Scientific Visualization
and Computer Graphics
University of Groningen

Visualization and Visual Analytics

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http://www.cs.rug.nl/svcg/

Summary

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- Multidimensional Visualization Techniques
- Visual Analytics
- Interaction Techniques
- Applications in Astronomy

Volume Rendering

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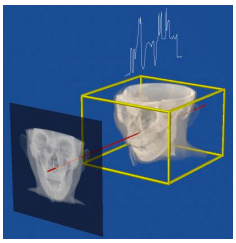
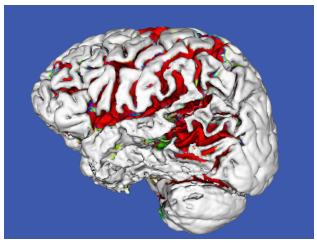
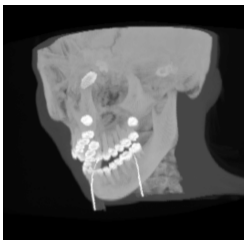
- Surface rendering: reduce volume to isosurfaces
  S(c) : f(x,y,z) = c of a density function f (x, y, z) representing the boundary between materials.
- Direct volume rendering: map volume data directly on screen (no graphical primitives)



Ray casting



Surface rendering



Direct rendering (MIP)

Building a 2D transfer function

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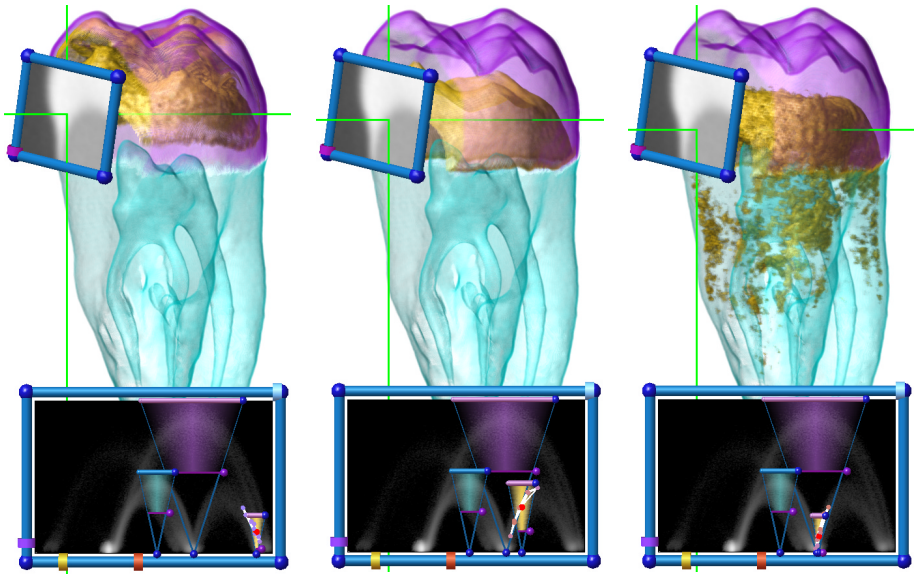

Vector Field Visualization

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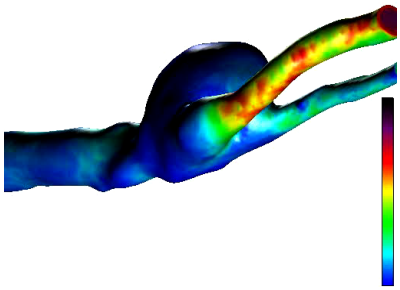
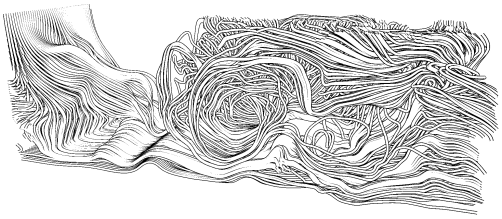
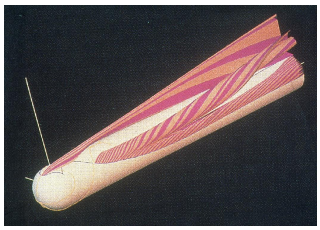


Line Integral Convolution



Streamlines



Flow field topology

Tensor Field Visualization

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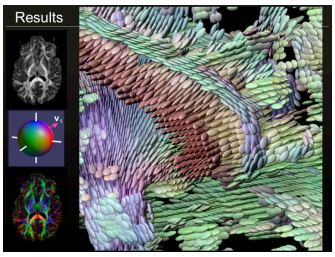
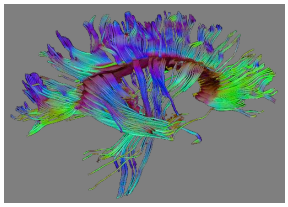
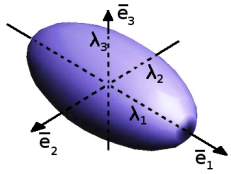


Glyphs

D_{xx}	D_{xy}	D_{xz}
D_{xy}	D_{yy}	D_{yz}
D_{xz}	D_{yz}	D_{zz}

Principal directions
of the diffusion tensor





Fiber tracts

Information Visualization

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Tasks:

1. overview: gain an overview of the entire set of data
2. zoom: zoom in on a subset of items of interest
3. filter: filter out uninteresting items
4. details-on-demand: select on or more items and get details
5. relate: view relationship among items
6. history: keep a history of actions to support undo, replay, and progressive refinement
7. extract: allow extractions of subsets of items

Context

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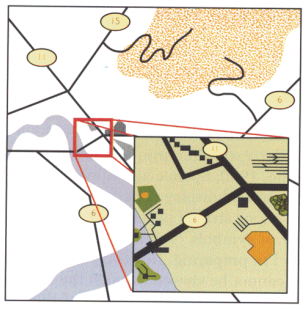
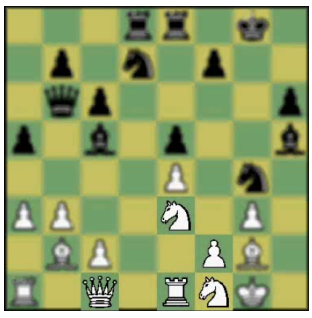


Focus+Context



Semantic Depth of Field

Scatterplot matrix

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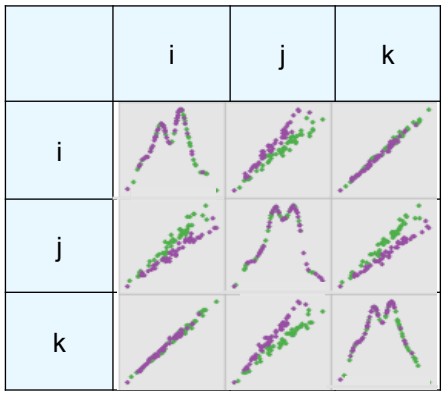
Pairwise scatterplots of p variables in matrix format



Software: Ggobi http://www.ggobi.org/

Parallel Coordinate Plot

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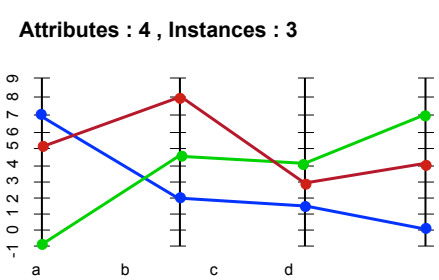
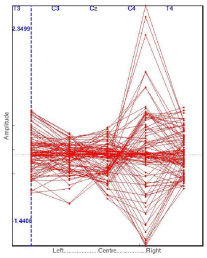
Data matrix: N attributes (columns), M instances (rows)
Instances are represented by a line trace, connecting the case value on each attribute axis

Number of lines = Number of instances



4 attributes, 3 instances



5 attributes, 100 instances
(multichannel EEG data)

Star Coordinate Plot

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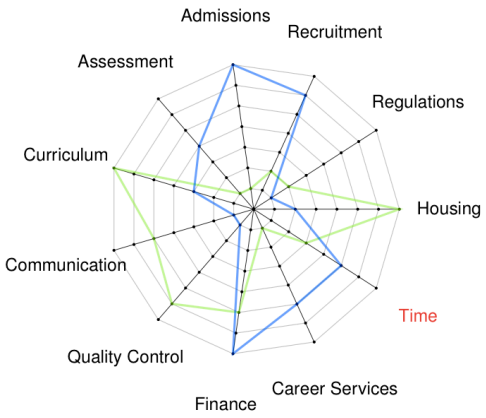
Same as parallel coordinate plot, but with radial axes layout



11 attributes, 2 instances

Linked Views

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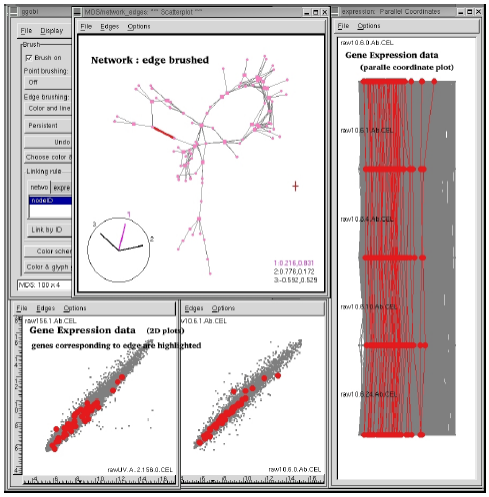

Linking gene network with corresponding expression values using parallel coordinates and scatter plot techniques (source: Lee et al. 2004).

Tree Visualization

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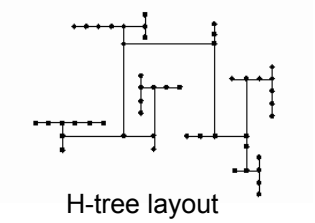
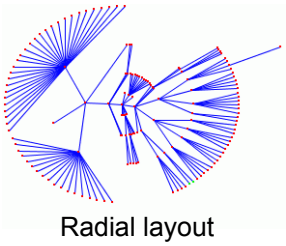
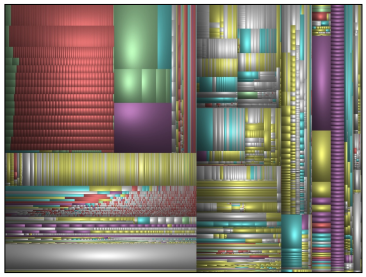


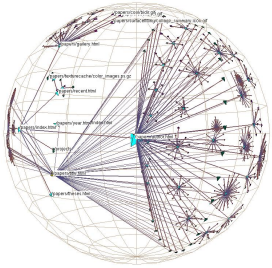
H-tree layout



Radial layout



Tree map (Sequoiaview, v Wijk, TU/e)



3D hyperbolic layout

Graph & Network Visualization

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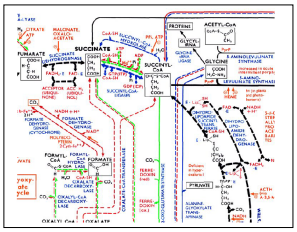
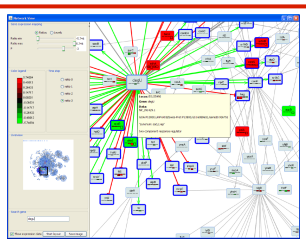
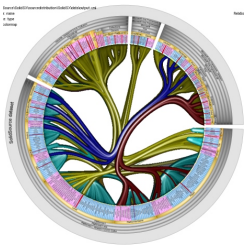


Boehringer-Mannheim (Metabolic network)



Gene networks (Westerberg et al., 2006)



Graph bundling

Software Visualization

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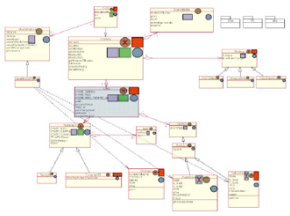
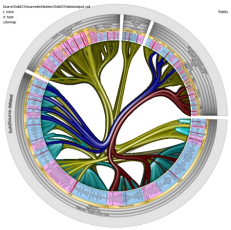
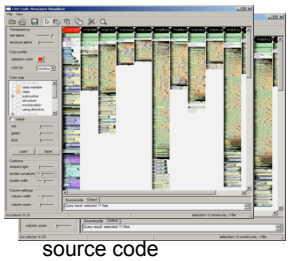


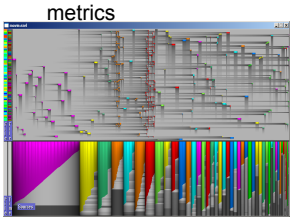
UML diagrams & metrics



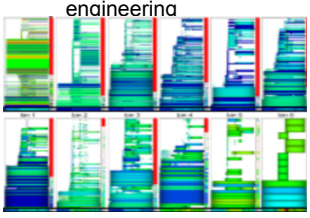
reverse engineering



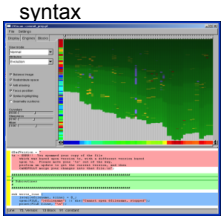
source code syntax



peer-to-peer transactions



memory allocations



software evolution

(A Telea, RUG)

Dimensionality reduction

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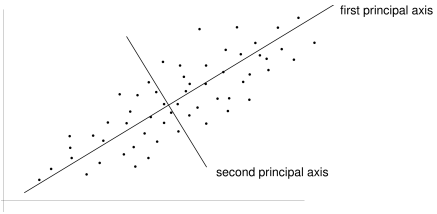
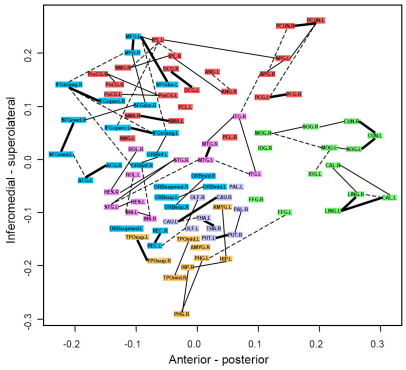


PCA

Martins et al. 2012)



Salvador et al., 2005

Multidimensional projections: preserve N-dimensional distances in 2D

Provenance

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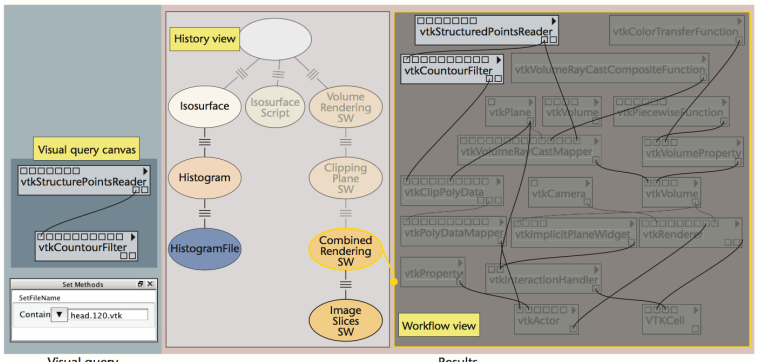
Oxford English Dictionary: the source or origin of an object; its history and pedigree; a record of the ultimate derivation and passage of an item through its various owners.



Freire et al., 2008 See also http://www.vistrails.org/

Strong link to data lineage (Astrowise)

Visual Analytics

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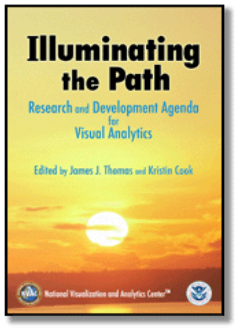
- Founder: Jim Thomas, NVAC
- *Illuminating the Path*, 2004



Visual Analytics:
The science of analytical reasoning facilitated by interactive visual interfaces

Disciplines:
- Data mining
- Statistics
- Perception/cognition
- Visualization
- Human-computer interaction

The Visual Analytics Process

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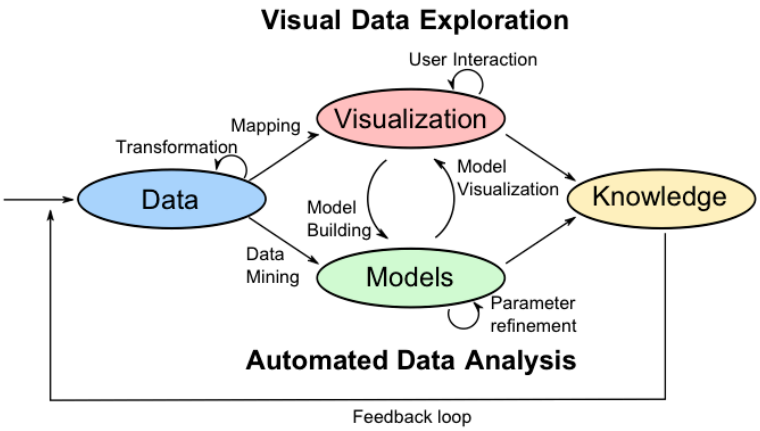

The Visual Analytics Process is characterized through interaction between data, visualizations, models about the data, and the users in order to discover knowledge. (© J v Wijk, TU/e)

Linking displays via `dynamic filtering

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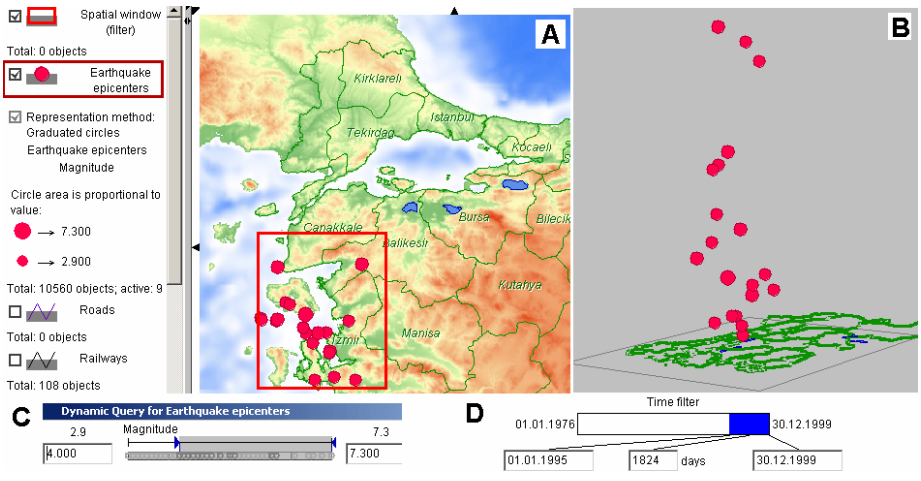

Figure produced using the CommonGIS visual analytics toolkit (Andrienko & Andrienko, 2006)

NWO
Netherlands Organisation for Scientific Research

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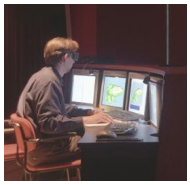
ASTROVIS Project 2006-2011
Part of NWO STARE: "STAR E-SCIENCE"

Comp. Science-RUG Astronomy-RUG






- Search for interesting relations in immense databases of digital sky surveys (Sloan, Lofar, OmegaCAM)
- Automatic pattern recognition (power of computer)
- Interactive visualization (power of human brain)

Interactive Search & Exploration

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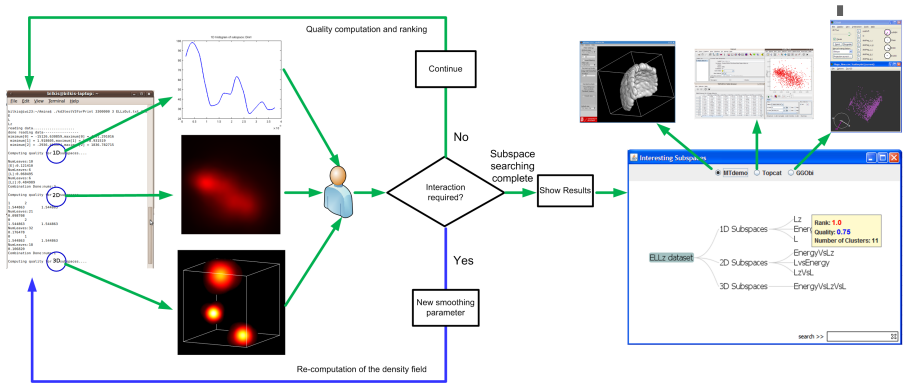

B Ferdosi, H Buddelmeijer, S Trager, M Wilkinson, J Roerdink.
Finding and Visualizing Relevant Subspaces for Clustering High Dimensional Astronomical Data using Connected Morphological Operators. IEEE VAST, Oct 2010

Experiments & Results

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Astronomical dataset: *Galaxy sample from Sloan Digital Sky Survey (SDSS)*

- galaxies in the Northern Galactic Cap of **SDSS Data Release 7**
- **32228 galaxies** with **15 attributes**: magnitude (in red band), 10 colors (u-g, u-r, u-i, u-z, g-r, g-i, g-z, r-i, r-z, i-z), logMass, logDensity, iC, SBr

Experiments & Results

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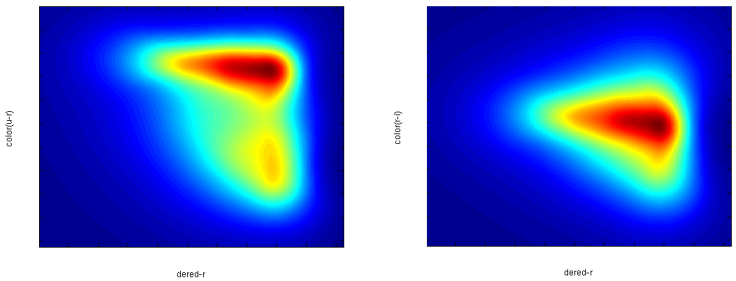
Astronomical dataset: *Galaxy sample from SDSS (Sloan Digital Sky Survey)*



Color vs Magnitude relation. Left: ranked 1 in our method: magnitude vs color(u-r). Right: ranked 1 in SURFING: magnitude vs color(r-i).

Visualization Environments

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- Immersion, versus interaction and collaboration
- “Make it mobile”: visualization at the user’s fingertips
- 3D visualization in your browser (desktop, mobile)

Touch Display: 3D Navigation

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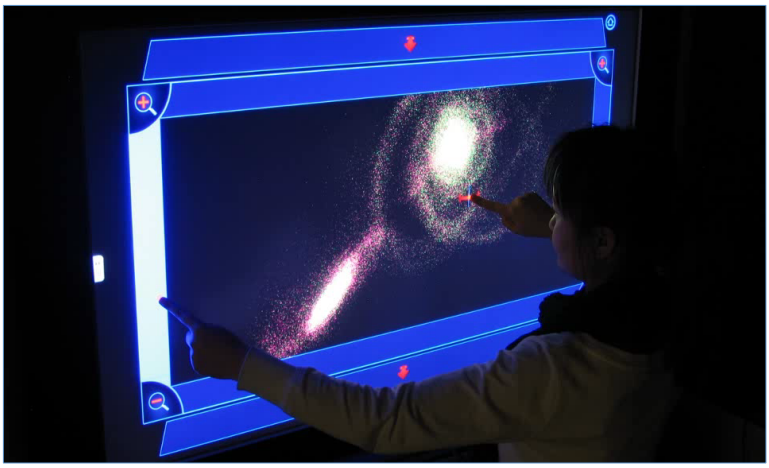

Yu et al., *FI3D: Direct-touch Interaction for the Exploration of 3D Scientific Visualization Spaces*. IEEE TVCG 16(6):1613–1622, 2010.
http://tobias.isenberg.cc/VideosAndDemos/Yu2010FDT

Selection by Direct Touch

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Yu et al., *Efficient Structure-Aware Selection Techniques for 3D Point Cloud Visualizations with 2DOF Input*. IEEE TVCG 18(12):2245–2254, 2012
http://tobias.isenberg.cc/VideosAndDemos/Yu2012ESA

User Evaluation

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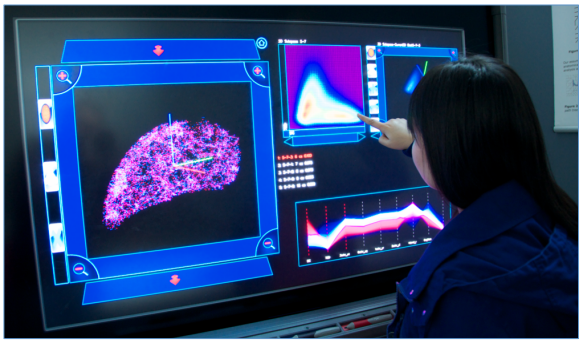
- 4 astronomical domain experts
- 52” LCD screen with DViT overlay from Smart Technologies
- Observational study



netherlands eScience center
by SURF & NWO

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e-Visualization of Big Data

Comp. Science

Astronomy

Center Inform Techn

- Target: very large data archives (petabyte range)
- Query driven visualization - Visual Analytics
- Medical imaging, astronomy, 3D electron microscopy
- Collaborative environments (touch displays, Infoversum)

Acknowledgements

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Computer Science

Henk Bekker
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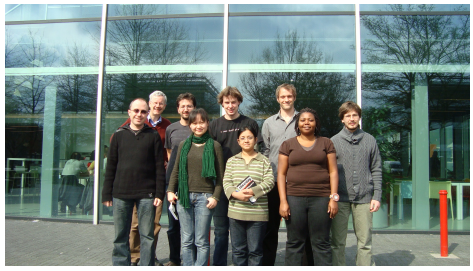
Lingyun Yu
David Williams

Kapteyn Astronomical Institute

Hugo Buddelmeijer
Scott Trager
Thijs van der Hulst
Edwin Valentijn
Amina Helmi
Parisa Noorishad



Scientific Visualization and Computer Graphics http://www.cs.rug.nl/svcg/