

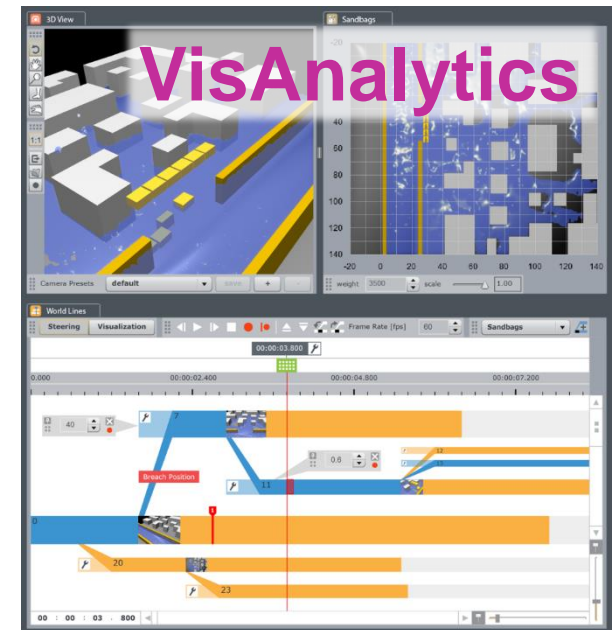
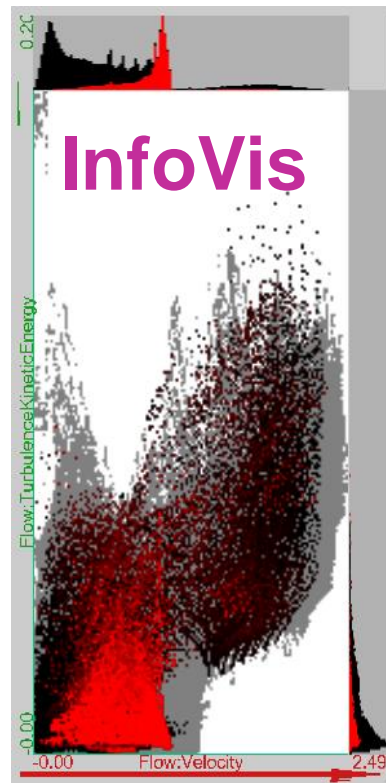
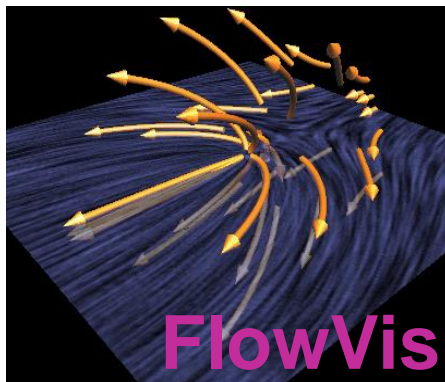
Comparative Visualization

Eduard Gröller

Institute of Computer Graphics and Algorithms
Vienna University of Technology



“The use of computer-supported, interactive, visual representations of (abstract) data to amplify cognition”

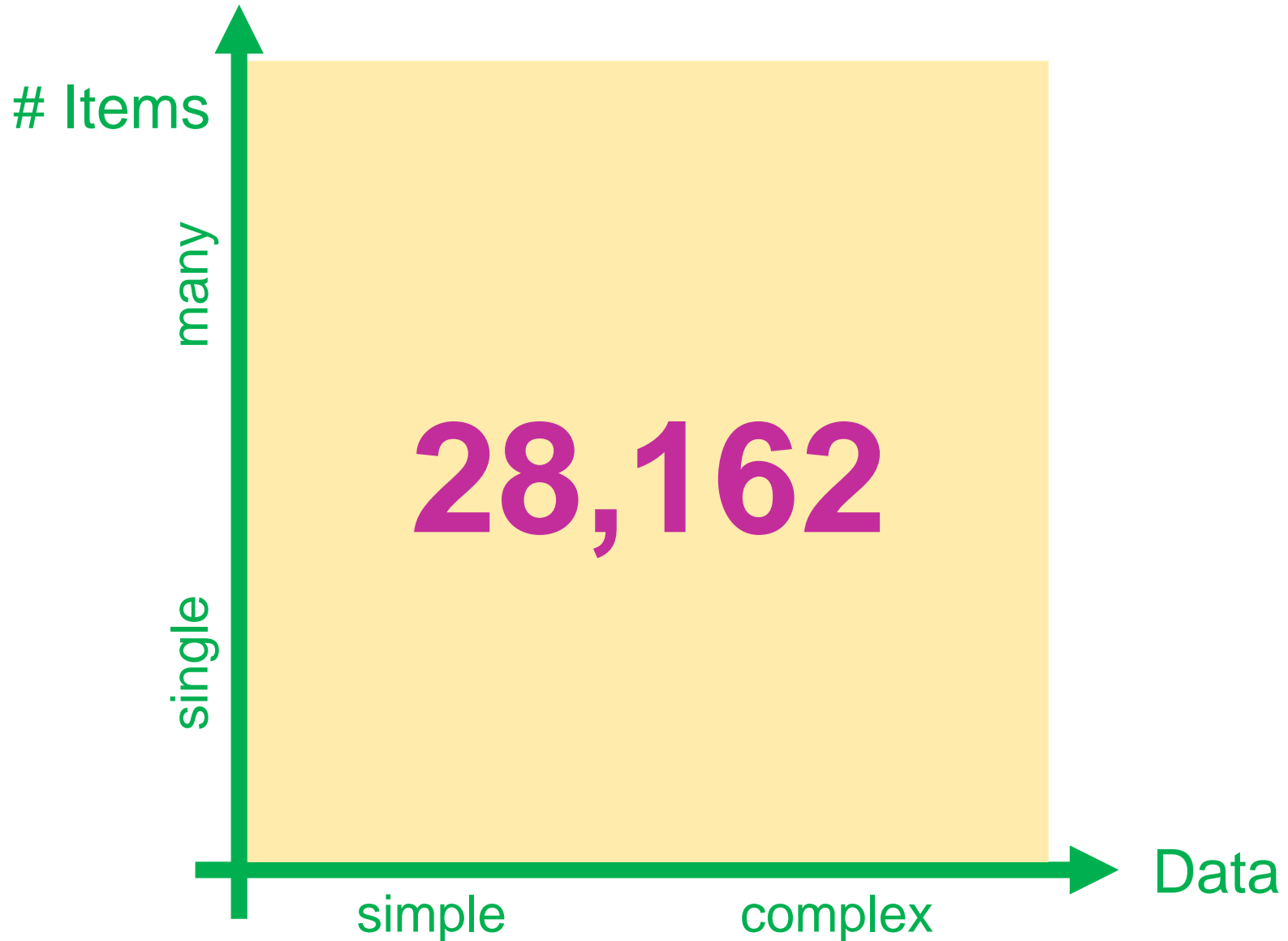


- Data is increasing in complexity and variability

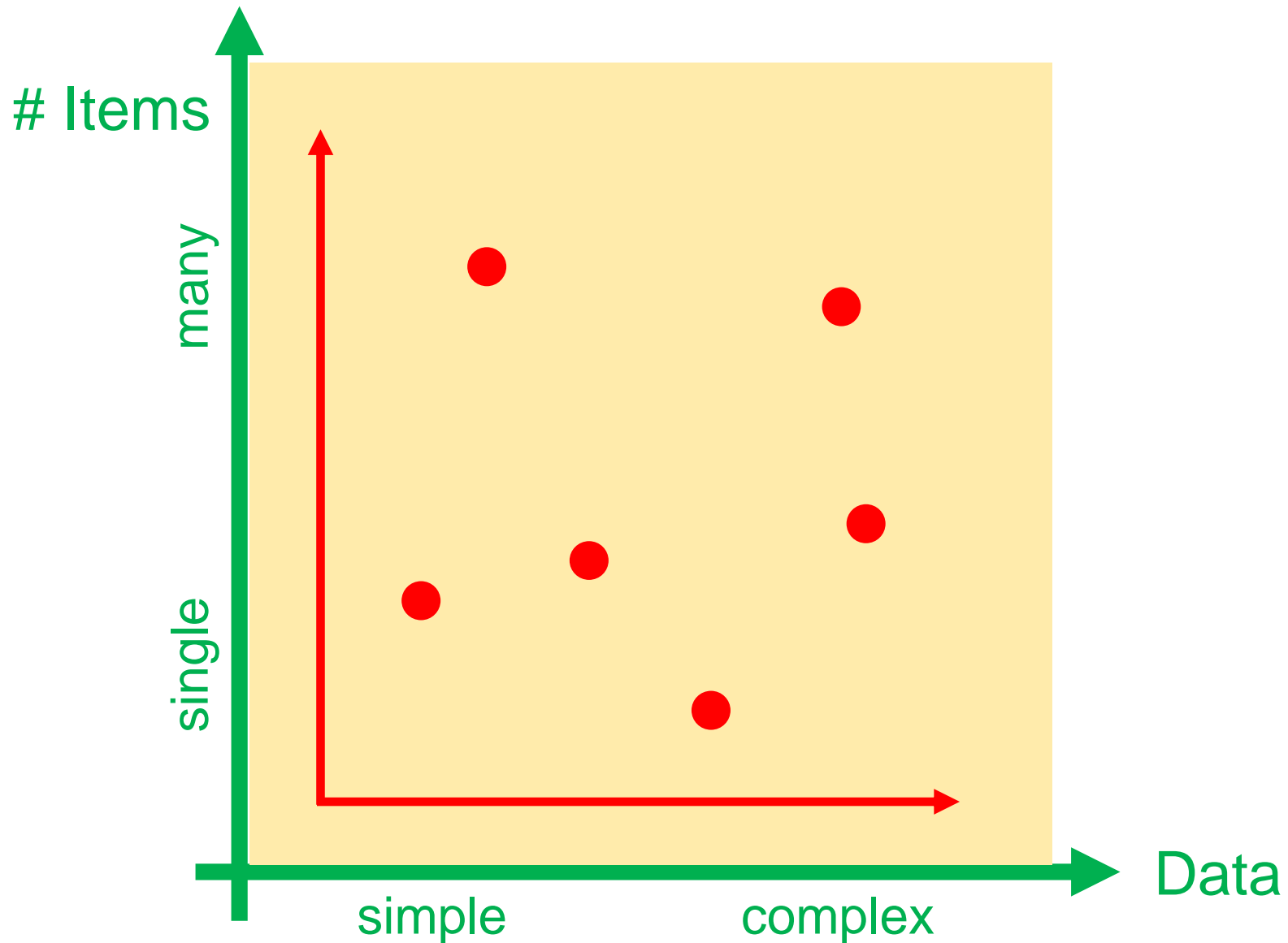




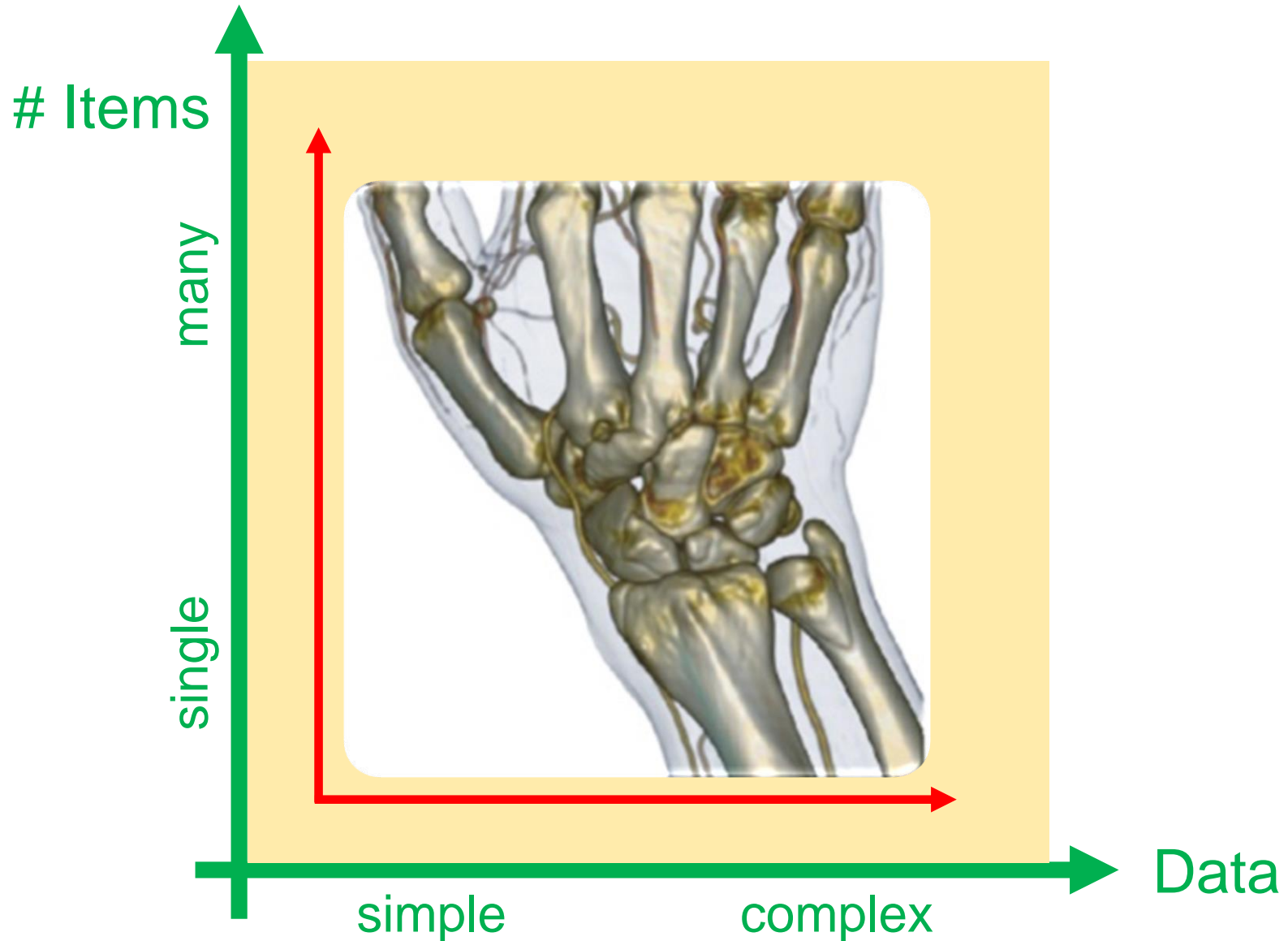
Comparative Vis.: Where does it fit in?



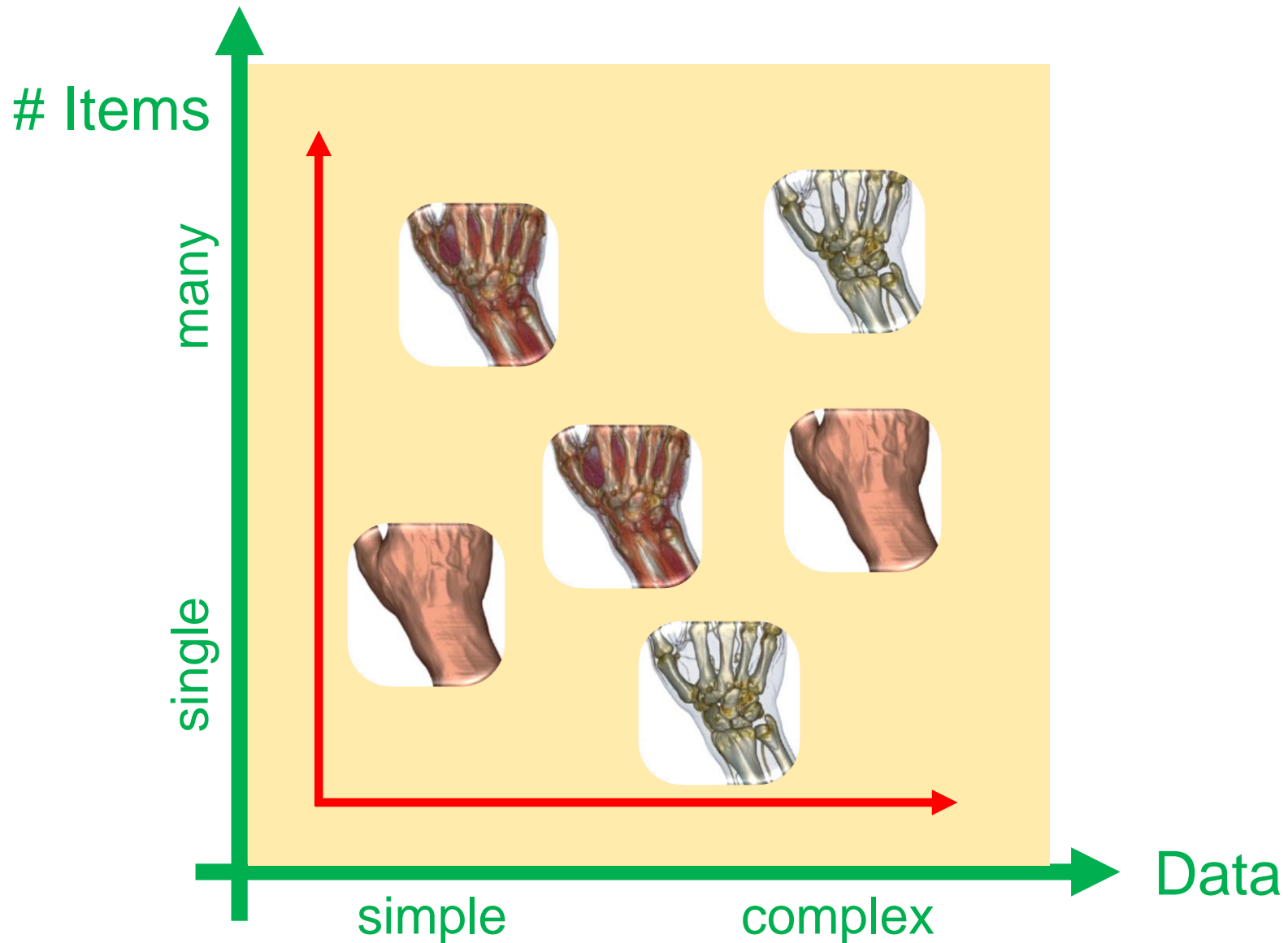
Comparative Vis.: Where does it fit in?



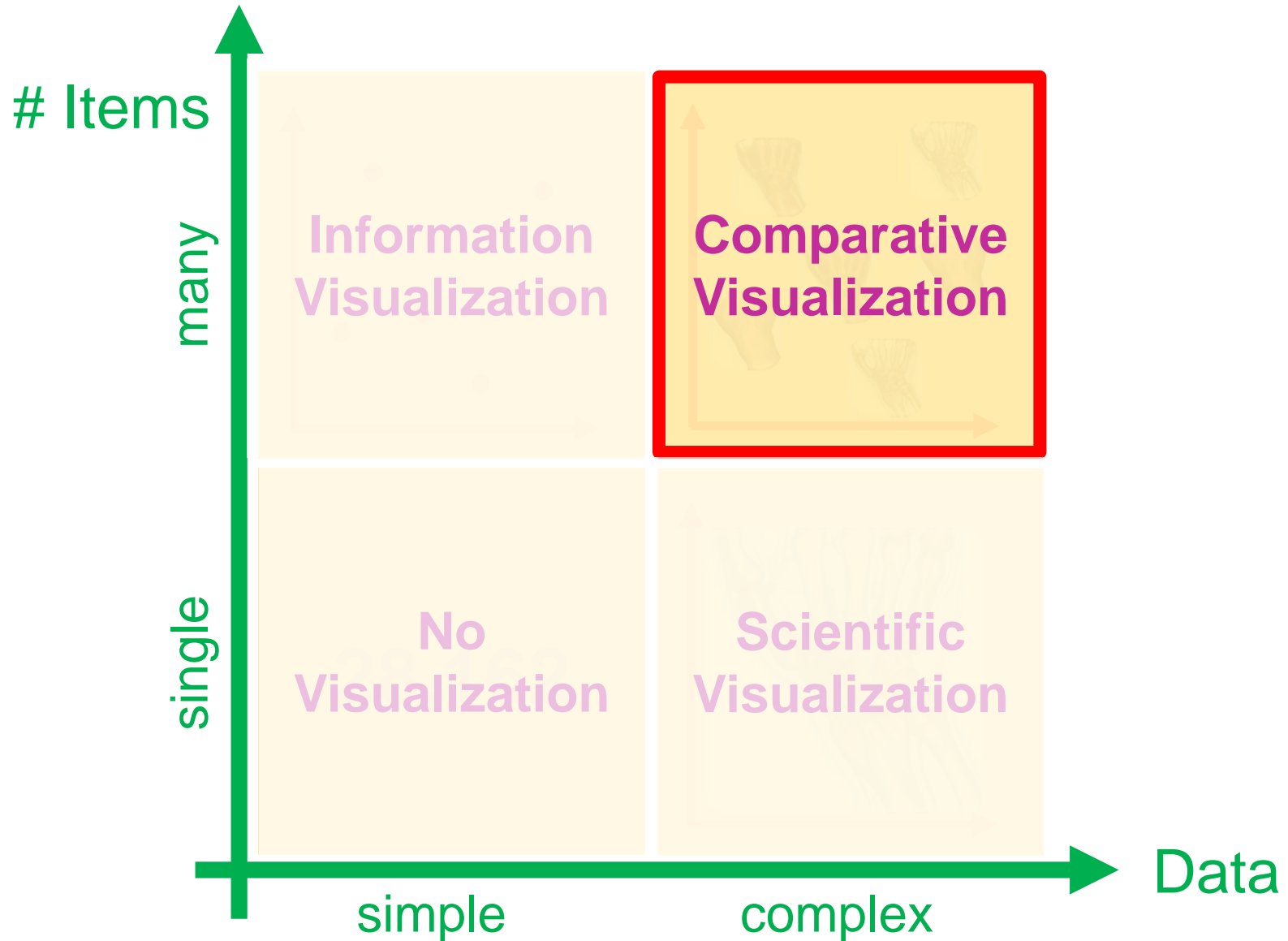
Comparative Vis.: Where does it fit in?



Comparative Vis.: Where does it fit in?



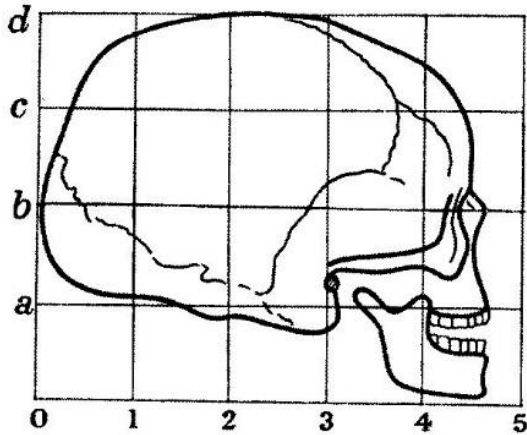
Comparative Vis.: Where does it fit in?



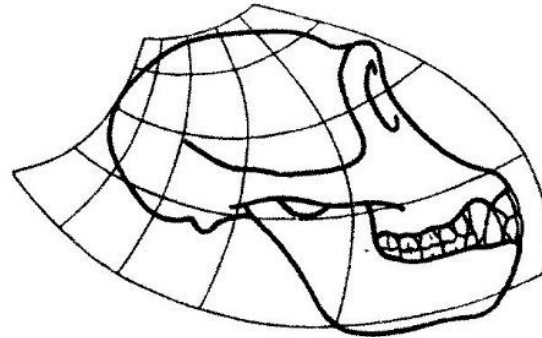
Early Examples



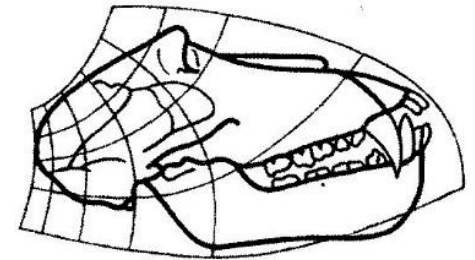
On Growth and Form – D'Arcy Thompson



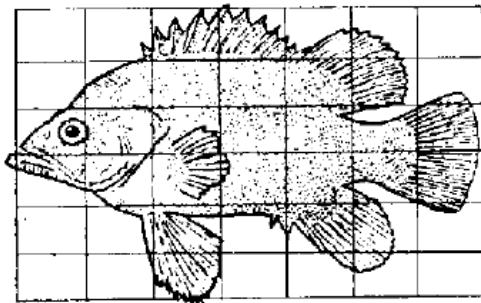
Human Skull



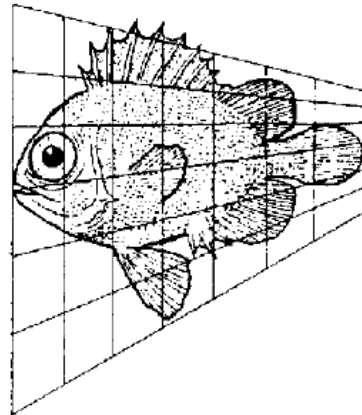
Skull of Chimpanzee



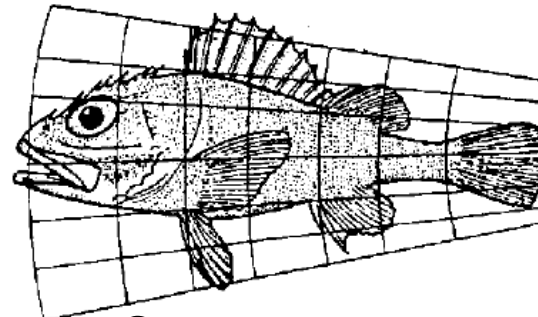
Skull of Baboon



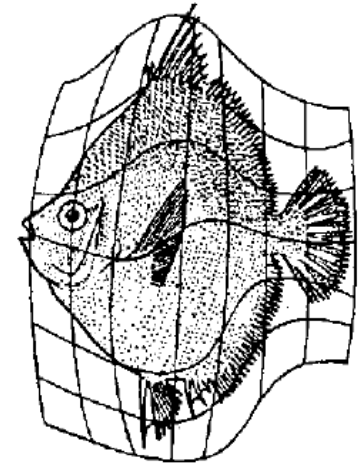
Polyprion



Pseudopriacanthus alt.



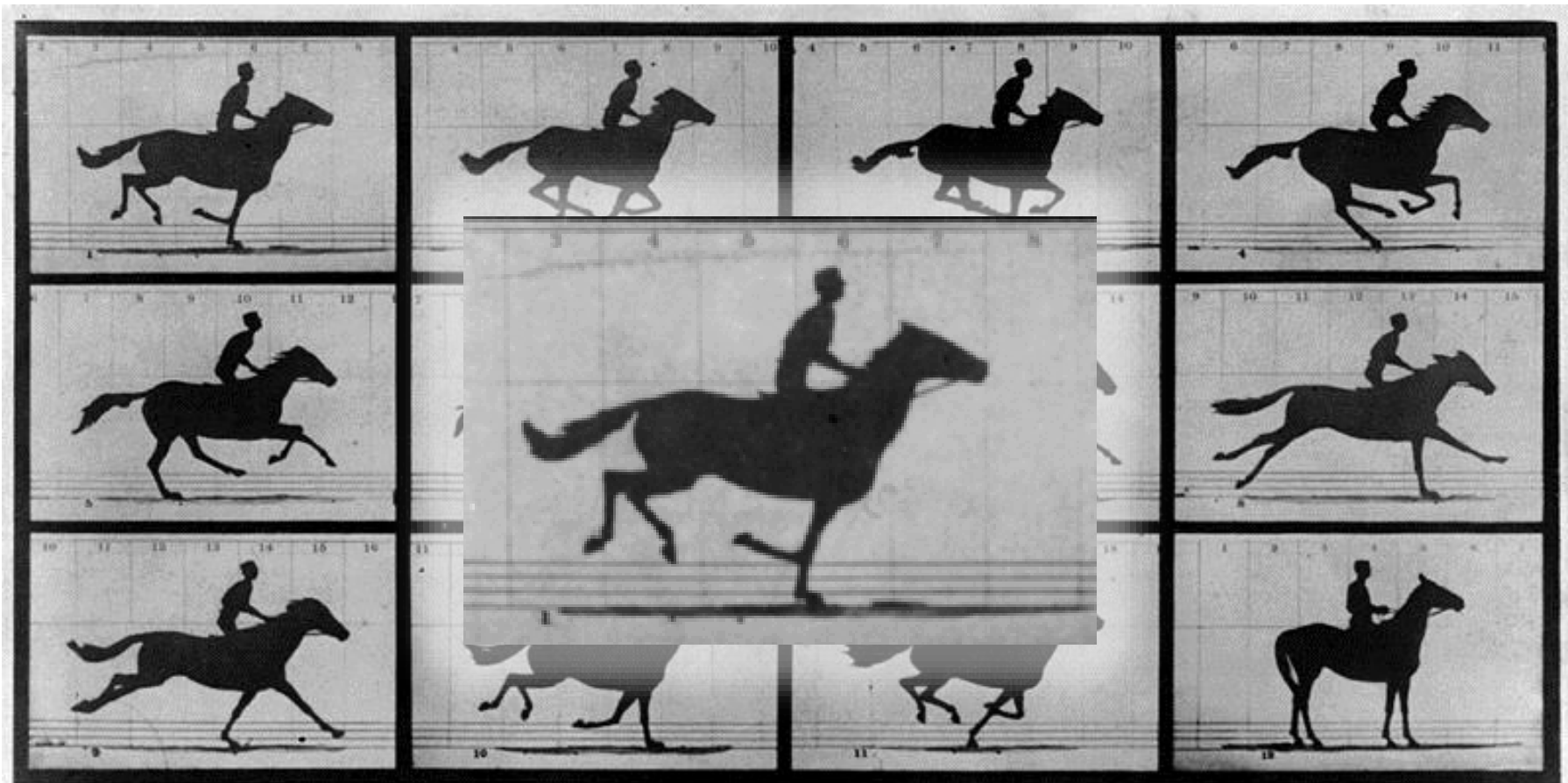
Scorpaena sp.



Antigoniacapros



Studies of Motion - Muybridge



Copyright, 1878, by MUYBRIDGE.

MORSE'S Gallery, 417 Montgomery St., San Francisco.

THE HORSE IN MOTION.

Illustrated by
MUYBRIDGE.

AUTOMATIC ELECTRO-PHOTOGRAPHY.

"SALLIE GARDNER," owned by LELAND STANFORD; running at a 1.40 gait over the Palo Alto track, 19th June, 1878.

The negatives of these photographs were made at intervals of twenty-seven inches of distance, and about the twenty-fifth part of a second of time; they illustrate consecutive positions assumed in each twenty-seven inches of progress during a single stride of the mare. The vertical lines were twenty-seven inches apart; the horizontal lines represent elevations of four inches each. The exposure of each negative was less than the two-thousandth part of a second.





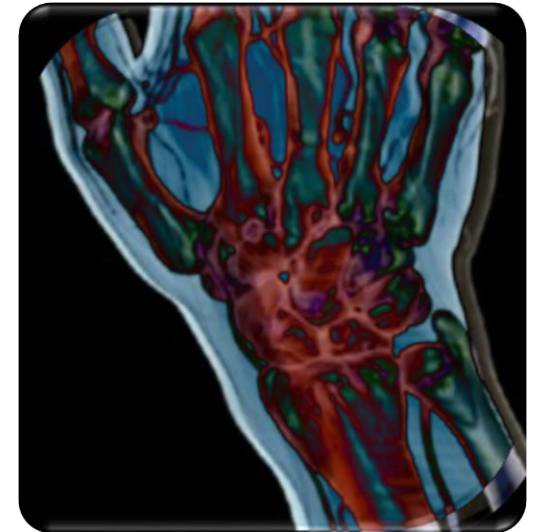
Juxtaposition



Superposition



Explicit Encoding

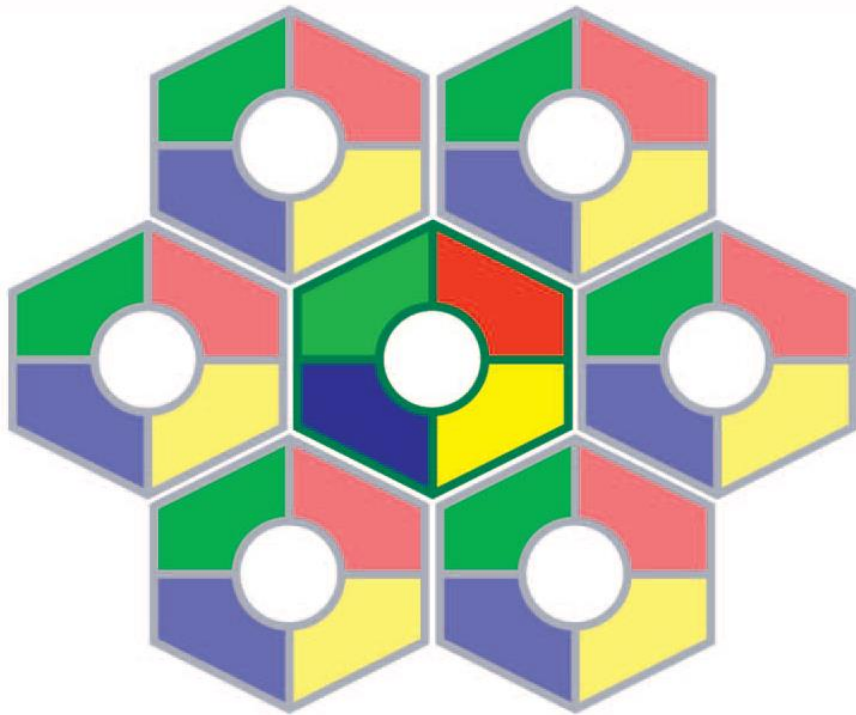


[Gleicher et al.]



Comparative Vis.: Selected Example 1





Parameter Studies of Dataset Series

Malik, M.M., Heinzl, Ch.; Gröller, E.: **Comparative Visualization for Parameter Studies of Dataset Series.** IEEE Transactions on Visualization and Computer Graphics, 16(5):829–840, 2010.



Dataset Series in Computed Tomography

Parameters	Dataset Resolution	No of Datasets	Series Size
Voltage	1000 * 1000 * 882	4	8.21 GB
No of Projections	1000 * 1000 * 882	6	9.86 GB
Current	856 * 856 * 882	6	7.22 GB
Integration Time	800 * 800 * 882	5	5.26 GB
Pre- and Post Filter Plates	848 * 848 * 882	15	17.72 GB
Mean Value Measurement	1000 * 1000 * 882	3	4.93 GB
Orientation	1000 * 1000 * 882	5	8.21 GB



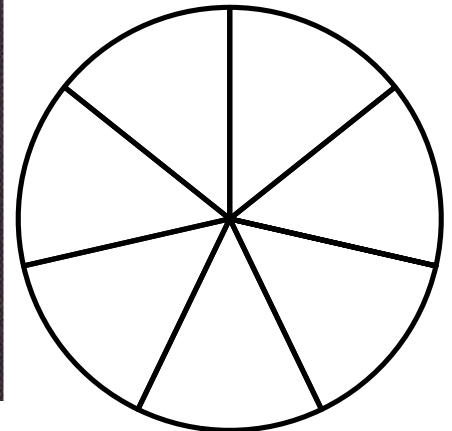
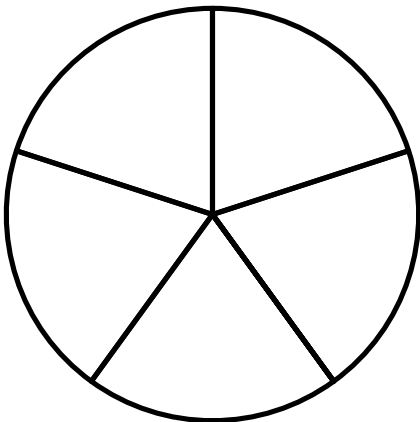
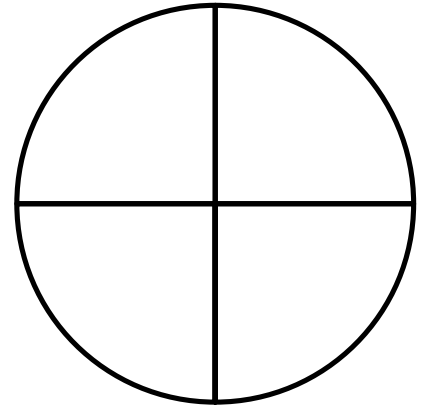
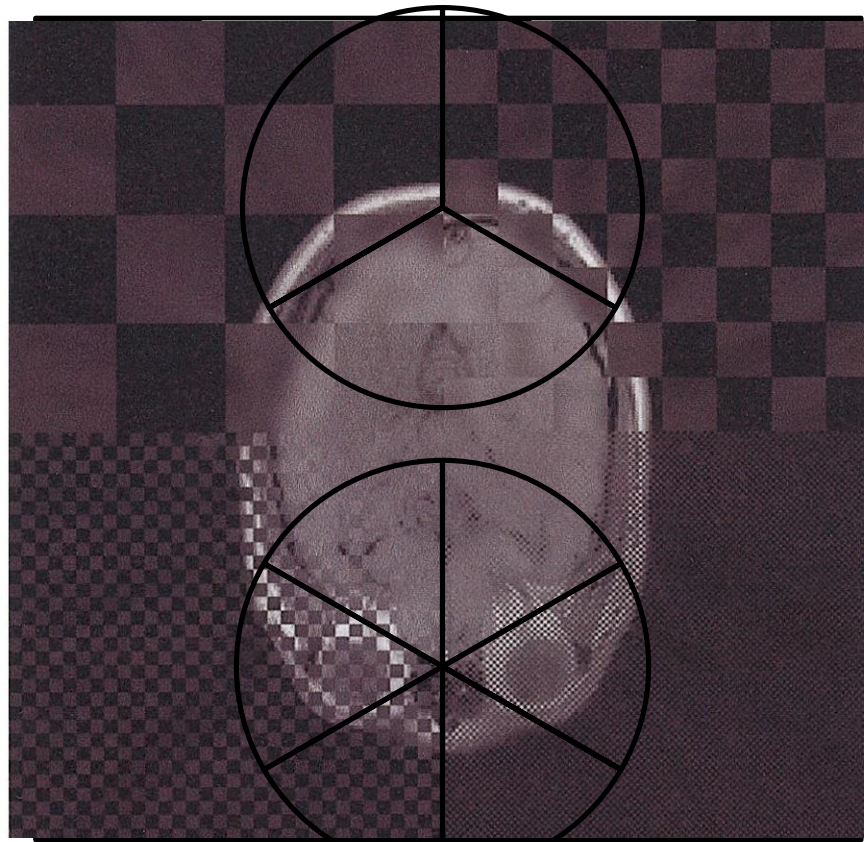
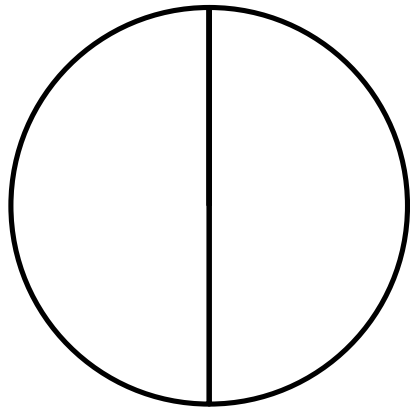
Orientation 0 degrees



Orientation 90 degrees



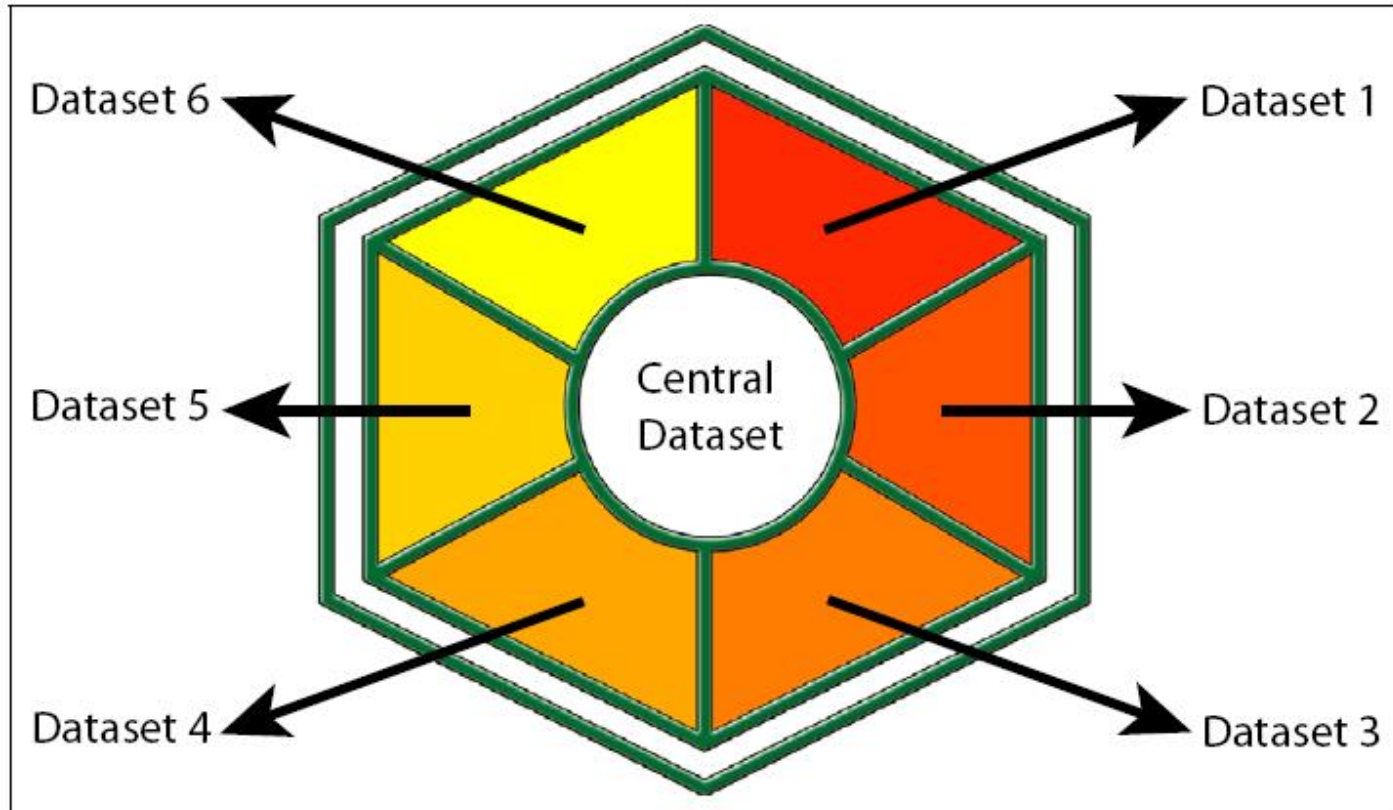
- Viewing two datasets on a single screen
- Viewing multiple datasets on a single screen



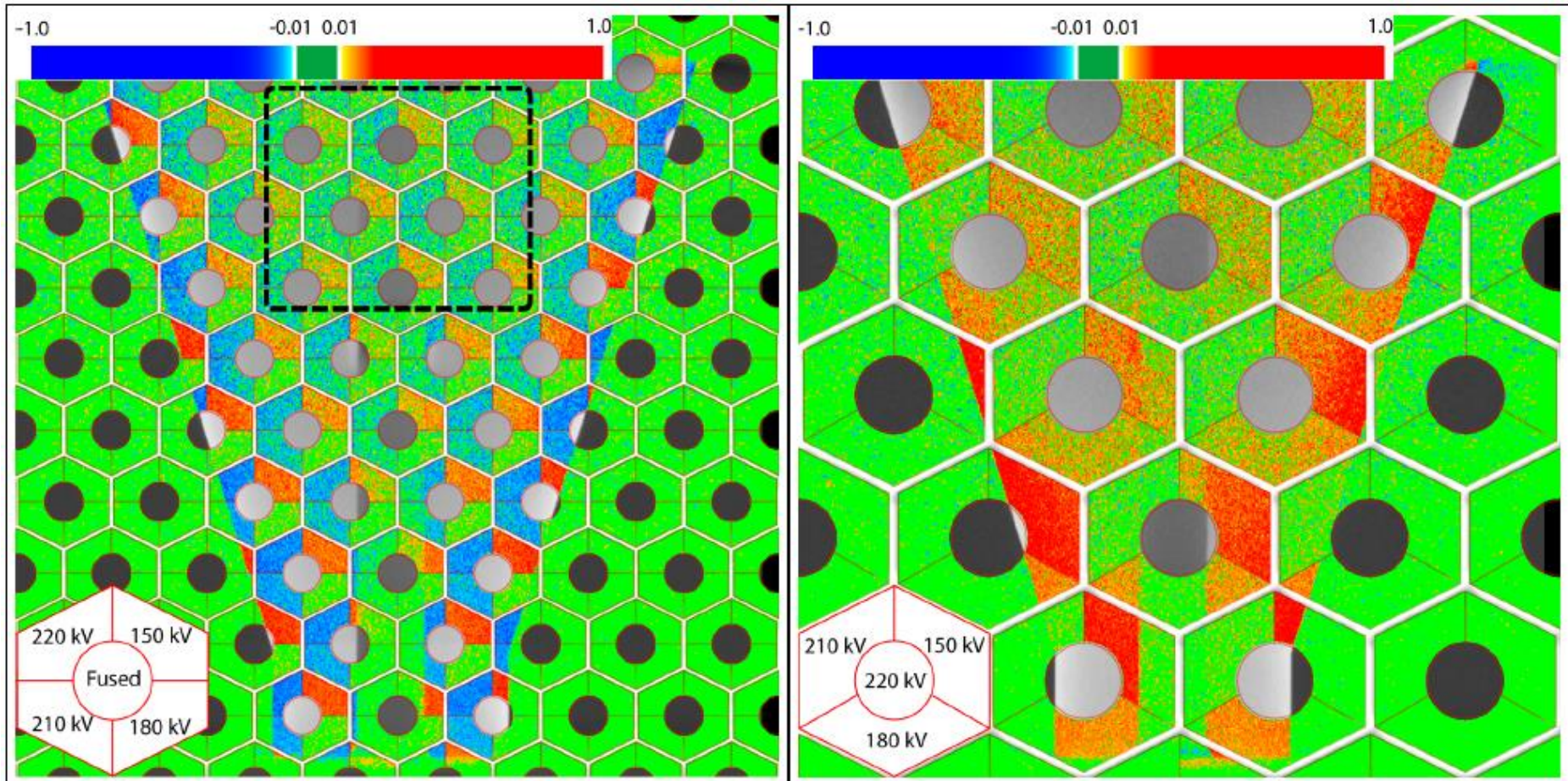
Stokking et al. [2003]

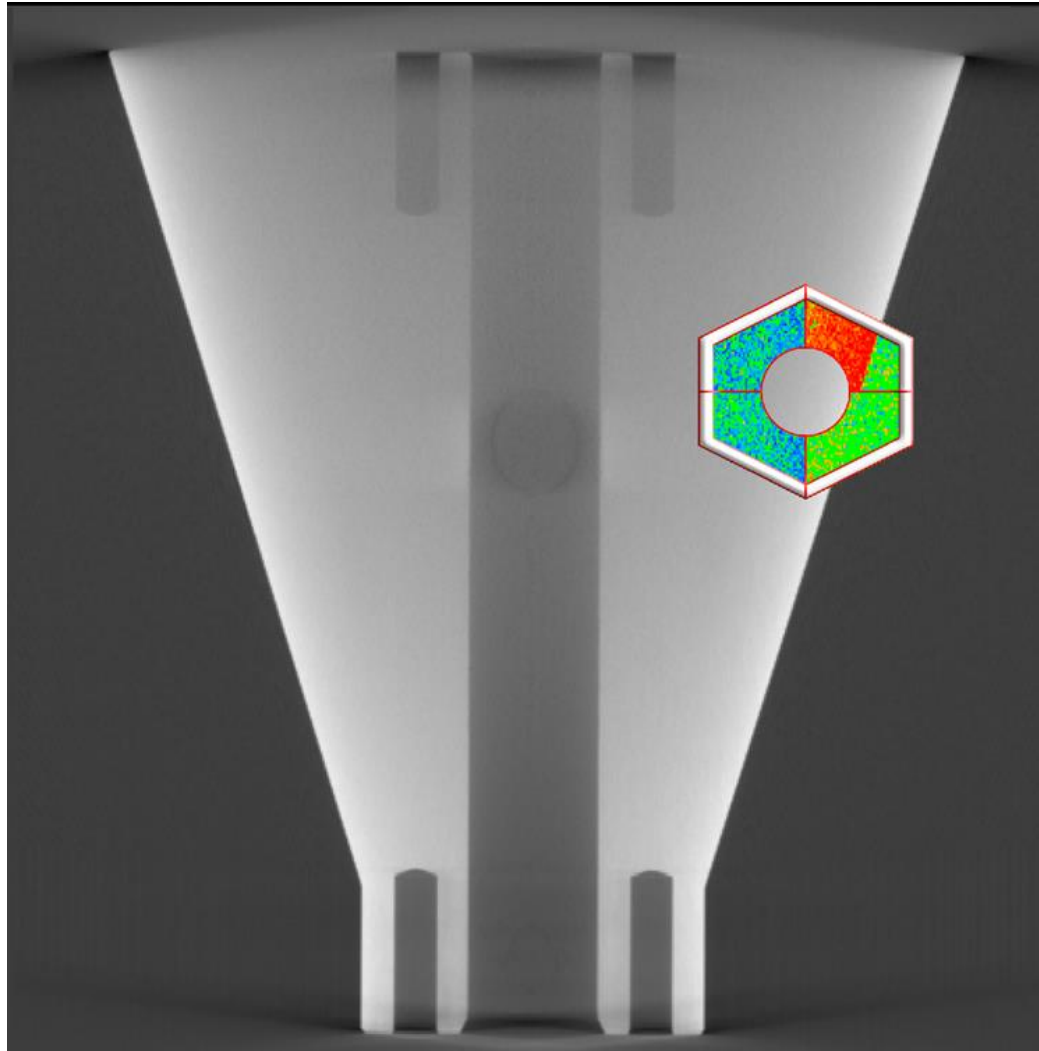


- Each slice shows part of each dataset



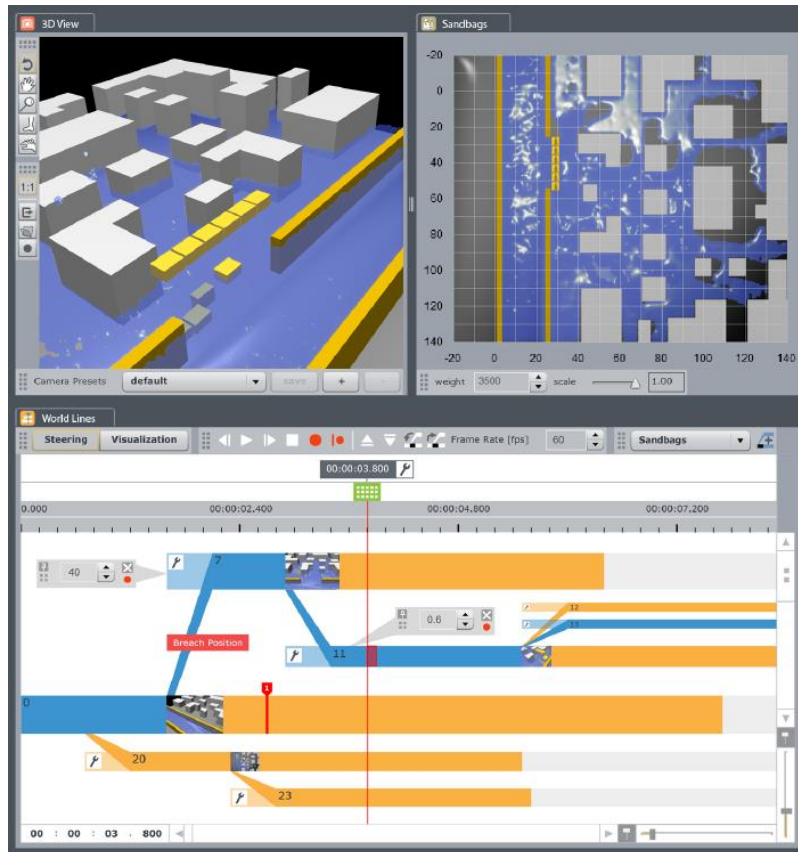
- Direct density visualization
- Relative density visualization





Comparative Vis.: Selected Example 2





Visual Steering to Support Decision Making in Visdom

J. Waser, R. Fuchs, H. Ribičić, Ch. Hirsch,
B. Schindler, G. Blöschl, E. Gröller

Flood emergency assistance

- **New Orleans 2005: 17th canal levee breach**



Image courtesy of USACE, US Army Corps of Engineers

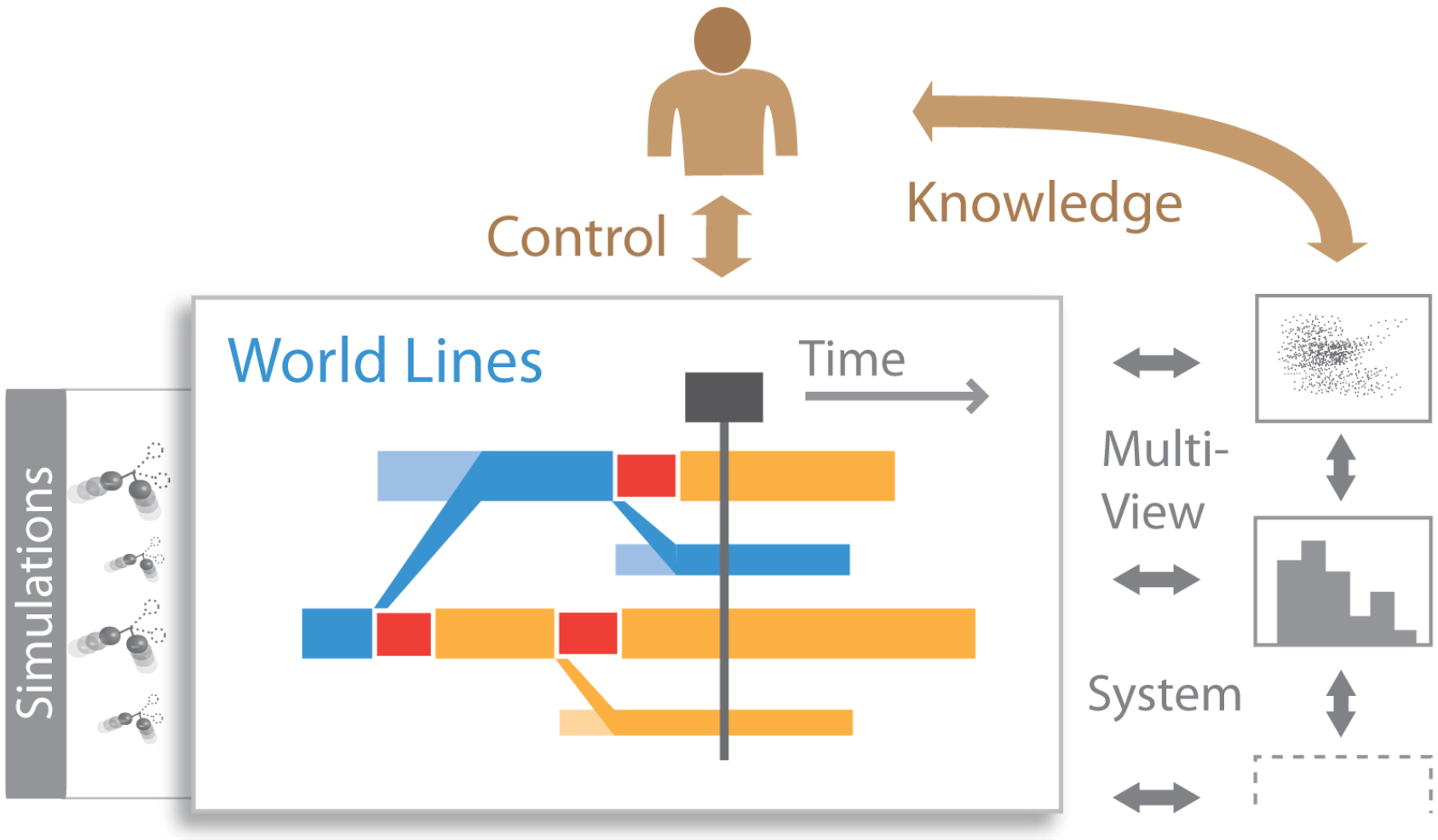
Flood emergency assistance

- Evaluation of breach-closure techniques in a laboratory model

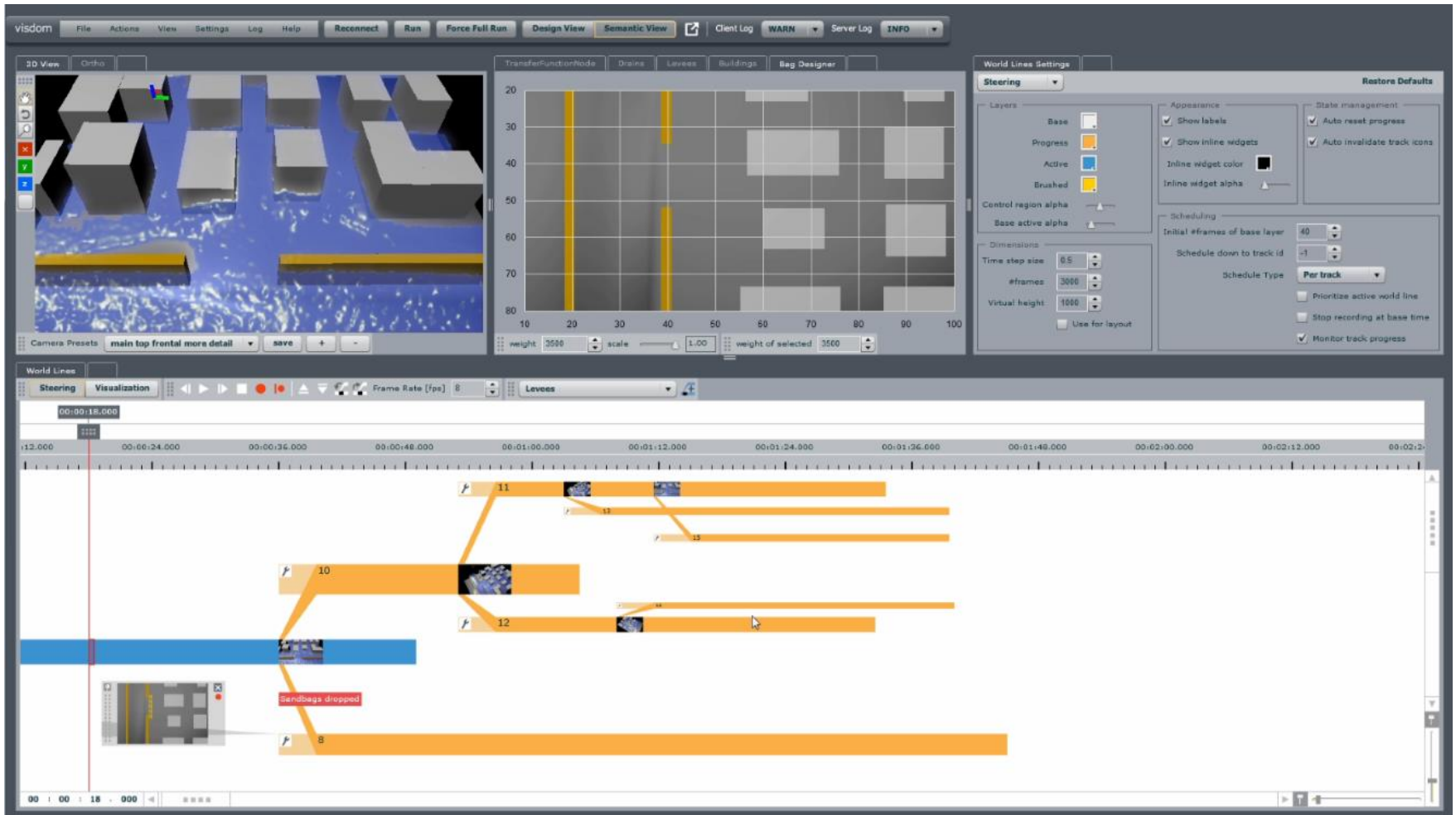


A. Sattar, A. Kassem, and M. Chaudhry. 17th street canal breach closure procedures. *Journal of Hydraulic Engineering*, 134(11):1547–1558, 2008.

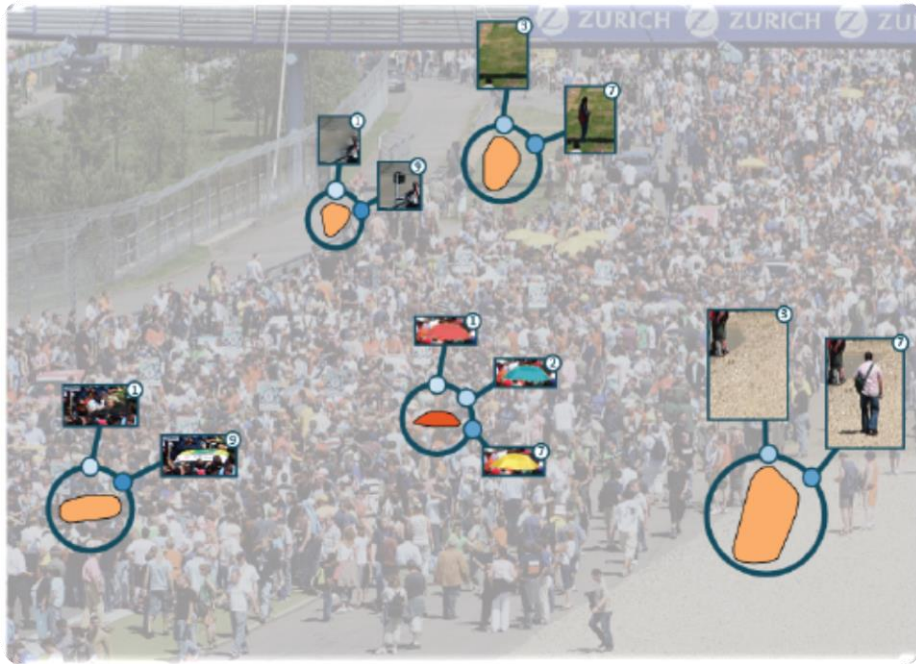
Computational Steering: World Lines



Video: World Lines - Features







Visual Image Comparison

Schmidt, J., Gröller, E., Bruckner, S.: **VAICo: Visual Analysis for Image Comparison**. IEEE Transactions on Visualization and Computer Graphics, 19(12): 2090–2099, 2013.

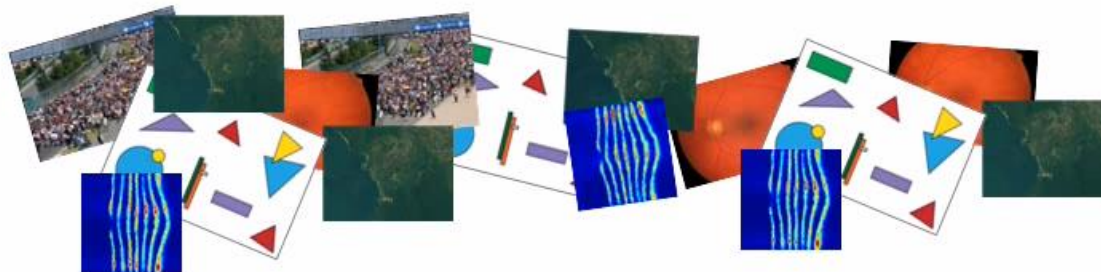


Analysis of Image Set Differences



VAICo

Visual Analysis for Image Comparison



Johanna Schmidt

*Vienna University of
Technology, Austria*

M. Eduard Gröller

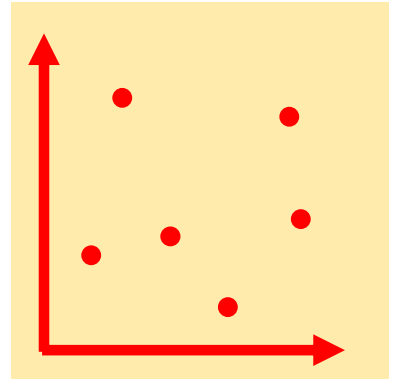
*Vienna University of
Technology, Austria*

Stefan Bruckner

*University of Bergen
Norway*

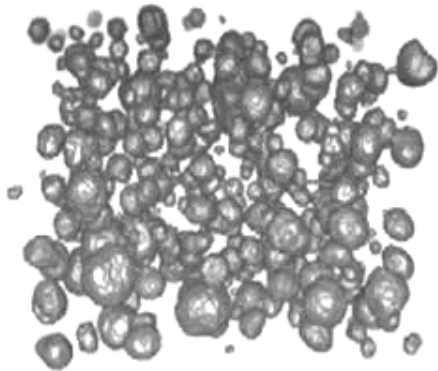


- What to compare? How to compare?
- Scatterplot to illustrate nD point sets
 - Use points as primitives
 - Eliminate most dimensions
 - Visualize distances in 2D



- MObjects to illustrate pores in XCT of CFRP
 - Use pores as primitives
 - Eliminate spatial location
 - Visualize pore orientations



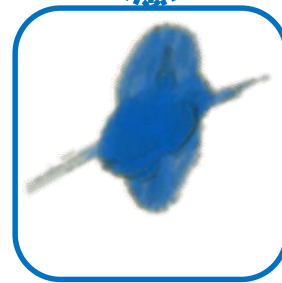
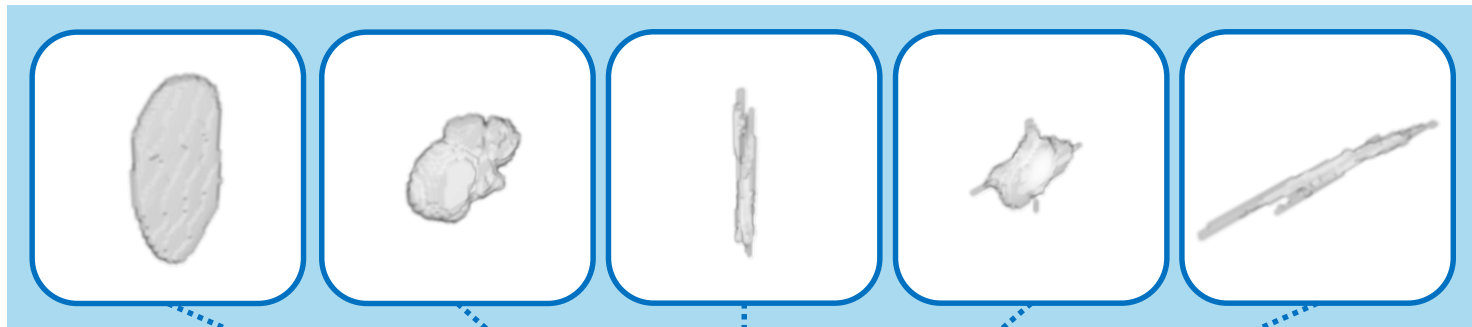


Many pores
(shape variation
not visible)

[Reh et al.]



Individual Objects



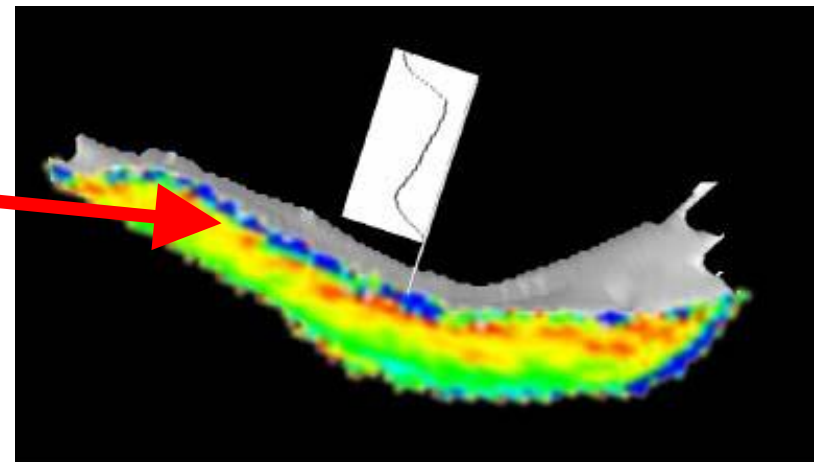
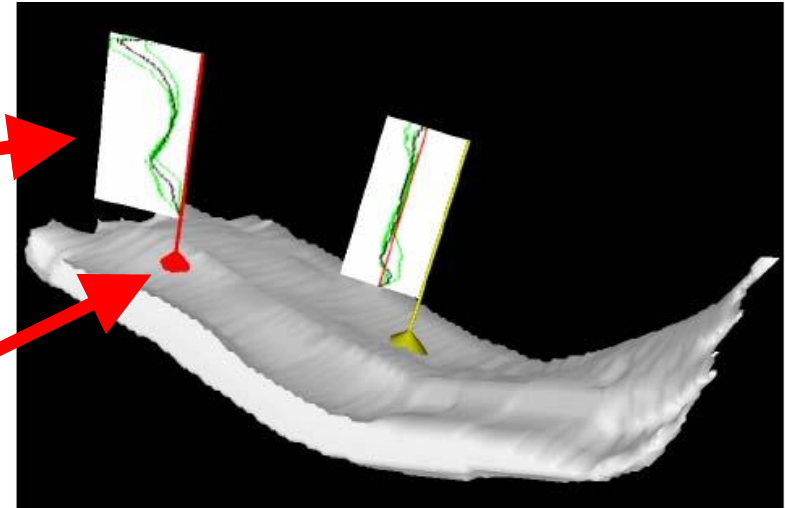
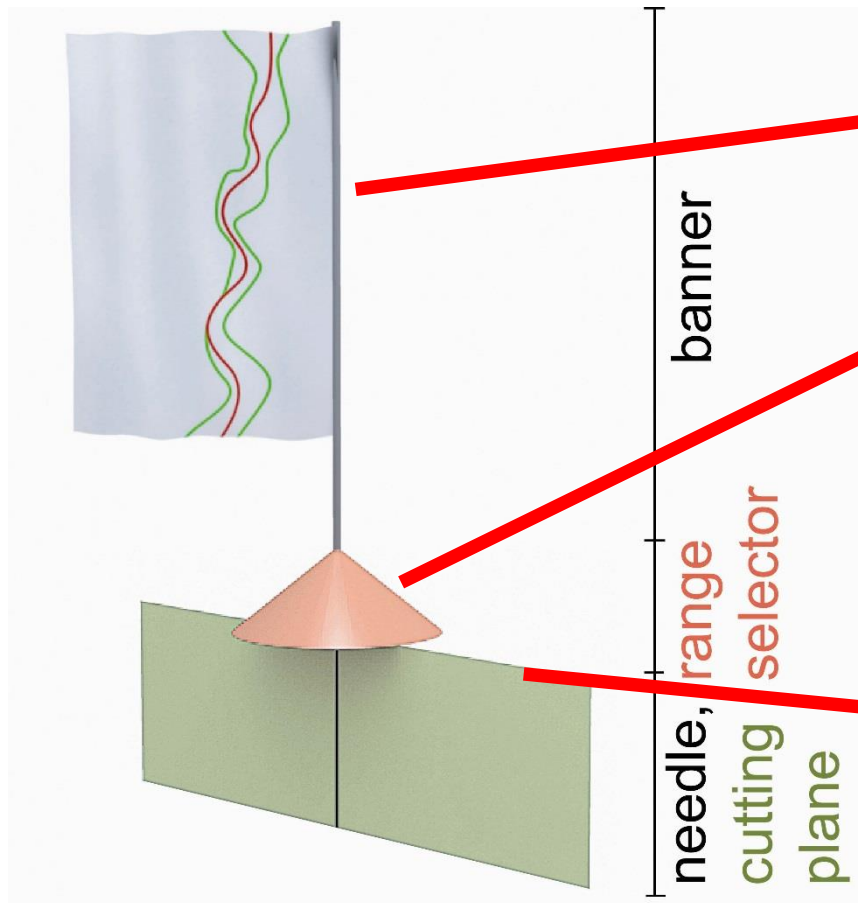
MObject

[Reh et al.]



- „Similarity is in the eye of the beholder“ –
Task dependency to visualize
 - Similarities/dissimilarities
 - Outliers
 - Trends
 - Clusters
 - Deviations
 - Same/different items
 - Larger/smaller items
- Complex data lead to complex metrics: How to compare?
 - Curves (e.g., Profile Flags)
 - Surfaces (e.g., Maximum Similarity Isosurfaces)
 - Volumes, flows, tensors
 - Trees, graphs

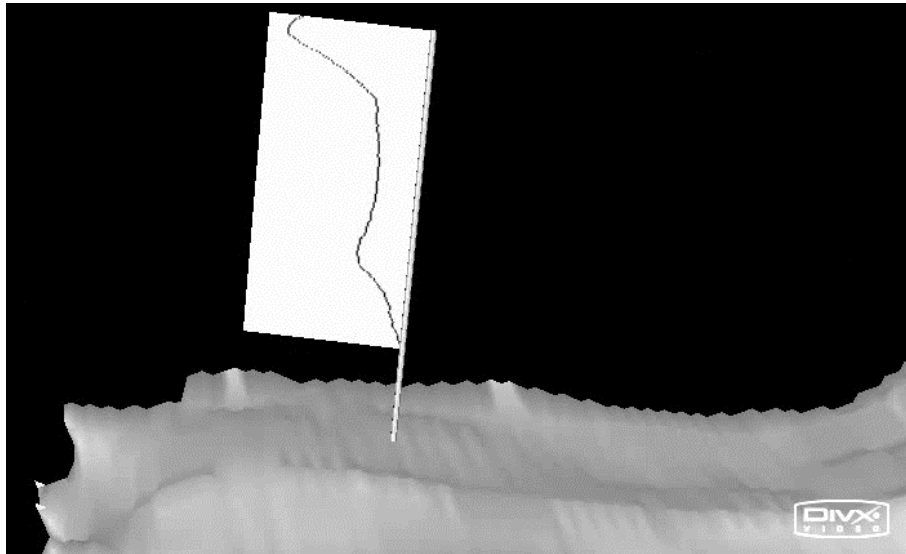




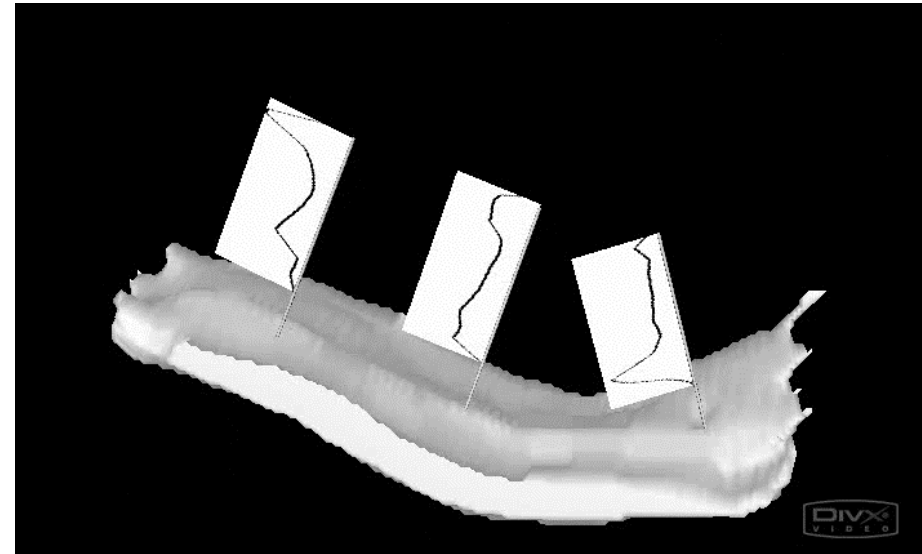
Profile flags

[Mlejnek et al.]





- Profiles in a local neighborhood

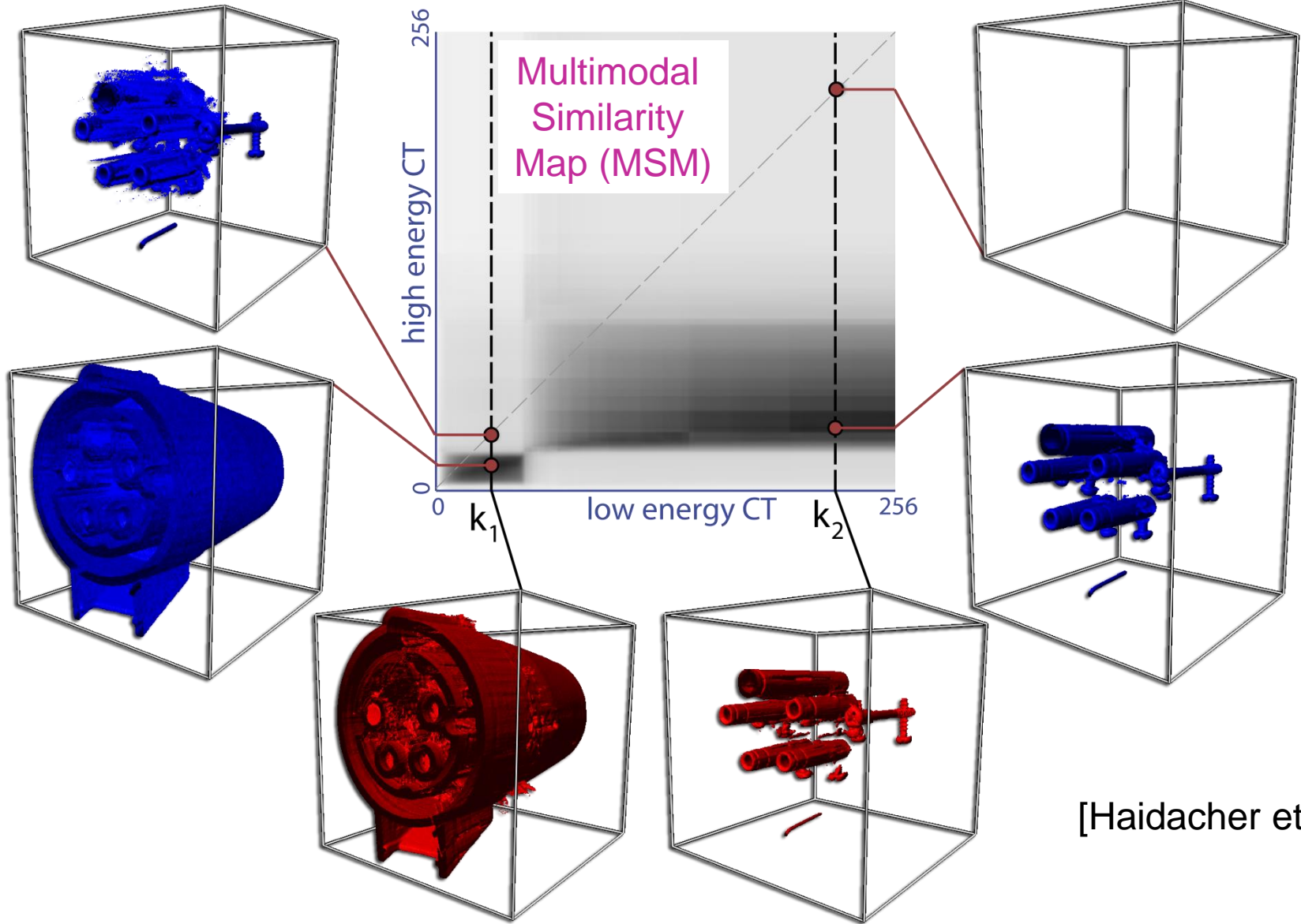


- Reference profile with deviation profiles

[Mlejnek et al.]



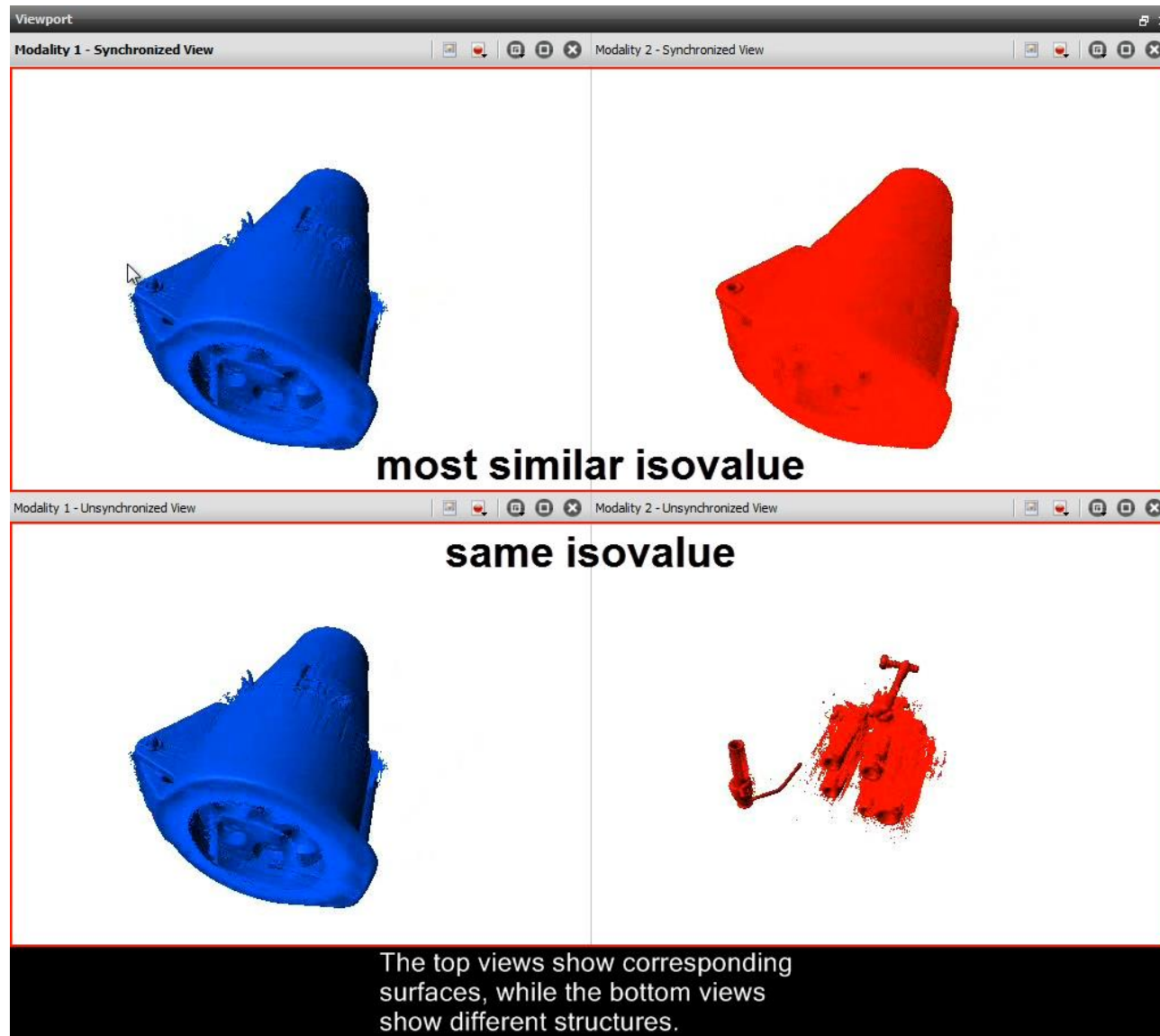
Maximum Similarity Isosurfaces (1)



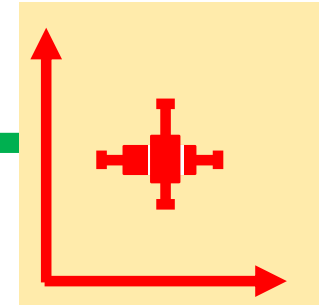
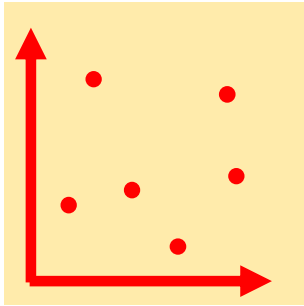
[Haidacher et al.]



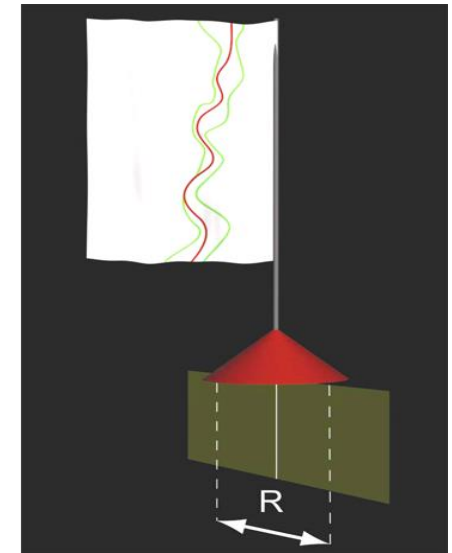
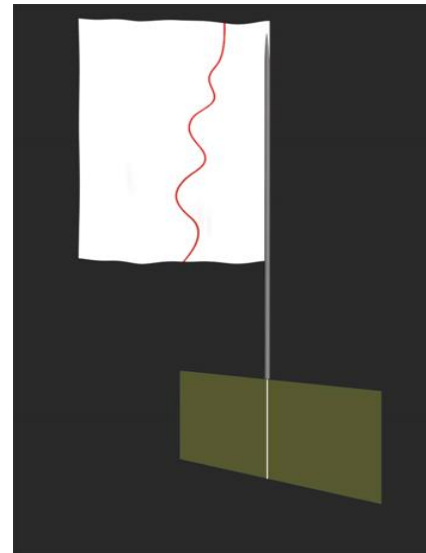
Maximum Similarity Isosurfaces (2)



- Visualization of sets \leftrightarrow statistical visualization



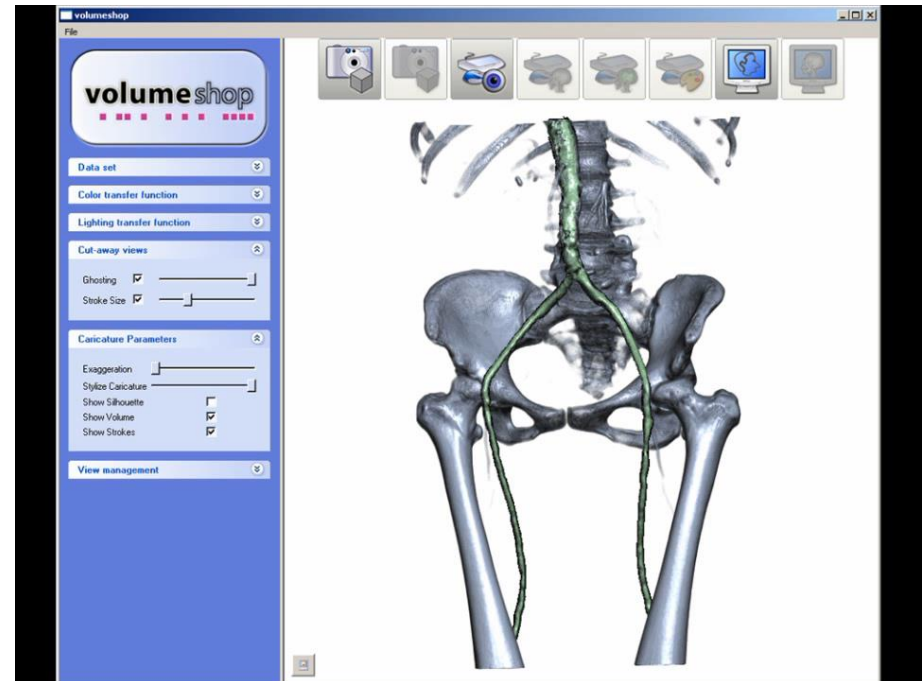
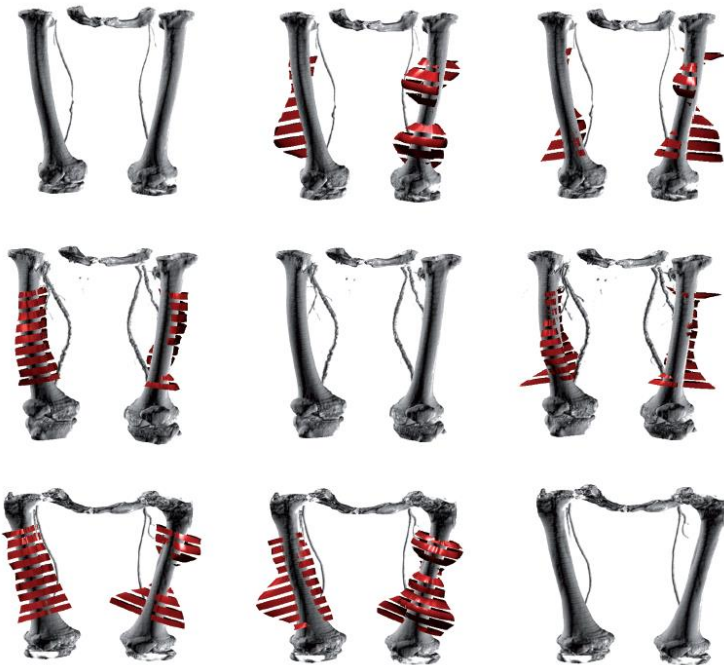
- Localize analysis in space and/or time
- Requires/allows interactive exploration



- Explicit encoding: How to emphasize subtle differences?
- Differences visualized through
 - Color
 - Cut-outs, cut-aways
 - Ghosting
 - Exploded views
 - Focus+context
 - Distortion (e.g., Caricaturistic Visualization)



- Extrapolate the differences between
 - Two individual items
 - Individual item and average



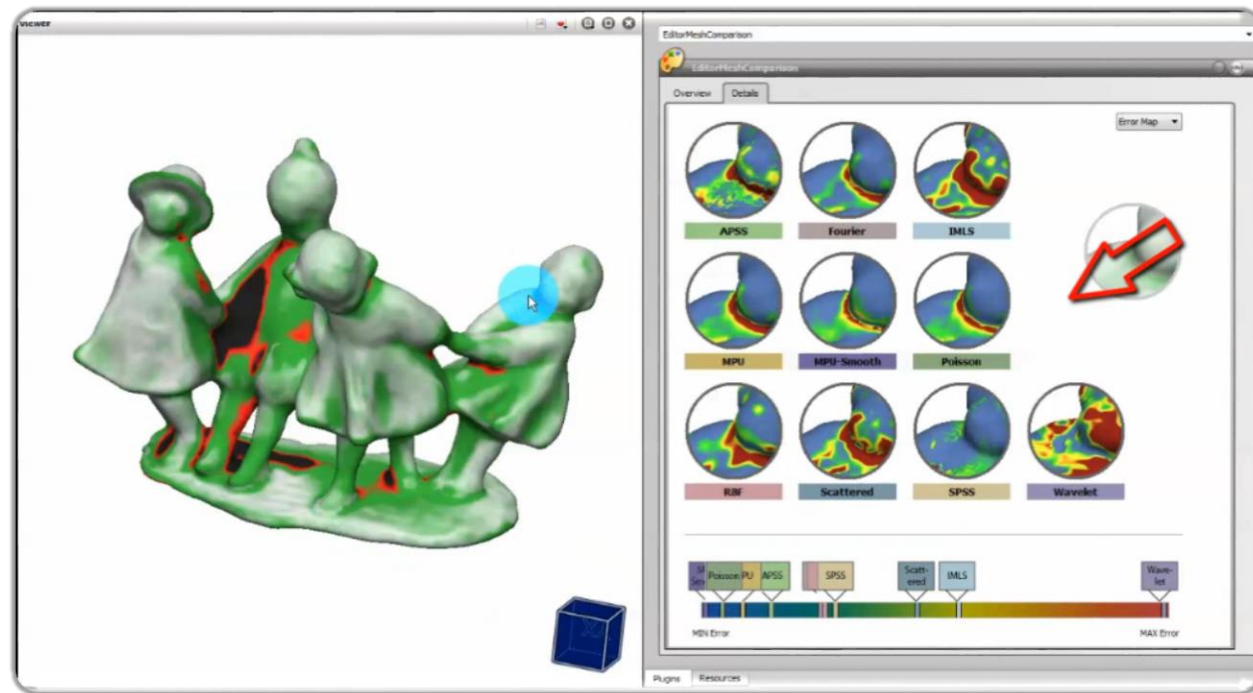
[Rautek et al.]



- Further topics/issues
 - Parameter space analysis
 - Uncertainty
 - Variability, robustness
 - Mapping complex objects onto each other (e.g., gene sequences, molecules, surfaces with varying topology)
 - Scalability with respect to
 - # Items
 - Data complexity



Questions ?
Comments?



Acknowledgments

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Raphael Fuchs
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Matej Mlejnek
Harald Piringer
Peter Rautek
Andreas Reh

Hrvoje Ribičić
Johanna Schmidt
Anna Vilanova
Ivan Viola
Jürgen Waser

...





Visualization uses computer-supported, interactive, visual representations of (abstract) data to amplify cognition. In recent years data complexity and variability has increased considerably. This is due to new data sources as well as the availability of uncertainty, error and tolerance information. Instead of individual objects entire sets, collections, and ensembles are visually investigated. This raises the need for effective comparative visualization approaches. Visual data science and computational sciences provide vast amounts of digital variations of a phenomenon which can be explored through superposition, juxtaposition and explicit difference encoding. A few examples of comparative approaches coming from the various areas of visualization, i.e., scientific visualization, information visualization and visual analytics will be treated in more detail.

Comparison and visualization techniques are helpful to carry out parameter studies for the special application area of non-destructive testing using 3D X-ray computed tomography (3DCT). We discuss multi-image views and an edge explorer for comparing and visualizing gray value slices and edges of several datasets simultaneously.

Visual steering supports decision making in the presence of alternative scenarios. Multiple, related simulation runs are explored through branching operations. To account for uncertain knowledge about the input parameters, visual reasoning employs entire parameter distributions. This can lead to an uncertainty-aware exploration of (continuous) parameter spaces.

VAICo, i.e., Visual Analysis for Image Comparison, depicts differences and similarities in large sets of images. It preserves contextual information, but also allows the user a detailed analysis of subtle variations. The approach identifies local changes and applies cluster analysis techniques to embed them in a hierarchy. The results of this comparison process are then presented in an interactive web application which enables users to rapidly explore the space of differences and drill-down on particular features.

Given the amplified data variability, comparative visualization techniques are likely to gain in importance in the future. Research challenges, directions, and issues concerning this innovative area are sketched at the end of the talk.



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