Semi-abstract visualization of rich scientific data

Helwig Hauser
University of Bergen

The real voyage of discovery
consists not in seeking new landscapes,
but in having new eyes.

Marcel Proust (1871—1927)

Helwig Hauser
University of Bergen

Example: log-log plot

Grand visualization in relation to power laws

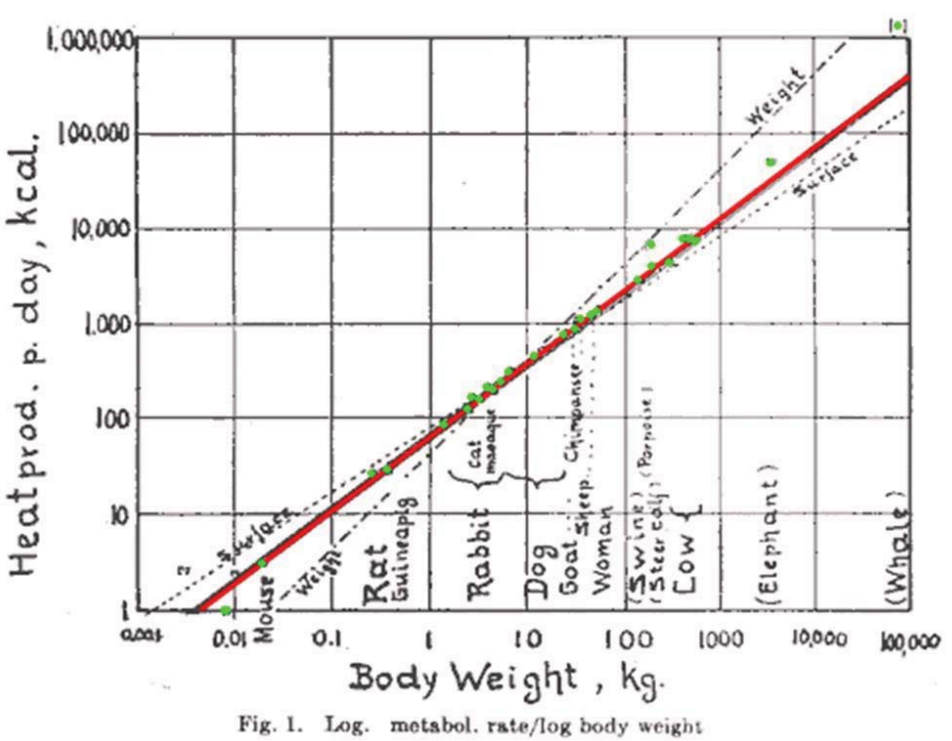


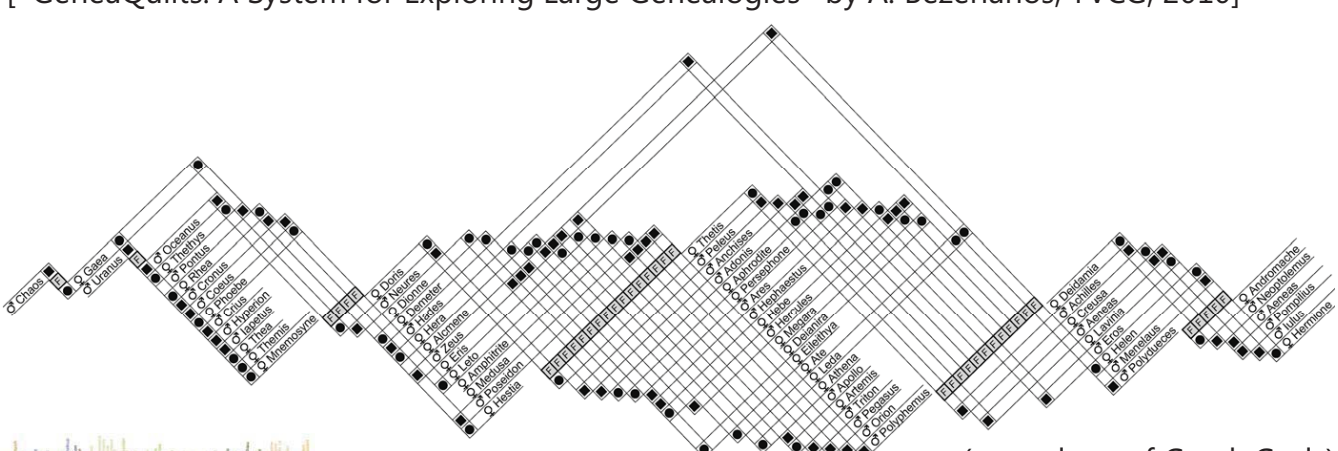
Fig. 1. Log. metabol. rate/log body weight

[«Body Size and Metabolic Rate» by M. Kleiber, Physiological Reviews, 1947]

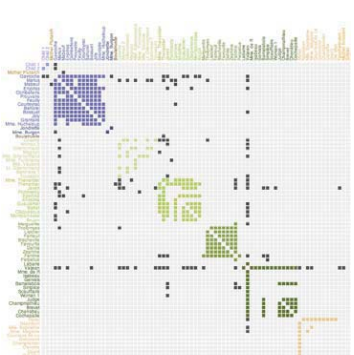
Example: adjecency matrix visualization

Revealing insight into large graphs – here: GeneaQuilts

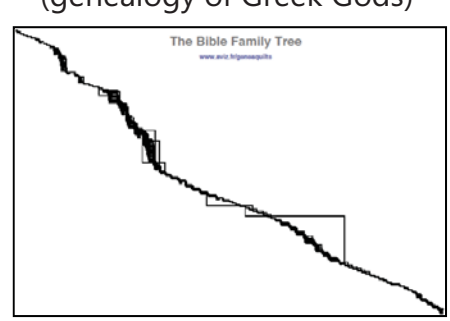
[«GeneaQuilts: A System for Exploring Large Genealogies» by A. Bezerianos, TVCG, 2010]



(genealogy of Greek Gods)



(character interaction in Les Misérables)



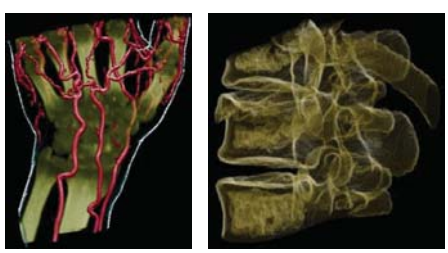
Starting point: classical SciVis ...

Central to visualization:

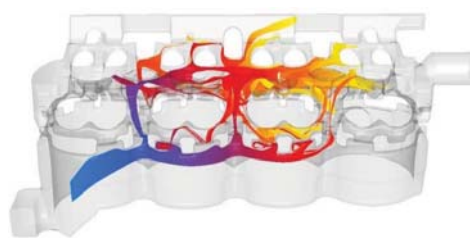
- visualization mapping:
  phenomenon of interest into visualization space
- visualization space:
  usually 3D (or 2D) Cartesian space

Typical in SciVis:

- mapping the spatial aspects of the phenomenon of interest
  onto the 3 (or 2) axes of the visualization space



[«Two-level Volume Rendering» by HH *et al.*, TVCG 2001]

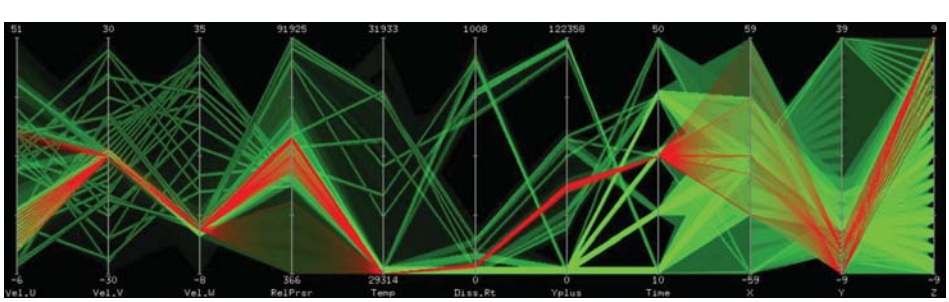


[«Visual Analysis and Exploration of Fluid Flow in a Cooling Jacket» by R. Laramee *et al.*, Vis 2005]

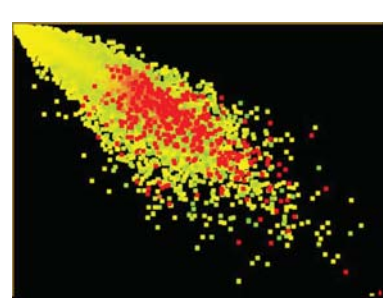
... vs.: abstract (sci.) data visualization

InfoSciVis:

- mapping other aspects of the phenomenon of interest
  onto the 3 (or 2) axes of the visualization space



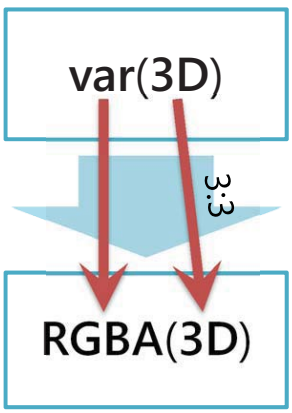
[«Outlier-preserving Focus+Context Visualization in Parallel Coordinates» by M. Novotný *et HH*, TVCG 2006]

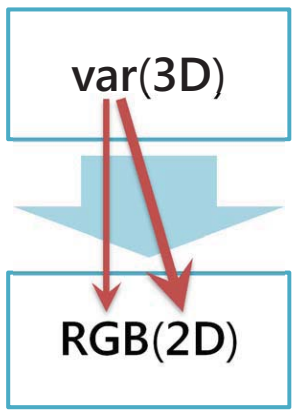


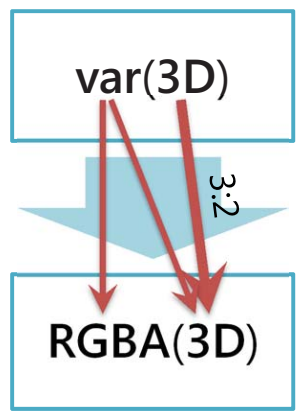
[«Visual Exploration and Analysis of Perfusion Data» by St. Oeltze, 2010]

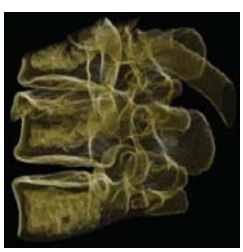
Or: semi-abstract visualization

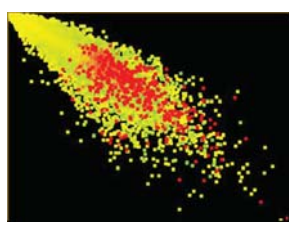
Mapping the spatial aspects to a subset of the vis.-space, using the other subset to represent other data aspects

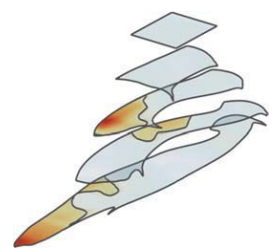




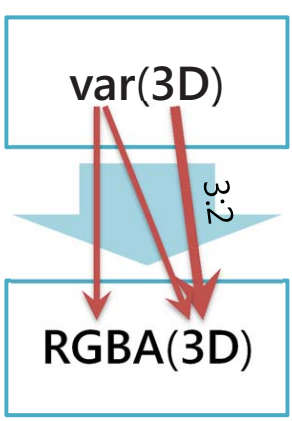








Semi-abstract visualization



data: $(x, y, z, a, b, c, \ldots)^T$

$p(.)$

visualization: $(x, y, z, r, g, b, \ldots)^T$

Lower-dimensional embedding p(.) of the spatial aspects

- by projection
- by transformation
- by abstraction

Additional space for alternative data aspects, *e.g.*, "*b*"

Trade-off

Prize:

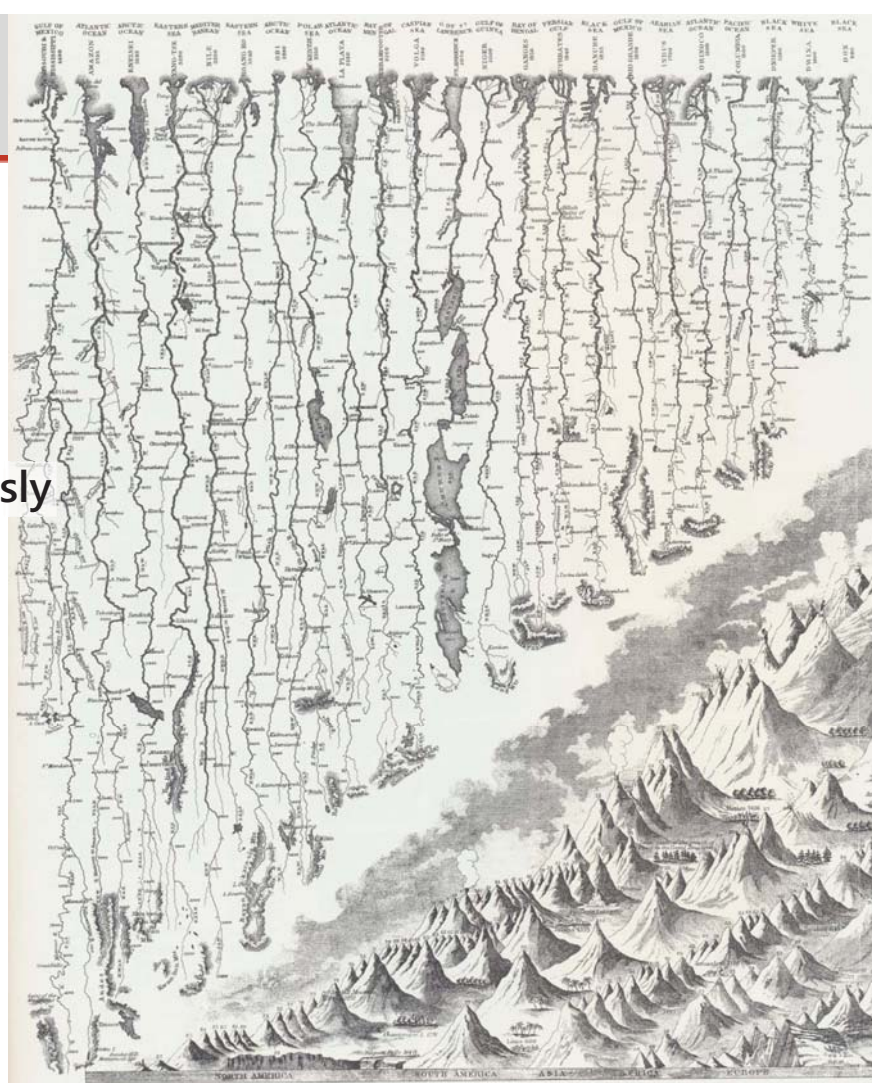
- "lossy" **p**(.) – data's spatiality not 100% represented

Potential benefit:

- comparative visualization of multiple phenomena
- single-picture summary of time-dependent data
  - devoting one vis.-space axis to time
- crossing SciVis with InfoVis
  - putting a function graph onto a spatial abstraction
  - visualizing statistics across a spatial abstraction

Tufte, 1997

"Spatial parallelism takes advantage of our notable capacity to compare and reason about multiple images that appear simultaneously within our eyespan"



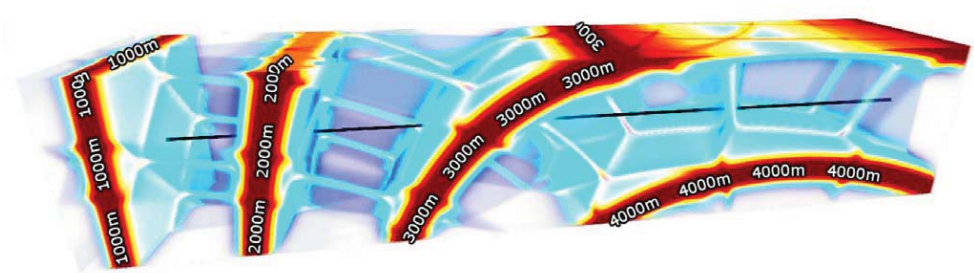
[«Visual Explanations: Images and Quantities, Evidence and Narrative» by E. R. Tufte, Graphics Press 1997]

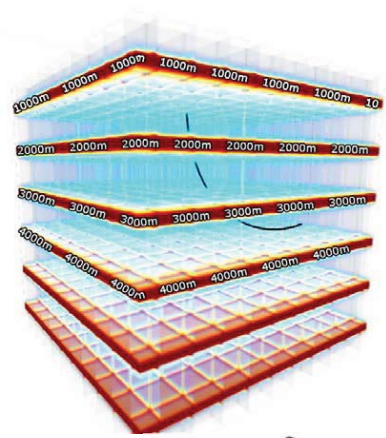
Three recent examples

VisGroup Bergen *et al.*

Curve-centric volume reformation example

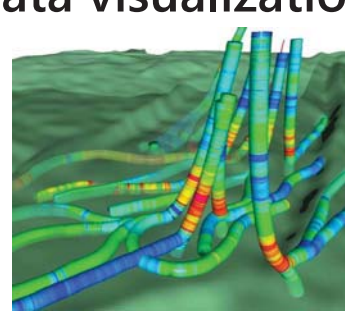
Reforming a data volume such that a reference curve straightens

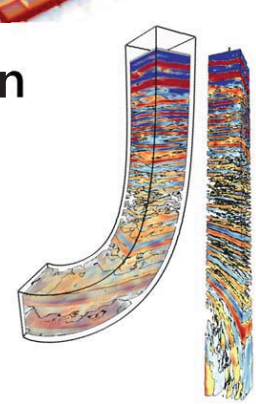




Application context: bore hole data visualization

- lots of data from drilling, incl.
  - 3D seismic data
  - US borehole images
  - drilling process data

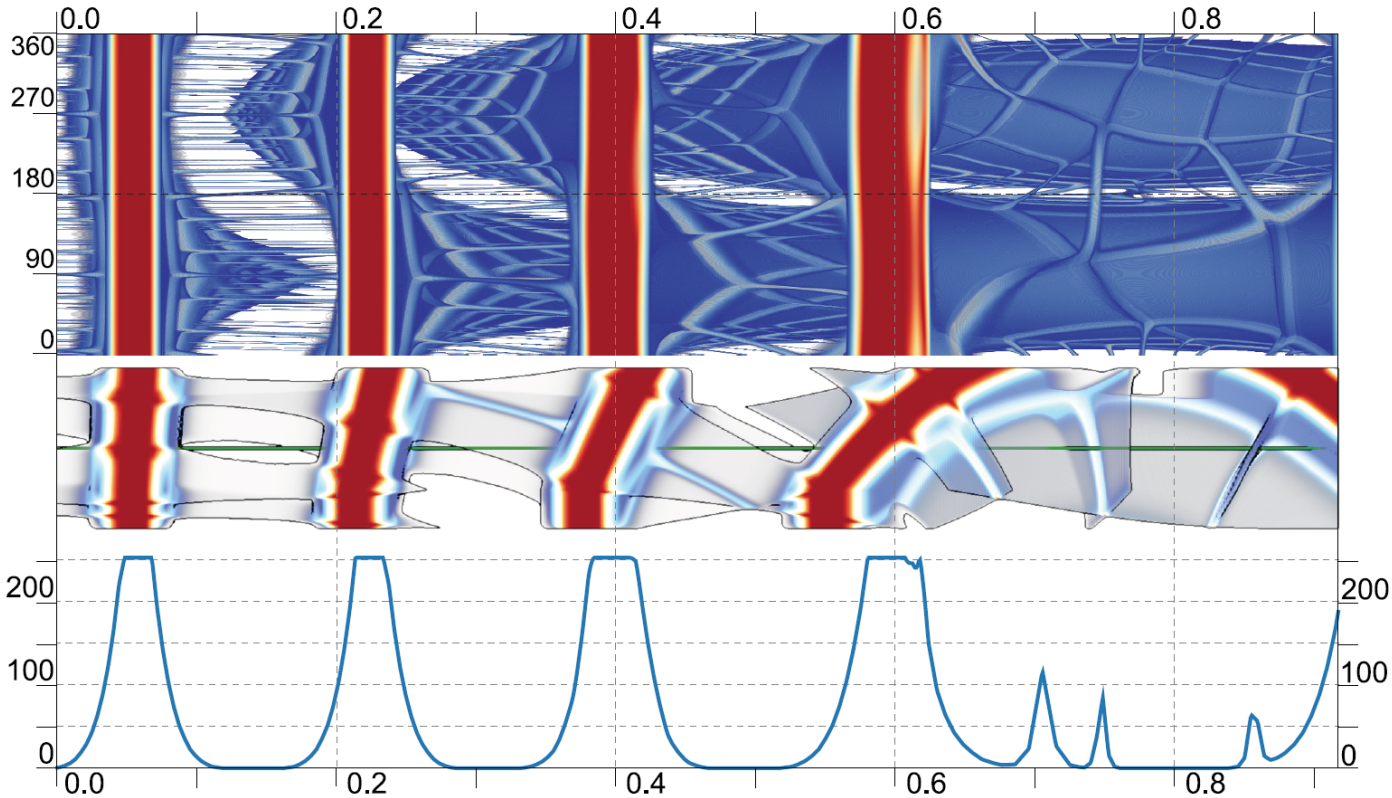




[«Curve-Centric Volume Reformation for Comparative Visualization» by Ove Daae Lampe *et al.*, TVCG 2009]

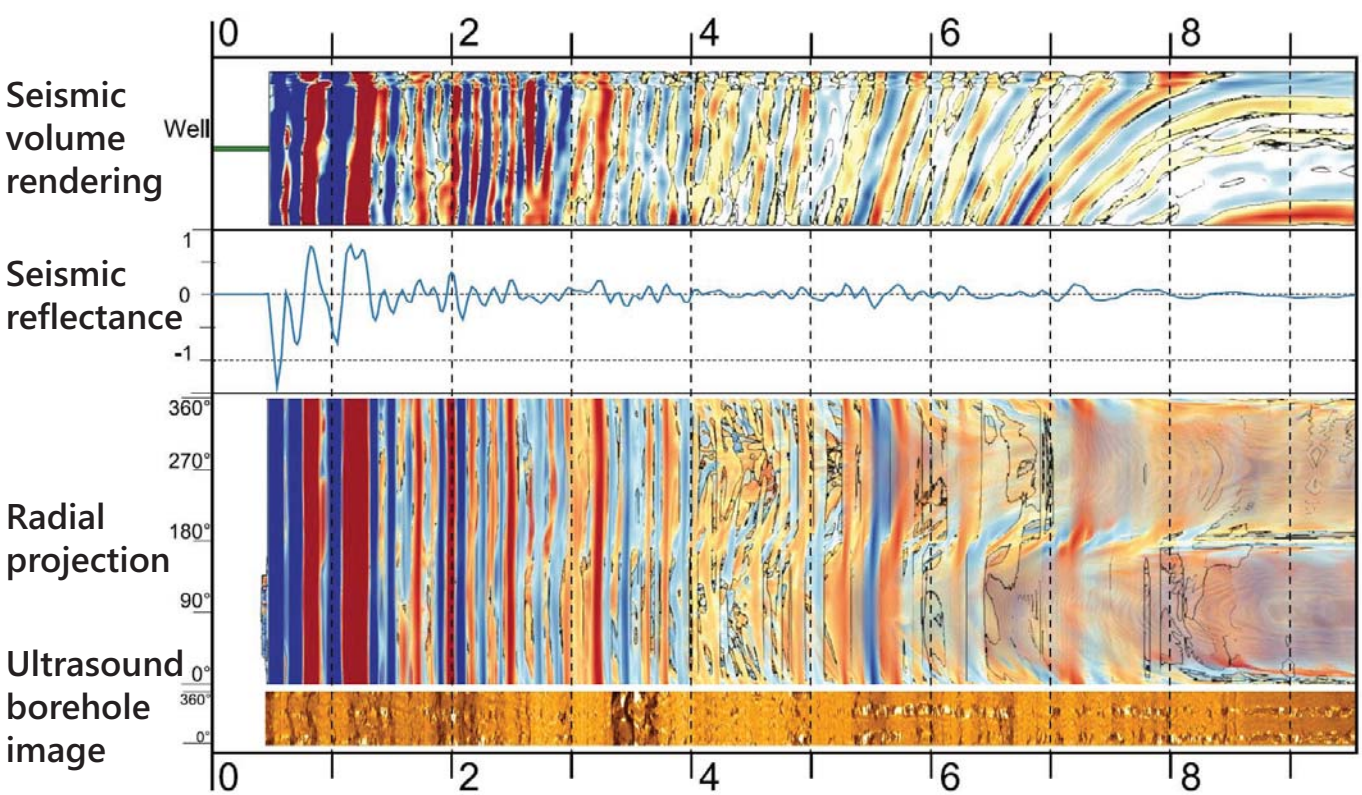
Semi-abstract CCVR-based visualization

Radial projection + volume rendering + density graph



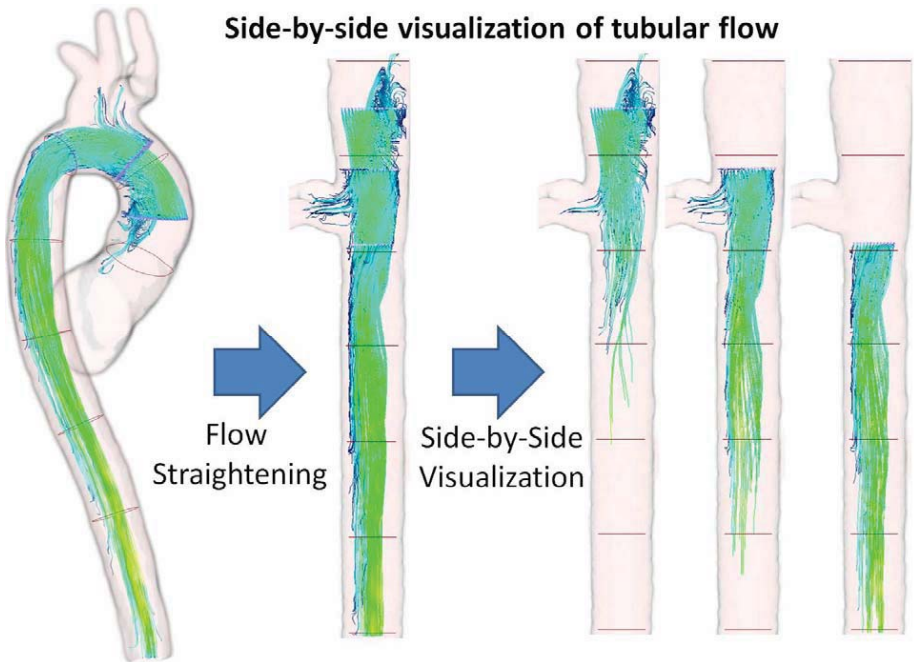
Semi-abstract CCVR-based visualization

Seismic VR & seismic reflectance & RadProj & UBI



Straightening tubular flow example

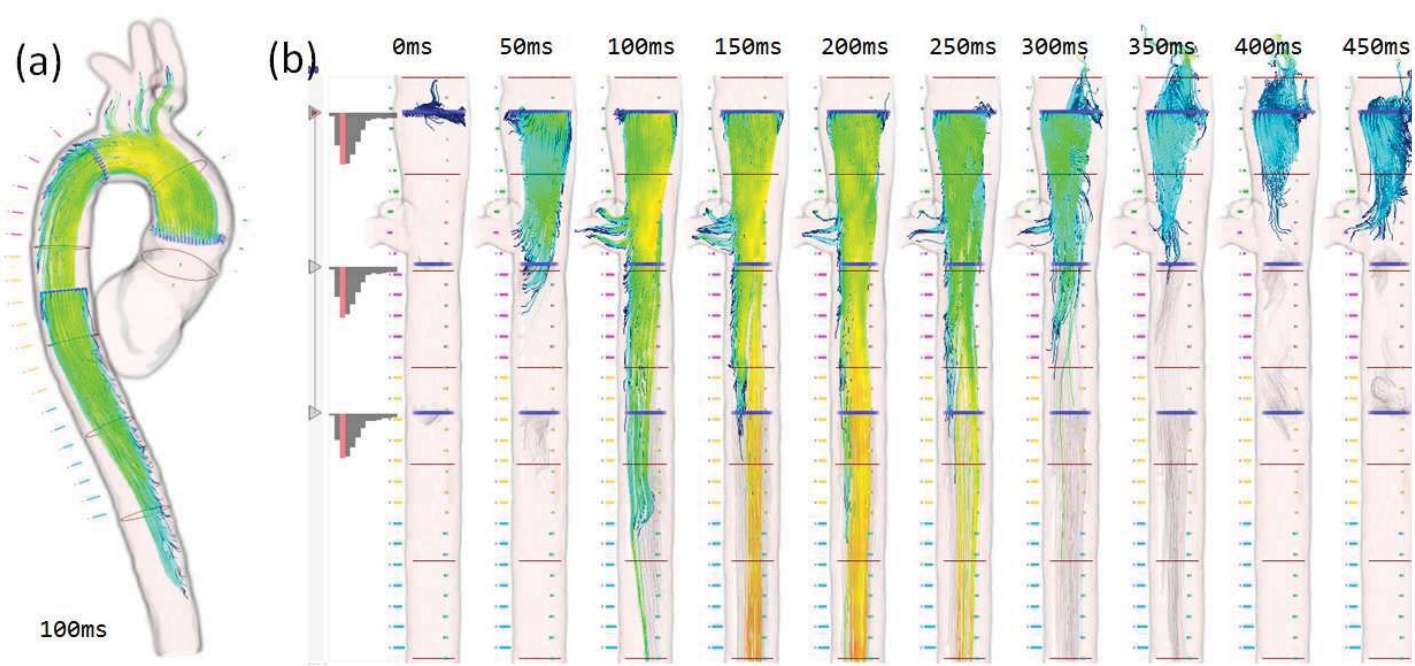
Reforming a 3D flow field such that a reference curve straightens



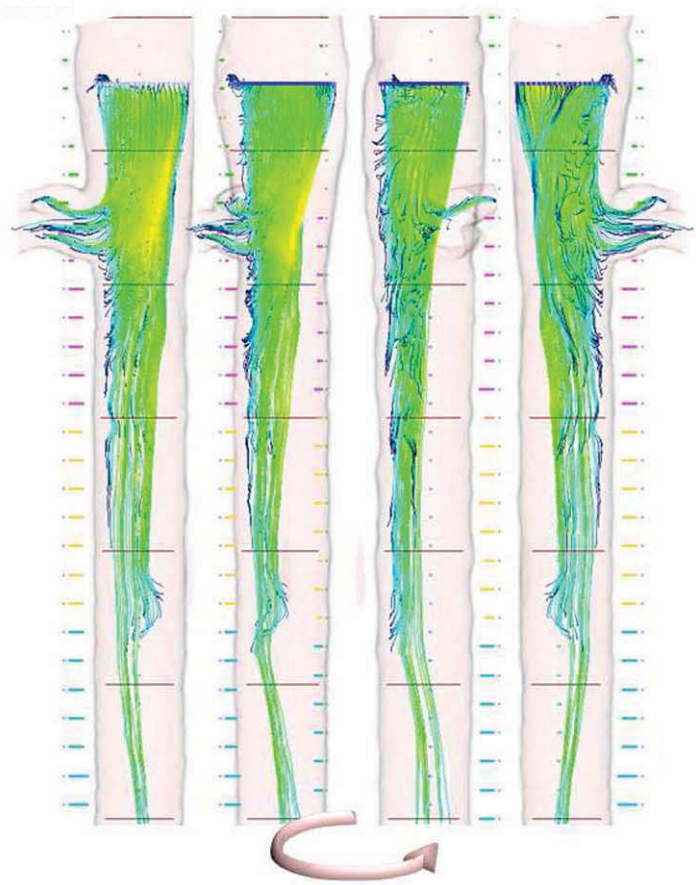
[«Straightening Tubular Flow for Side-by-Side Visualization» by Paolo Angelelli *& HH*, TVCG 2011]

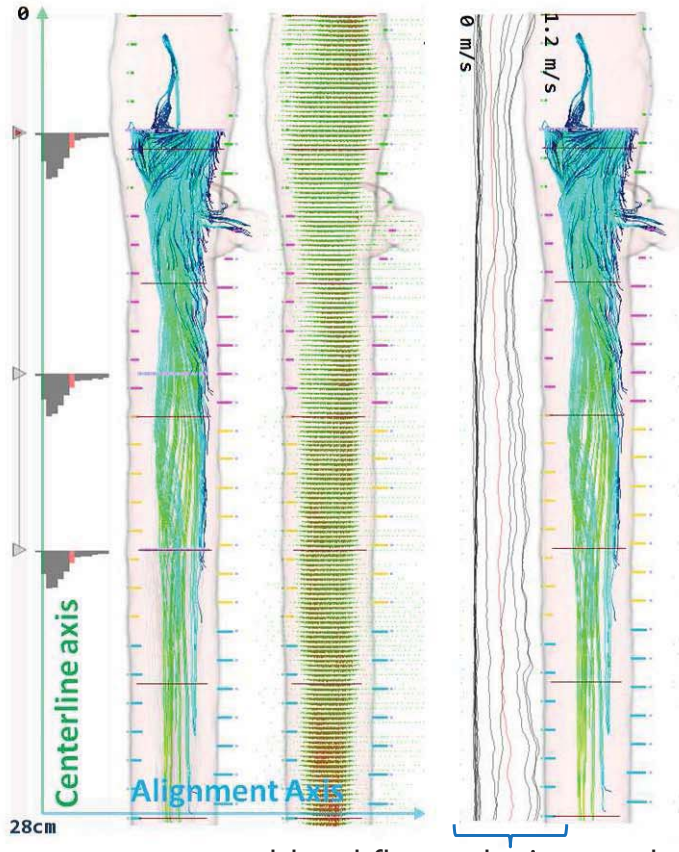
Semi-abstract straightened FlowVis

Side-by-side summary of time-dep. aortic blood flow



Semi-abstract straightened FlowVis

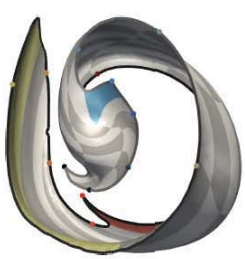




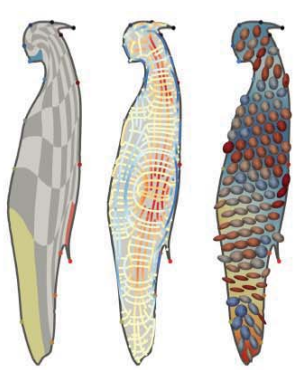
blood flow velocity graphs

Planar surface reformation example

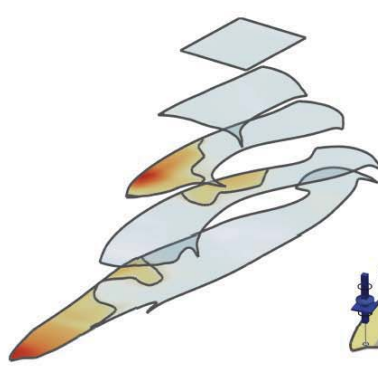
Reforming time surfaces from 3D to 2D to enable comparative visualization



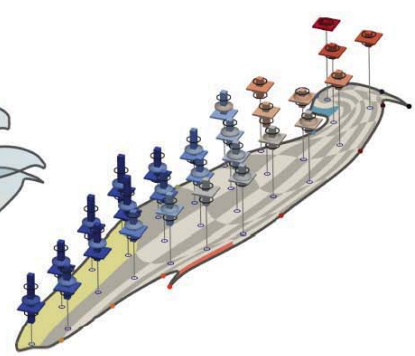
time surface in 3D



time surface in 2D (3*)



flattened time surfaces, stacked in 3D



statistical flow vis., with ref. to a flattened time surface in 3D

[unpublished, 2014]

Conclusions

New mappings can give new insight

- many historic examples exist

New mappings are not immediately intuitive

- some learning curve may be required
- literacy may possibly follow

Scientific data is getting information-rich

- giving more space to all this data may pay off

Acknowledgements

You!

We'd like to hire
- **1 PhD cand.**
- **1 PostDoc**

Collaborators:
Ove Daae Lampe,
Paolo Angelelli,
Andrea Brambilla,
Ivan Kolesar,
et al.

UNIVERSITY OF BERGEN

Upcoming Job Opportunities in Visualization at the University of Bergen

The visualization research group at the University of Bergen's Department of Informatics, Norway (UiB), is preparing the announcement of two open positions. We invite all potentially interested applicants to contact us directly for further details.

1 PhD Fellowship (4 years):

We are looking for a highly motivated individual with interest in the visualization of medical data. Suitable applicants should have a background in visualization, human-computer interaction, and/or computer graphics and very good programming skills. Since eligible candidates are required to have completed their Master's degree prior to the upcoming job announcement, we ask all interested candidates to contact us as soon as possible.

Contact: Prof. Stefan Bruckner (stefan.bruckner@uib.no)

1 Postdoctoral Fellowship (4 years):

We are looking for a promising scholar to fill a postdoctoral fellowship in visualization. This strategic position is not associated with a specific research project, but meant to strengthen the core visualization research activities in Bergen – considerable flexibility in terms of filling this appointment is envisioned. Applicants should have a completed PhD degree in visualization or a closely related subject, a strong publication record, a strong interest in high-quality research and also substantial interest in teaching of visualization and related topics.

Contact: Prof. Helwig Hauser (helwig.hauser@uib.no)

The University of Bergen

The University of Bergen, Norway (UiB), has approximately 14,500 enrolled students and 3,200 faculty and staff. Six faculties cover most of the traditional university disciplines. Within the faculties there are 40 different specialized departments, multi-disciplinary research centers, and institutes. The University is engaged in the European Union's Framework programs for research and technological development and has been designated as a European Research Infrastructure and a Research Training Site in several scientific fields. Since 1997 more than 500 European researchers (professors, senior researchers, post docs and PhD candidates) have visited Bergen on EU grants, making UiB one of the most international universities, setting out to attract both established and junior scientists to contribute to research teams and work in multidisciplinary research groups. **Further information:** http://www.uib.no/en

The Visualization Group

The Department of Informatics at UiB is a dynamic international environment. The visualization research group was established in 2007 and focuses on new solutions for the effective and efficient visualization of large and complex data from measurements (e.g., from medical imaging or from seismic/sonar sensors), computational simulation (e.g., from computational fluid dynamics), or from analytic modeling (e.g., in the form of differential equations) for the purpose of data exploration, analysis, and presentation. Despite being a still relatively young group, the recent ten-year evaluation of all 62 informatics research groups in Norway conducted by an international evaluation panel on behalf of Norway's Research Council, found that the group's "(...) accomplishments made so far are excellent." and concluded with an overall assessment of "very good to excellent". **Further information:** http://www.ii.uib.no/vis

The City of Bergen

Bergen is Norway's second largest city with over 260,000 inhabitants and is located in the county of Hordaland on the south-western coast of Norway. Known as the "gateway to the fjords", Bergen is surrounded by spectacular scenery. As one of the offices of the Hanseatic League, Bergen was for several hundred years the center of prosperous trade between Norway and the rest of Europe. Today, Bergen is a lively and vibrant city with an international flair. Every semester the city with its university and colleges are proud and enthusiastic to welcome students from all over the world. Bergen is one of the most popular student cities in Scandinavia with 30,000 students in many different educational institutions. Its international atmosphere, together with the fact that Norway has been voted #1 in standard of living by the UNDP's Human Development Index for several years, make Bergen a very attractive place for life and study. **Further information:** http://www.visitbergen.com/en