

Visual perception in Visualization

- 1 Introduction to Scientific Visualization
- 2 Visual Perception: Motivation
- 3 Perception of Depth – Application to DVR evaluation
- 4 Perception of Noise – Application to Uncertainty Vis.
- 5 Perception of Shape – Application to Image manipulation

Georges-Pierre Bonneau, Laboratoire Jean Kuntzmann, UGA, G-INP & INRIA Grenoble

Background



Project-team MAVERICK at INRIA Grenoble & University of Grenoble

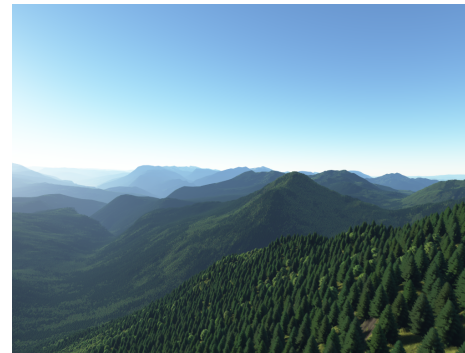
Realistic rendering



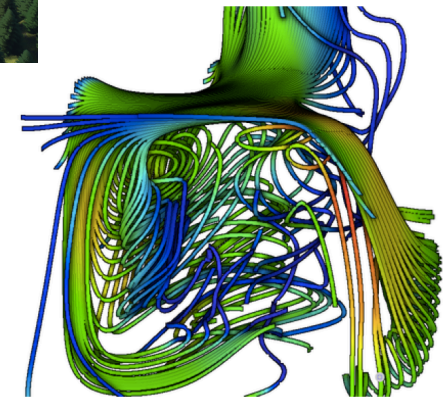
Expressive rendering



Complex scenes



Visualization



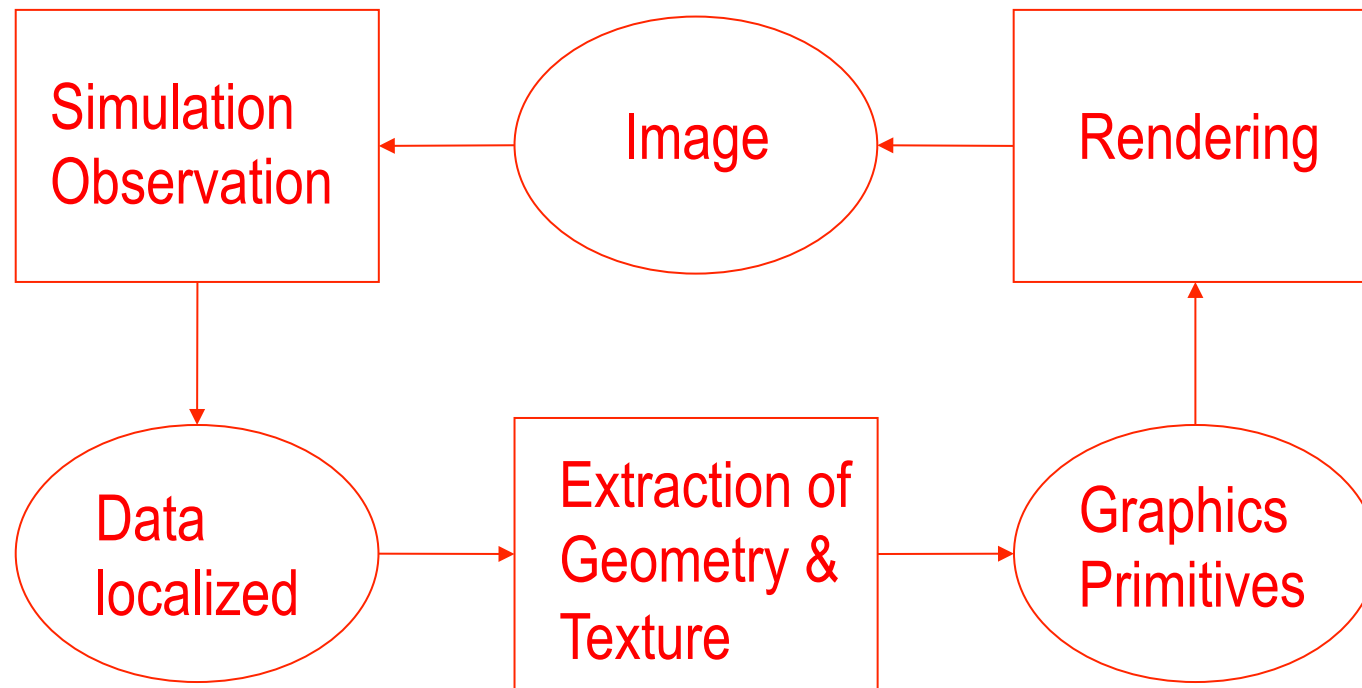


Scientific Visualization

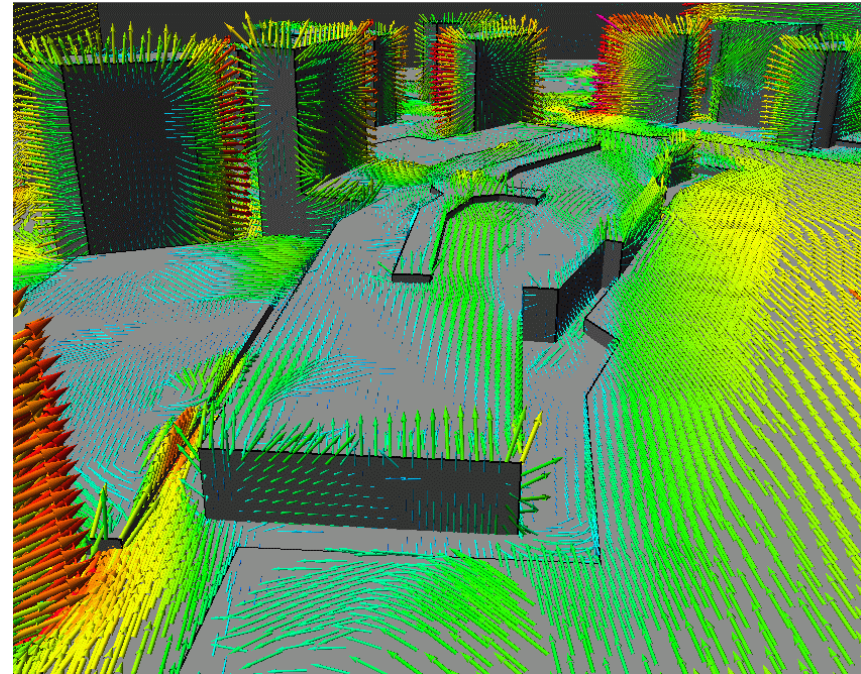
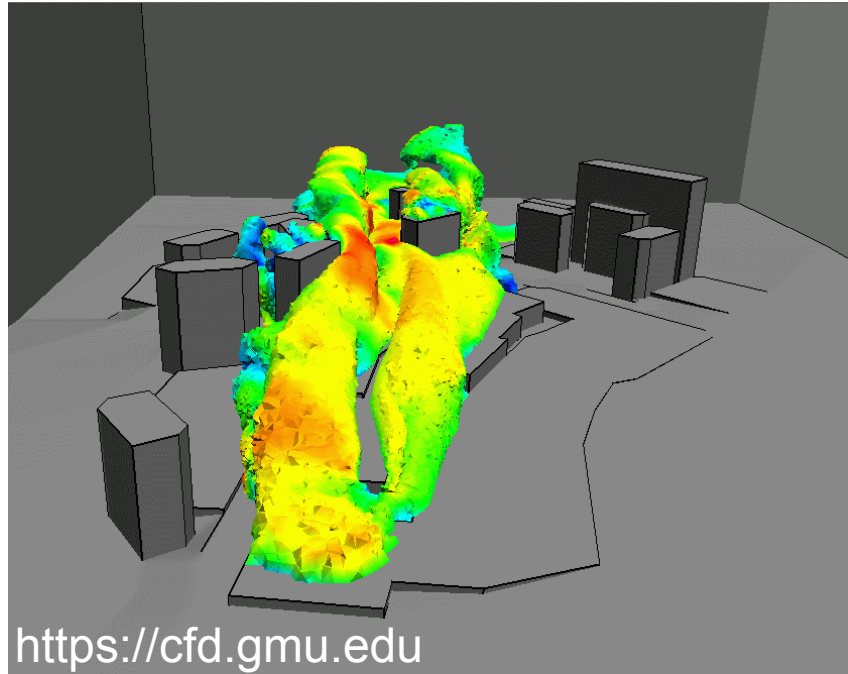
a brief introduction

1

Data <-> Visualization loop



Contaminant transport



Data: concentration : 1 scalar defined in the volume
velocity: 1 3D vector defined in the volume

Techniques: Colored Isosurfaces, Colored Arrows

Colormap:

- histogram of data

- perception of colors, HSV or Lab colorspace

- color deficient vision

Isosurface computation:

- Marching cube algorithm

- hundreds of papers on extension, optimization...

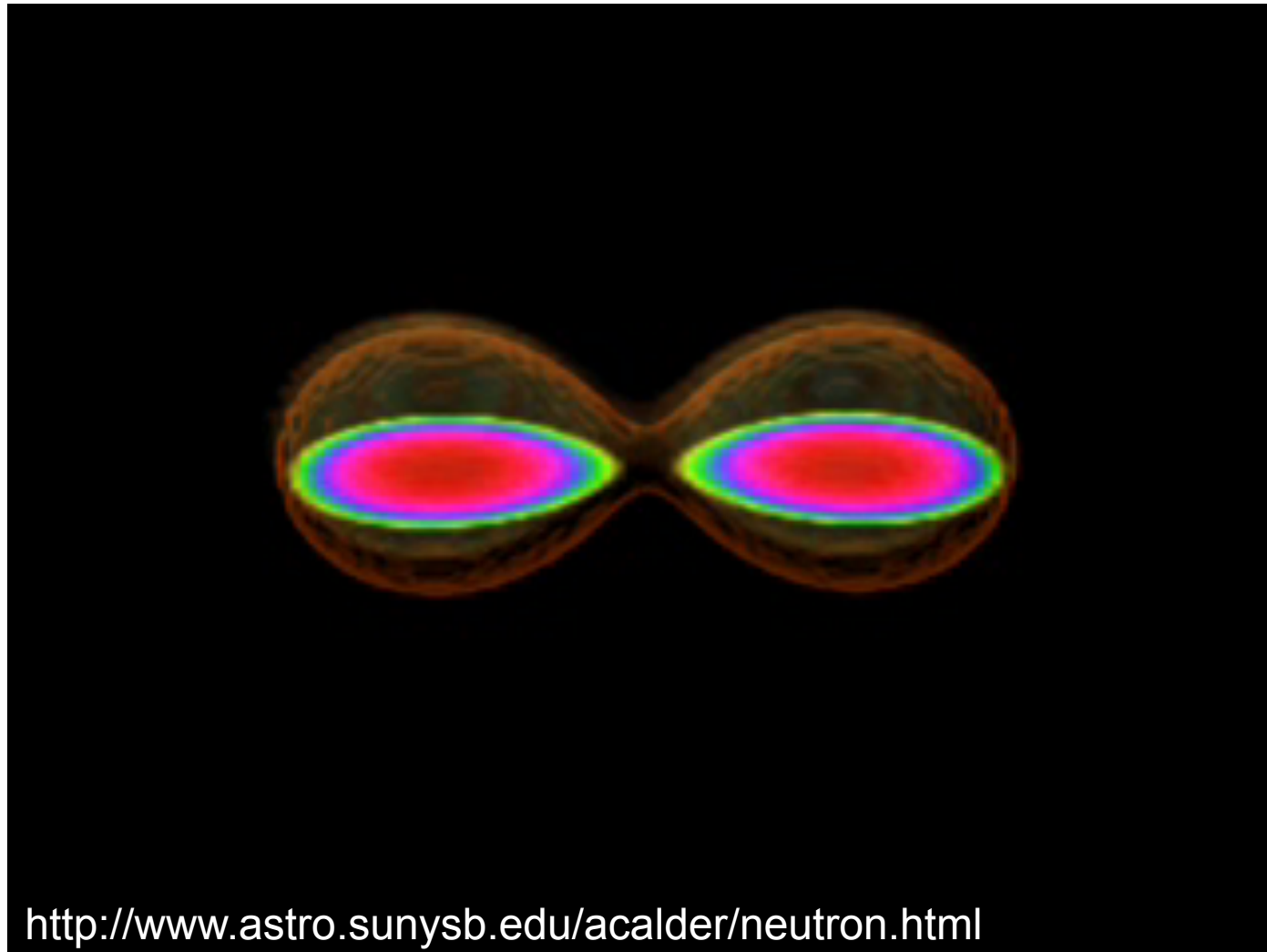
Rendering of vectors:

- 3d cylinders, occlusion and shading to resolve orientation ambiguity

- subsampling to remove clutter

- norm as colors

Merging of neutron stars



High density:
planar slice
colormap

Mean density:
Isosurface
transparency from orientation

Low density:
Direct volume rendering

Data: MRI



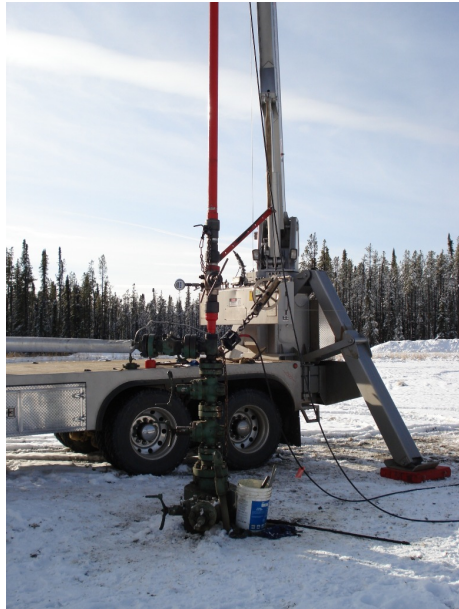
<http://www.unige.ch/>



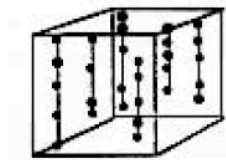
X_i	Y_j	Z_k	Density
0.000	0.000	0.000	243
0.000	0.000	0.015	175
.	.	.	.
.	.	.	.
.	.	.	.
0.000	0.000	1.000	186
0.000	0.016	0.000	187
.	.	.	.
.	.	.	.
.	.	.	.

Data: $F_{ijk} = F(x_i, y_j, z_k) \quad i, j, k = 1, \dots, N.$

Data: Drilling



- **WELL LOG DATA** (Courtesy D.Lane & D.Krinsel)



	Location			Mineral
5.50	1.00	0.00	11.0	
5.50	1.00	10.00	10.0	
.	.	.	.	
.	.	.	.	
.	.	.	.	
.	.	.	.	
.	.	.	.	

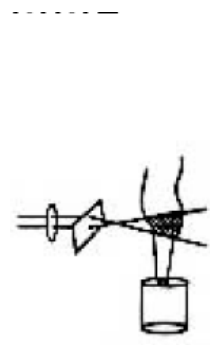


Data: $(x_i, y_i, z_{i_j}; M_{i_j}) \quad i = 1, \dots, N, \quad i_j = 1, \dots, N_i.$

Data: Combustion



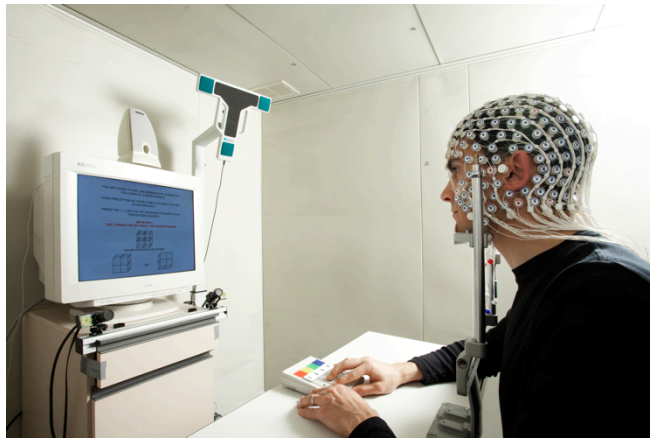
liiscience.org



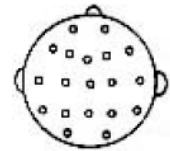
	Location		Concentration
0.00	0.00	0.02	001
0.00	0.00	0.04	007
0.00	0.00	0.06	003
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.

Data: $(r_i \cos(\Phi_j), r_i \sin(\Phi_j), z_k; C_{ijk})$

Data: EEG



<http://www.unige.ch/>



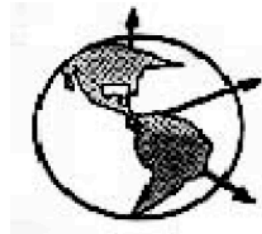
	Location			Voltage
6.54	4.56	5.64	0.033	
9.14	-3.14	1.38	0.086	
9.45	2.12	1.19	0.310	
.	.	.	.	
.	.	.	.	
.	.	.	.	
.	.	.	.	

Data: $(x_i, y_i, z_i; V_{ij})$, $i = 1, \dots, N$,
 $j = 1, \dots, 6$.

Data: rainfall



<http://www.crh.noaa.gov/>



Longitude	Latitude	Rainfall
43 19' 34"	23 36' 13"	14.6
21 35' 59"	45 09' 36"	23.6
43 19' 34"	23 36' 13"	14.6
.	.	.
.	.	.
.	.	.
.	.	.

Data: $(x_i, y_i, z_i) = (\sin\Phi_i \cos\Psi_i, \sin\Phi_i \sin\Psi_i, \cos\Phi_i)$

Data taxonomy

Position:

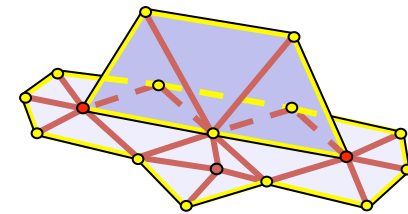
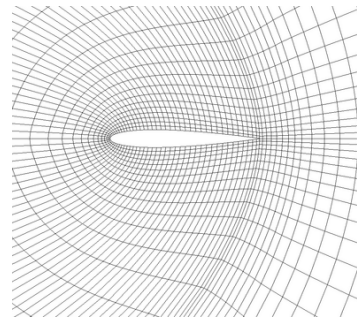
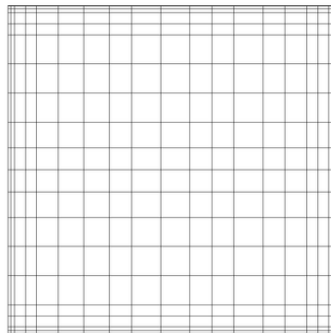
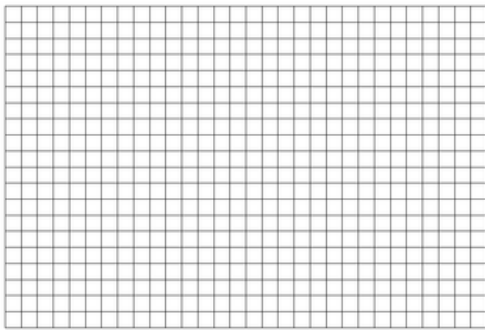
- dimension
- discretisation

Nature:

- scalar
- vector
- tensor

Localization of data

- Dimension:
 - 1, 2, 3 dimensions + time
- Simple domain or complex topology
- Regular/Irregular discretization



<http://vtk.org>

Nature of data

Scalar:

- temperature, pressure, concentration...

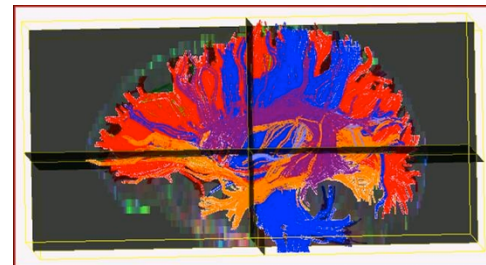
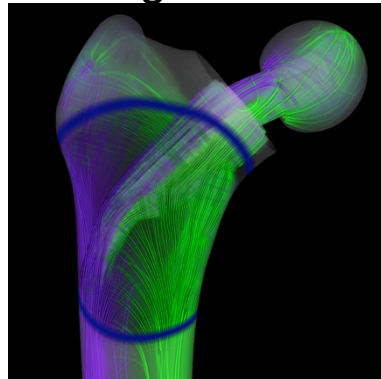
Vector:

- Magnetic field, velocity...

Tensor:

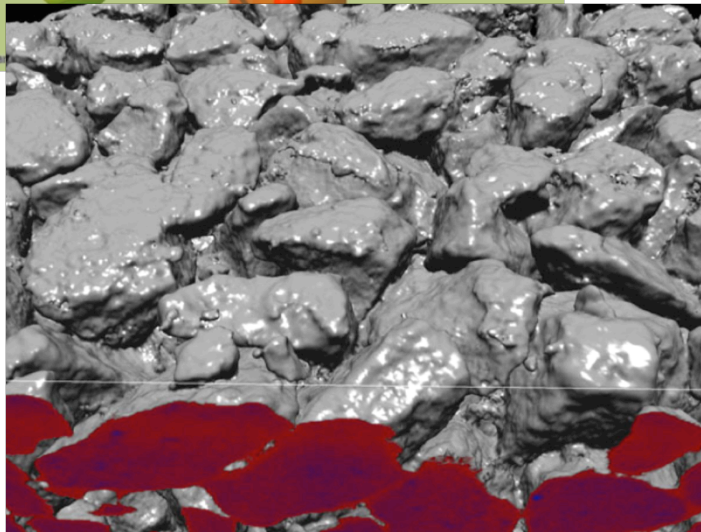
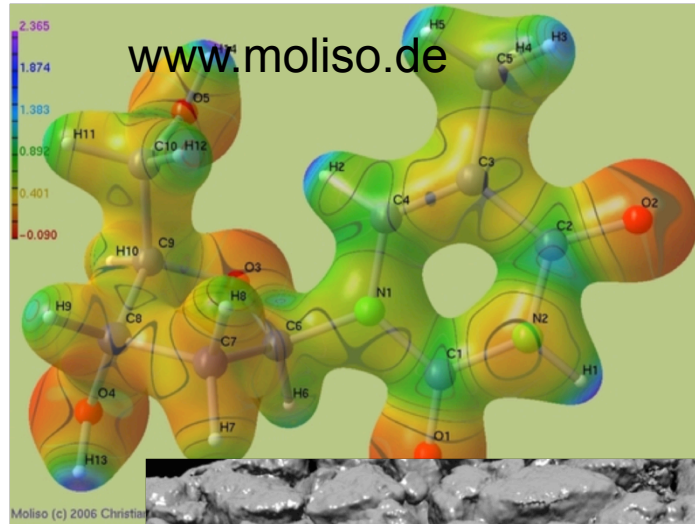
- Mechanical stress, functional MRI

www.cg.in.tum.de

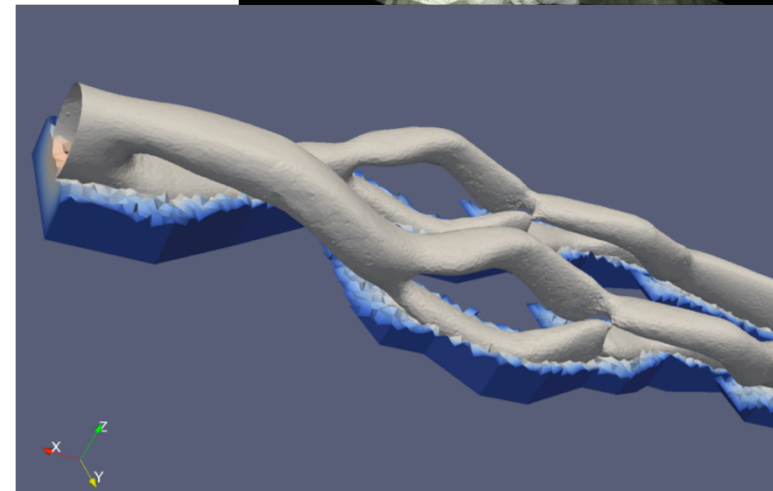


www.tnw.tudelft.nl

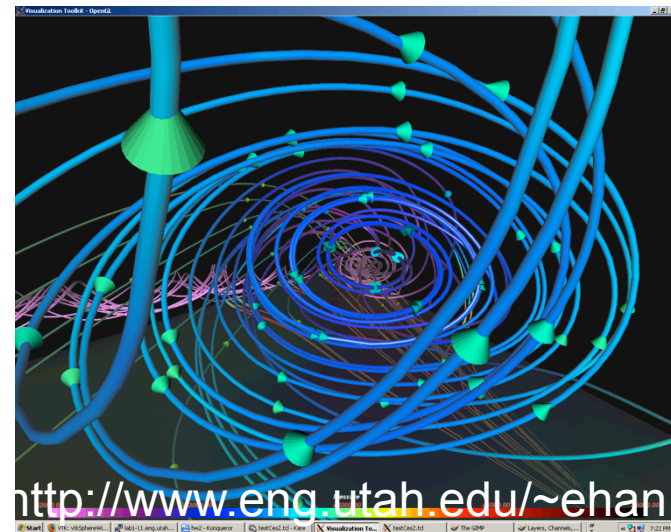
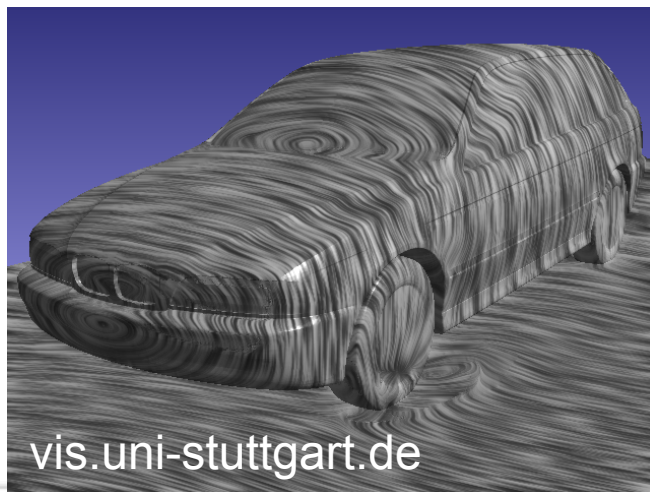
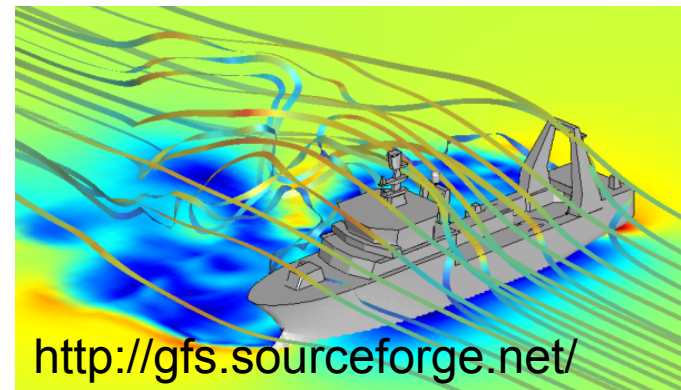
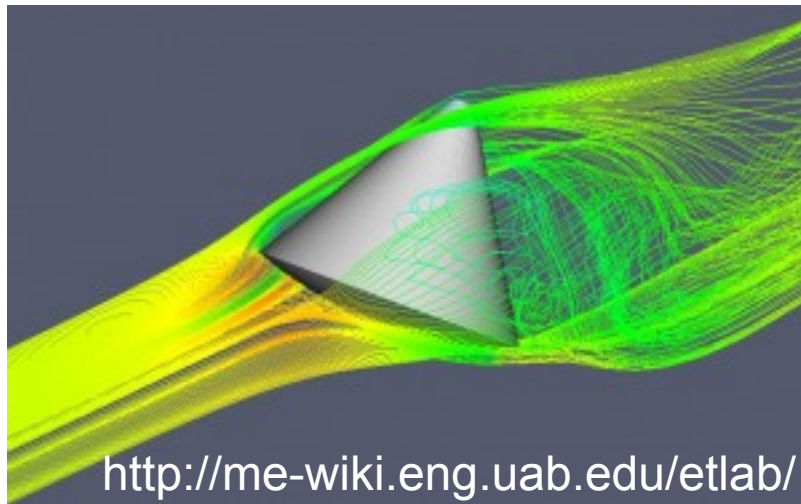
Technique: Isovalue surfaces



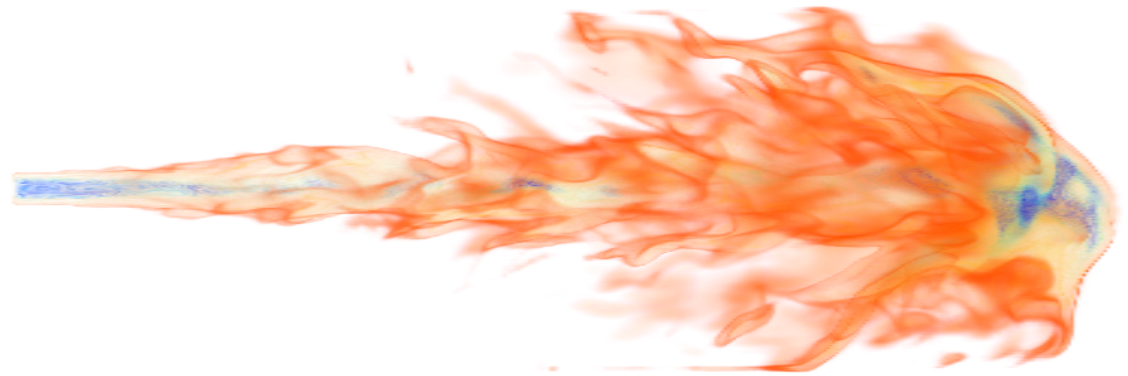
www.hlrs.de



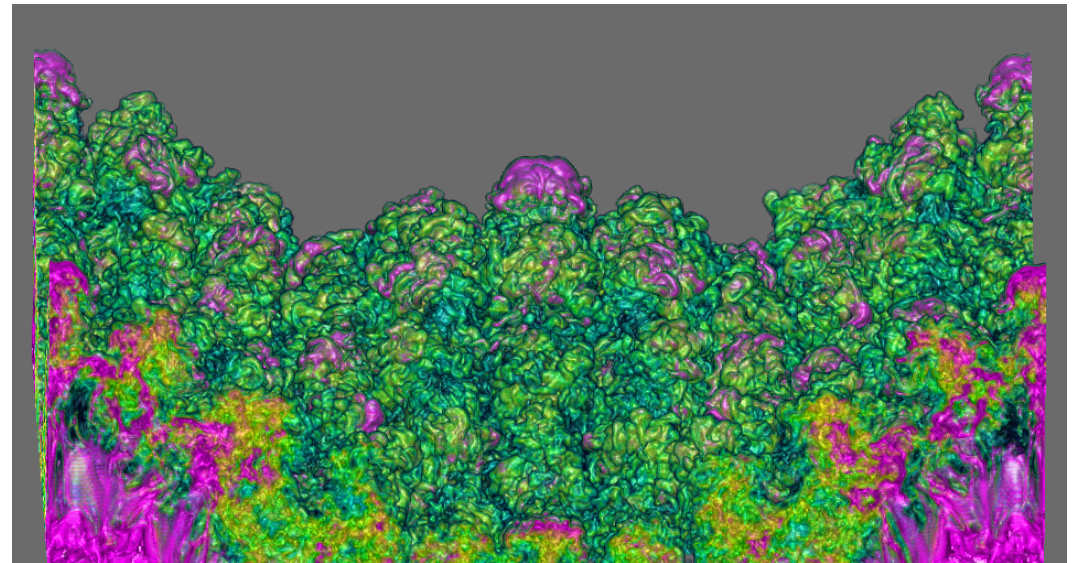
Technique: Flow lines (ribbons/tubes)



Technique: Direct Volume Rendering



[Grosset &al,PVis13]



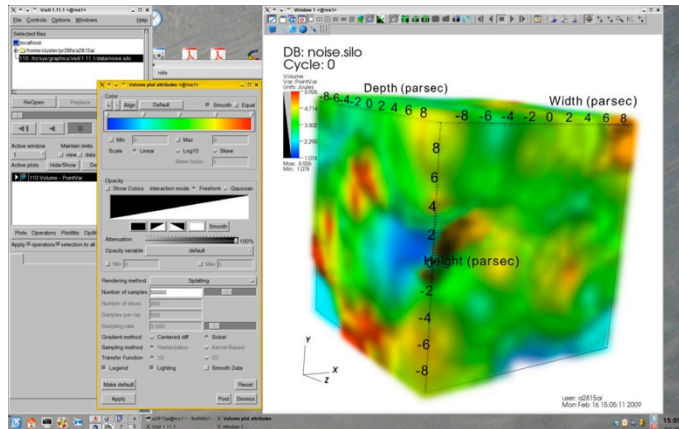
Transversal issue: Large data size

Does the data fit into:

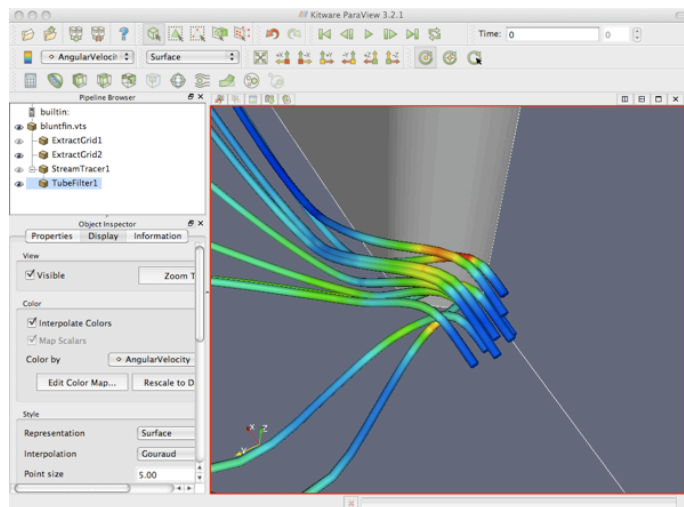
- GPU
- RAM
- Local disk
- NFS

=> Multiresolution visualization methods

Free libraries and software



VisIt Visualization Tool
<https://wci.llnl.gov/codes/visit/>



Paraview <http://paraview.org>

Vtk (librairie C++) <http://vtk.org>

Journal and Conferences

IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS

A publication of the IEEE Computer Society

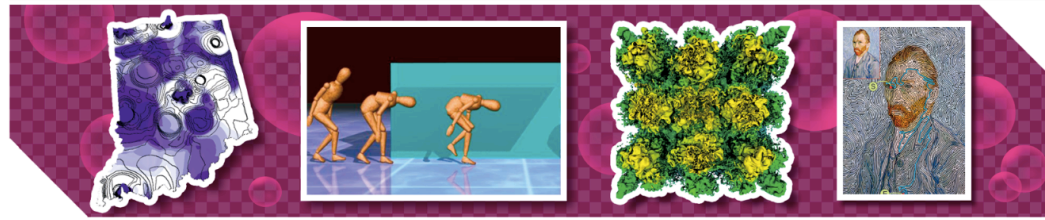
MARCH/APRIL 2010

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VIS 2017

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1-6 October 2017 Phoenix, Arizona USA



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Inria

HSC 19, 15th May 2017, Visual perception in Visualization, G.-P. Bonneau



Visual Perception

basic facts

2

Motivation

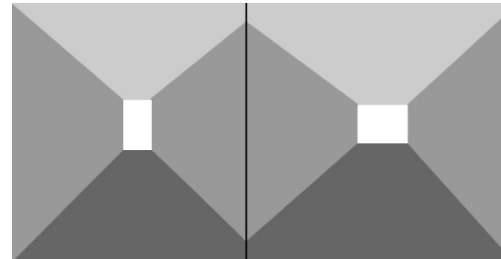


<http://nivea.psycho.univ-paris5.fr/>

Visual Perception

Perception is the organization, identification and interpretation of sensory information in order to represent and understand the environment.

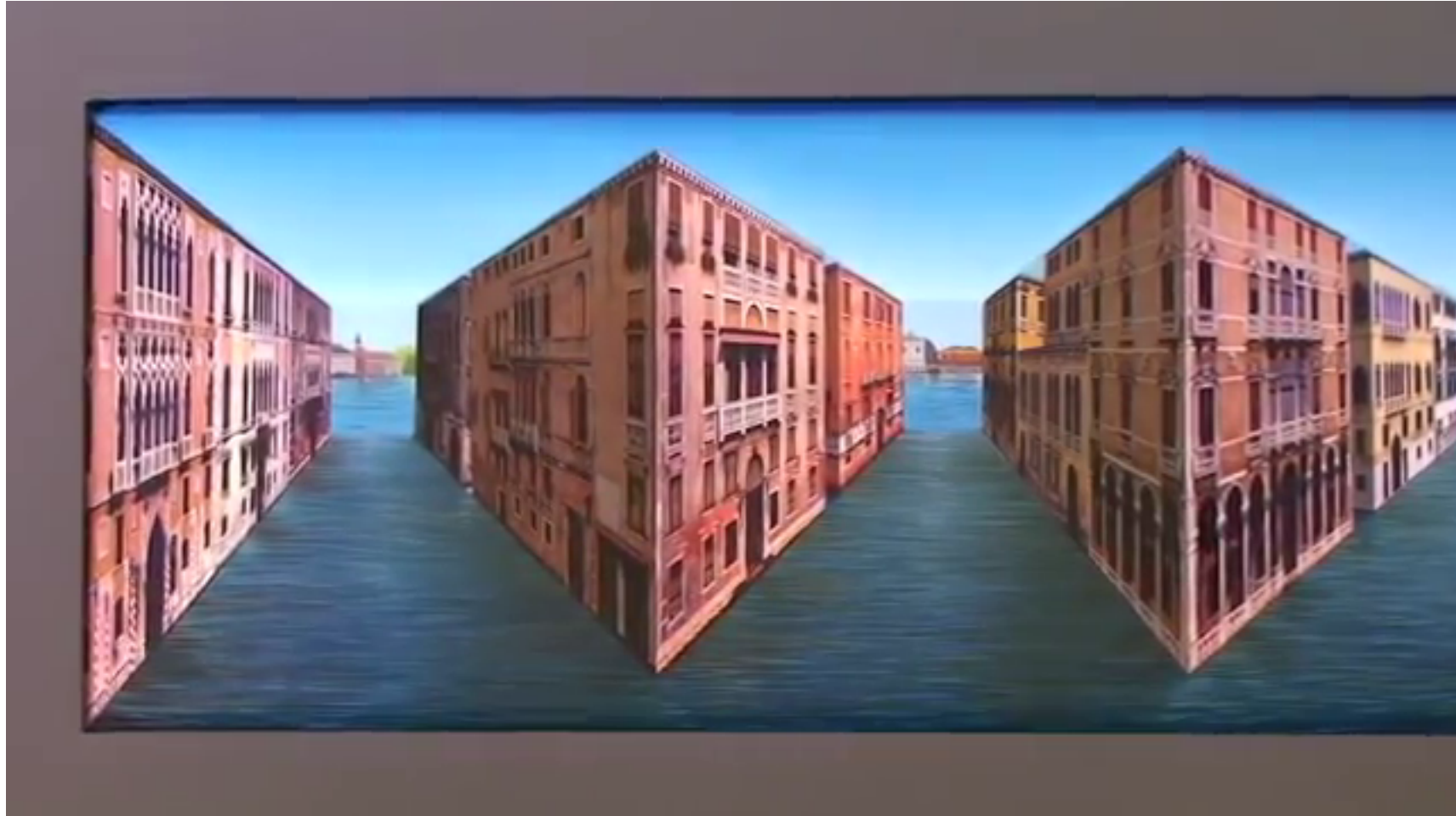
« Perceiving is identify something somewhere, and this need for localized identification persists even when we look at some abstract configurations, for which we cannot build on any previous experience » (Gombrich, in *Art and Illusion*)



Reverspective
<http://www.patrickhughes.co.uk/>



Reverspective



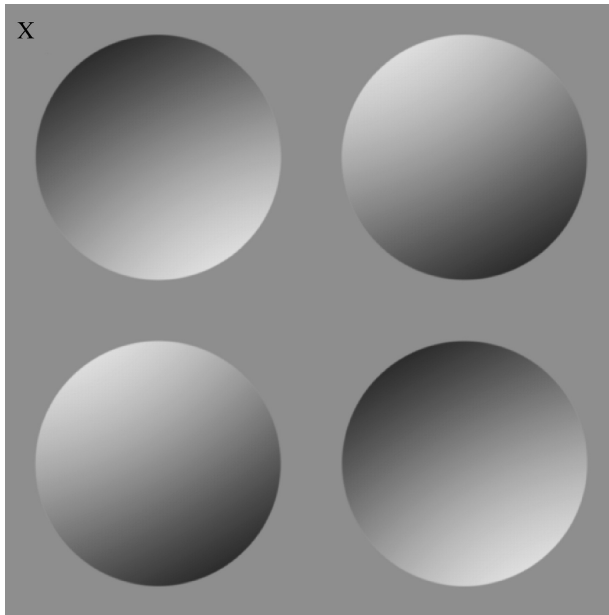
<http://www.patrickhughes.co.uk/>

A priori in Visual perception



<http://michaelbach.de/>

A priori in Visual perception



[Stone&al.,2009]

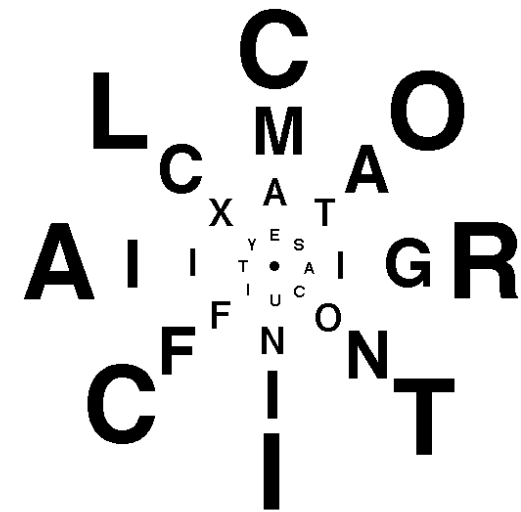
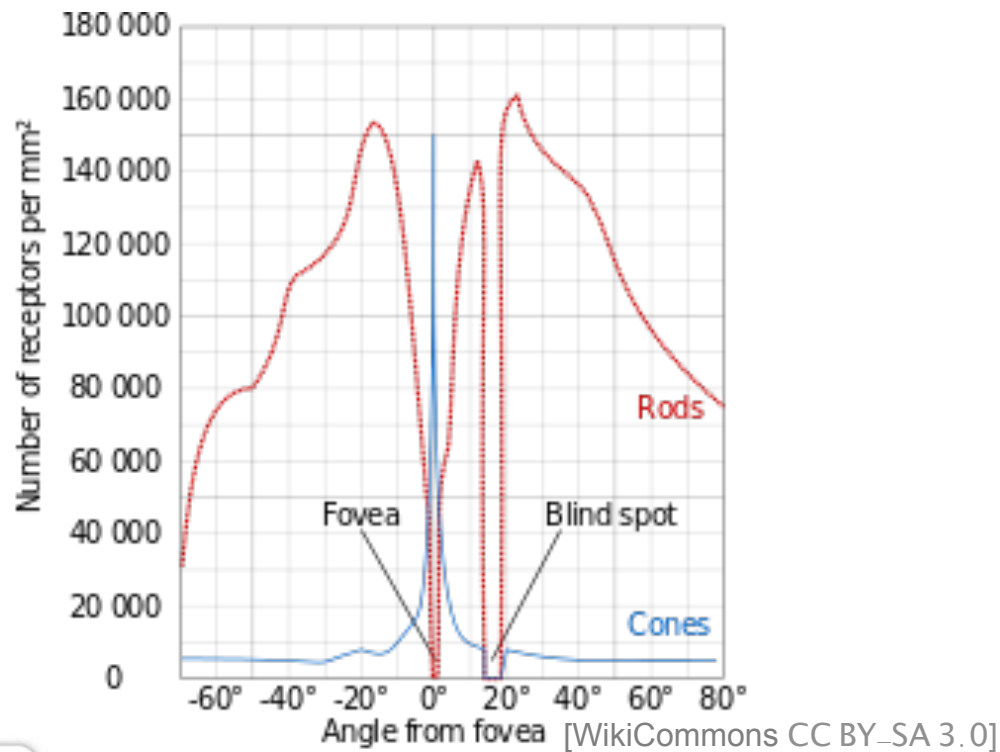


Basic Vision, pp. 226

Visual Acuity

Contrast: 120 millions rodes

Color: 5 millions cones



Anstis, S. (1974).

Saccadic eye movements



I. E. Repin, *Un visiteur inattendu* (1884)



Free viewing



Ages ?



Previous activity ?



Remember clothes



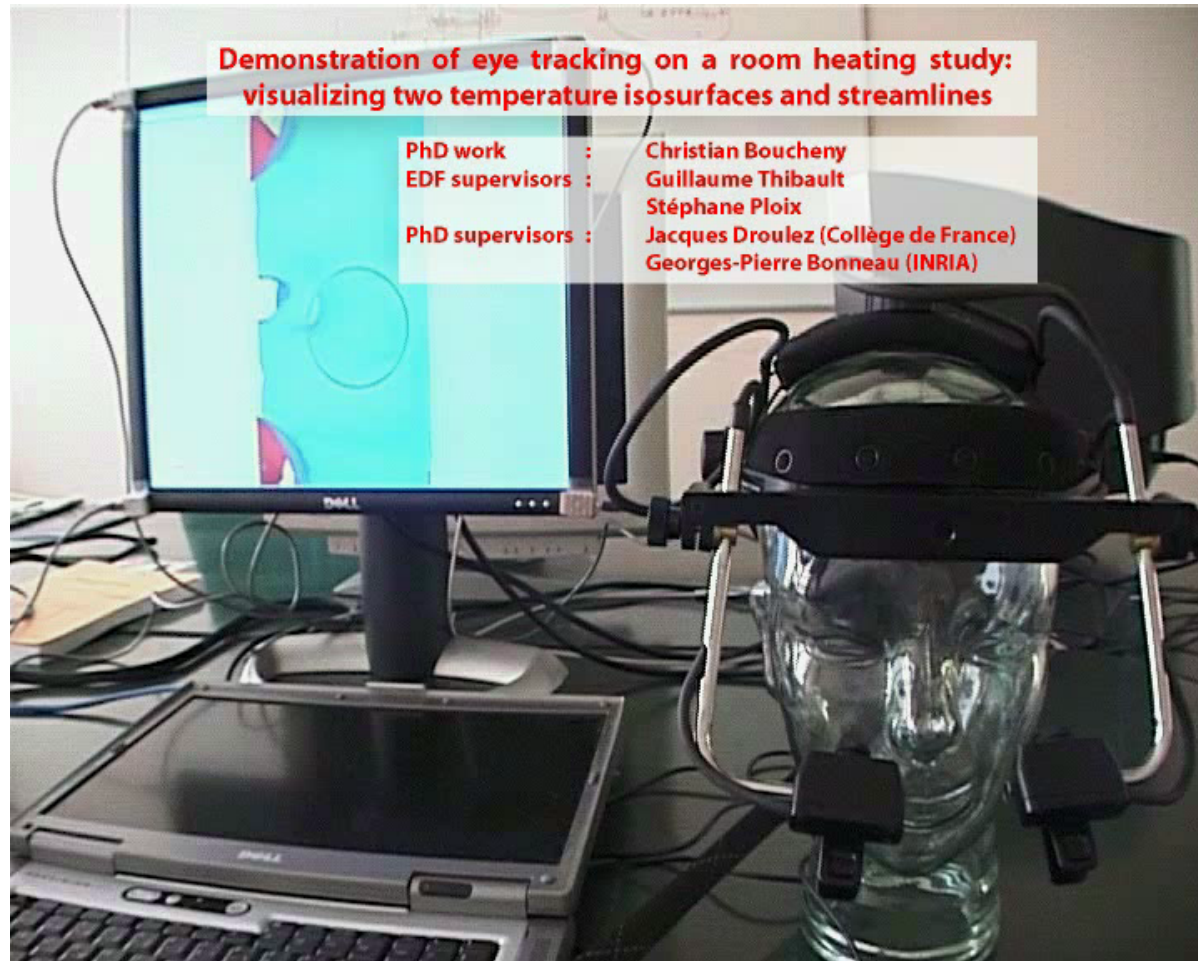
Remember objects



Away for how long?

Yarbus, *Eye movement and Vision*, 1967, fig. 109

Gaze guided visualization





Depth perception

In Direct Volume Rendering

3

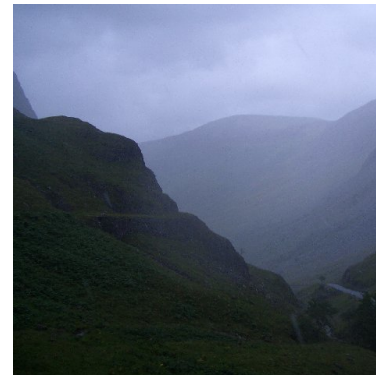
Depth perception



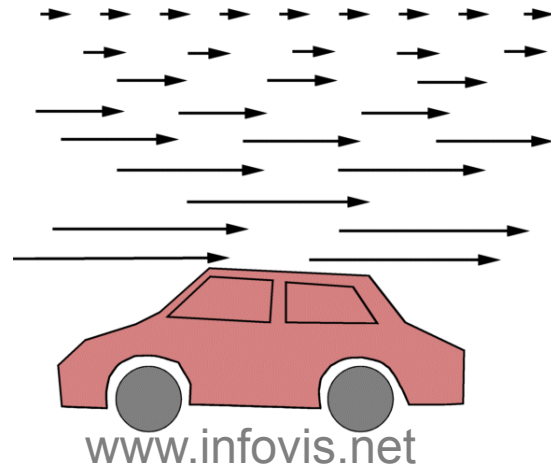
wikipedia

Ten monocular cues

Two binocular cues



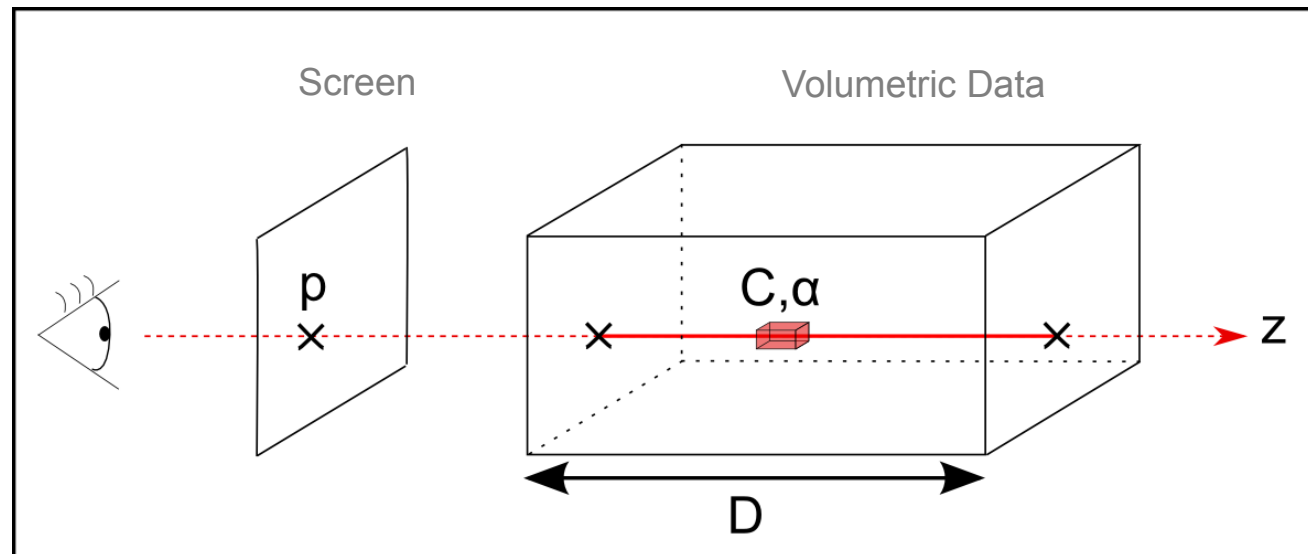
wikipedia



www.infovis.net

Direct Volume Rendering

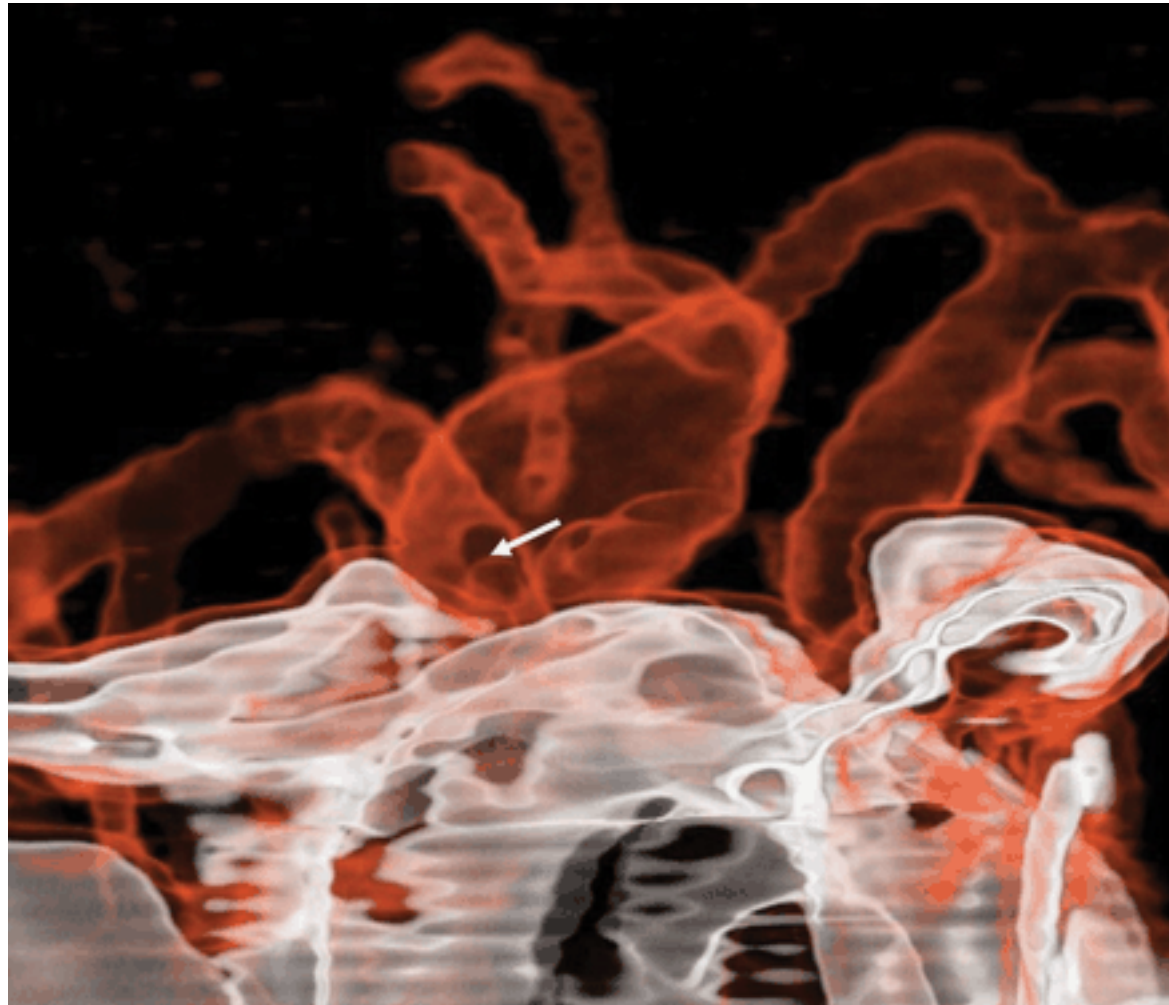
$$\text{TF} : s \longrightarrow (C, \alpha)$$



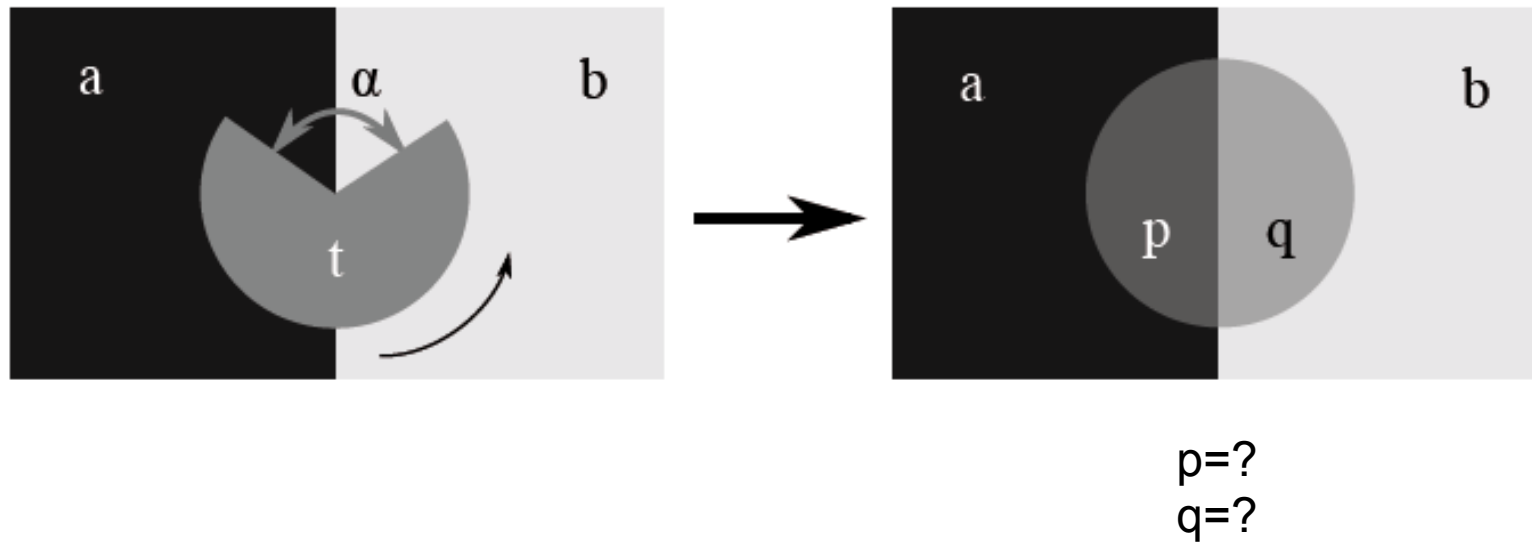
$$C(p) \approx \sum_{i=0}^n C_i \prod_{j=0}^{i-1} (1 - \alpha_j)$$

Direct Volume Rendering

radiographics.rsna.org

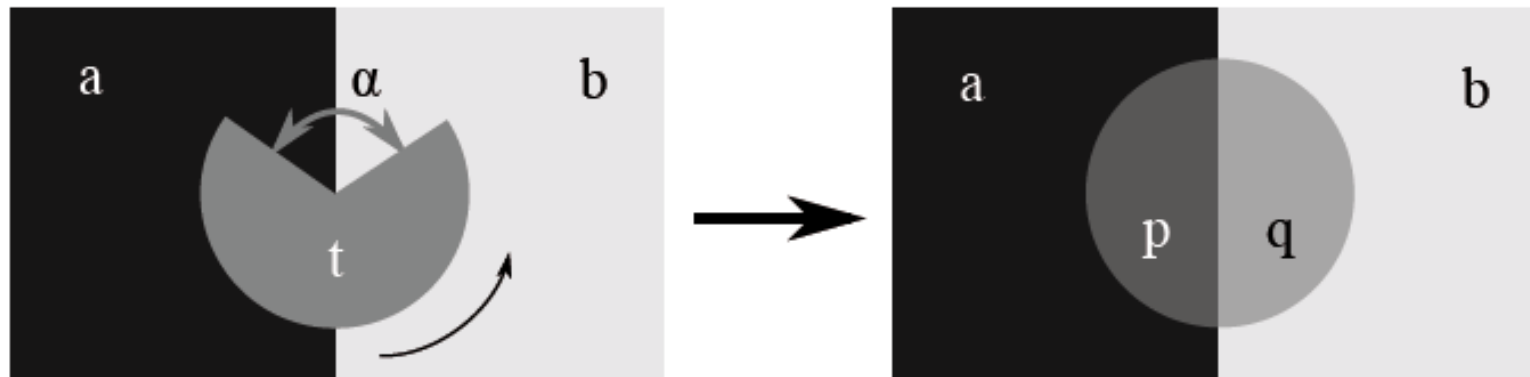


Transparency perception



[Metelli, 1974]

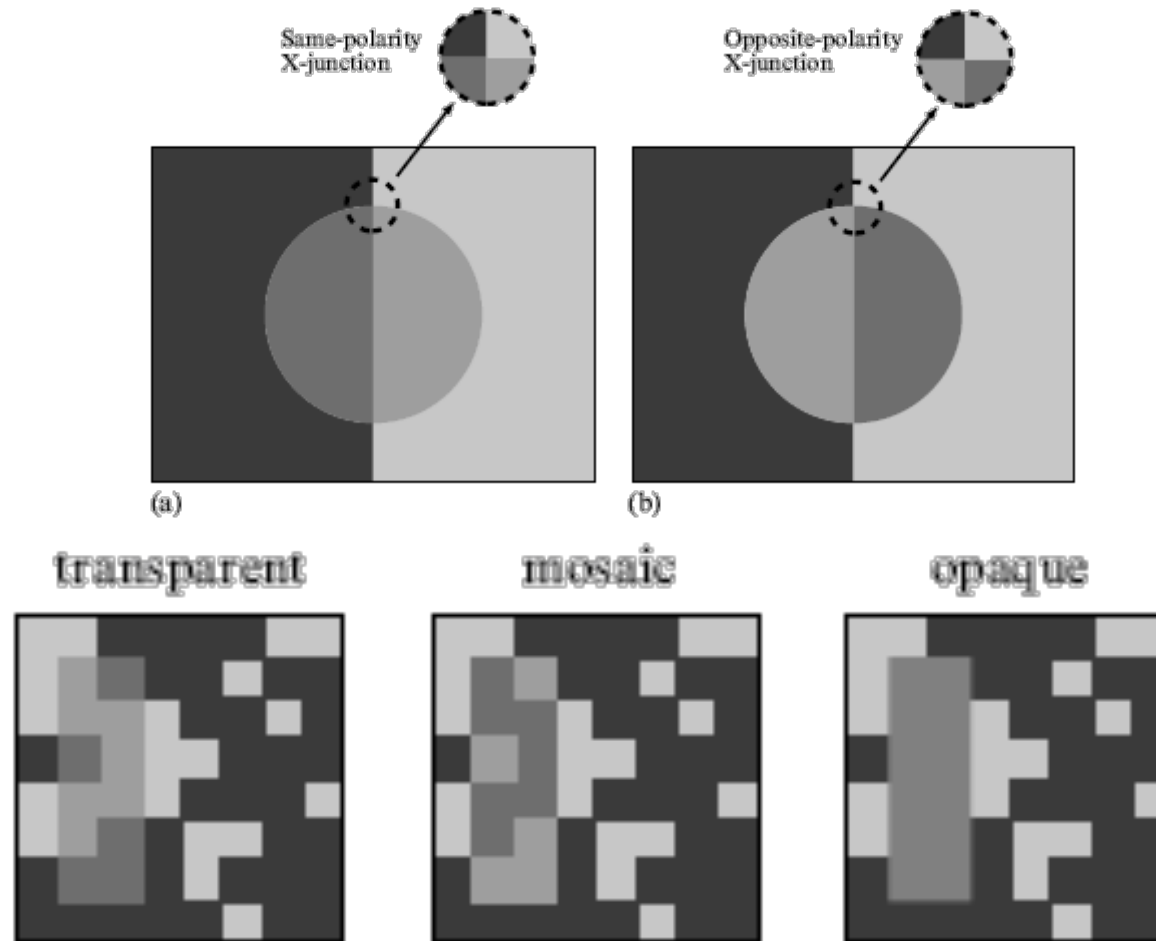
Transparency perception



$$p = (1 - \alpha) t + \alpha a$$
$$q = (1 - \alpha) t + \alpha b$$

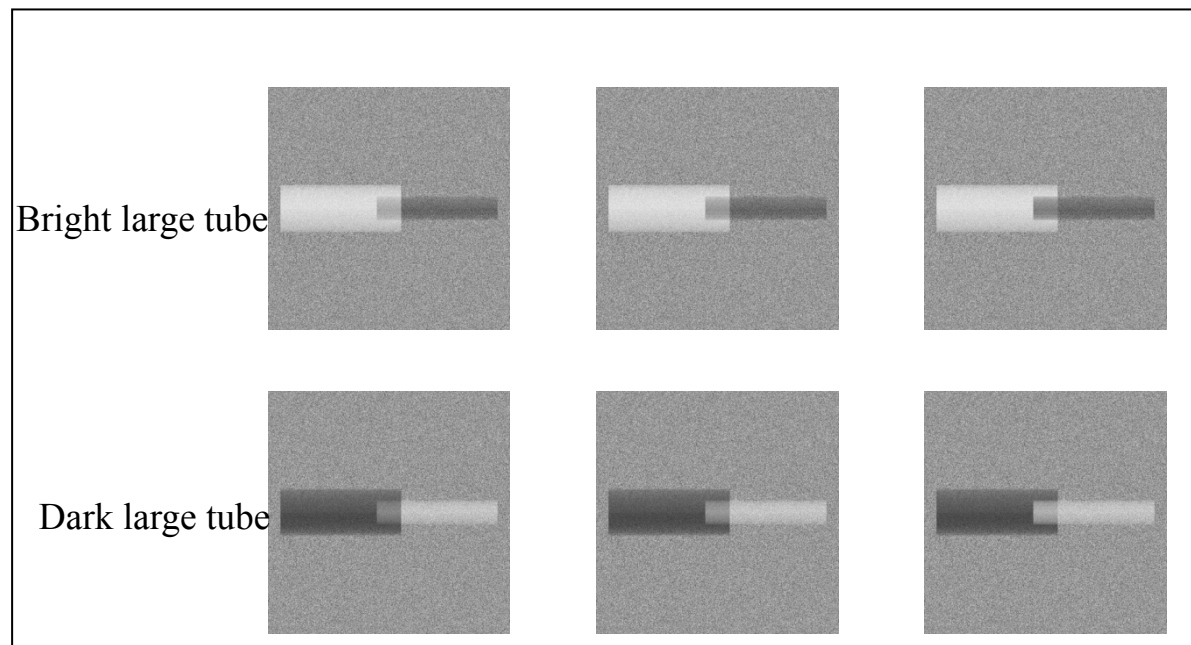
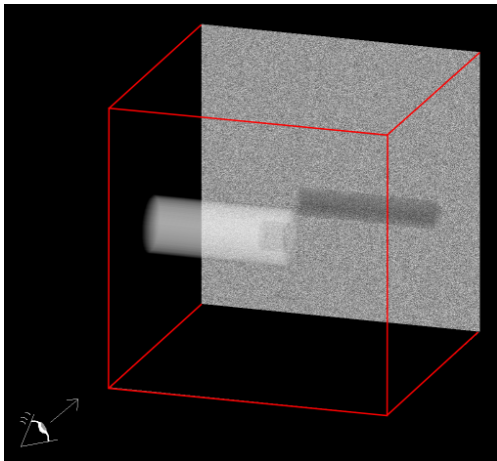
[Metelli, 1974]

Transparency perception



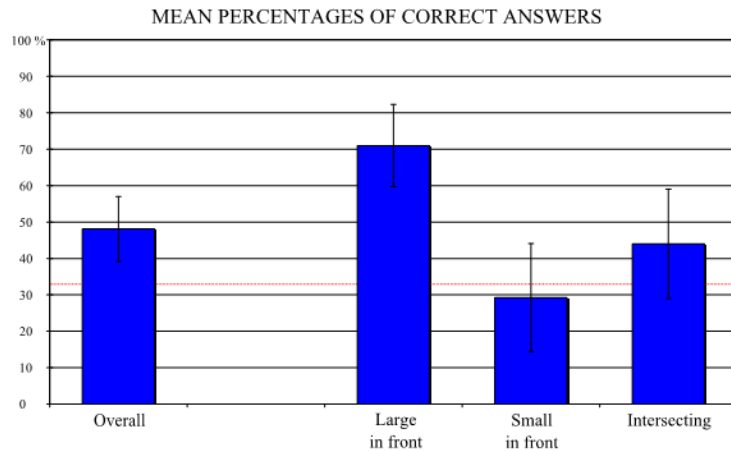
Evaluation of Depth Perception in DVR

Static experiment



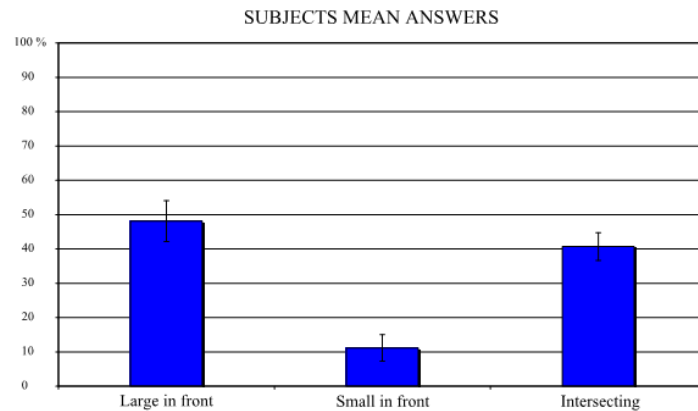
Boucheny, Bonneau & al, APGV 2007

Static experiment results

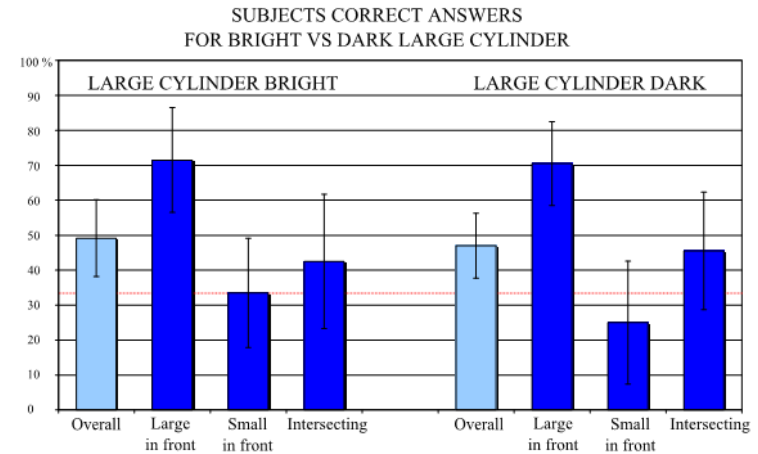


- Poor global performances

Boucheny, Bonneau & al, APGV 2007



Bias for Large tube in front



Luminance does not impact