

Introduction to Scientific Visualization

M2S



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T. Carrard, J.P. Nominé, J. Tierny

What is Visualization?

- Conveying information through **visual** representations

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 - Visual information is **dense**

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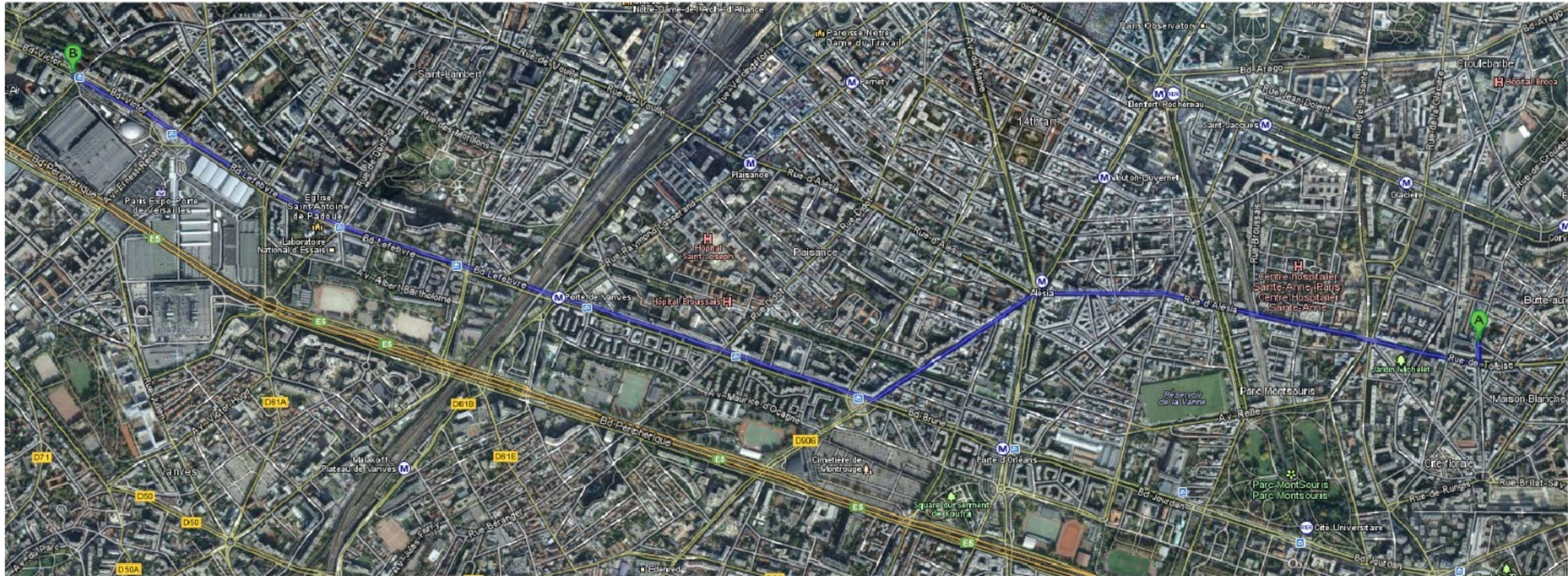
What is Visualization?

- Conveying information through **visual** representations
 - Probably the simplest information representation... ever!



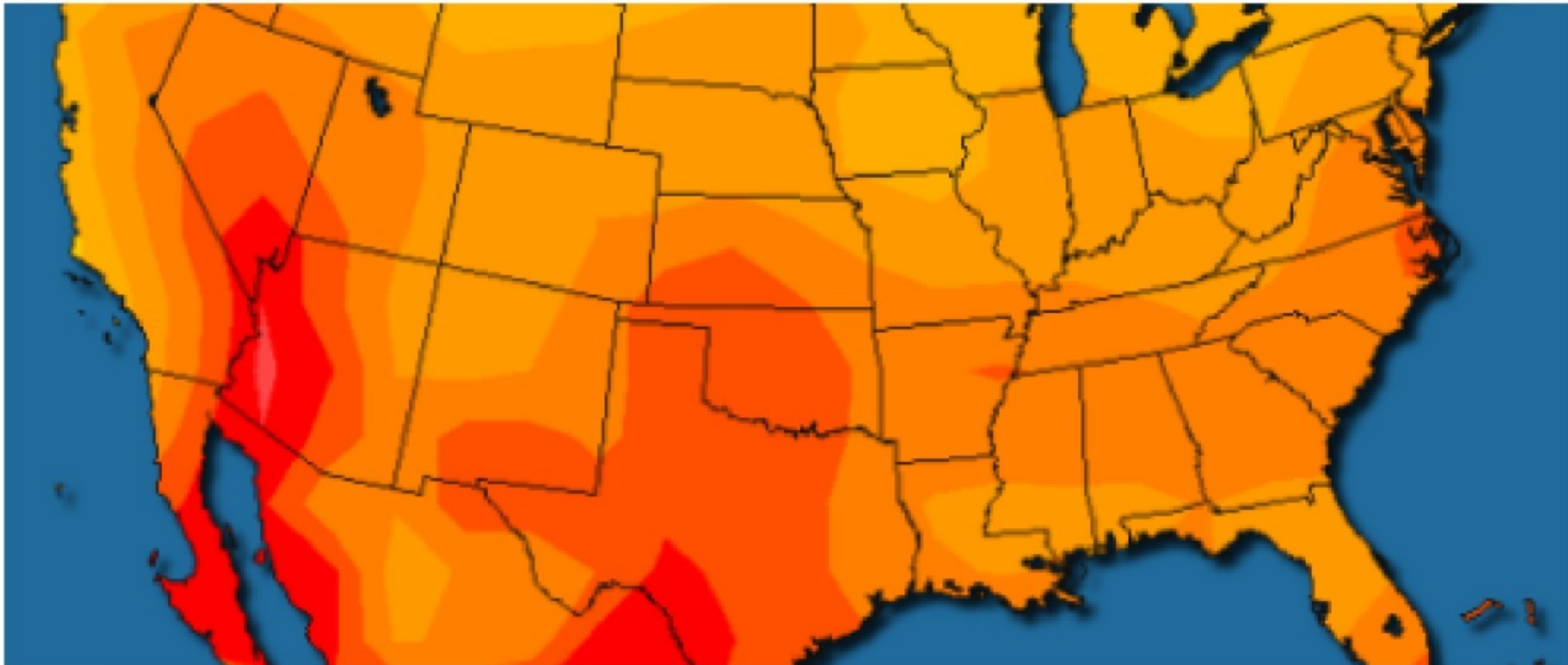
What is Visualization?

- Conveying information through **visual** representations
- We all massively use spatial reasoning



What is Visualization?

- Conveying information through **visual** representations
 - More than cultural or spatial: perceptual



What is it useful for?

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- Spatial Thinking

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$$\sum_{i=0}^n (2i + 1) = (n + 1)^2$$

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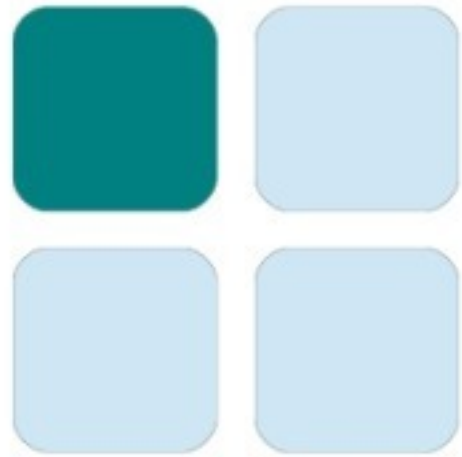
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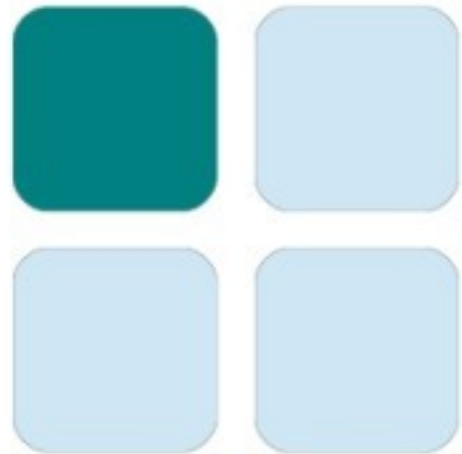
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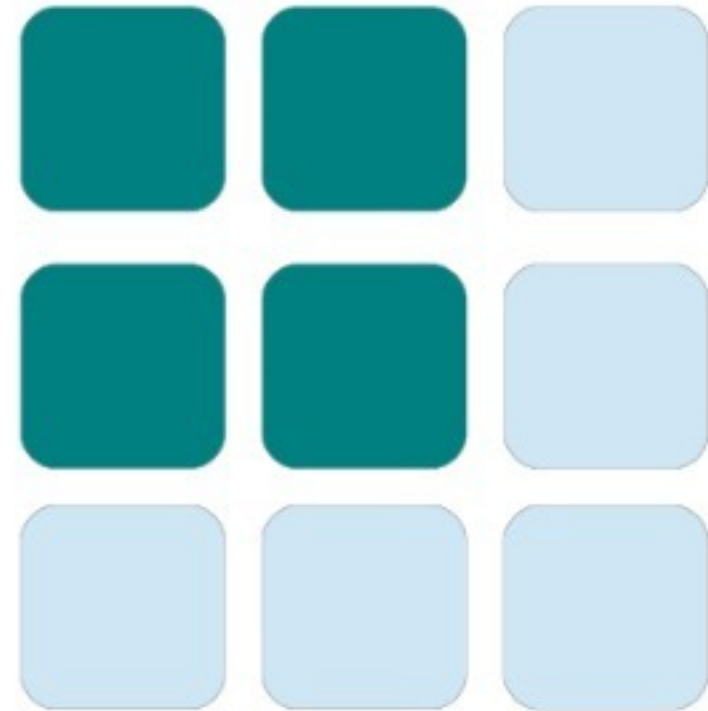
$i = 0$



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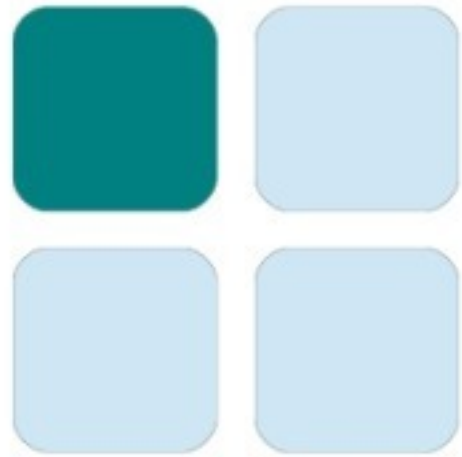
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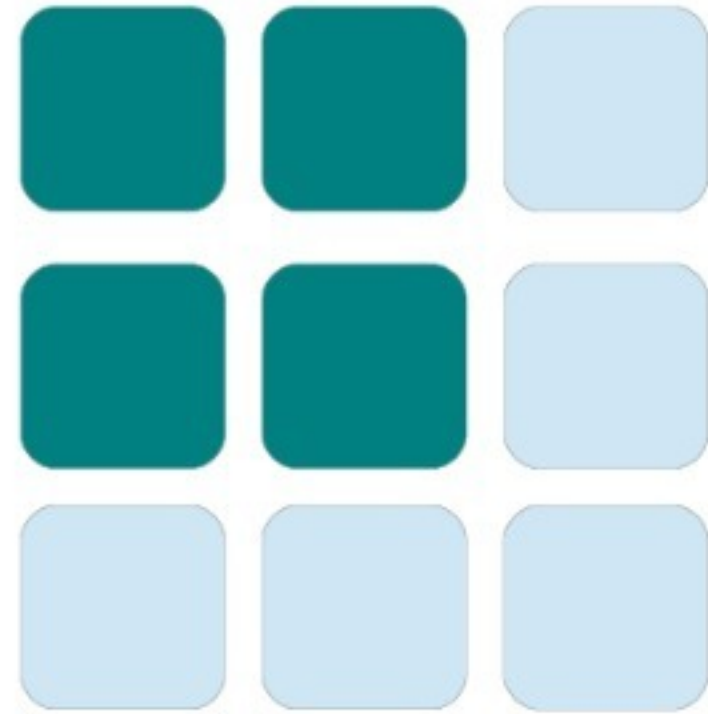
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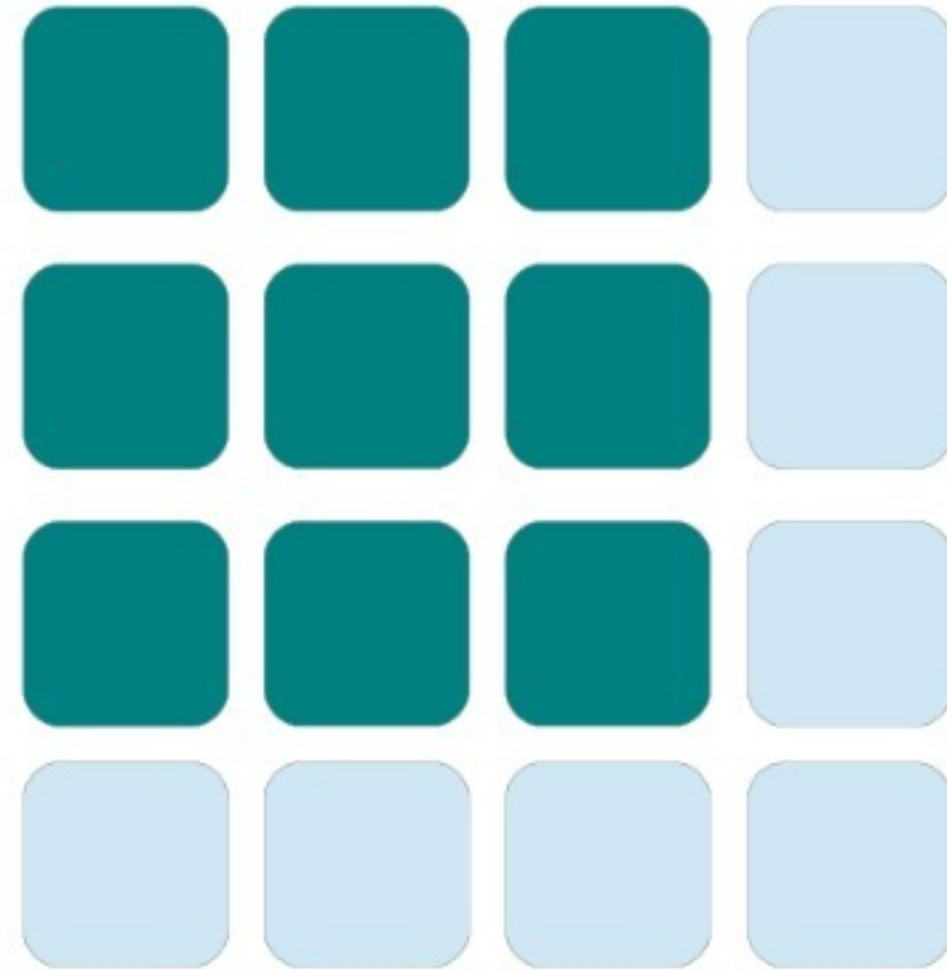
$i = 1$



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$i = 3$



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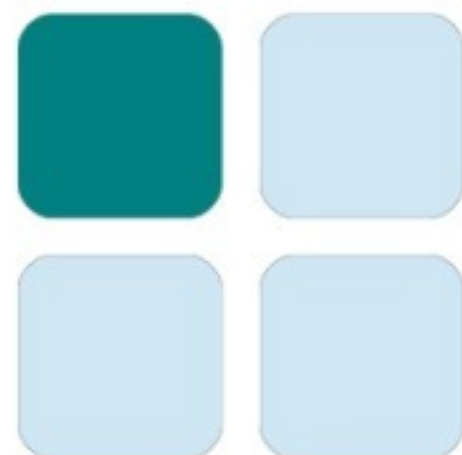
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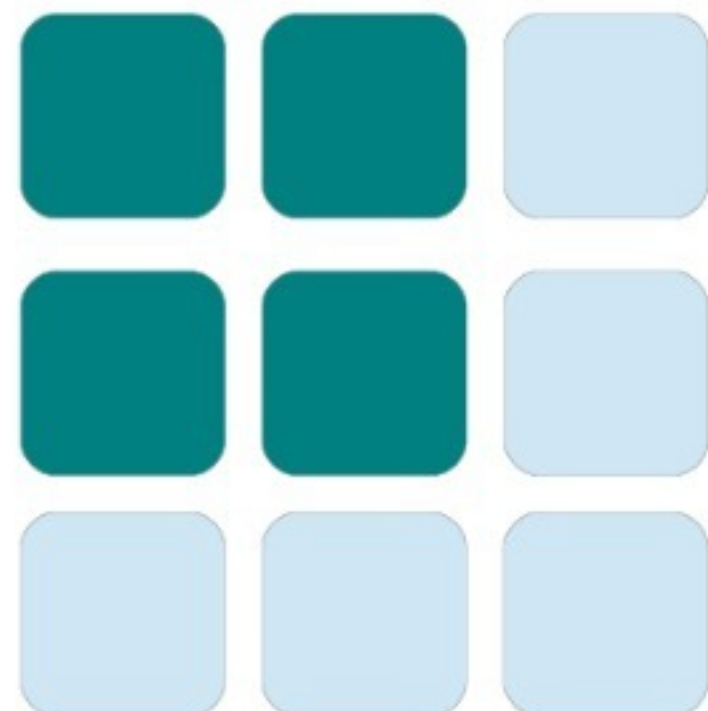
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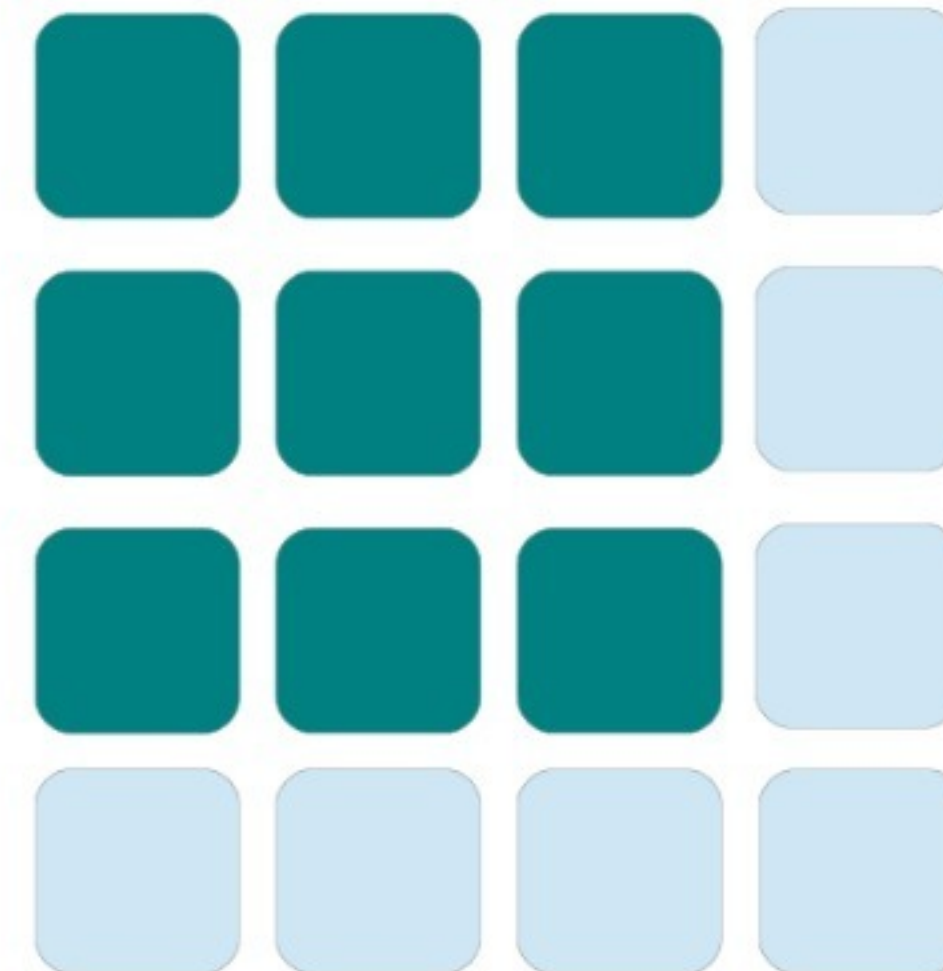
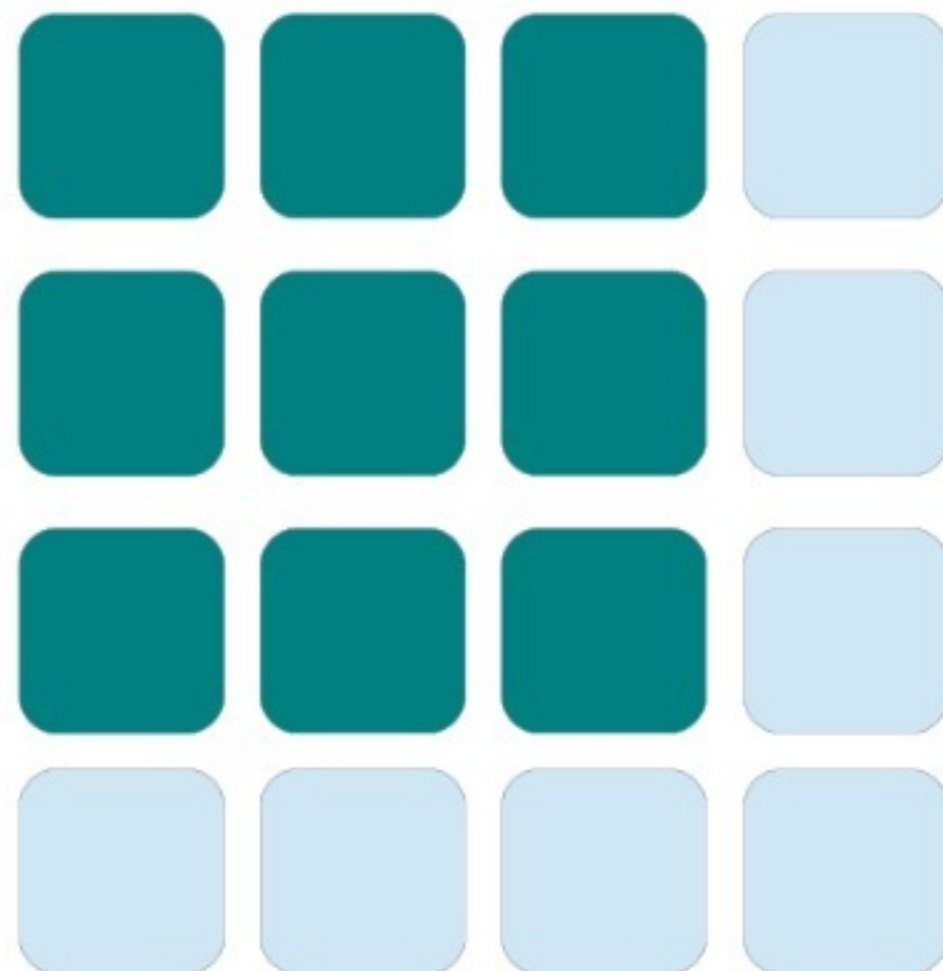
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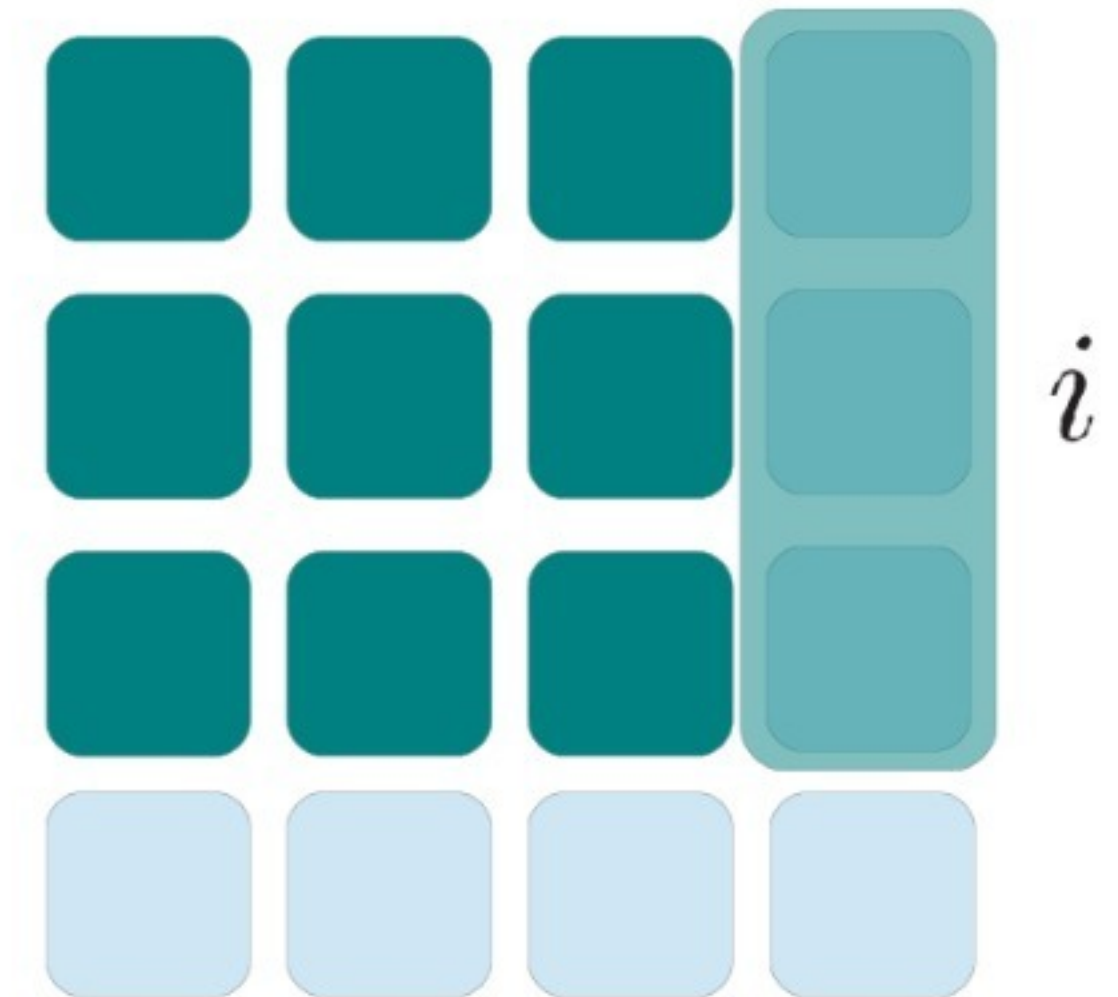
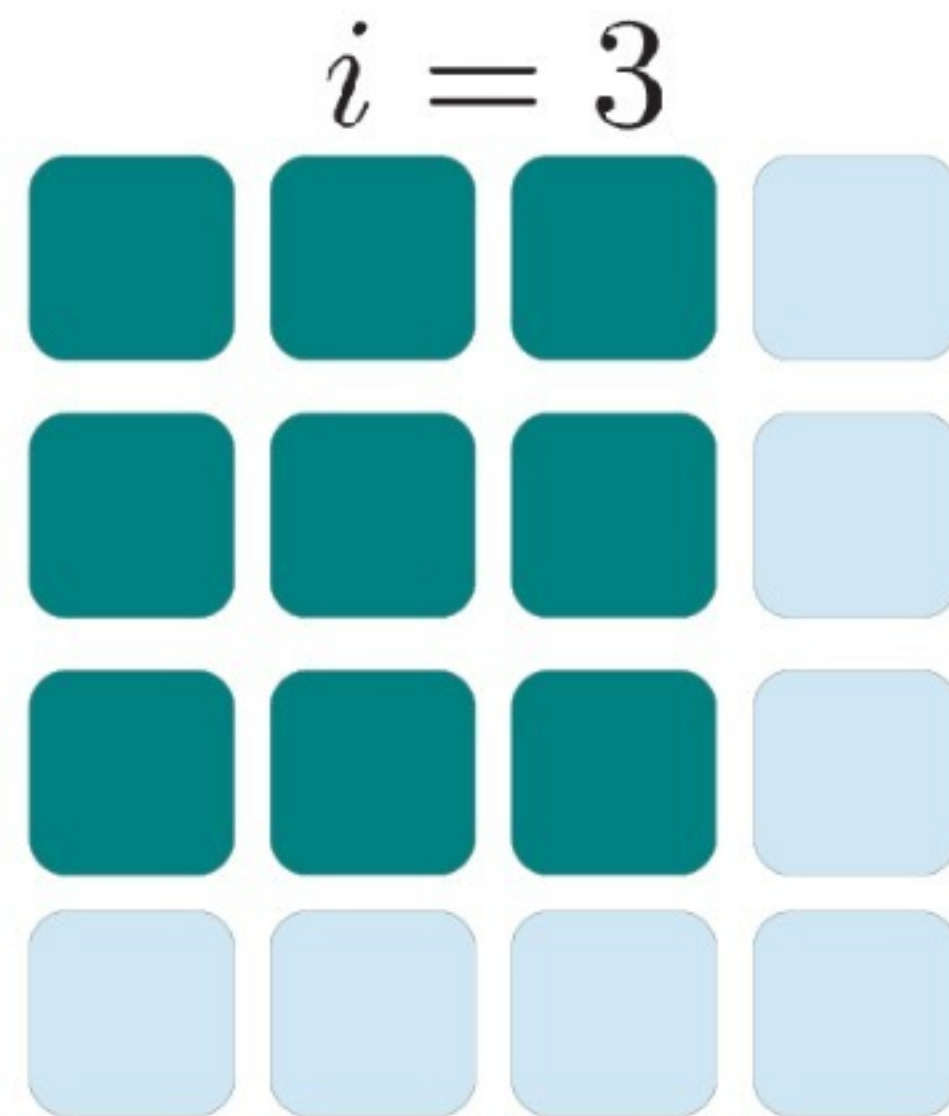
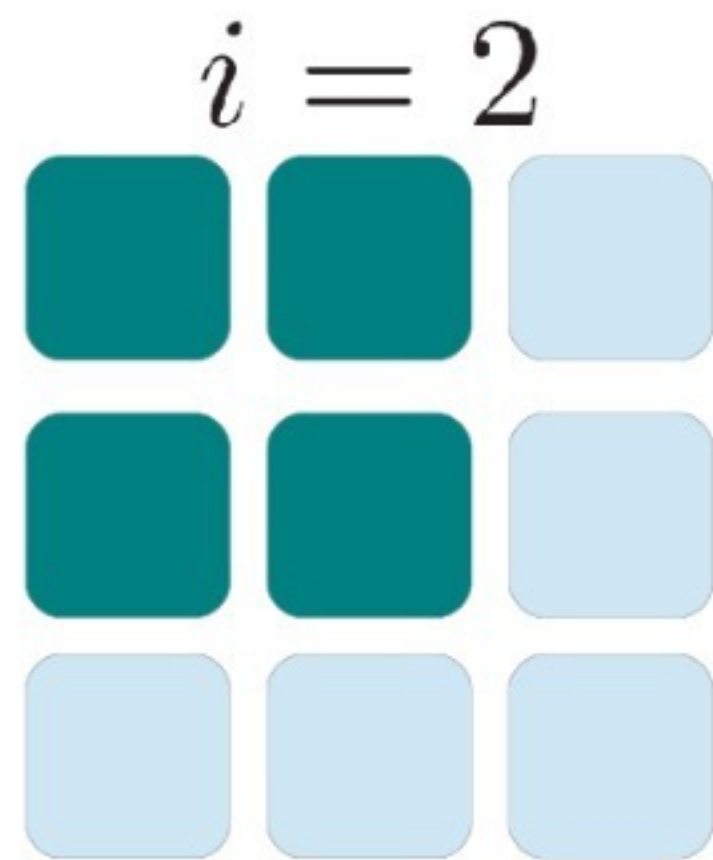
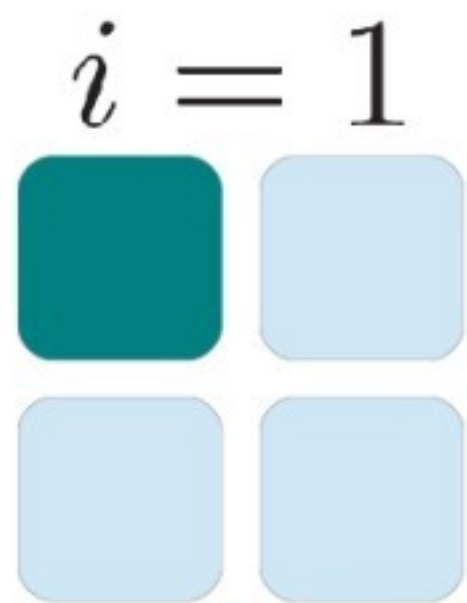
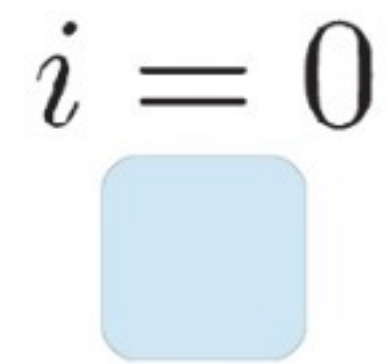
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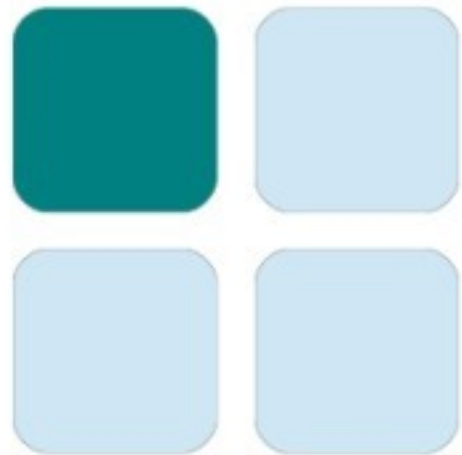
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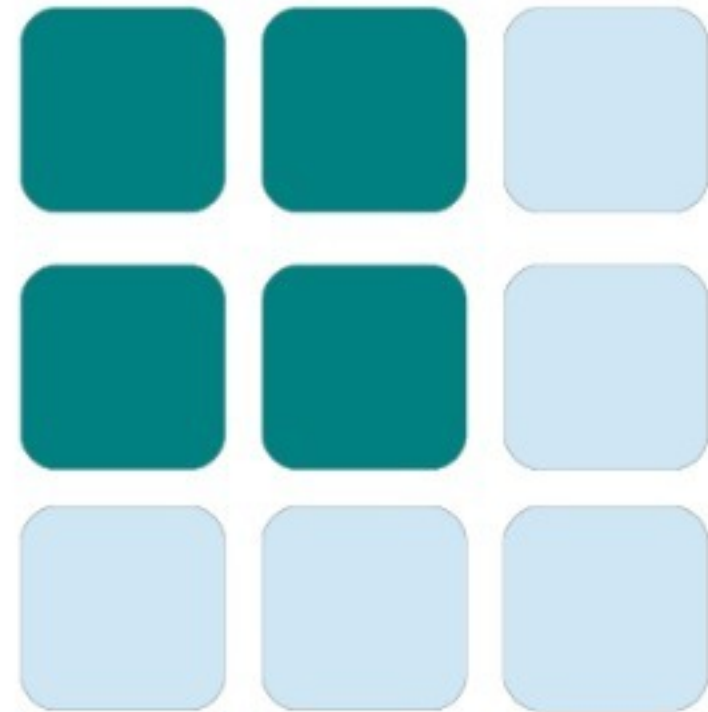
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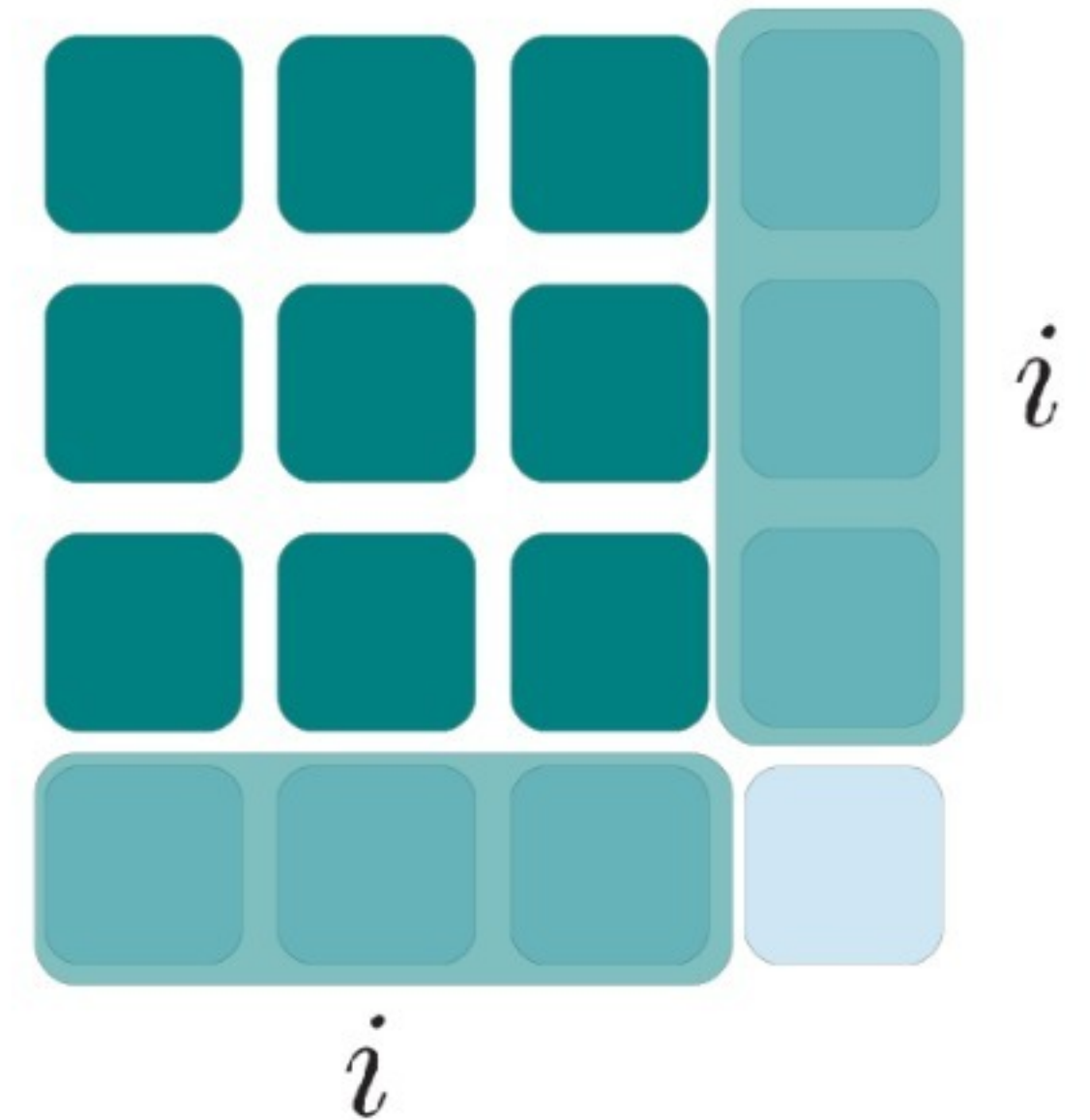
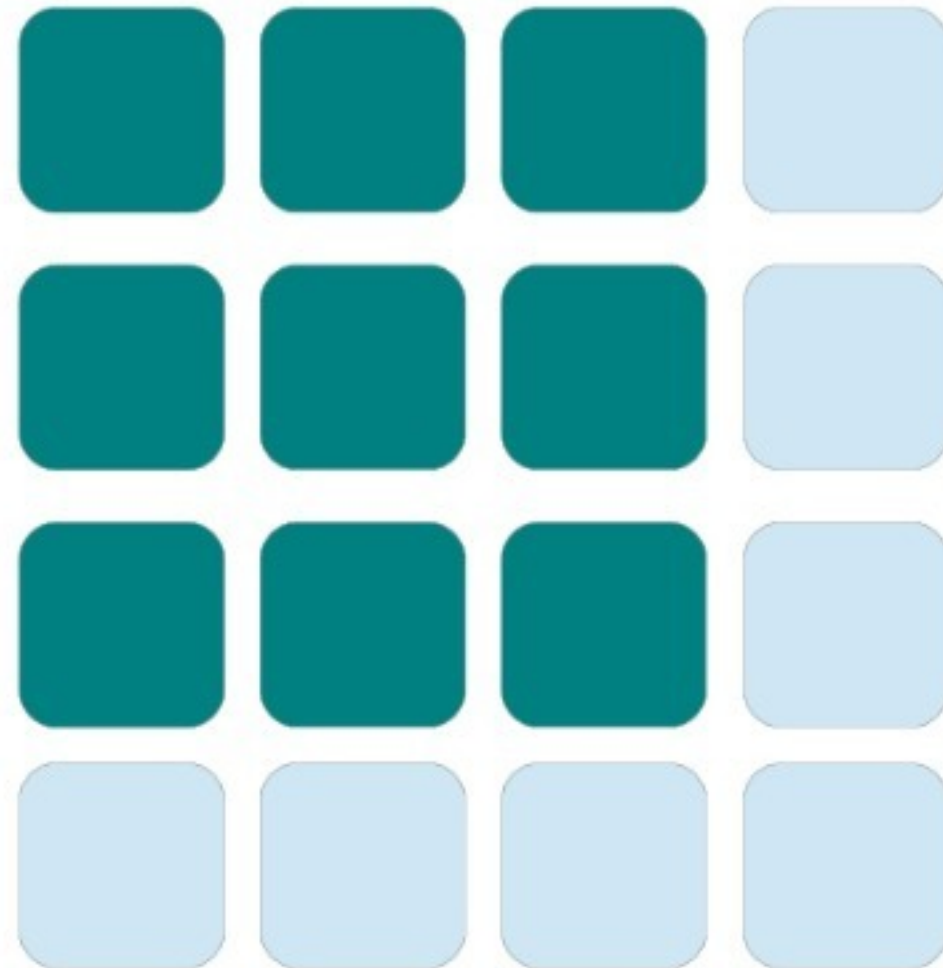
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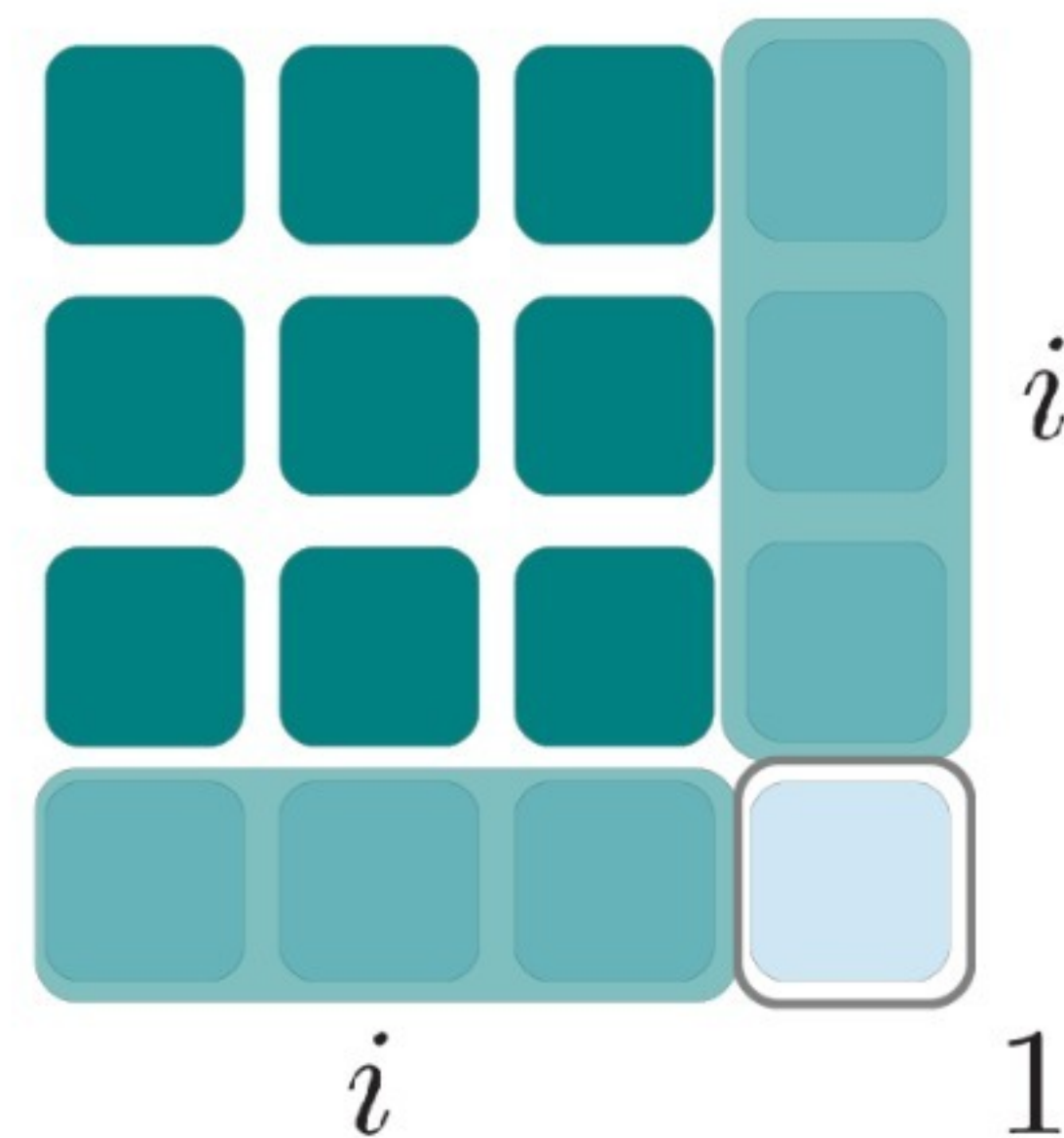
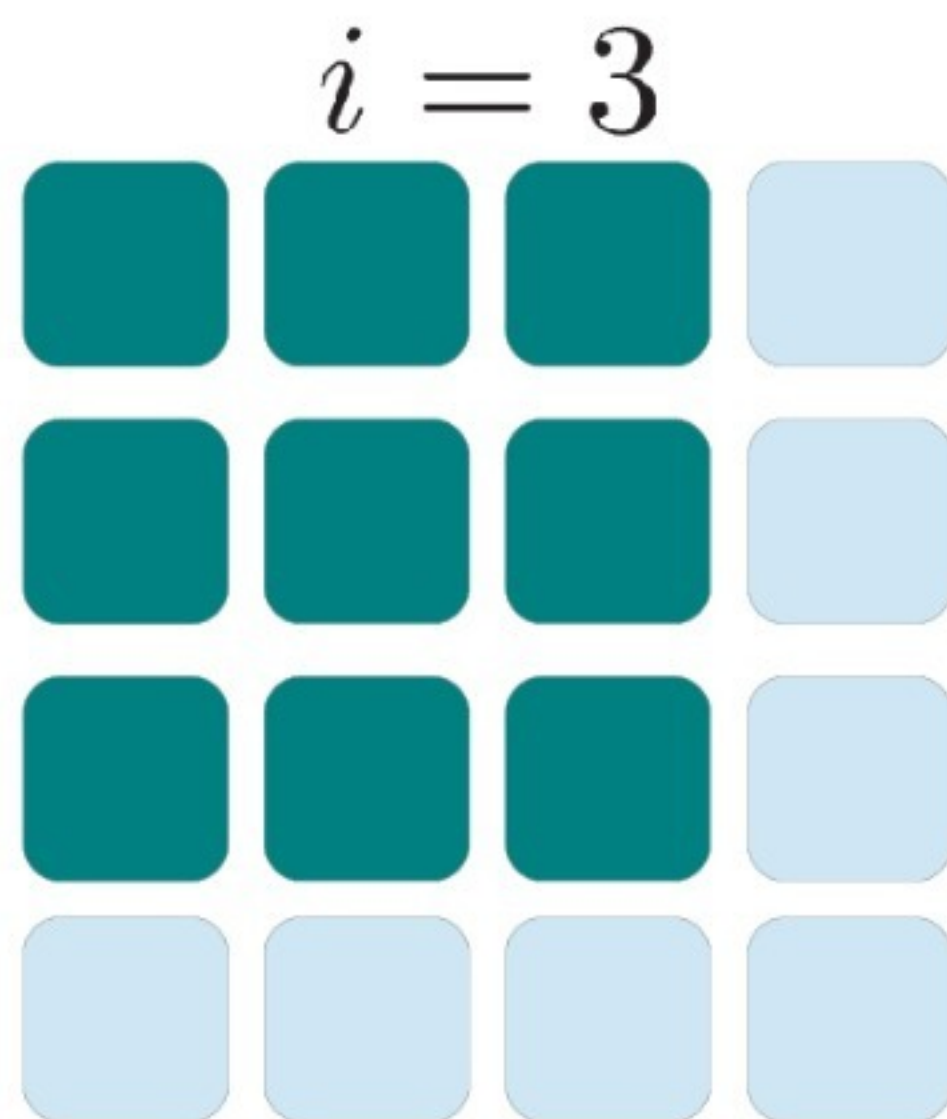
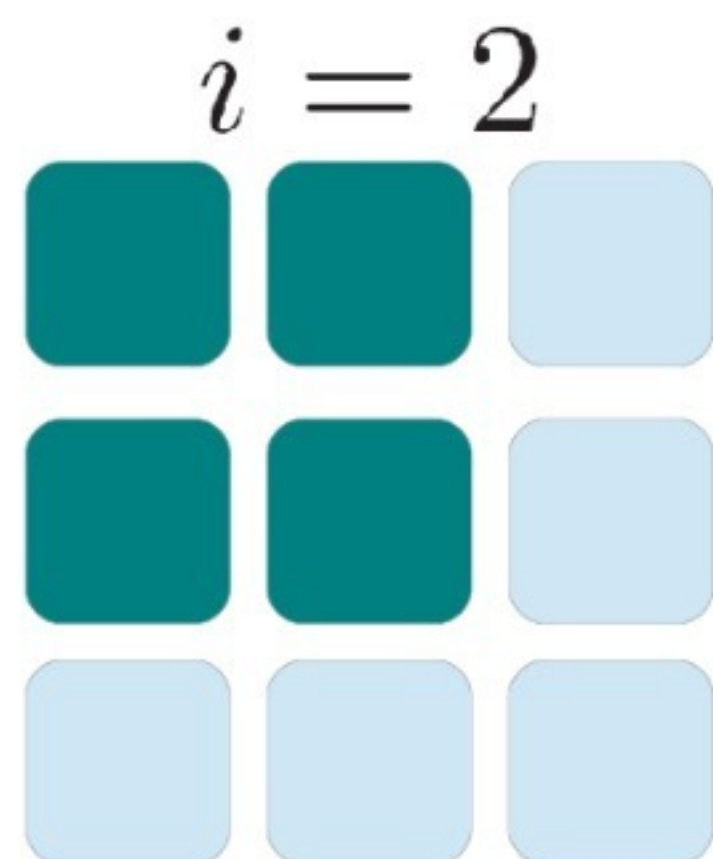
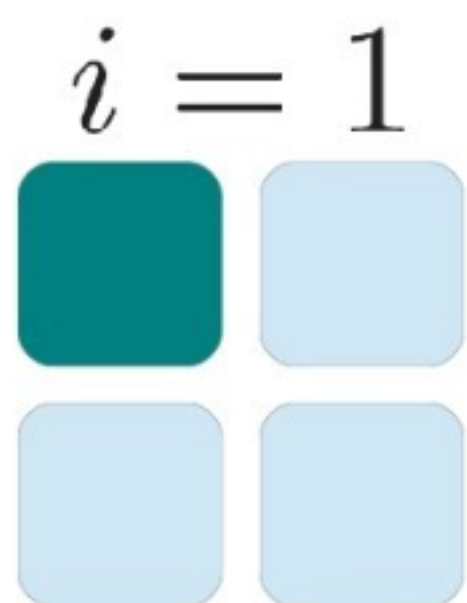
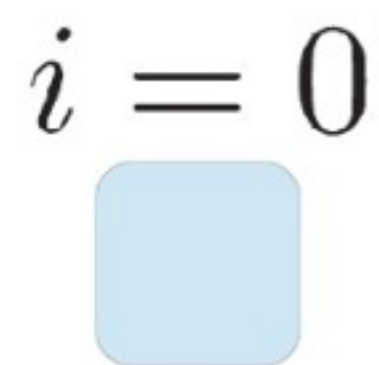
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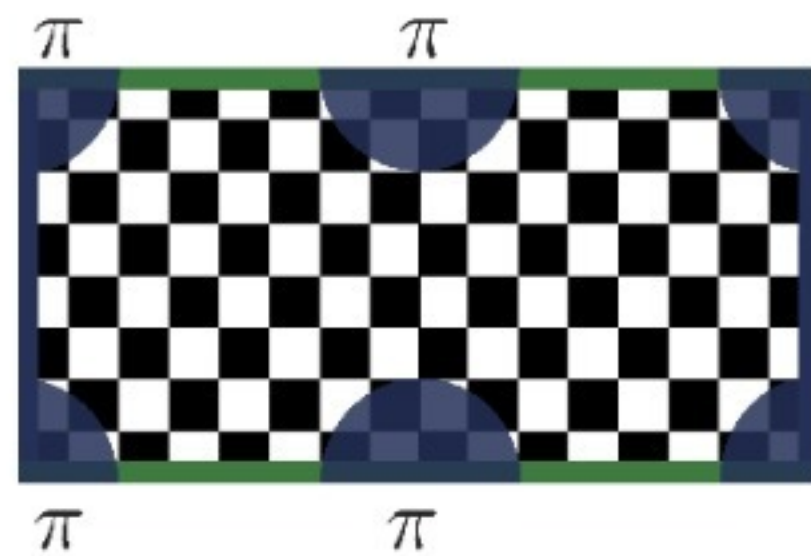
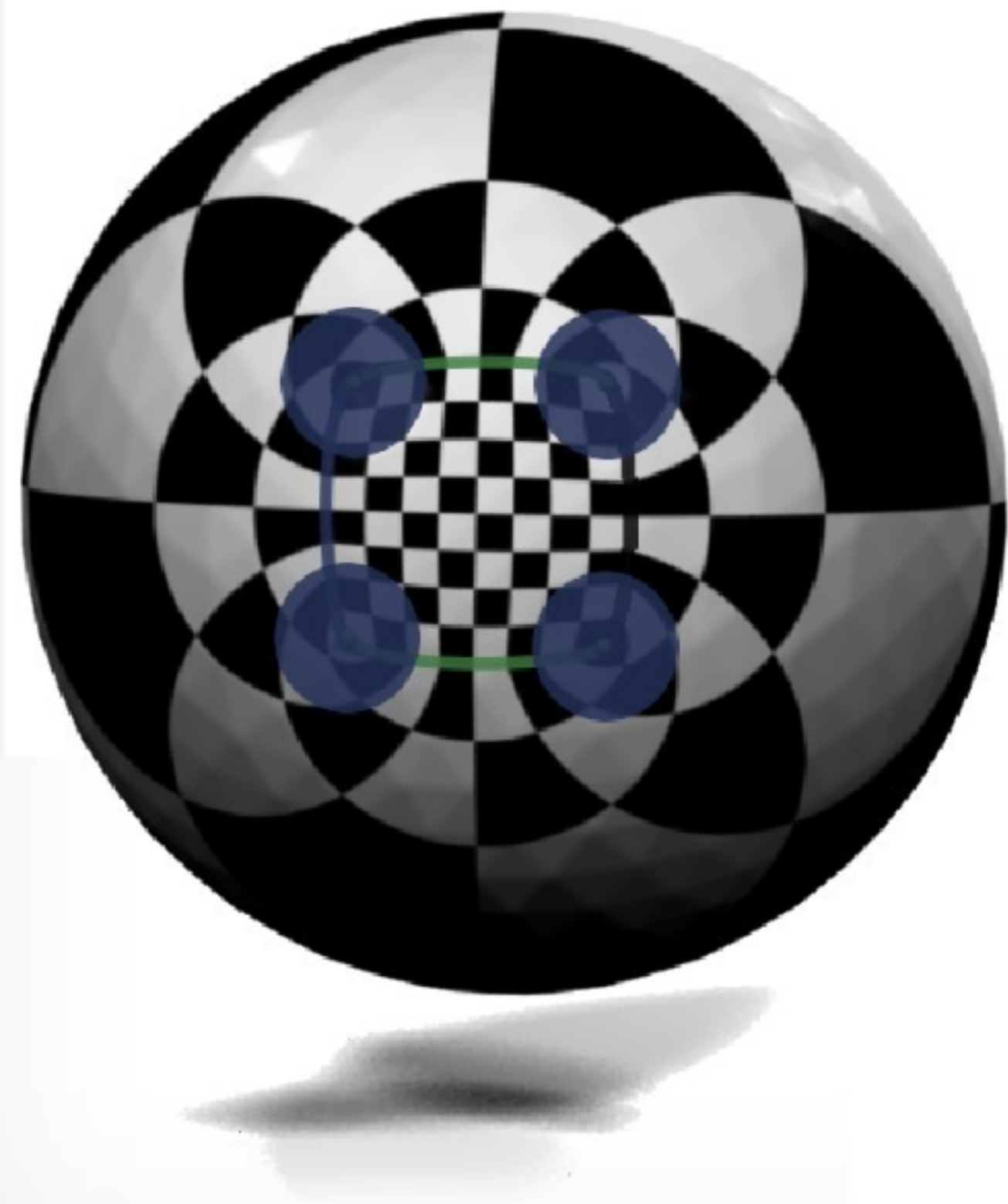
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$$\int_{\mathcal{S}} K dA = 2\pi\chi(\mathcal{S})$$

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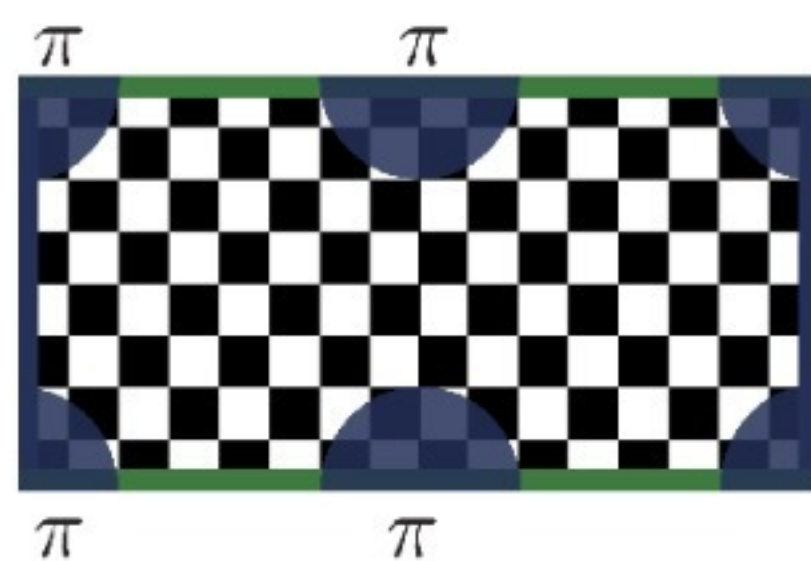


$$4 \times \pi = 4\pi$$

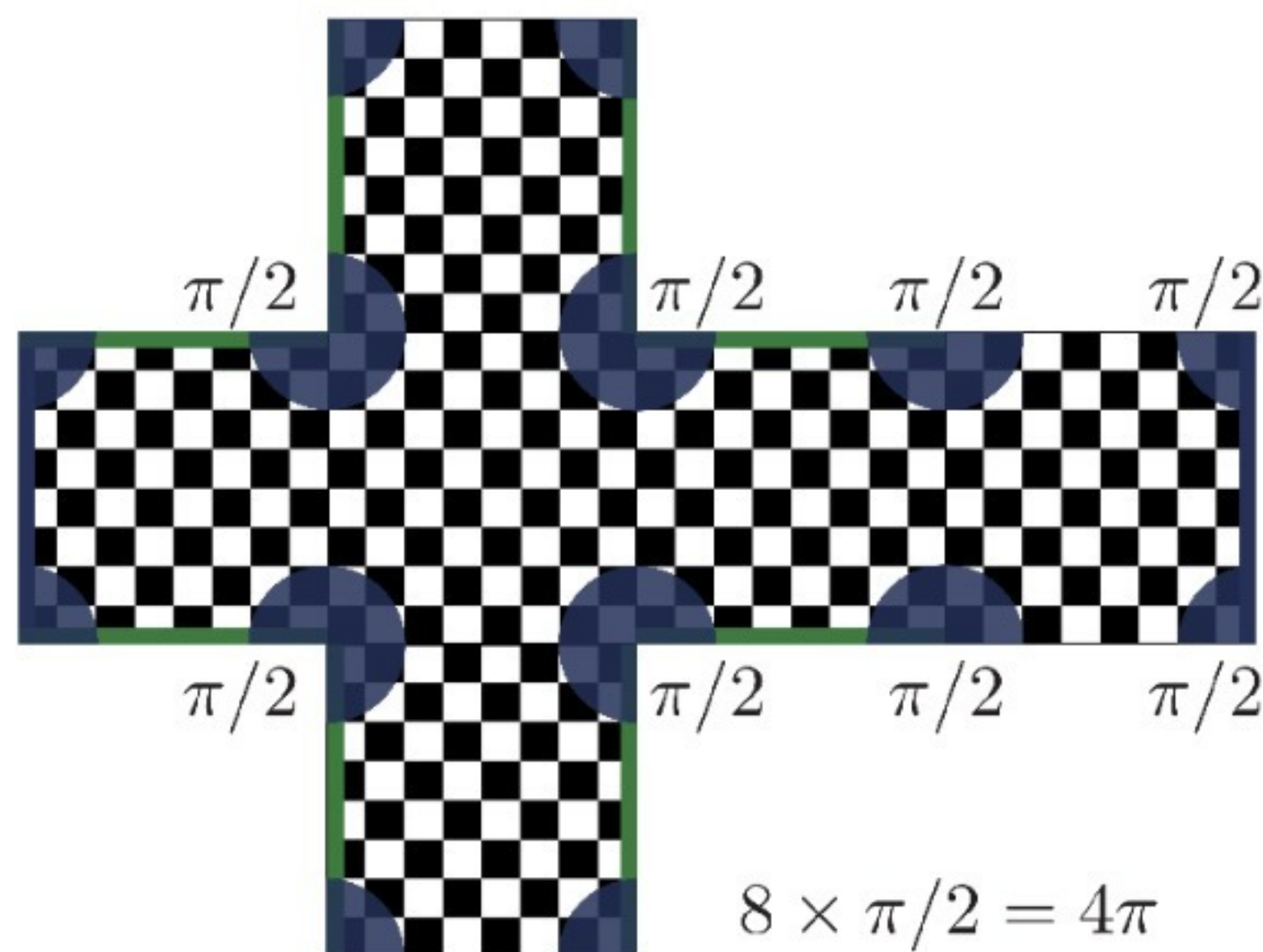
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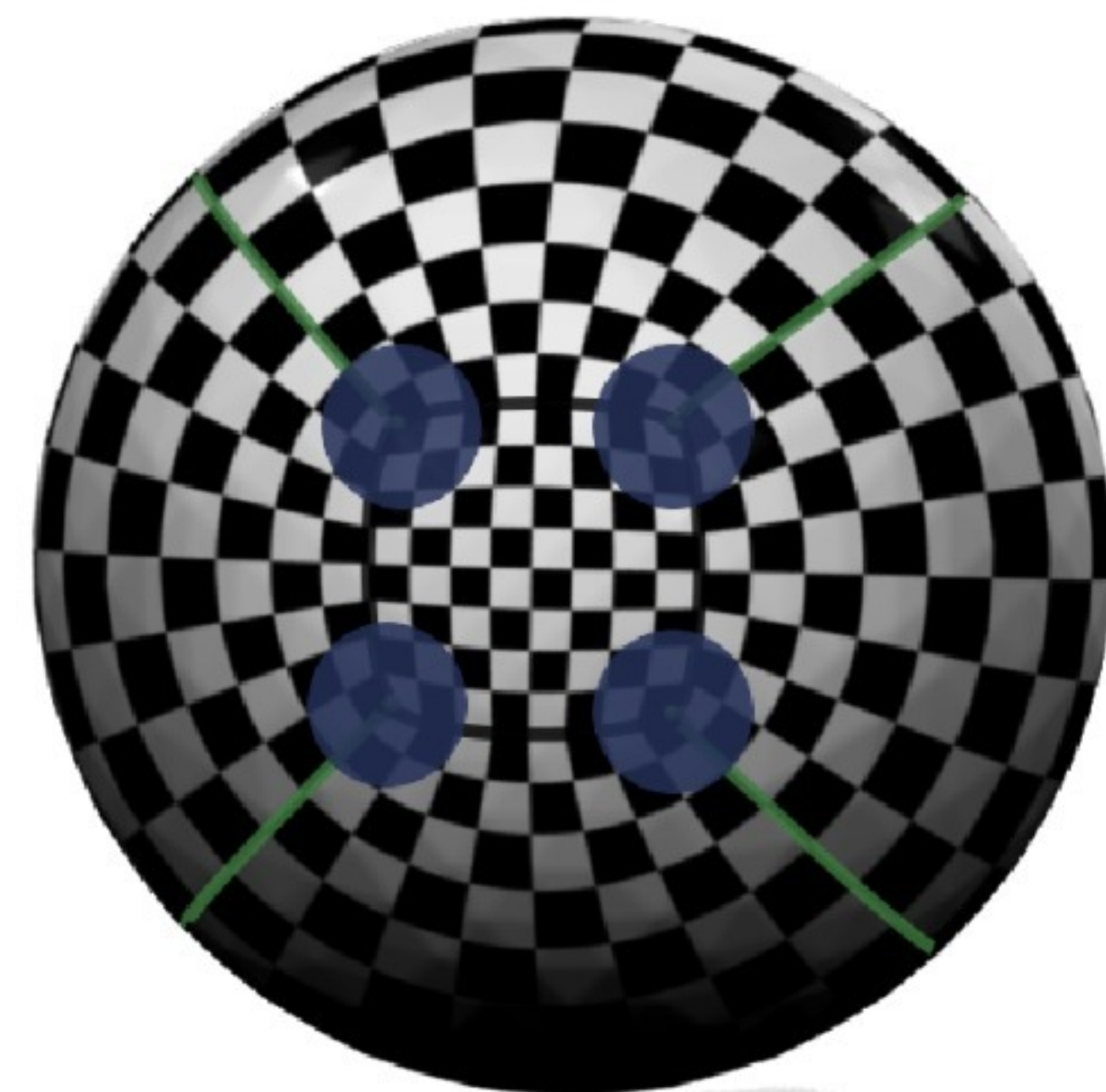
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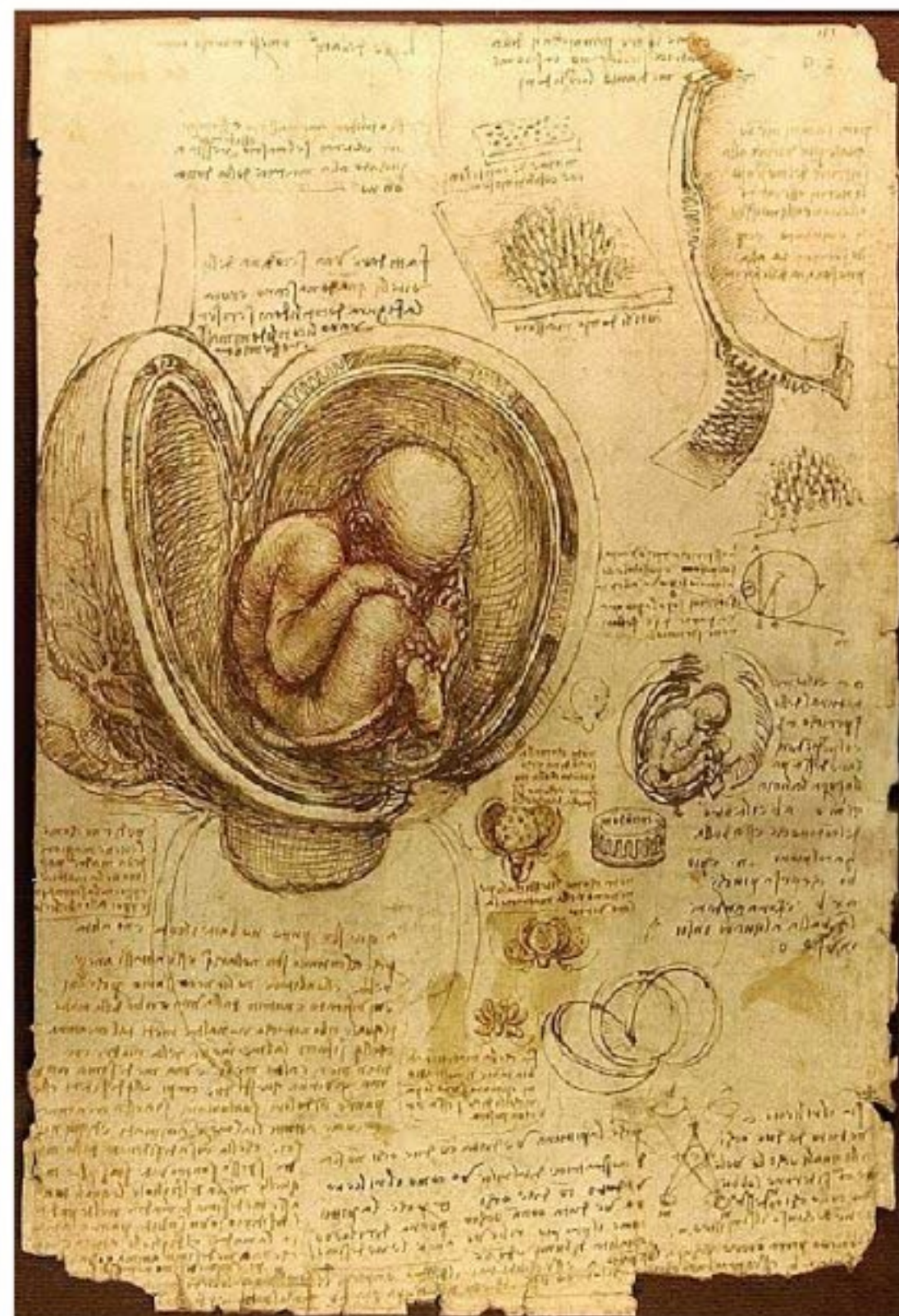


$$8 \times \pi/2 = 4\pi$$



What is it useful for?

- Illustrating/communicating knowledge



What is it useful for?

- **Interpreting data**

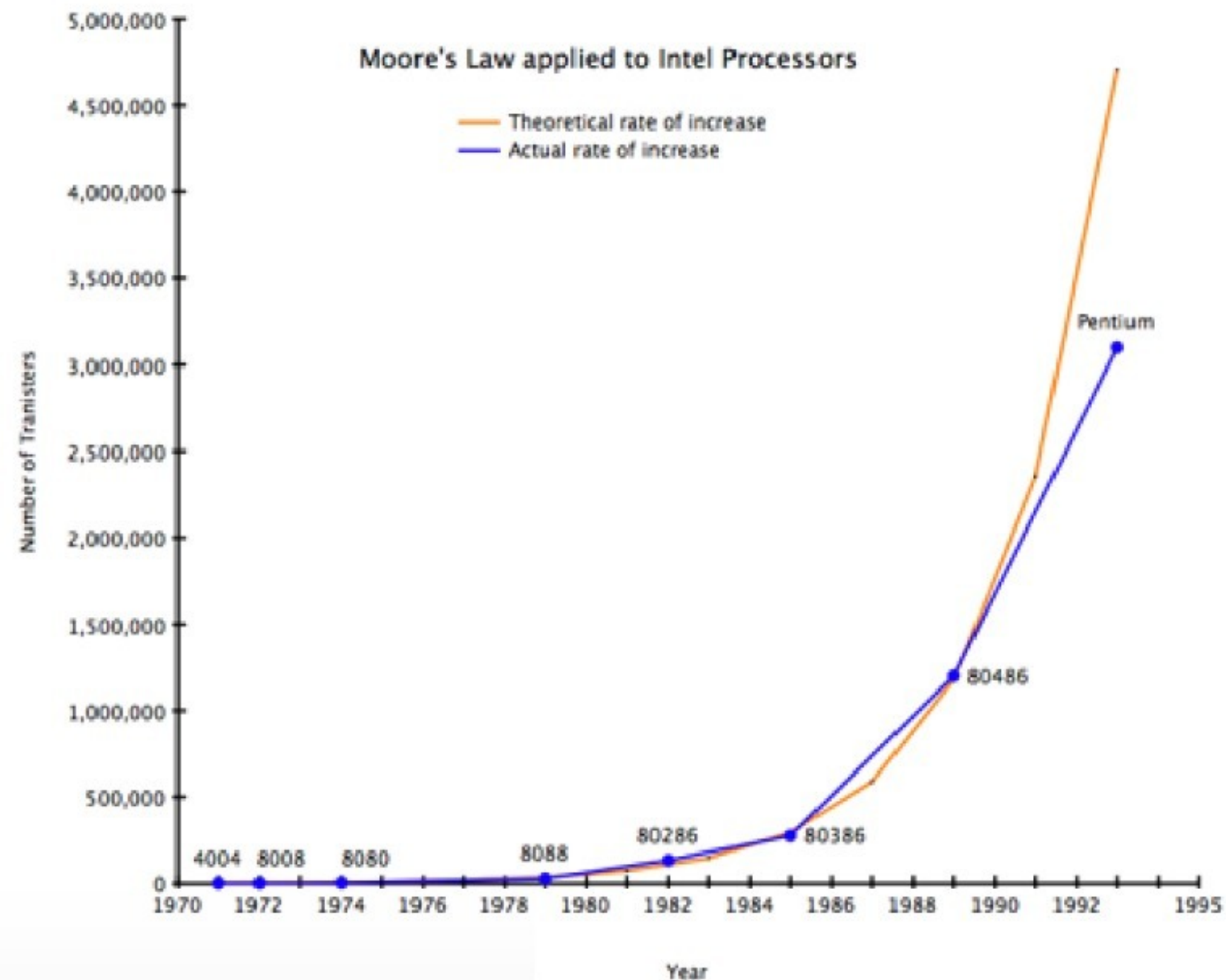
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- **Interpreting data**
 - *“Data industrial revolution”*

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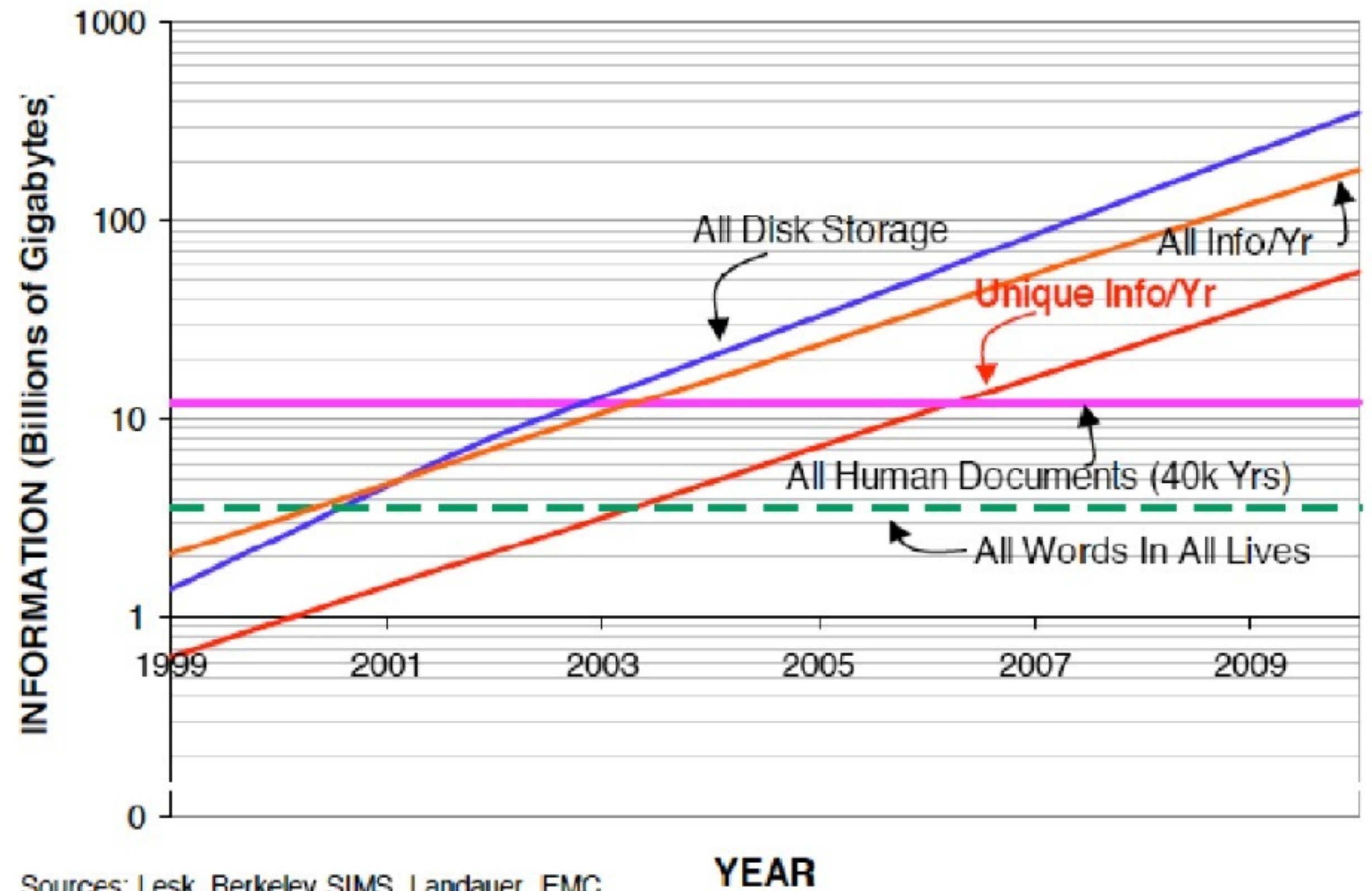
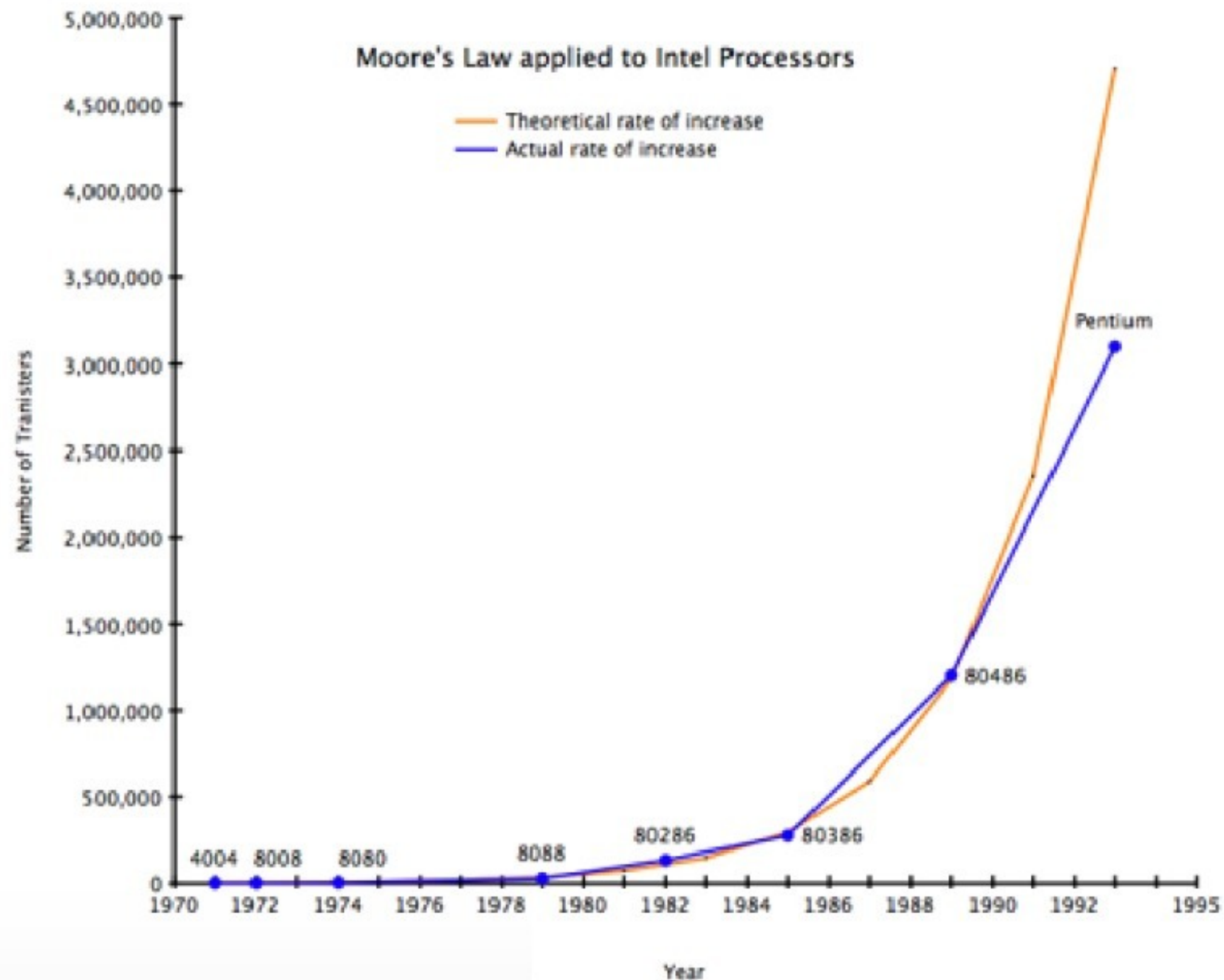
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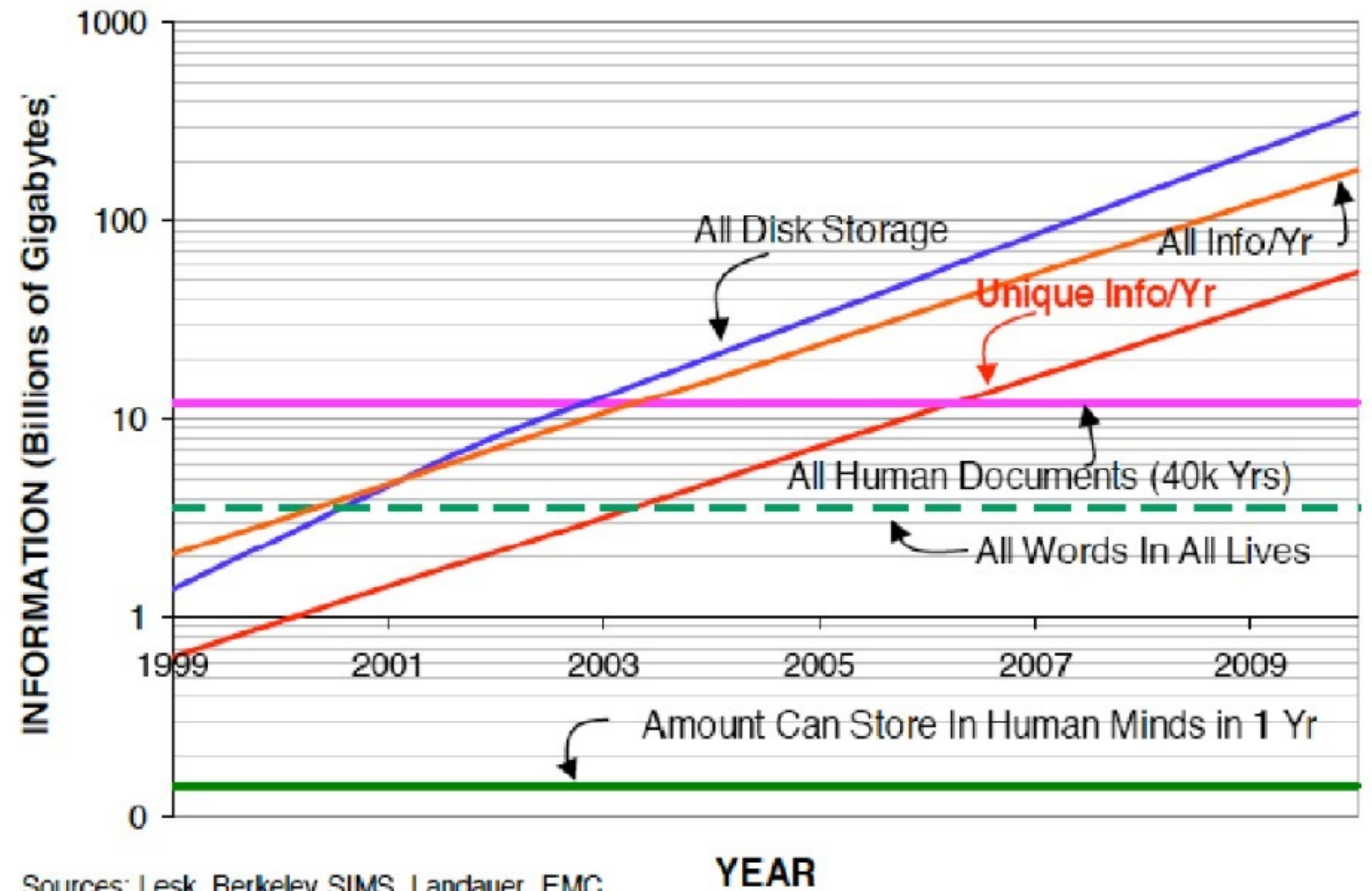
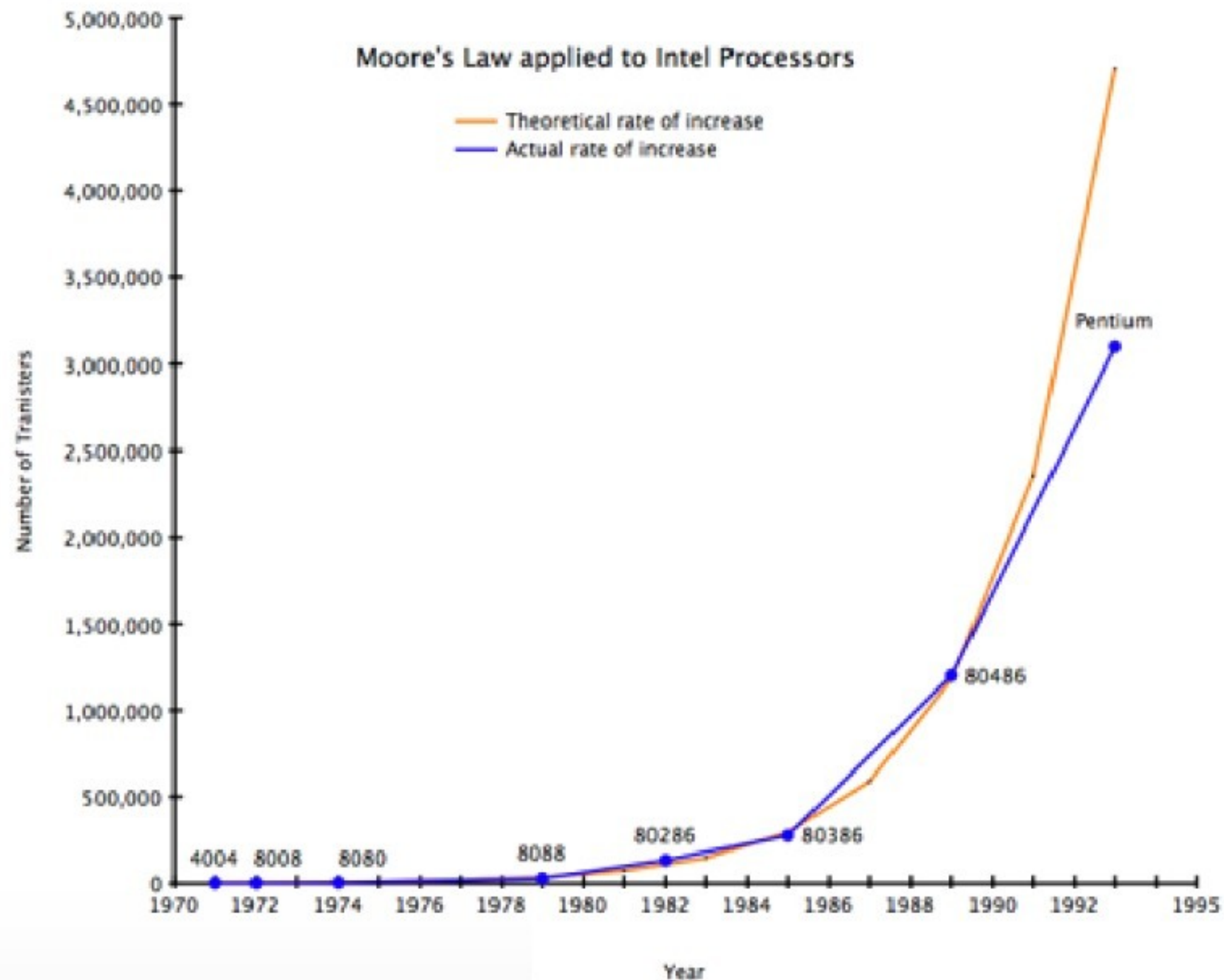


Sources: Lesk, Berkeley SIMS, Landauer, EMC

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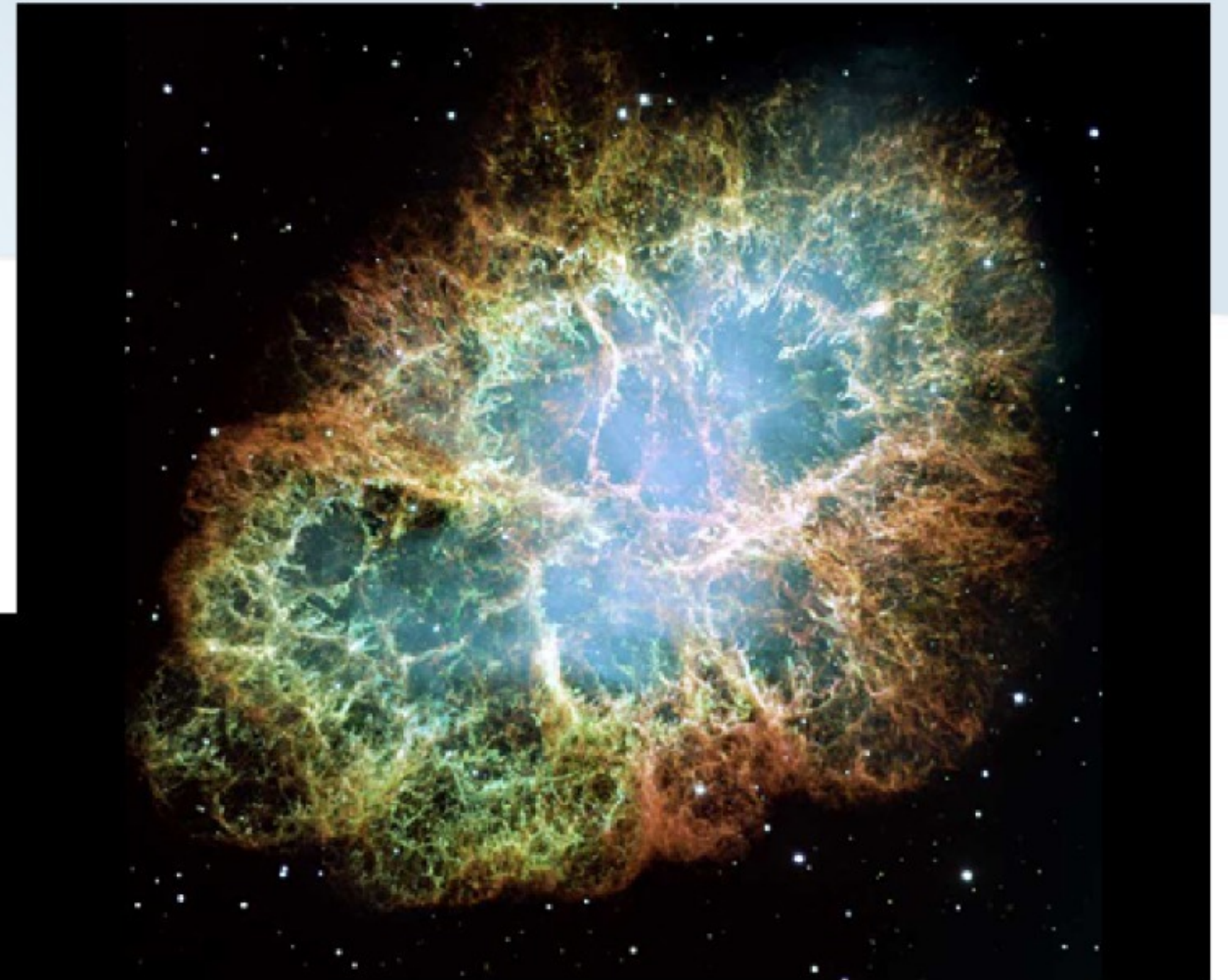
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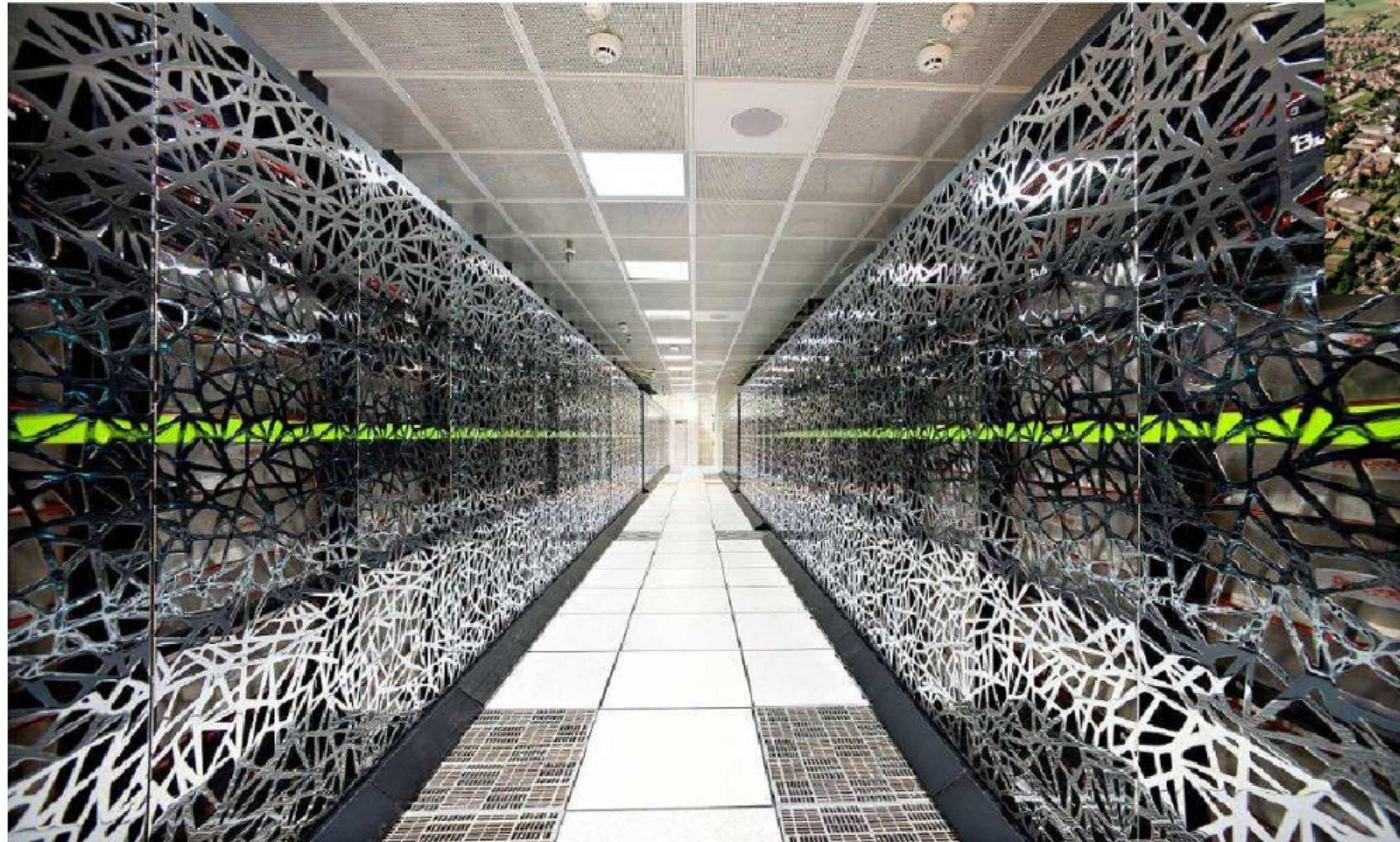
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- **Interpreting data**
 - *“Data industrial revolution”* (1996 CTBT)



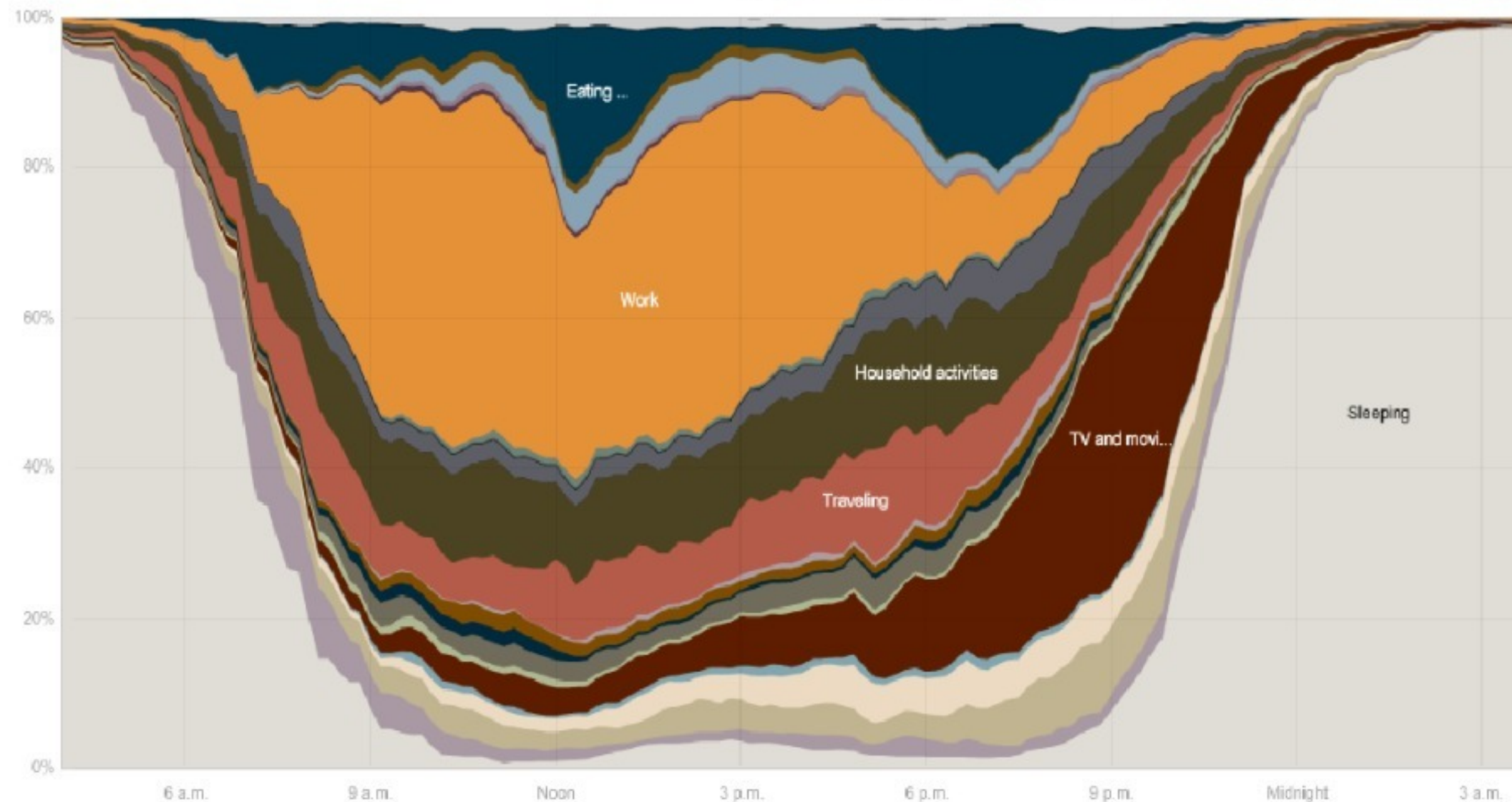
What is it useful for?

- Interpreting data
 - Identifying patterns (“Organization of the day”, H. Pfister)

People with advanced degrees

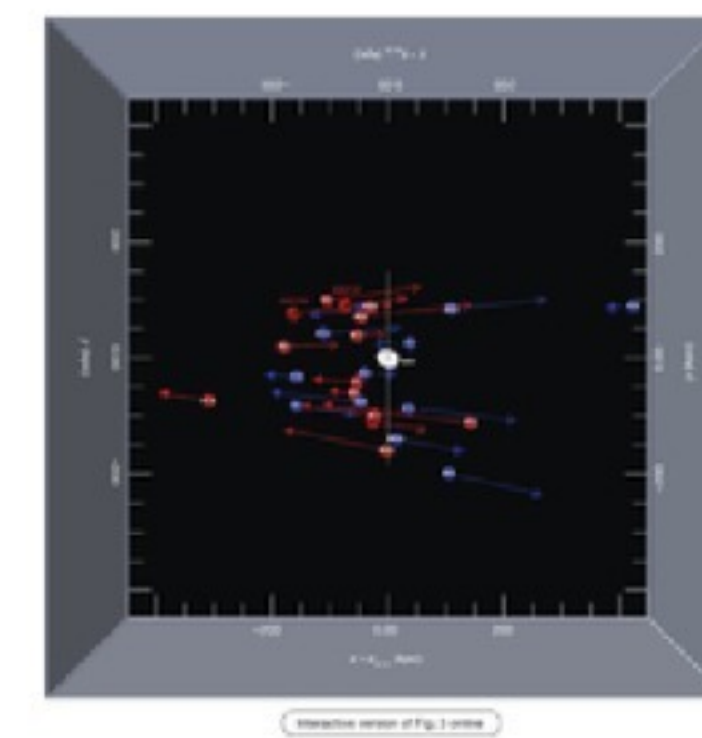
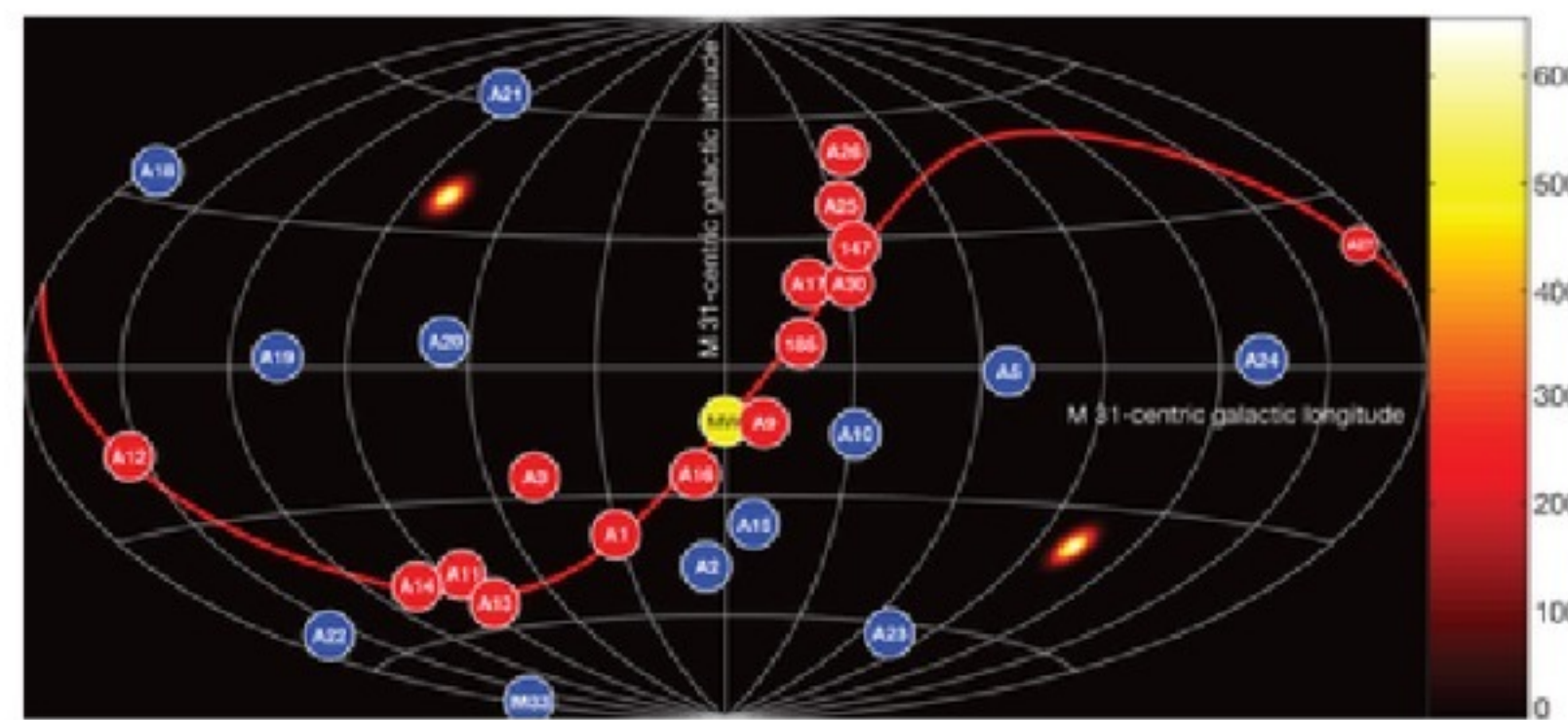
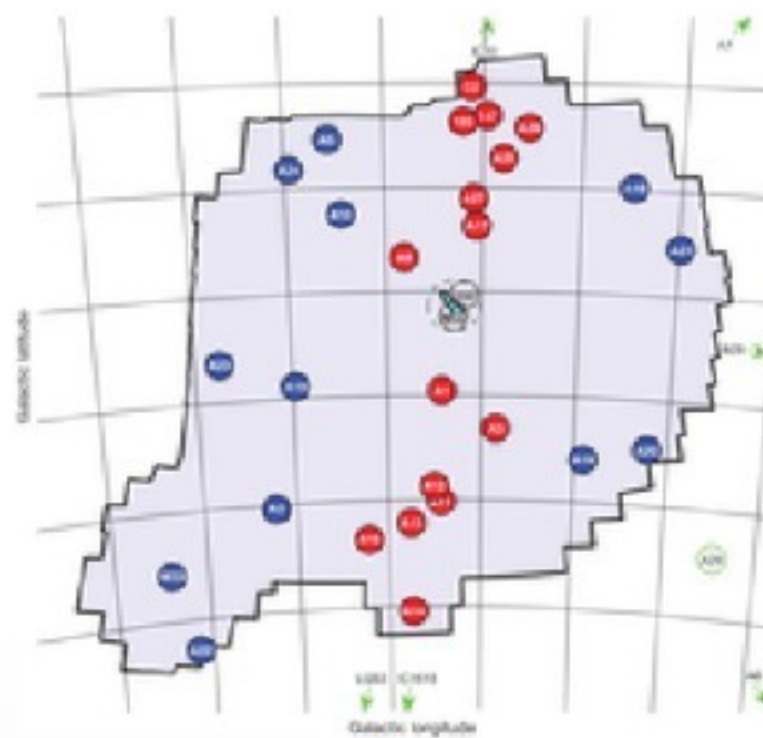
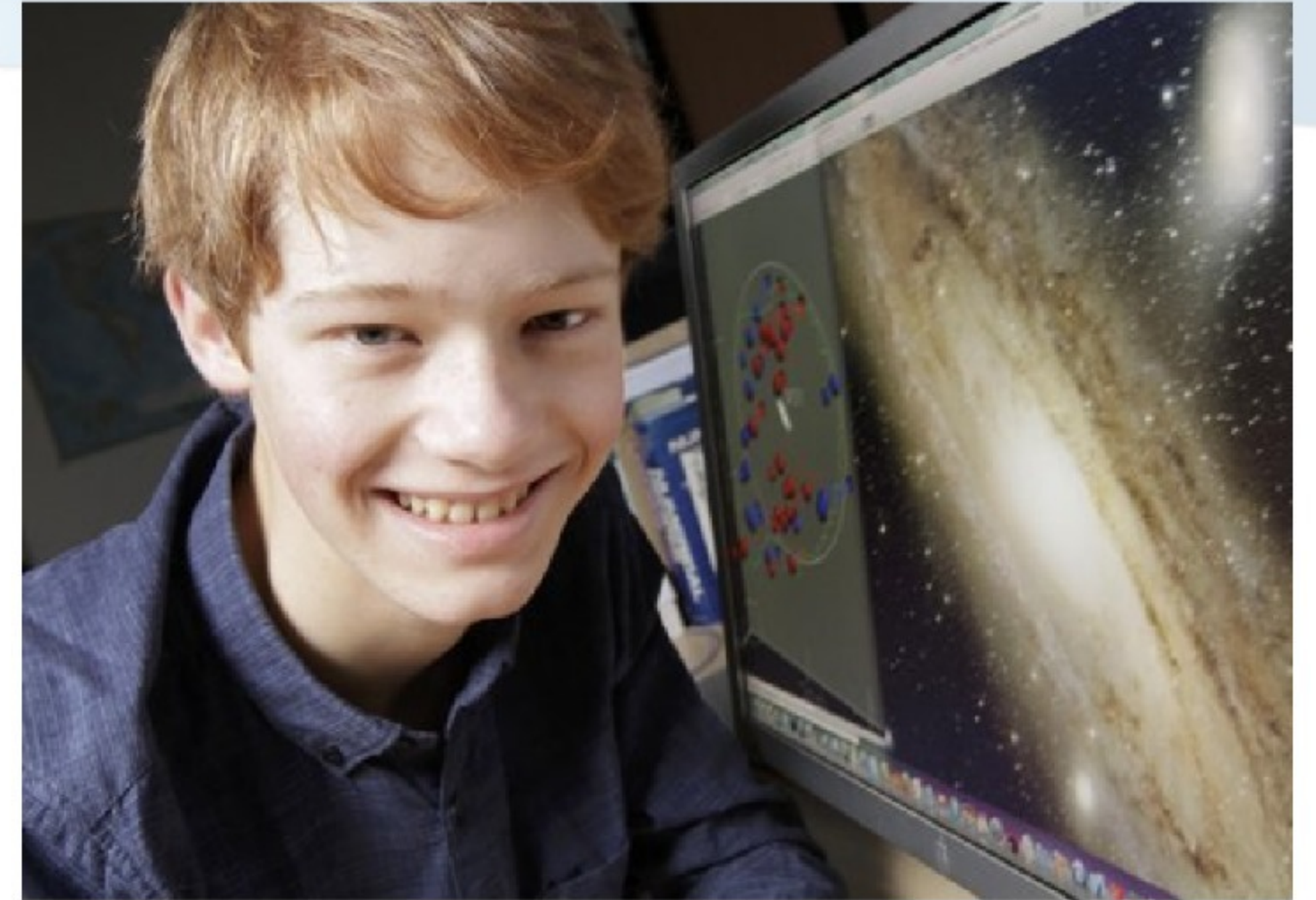
Those with advanced degrees spend the most time volunteering: 14 minutes a day (or more than an hour and a half a week), on average.

Everyone	Employed	White	Age 15-24	H.S. grads	No children
Men	Unemployed	Black	Age 25-64	Bachelor's	One child
Women	Not in lab...	Hispanic	Age 65+	Advanced	Two+ children



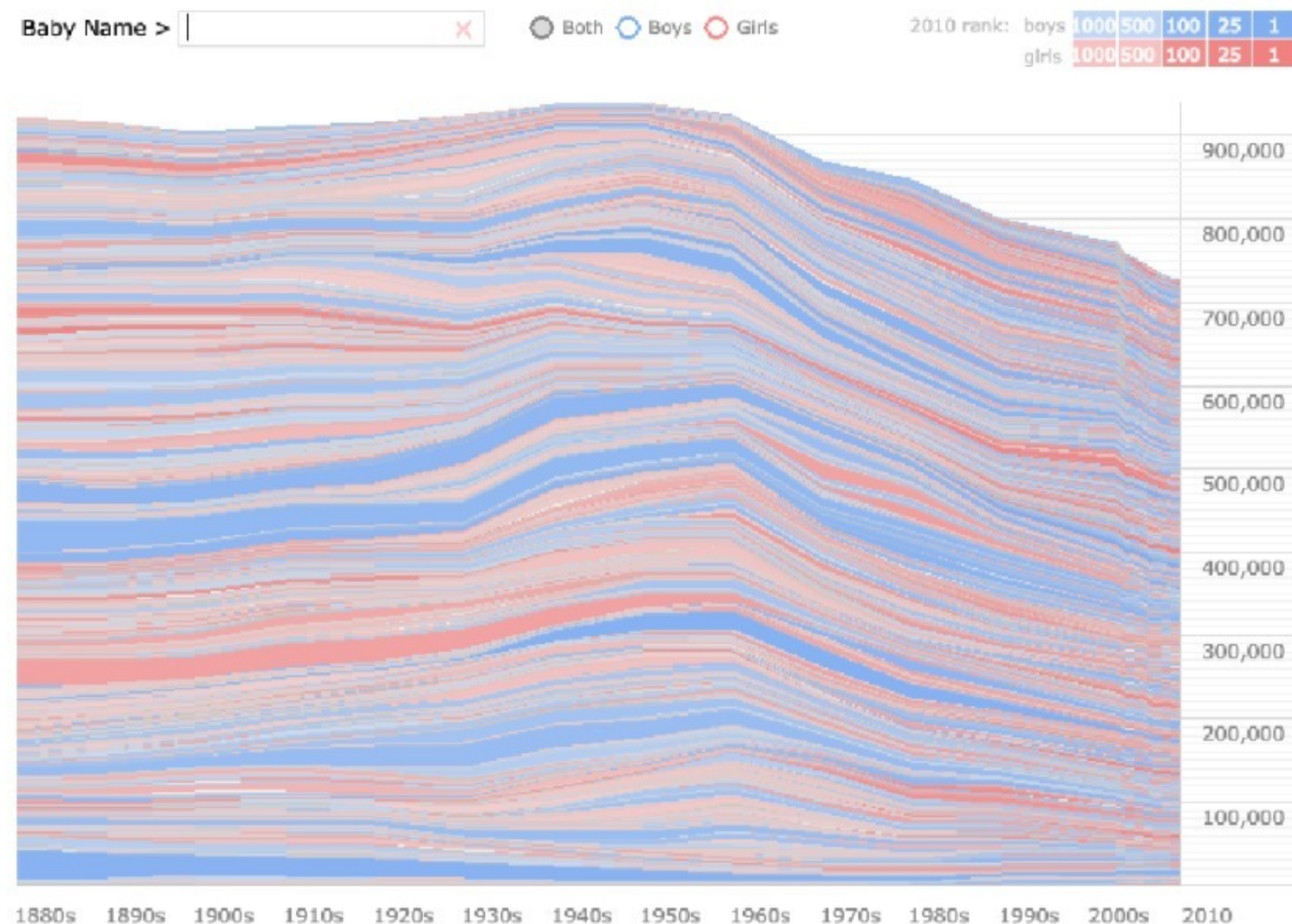
What is it useful for?

- Interpreting data
 - Identifying patterns:
 - Dwarf galaxies orbiting the Andromeda Galaxy
 - *Nature*, January 3rd, 2013



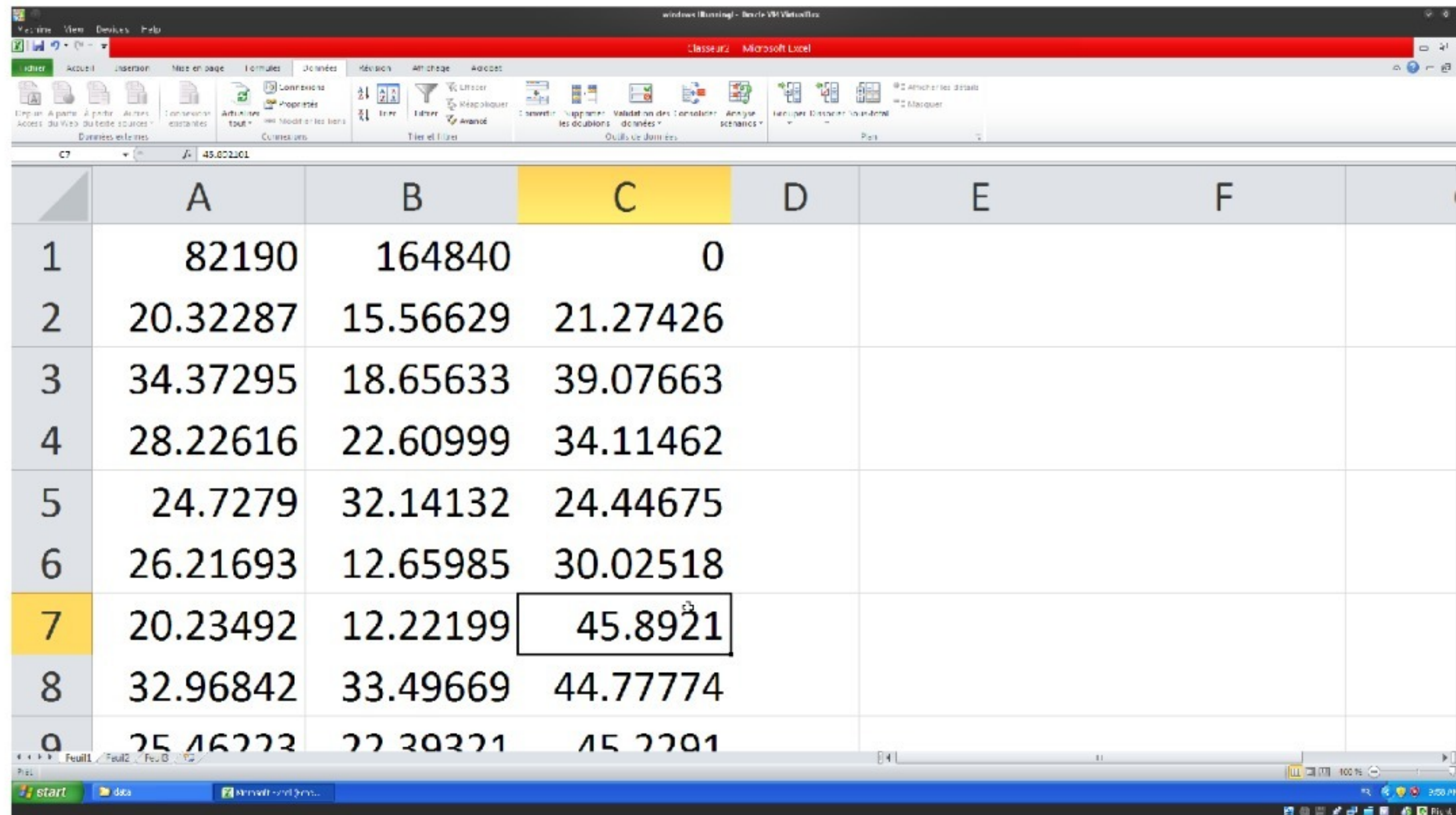
What is it useful for?

- Interpreting data
 - Exploring data (“Baby names”, H. Pfister)



What is it useful for?

- Interpreting data
- Exploring data

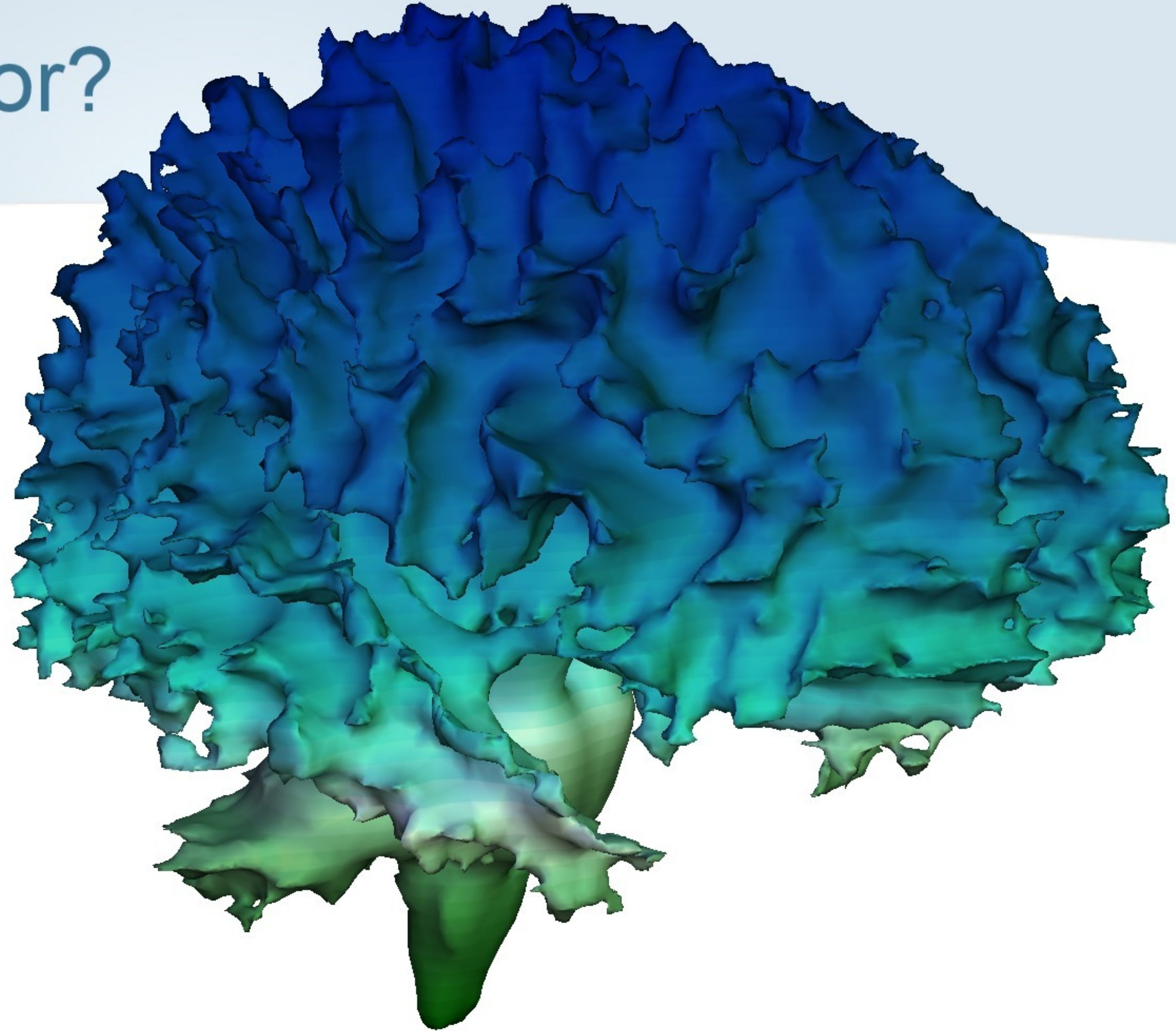


The screenshot shows a Microsoft Excel spreadsheet with the following data:

	A	B	C	D	E	F
1	82190	164840	0			
2	20.32287	15.56629	21.27426			
3	34.37295	18.65633	39.07663			
4	28.22616	22.60999	34.11462			
5	24.7279	32.14132	24.44675			
6	26.21693	12.65985	30.02518			
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8	32.96842	33.49669	44.77774			
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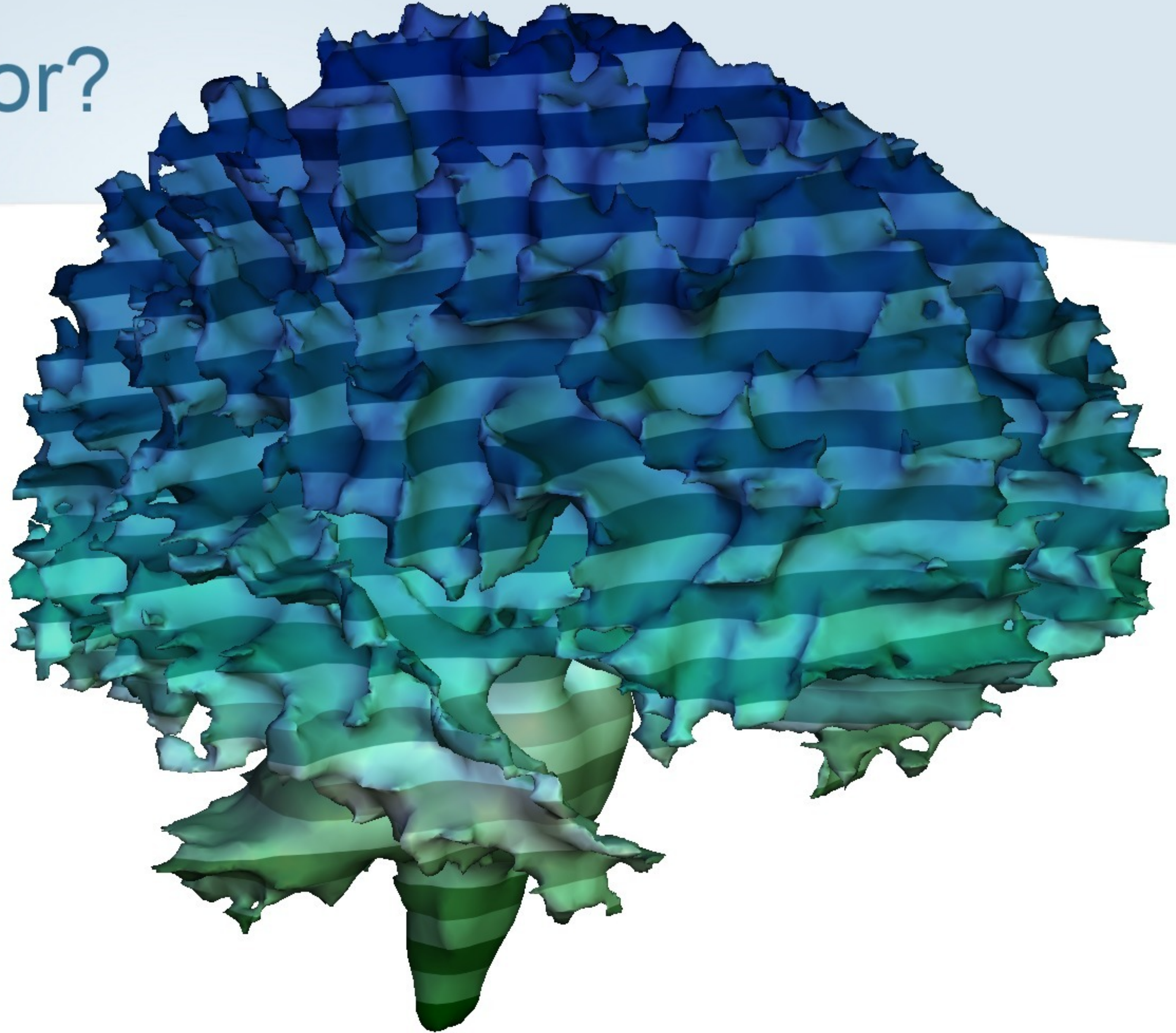
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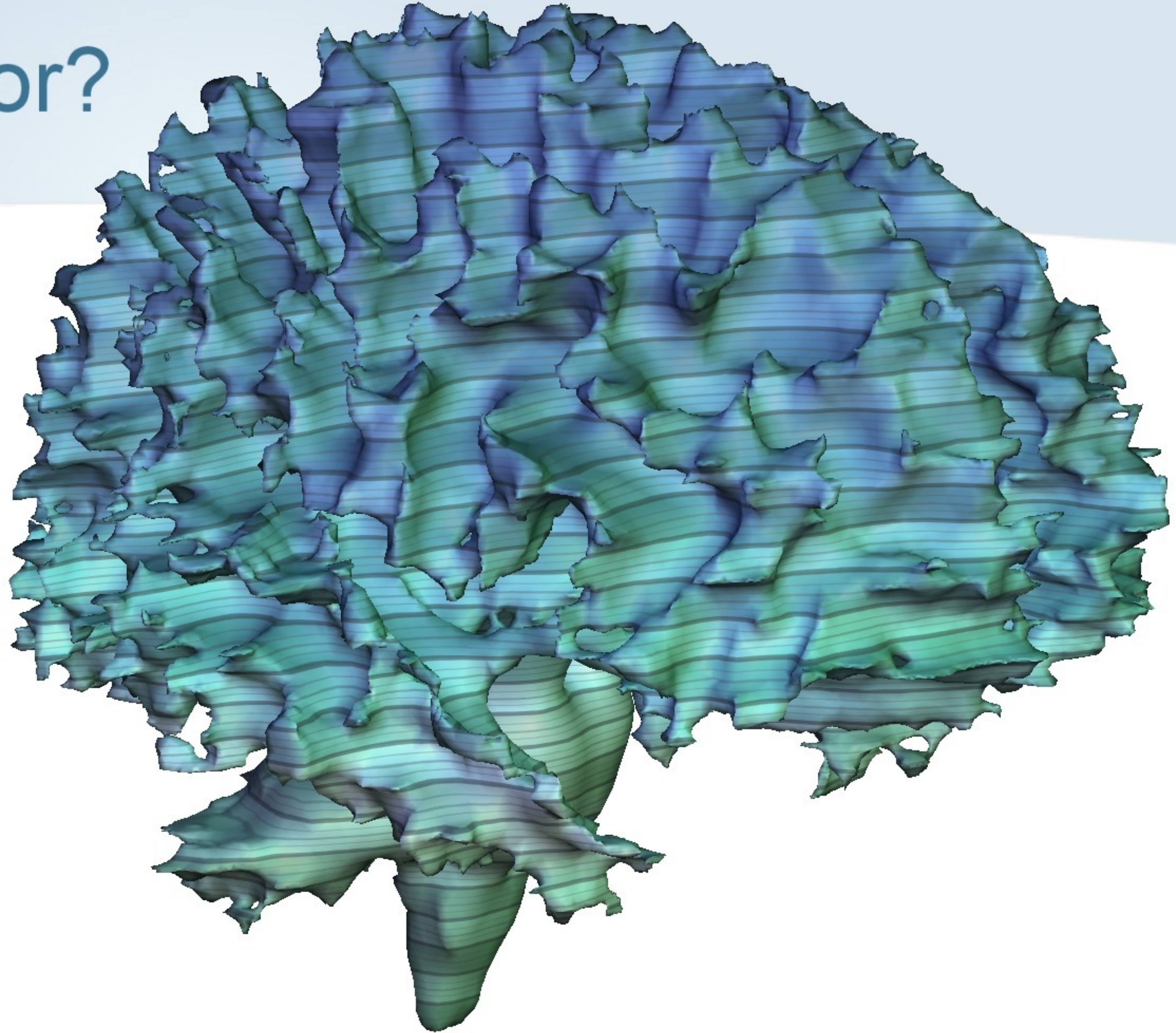
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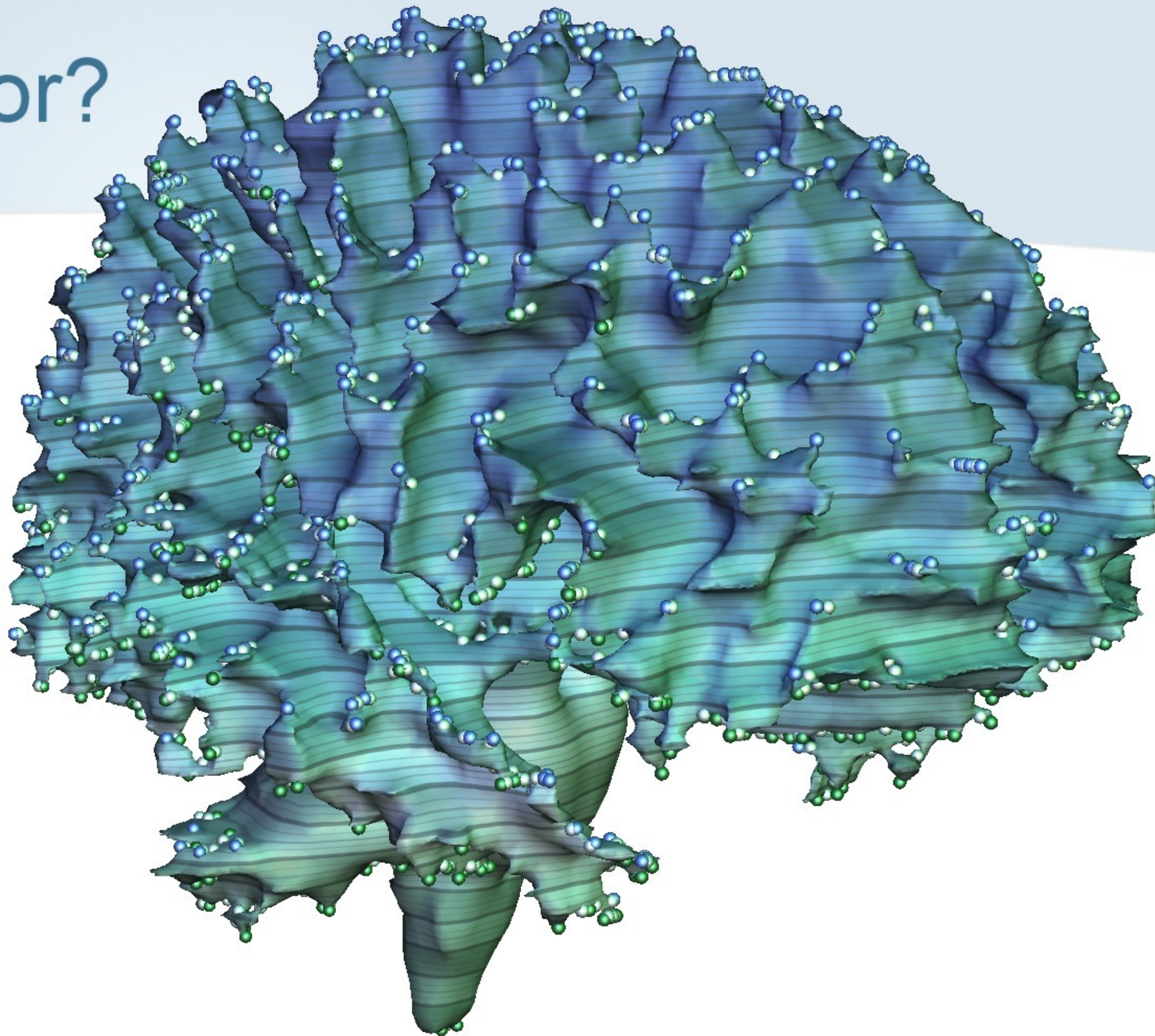
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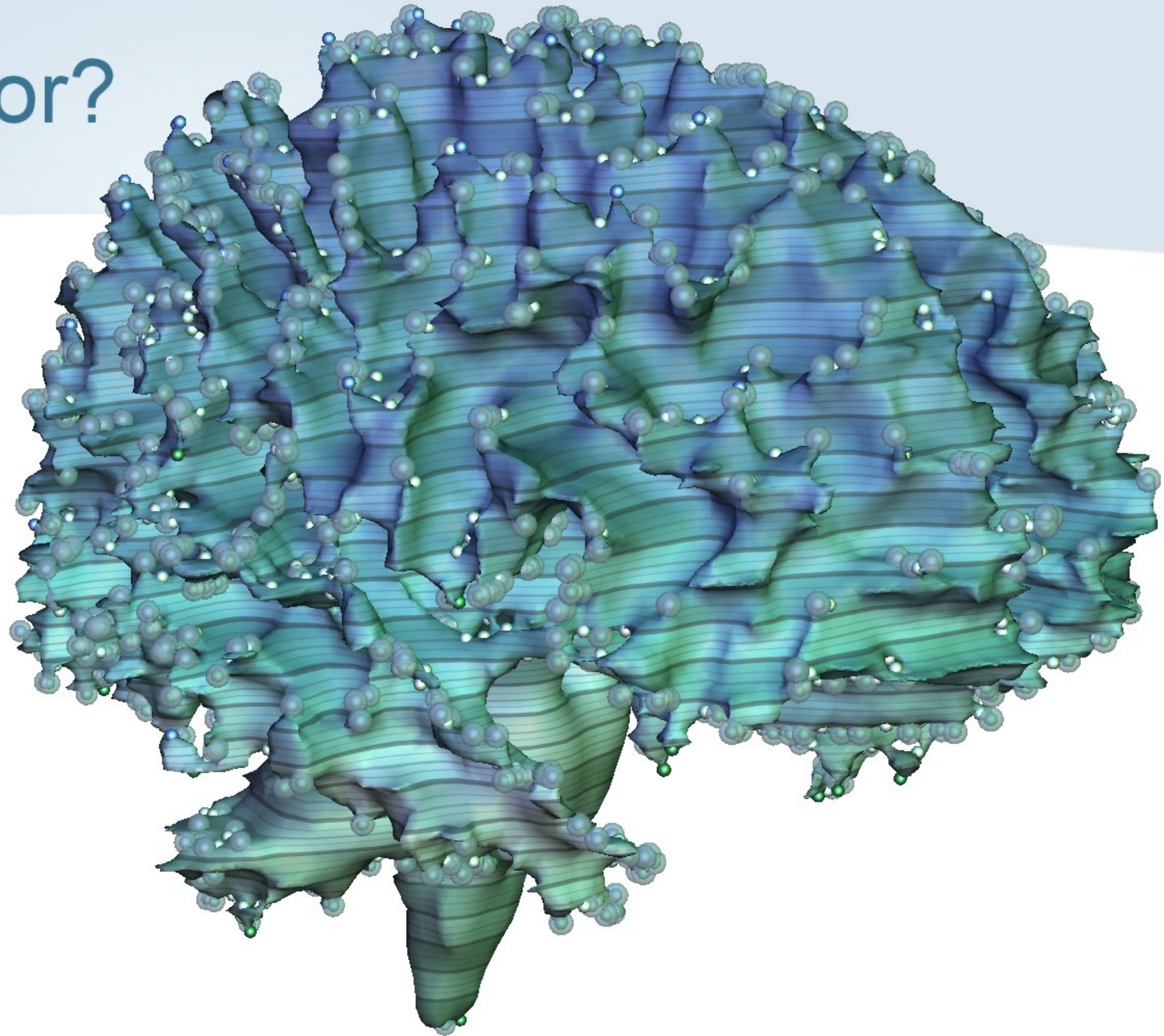
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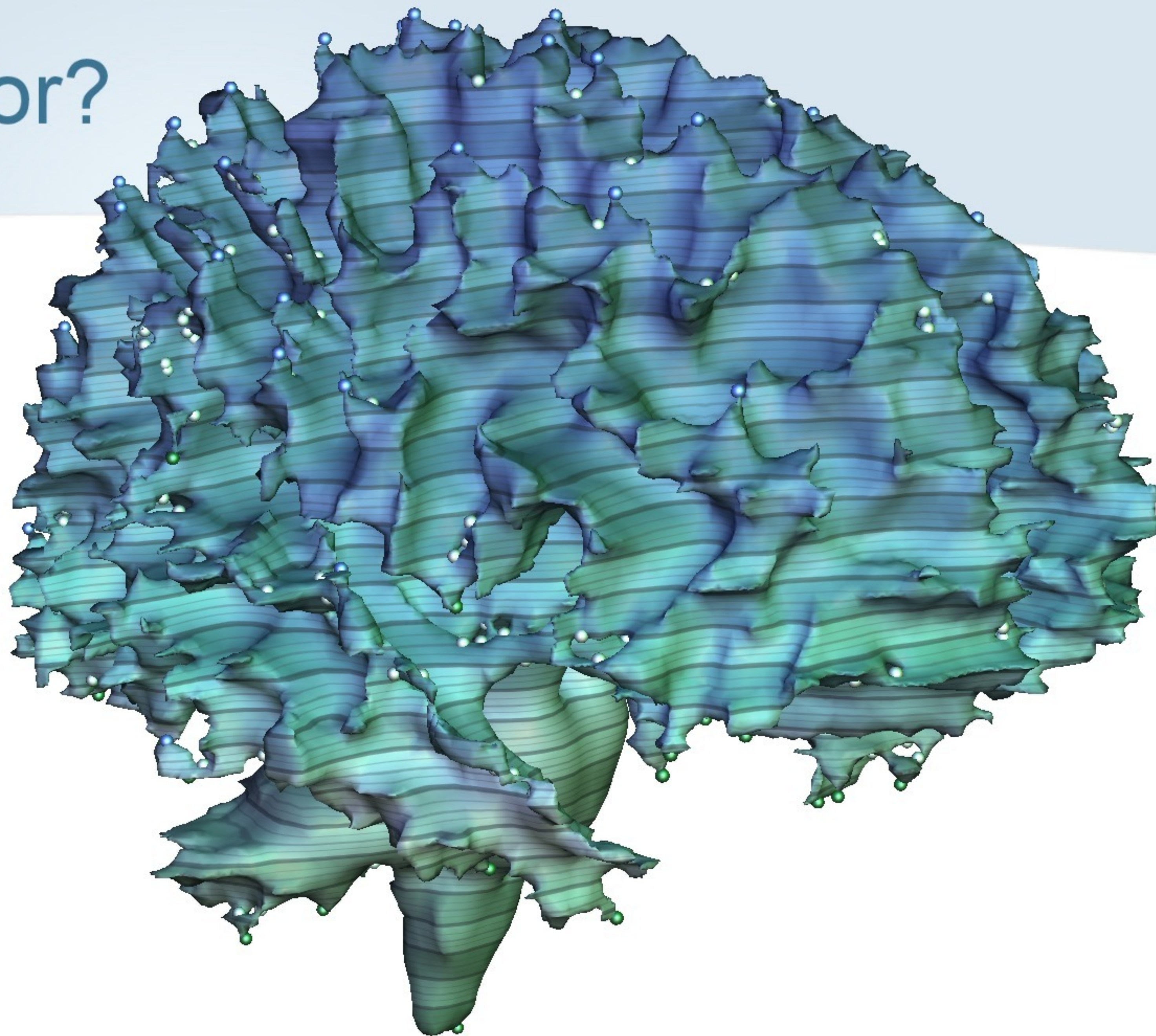
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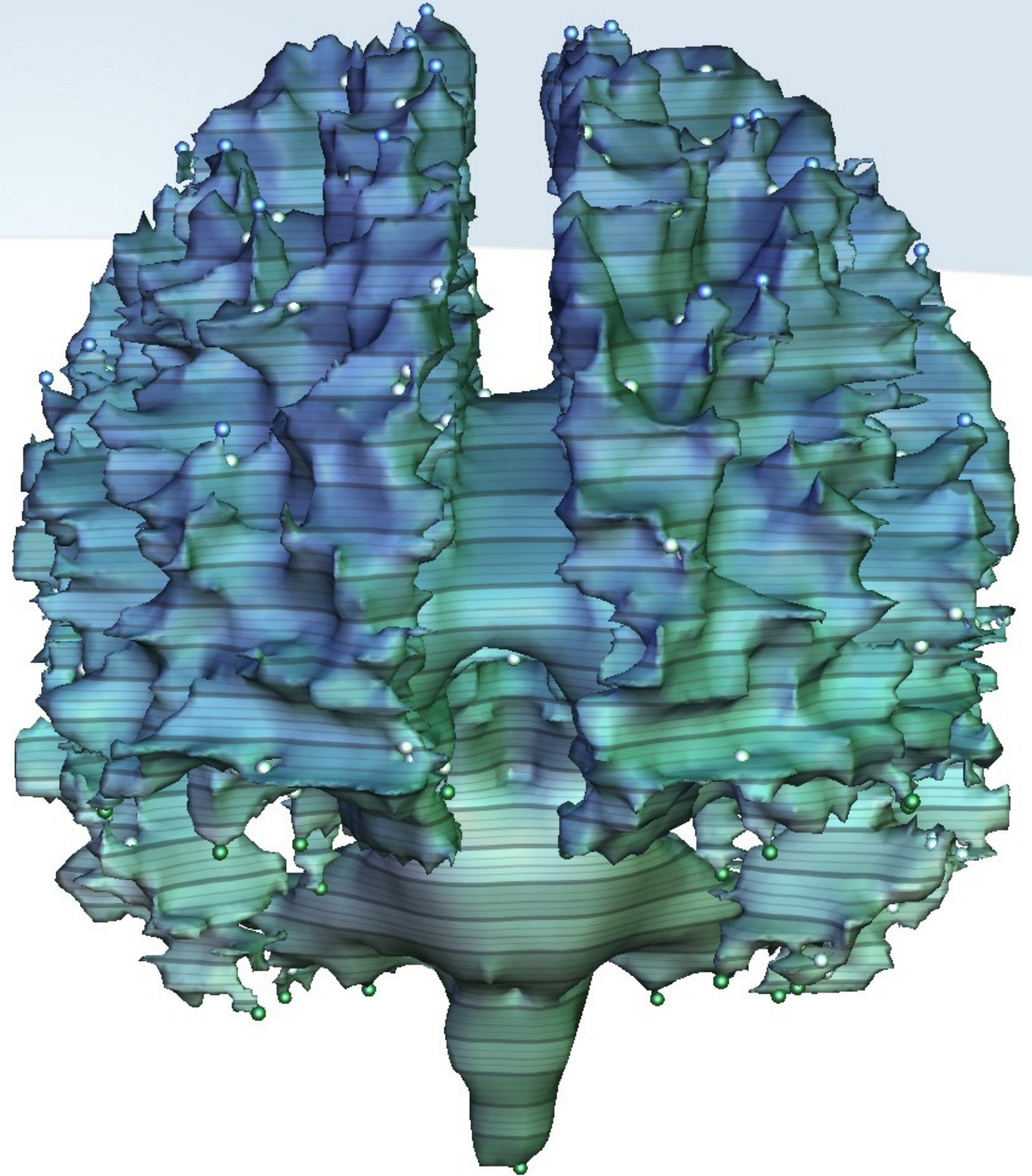
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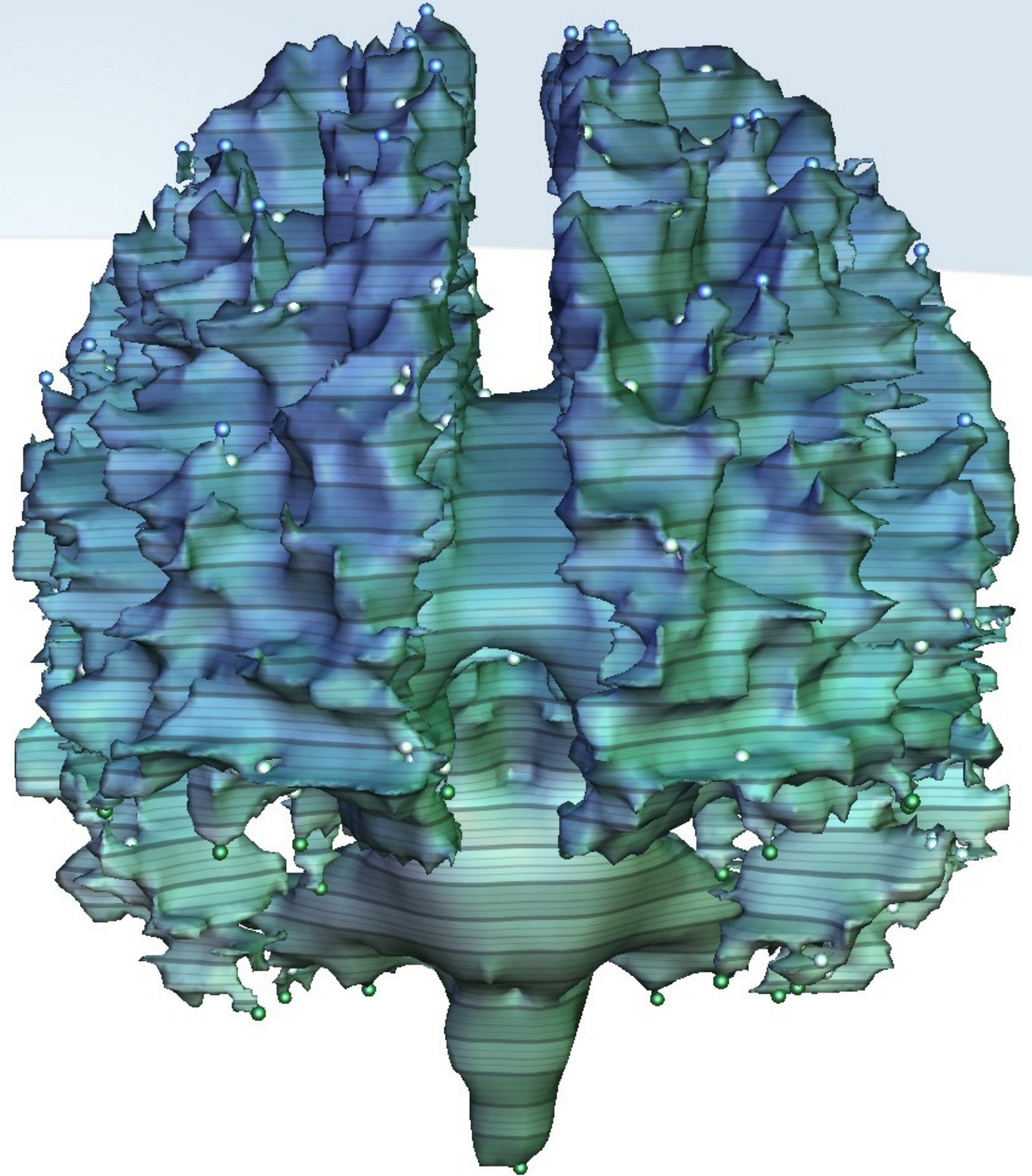
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What is it useful for?

- Show to convince
 - Rivera stats (H. Pfister)



What is *Scientific* Visualization?

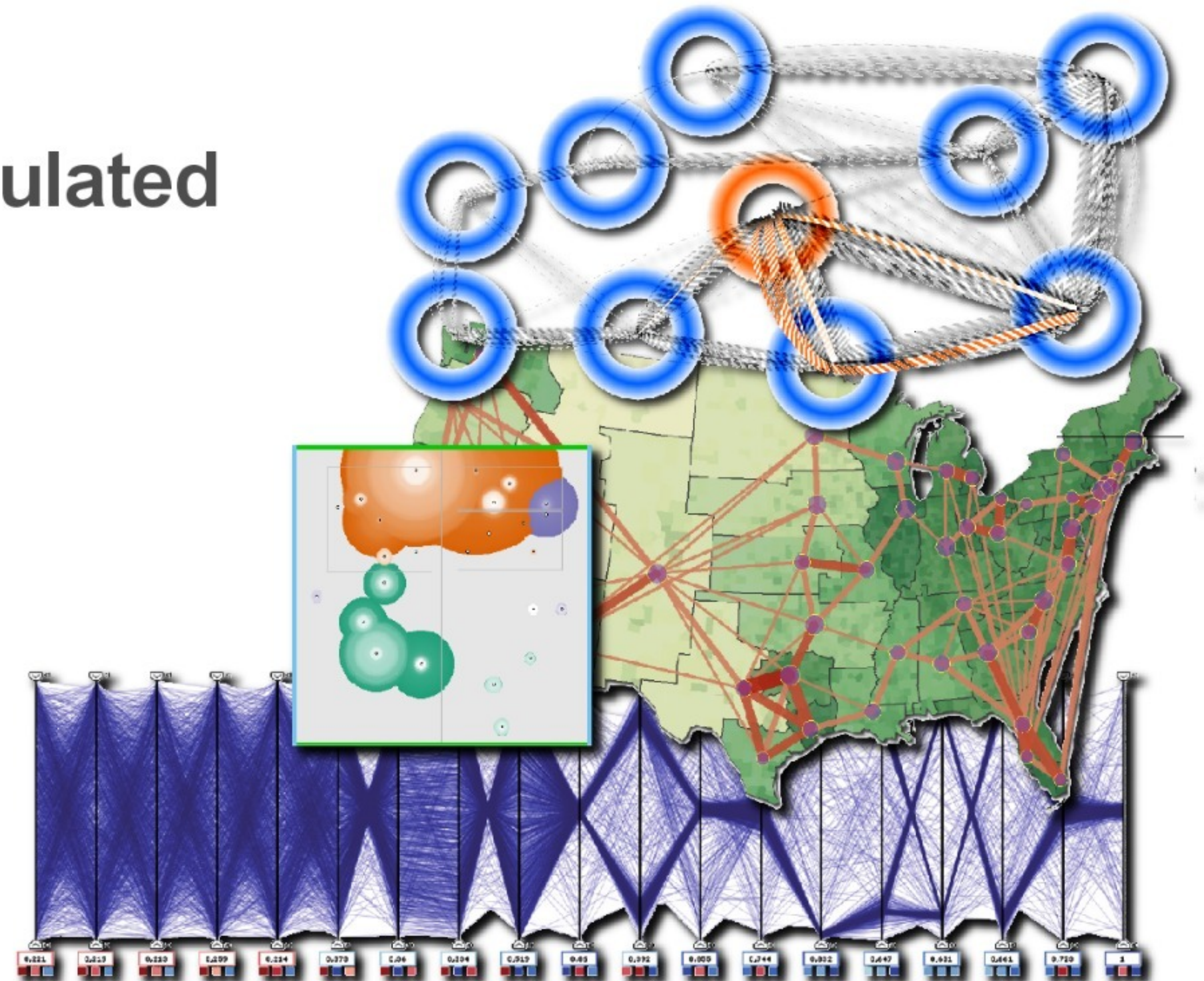
What is *Scientific* Visualization?

**Visualization of acquired or simulated
spatio-temporal data**

What is *Scientific Visualization*?

Visualization of acquired or simulated
spatio-temporal data

≠ InfoVis



In short...

- Scientific Visualization:

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Computing techniques for

In short...

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**Computing techniques for
the transformation and**

In short...

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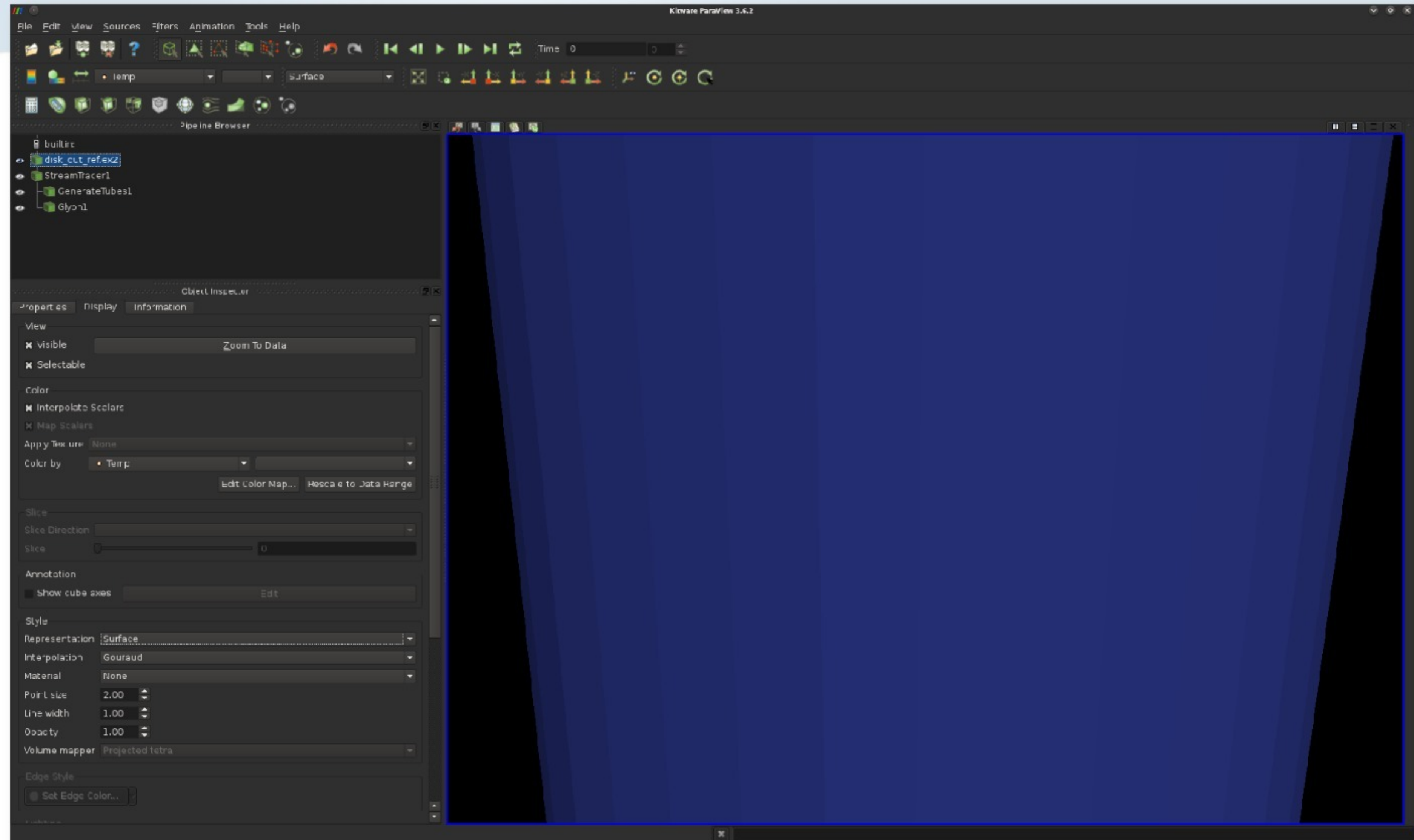
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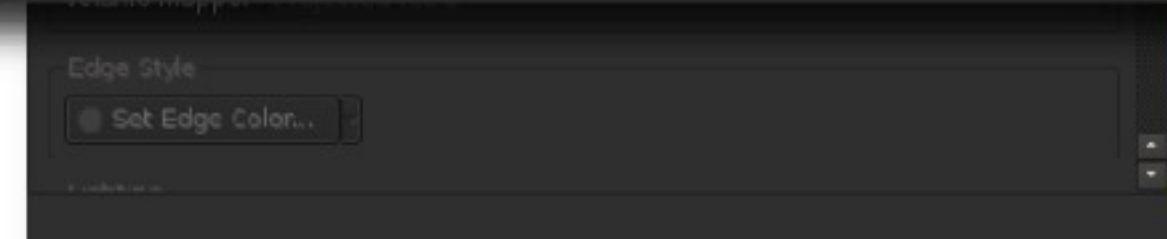
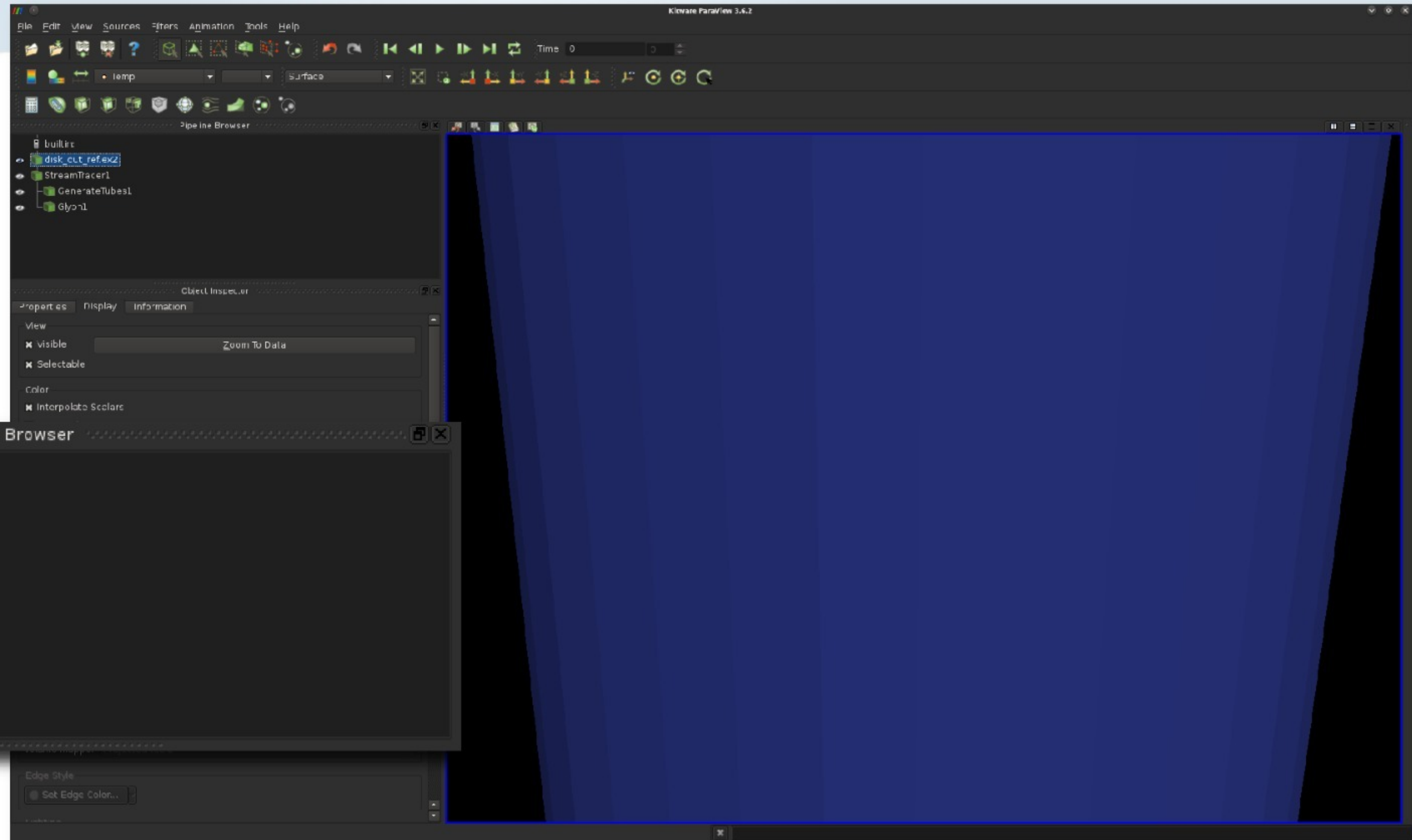
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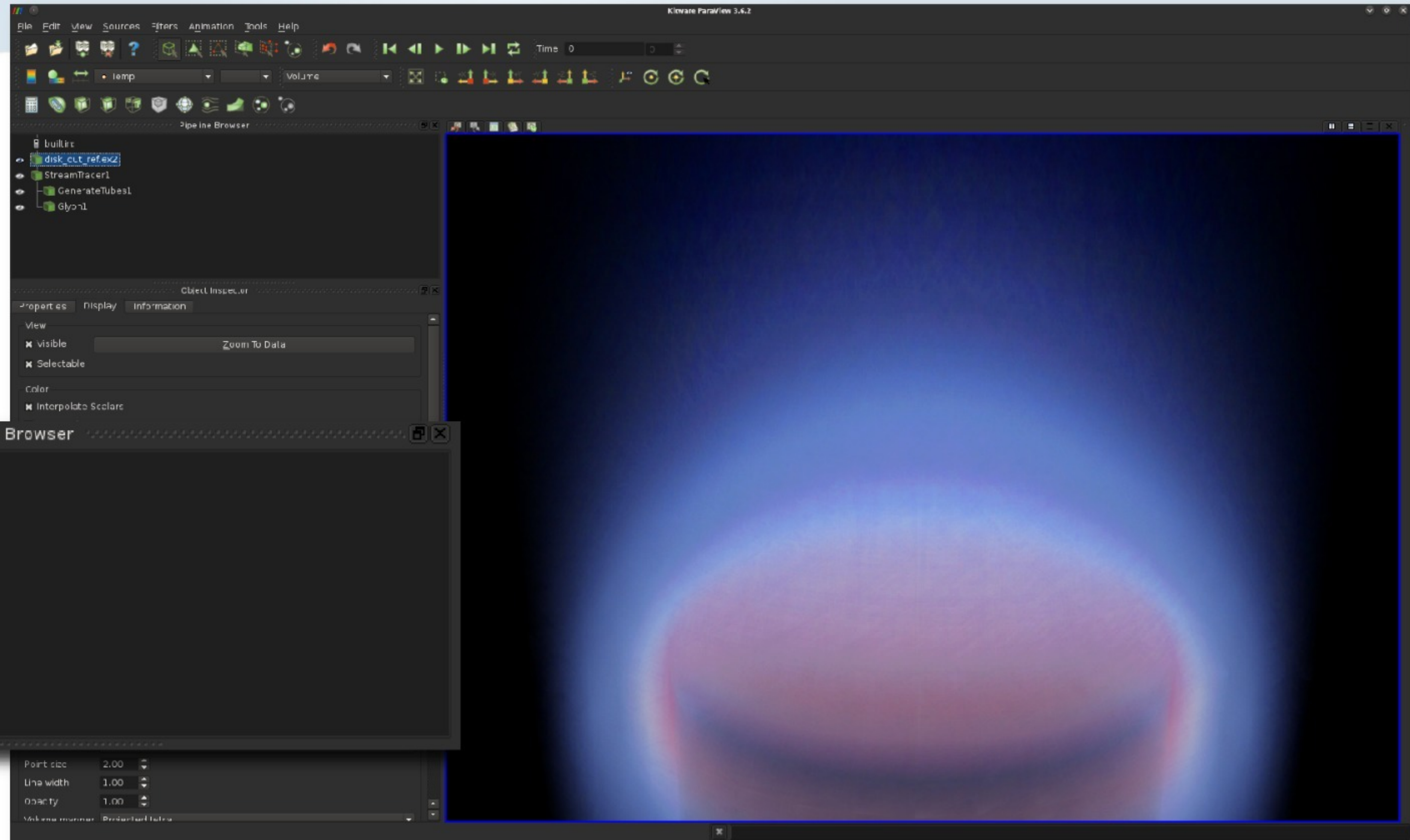
The Visualization Pipeline



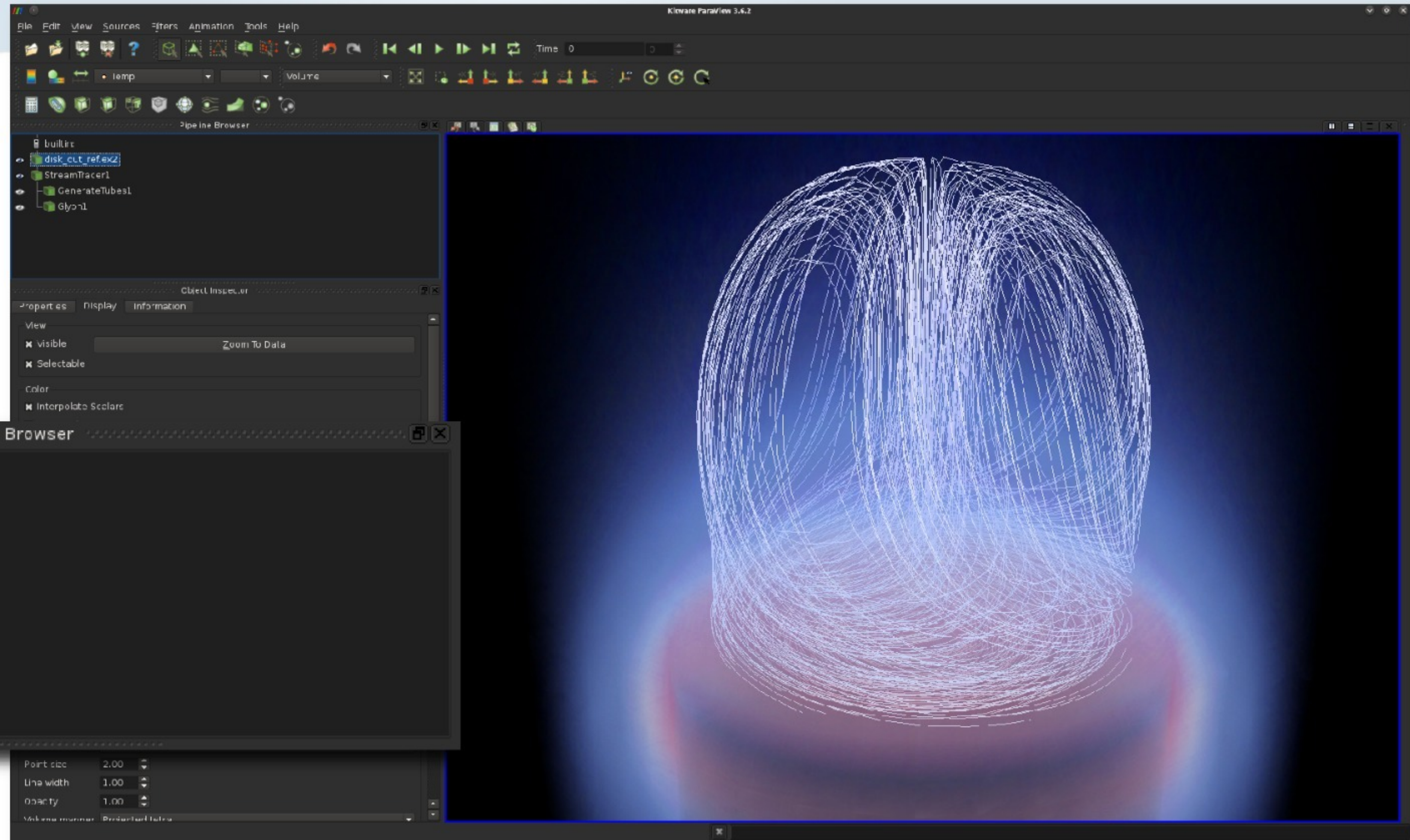
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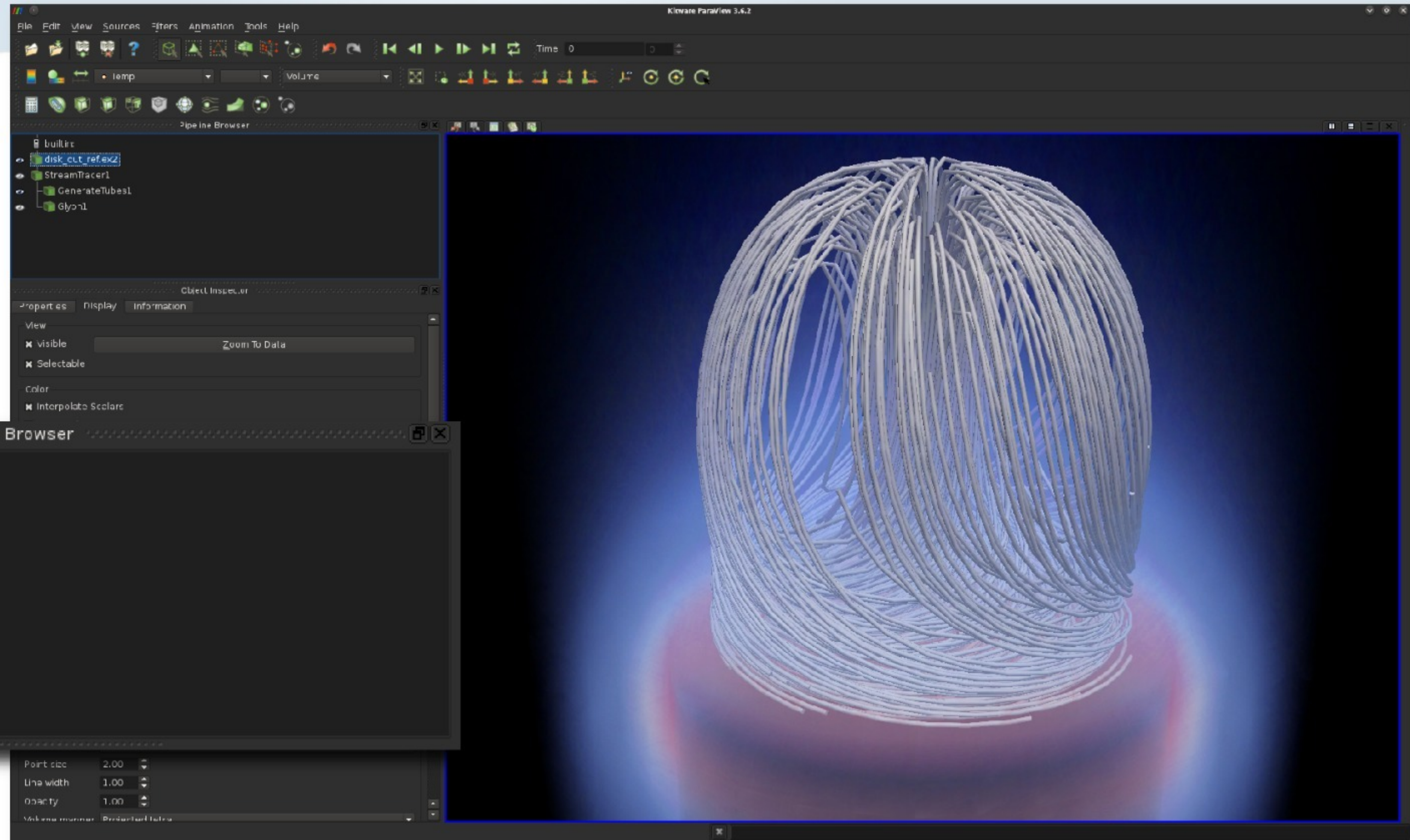
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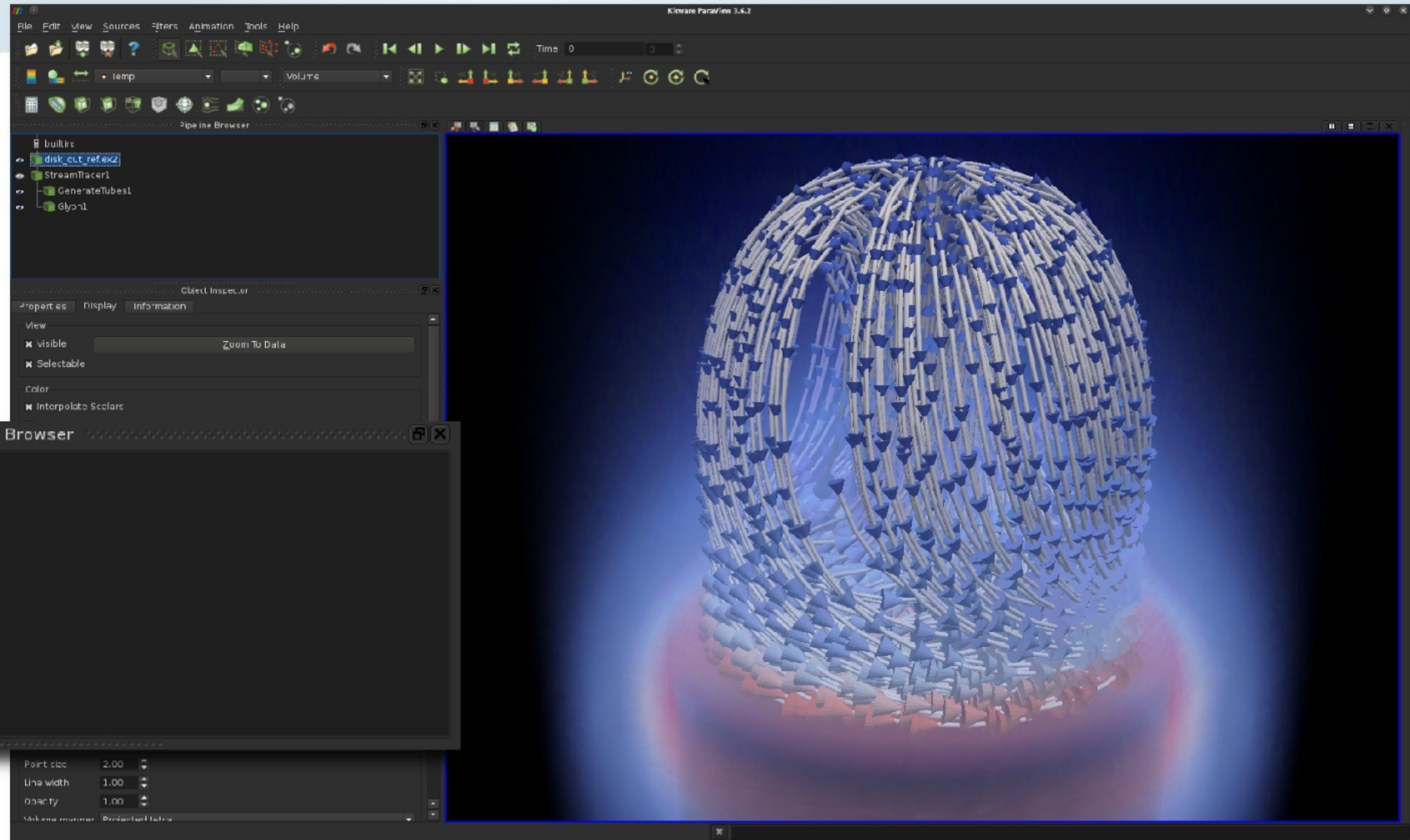
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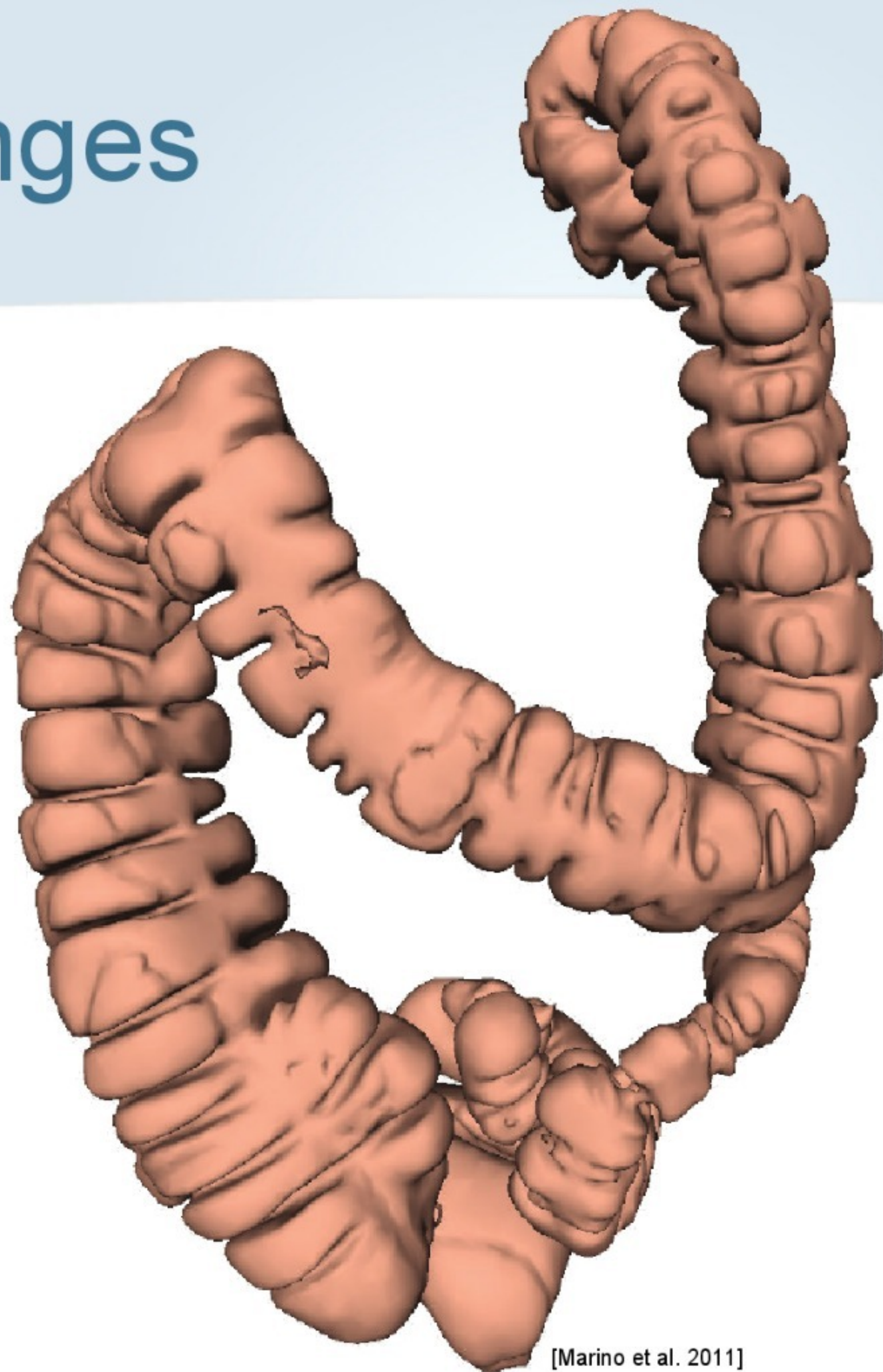
Key Challenges

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- Dimensionality!

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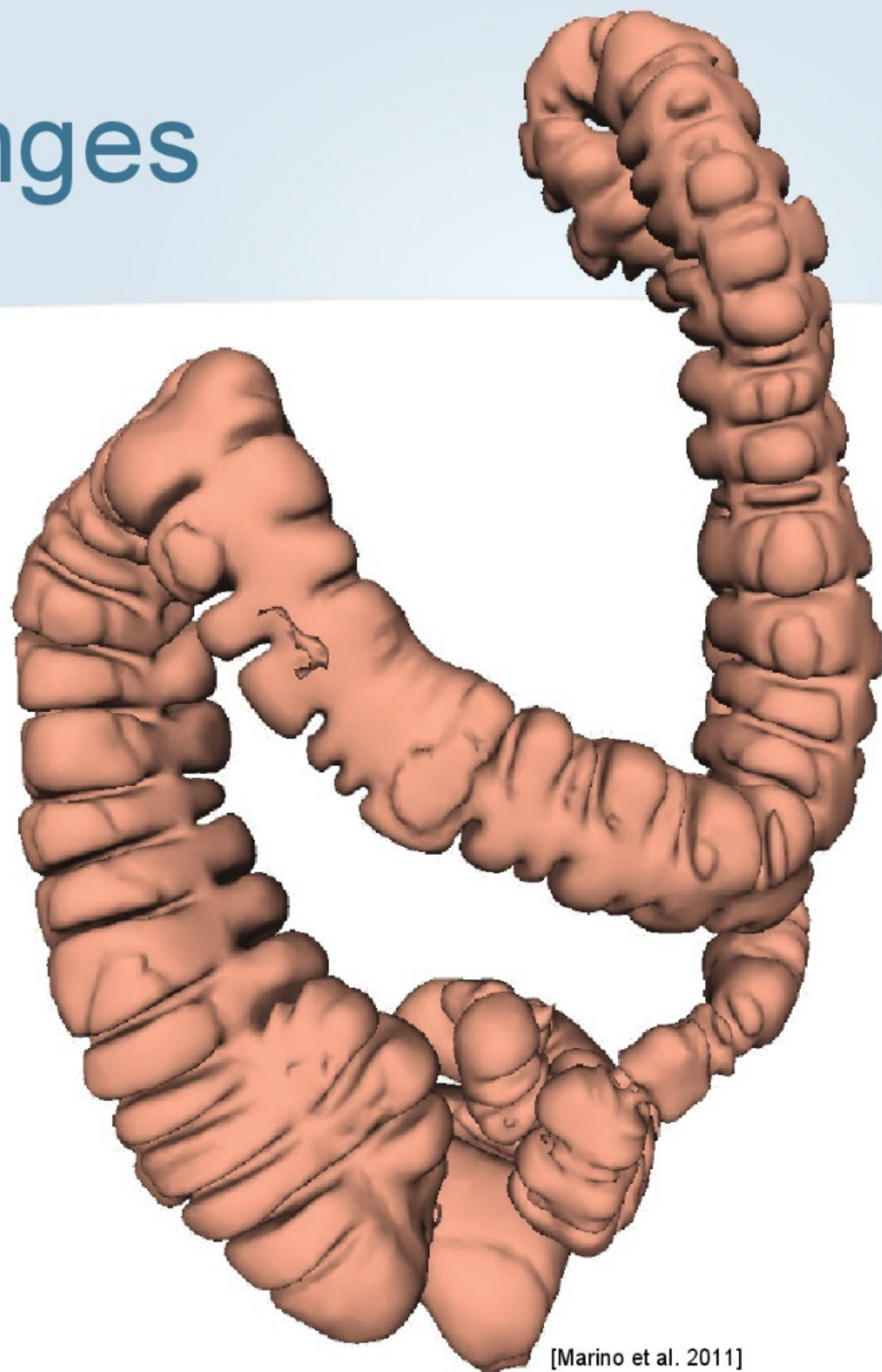
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[Marino et al. 2011]

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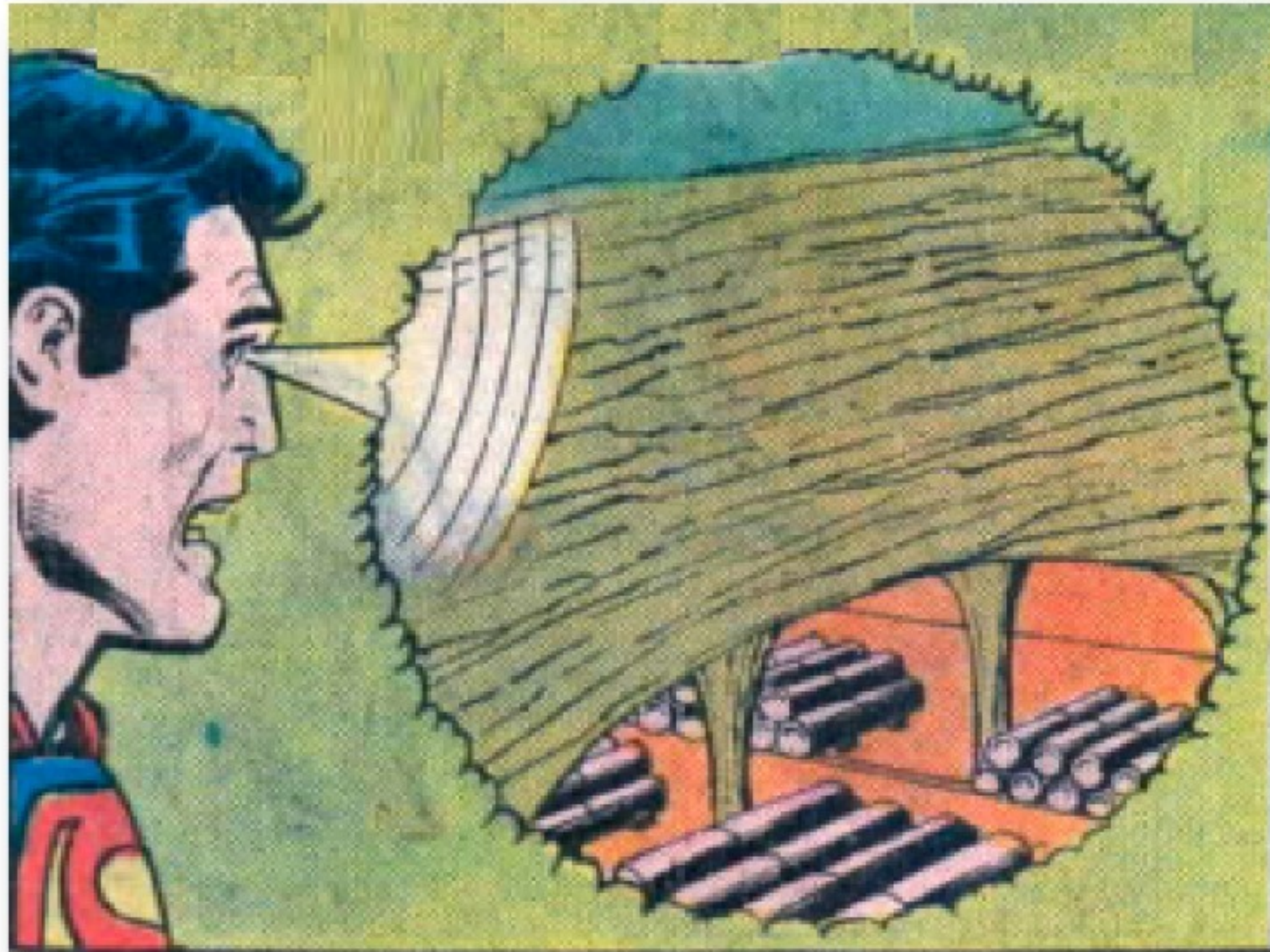
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[Marino et al. 2011]

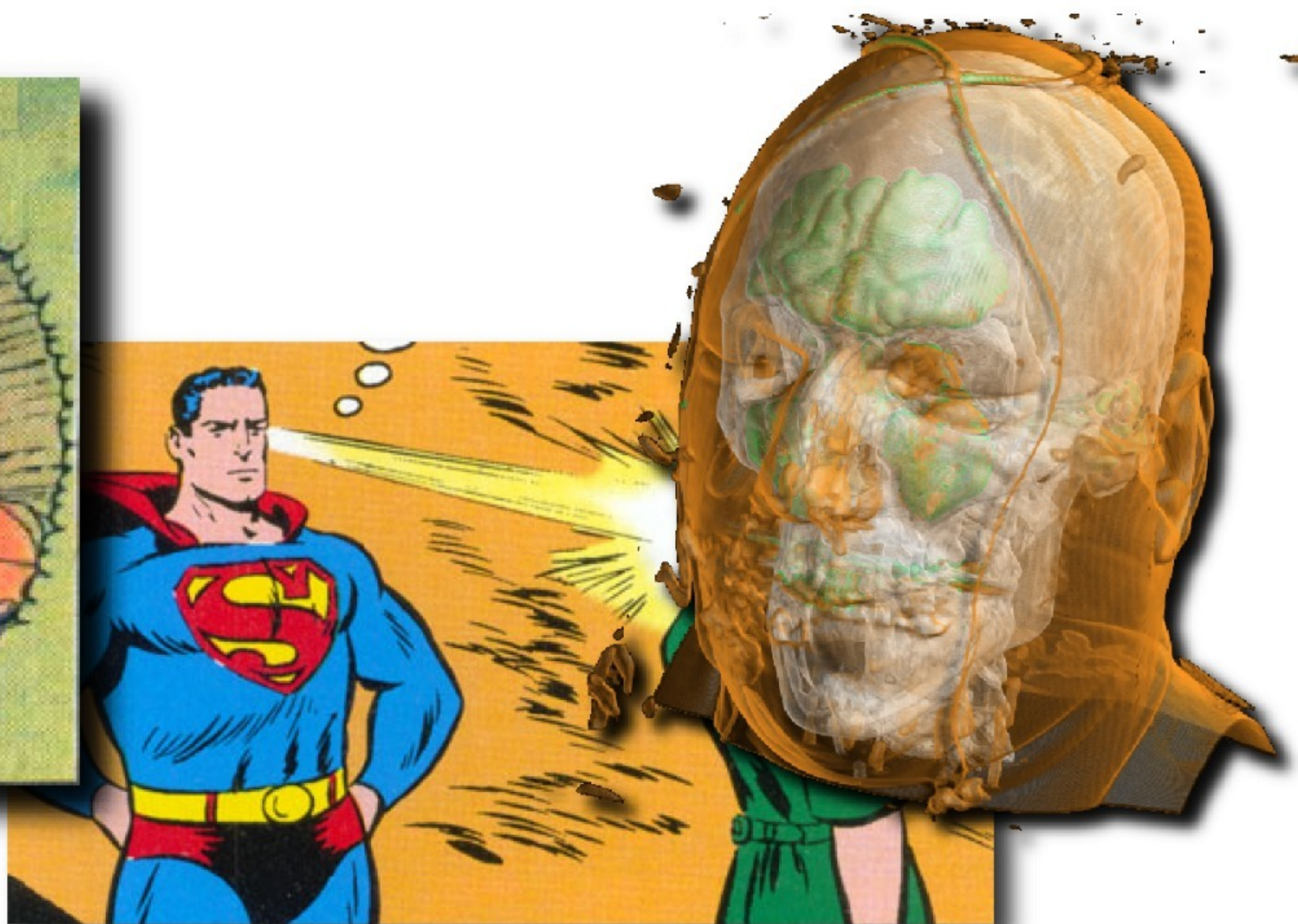
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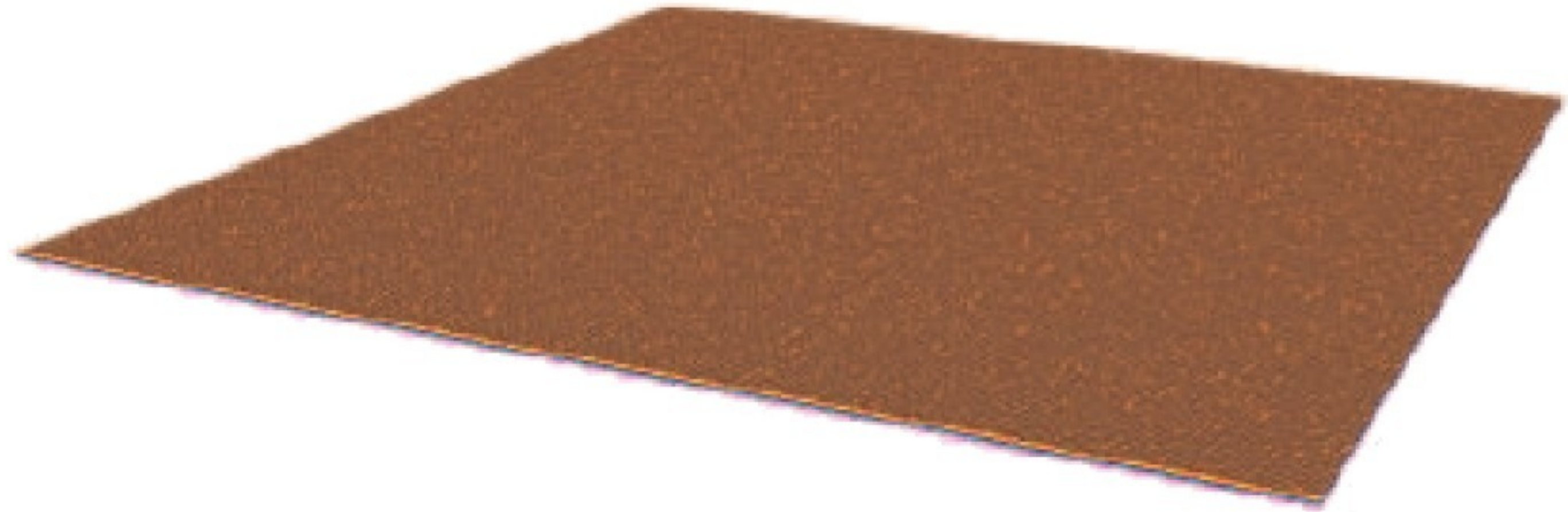
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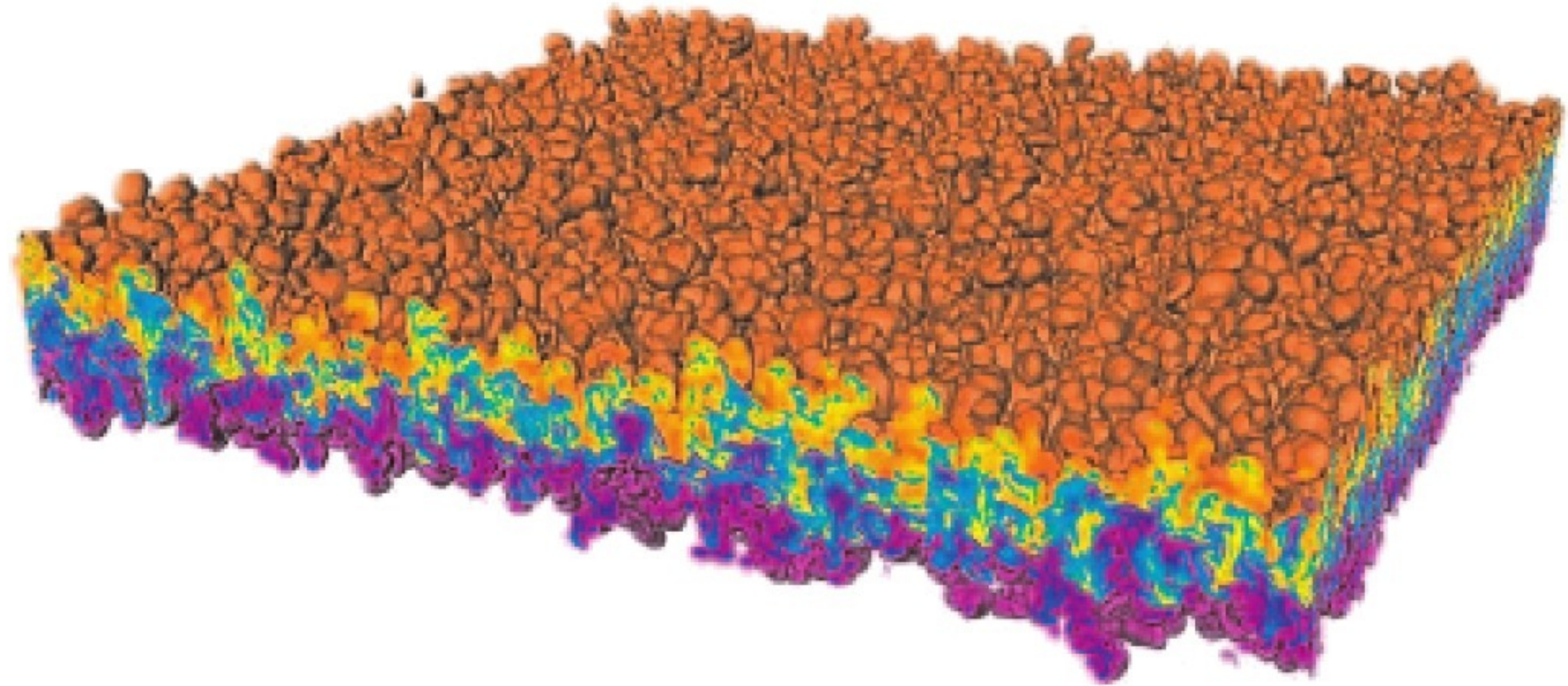
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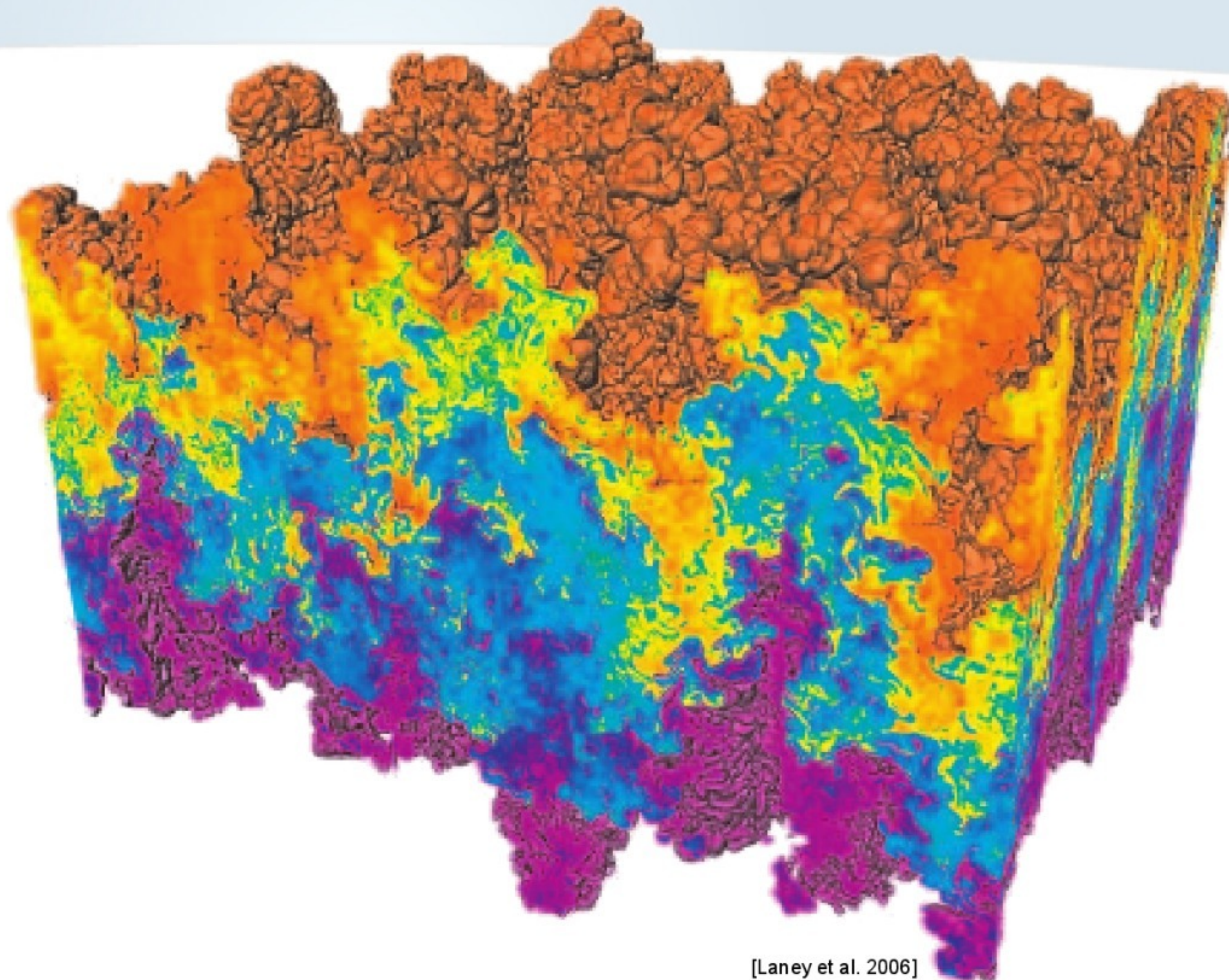
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Key Challenges

- Data filtering

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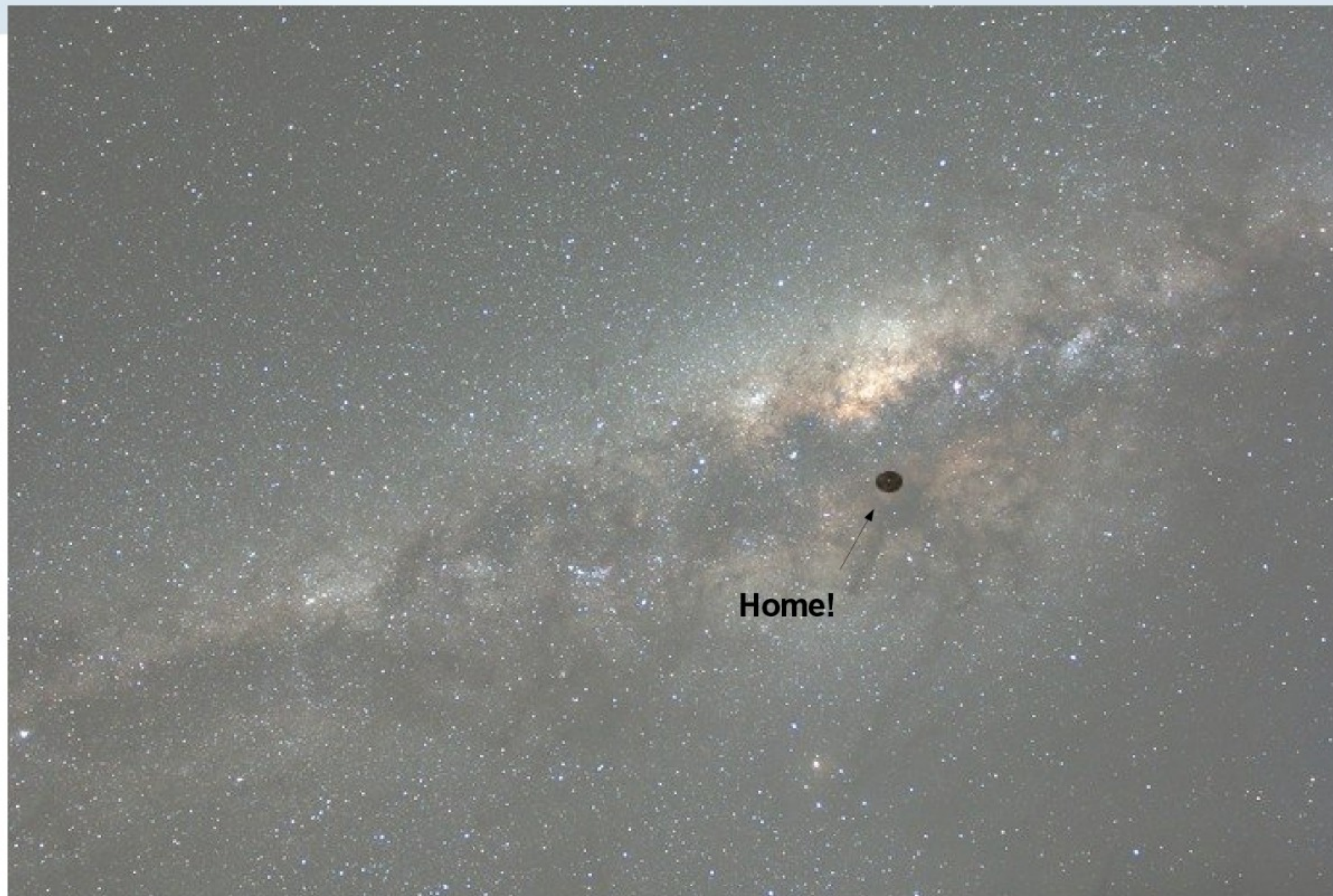
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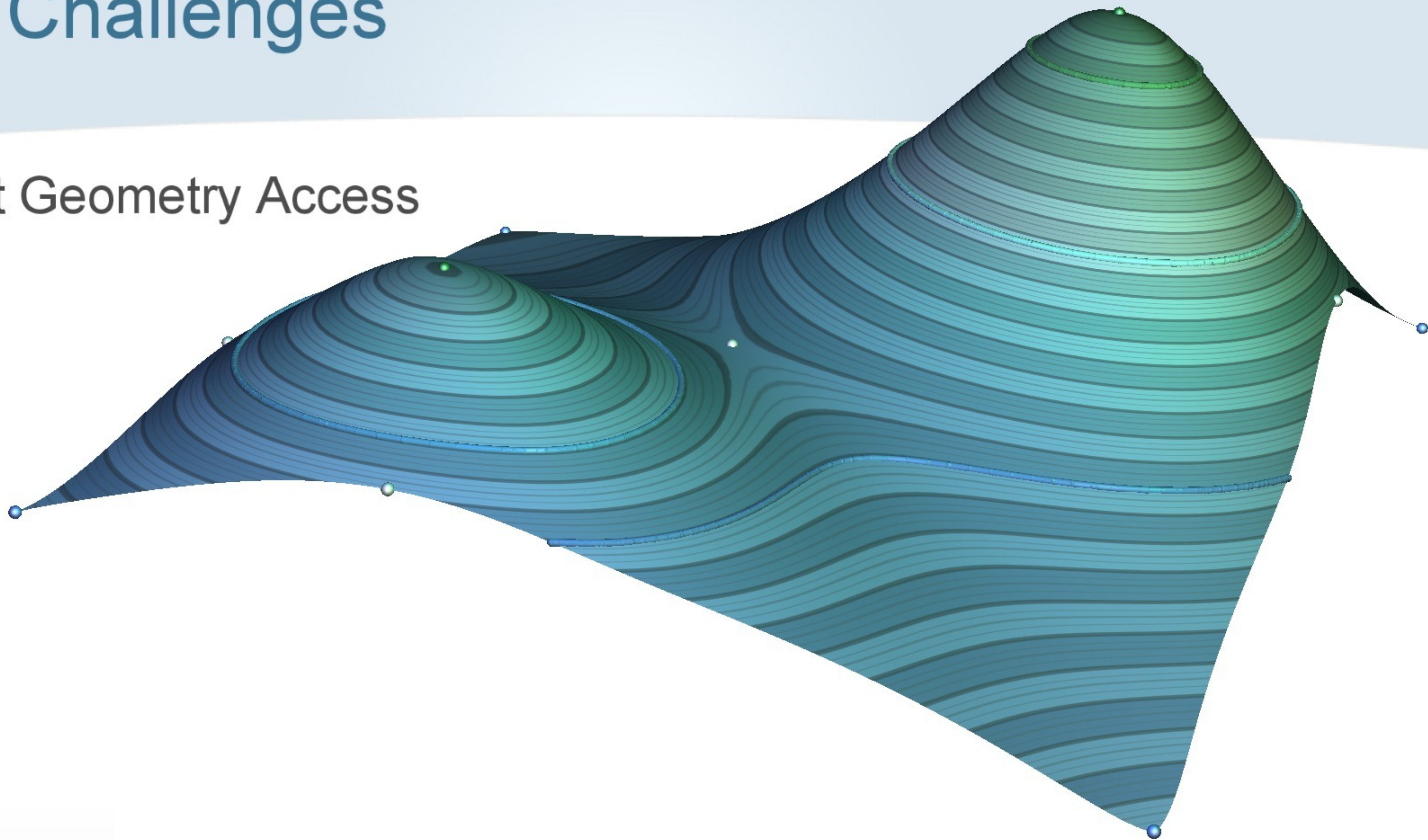


Key Challenges

- Efficient Geometry Access

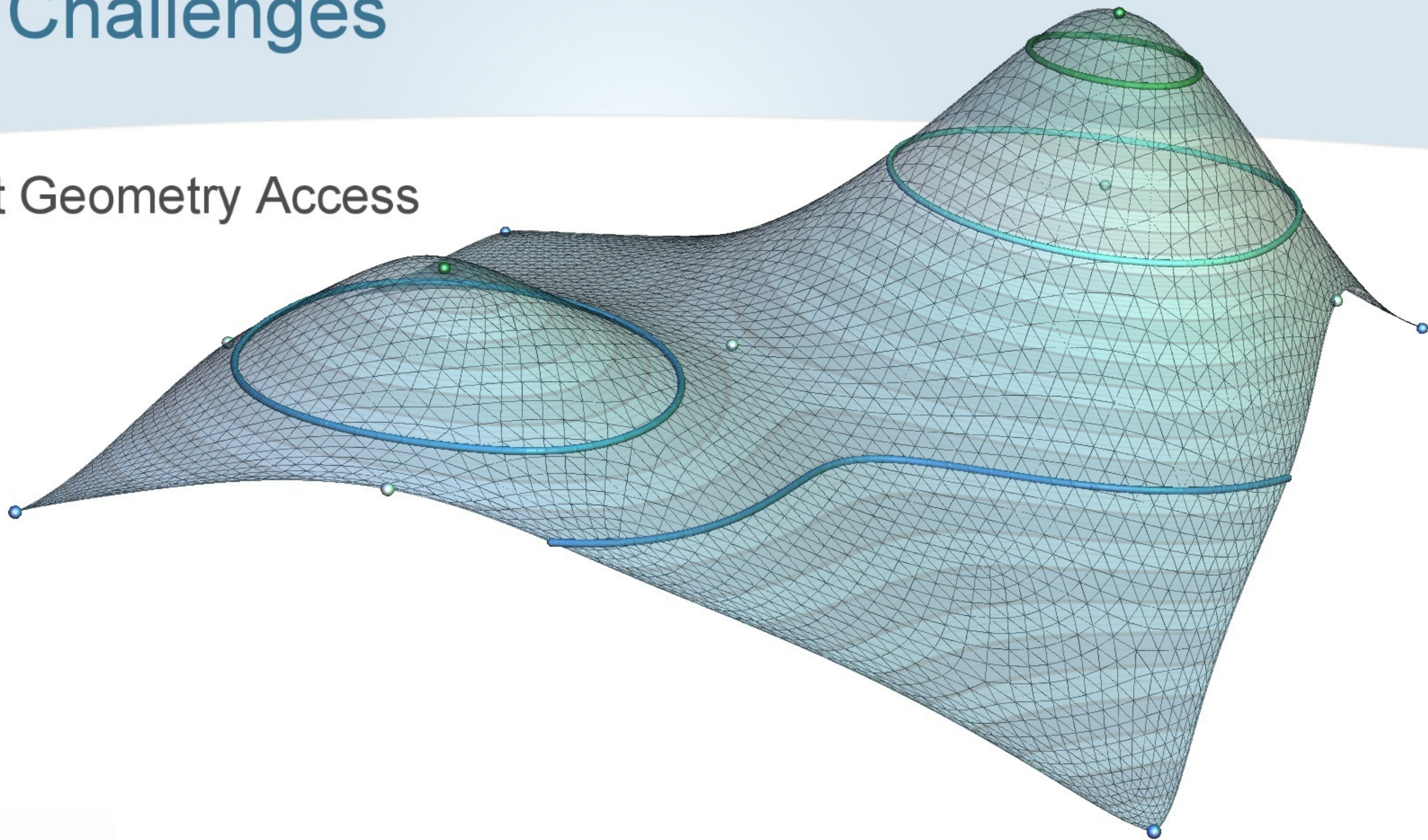
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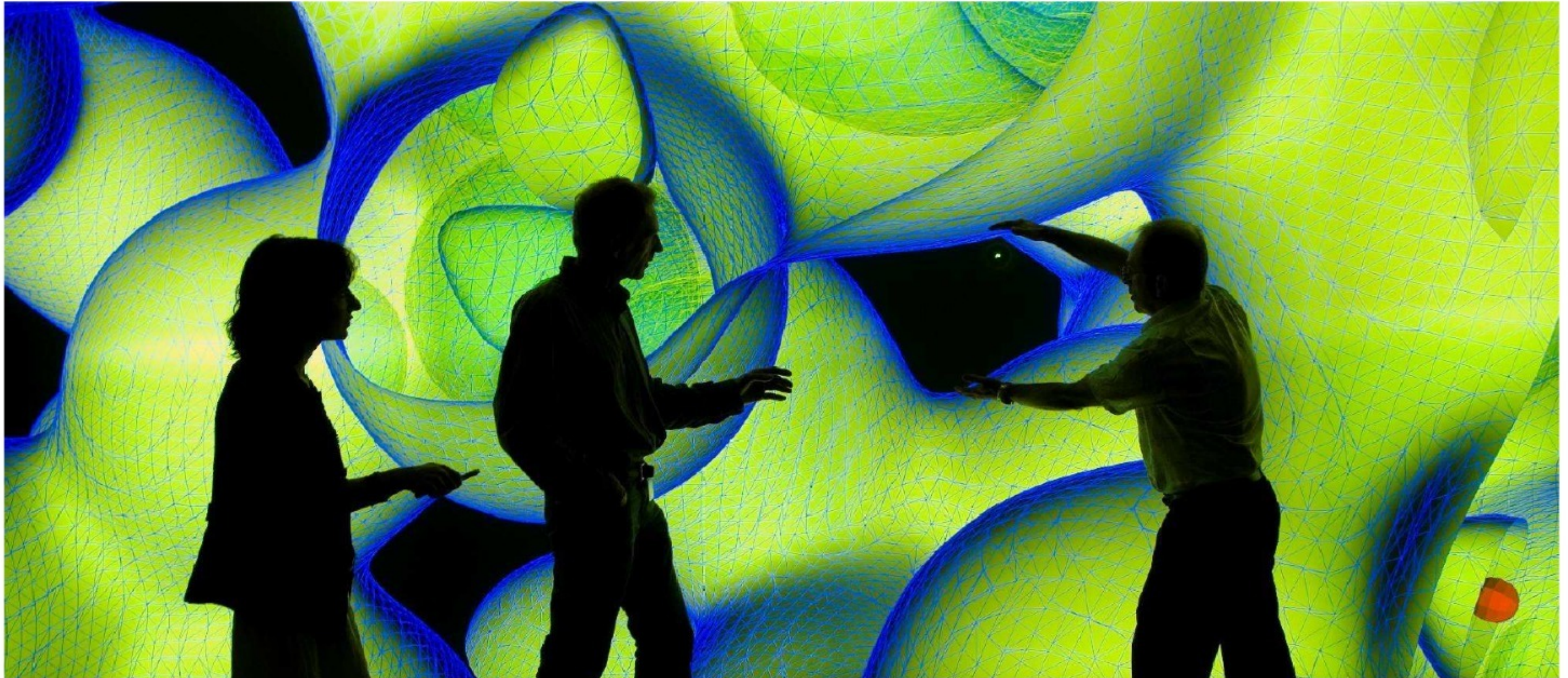
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- Efficient Geometry Access



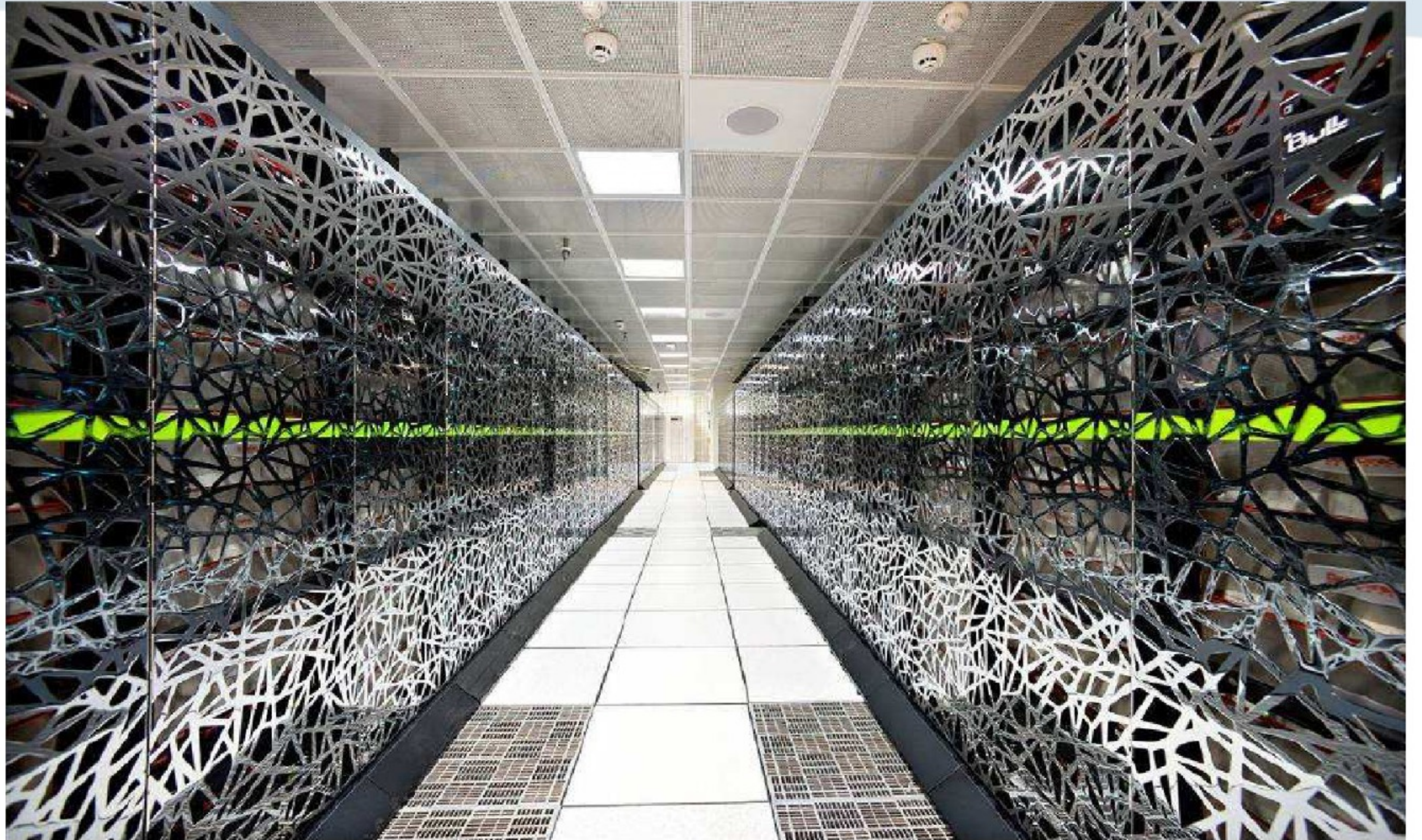
Key Challenges

- Interactivity



Key Challenges

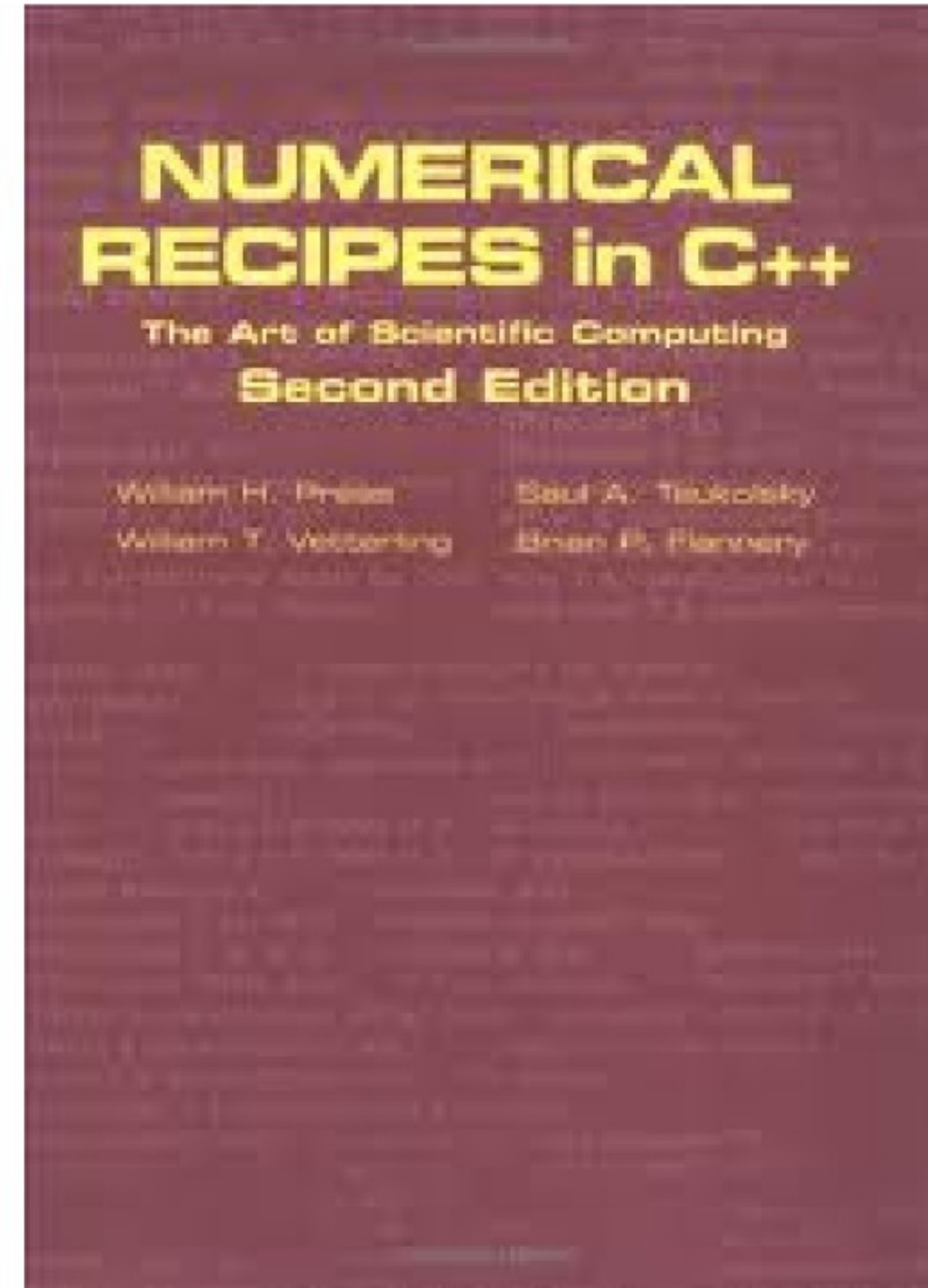
- Data size



Recurrent themes and required skills

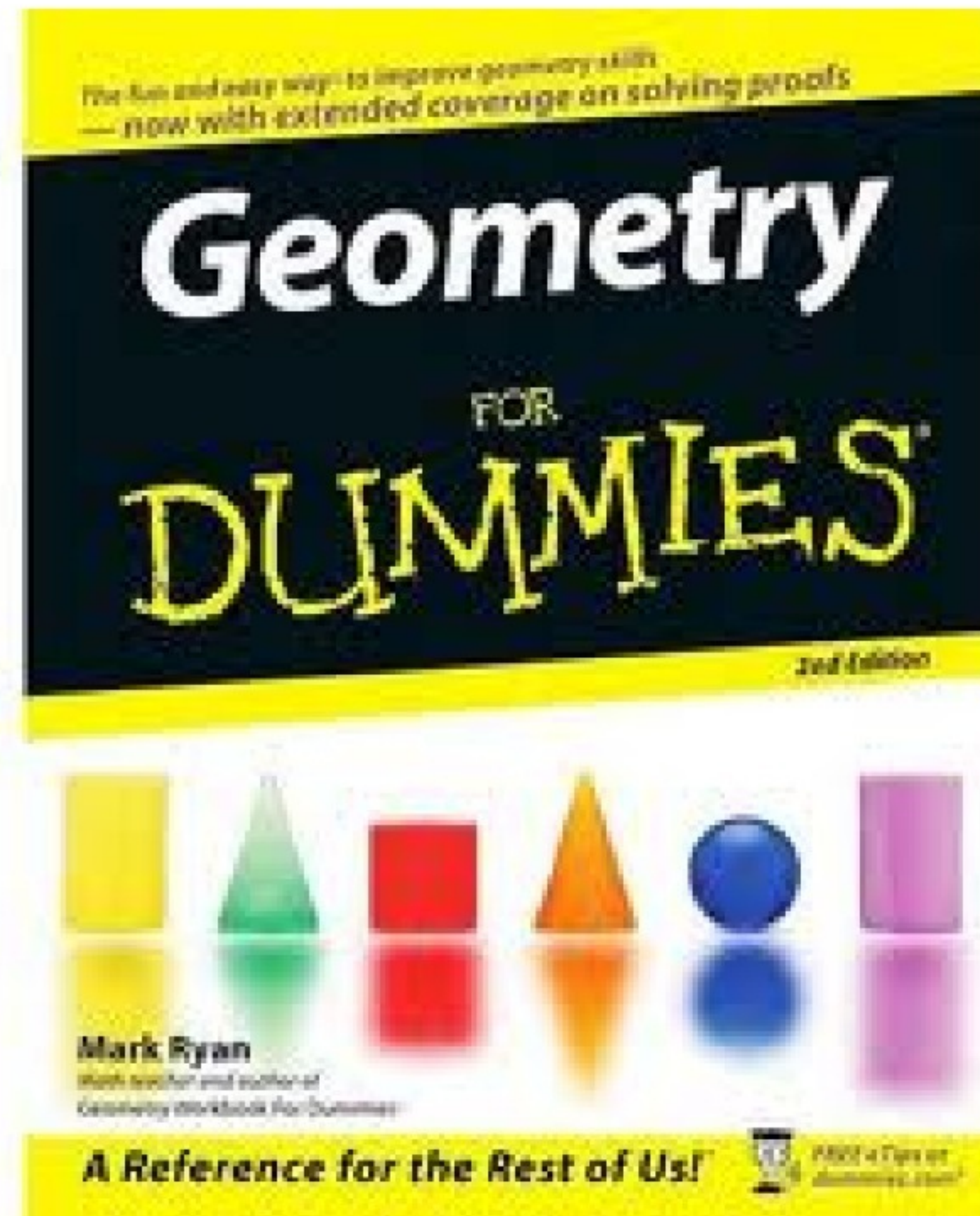
Recurrent themes and required skills

- Algorithms, programming



Recurrent themes and required skills

- Algorithms, programming
- Geometry



Recurrent themes and required skills

- Algorithms, programming
- Geometry
- Rendering



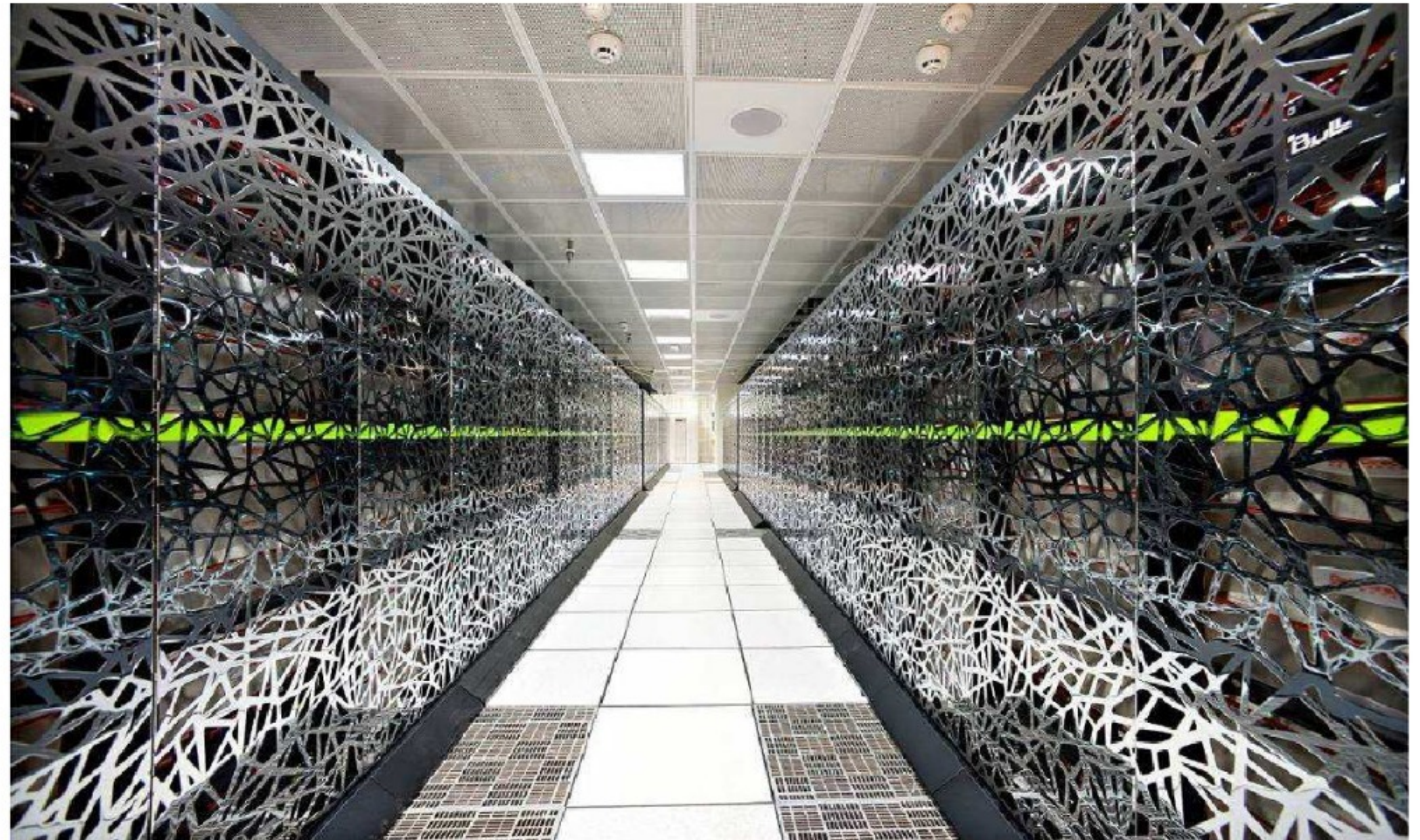
Recurrent themes and required skills

- Algorithms, programming
- Geometry
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- User interaction



Recurrent themes and required skills

- Algorithms, programming
- Geometry
- Rendering
- User interaction
- Large data-management



Course targets

Course targets

- Turning you into visualization experts

Course targets

- Turning you into ~~visualization experts~~ knowledgeable users

Course targets

- Turning you into ~~visualization experts~~ knowledgeable users
- Panorama of the main techniques
 - Core concepts
 - Some implementation details
 - Advantages and limitations
 - Practical understanding with Paraview
 - Working knowledge of what's under the hood

Course summary

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- Perception guide-lines for visualization
- Domain representations
- Techniques for scalar data
- Techniques for vector data
- Techniques for tensor data and others...

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- Practical sessions with Paraview
 - Seminars and exam

Assignments

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 - Group work – up to 3 persons
 - List of scientific papers
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 - Targets
 - Present the technique, its **contributions** and results, **criticisms**

Assignments

- Practical sessions
 - Short practical exam on **February 1st**
 - Given a data-set, generate an appealing Paraview visualization
 - Bring your own data-sets (encouraged!)
- Course exam
 - Short multiple choice exam, 30 minutes, on **February 15th**

Instructors

- Julien Tierny, CNRS, tierny@telecom-paristech.fr
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- Jean-Philippe Nominé, CEA, jean-philippe.nomine@cea.fr

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- Jean-Philippe Nominé, CEA, jean-philippe.nomine@cea.fr
- Internships, PhD thesis, etc.

References

References

- Books:

- “*The Visualization ToolKit*”, Schroeder, Martin, Lorensen, 2006
- “*The Visualization Handbook*”, Johnson and Hansen, 2004

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- Software:

- Paraview: <http://www.paraview.org>
- VTK: <http://www.vtk.org>