

Visual Data Analytics Visualization

Dr. Johannes Kehrer – Siemens Technology, Munich

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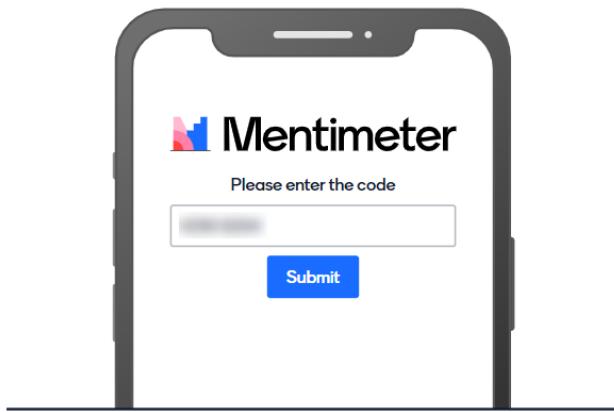
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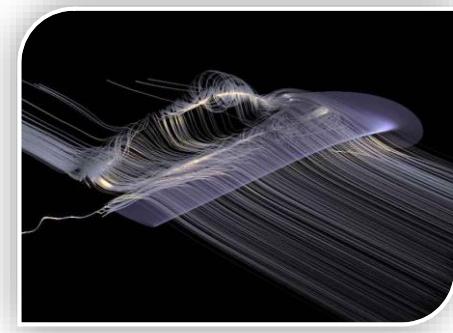
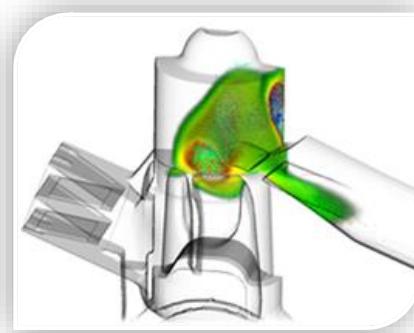
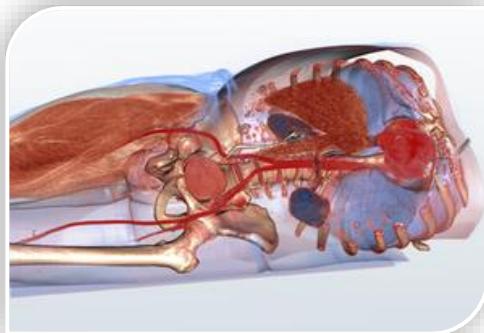
7582 8825



Or use QR code

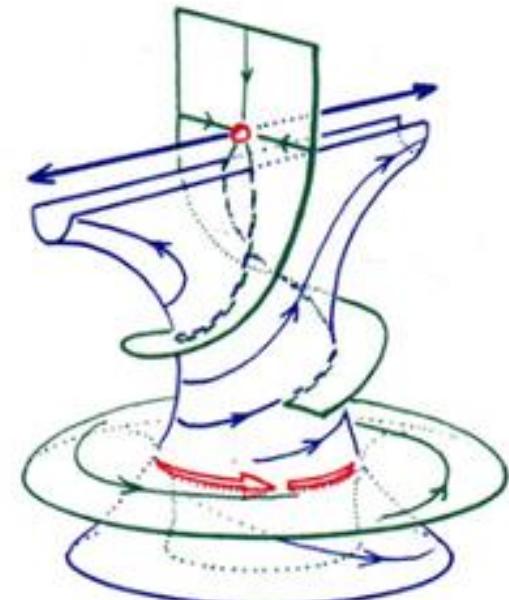
Visualization basics

Data sources & examples



Data sources

- Data may come from any source with arbitrary size
 - **Challenge**: efficiently visualize large-scale data sets and new data types
- Real world
 - Measurements and observation
- Theoretical world
 - Mathematical and technical models
- Artificial world
 - Data that is designed



Data sources

- Real-world measurements

- Medical Imaging (MRI, CT, PET)
- Geographical information systems (GIS)
- Electron microscopy

TB

- Meteorology and environmental sciences (satellites)

PB

- Seismic data

- Crystallography

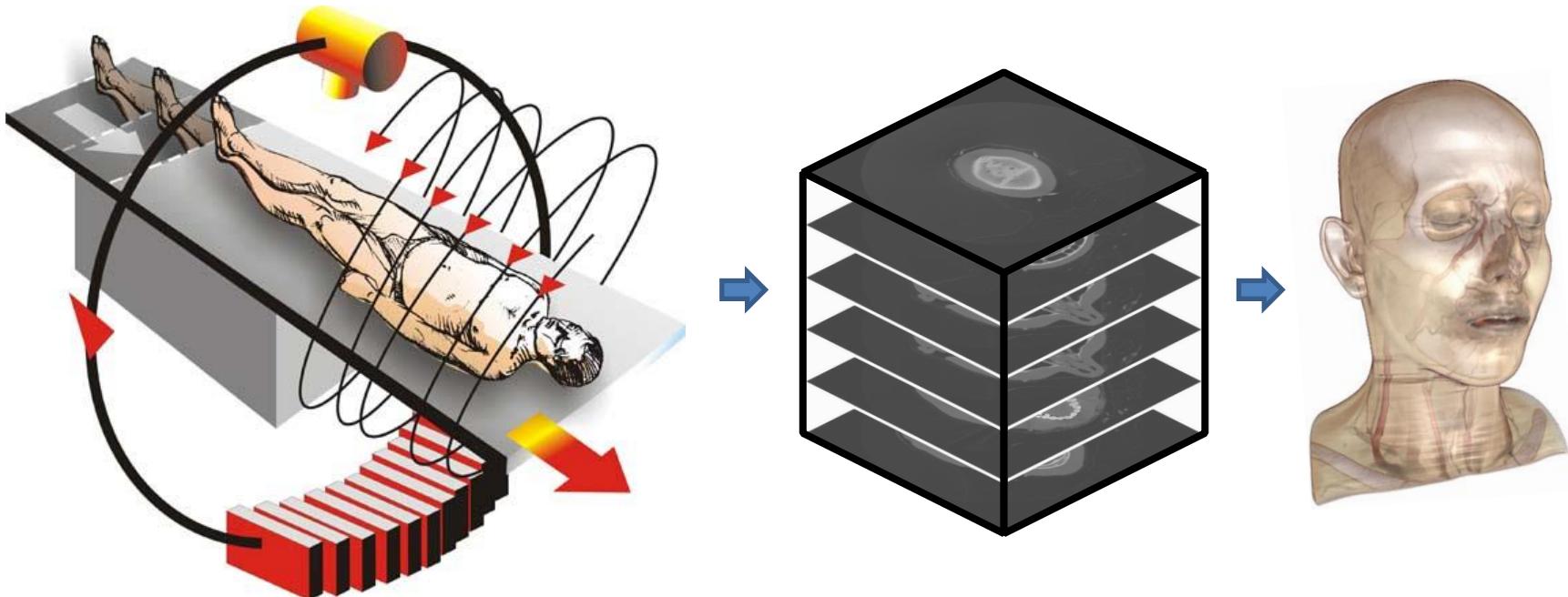
- High energy physic

PB

- Astronomy (e.g. Hubble Space Telescope 100MB/day)

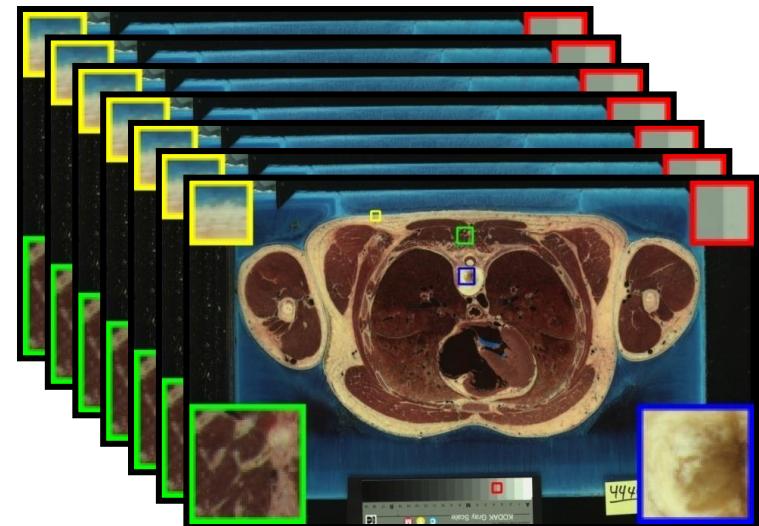
Data sources – medical imaging

- Visualization of medical data sets
 - Provide insight into 3D scans



Data sources – medical imaging

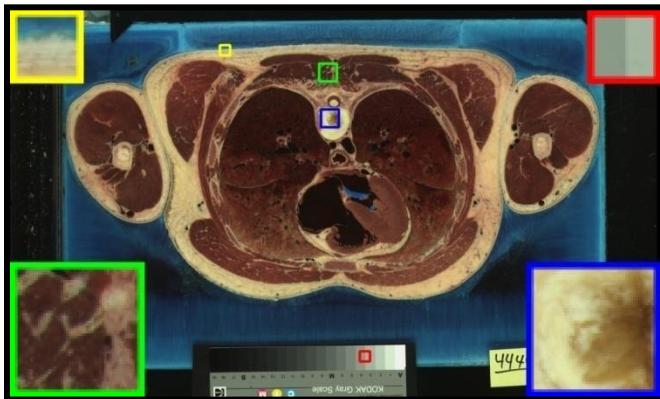
- Visualization of medical data sets
 - The Visible Human Project
 - www.nlm.nih.gov/research/visible/visible_human.html
 - Bodies were frozen in a special material to preserve tissues and organs
 - Sections were 'shaved' off the frozen block in micro-thin layers to expose underlying tissues
 - A picture is taken
 - A 'stack' of 2D images is obtained



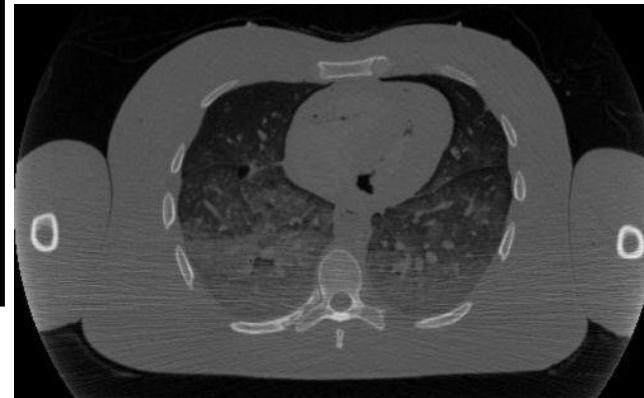
Data sources – medical imaging

- Visualization of medical data sets
 - The Visible Human Project – different imaging modalities

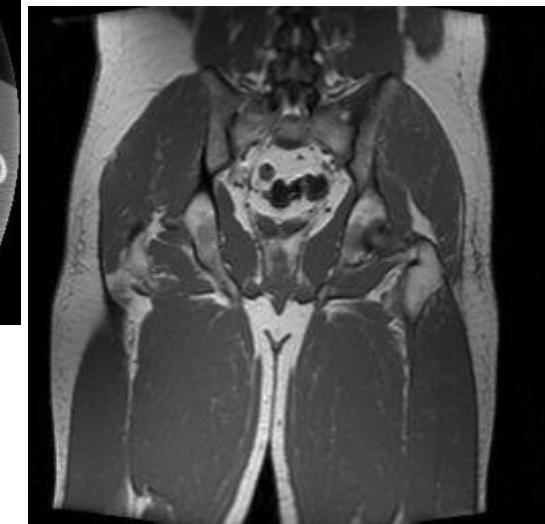
Color Cryosections



CT scan

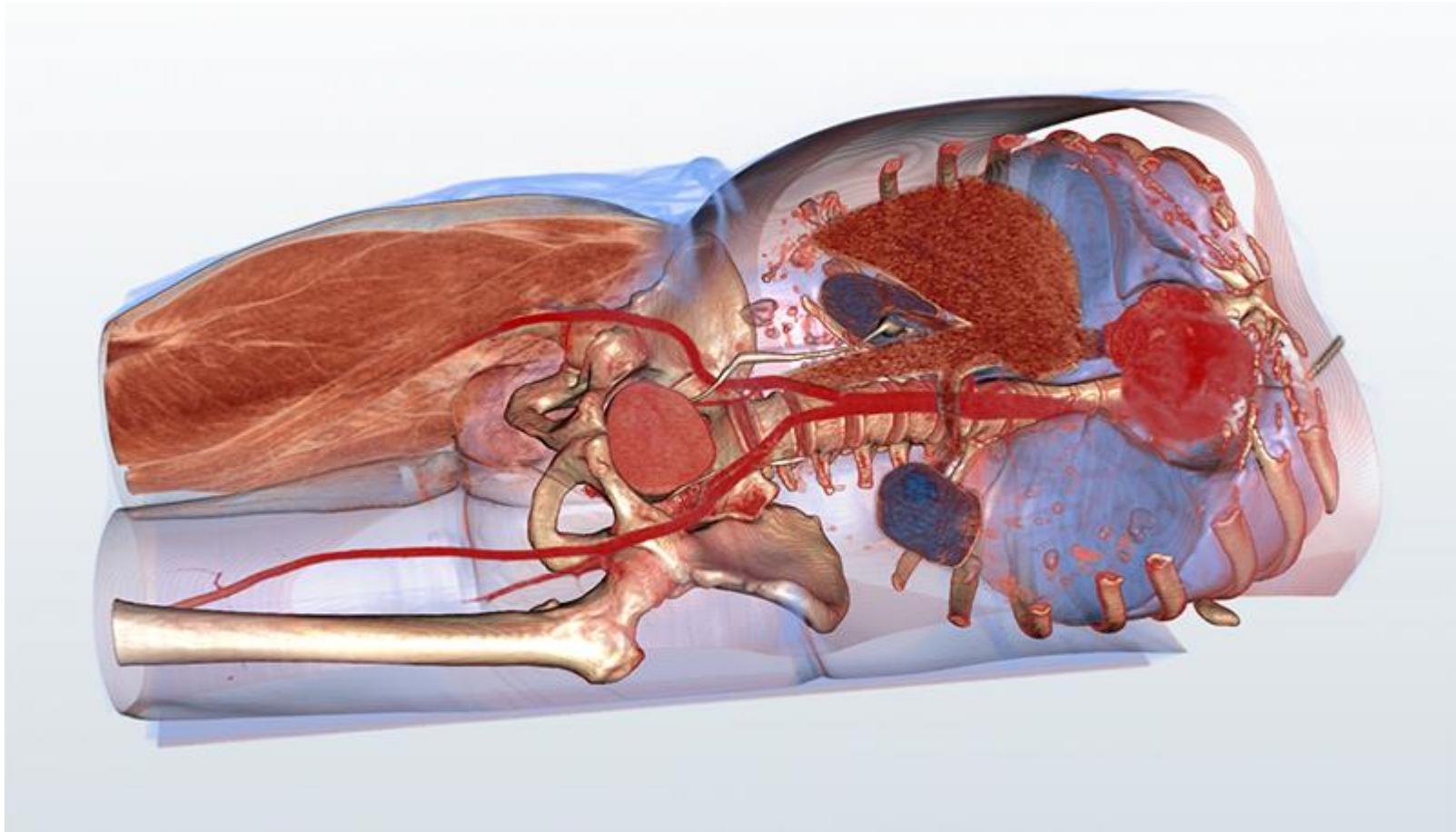


MRI scan



Data sources – medical imaging

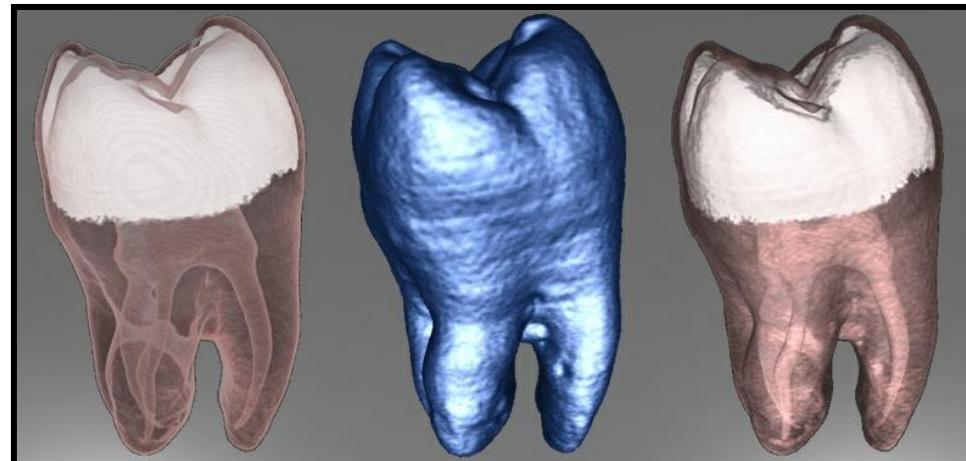
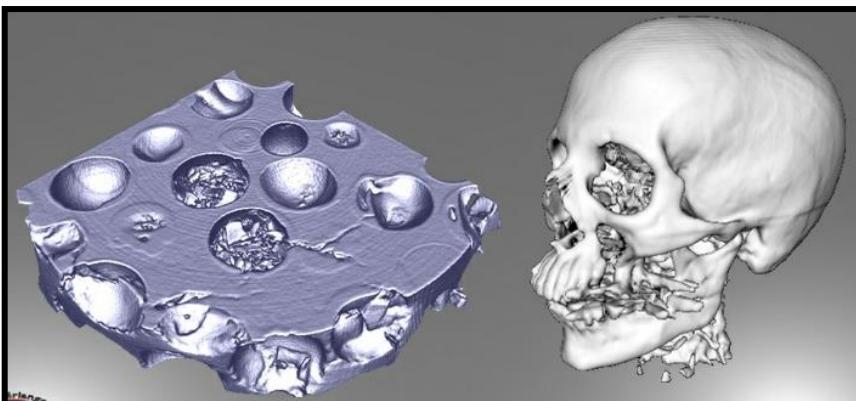
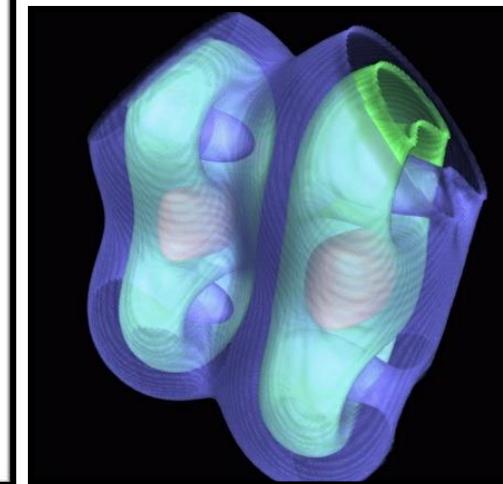
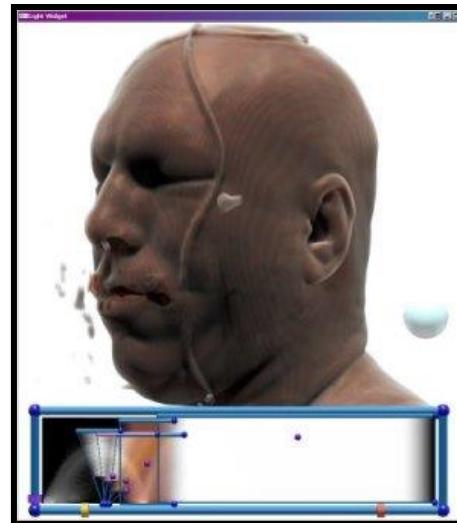
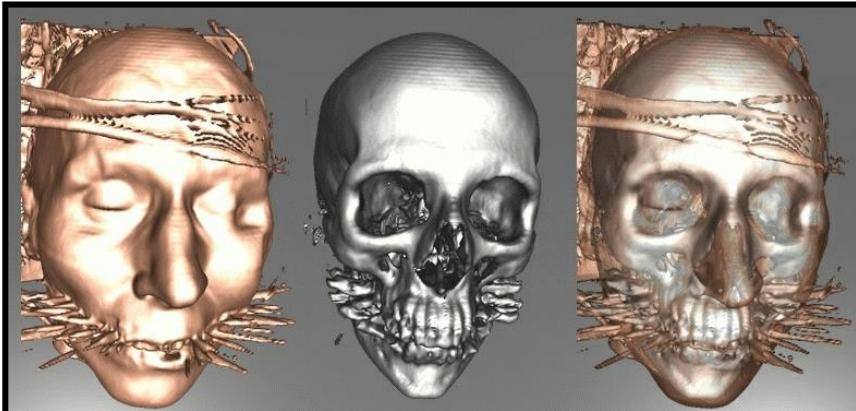
- The Visible Human Project – from 2D to 3D



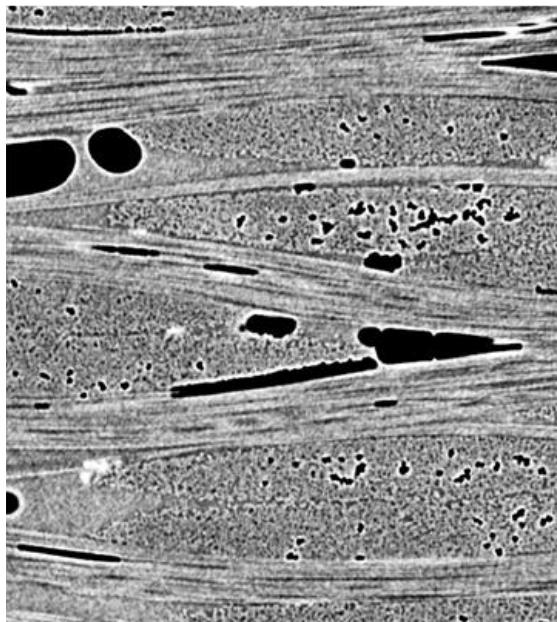
Data sources – medical imaging

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Ingenuity for life

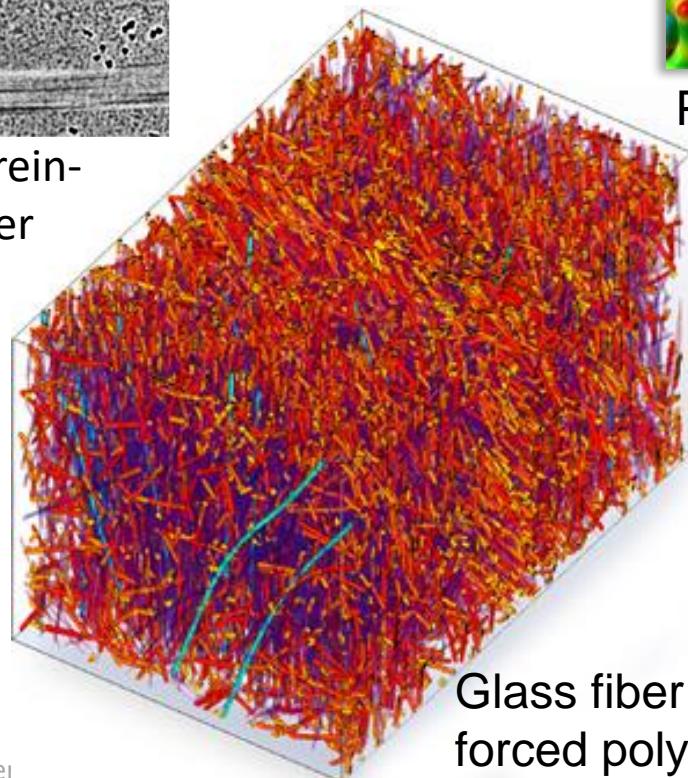
- High-quality volume visualization on consumer PC



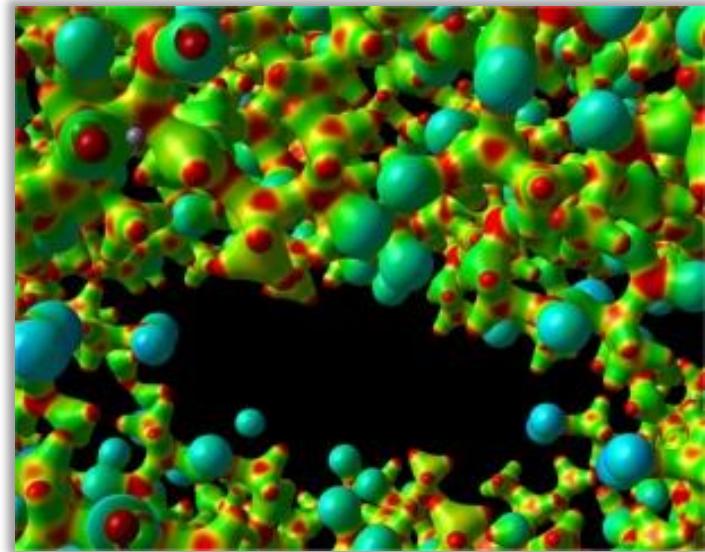
Data sources – material sciences



Carbon fiber rein-
forced polymer



Glass fiber rein-
forced polymer



Potential field in crystal structure



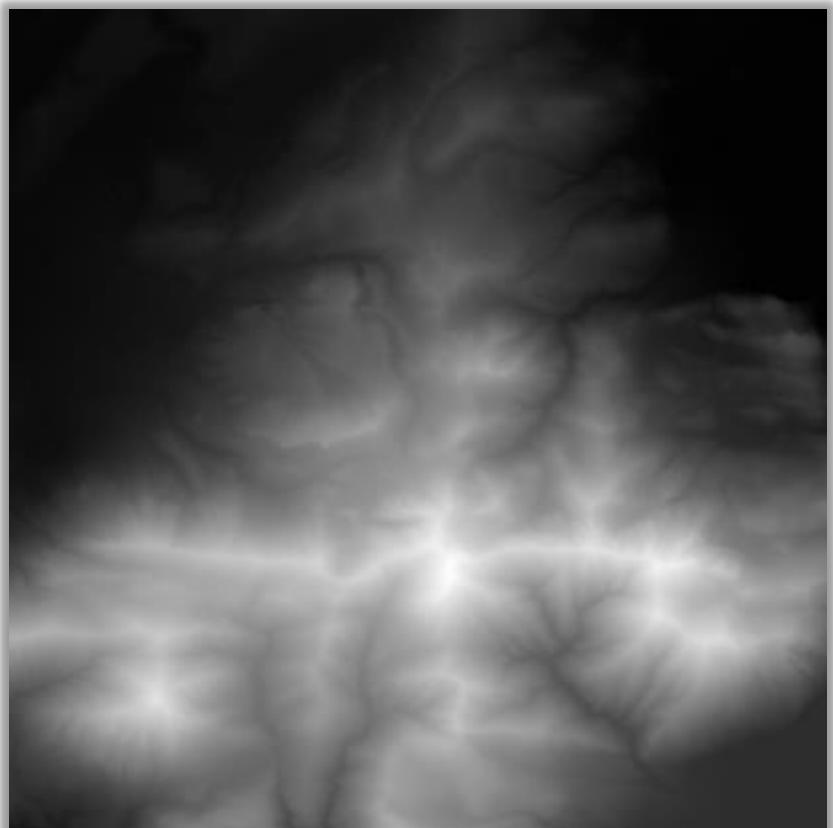
Porosity evaluation

Data sources – remote sensing

Orthophoto



Digital Elevation Map





Data sources

- Computer simulations

- Sciences

- Molecular dynamics
 - Quantum chemistry
 - Mathematics
 - Computational physics
 - Meteorology and climate research
 - Computational fluid dynamics (CFD)

TB

PB

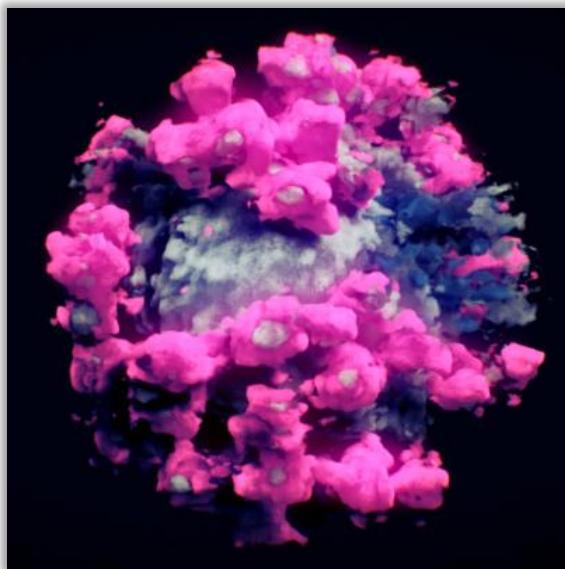
- Engineering

- Architectural walk-throughs
 - Structural mechanics
 - Car body design

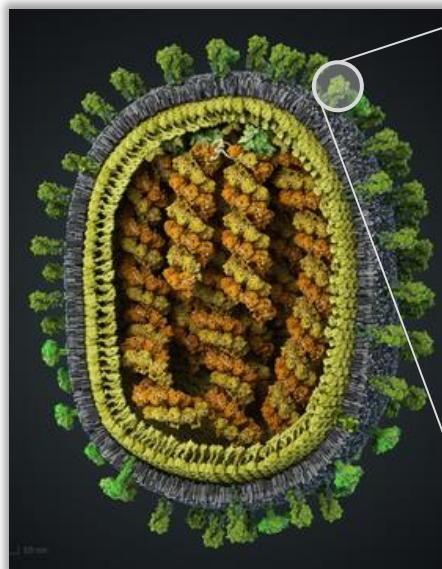
MB

GB

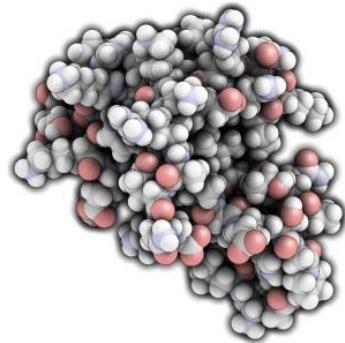
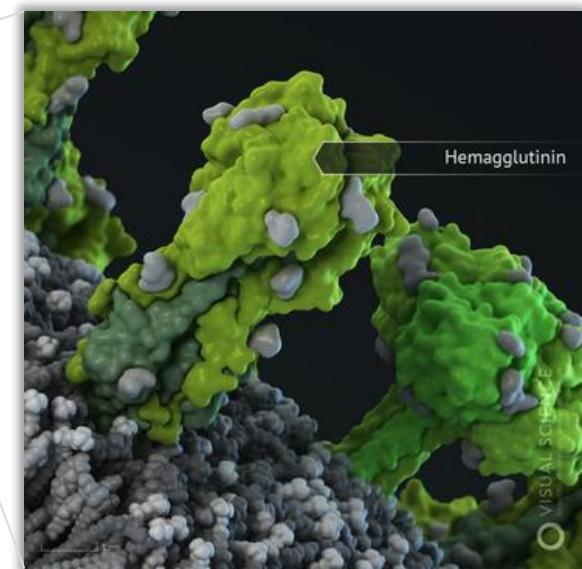
Data sources – bio sciences



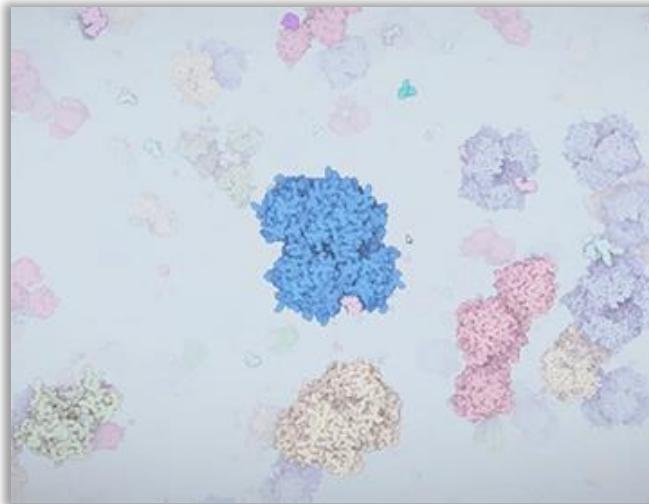
SARS-CoV-2 Cryo-ET ([link](#))



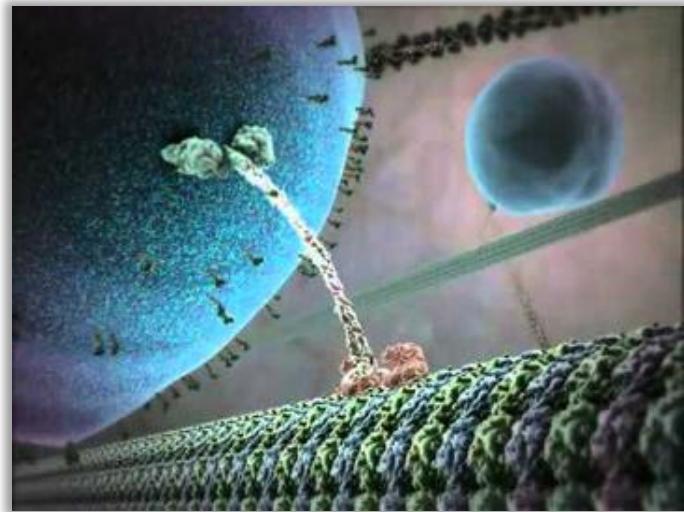
Influenza A/H1N1



Molecular
visualization



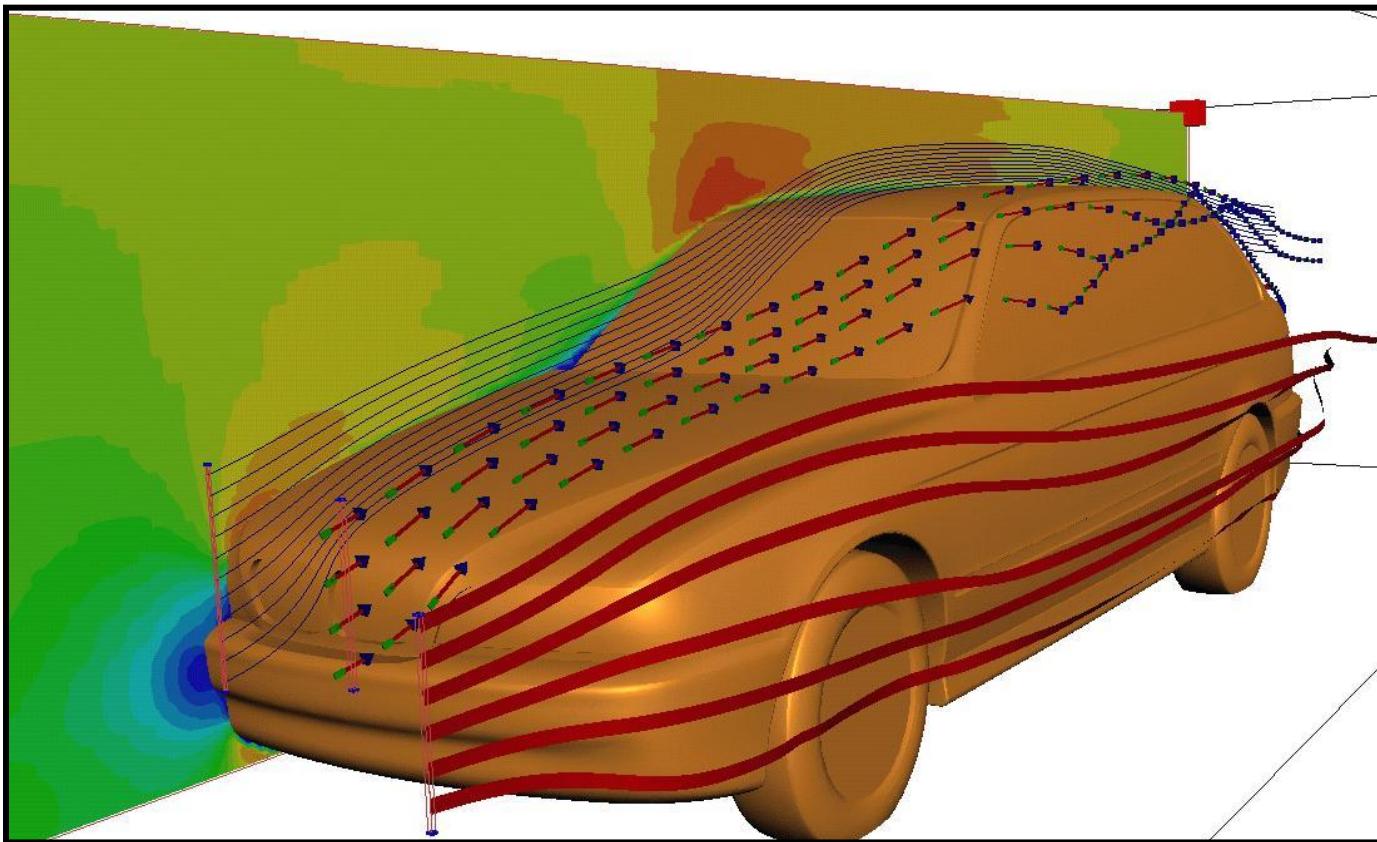
Molecular reactions ([link](#))



Inner life of a cell ([link](#))

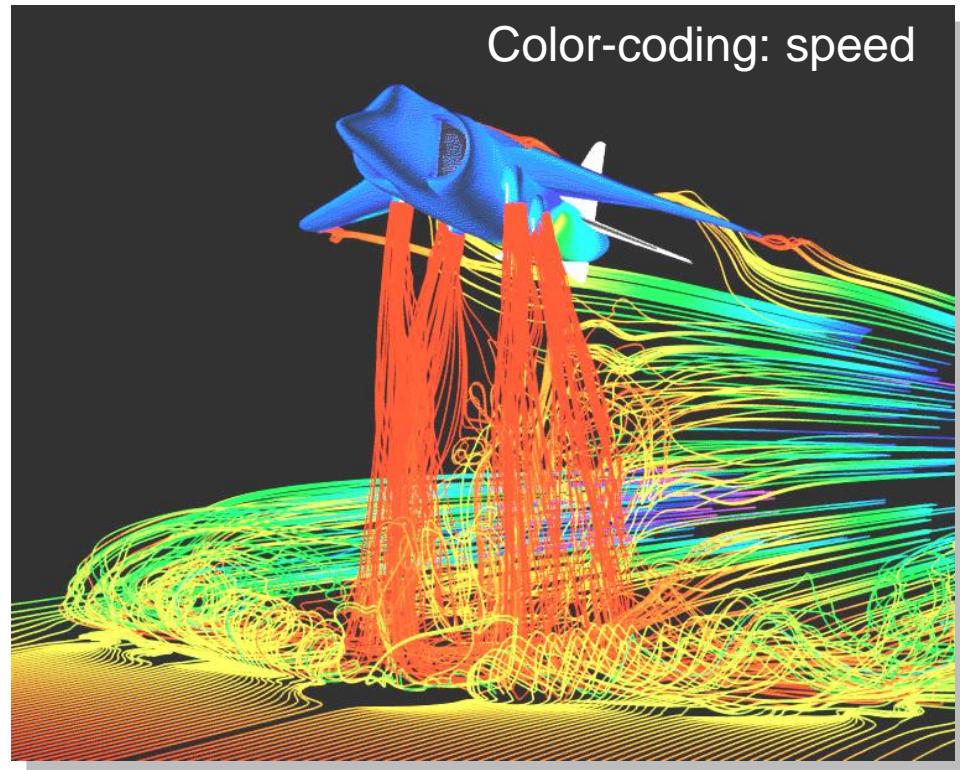
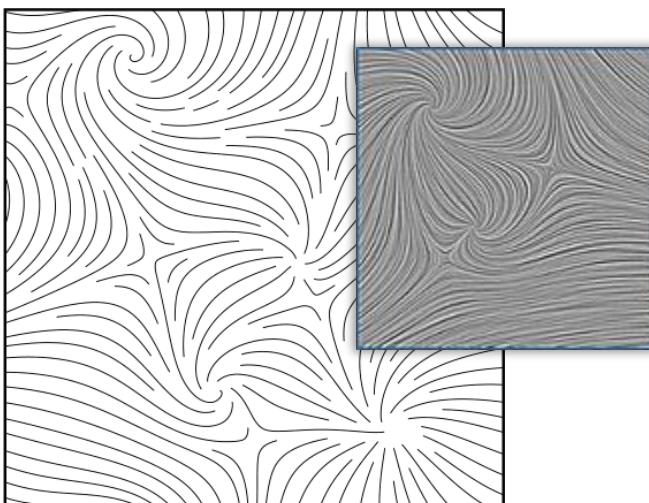
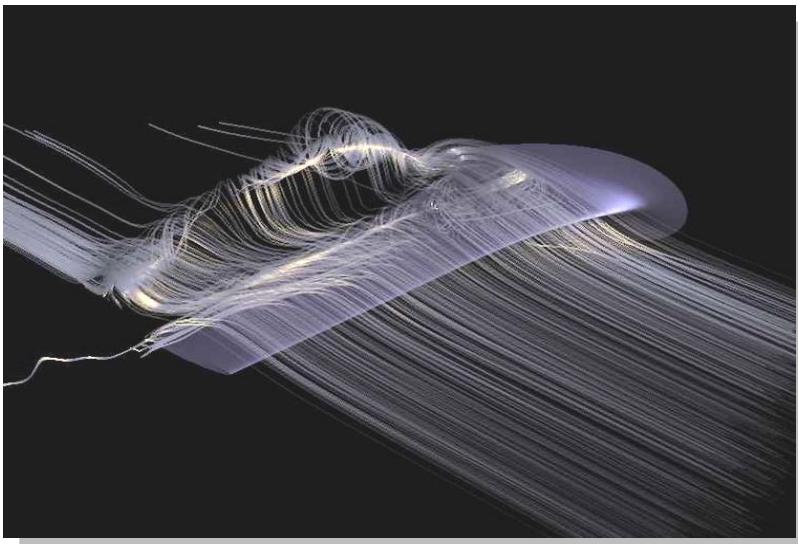
Data sources - CFD

- Visualization of flow data



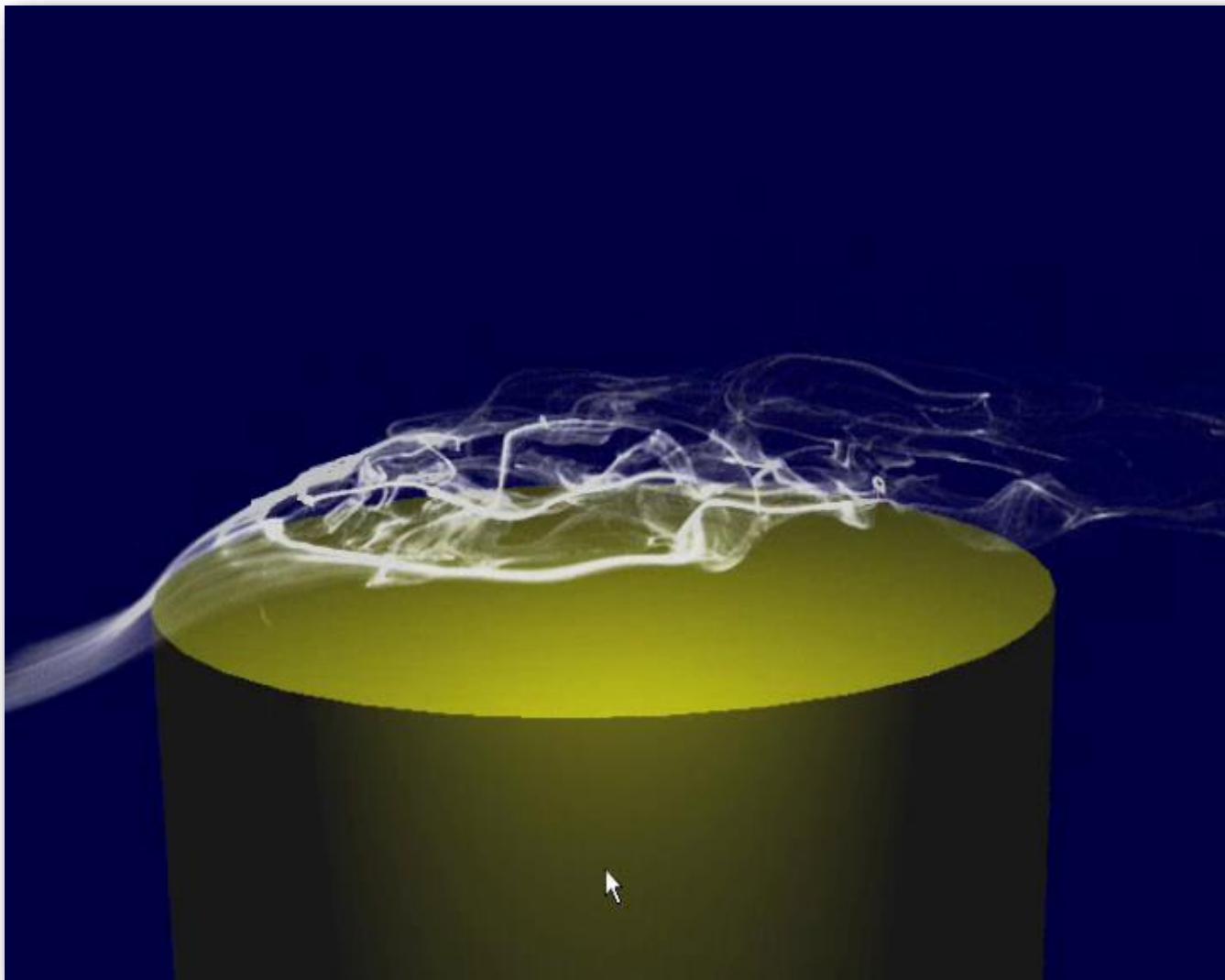
Data sources - CFD

- Visualization of flow data



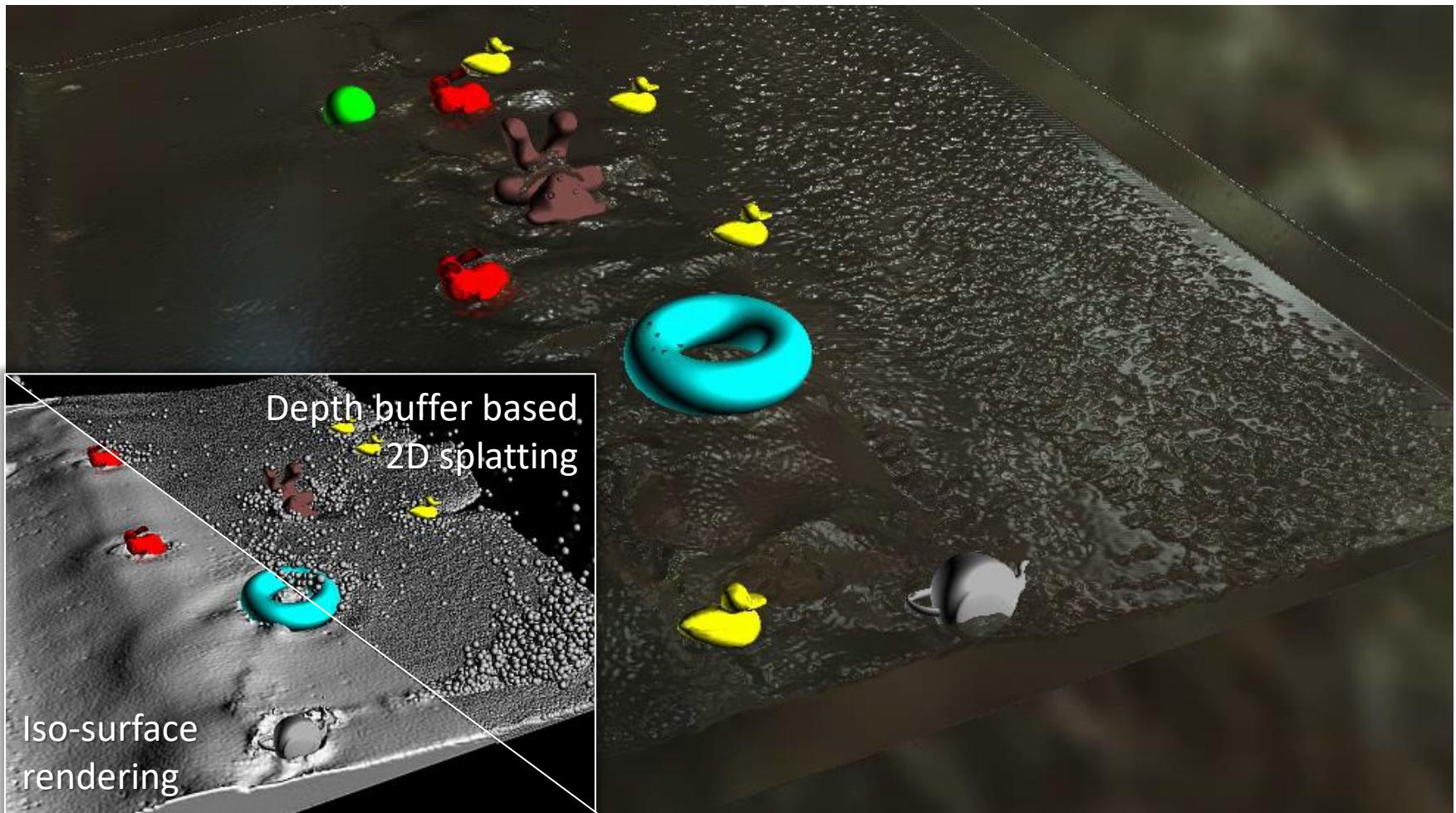
Data sources - CFD

- The virtual windtunnel



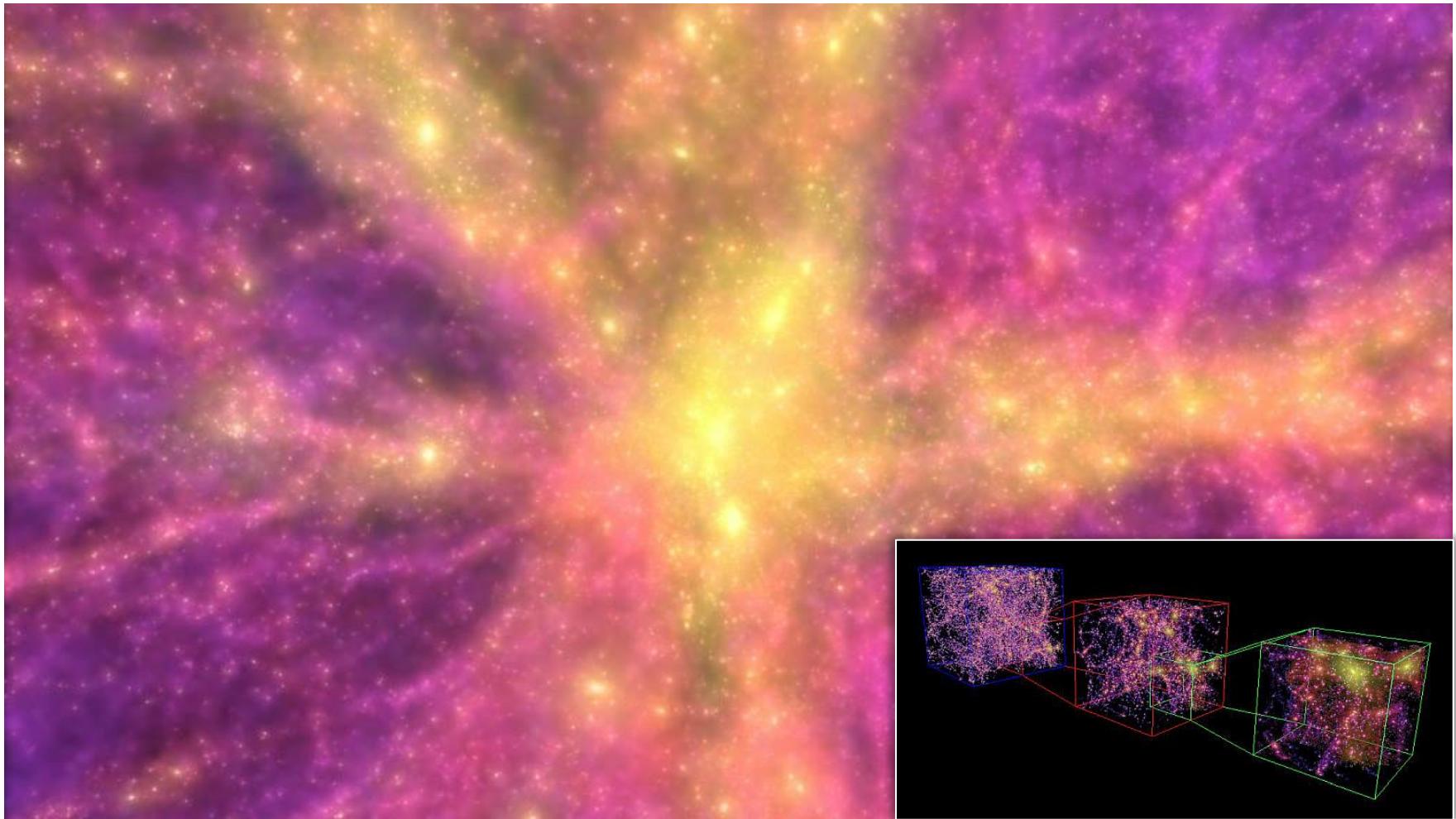
Data sources - CFD

- Visualization of particle simulation data



Data sources – gas dynamics

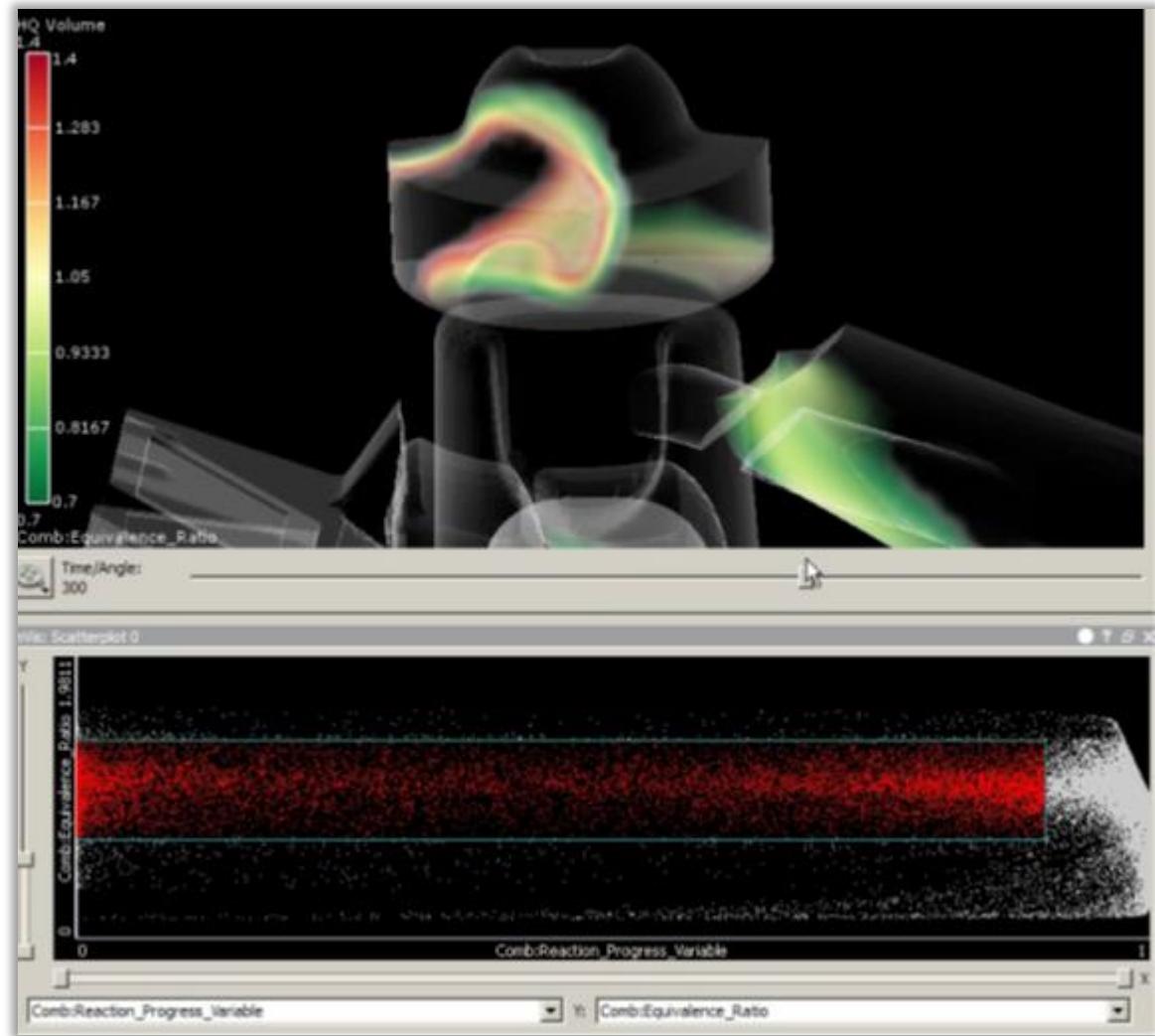
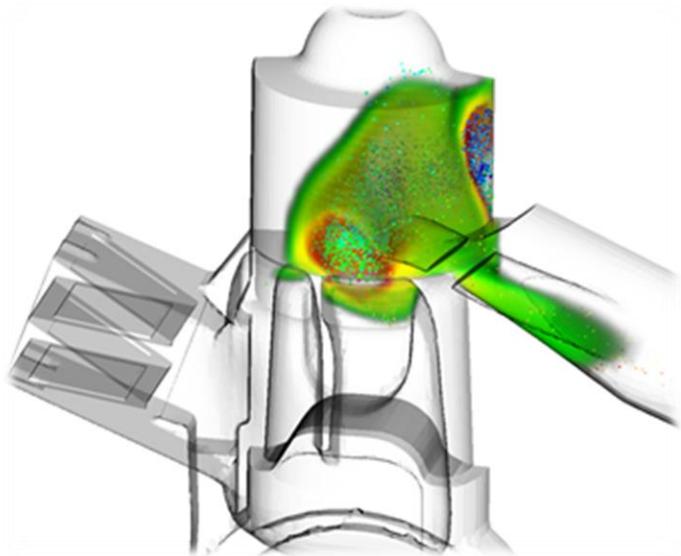
- Visualization of particle simulation data



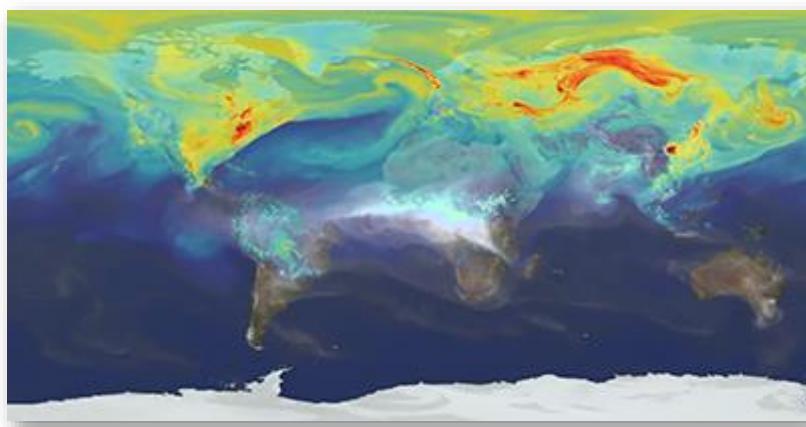
Millennium Run Dataset, 42 Million visible Particles

Data sources - CFD

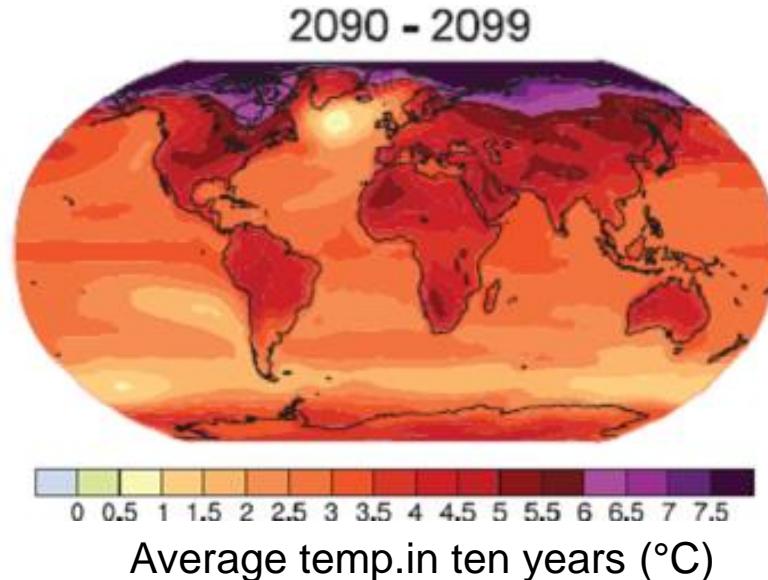
- Combustion process in a two-stroke engine



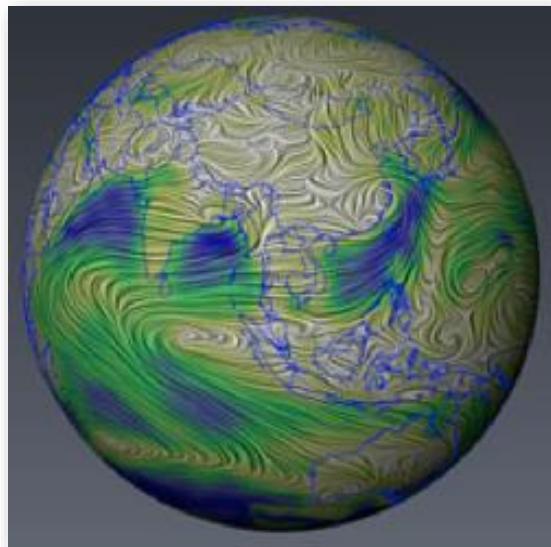
Data sources – geosciences



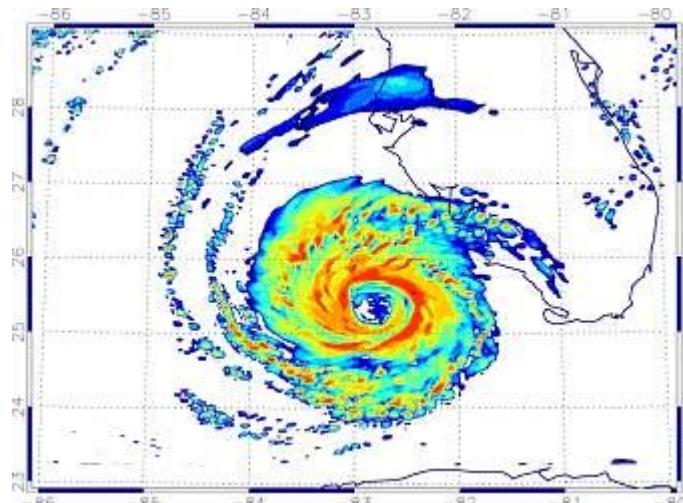
CO₂ in atmospheric flow ([link](#))



[from IPCC AR #4, 2007]



Wind flow paths over
Earth's surface



Hurricane visualization

Data sources

- Theoretical world
- Computer simulations

- Commercial

- Business graphics
 - Economic models
 - Financial modeling

TB

GB

- Artificial world

- Drawings
 - Painting
 - Publishing

MB

- TV (teasers, commercials)
 - Movies (animations, special effects)

GB

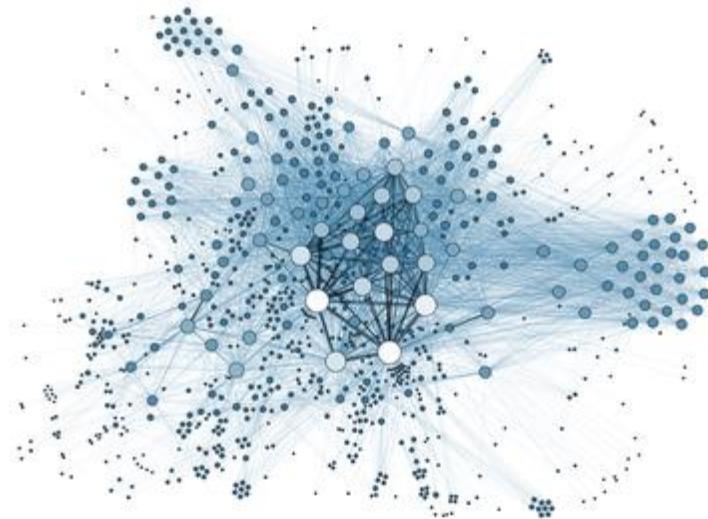
TB

Data sources

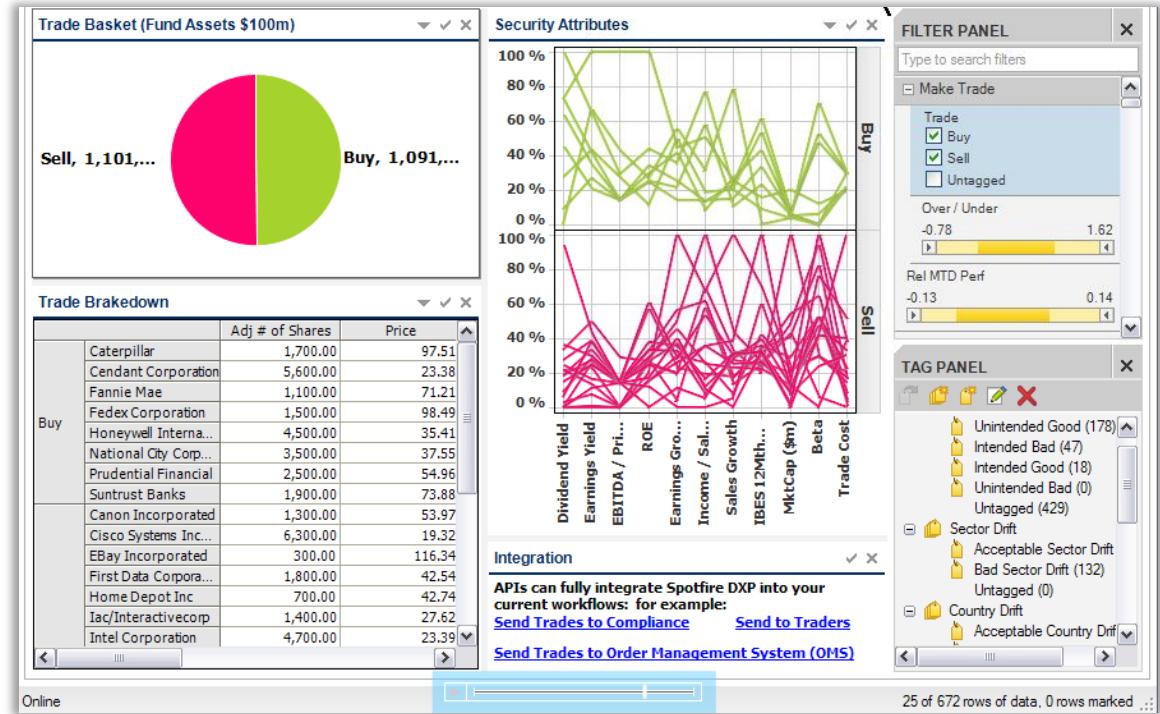
- Information systems

- Stock market
(billions of transactions per day)
- Social Networks
- World Wide Web !!!

PB



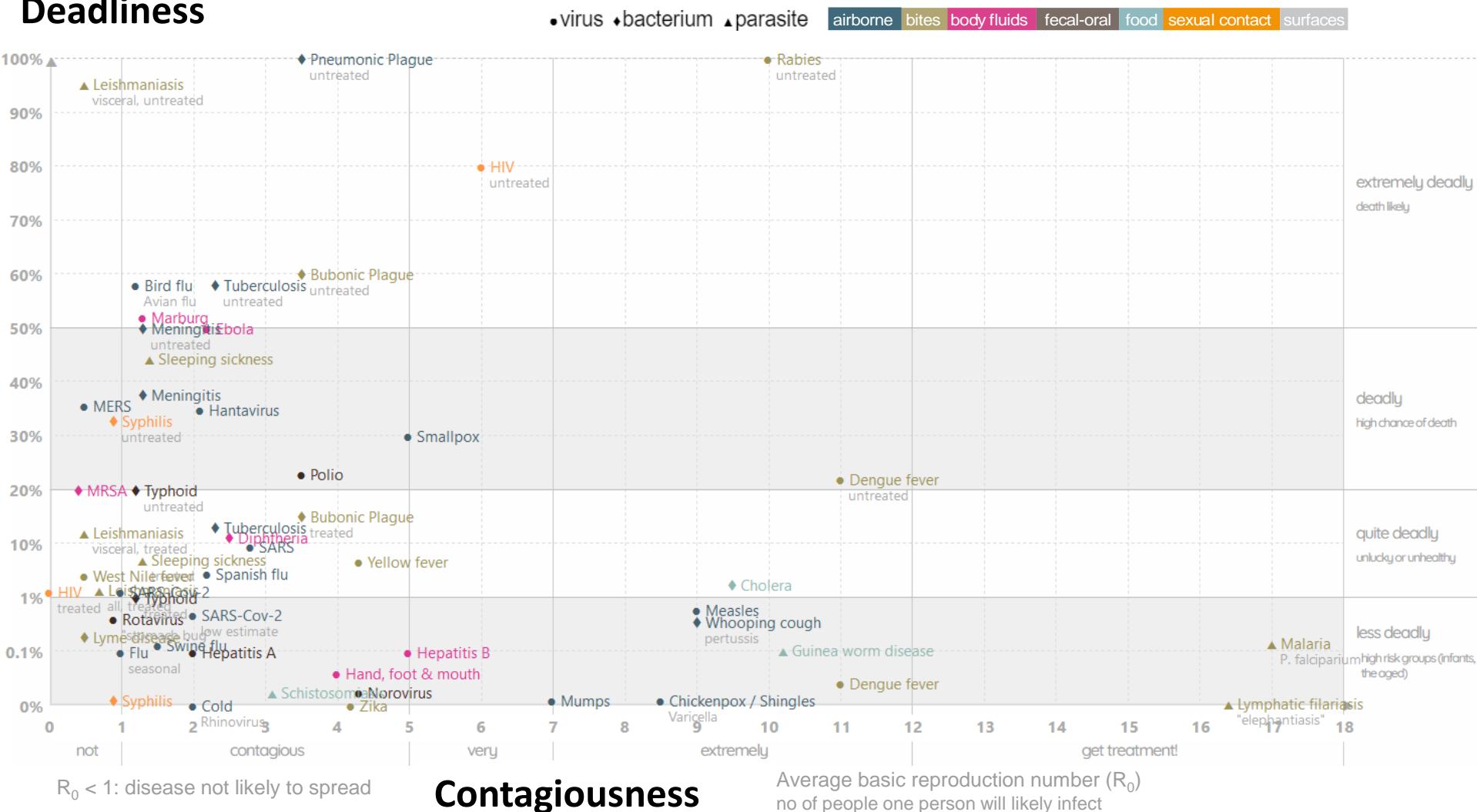
- Examples
 - Spotfire
 - Tableau
 - Google Analytics



Infectious Diseases in Context

David McCandless et al. (2014)

Deadliness



$R_0 < 1$: disease not likely to spread

Average basic reproduction number (R_0)
no of people one person will likely infect

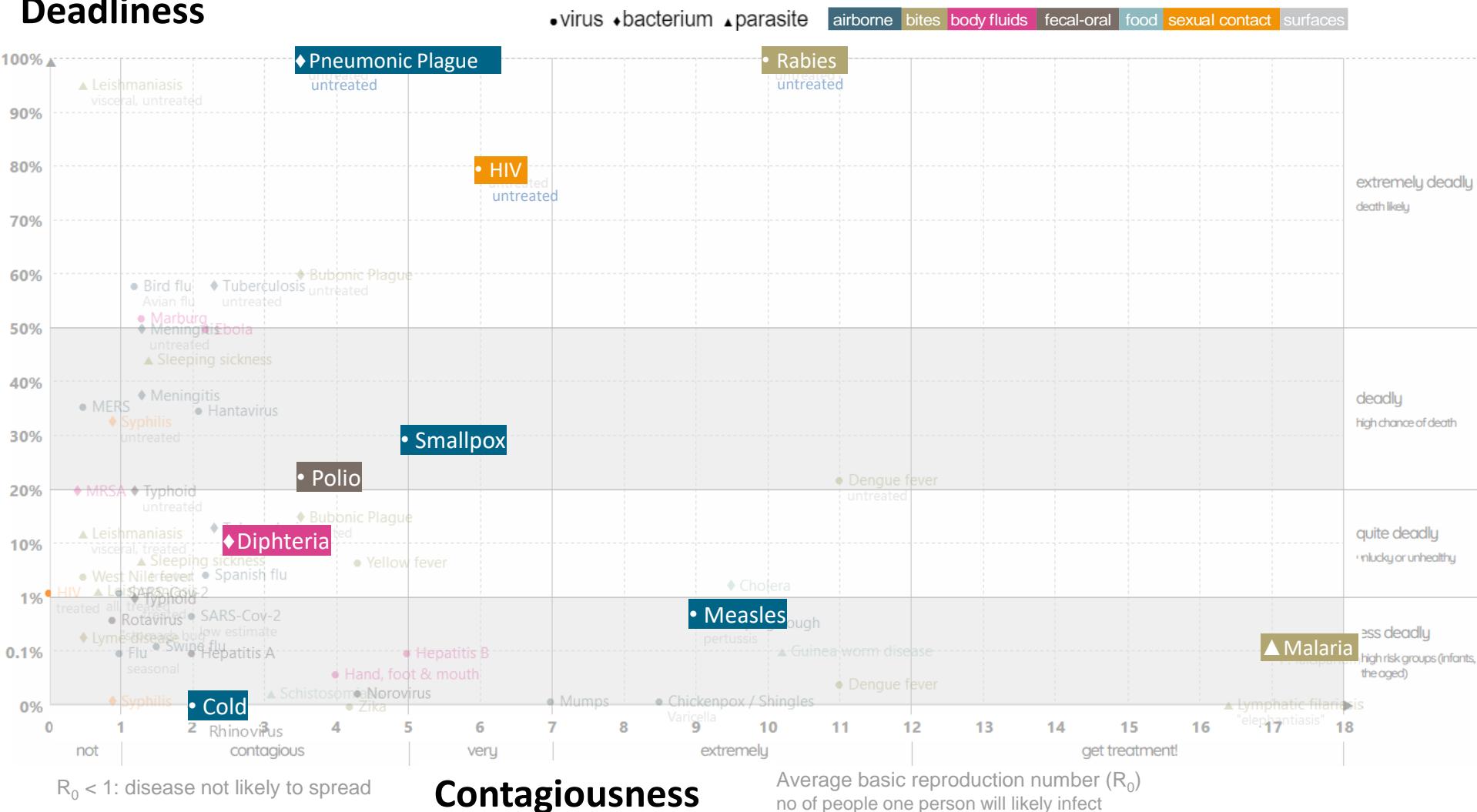
Sources: Centers for Disease Control, World Health Org, CIDRAP, studies

www.informationisbeautiful.net/visualizations/the-microbescope-infectious-diseases-in-context/

Infectious Diseases in Context

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Deadliness

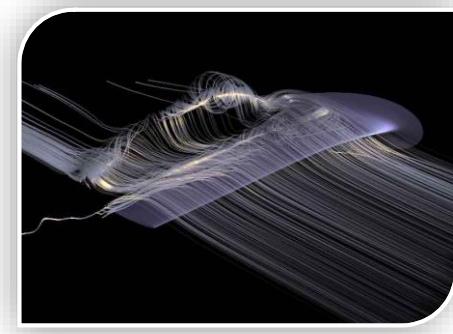
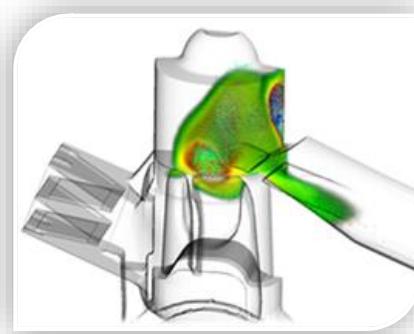
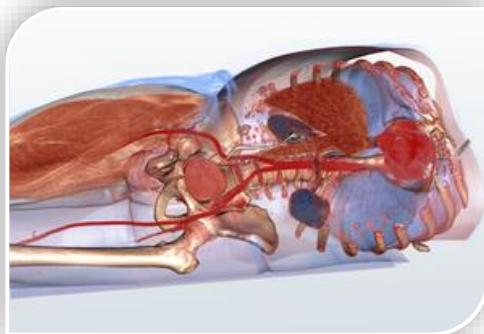


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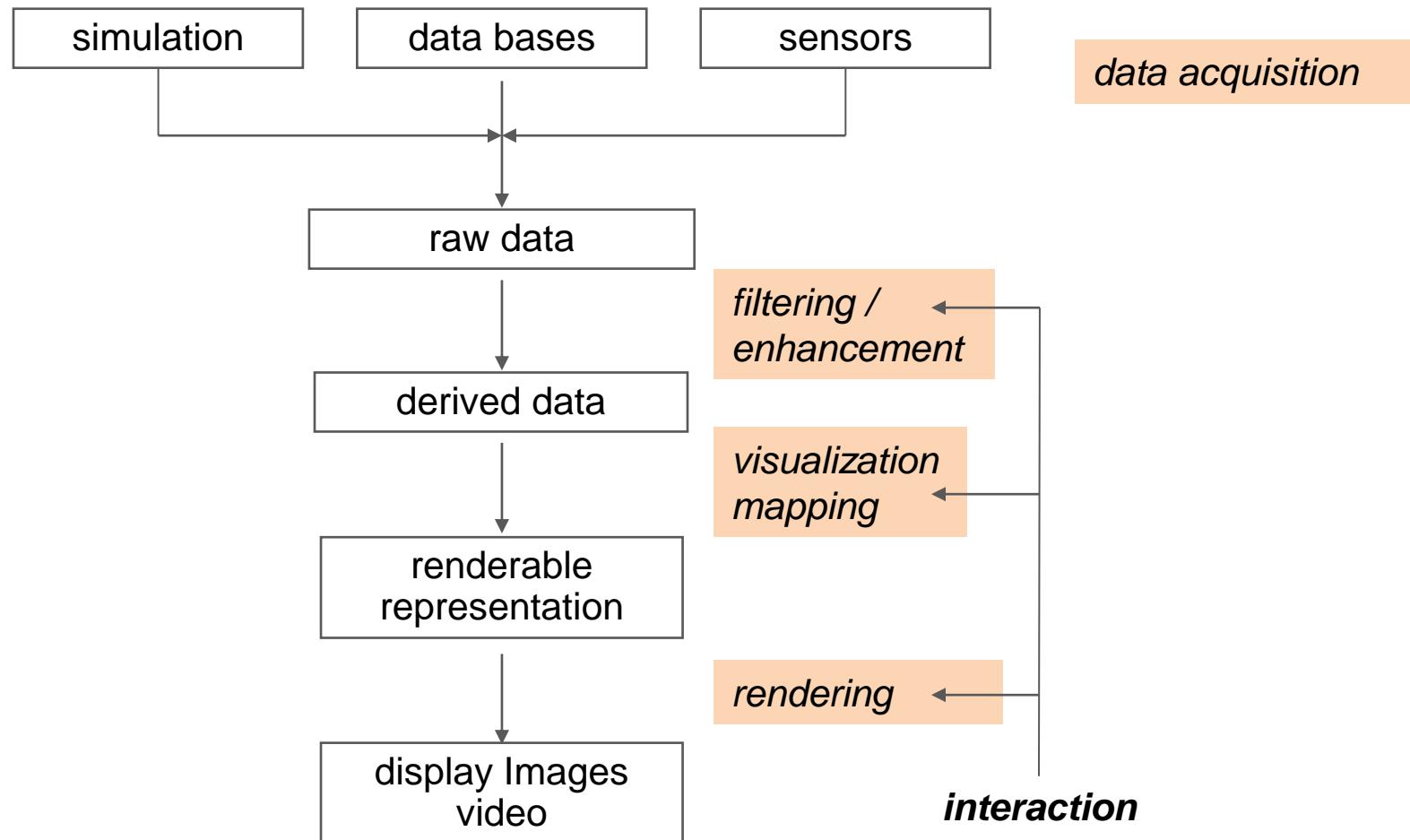
Visualization basics

Visualization pipeline & scenarios

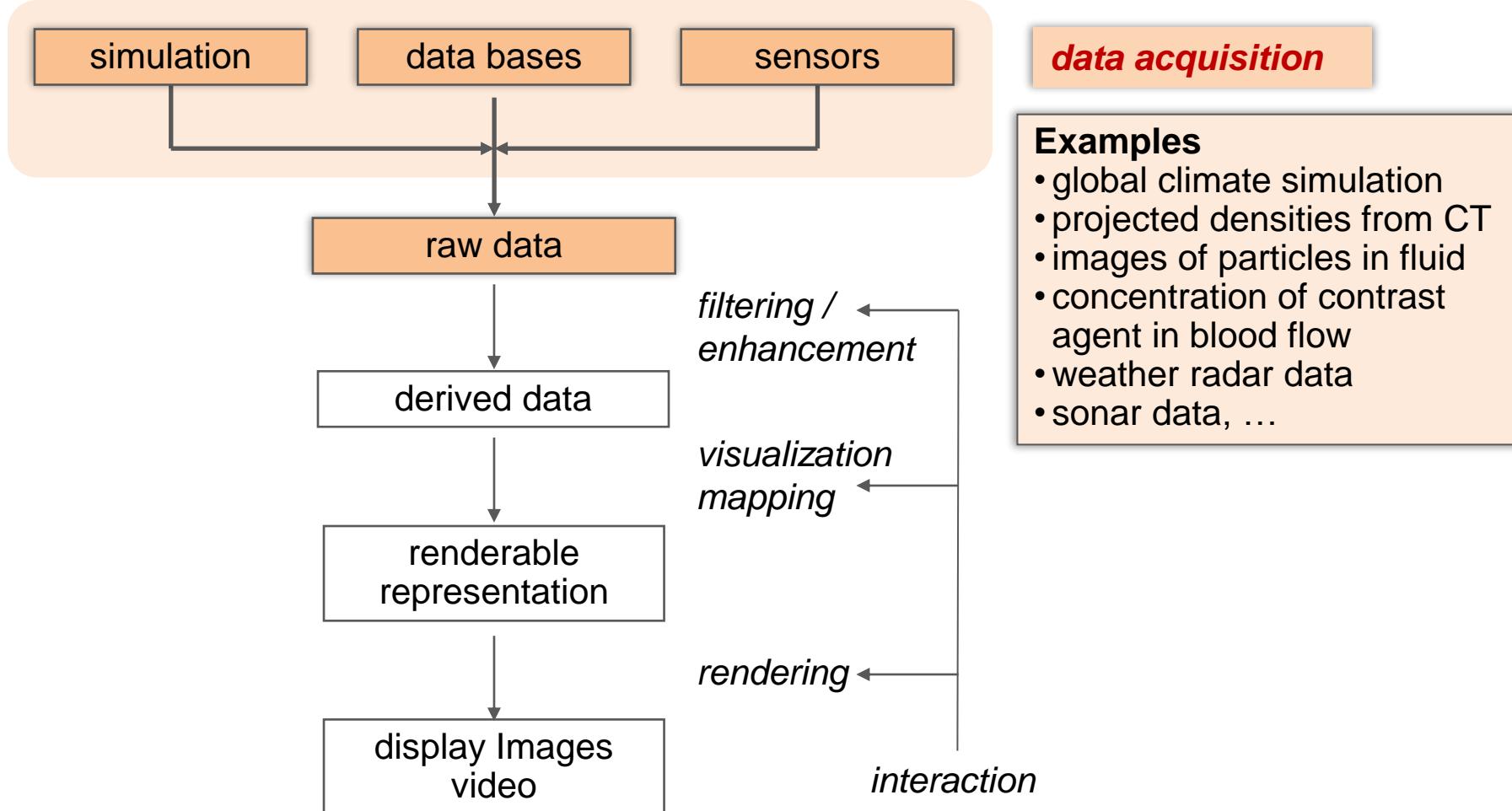


Visualization pipeline

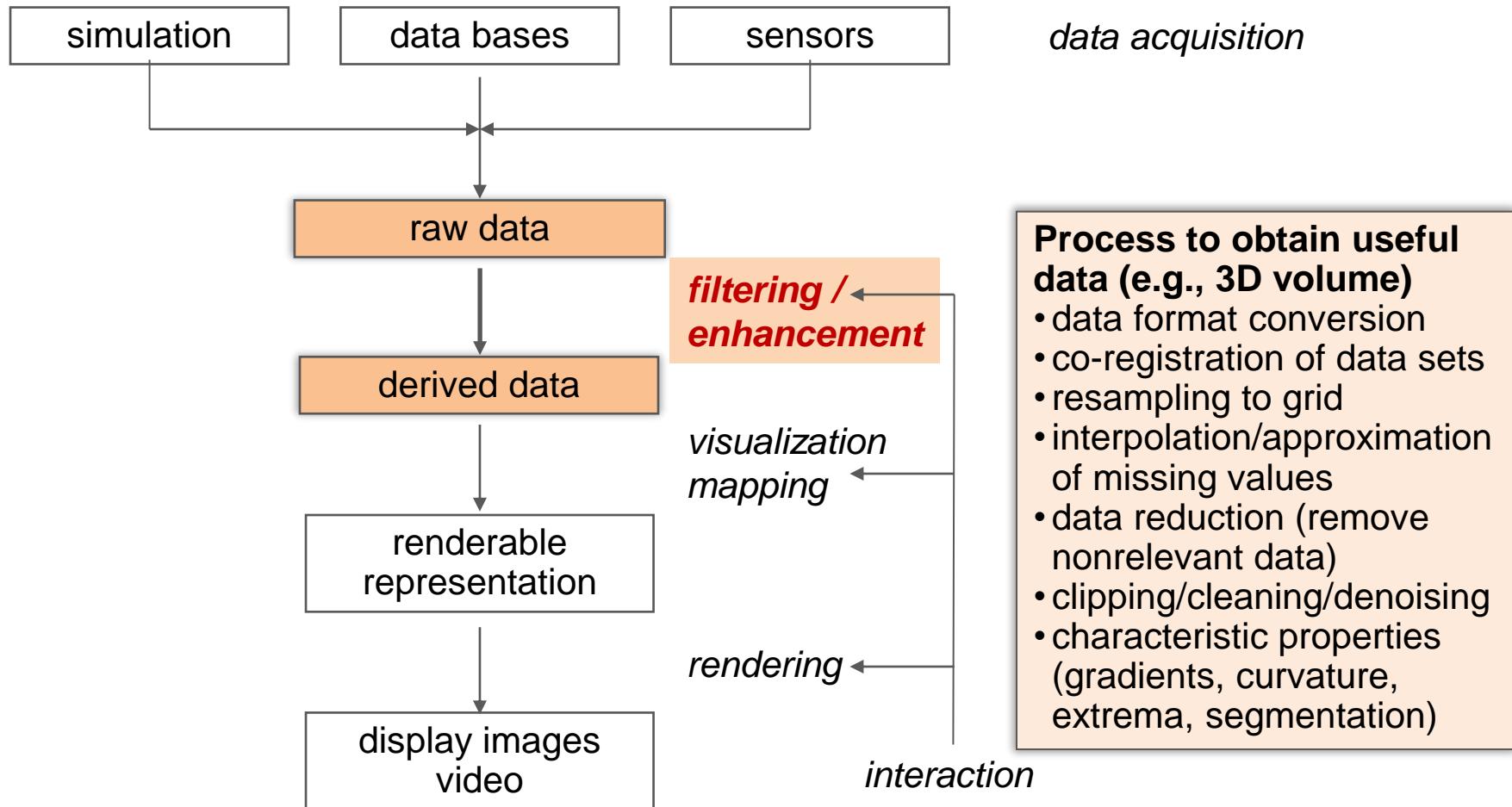
- A general model of visualization process with 4 stages
- User can interact with the process at each stage



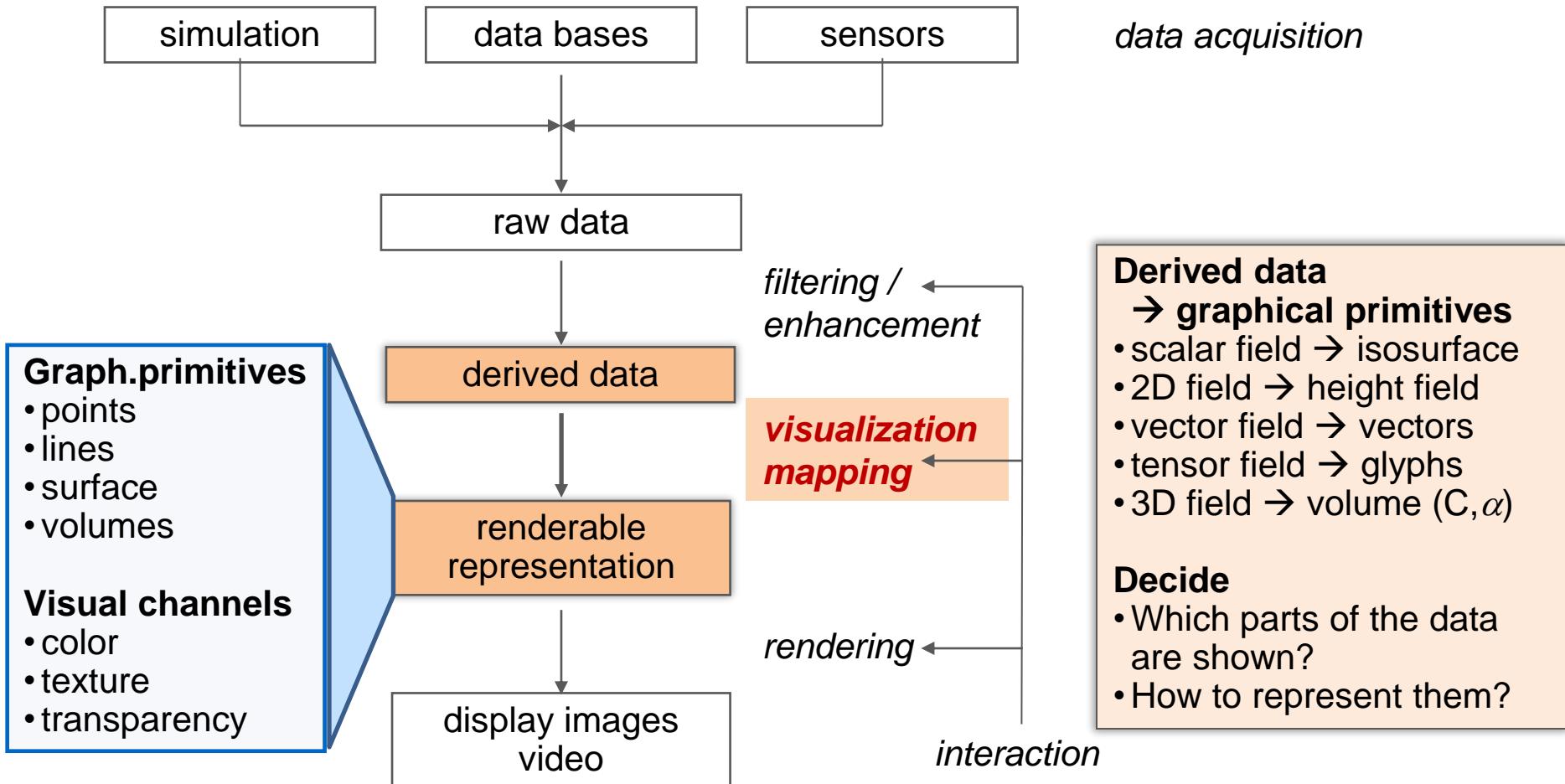
Visualization pipeline



Visualization pipeline

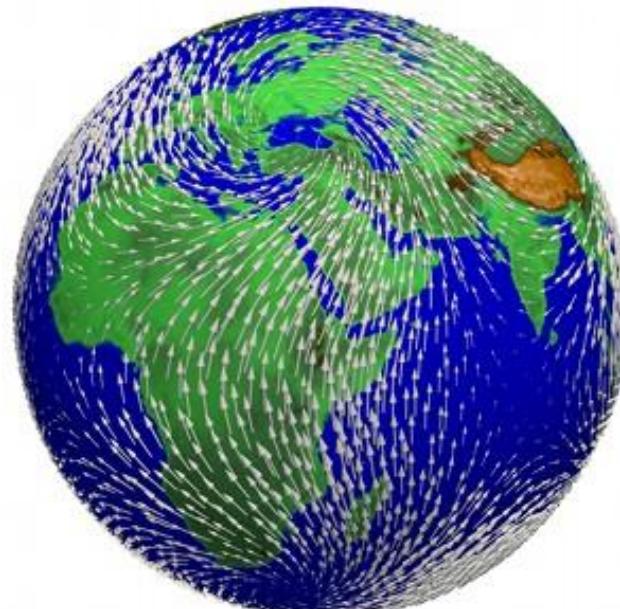
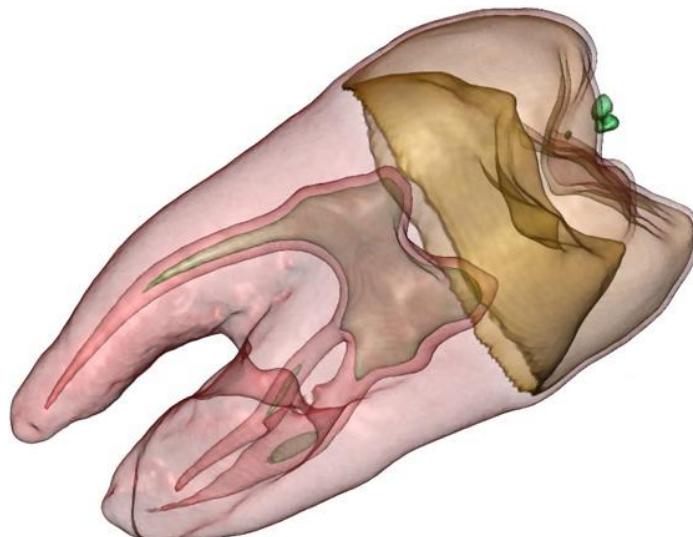
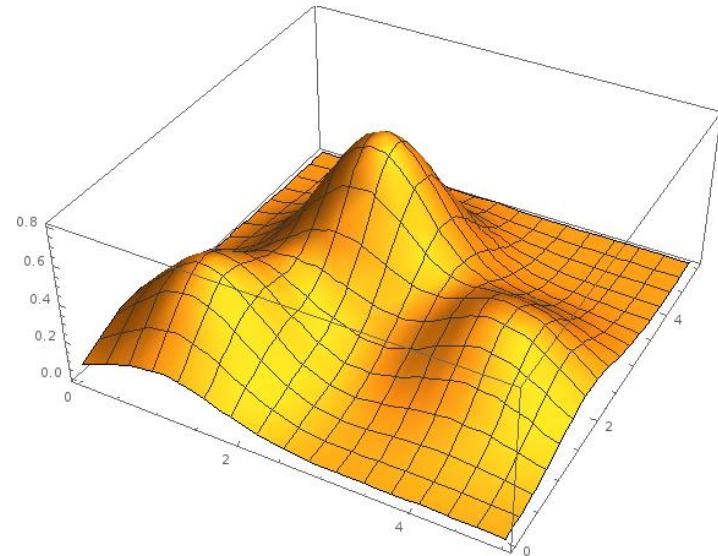
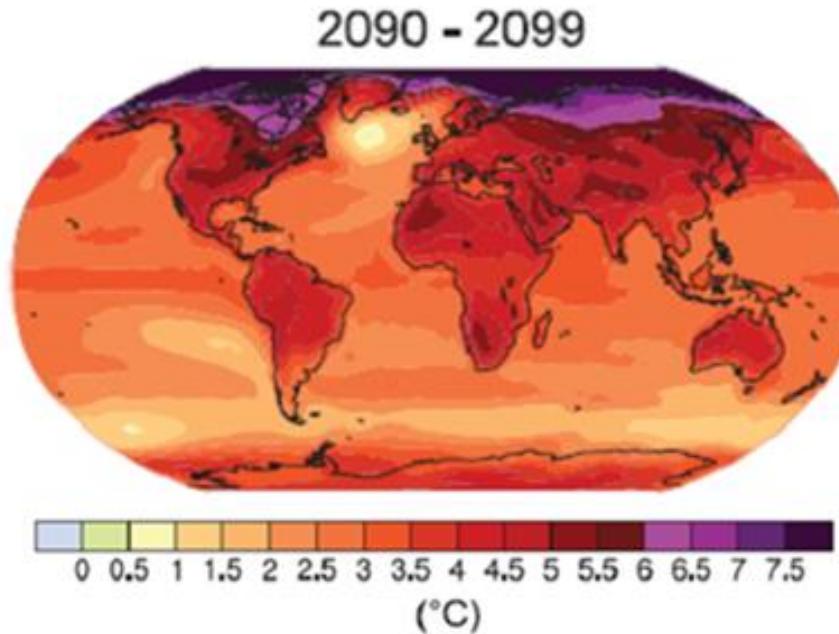


Visualization pipeline



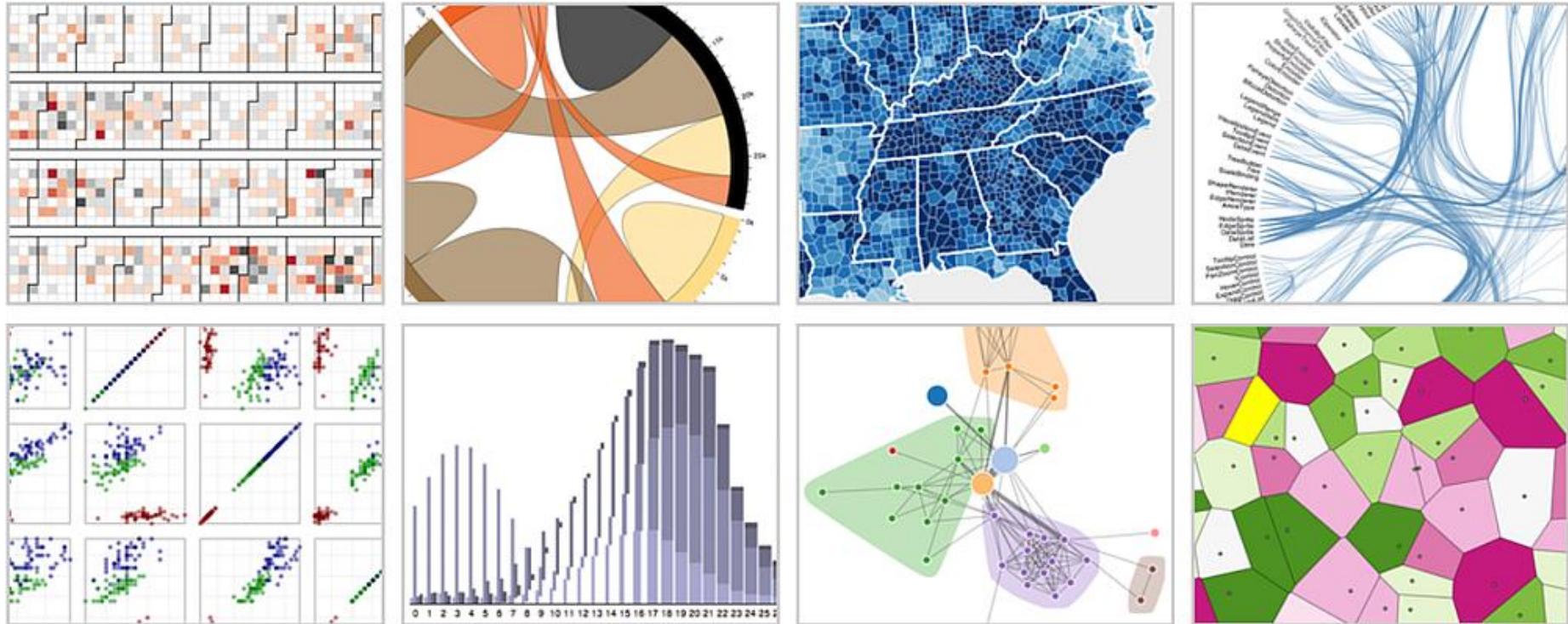
Visualization Mappings – Examples

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Visualization Mappings – Examples

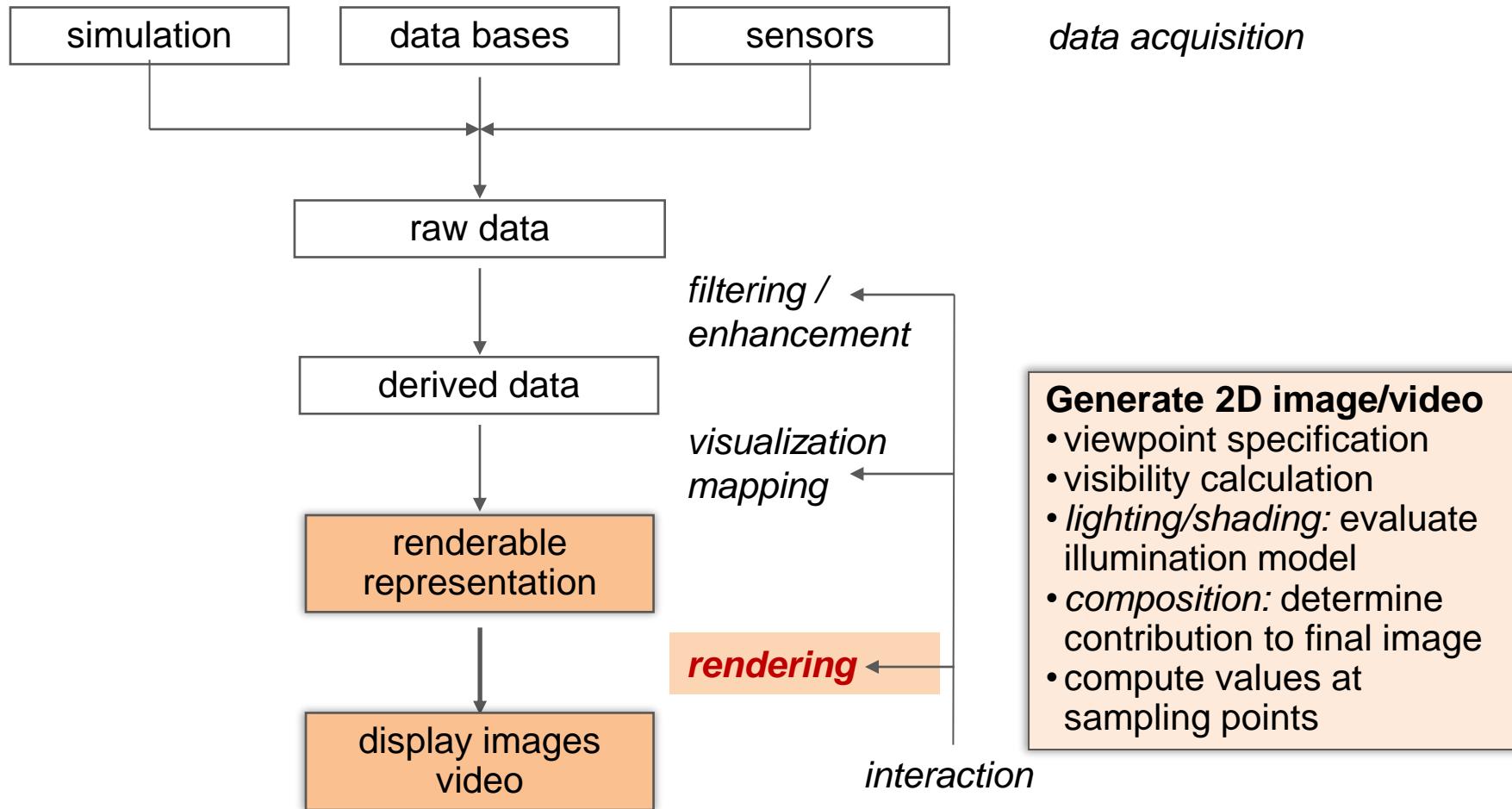
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Interactive visualizations built with D3. From left to right: calendar view, chord diagram, choropleth map, hierarchical edge bundling, scatterplot matrix, grouped & stacked bars, force-directed graph clusters, Voronoi tessellation

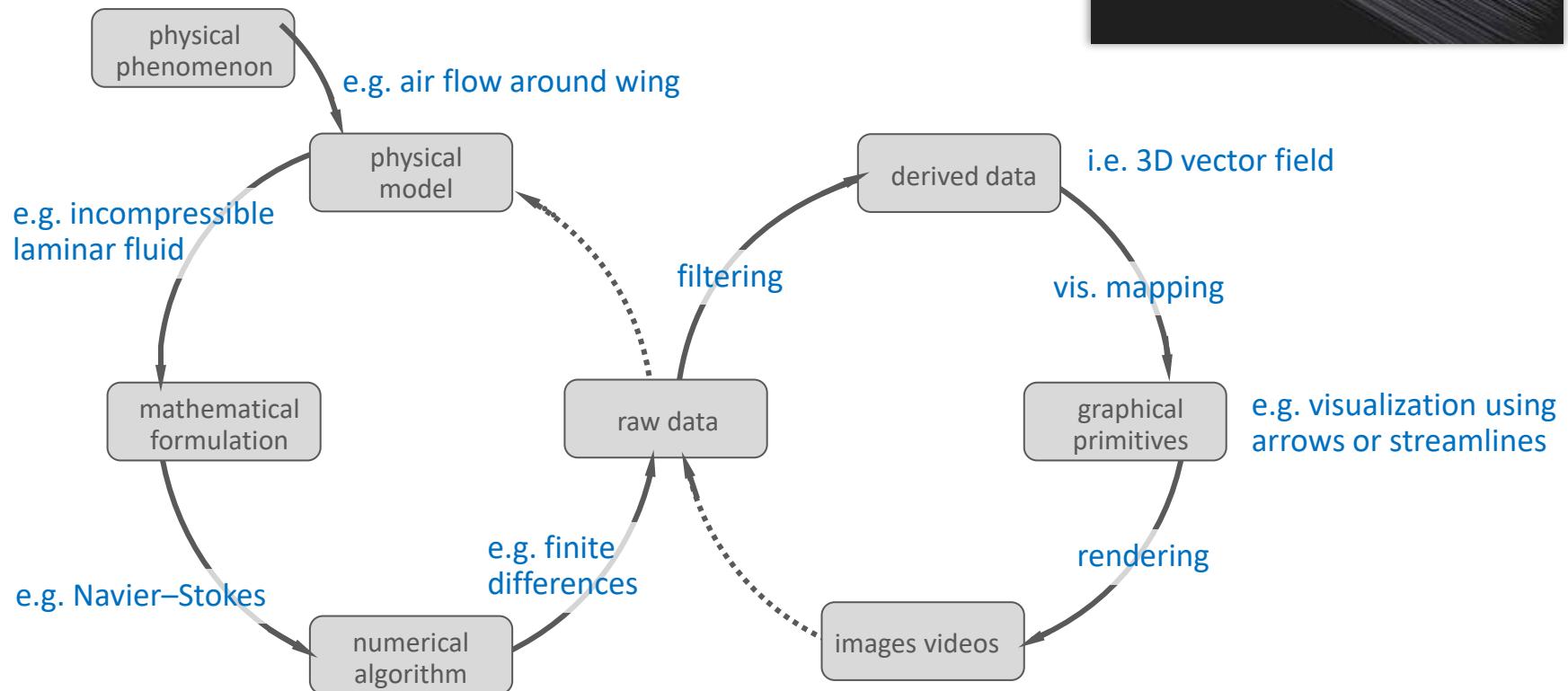
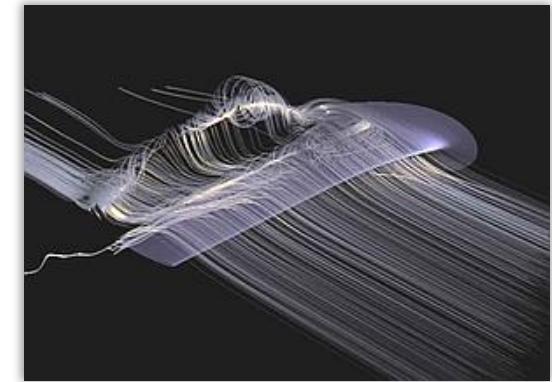
<https://d3js.org/>

Visualization pipeline



Visualization pipeline

- Example: simulation of the flow around an airplane wing

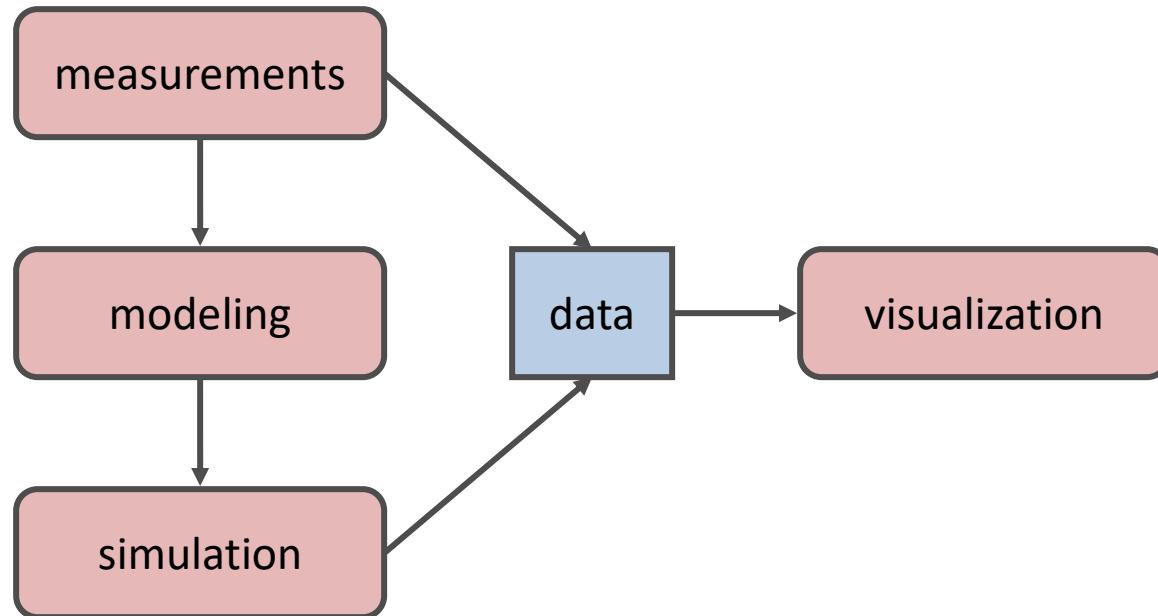


Data, Visualization, Interaction

- Data generation/acquisition
 - Measuring, simulation, modeling
 - Can take very long (measuring, simulation)
 - Can be very expensive (simulation, modeling)
- Visualization (rest of vis. pipeline)
 - Data filtering/enhancement, vis.mapping, rendering
 - Depends on computer/implementation: fast or slow
- Interaction (user input)
 - How can users change parameters, viewpoint, etc.

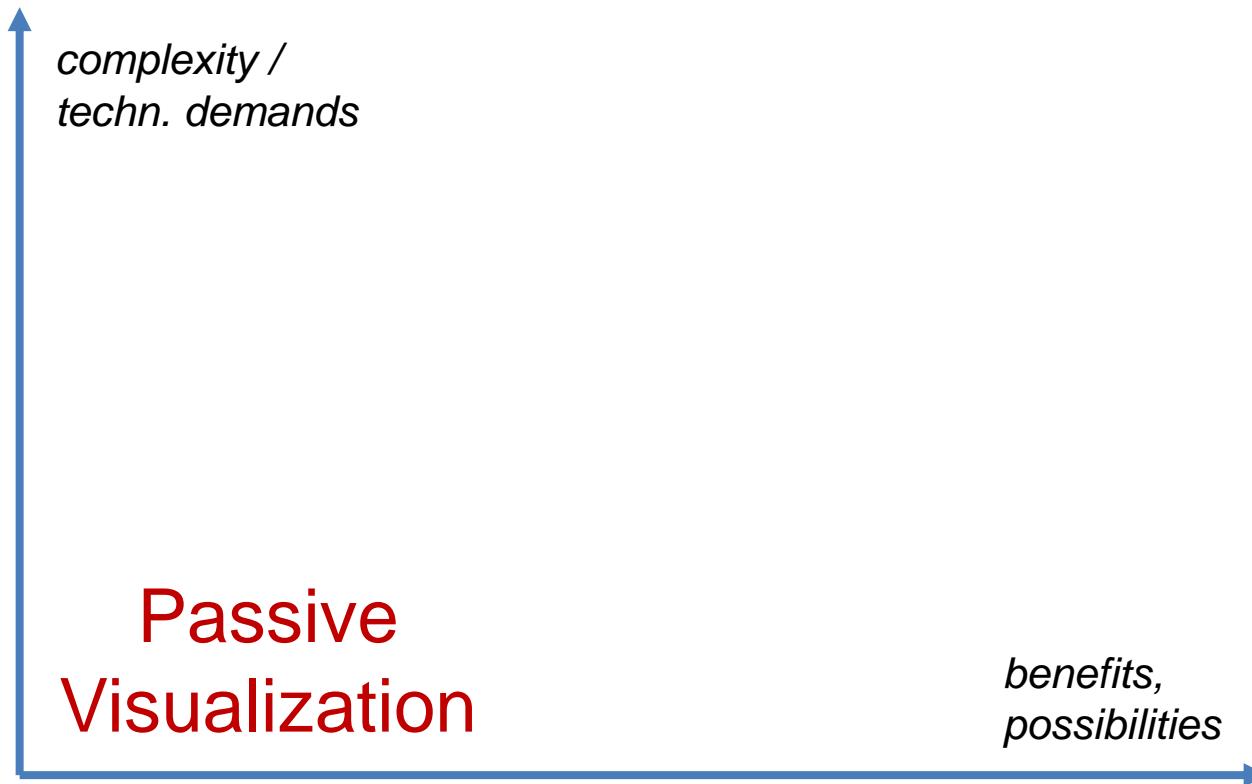
Visualization Scenarios

- How closely is visualization connected to data generation?
- Scenario: Passive visualization



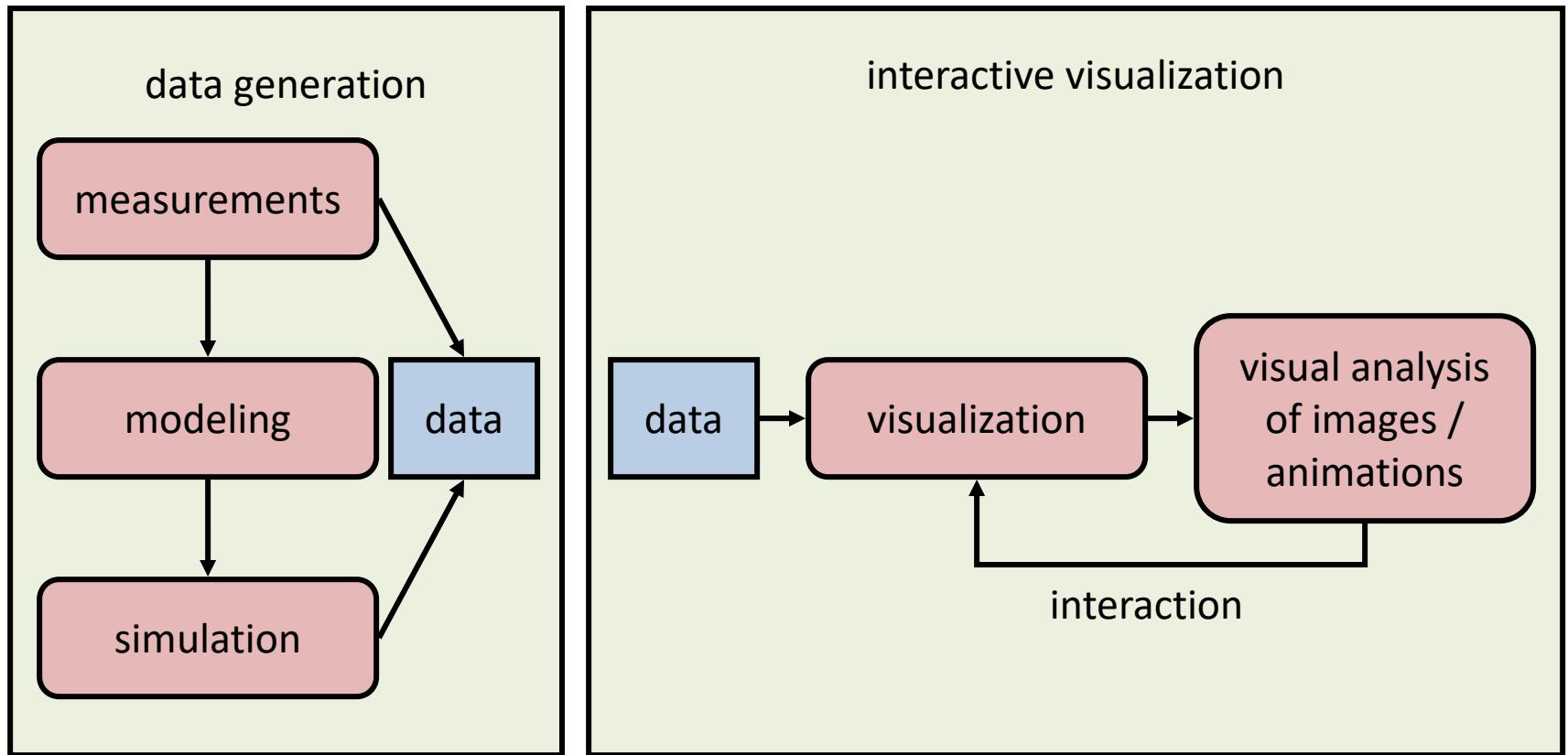
Visualization Scenarios

- How closely is visualization connected to data generation?



Visualization Scenarios

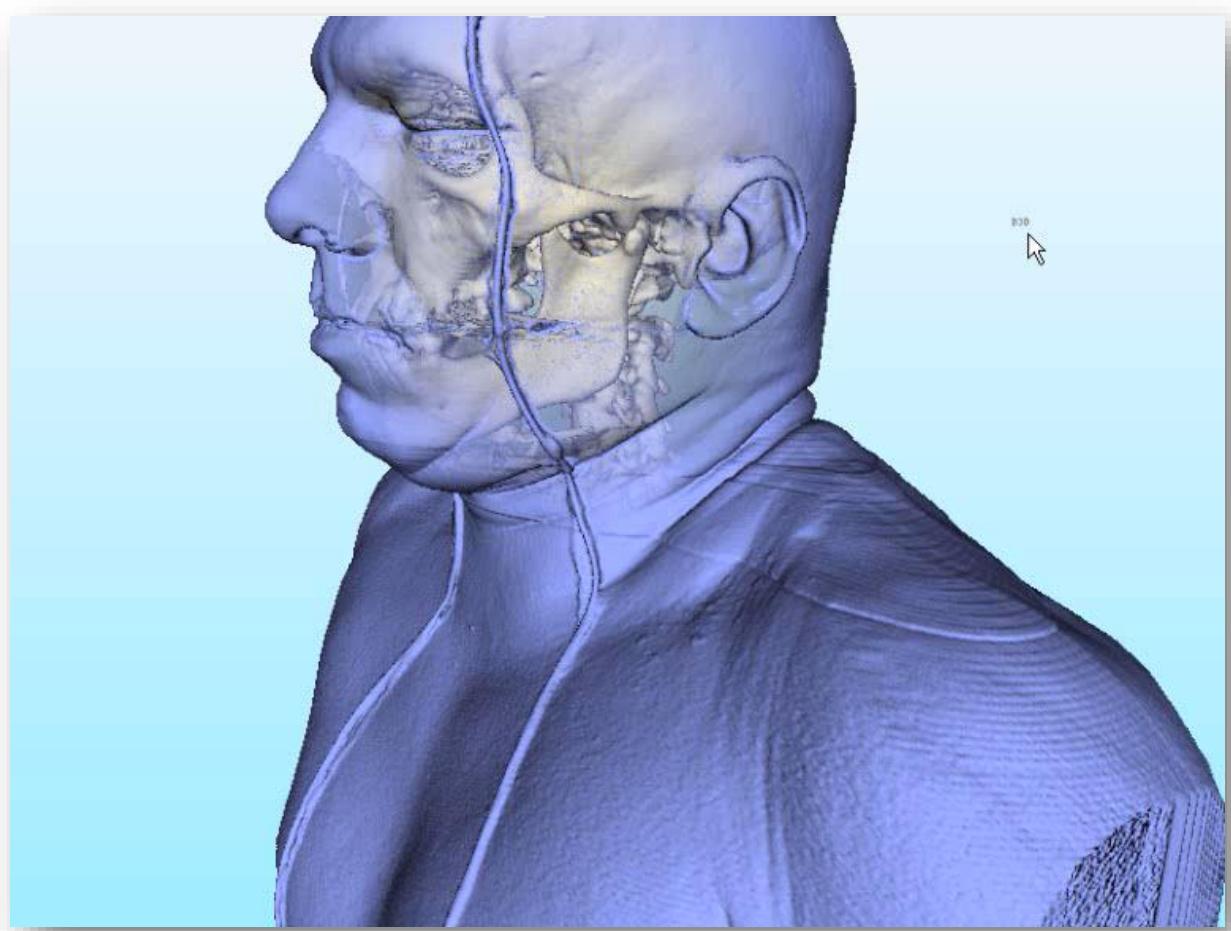
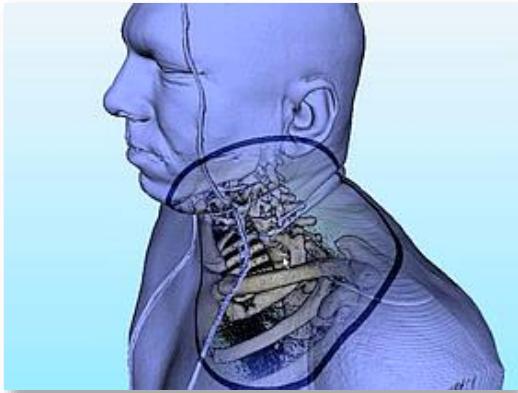
- Scenario: Interactive visualization



Example: Interactive Visualization

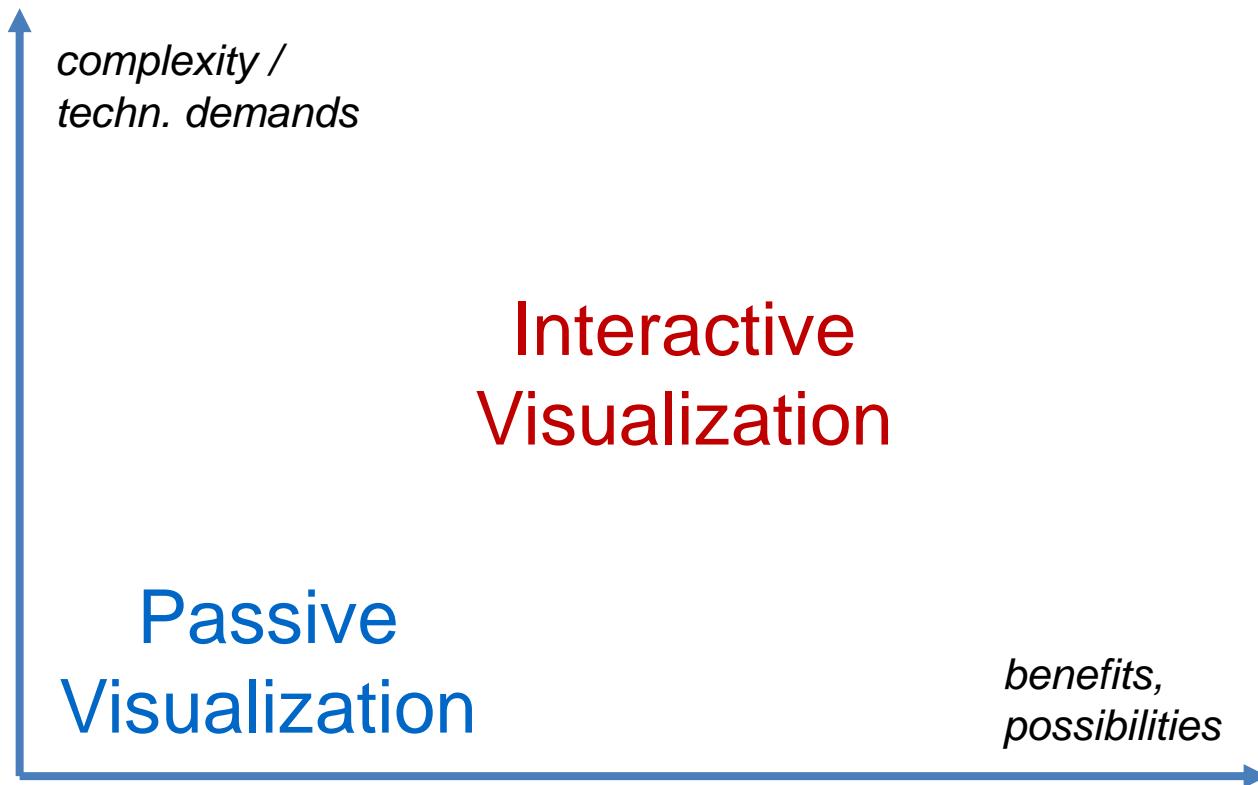
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- Exploration of volumetric dataset



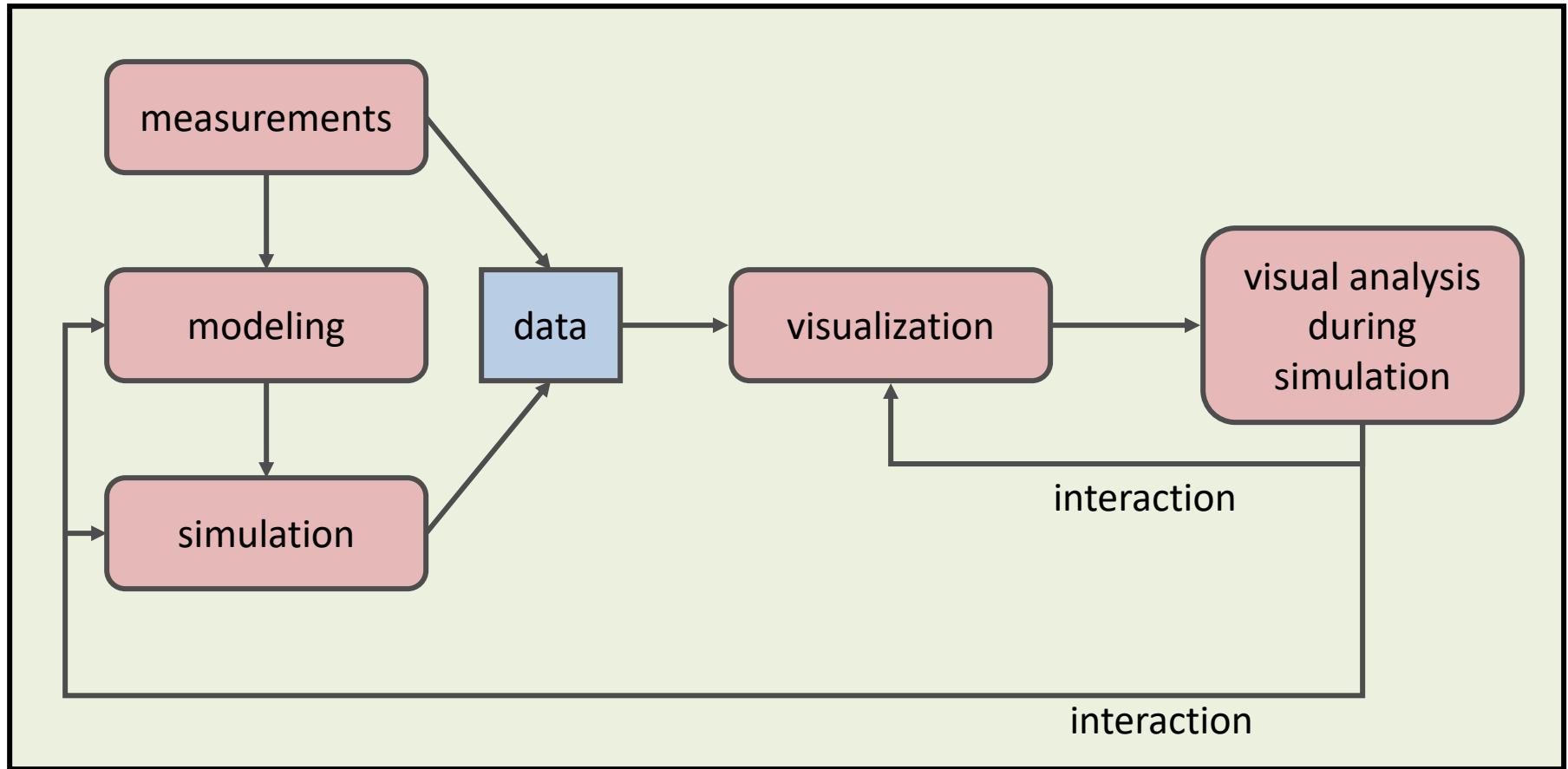
Visualization Scenarios

- How closely is visualization connected to data generation?



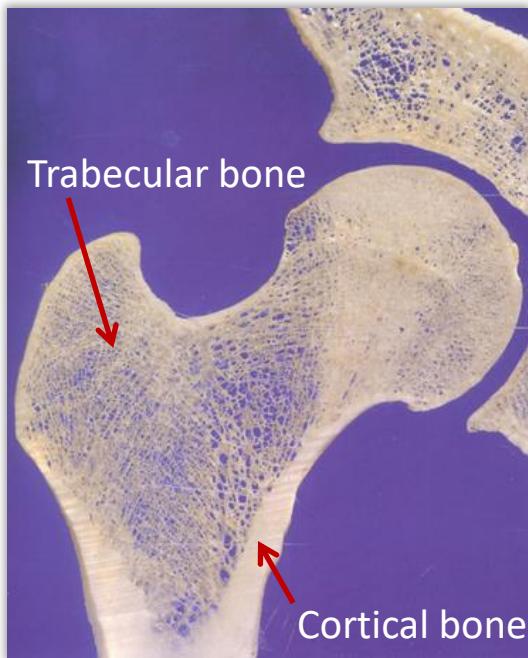
Visualization Scenarios

- Scenario: Computational / visual steering



Example: Visual Steering

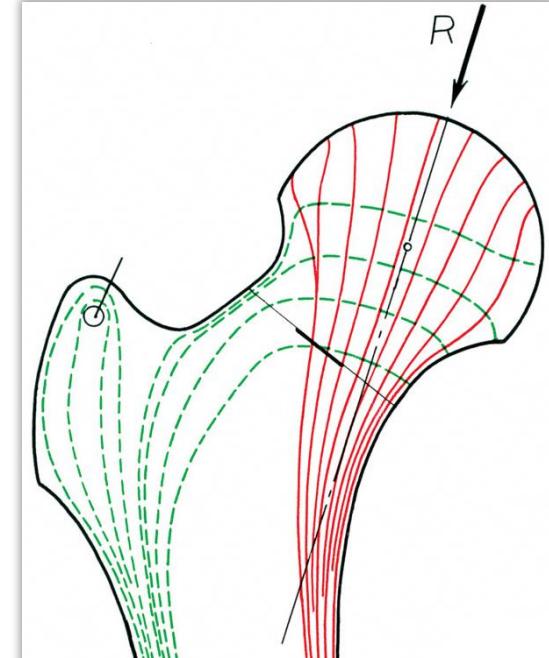
- Two types of bone tissue
 - Trabeculae are aligned along the principal stress directions (Wolff's law)



Cross section



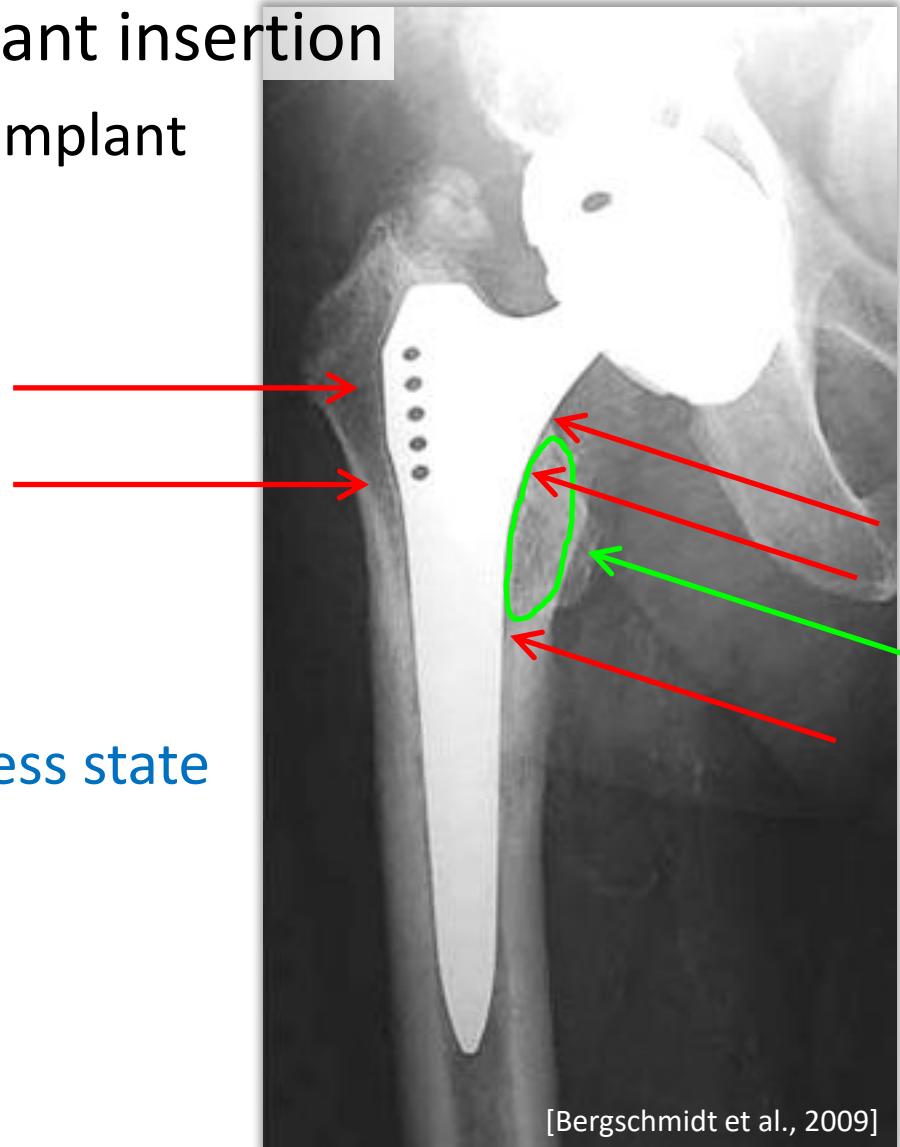
X-ray



Principal stress directions
[Pauwels, 1973]

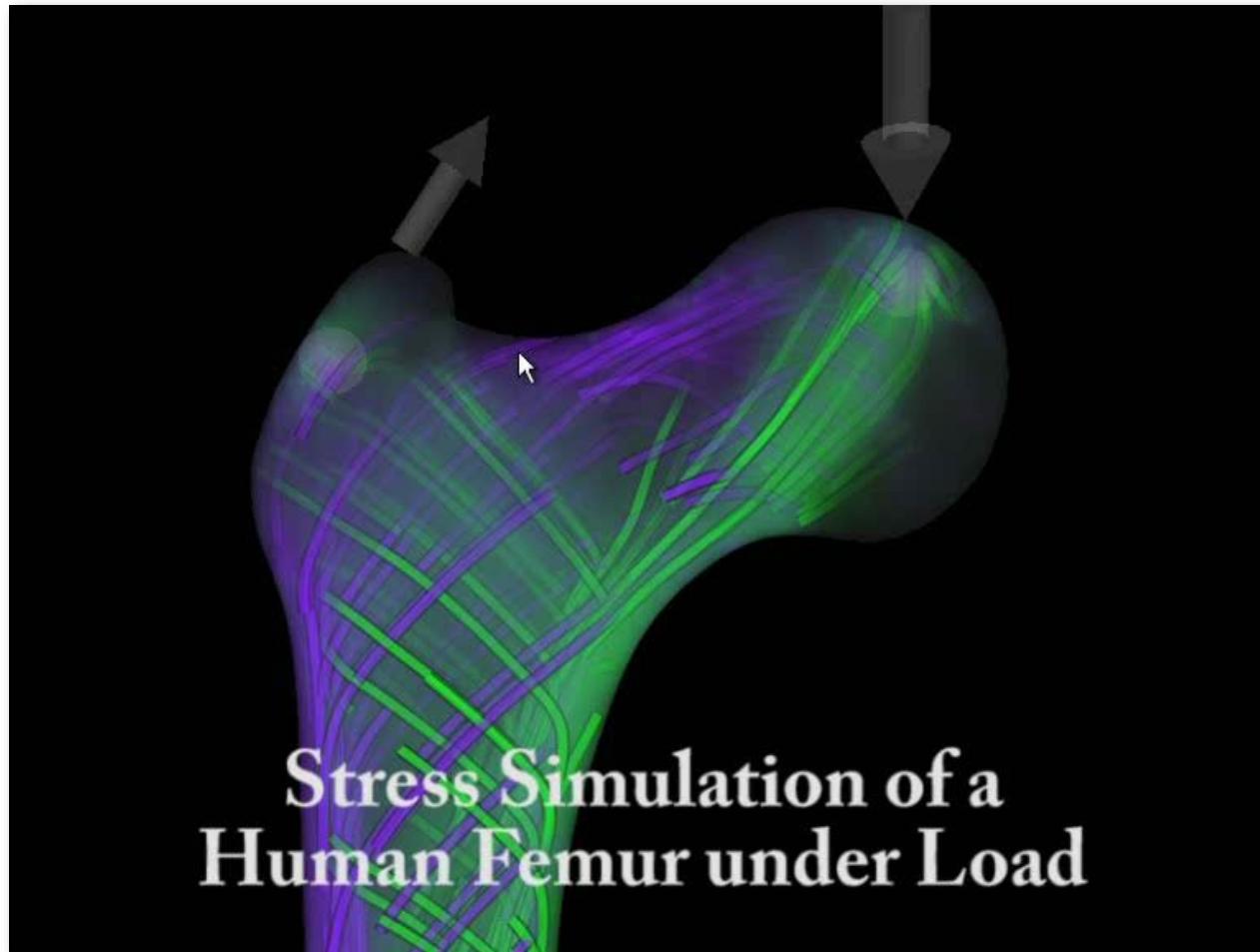
Example: Visual Steering

- Stress Shielding due to implant insertion
 - Stresses are **bypassed** by the implant
 - Adaptive **bone remodeling**
 - Bone degeneration,
fracture, loosening of
the implant
 - An optimal implant should
replicate the **preoperative stress state**



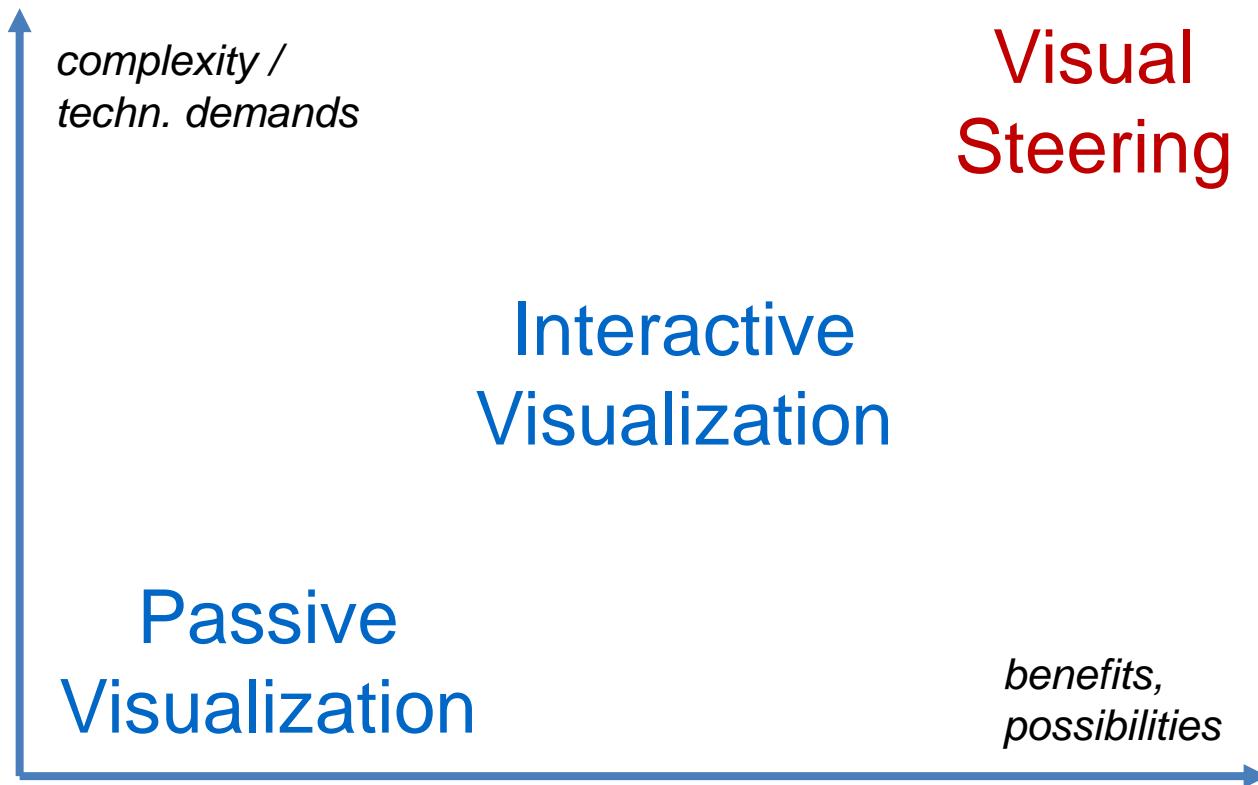
Example: Visual Steering

- Preoperative surgery planning



Visualization Scenarios

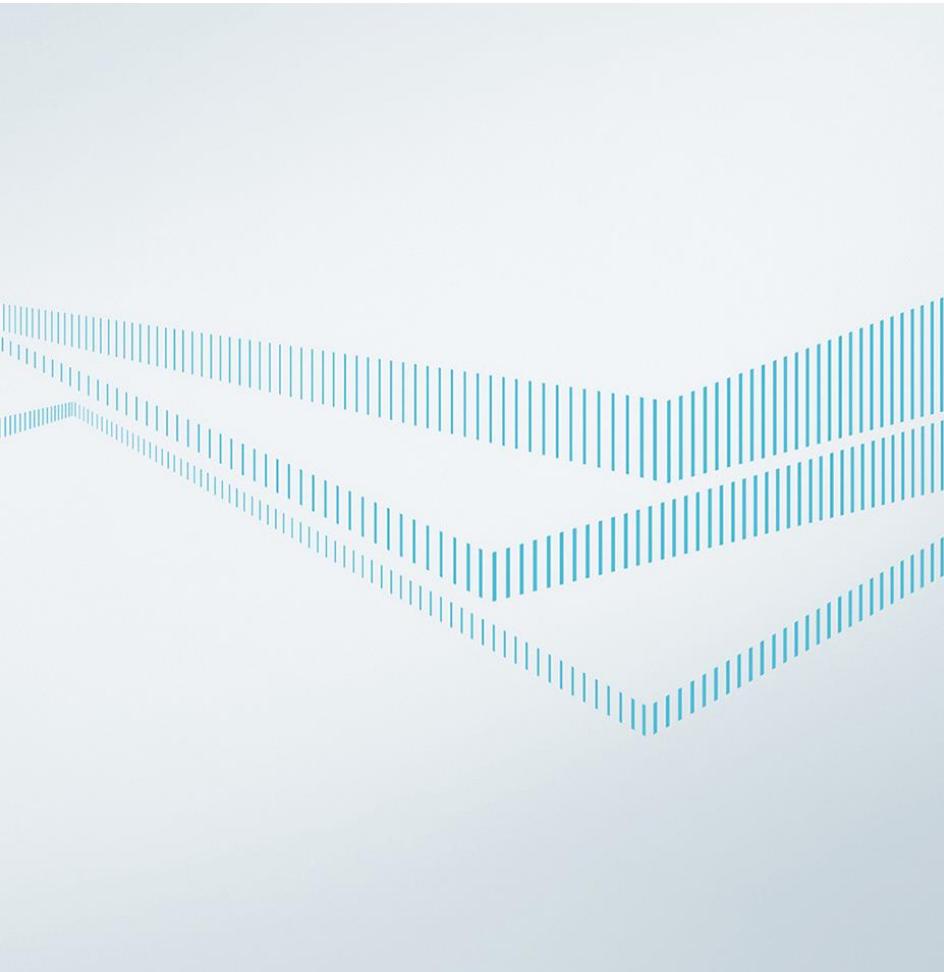
- How closely is visualization connected to data generation?



Acknowledgements

- M. Eduard Gröller
- Helwig Hauser
- Torsten Möller
- Tamara Munzner
- many more

Contact information



Dr. Johannes Kehrer

Siemens AG
Technology
T DAI HCA-DE
Otto-Hahn-Ring 6
81739 München, Deutschland

E-mail:
kehrer.johannes@siemens.com

Internet
siemens.com/innovation