浙江大学 ZHEJIANG UNIVERSITY

2019 ZJU
International Summer School on Visual Analytics

Spatial Data Visualization

Yingcai Wu

Professor
State Key Lab of CAD&CG
Email: ycwu@cad.zju.edu.cn

SciVis

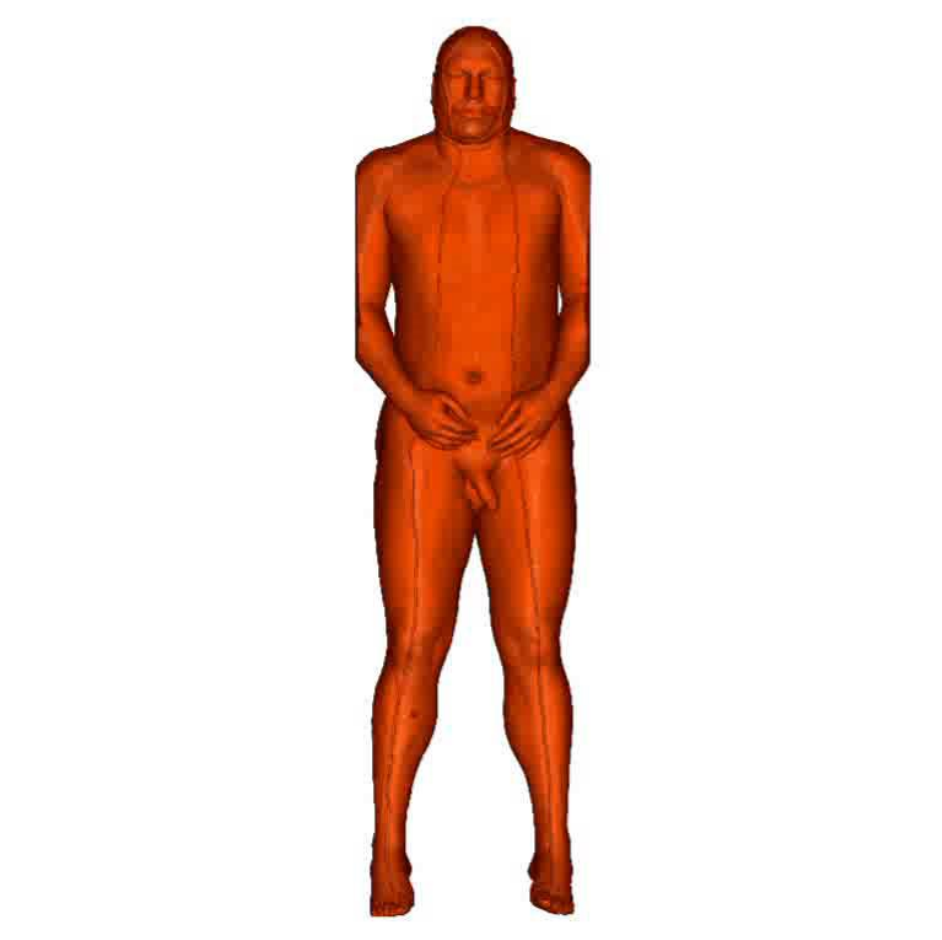
- Distributed and Collaborative Visualization
- Flow Visualization
- Information Visualization
- Isosurfaces and Surface extraction
- Large Data Visualization
- Multi-Resolution Techniques
- Multimodal Visualization
- Novel Mathematics for Visualization
- Parallel Visualization and Graphics Clusters
- Point-Based Visualization
- Security and Network Intrusion visualization
- Software Visualization
- Terrain Visualization
- Time Critical Visualization
- Time-Varying Data

分布式和协同可视化流程可视化
信息可视化
等值面和表面提取
•大数据可视化
•多分辨率技术
•多模态可视化
•可视化的新数学
并行可视化和图形集群•
•基于点的可视化
•安全和网络入侵可视化
•软件可视化
•地形可视化
•时间关键可视化
•时变数据

- Uncertainty Visualization
- Unstructured Grids
- Usability and Human Factors in Visualization
- Vector/Tensor Visualization
- Virtual Environments
- Visual Knowledge Discovery
- Visualization Systems
- Visualization in Earth, Space, and Environmental Sciences
- Visualization in Physical Sciences, Life Sciences and Engineering
- Visualization in Social and Information Sciences
- Visualization over Networks, Grids, and the Internet
- Volume Visualization

不确定性可视化
•非结构化网格
•可视化中的可用性和人为因素
•矢量/张量可视化•
虚拟环境
视觉知识发现
可视化系统
地球，空间和环境科学的可视化
物理科学，
生命科学和工程学的可视化
社会和信息科学的可视化
网络，网格和互联网上的可视化
•体积可视化

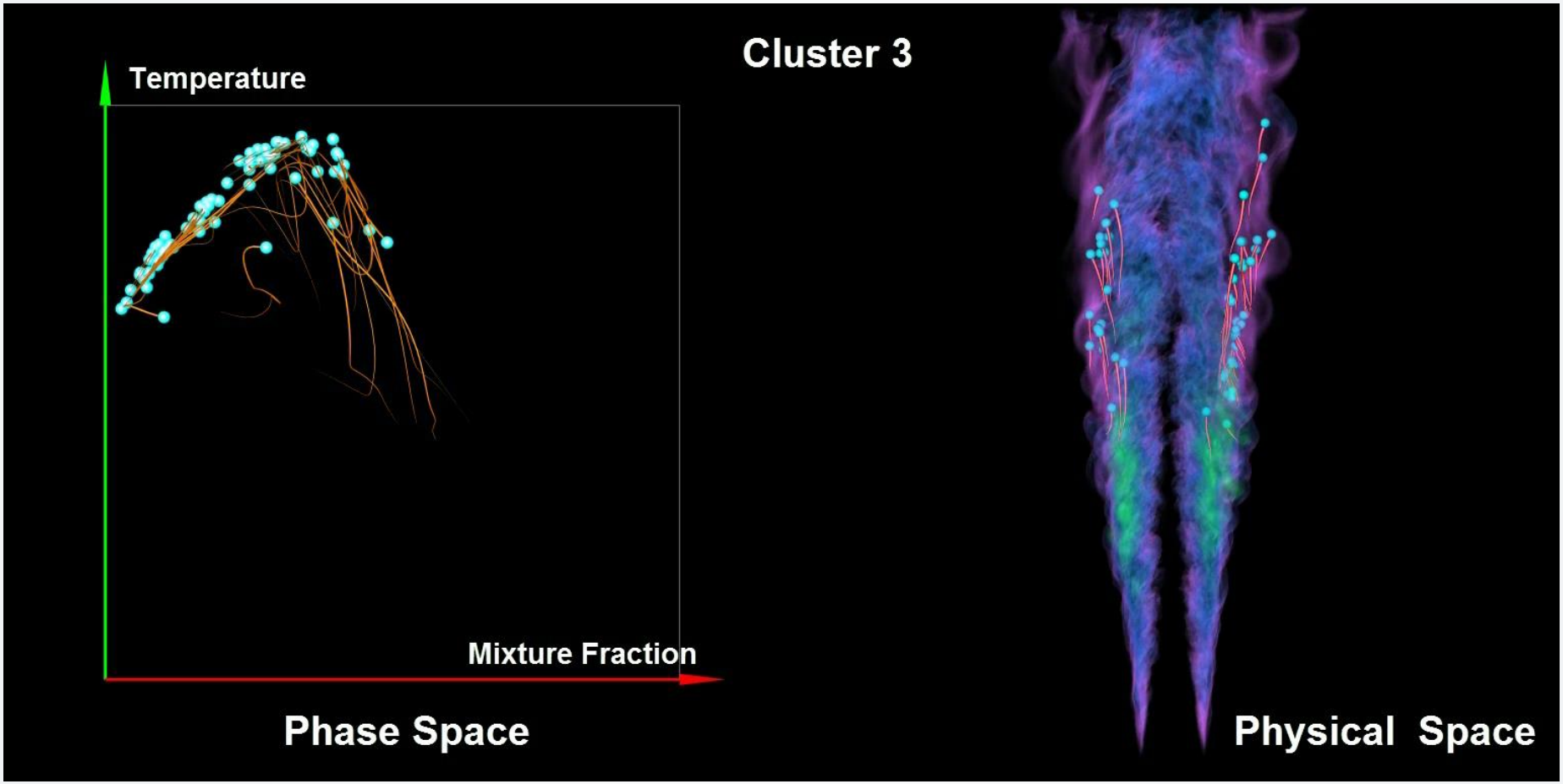
SciVis — Revealing Structures and Features



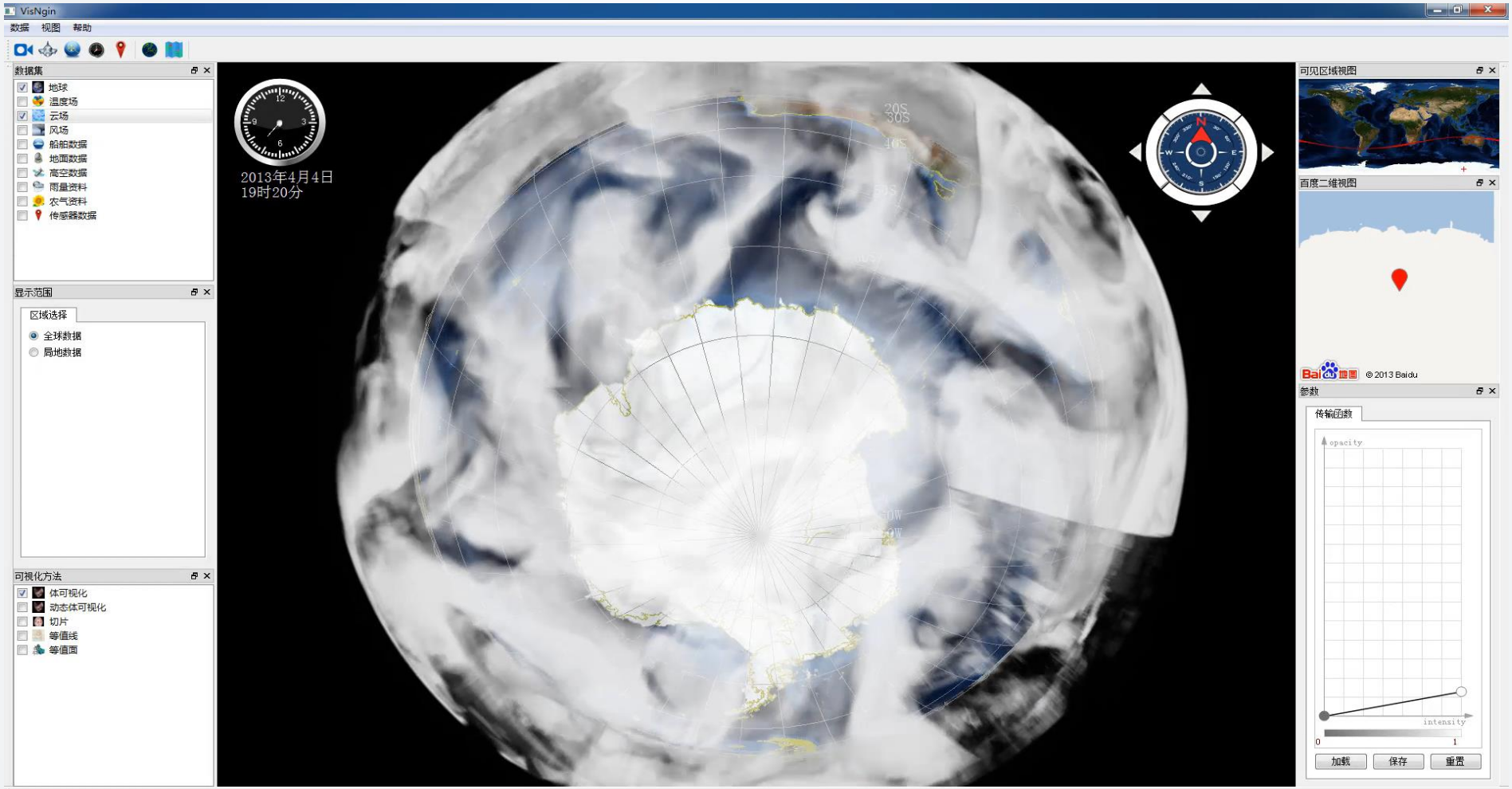
SciVis — Presenting Evolution Laws

SciVis — Presenting Evolution Laws

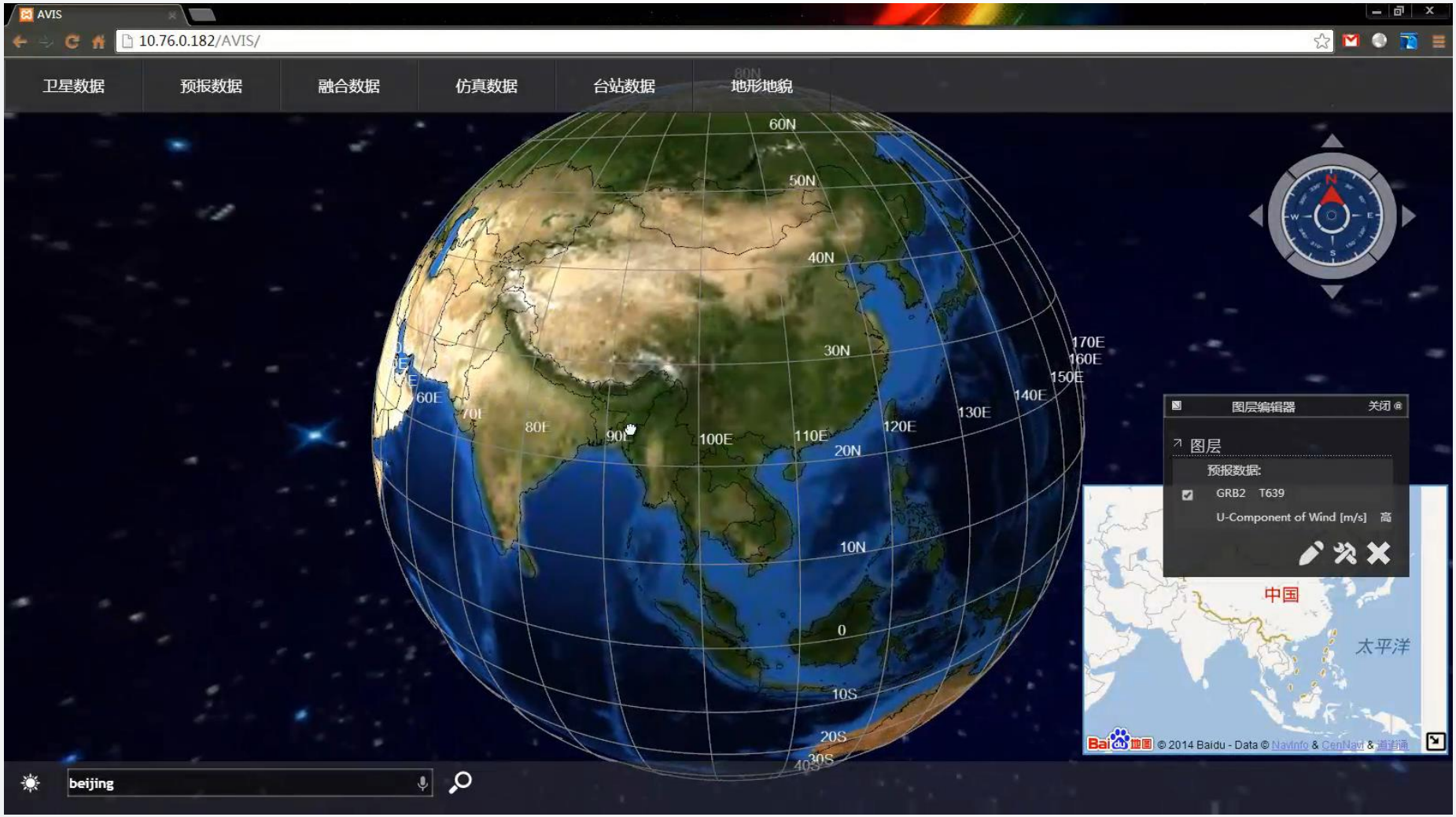
SciVis — Simulation and Visualization



3D Atmosphere Visualization



3D Atmosphere Visualization



1D数据可视化
2D数据可视化
3D体积可视化
矢量场和张量场
医学数据可视化

OUTLINE

1. 1D Data Visualization
2. 2D Data Visualization
3. 3D Volume Visualization
4. Vector Field and Tensor Field
5. Medical Data Visualization

Spatial Data

- What is spatial data?
  - Spatial data is usually stored as coordinates and topology.

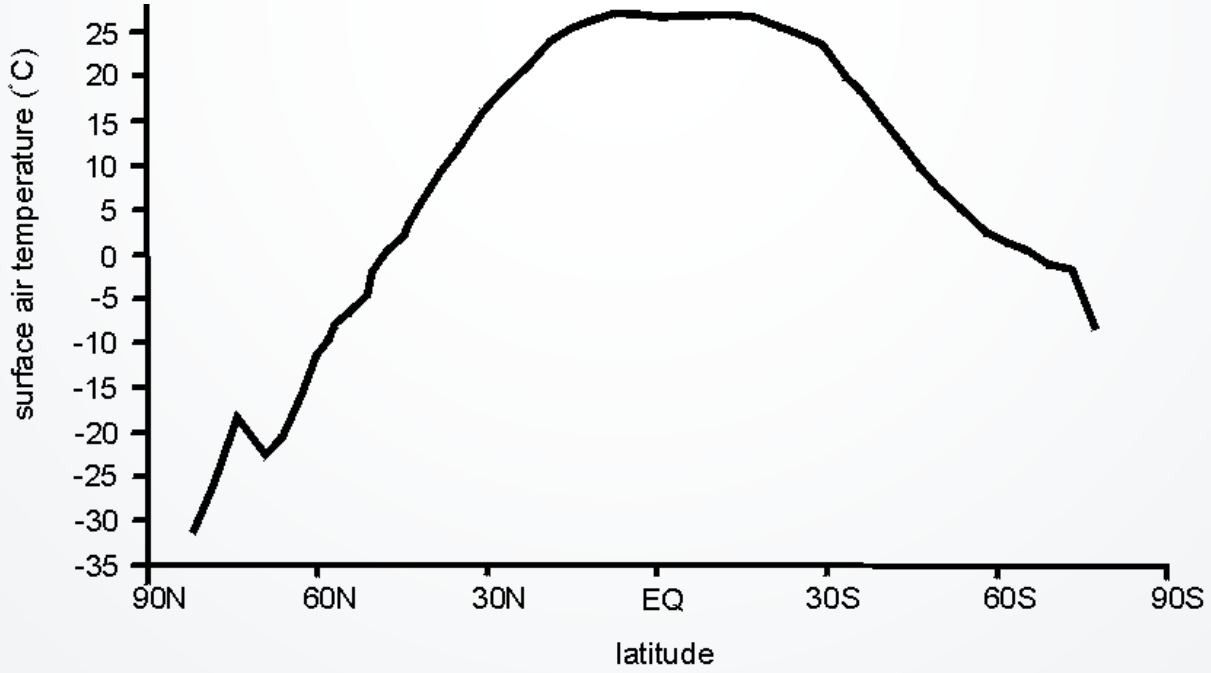
- Spatial data can be
  - 1D data, 2D data, 3D data and high dimensional data
  - scalar data, vector field data and tensor field data
  - medical data, atmosphere data, geographical data and volume data

OUTLINE

1. 1D Data Visualization
2. 2D Data Visualization
3. 3D Volume Visualization
4. Vector Field and Tensor Field
5. Medical Data Visualization

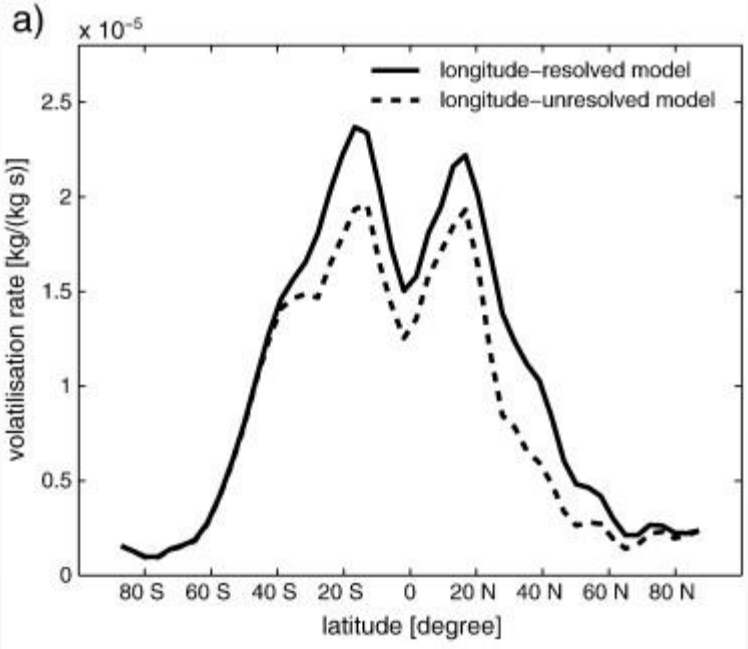
1D Data

- Sampling data obtained along a certain path in the space
- Examples
  - Soil depth obtained in soil drilling
  - Air pressure along a certain longitude



Visualization

- Statistical charts are widely used for 1D spatial data visualization.
- Usually the spatial information is encoded as variable, and codomain is the measured values.



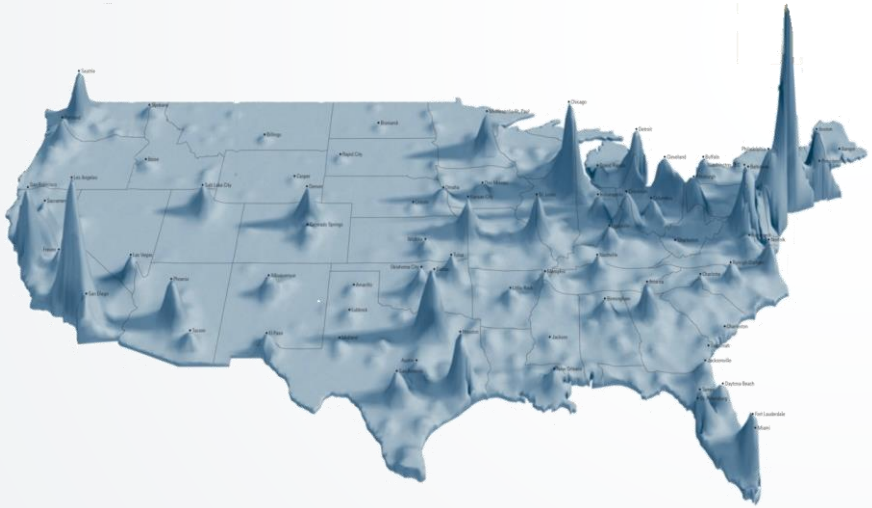
Air–sea exchange
latitude VS. water volatilisation rate

OUTLINE

1. 1D Data Visualization
2. 2D Data Visualization
3. 3D Volume Visualization
4. Vector Field and Tensor Field
5. Medical Data Visualization

2D Data

- Medical data
- Geographical data

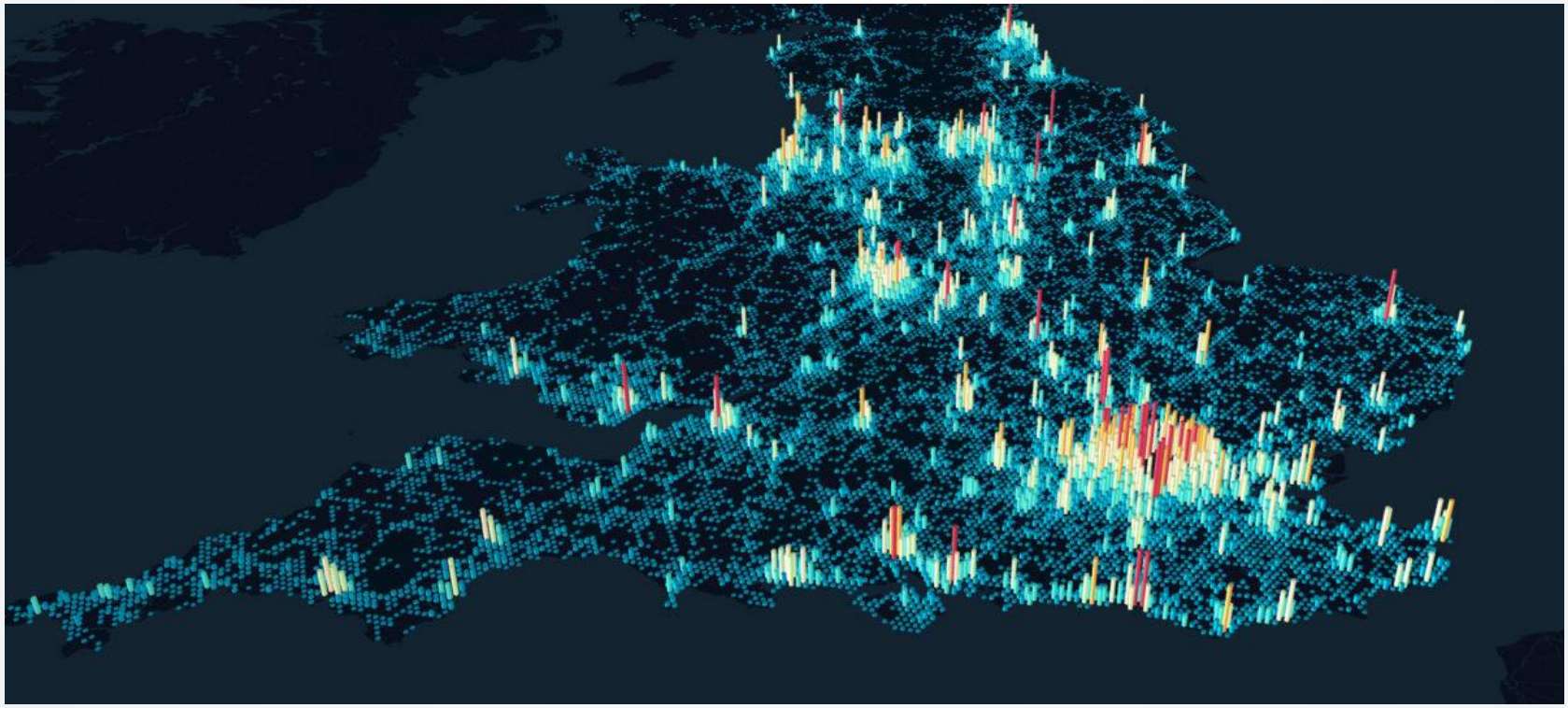


American population map

The first x-ray image

Heightmap

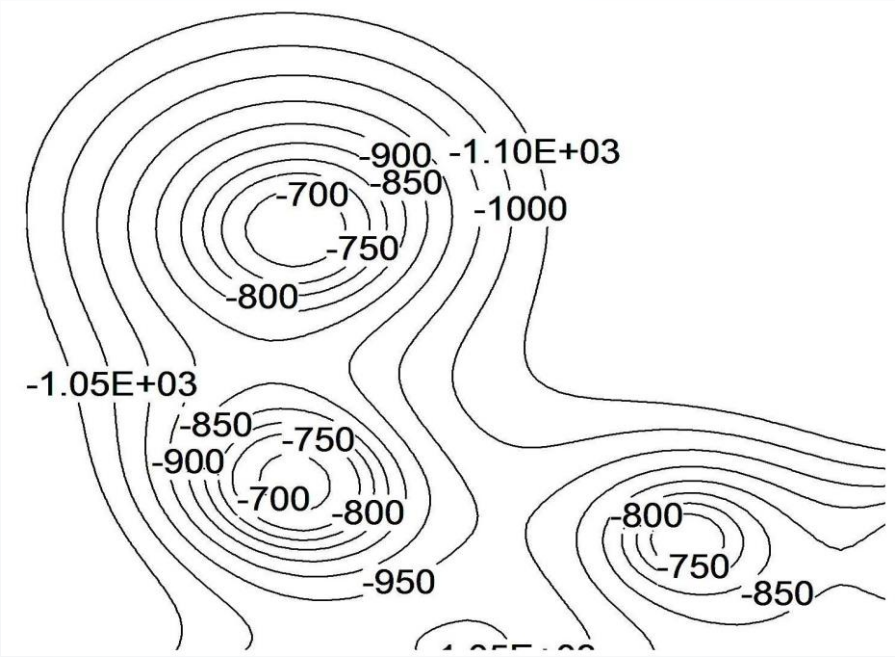
- Height is used to encode measured values

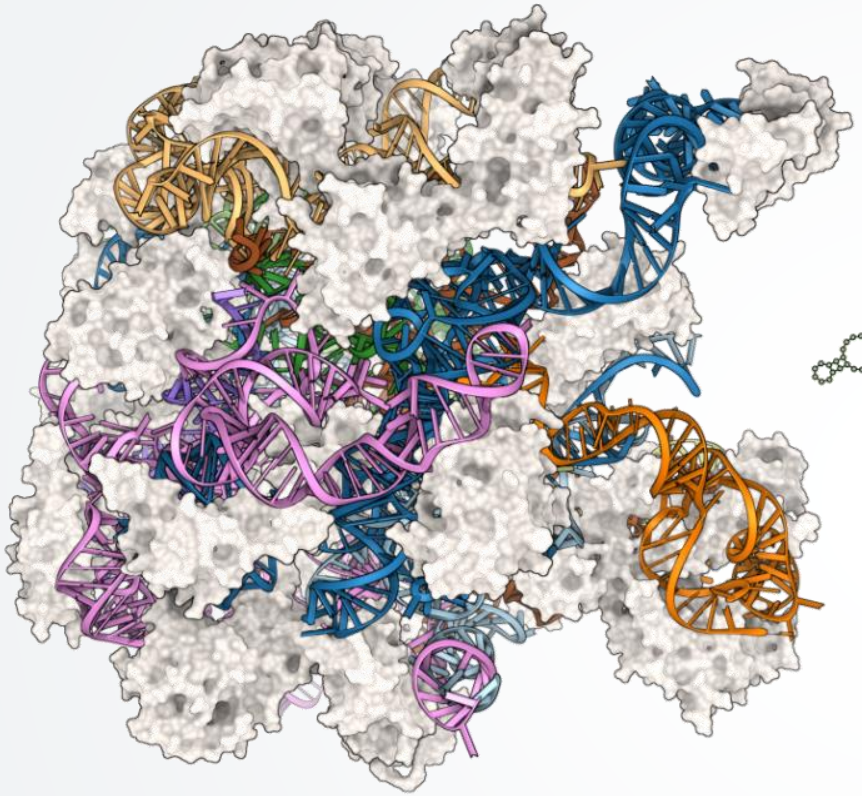


Personal injury road accidents in GB from 1979

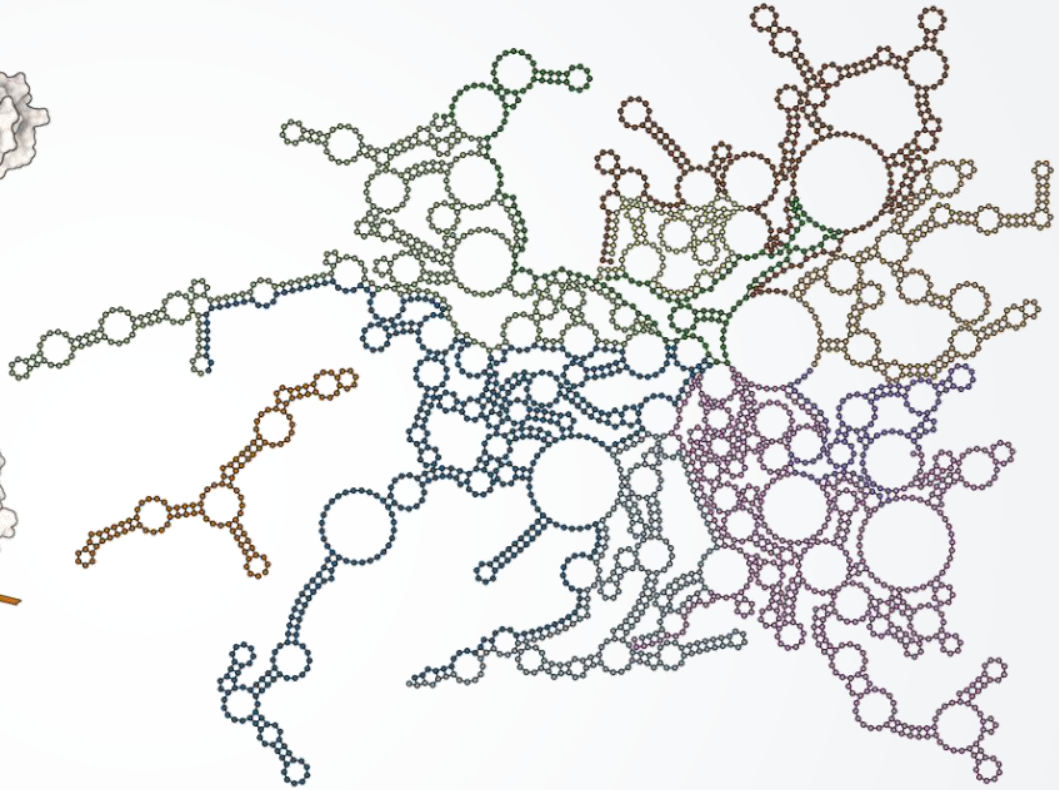
Isocontours

- A level set of curve where the function takes on a given constant value
  - The line formed by a same function value
  - Iso: equal
  - Contour: line



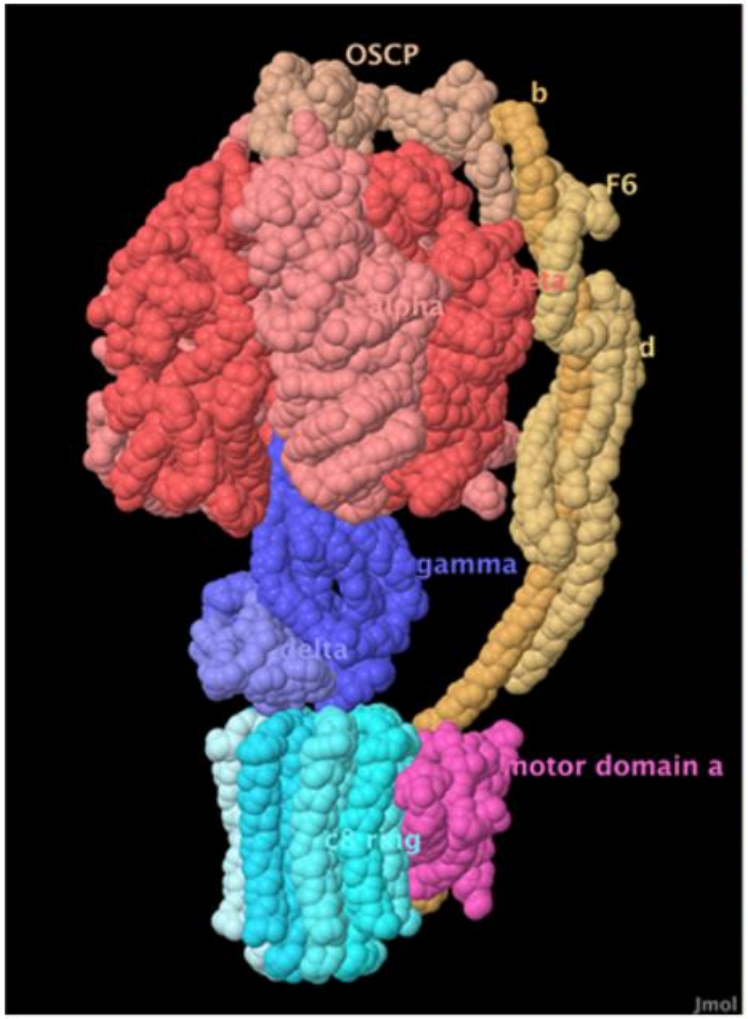


ribosomal RNA-3D model



ribosomal RNA-2D model

Lindow, Norbert, et al. "Interactive Visualization of RNA and DNA Structures." IEEE transactions on visualization and computer graphics (2018).

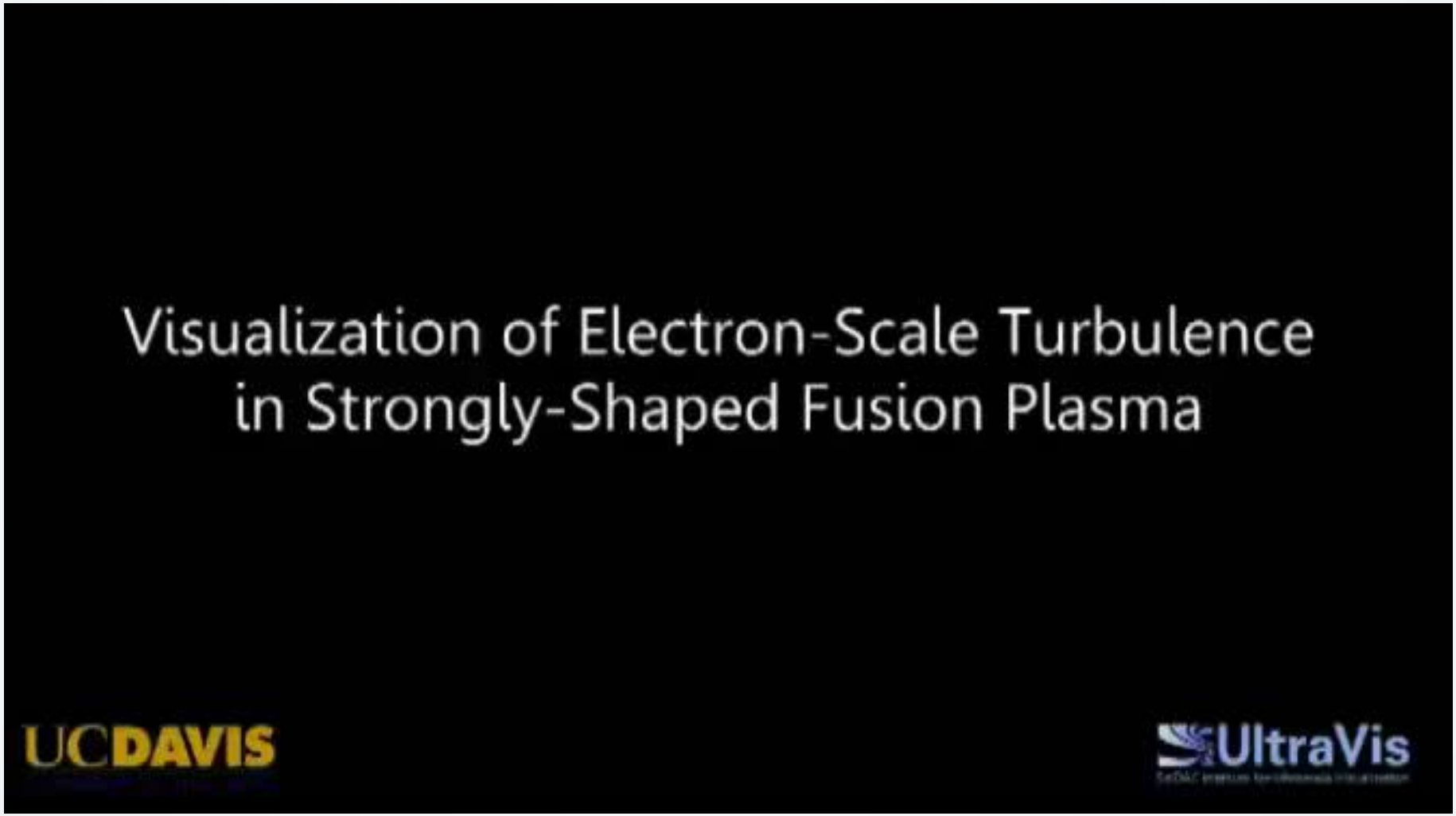


ATP synthase

molecular processes in insulin signaling

Kouřil, David, et al. "Labels on Levels: Labeling of Multi-Scale Multi-Instance and Crowded 3D Biological Environments." IEEE transactions on visualization and computer graphics(2018).

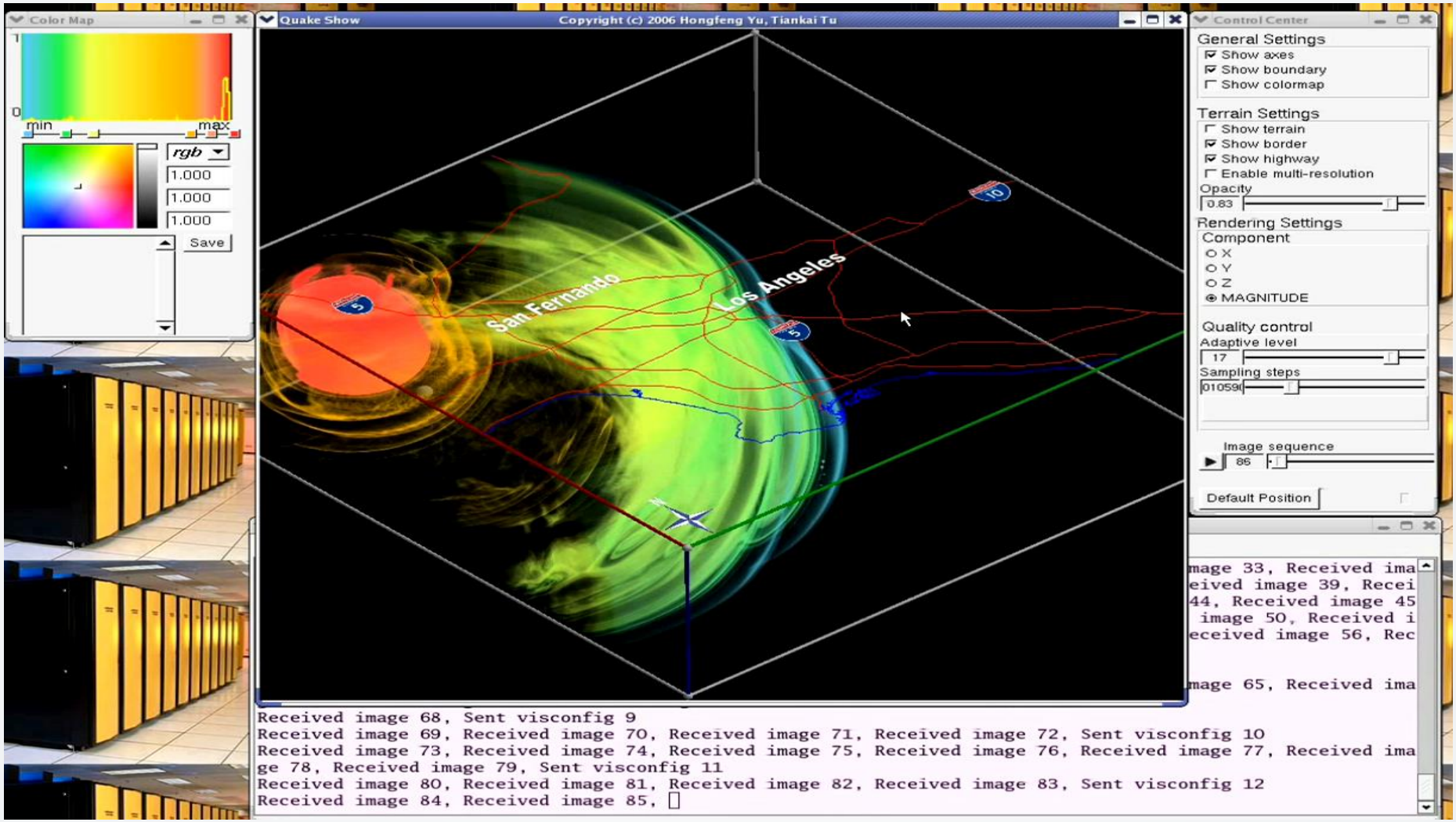
Iso-contours

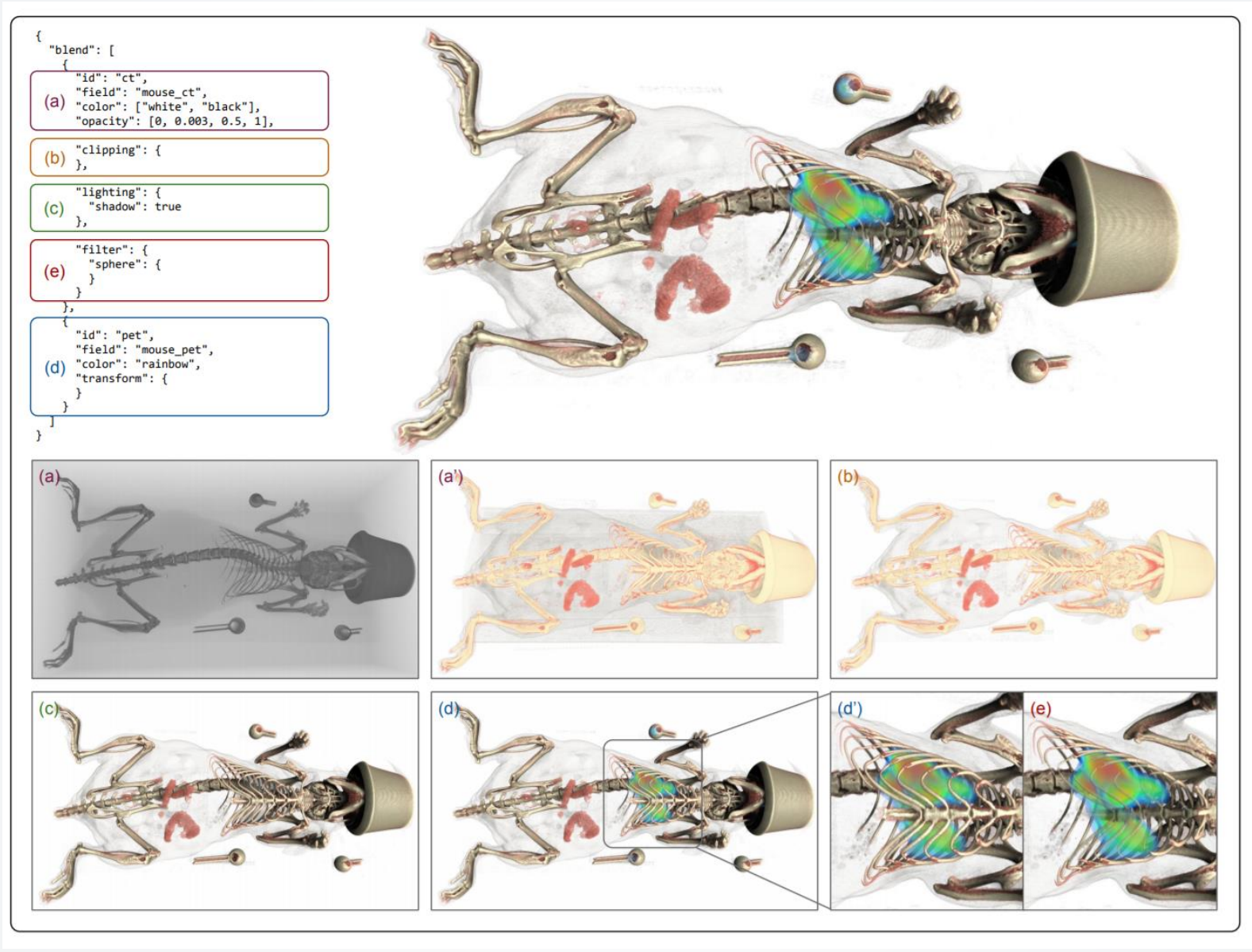


OUTLINE

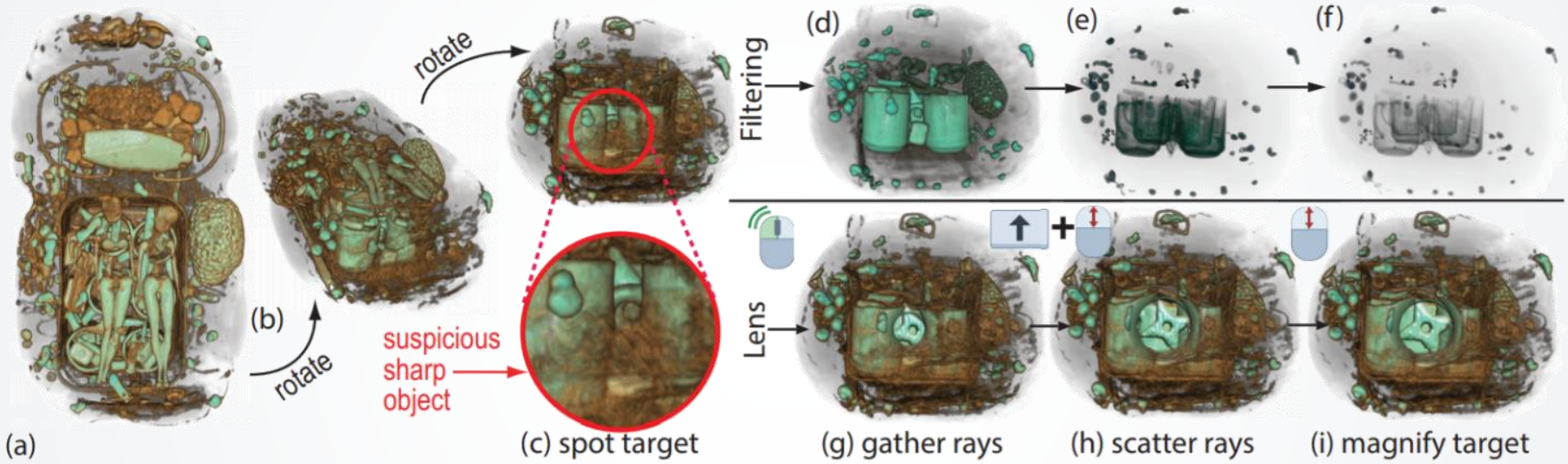
1. 1D Data Visualization
2. 2D Data Visualization
3. 3D Volume Visualization
4. Vector Field and Tensor Field
5. Medical Data Visualization

Direct Volume Tendering





Shih, Min, Charles Rozhon, and Kwan-Liu Ma. "A Declarative Grammar of Flexible Volume Visualization Pipelines." IEEE transactions on visualization and computer graphics (2018).



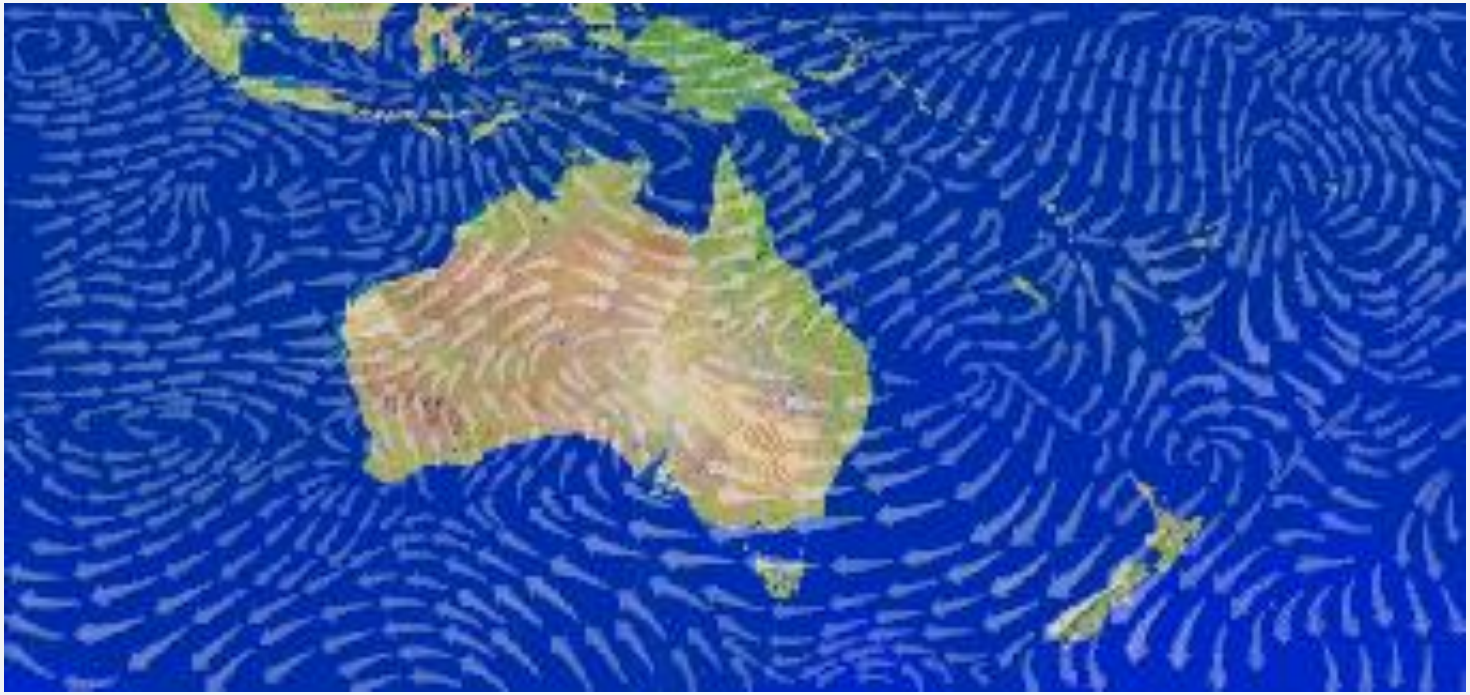
Traoré, Michael, Christophe Hurter, and Alexandru Telea. "Interactive obstruction-free lensing for volumetric data visualization." IEEE transactions on visualization and computer graphics (2018).

OUTLINE

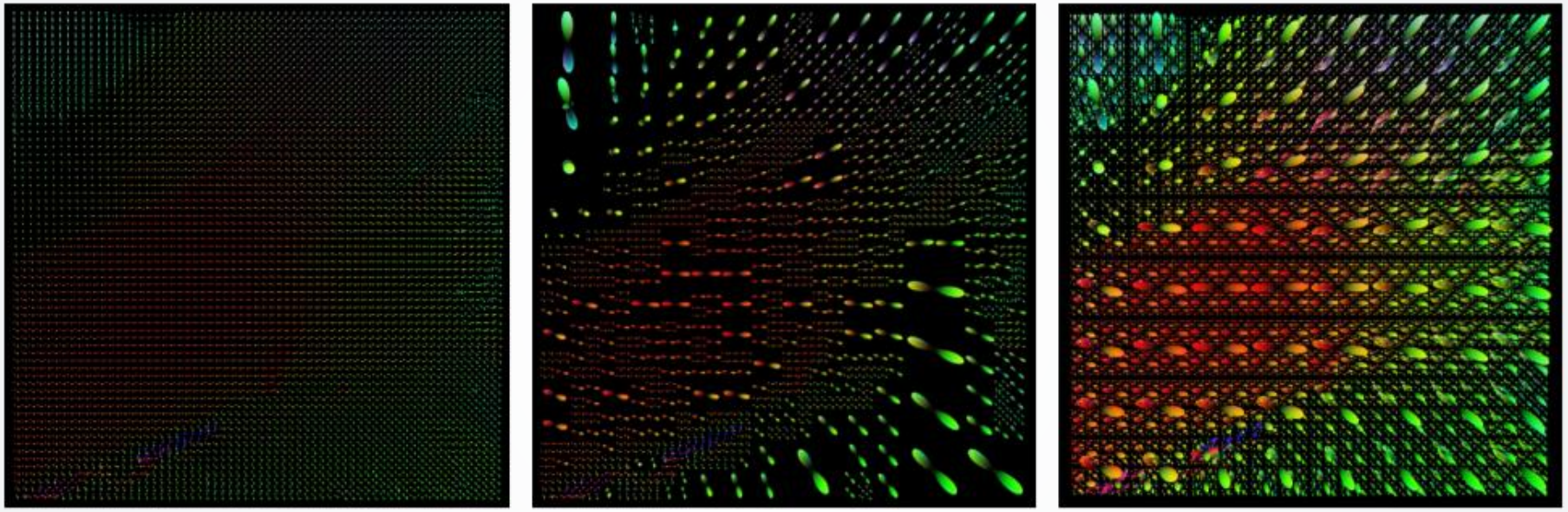
1. 1D Data Visualization
2. 2D Data Visualization
3. 3D Volume Visualization
4. Vector Field and Tensor Field
5. Medical Data Visualization

Vector Visualization

- Data set is given by a vector component and its magnitude
- General Goal:
  - Display the field's directional information
  - Convey patterns



Vector Visualization



(a) Spherical harmonics (b) Automatic clustering (c) Comparing view

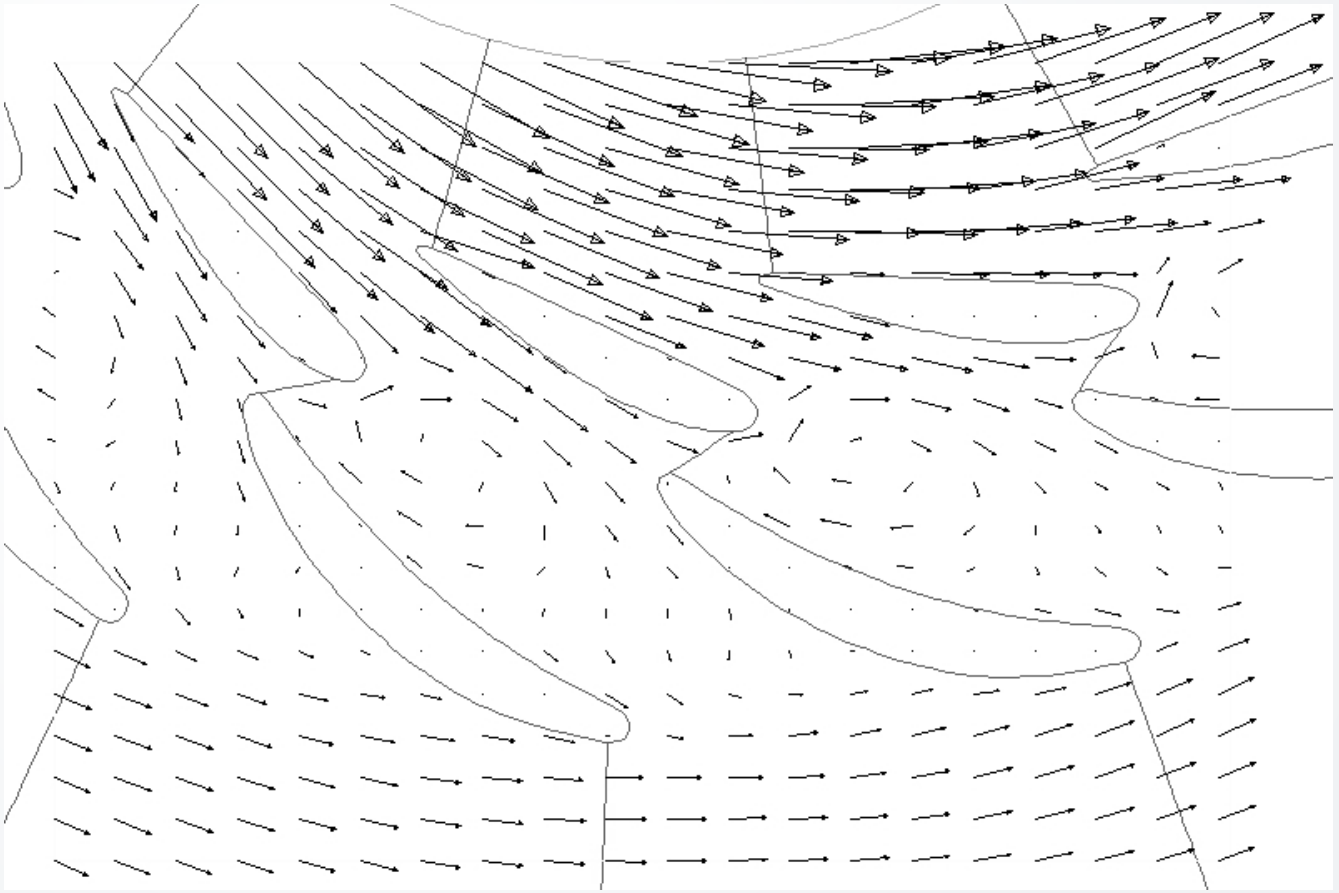
Hänel, Claudia, et al. "Interactive level-of-detail visualization of 3D-polarized light imaging data using spherical harmonics." Eurographics Conference on Visualization. 2017.

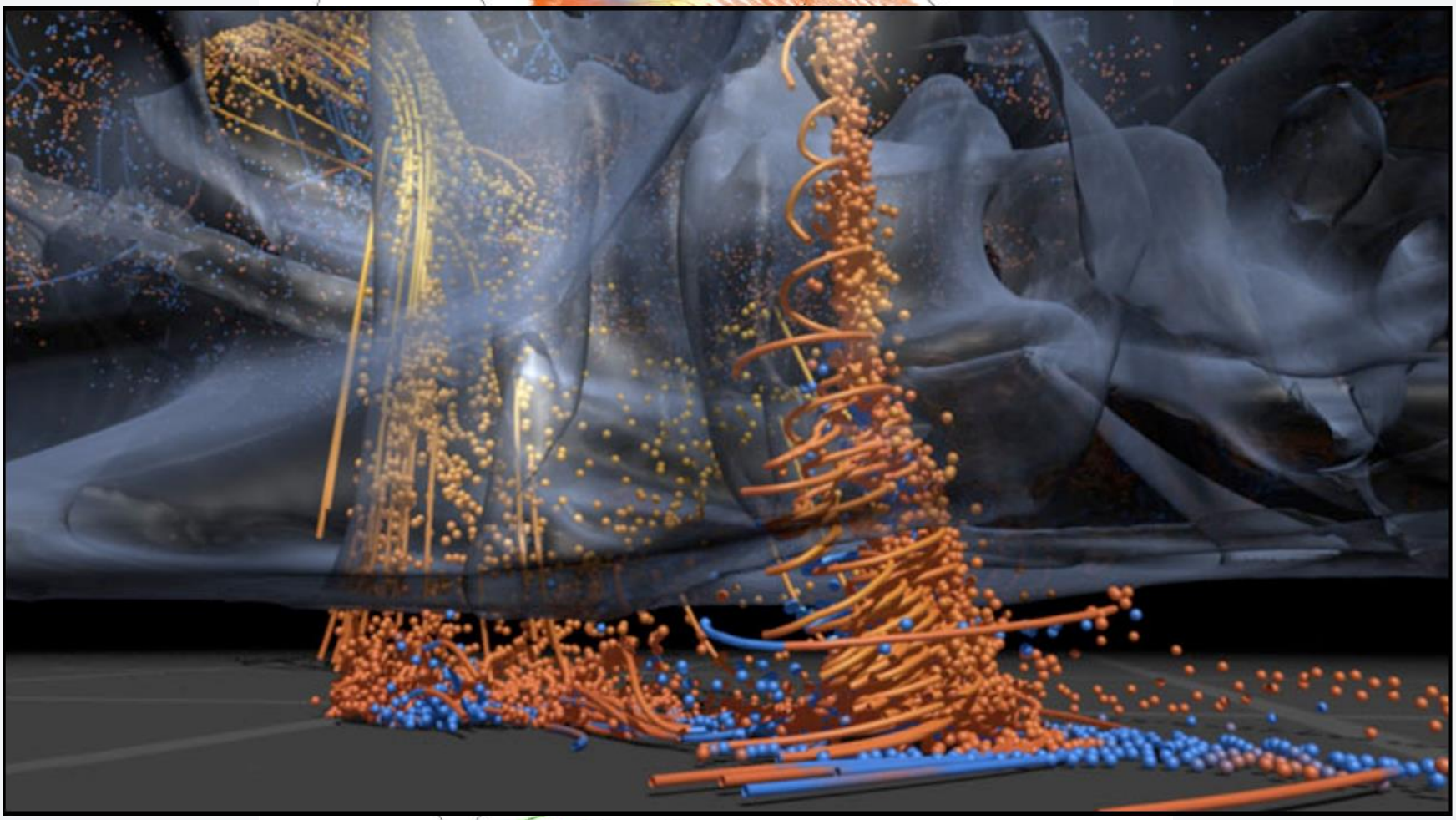
Vector Visualization Methods

- Direct visualization
- Streamline-based methods
- Texture-based and dense methods
- Topology*
- Feature extraction*
- Coherent structures*

Direct Visualization

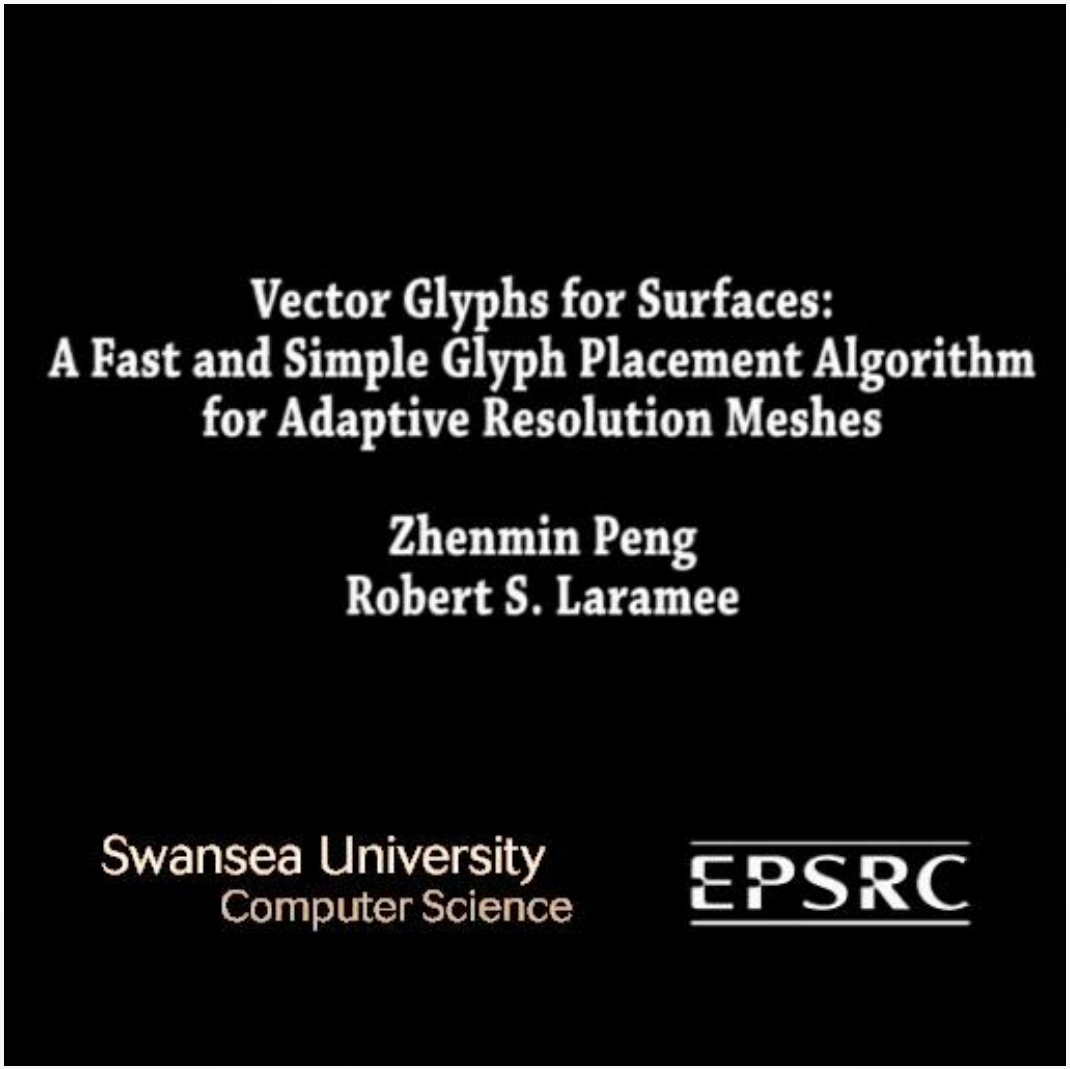
- Glyph
  - Hedge hogs
  - Arrows
  - Oriented glyphs





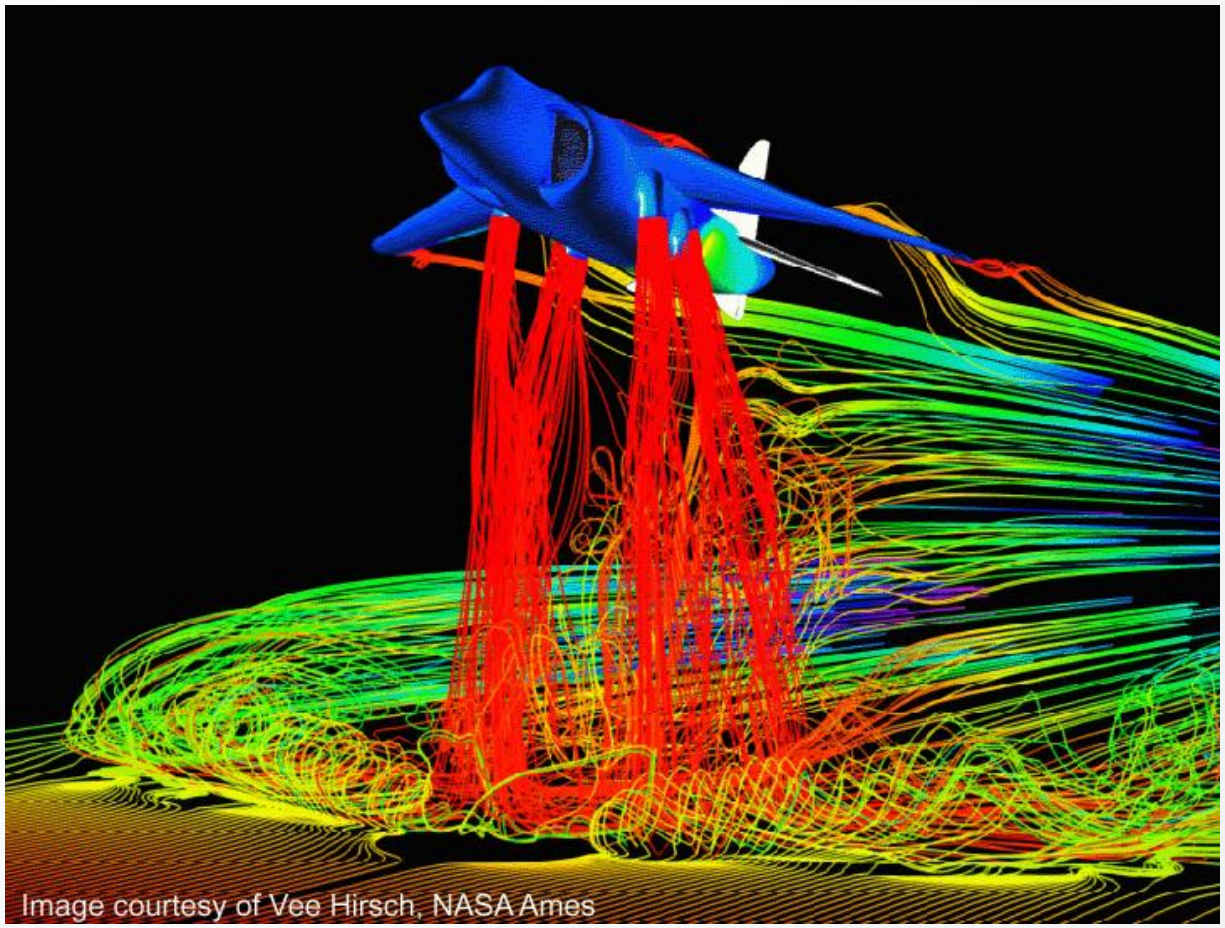
Dan Alcantara

Hedge Hogs


Vector Glyphs for Surfaces:
A Fast and Simple Glyph Placement Algorithm
for Adaptive Resolution Meshes
Zhenmin Peng
Robert S. Laramee
Swansea University
Computer Science
EPSRC

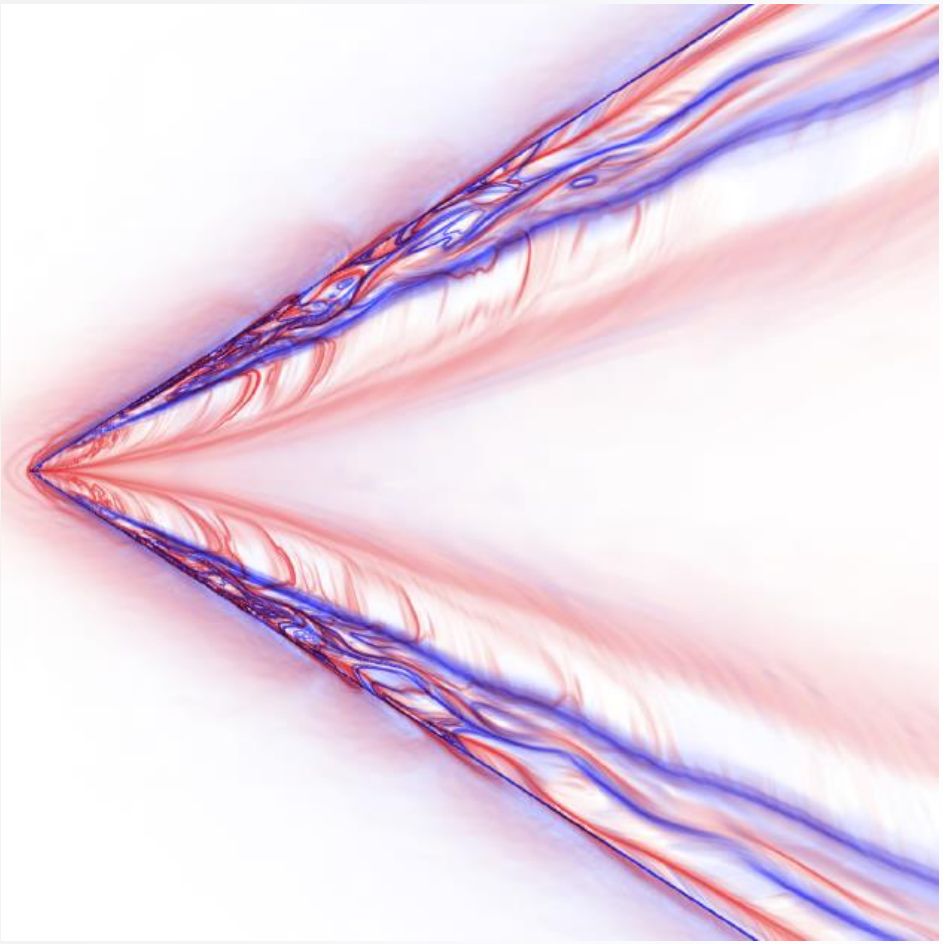
Streamline-based Methods

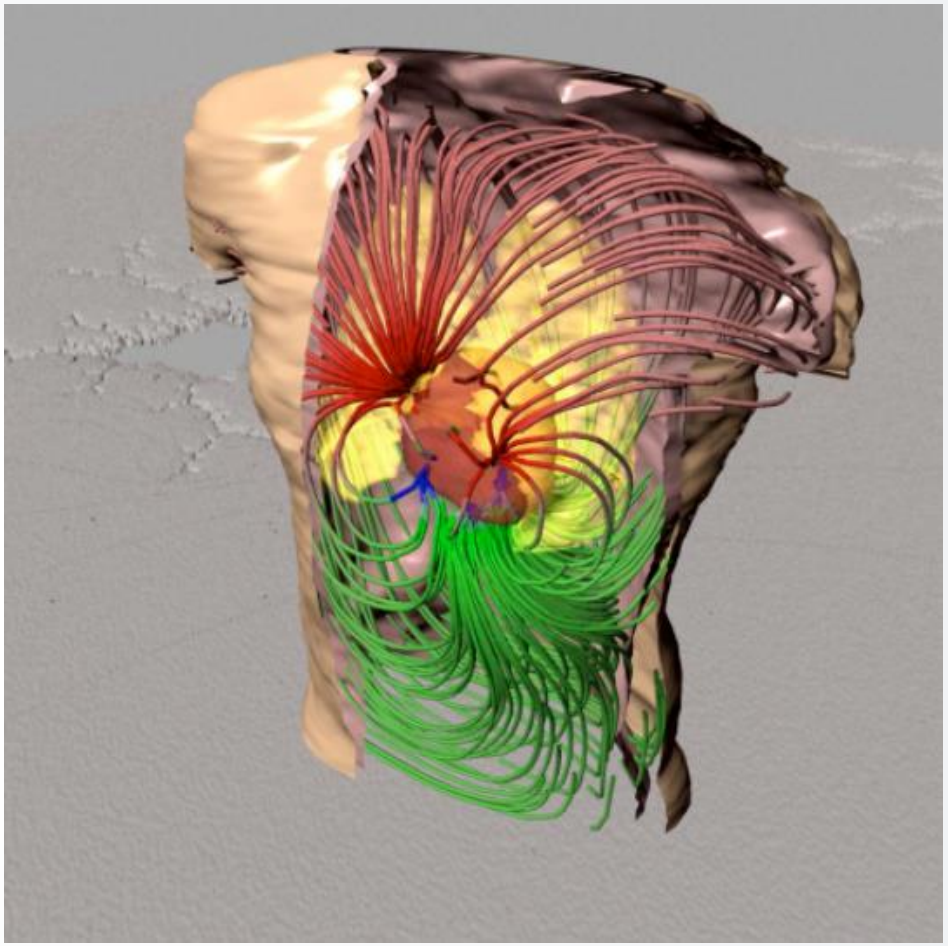
- Streamline, pathline, timeline and streakline
- Ribbons
- Tubes and bubbles
- Stream surfaces
- Stream volumes



Definitions*

- Streamline
  - Trajectory of massless particle in a steady flow or path of a particle in a frozen unsteady field (non-physical)
- Pathline
  - Trajectory of massless particle in an unsteady flow
- Timeline
  - Connect particles released simultaneously at discrete time-steps
- Streakline
  - Continuously inject particles at a point in the flow and connect the particles

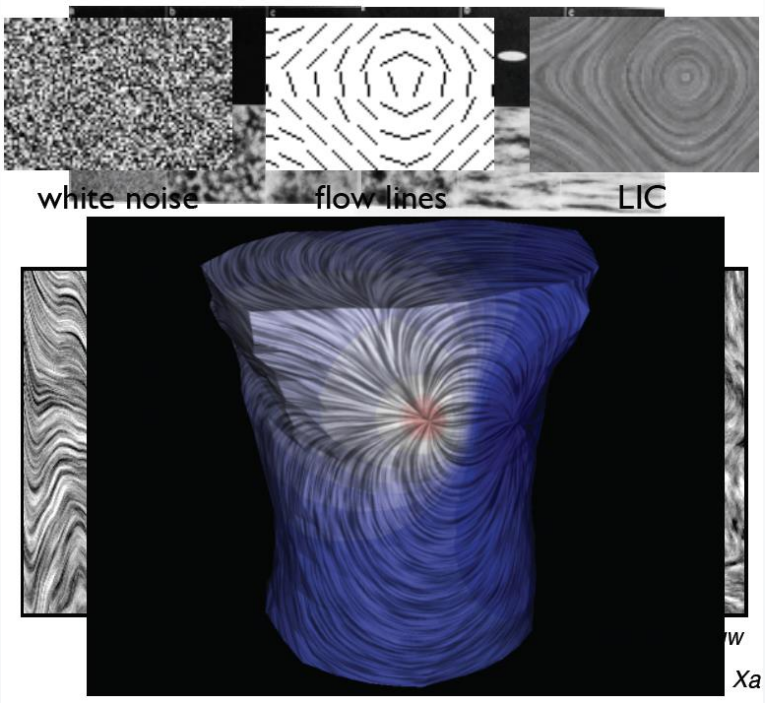


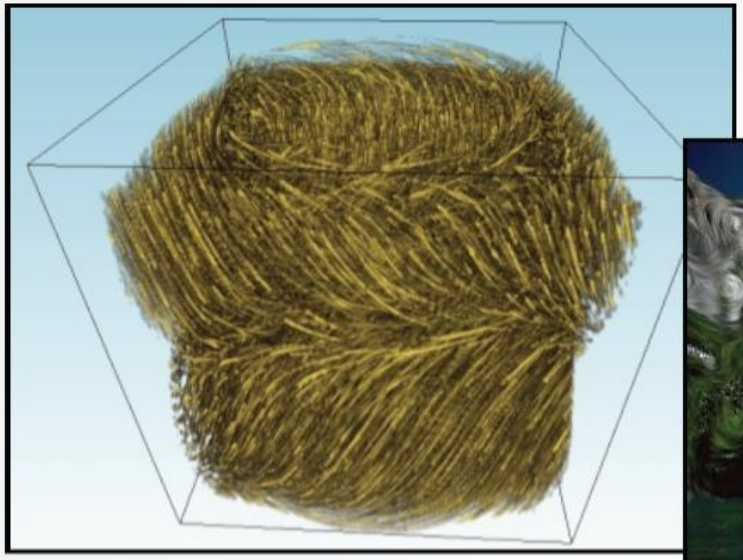


红线：迹线pathline
绿线：纹线streakline
黑线：流线streamline

Texture-based and Dense Methods

- Spot noise
  - Convolve blurred spot with random noise
- Line integral convolution (LIC)
  - Integrate white noise with flow field





Anders Helgeland

Gui-Shi Li

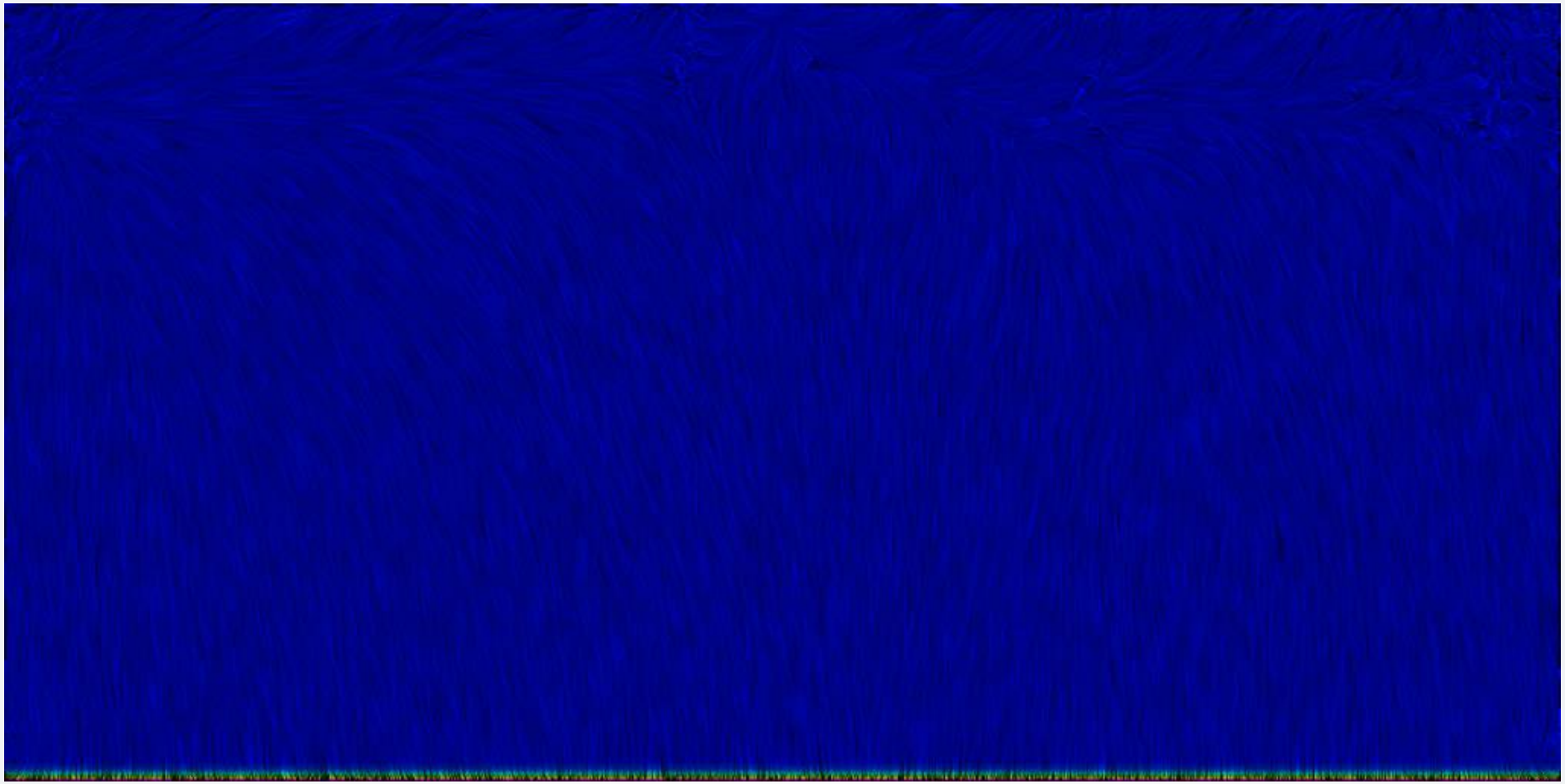
Noise Texture

Texture Advection on Stream Surfaces: A Novel Hybrid Visualization Applied to CFD Simulation Results

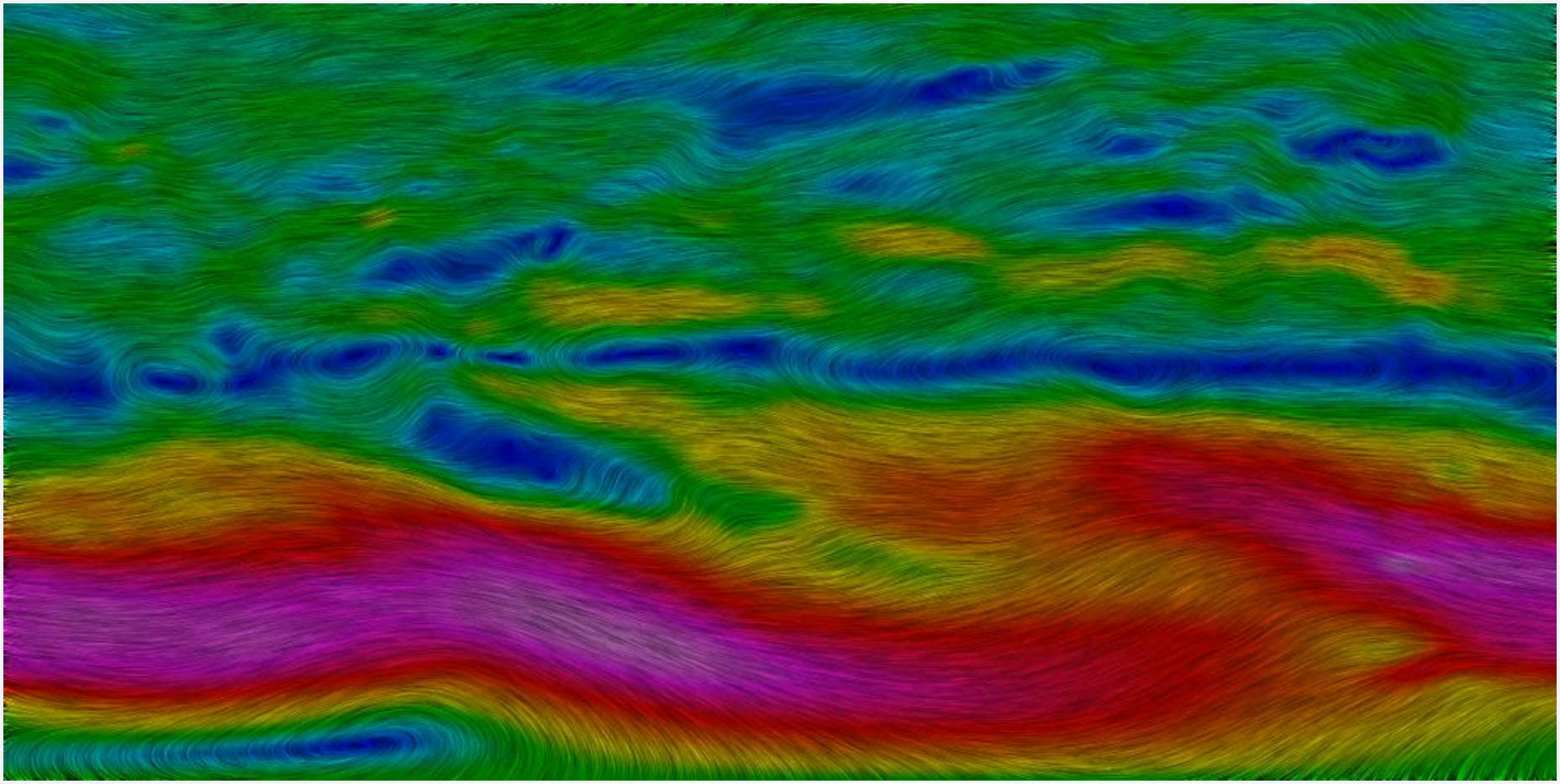
Robert S. Laramee
Christoph Garth
Juergen Schneider
Helwig Hauser

Technische Universität Kaiserslautern

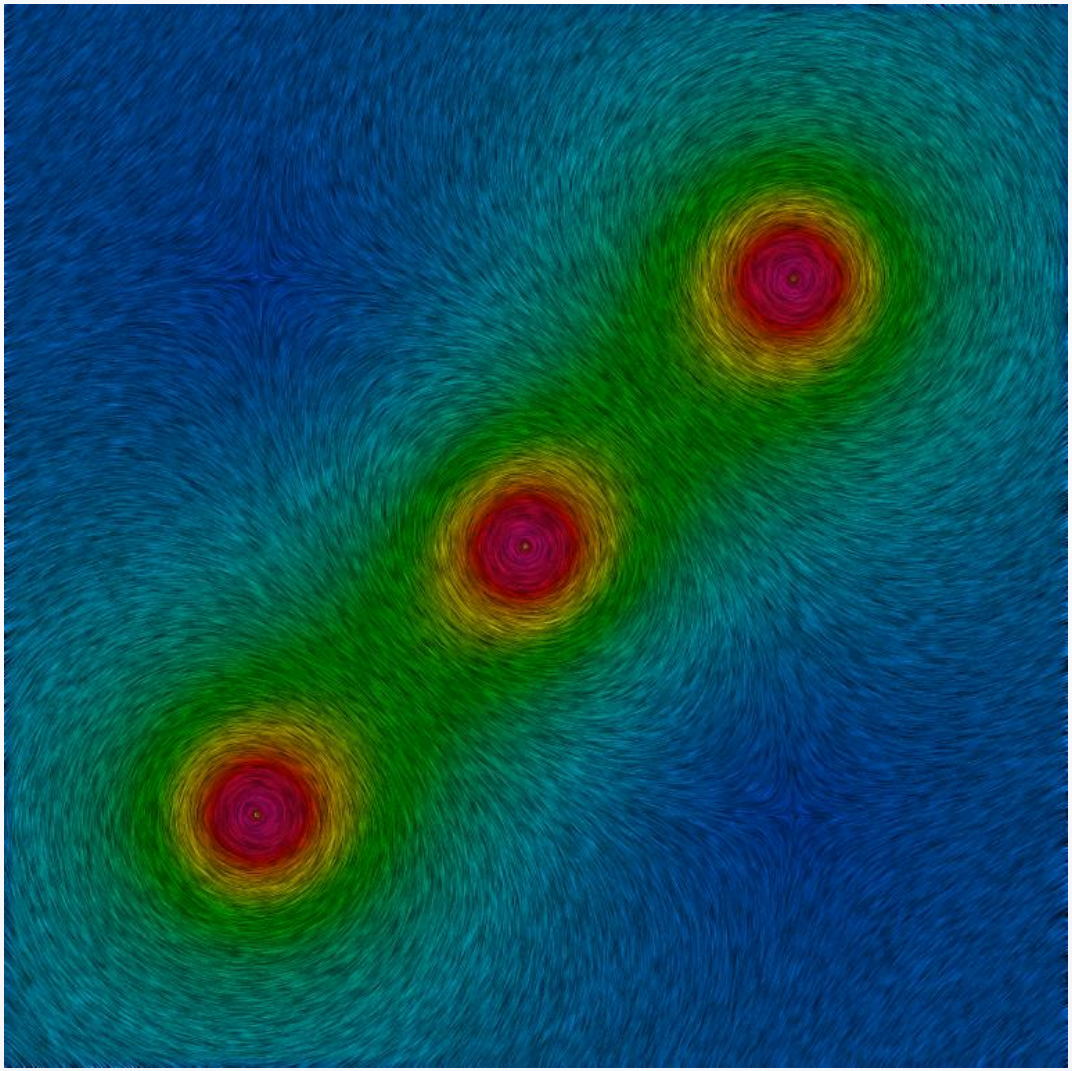
LIC



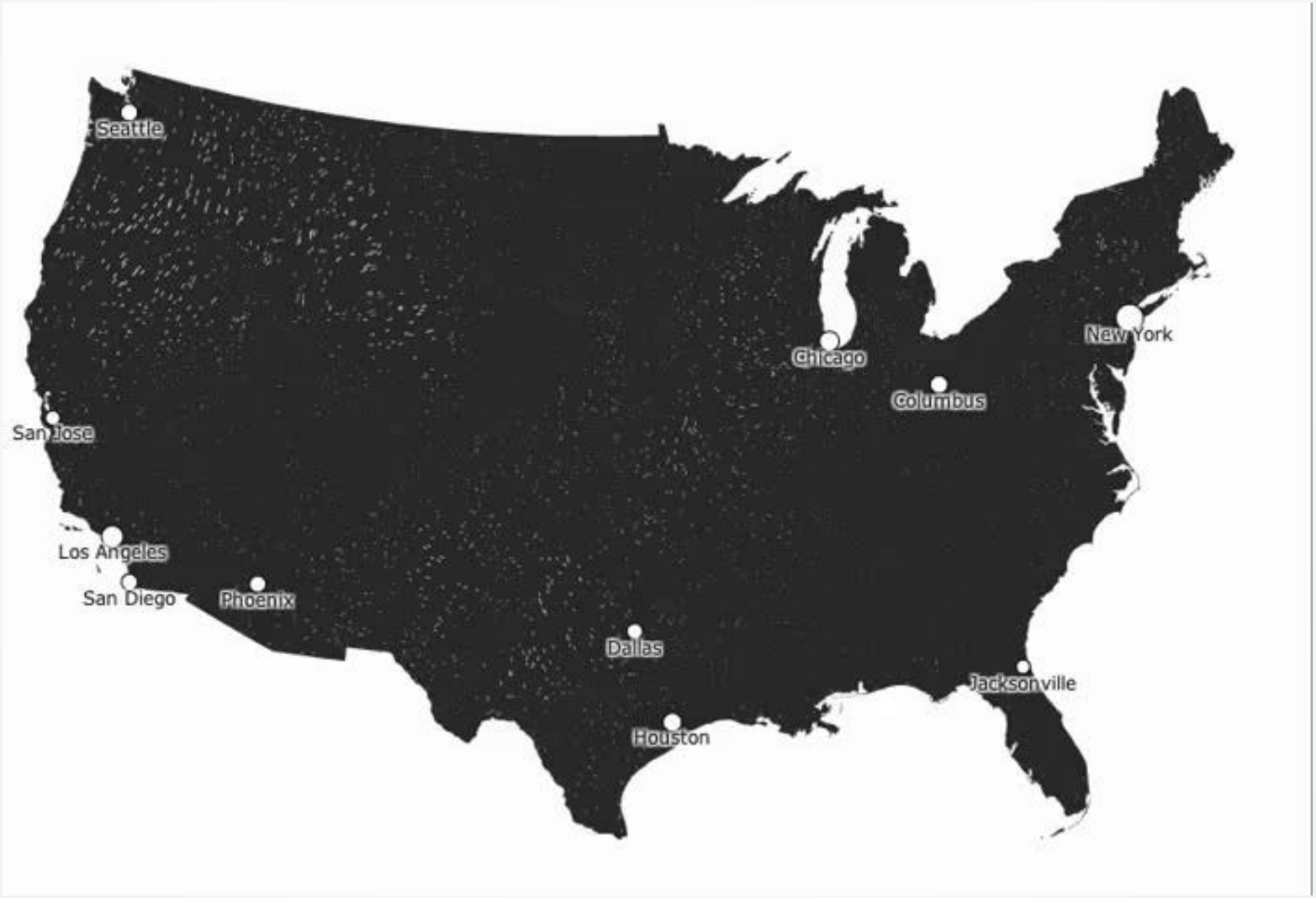
LIC



LIC



Wind map

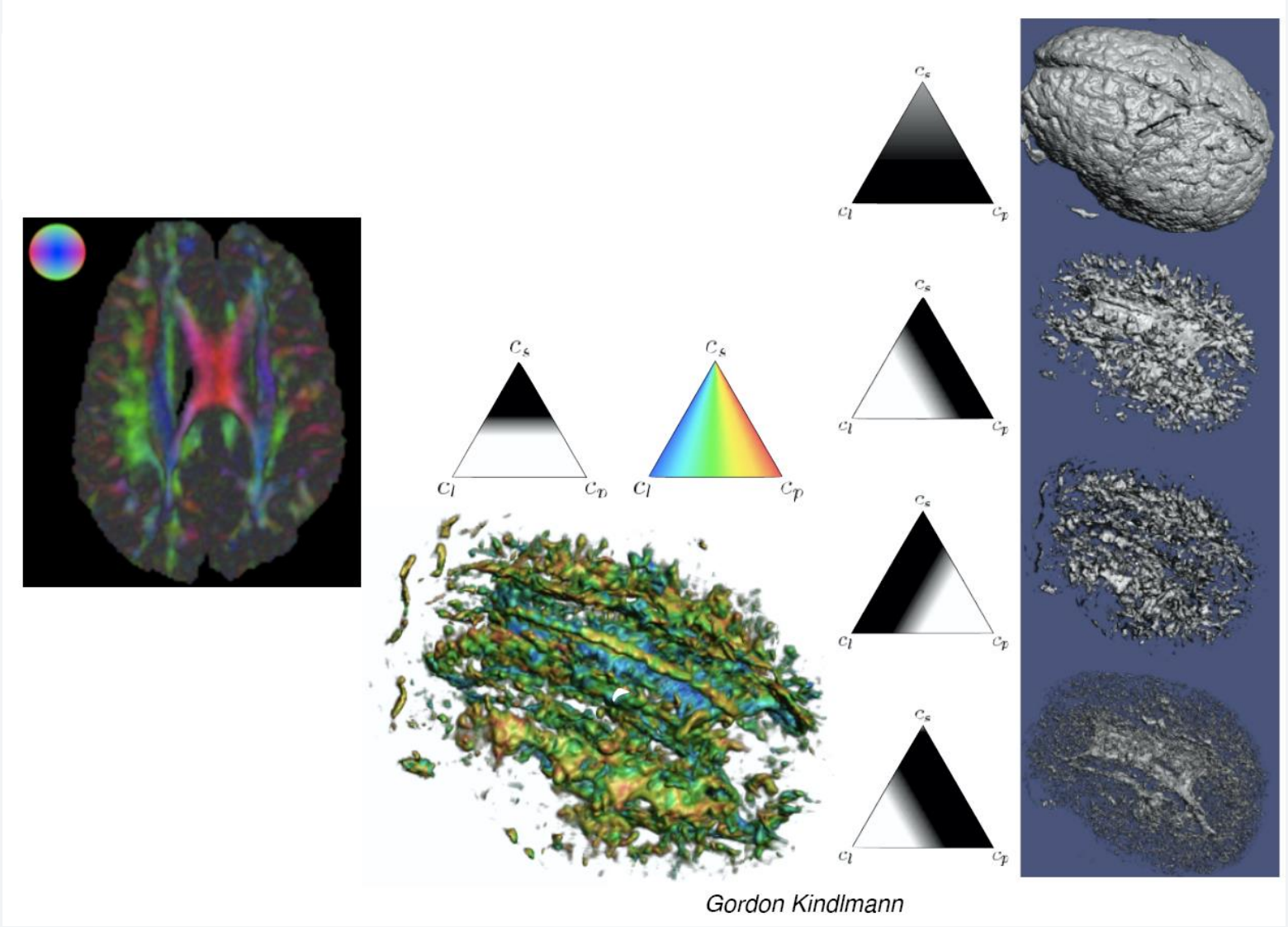

Seattle
Chicago
New York
Columbus
San Jose
Los Angeles
San Diego
Phoenix
Dallas
Jacksonville
Houston

Starry Night

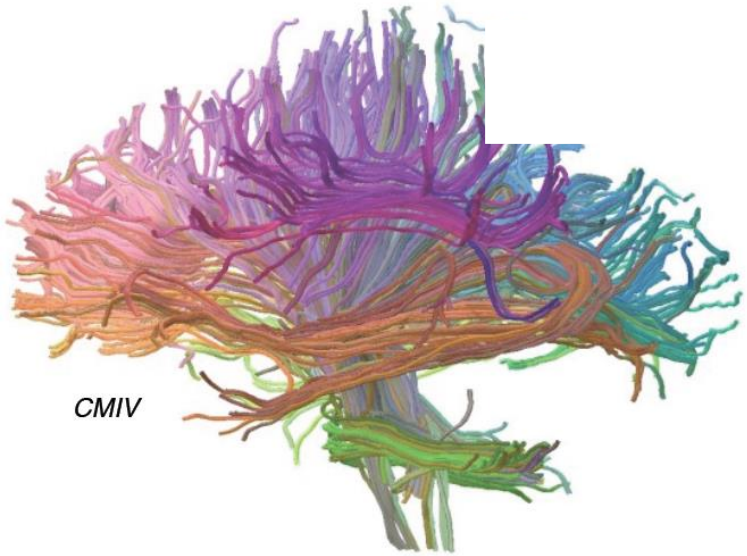
Tensor Field Visualization

- *n*D array of values at each data point
  - For 3D data, usually a 3x3x3 tensor
- Describes how data changes in a small sphere around the data point
  - From scanning devices: diffusion of water in brain
  - From simulations: stress, strain

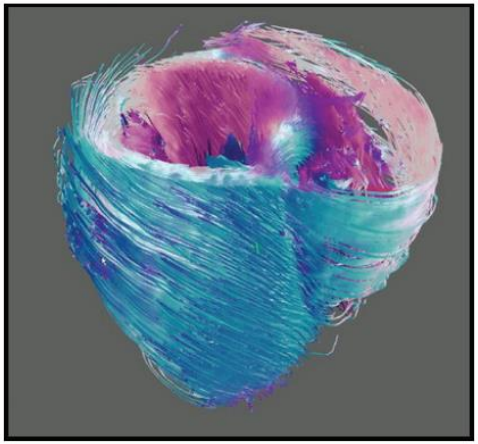
Color Encoding



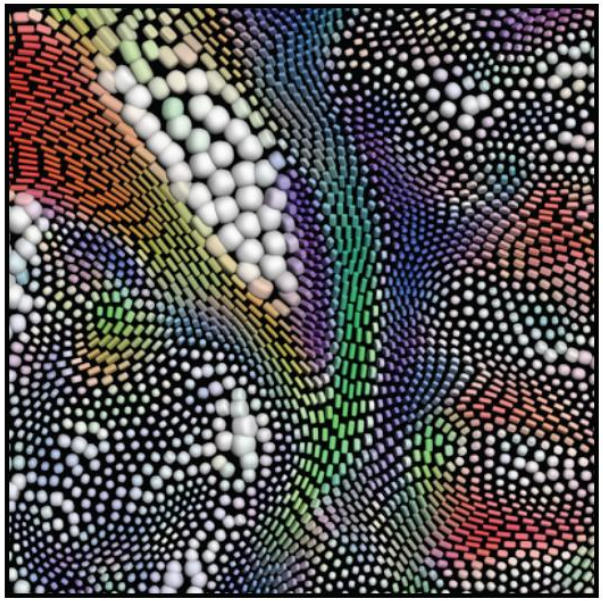
Steams and Glyphs



CMIV

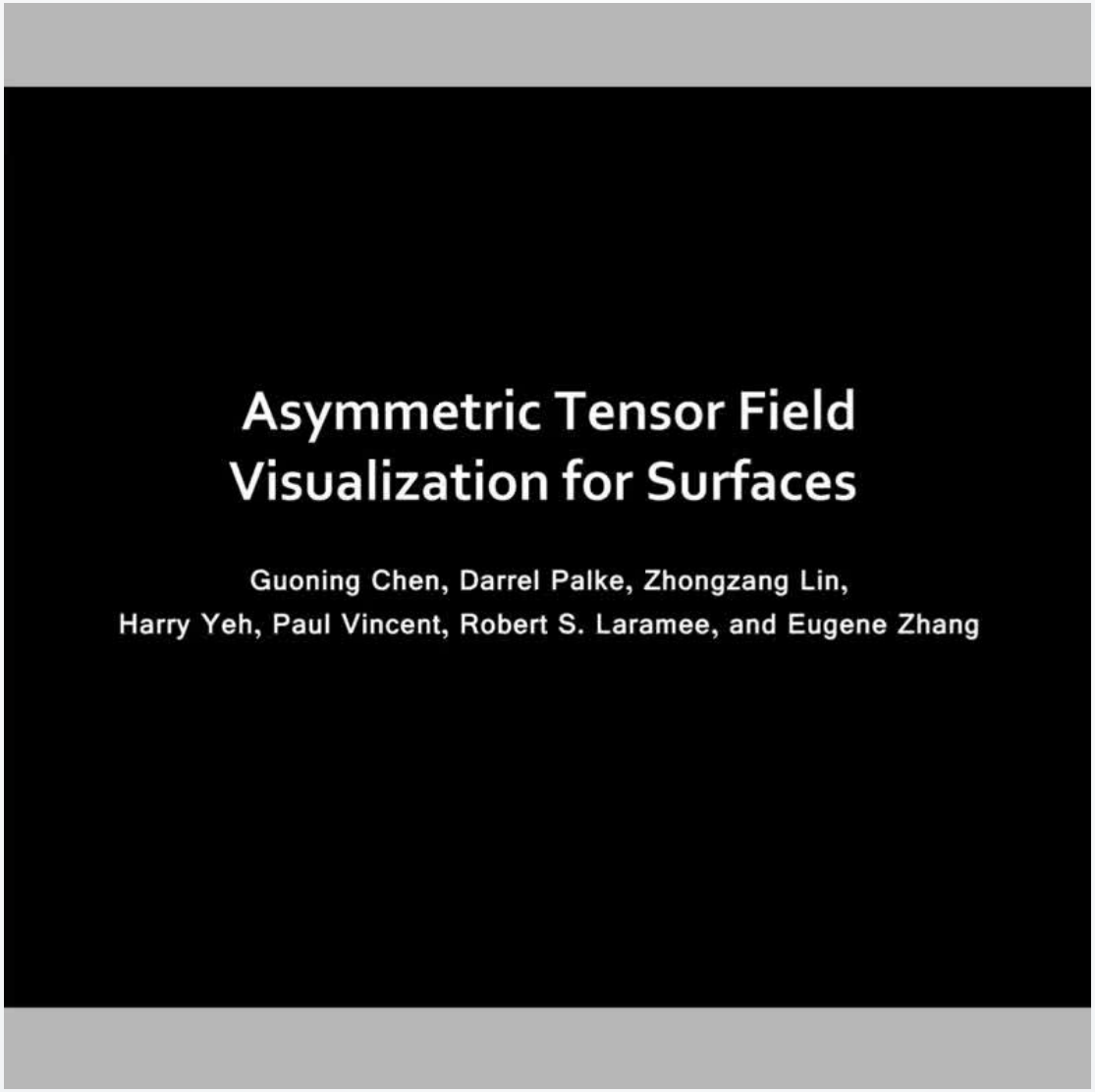


Leonid Zhukov



Gordon Kindlmann

Glyphs


Asymmetric Tensor Field
Visualization for Surfaces
Guoning Chen, Darrel Palke, Zhongzang Lin,
Harry Yeh, Paul Vincent, Robert S. Laramee, and Eugene Zhang

OUTLINE

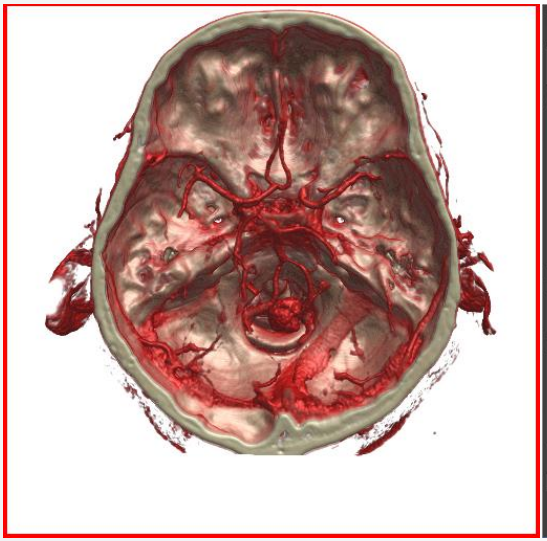
1. 1D Data Visualization
2. 2D Data Visualization
3. 3D Volume Visualization
4. Vector Field and Tensor Field
5. Medical Data Visualization

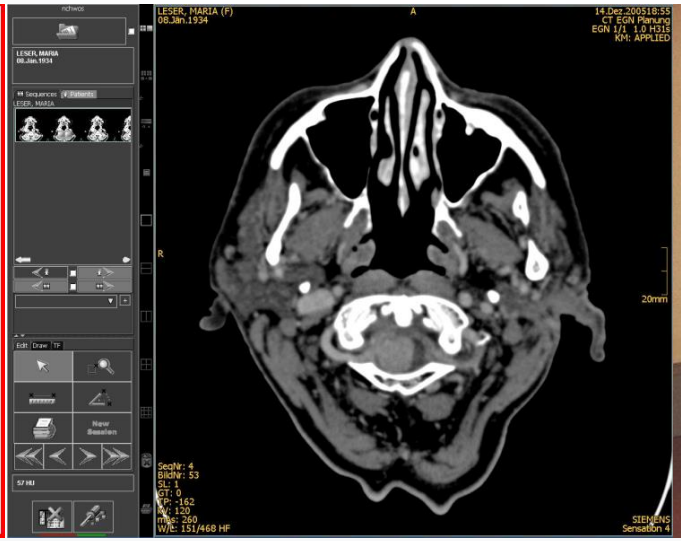
Data Sources

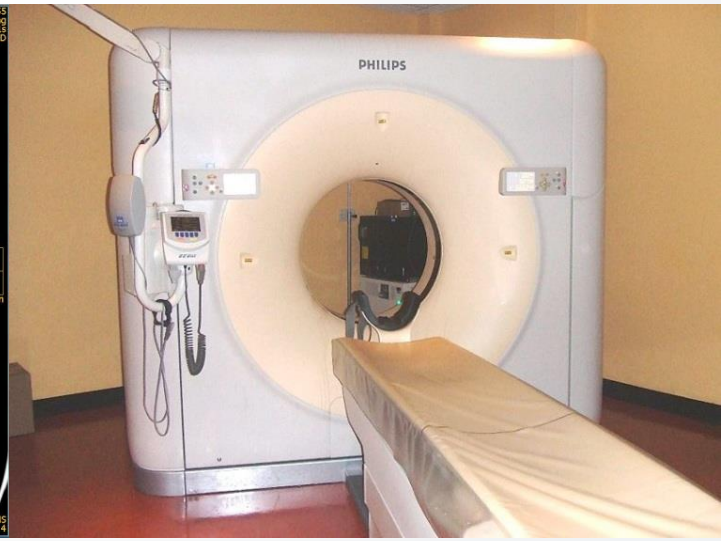
- Scanning devices:
  - MRI
  - CT
  - Ultrasound
  - X-ray

CT

- Computed Tomography
- 3D X-rays
- Rebuild from image slices

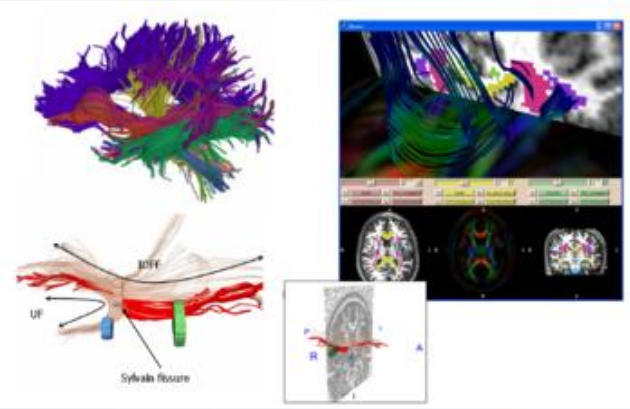


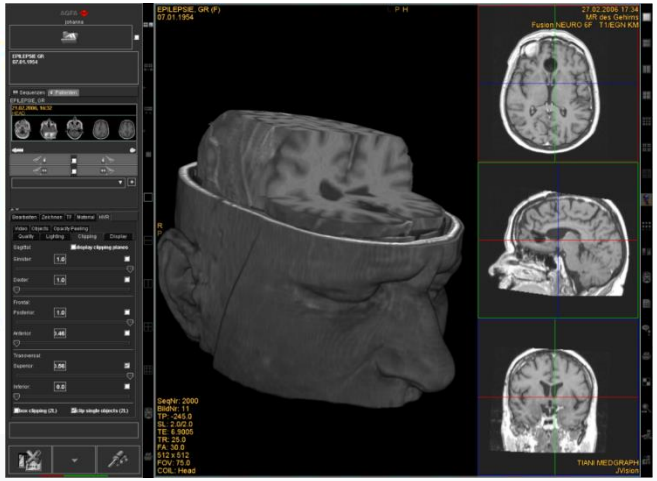




MR I

- Magnetic Resonance Imaging
- FMRI and DTI

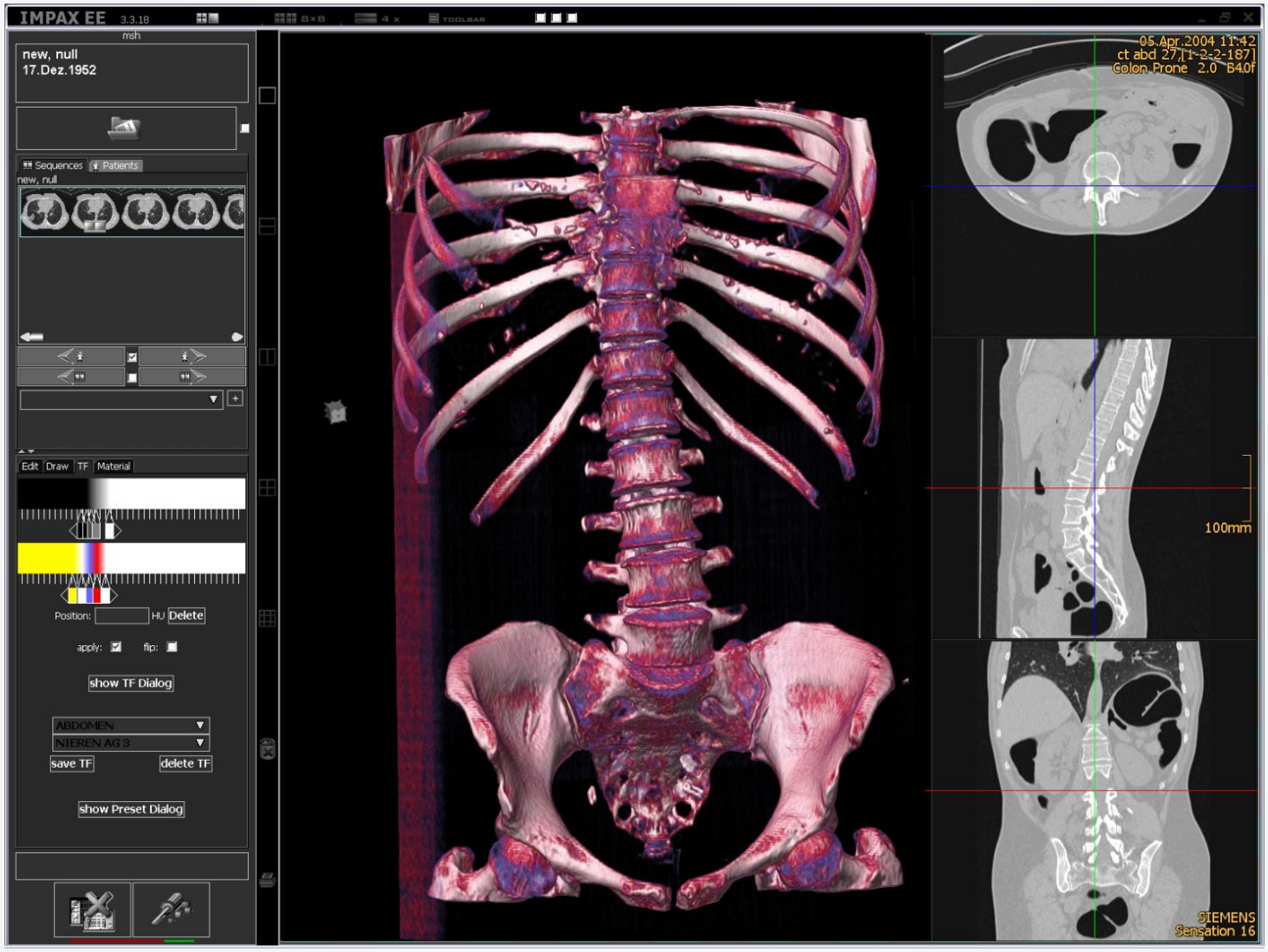




Ultrasound

- 2-18MHz
- Time and echo length
- Contour and texture

Medical Workstation Plugin

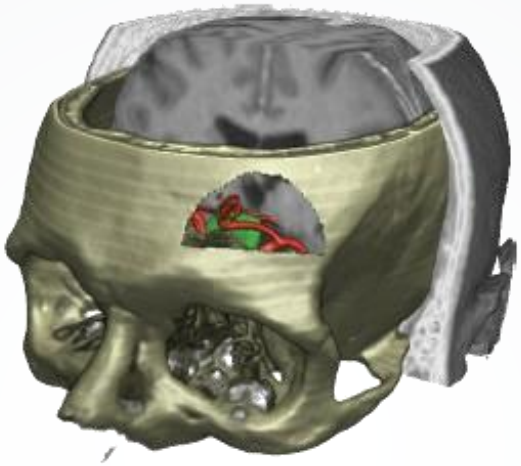


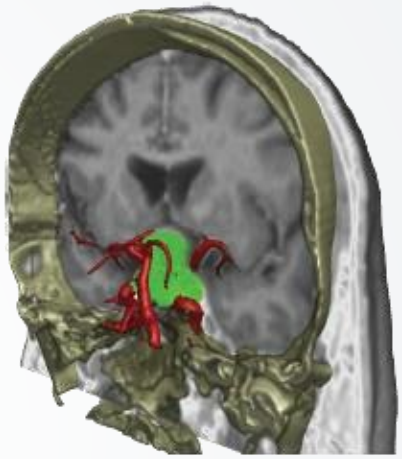
Medical Visualization

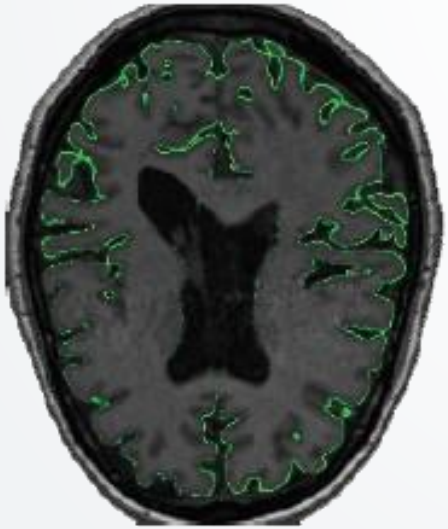
- Diagnostics
- Pre-operative planning
- Training and education
- Intra-operative support and navigation

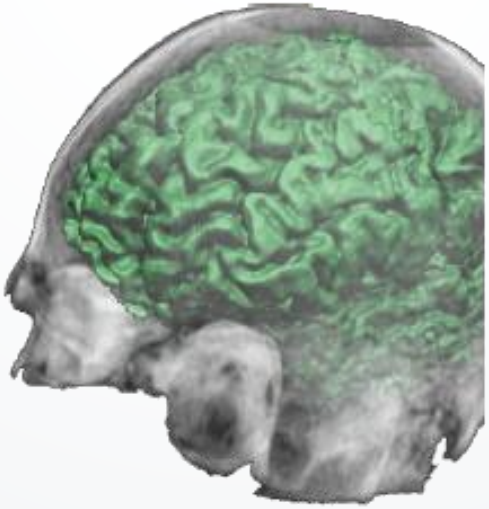
Medical Visualization

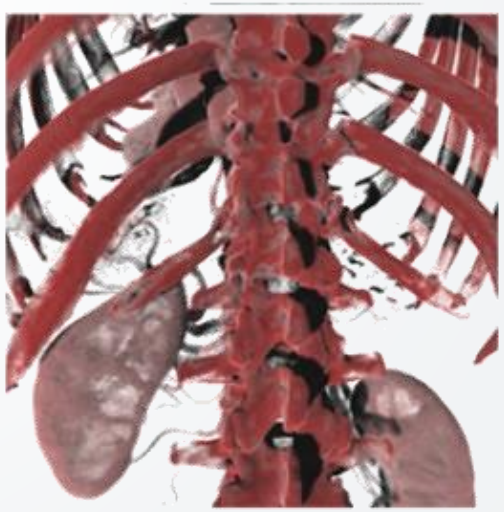
- Volume visualization
- Segmentation
- Analysis
- Measurements



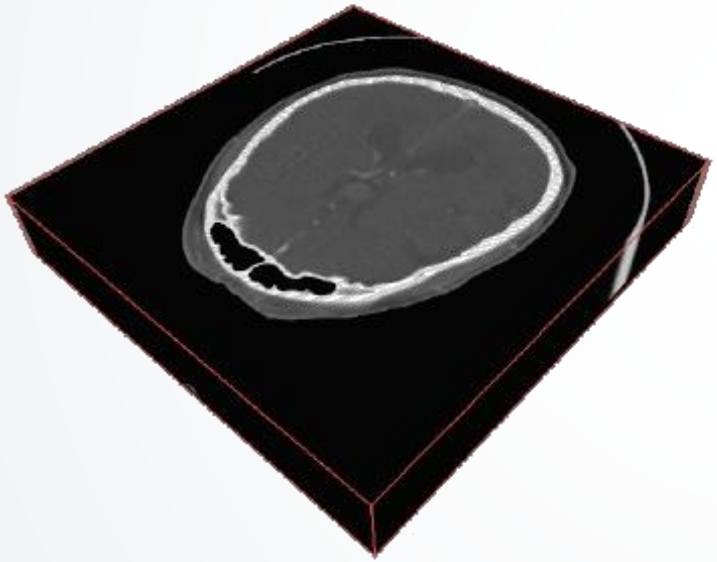








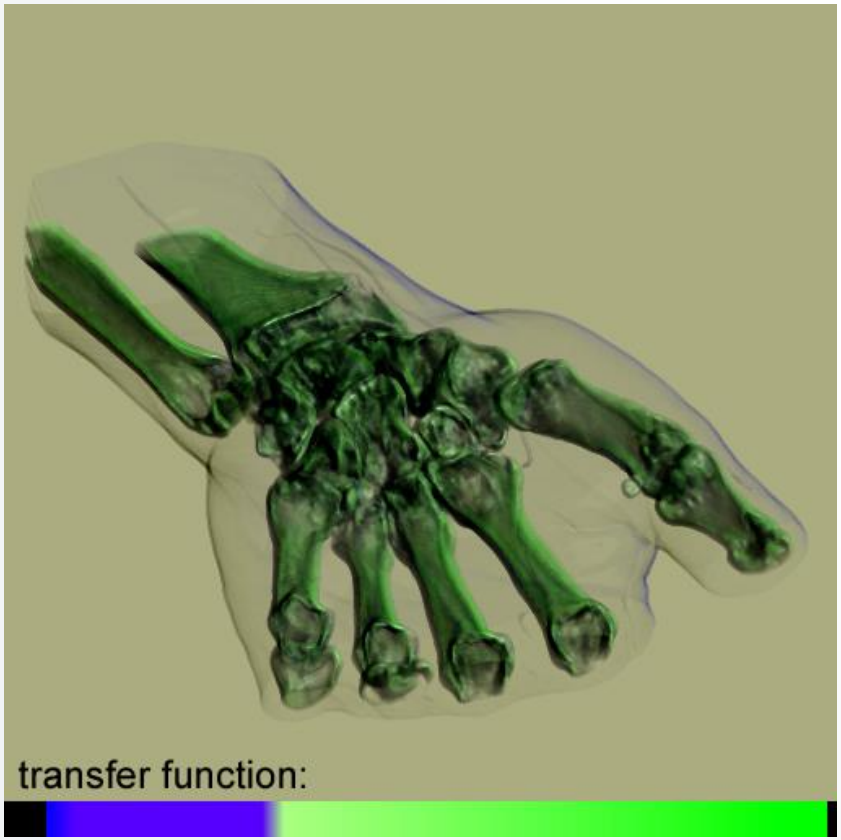
Direct Volume Visualization



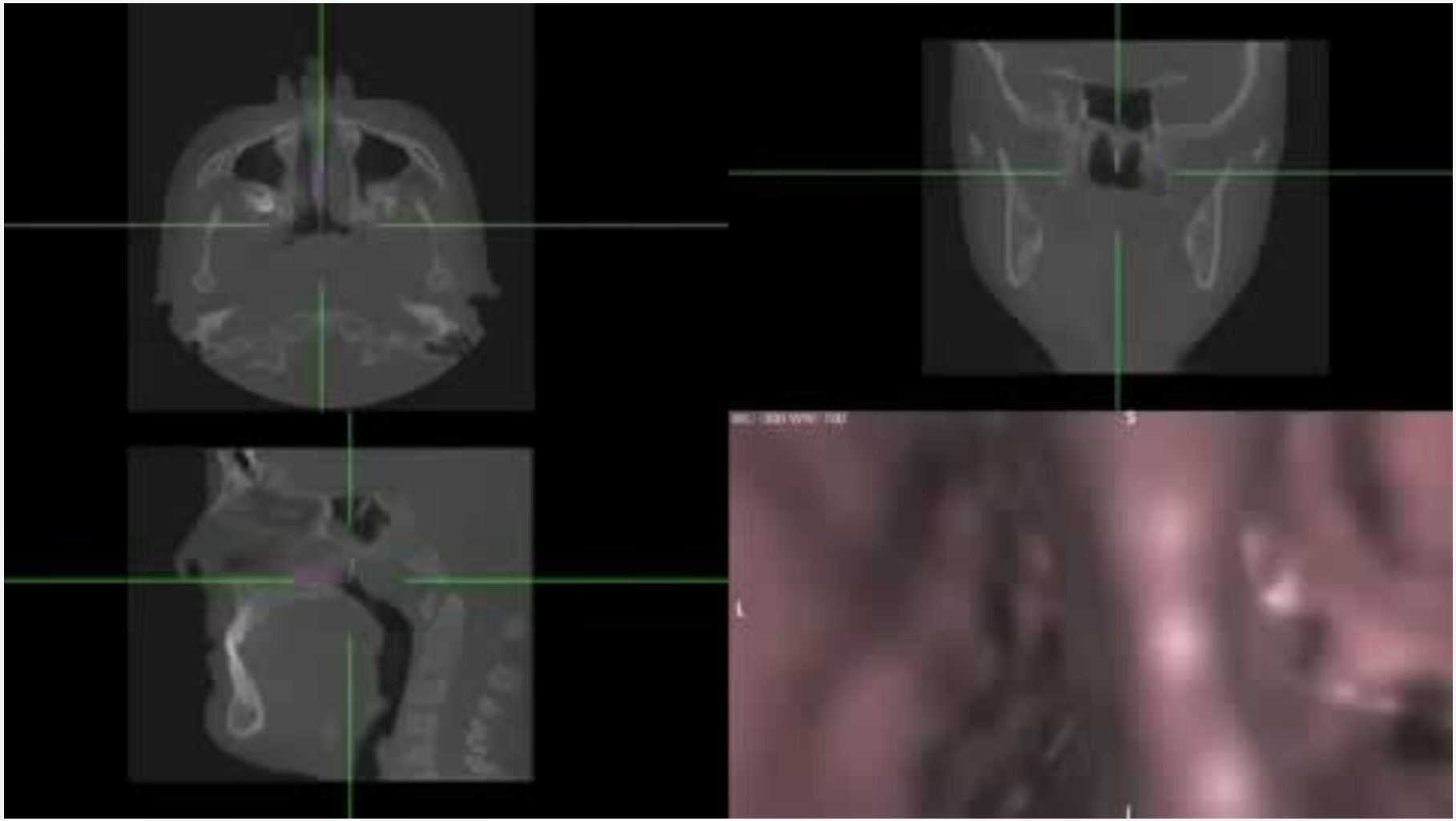
Rebuild from slices

Transfer Function (TF)

- Mapping of density, … to optical properties
- Simplest: color table with opacity over density

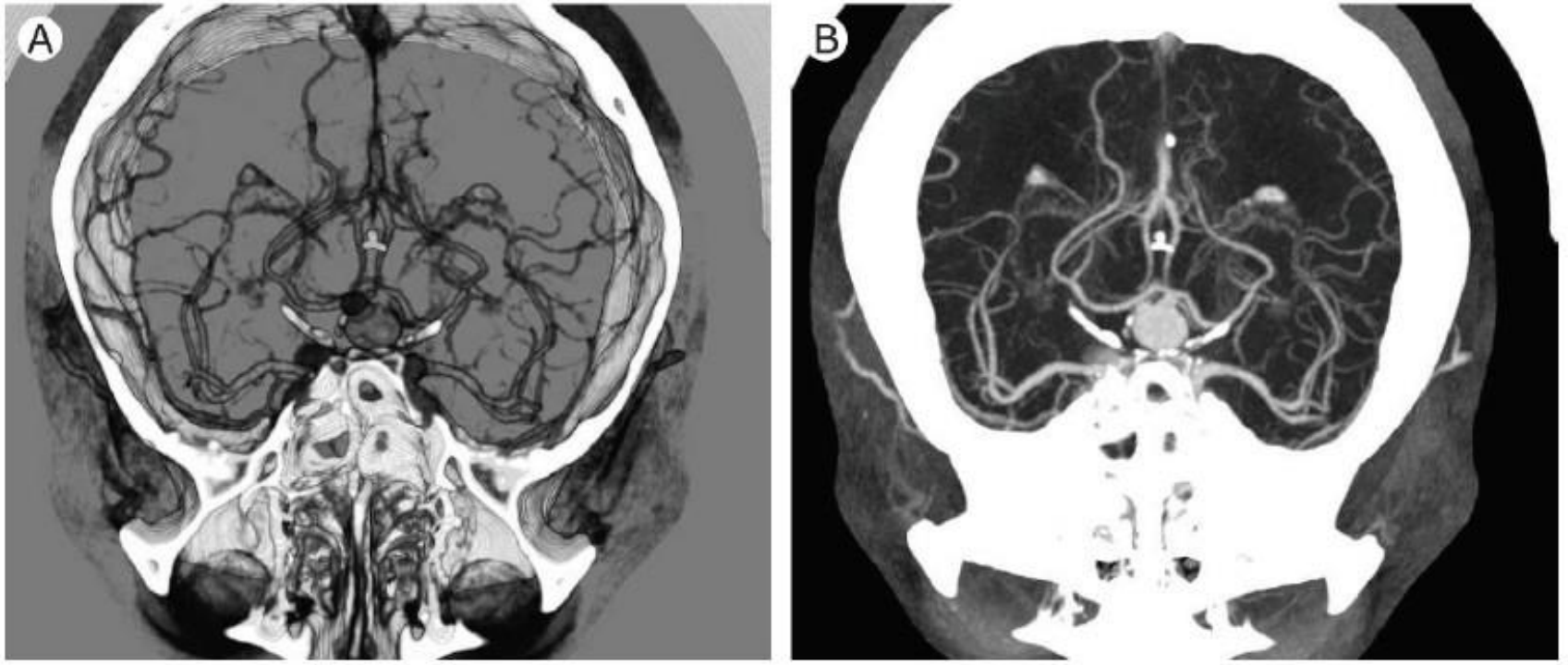


Virtual Endoscopy

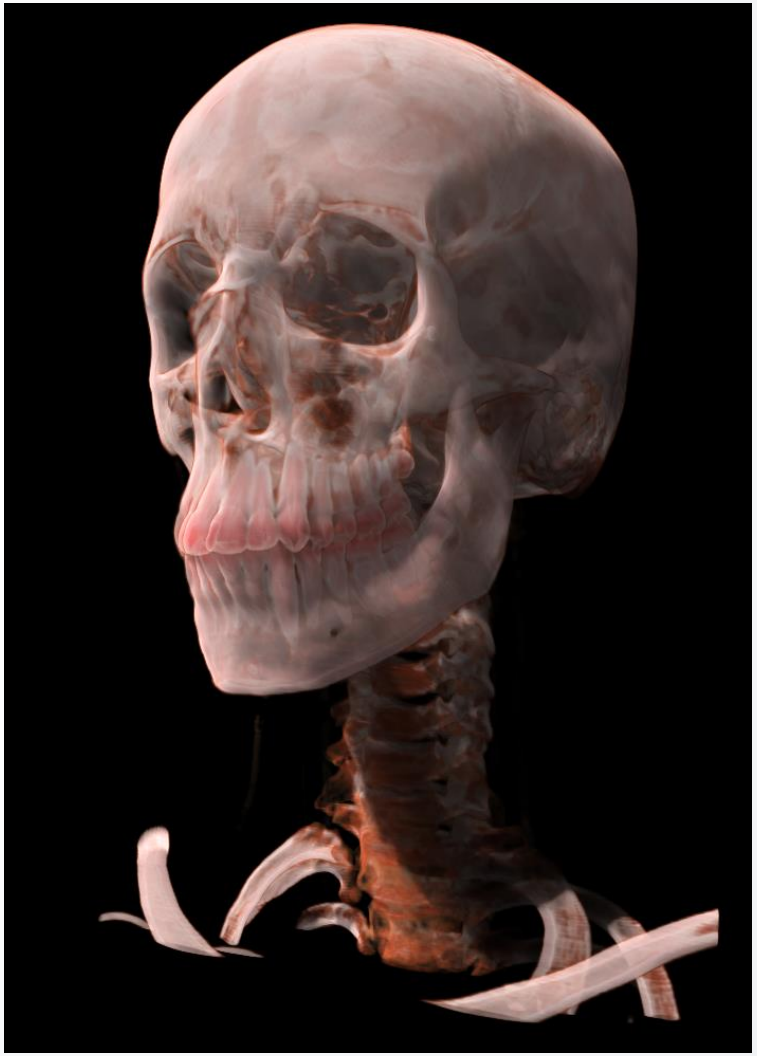


Maximum Intensity Projection

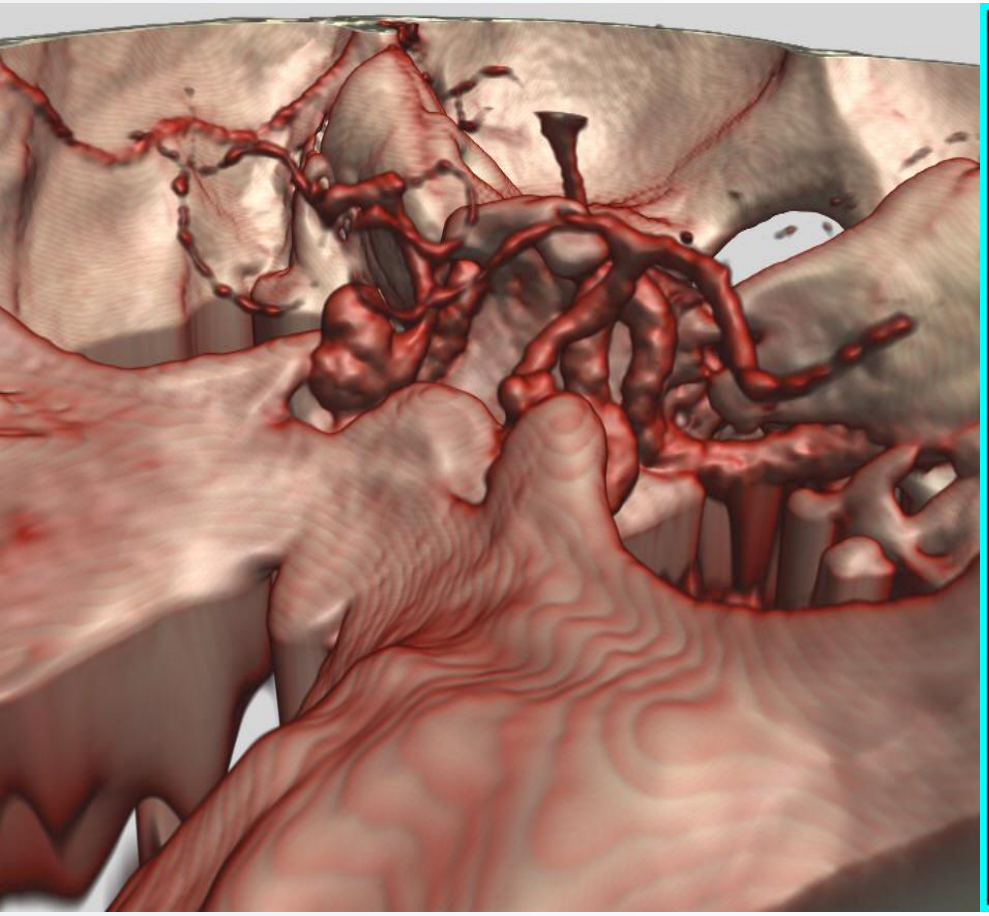
- Keeps structure of maximum intensity visible



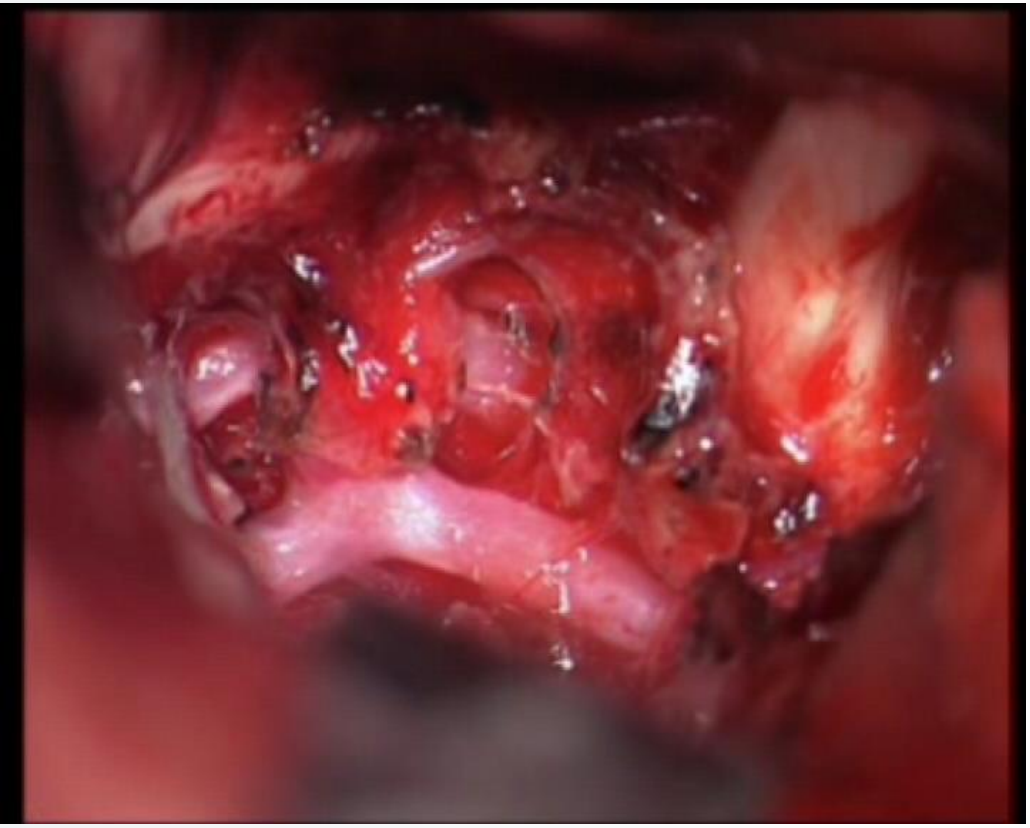
Advanced Lighting

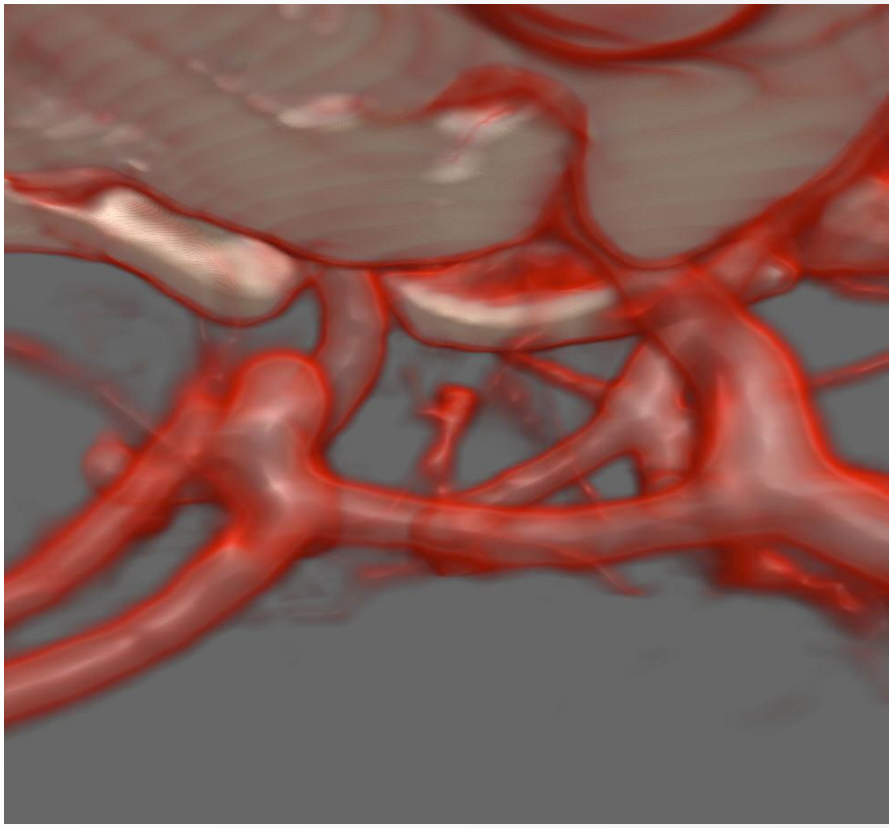


CTA, DSA



Aneurysm





Intra-operative vs. CTA

Medical Image Management and Visualization Platform

- DICOM image management and analysis
- 3D segmentation, registration and fusion
- 3D/4D/5D visual analytics
- Plugin based development

Medical Image Management and Visualization Platform

Thanks