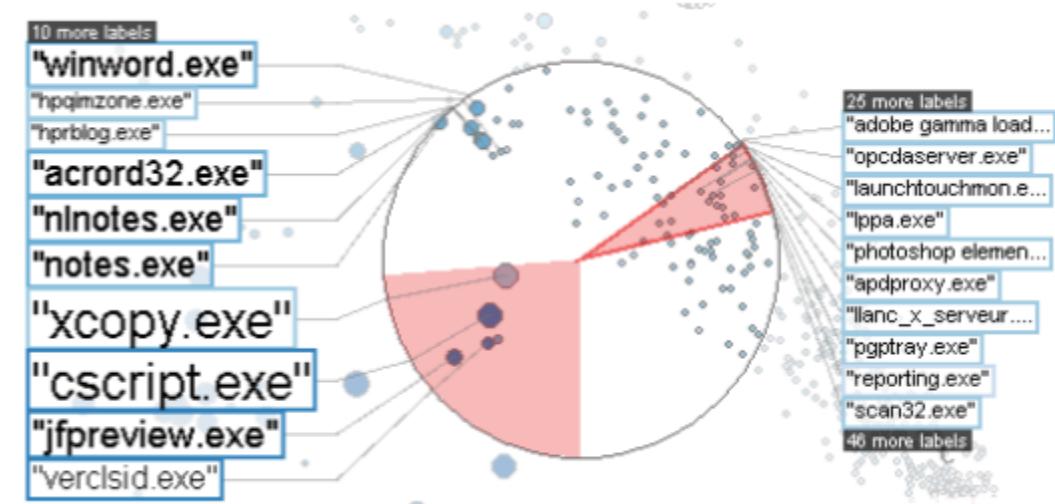
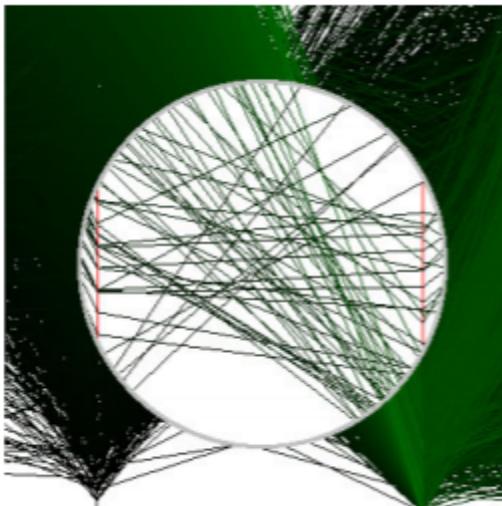
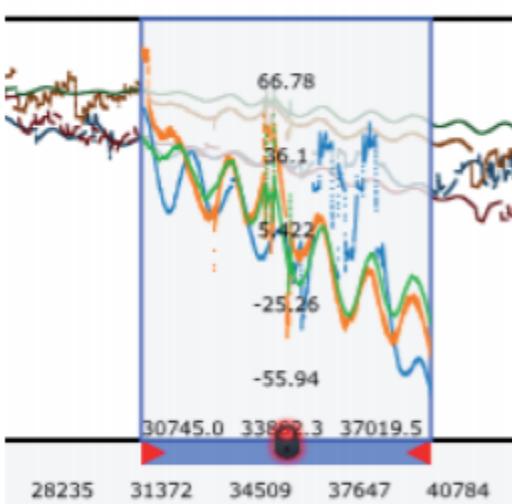
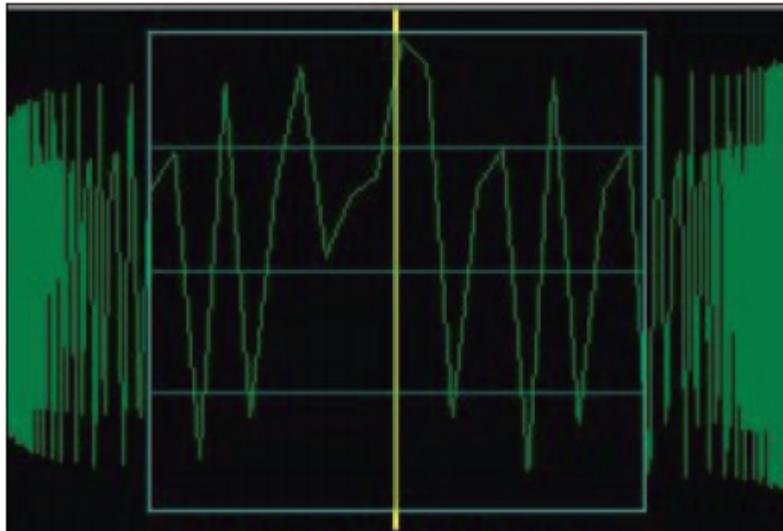
Border

Inside



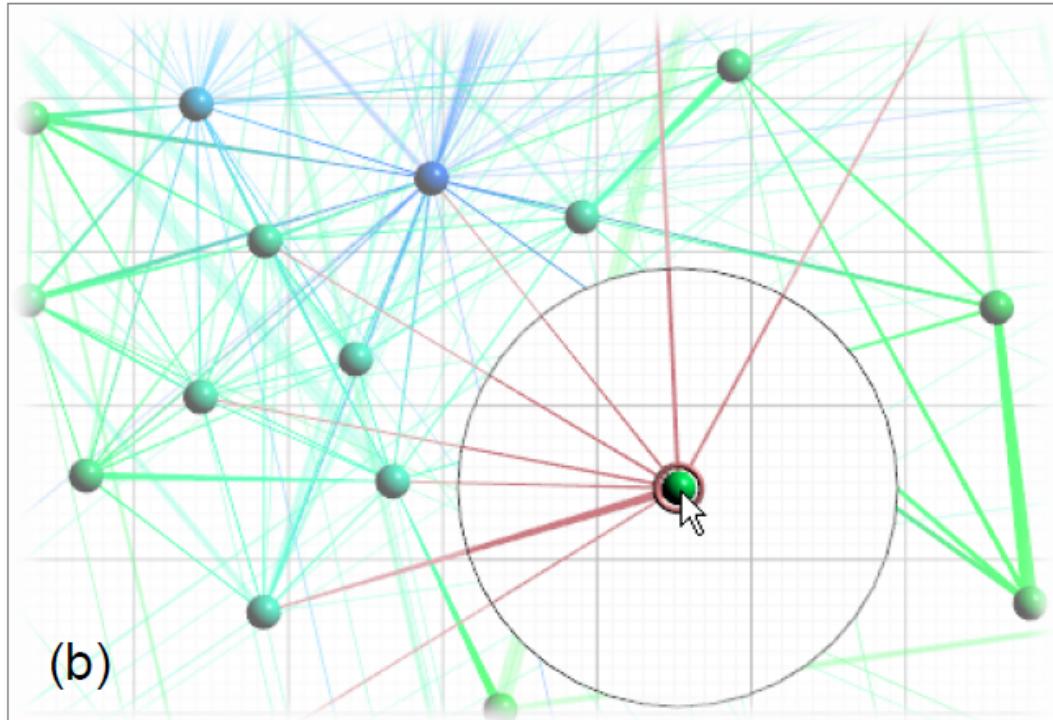
INTERACTIVE LENSES

[Tominski et al. 2017]



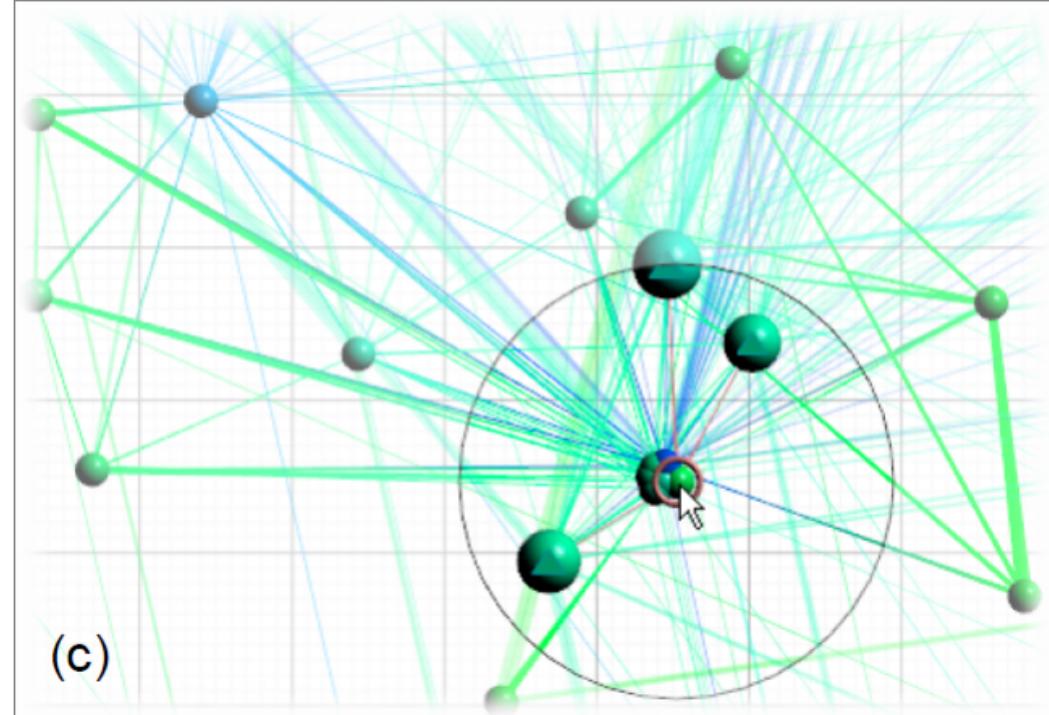
SMART LENSES

[Tominski et al. 2009]



(b)

Local-Edge-Lens shows only
edges incident to the nodes inside



(c)

Bring-Neighbors-Lens gathers all
neighbors of the center node

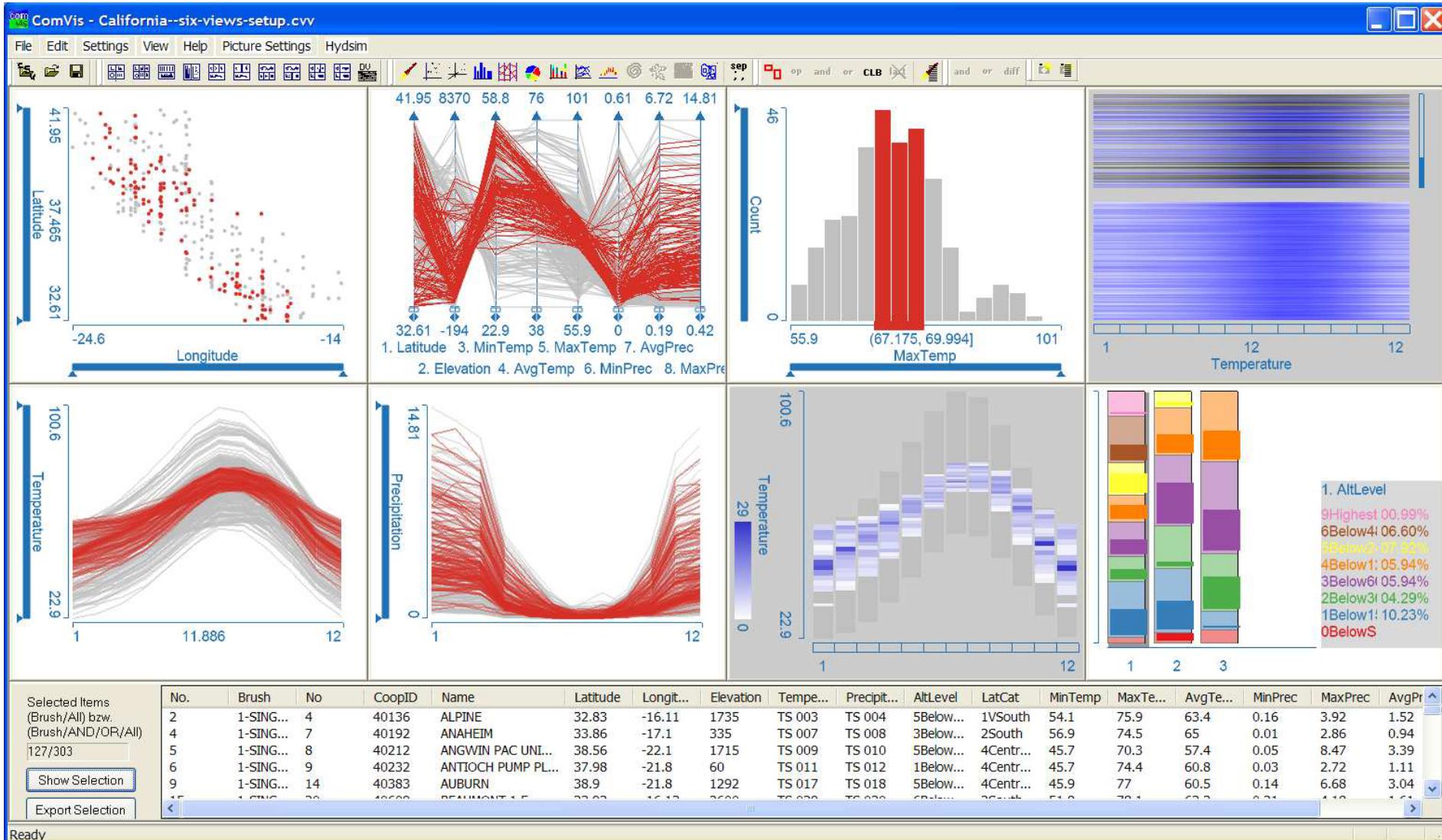




MULTIPLE COORDINATED VIEWS



MULTIPLE COORDINATED VIEWS

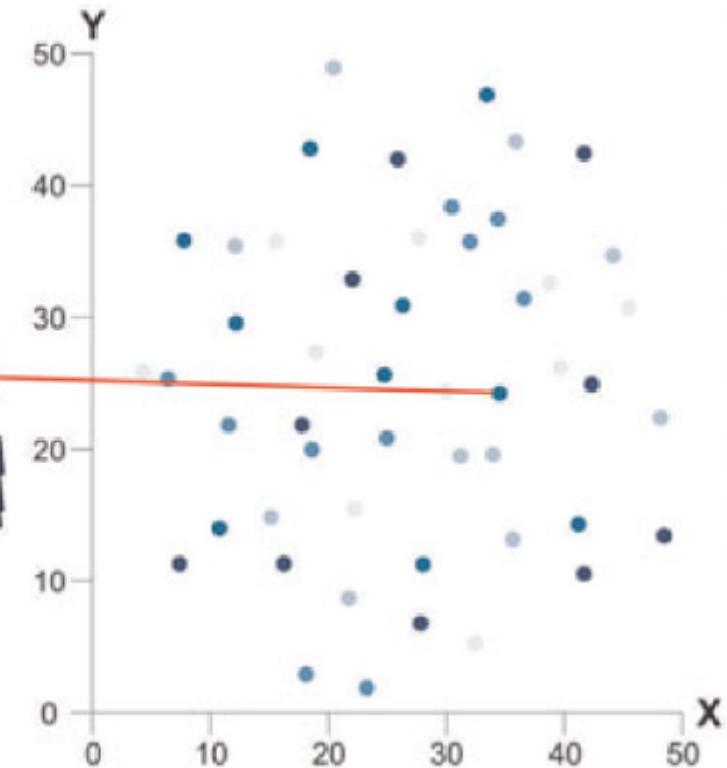
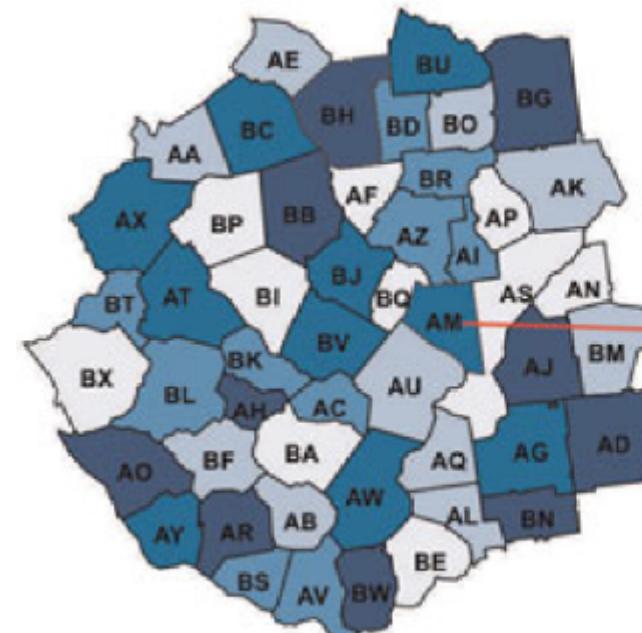
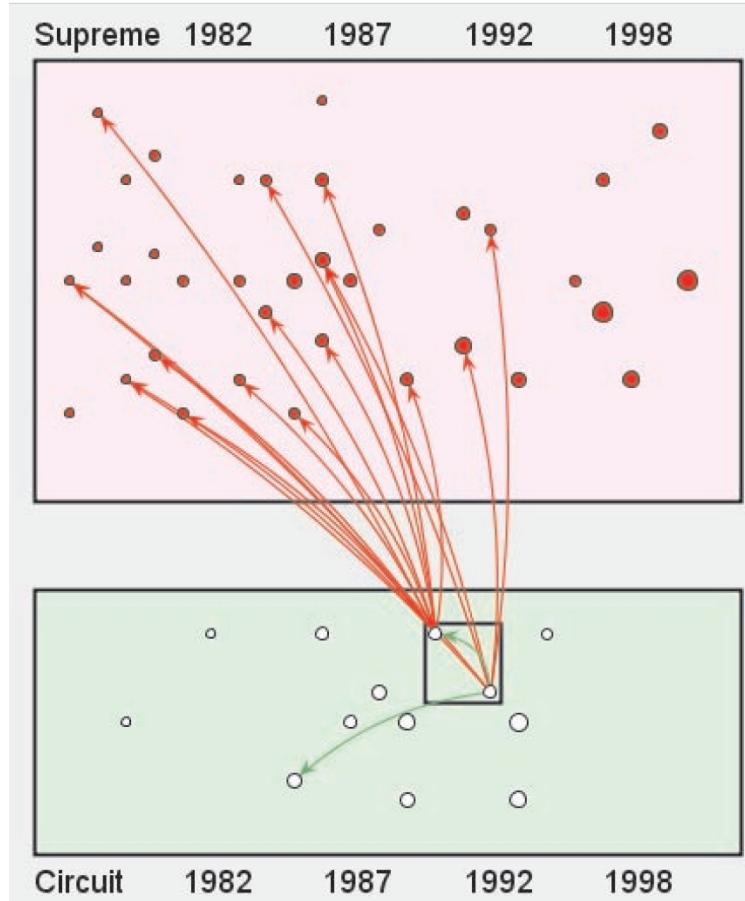


WHEN AND HOW TO USE MCV?

[Baldonado et al. 2000]

- **Rule of Diversity:** Use MCV in case of many attributes, purposes, users,...
- **Rule of Complementarity:** Use MCV to show different aspects of the data
- **Rule of Decomposition:** Use MCV to deconstruct complex data into manageable / understandable parts
- **Rule of Parsimony:** Don't use MCV when a single view suffices
- **Rule of Space/Time Resource Optimization:** The resources saved by MCV should outweigh their costs.
- **Rule of Self-Evidence:** Relations between views should be clear.

VISUAL LINKS ACROSS VIEWS

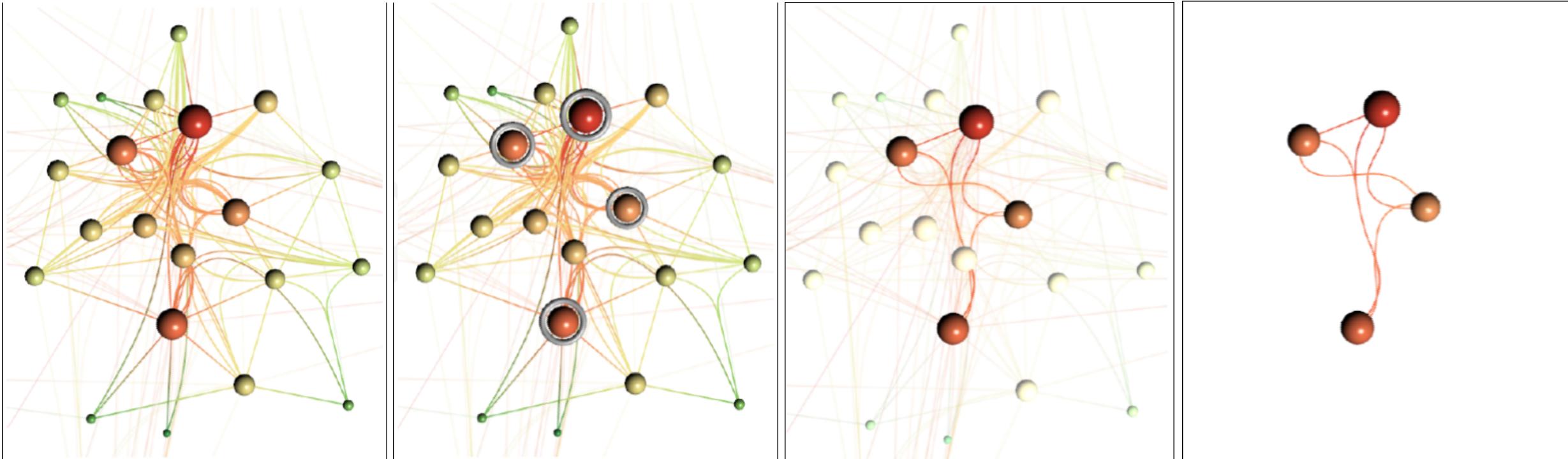


WHEN AND HOW TO USE MCV?

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- **Rule of Parsimony:** Don't use MCV when a single view suffices
- **Rule of Space/Time Resource Optimization:** The resources saved by MCV should outweigh their costs
- **Rule of Self-Evidence:** Relations between views should be clear
- **Rule of Consistency:** Use consistent interfaces and encodings across MCV
- **Rule of Attention Management:** Guide the user focus to the right view at the right time.

(DE)-EMPHASIZING & HIDING INFORMATION



Original

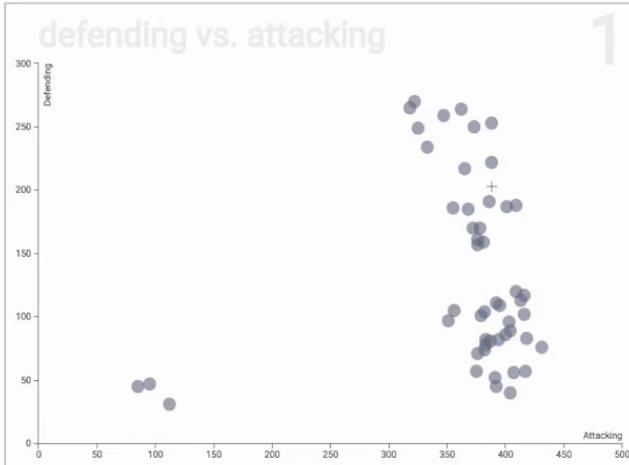
Highlighting

Dimming

Filtering



USER-DRIVEN EMPHASIS: BRUSHING + LINKING



TANGIBLE INTERACTION



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INTERACTION
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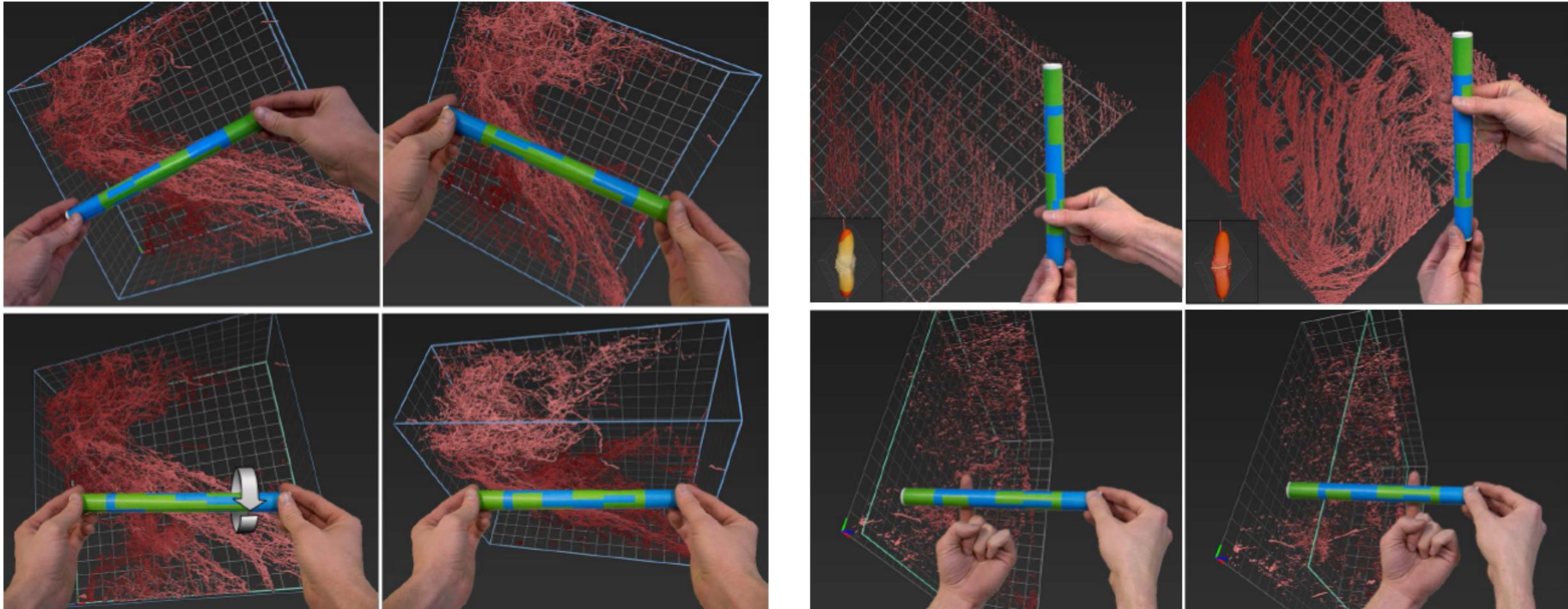


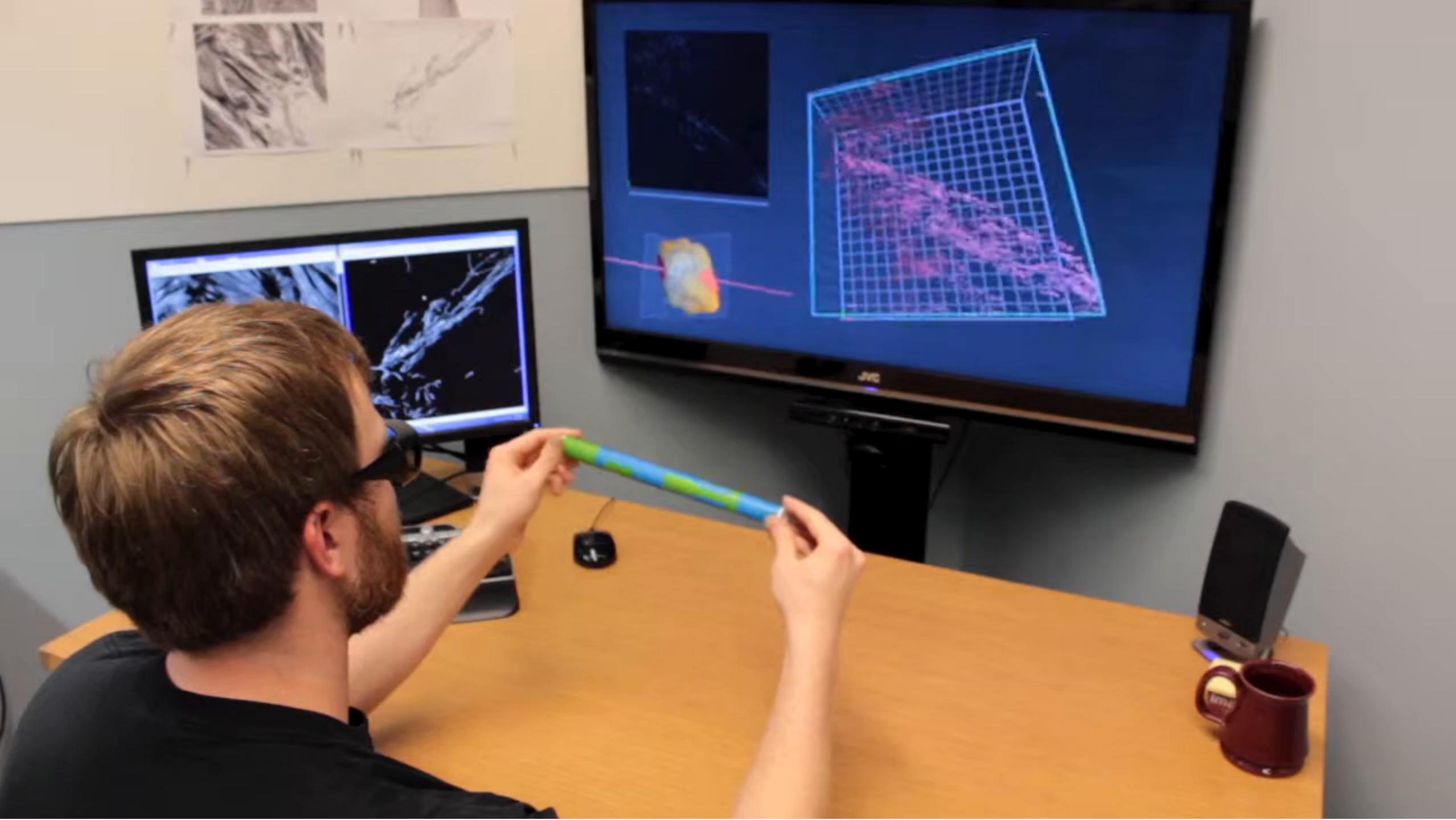


[Ebert et al. 2013]

TANGIBLE INTERACTION FOR 3D

[Jackson et al. 2013]



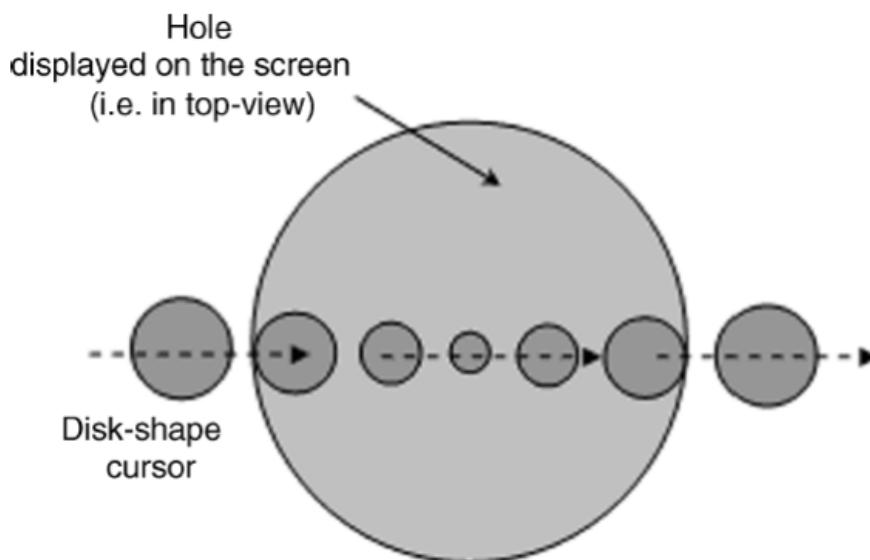
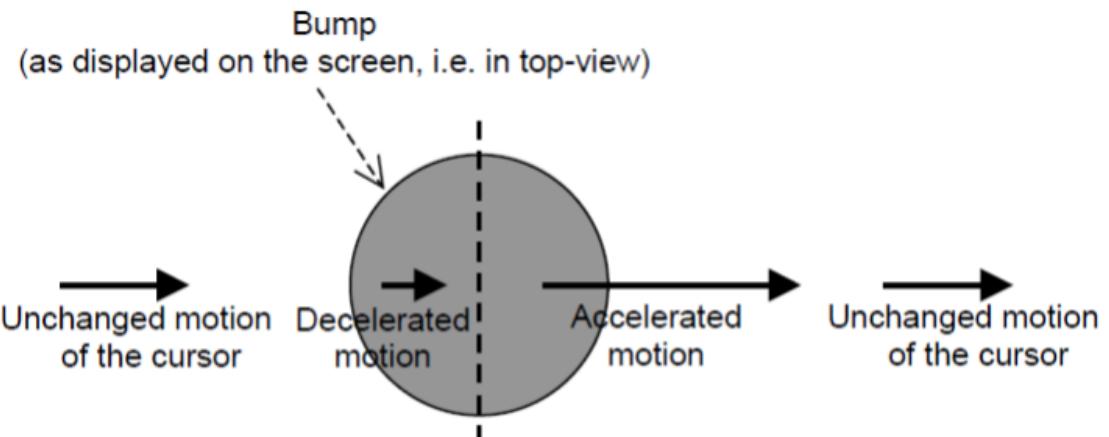
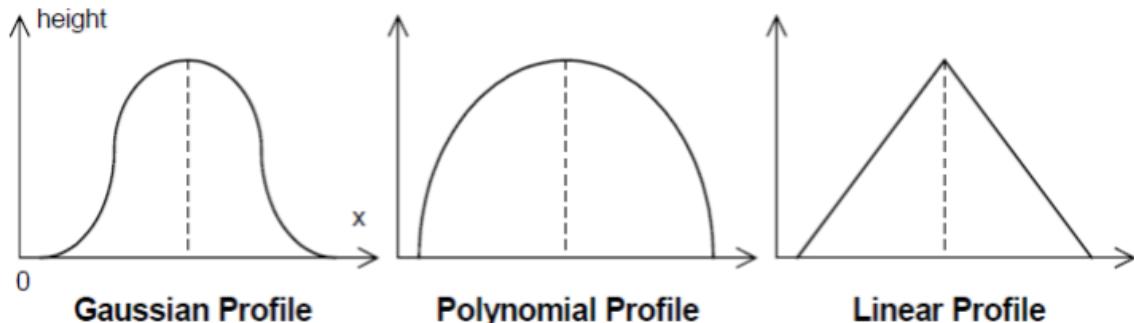


LIGHTWEIGHT HAPTICS FOR EVERYBODY

Pseudo-Haptic Modification of Cursor Speed

Pseudo-Haptic Modification of Cursor Size

Pseudo-Haptic Modification Profiles



LIST OF LITERATURE SOURCES

- Shneiderman 1996: <https://doi.org/10.1109/VL.1996.545307>
- Jessup et al. 2022: <https://doi.org/10.1109/TVCG.2021.3114786>
- Furnas & Bederson 1995: <https://doi.org/10.1145/223904.223934>
- V.Wijk & Nuij 2004: <https://doi.org/10.1109/TVCG.2004.1>
- Tominski et al. 2009: <https://doi.org/10.1016/j.cag.2009.06.002>
- Luboschik et al. 2012: <https://doi.org/10.1109/BioVis.2012.6378590>
- Tominski et al. 2006: <https://doi.org/10.1109/IV.2006.54>
- Rao & Card 1994: <https://doi.org/10.1145/191666.191776>
- John et al. 2008: <https://doi.org/10.1111/12.766440>
- Tominski et al. 2017: <https://doi.org/10.1111/cgf.12871>
- Matkovic et al. 2008: <https://doi.org/10.1109/IV.2008.87>
- Baldonado et al. 2000: <https://doi.org/10.1145/345513.345271>
- Koytek et al. 2017: <https://doi.org/10.1109/TVCG.2017.2743859>
- Ebert et al. 2013: <https://doi.org/10.1145/2468356.2468645>
- Jackson et al. 2013: <https://doi.org/10.1109/TVCG.2013.121>
- Lécuyer et al. 2004/2008: <https://doi.org/10.1145/985692.985723> / <https://doi.org/10.1145/1402236.1402238>

