

Lecture 17: Spatial, 3D, and Scientific Visualization, Continued...

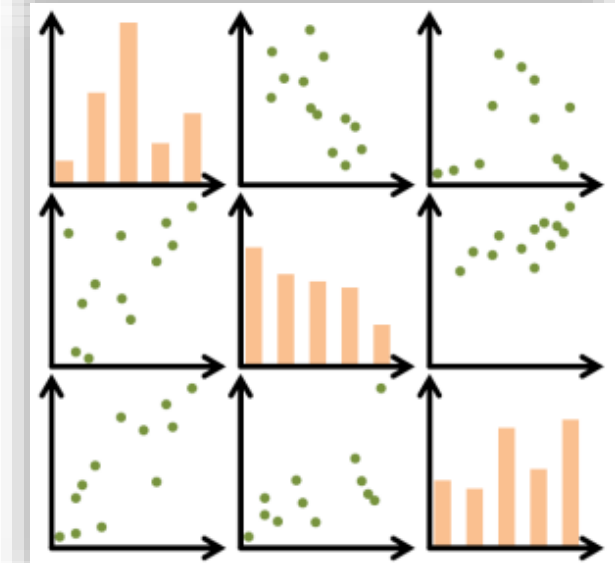
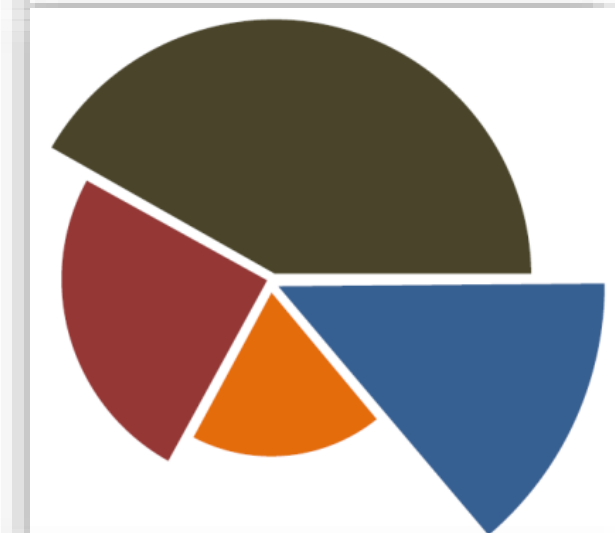
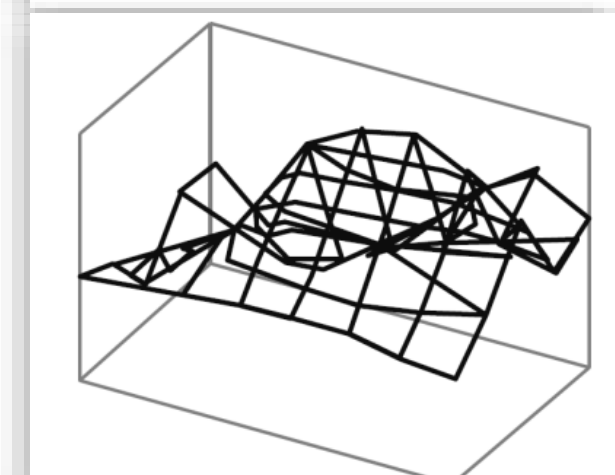
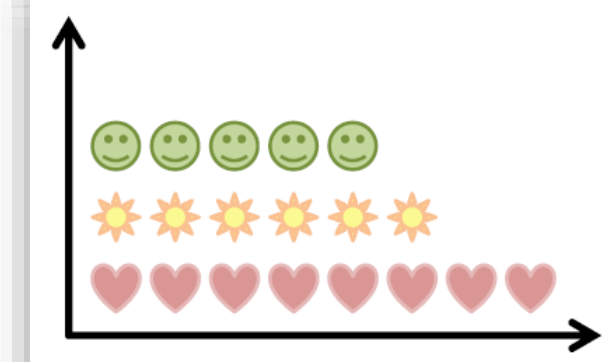
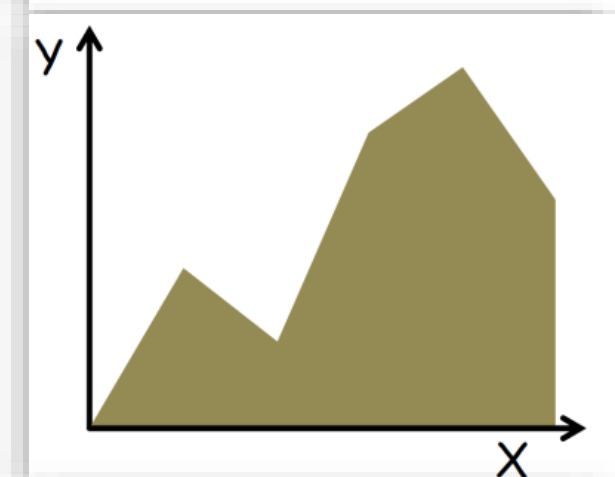
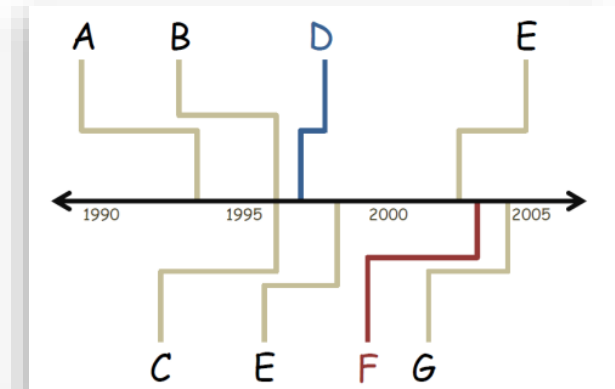
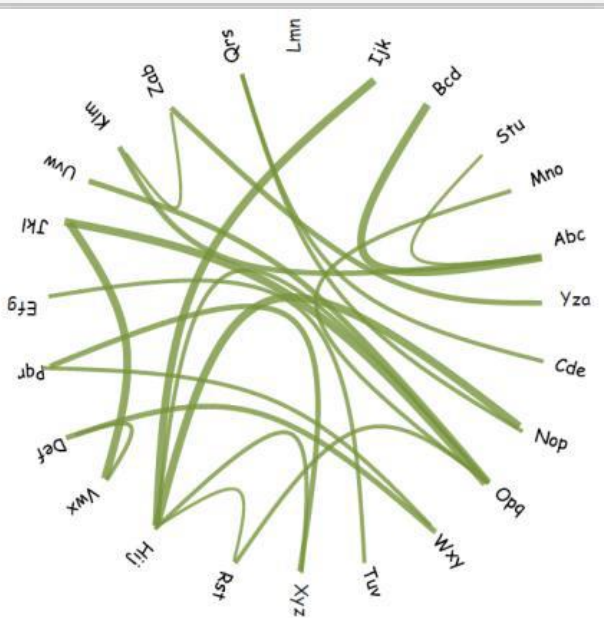
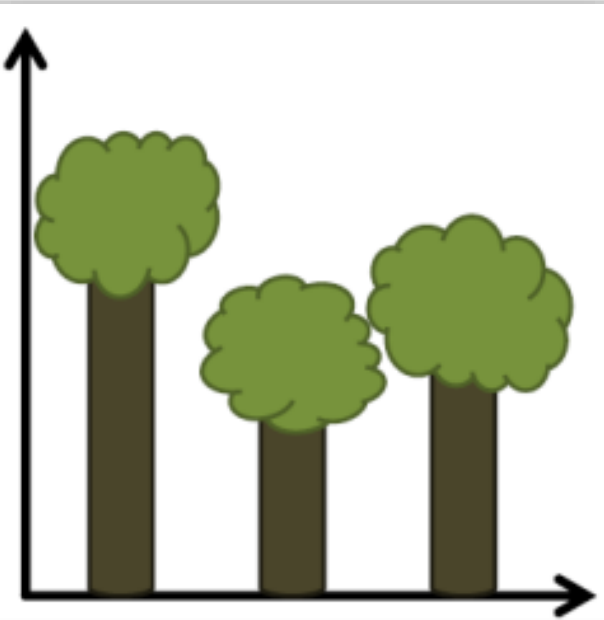
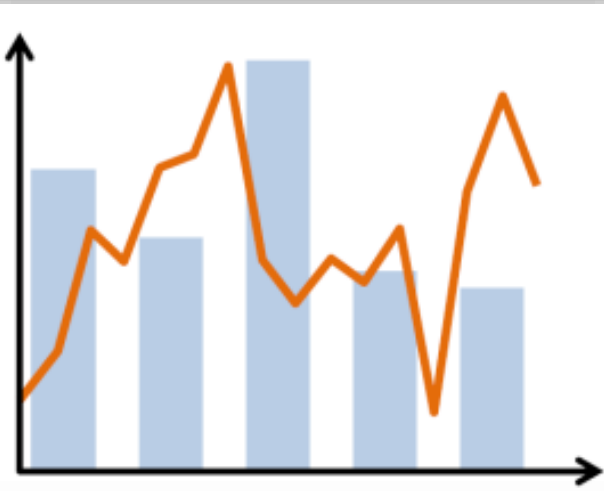
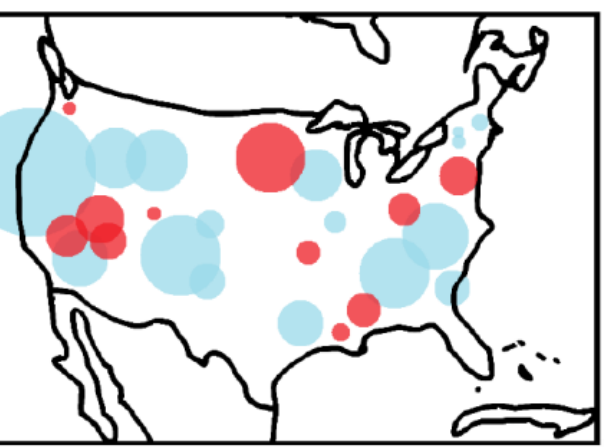
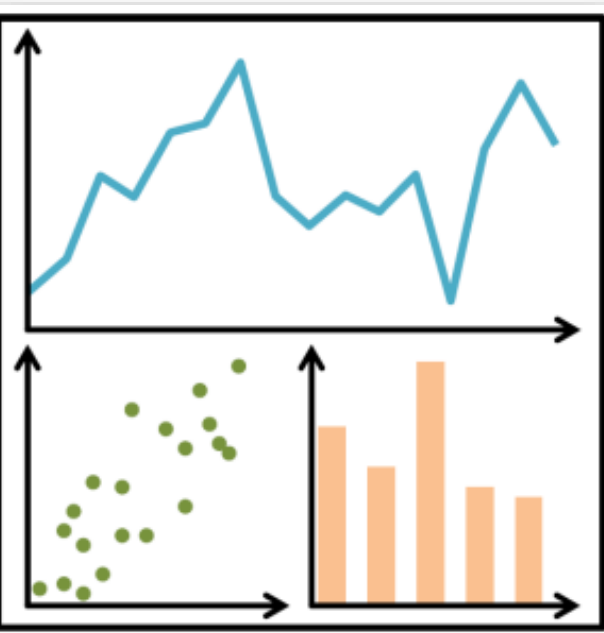
CS 7250

SPRING 2021

Prof. Cody Dunne

NORTHEASTERN UNIVERSITY

Slides and inspiration from Michelle Borkin, Krzysztof Gajos, Hanspeter Pfister, Miriah Meyer, Jonathan Schwabish, and David Sprague

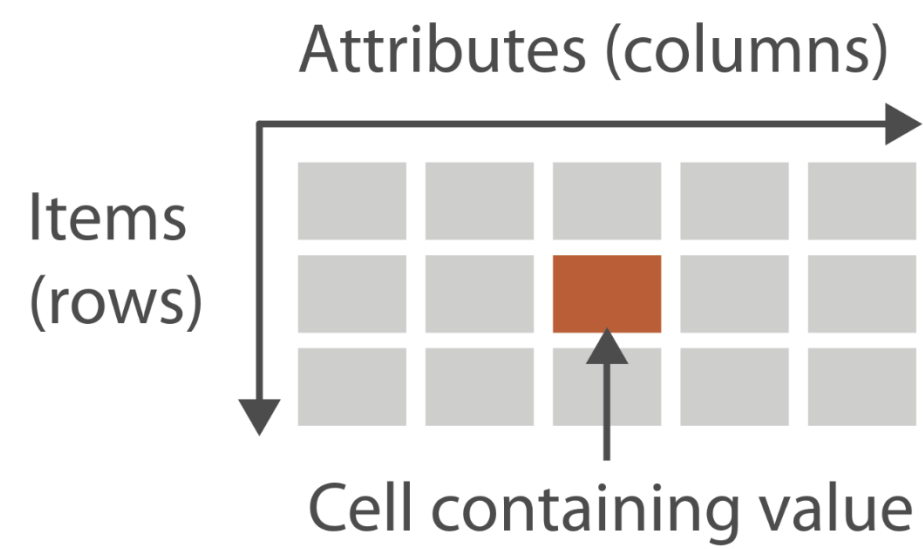


CHECKING IN

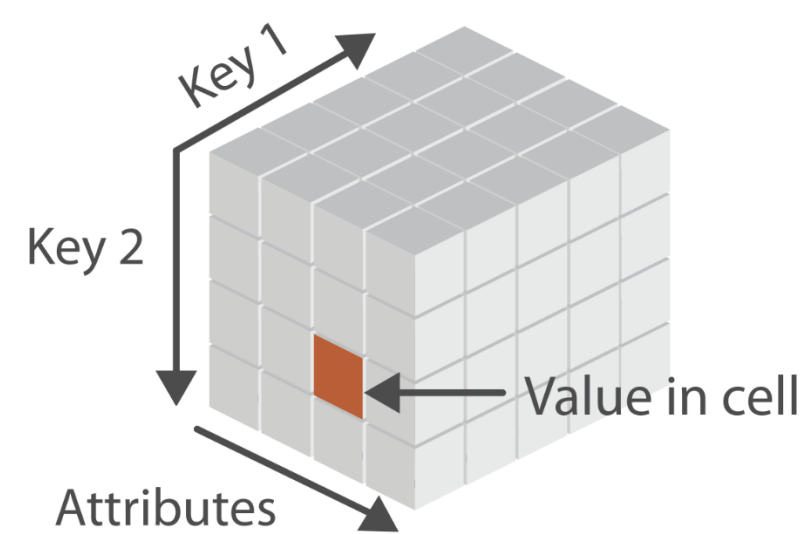
PREVIOUSLY, ON CS 7250...

➔ Dataset Types

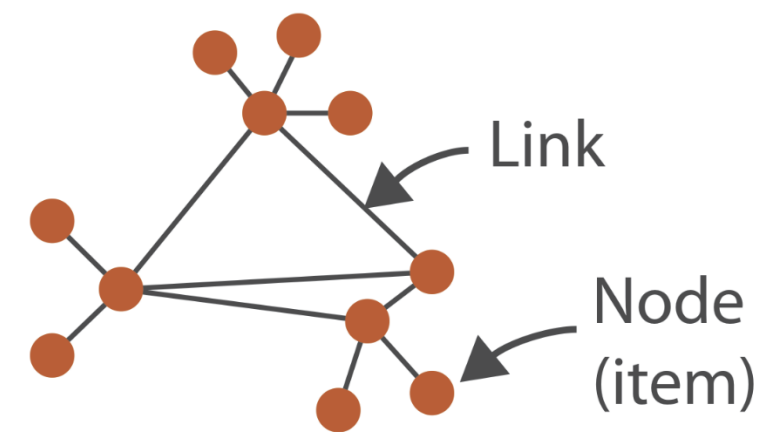
➔ Tables



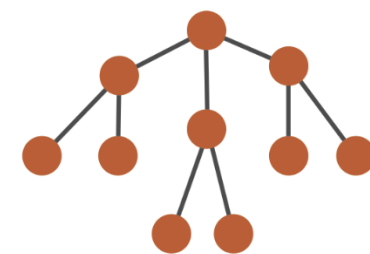
➔ *Multidimensional Table*



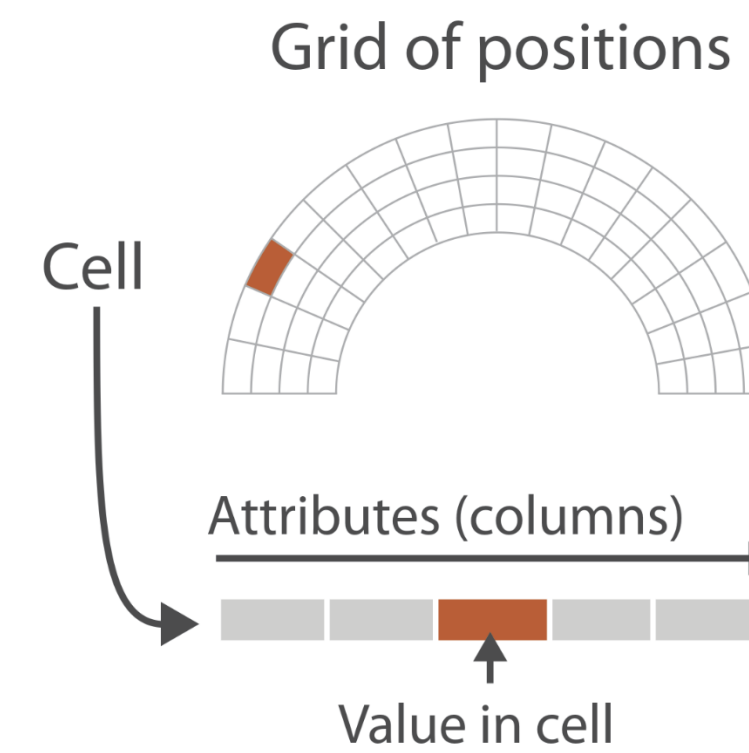
➔ Networks



➔ Trees



➔ Fields (Continuous)



➔ Geometry (Spatial)



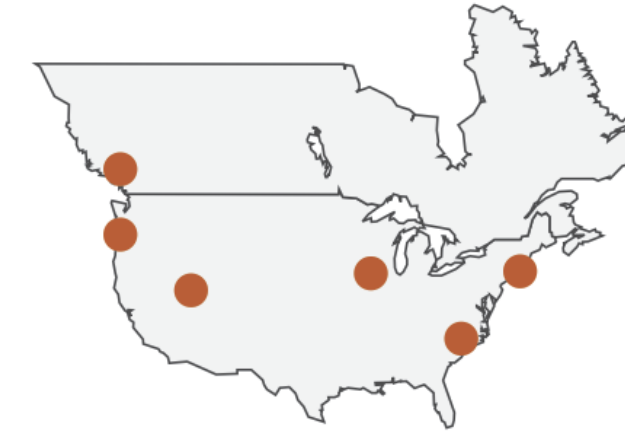
Arrange Spatial Data

→ Use Given

→ Geometry

→ *Geographic*

→ *Other Derived*

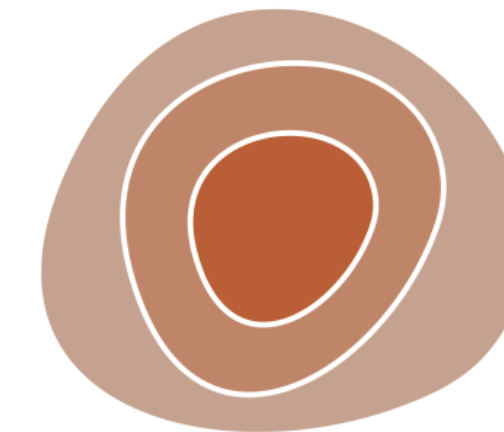


→ Spatial Fields

→ *Scalar Fields (one value per cell)*

→ *Isocontours*

→ *Direct Volume Rendering*



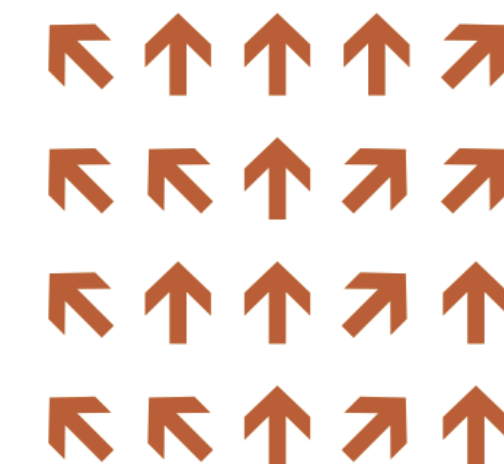
→ *Vector and Tensor Fields (many values per cell)*

→ *Flow Glyphs (local)*

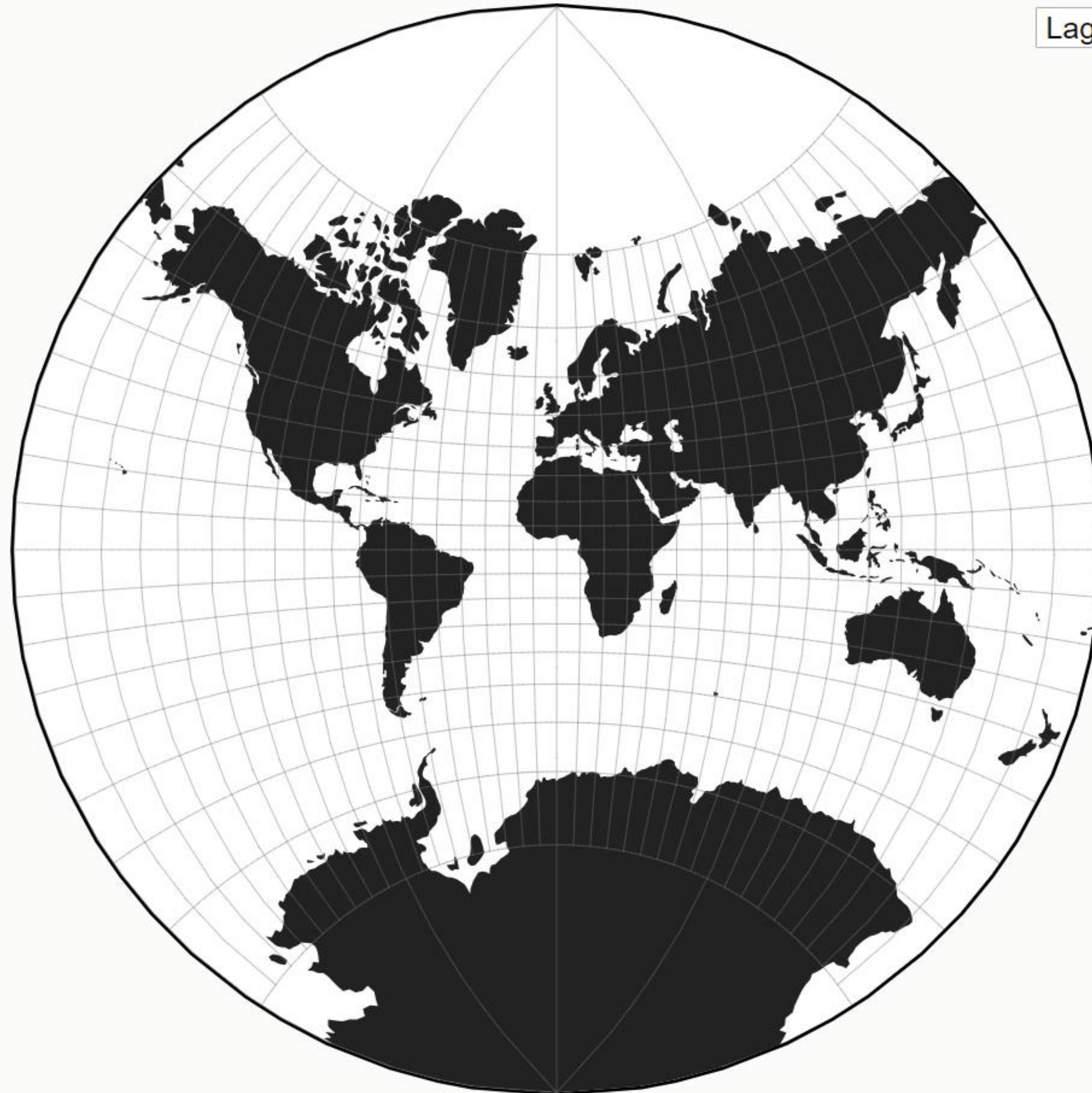
→ *Geometric (sparse seeds)*

→ *Textures (dense seeds)*

→ *Features (globally derived)*



Projection Transitions



Lagrange ▼

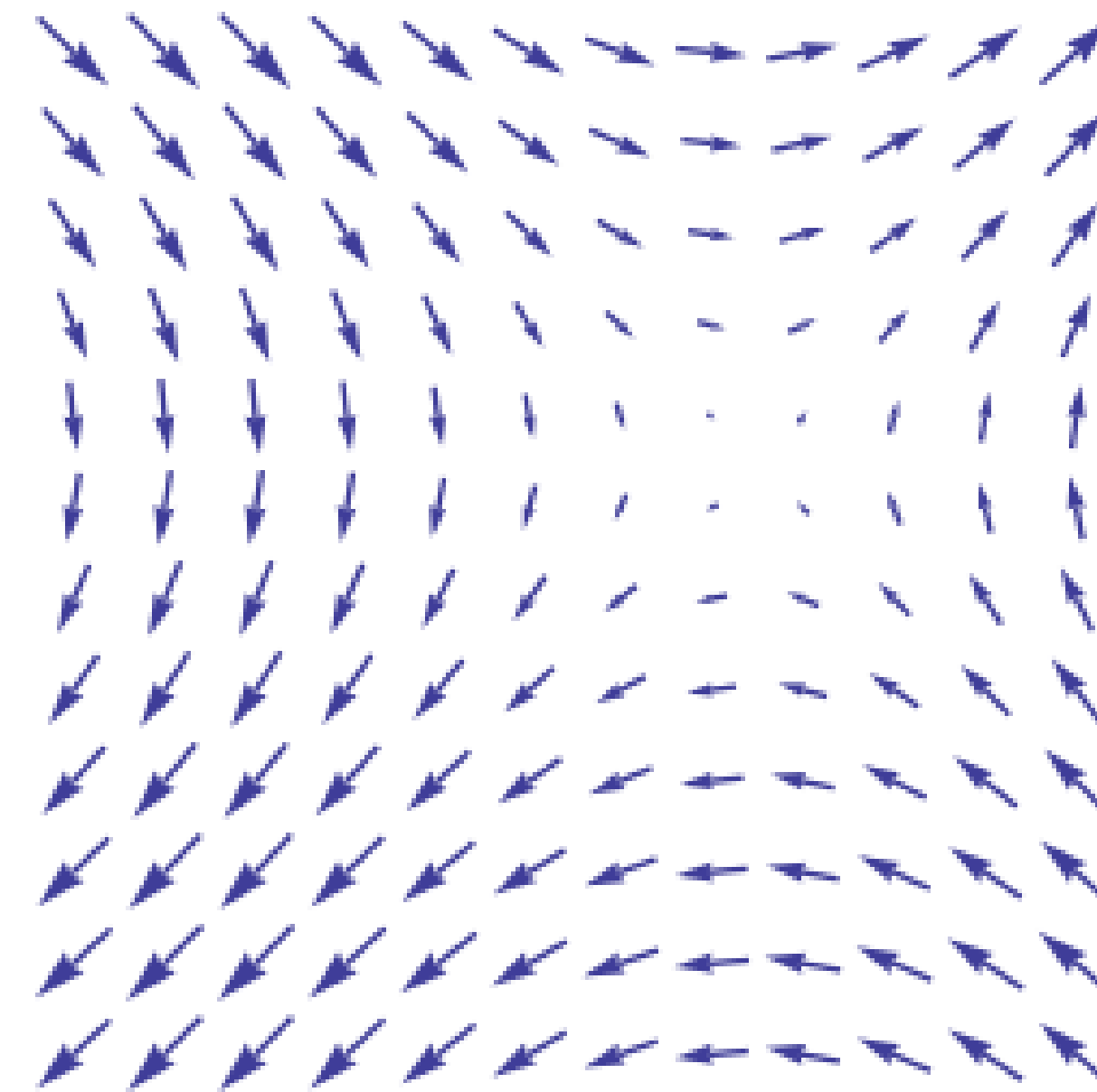
Spatial Fields

Scalar field = one value per cell

Vector or Tensor field = many values per cell

1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
7	7	5	5	6	5	5	5	8
1	1	1	1	5	6	6	6	8
2	2	2	1	5	6	6	6	8

Scalar
(magnitude)



Vector
(magnitude and direction)

Now, ON CS 7250...

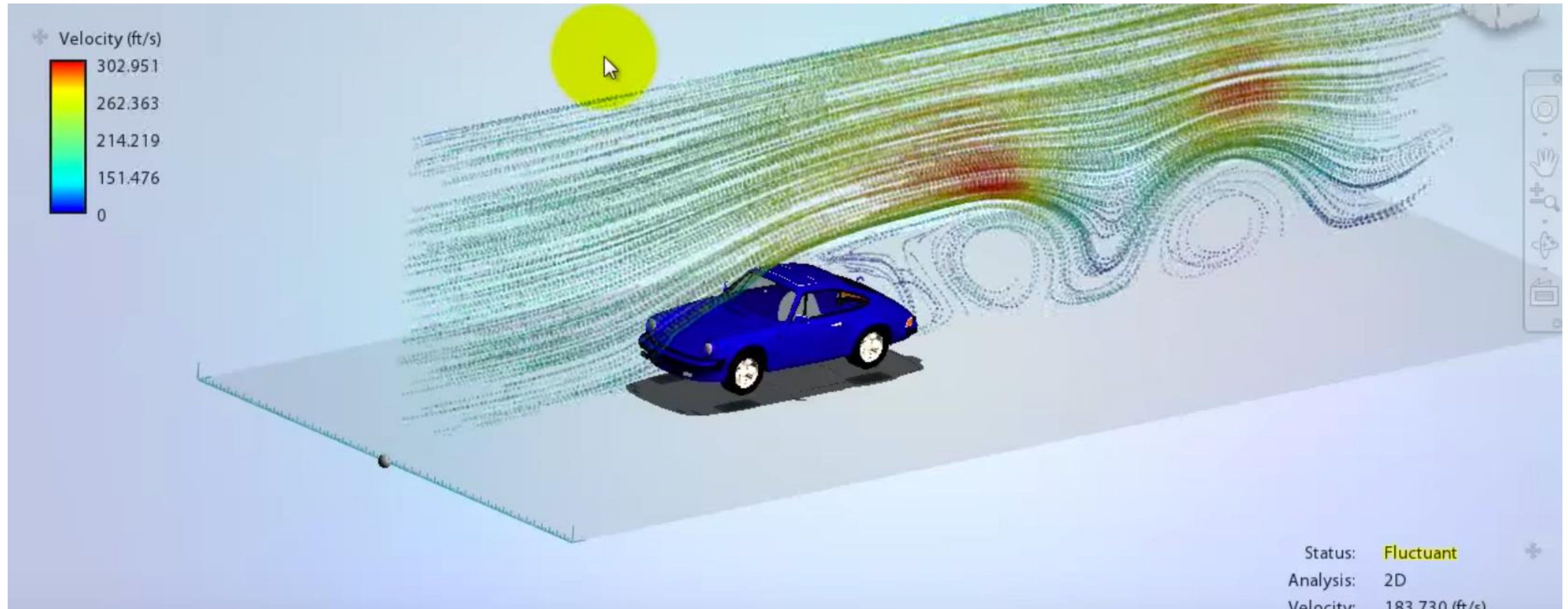
SPATIAL AND SCIENTIFIC VISUALIZATION

GOALS FOR TODAY

- Understand the concept of spatial fields, and how to visually encode.
- Learn about vector (and higher dimensional) representations.
- Learn about the two main ways to render 3D spatial data (isosurfaces and volume rendering).

SPATIAL FIELDS

Example: Fluid Flow Visualization



<https://www.youtube.com/watch?v=KUz0G09TGrl>



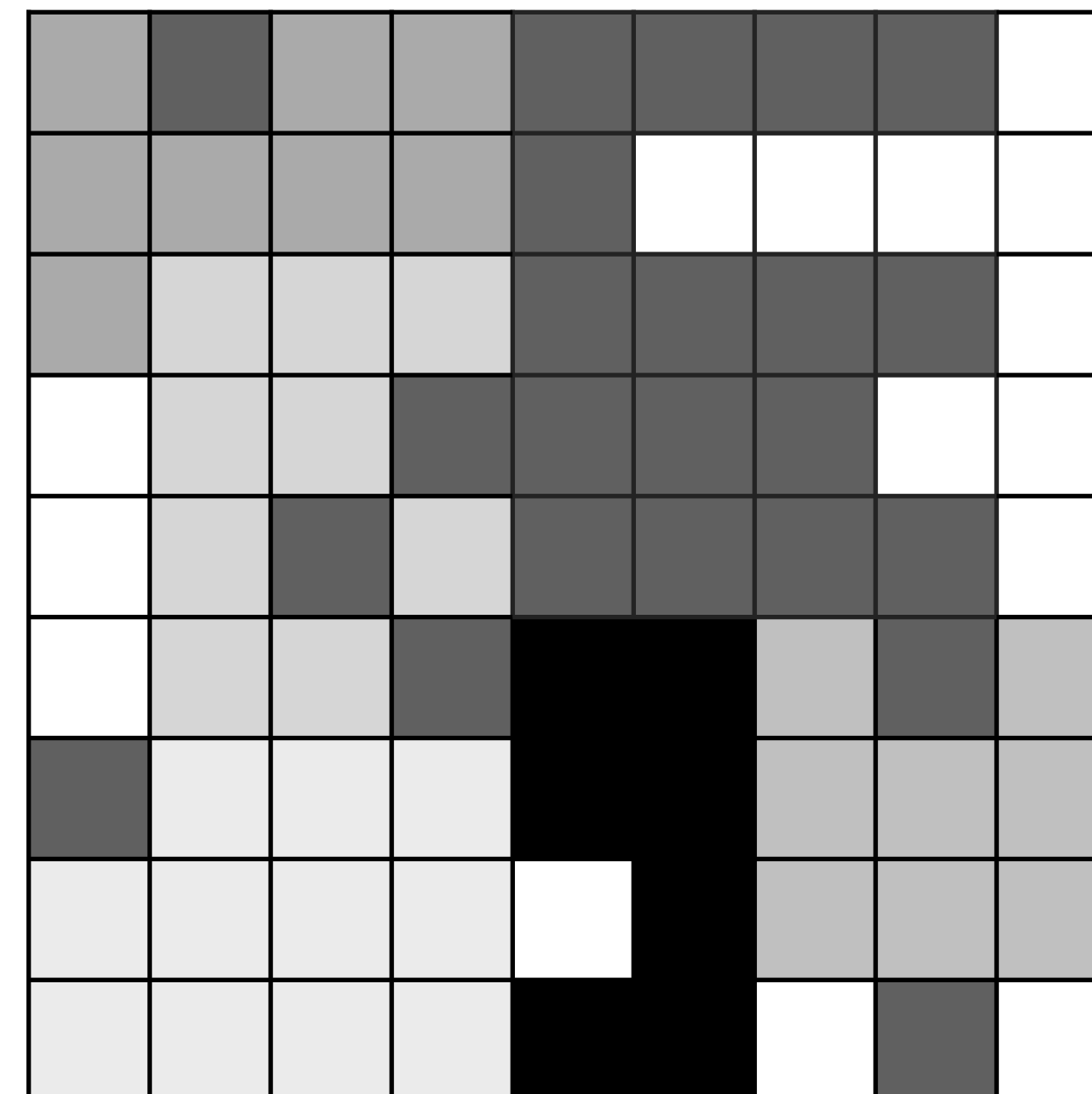
Spatial Fields

Scalar field = one value per cell

Encoding options:

1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
7	7	5	5	6	5	5	5	8
1	1	1	1	5	6	6	6	8
2	2	2	1	5	6	6	6	8

Scalar
(magnitude)

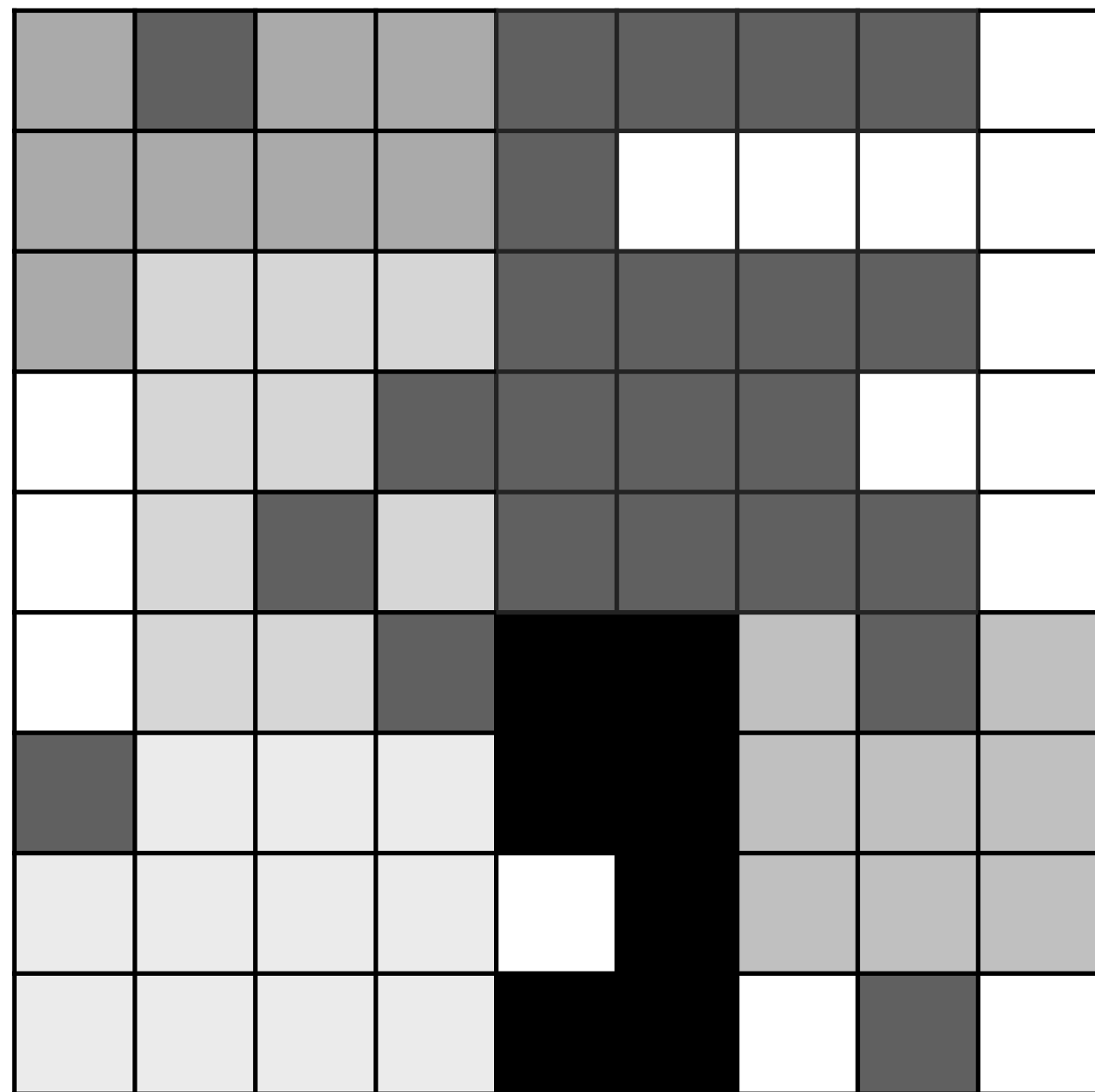


Image

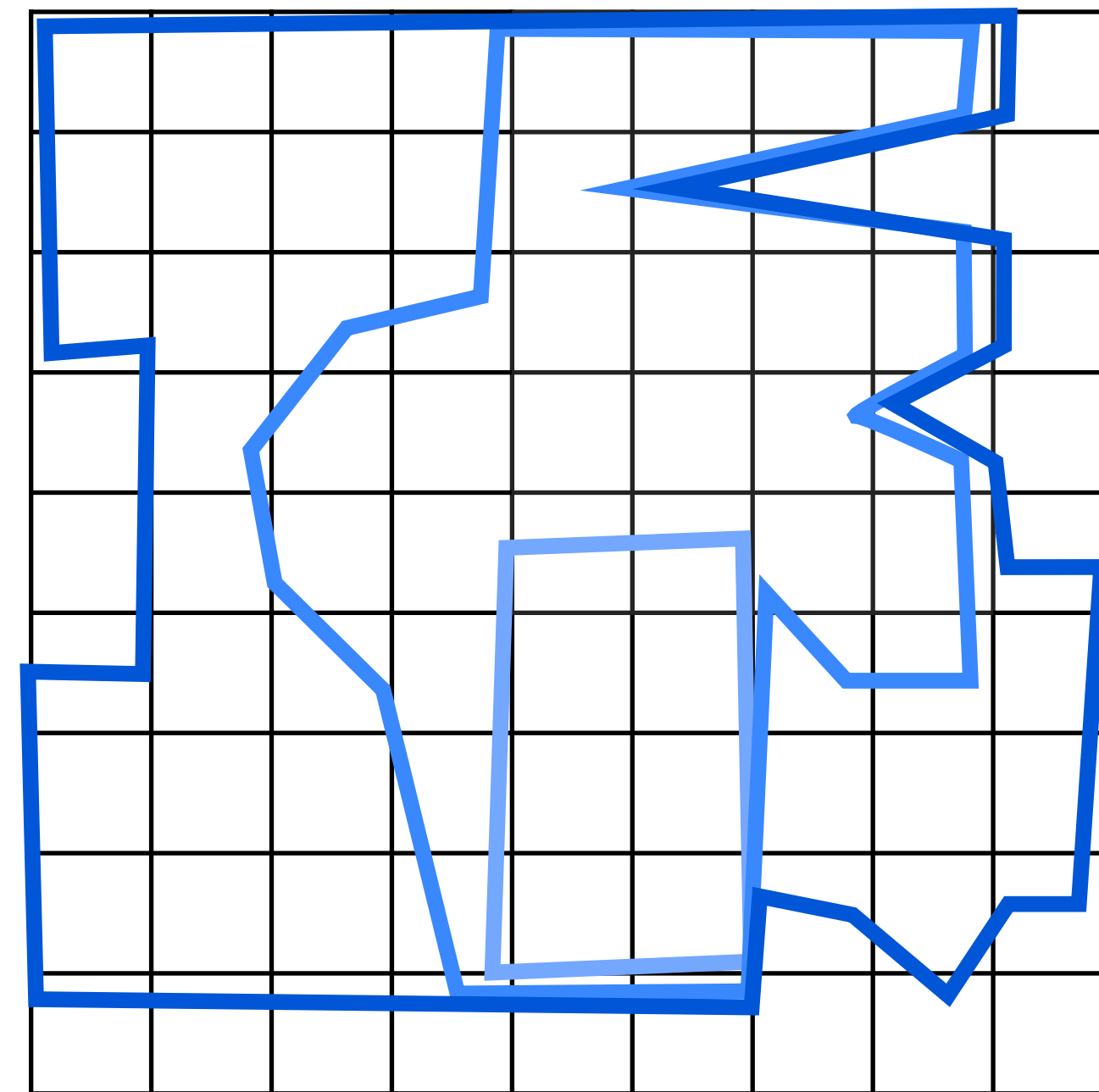
Spatial Fields

Scalar field = one value per cell

Encoding options:



Image



Isocontours

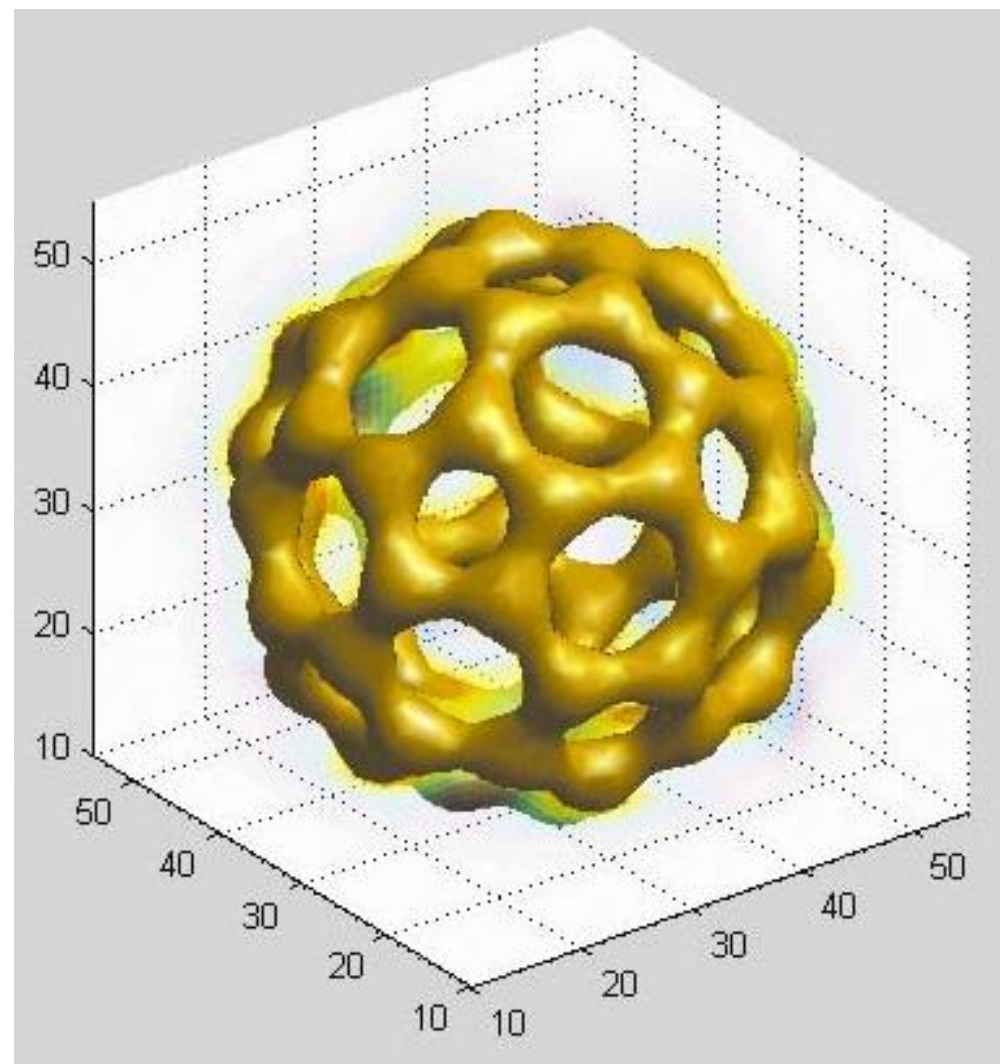
(Contour line as single scalar threshold value)

3D Spatial Fields

Scalar field = one value per cell

Encoding options:

Isosurface



Surface that represents points of a constant value

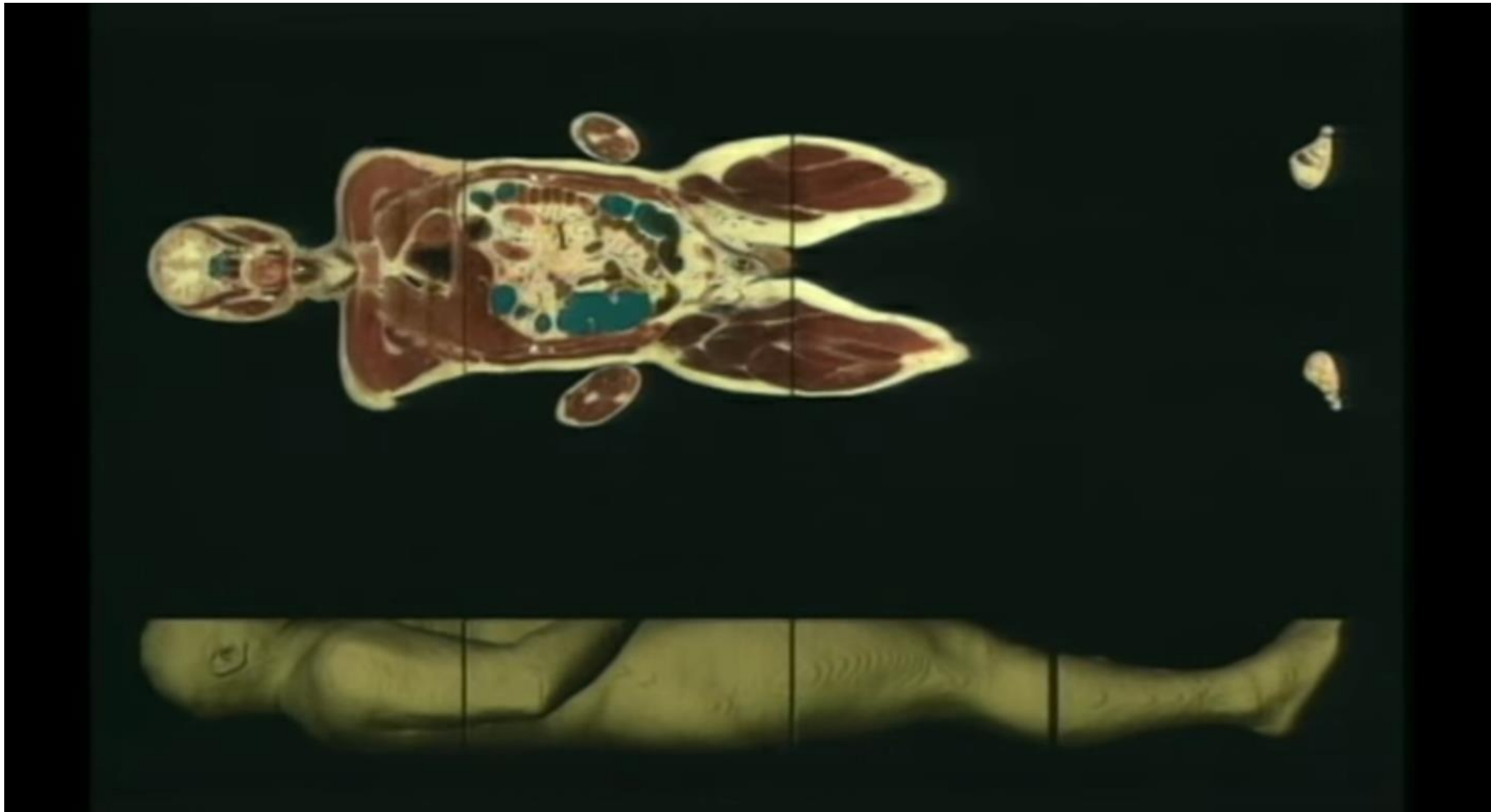
Volume Rendering



Every value is mapped to an opacity and a color via a "transfer function"

Isosurfaces & Volume Rendering

[Visible Human Project](#)



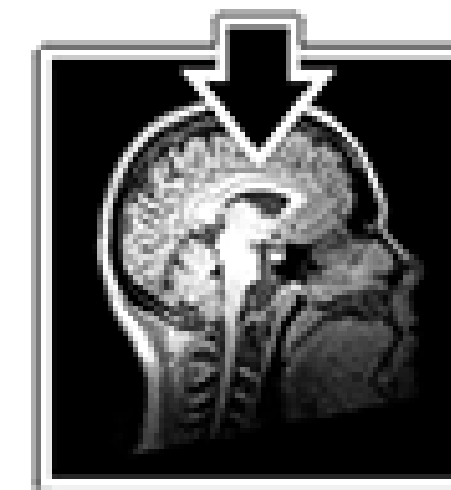
<https://www.youtube.com/watch?v=7GPB1sjEhIQ>



In-Class Exercise: Medical Imaging

In-Class Exercise: Slice:Drop

15m



Slice:Drop

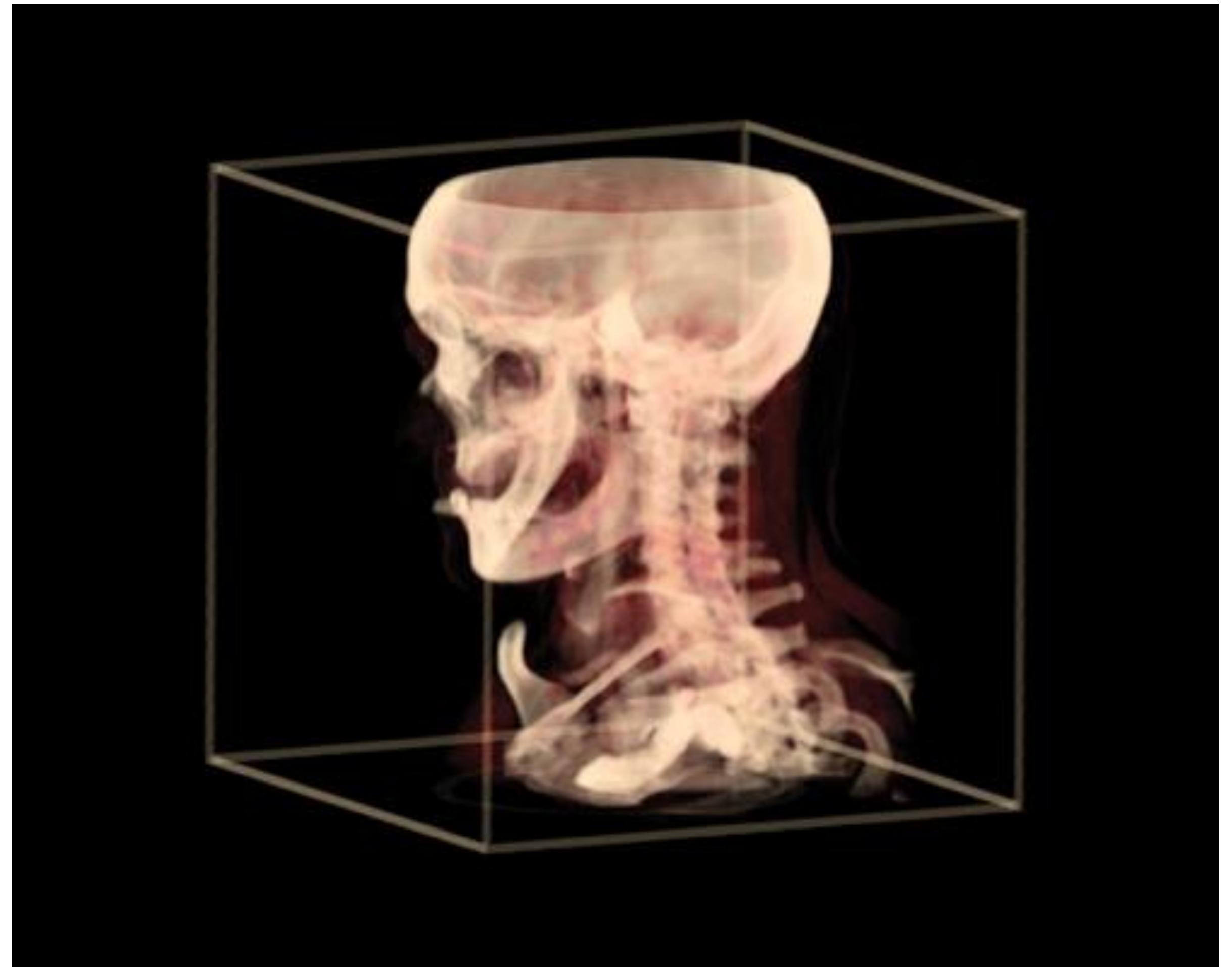
INSTRUCTIONS:

- Go to <http://slicedrop.com/>
- Click on the first example dataset in the top-right gallery “A 14 year old healthy male brain.”
- Explore the different views of the data using the hidden toolbars along the left side of the image:
- VOLUME: Explore the 2D and 3D view options.
- VOLUME: Experiment with the brightness/contrast (“Window level”) and data range (“Threshold”) sliders. Also try to change the colors.
- FIBERS: Experiment with the fiber threshold (i.e., data range).
- While in the 2D view, explore the slicing sliders. Also try dragging inside the small visualizations in this panel.

ISOSURFACES VS. VOLUME RENDERING

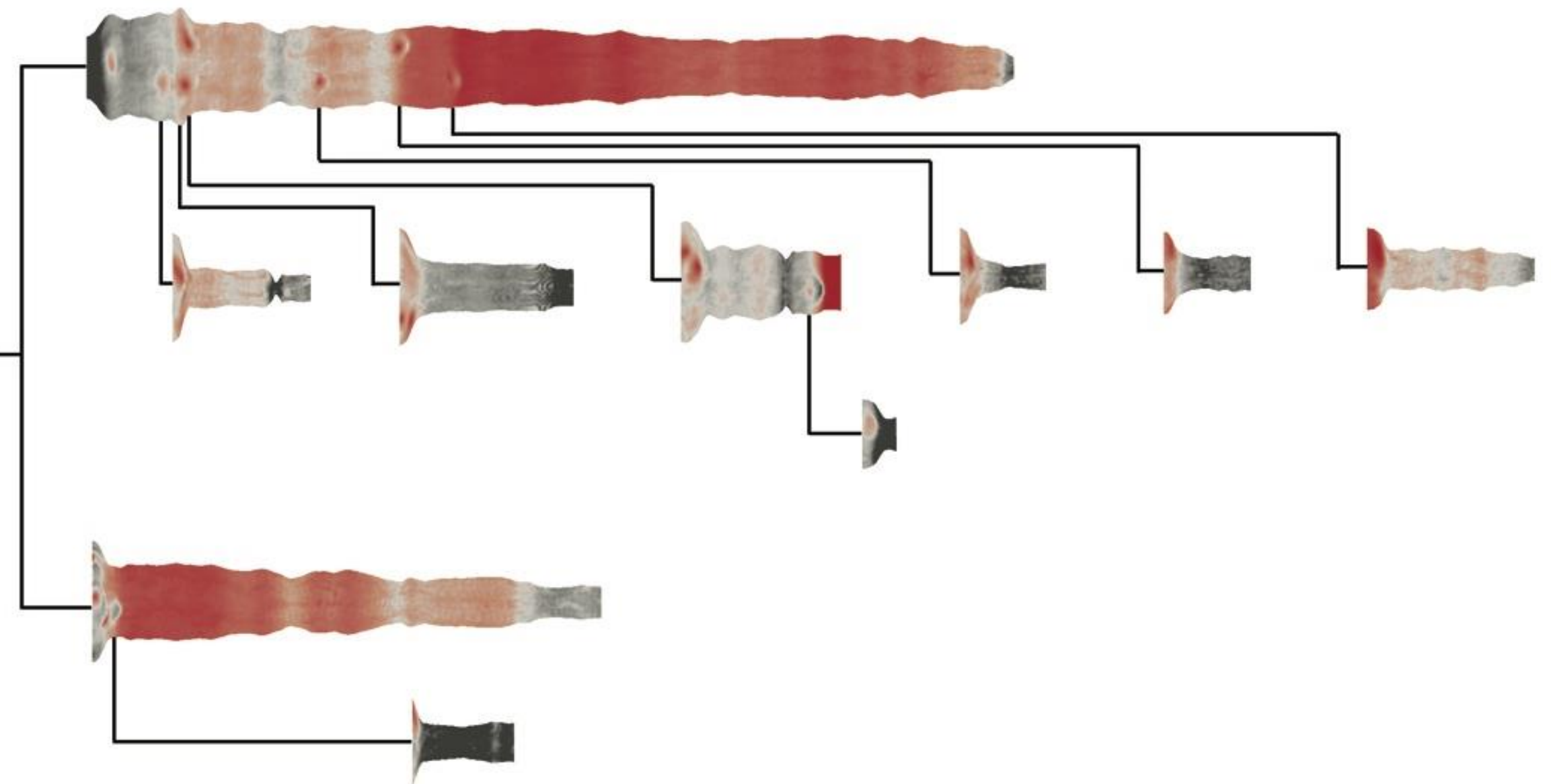
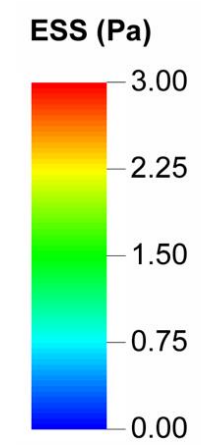
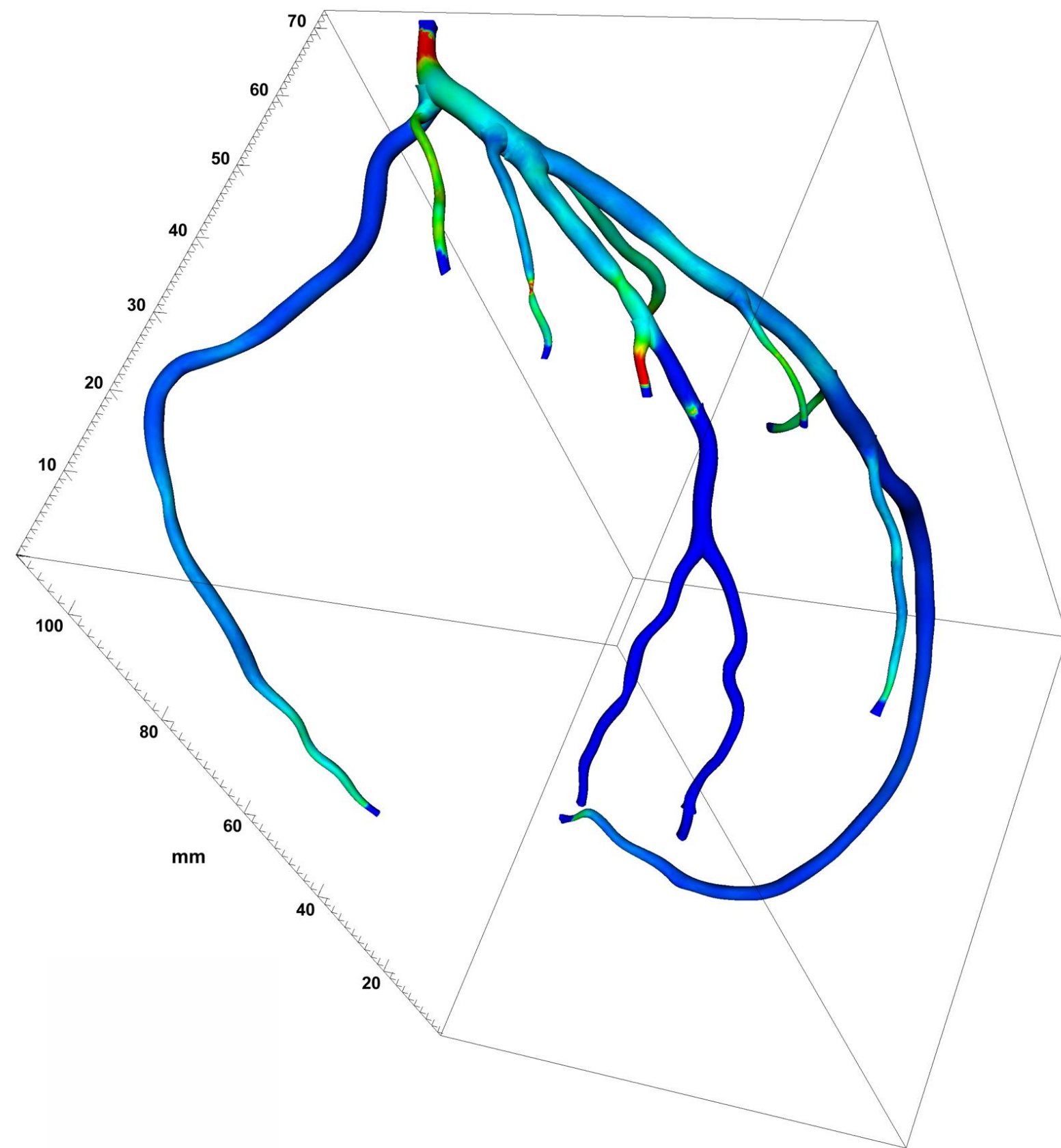


distinct objects
distinct thresholds (surfaces)



indistinct objects
blending or transparency important

Isosurfaces vs. Abstracted



PROJECT EXAMPLE — CEREBROVIS

CerebroVis: Designing an Abstract yet Spatially Contextualized Cerebral Artery Network Visualization

Aditeya Pandey, Harsh Shukla, Geoffrey S. Young, Lei Qin, Amir A. Zamani, Liangge Hsu, Raymond Huang, Cody Dunne, and Michelle A. Borkin

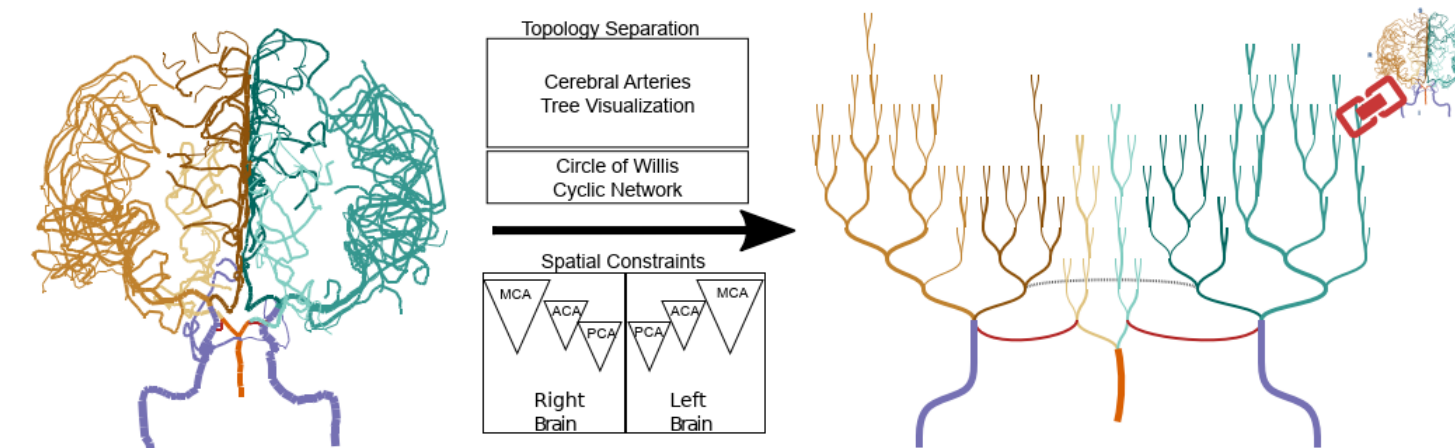


Fig. 1: CerebroVis is a novel network visualization for cerebral arteries. CerebroVis uses an abstract topology-preserving visual design which is put in spatial context by enforcing constraints on the network layout. Here we show the conversion of an almost symmetrical healthy human brain cerebral artery network from a 2D isosurface visualization (left) to CerebroVis (right). Each artery has the same categorical color in both views (see Sec. 3 for a legend).

Abstract—Blood circulation in the human brain is supplied through a network of cerebral arteries. If a clinician suspects a patient has a stroke or other cerebrovascular condition they order imaging tests. Neuroradiologists visually search the resulting scans for abnormalities. Their visual search tasks correspond to the abstract network analysis tasks of browsing and path following. To assist neuroradiologists in identifying cerebral artery abnormalities we designed CerebroVis, a novel abstract—yet spatially contextualized—cerebral artery network visualization. In this design study, we contribute a novel framing and definition of the cerebral artery system in terms of network theory and characterize neuroradiologist domain goals as abstract visualization and network analysis tasks. Through an iterative, user-centered design process we developed an abstract network layout technique which incorporates cerebral artery spatial context. The abstract visualization enables increased domain task performance over 3D geometry representations, while including spatial context helps preserve the user’s mental map of the underlying geometry. We provide open source implementations of our network layout technique and prototype cerebral artery visualization tool. We demonstrate the robustness of our technique by successfully laying out 61 open source brain scans. We evaluate the effectiveness of our layout through a mixed methods study with three neuroradiologists. In a controlled experiment our study participants used CerebroVis and a conventional 3D visualization to examine real cerebral artery imaging data and to identify a simulated intracranial artery stenosis. Participants were more accurate at identifying stenoses using CerebroVis (odds ratio 2.5, absolute risk difference 13%). More broadly, we discuss the applications of our design approach to a general design paradigm we call *Abstraction with Context*. A free copy of this paper, the evaluation stimuli and data, and source code are available at osf.io/e5sxt

Index Terms—Network Visualization, Spatial Context, Abstract Design, Flow Network, Medical Imaging, Cerebral Arteries.

1 INTRODUCTION

Arteries in the human brain form a network of blood flow, and a blockage or leakage in this network can lead to life-threatening cerebrovascular conditions such as a stroke or aneurysm. Strokes alone are the fifth leading cause of death as well as a leading cause of serious long-term disability in the United States, and is globally the second leading cause of death after heart disease [32]. Early detection and diagnosis of these conditions is essential for effective life-saving treatment. Conventional diagnostics

rely on an expert neuroradiologist identifying vascular abnormalities through examination of medical images (e.g., CTA, MRA). This data is commonly rendered in 3D in order to assist the doctor with identification of the abnormalities. However, prior research indicates that existing representations of the 3D cerebral arteries—e.g., isosurface, volume rendering, and Maximum Intensity Projection (MIPS)—introduce visual artifacts and task performance challenges such as overplotting/occlusion [19], false impression of geometry [19], and excessive artery bends.

In this design study, we present a novel 2D visualization of the cerebral artery system designed to assist doctors in the identification of cerebrovascular abnormalities. Inspired by existing visualization research which has demonstrated the effectiveness of 2D representations for spatial search tasks in other medical imaging cases, e.g., cardiovascular arteries [6] and connectomics [33], we present a novel 2D abstract representation of the cerebral arteries. To our knowledge, this is the first attempt to approach the cerebrovascular diagnostics tasks faced by neuroradiologists from the perspective of network science and using an abstract 2D visual encoding.

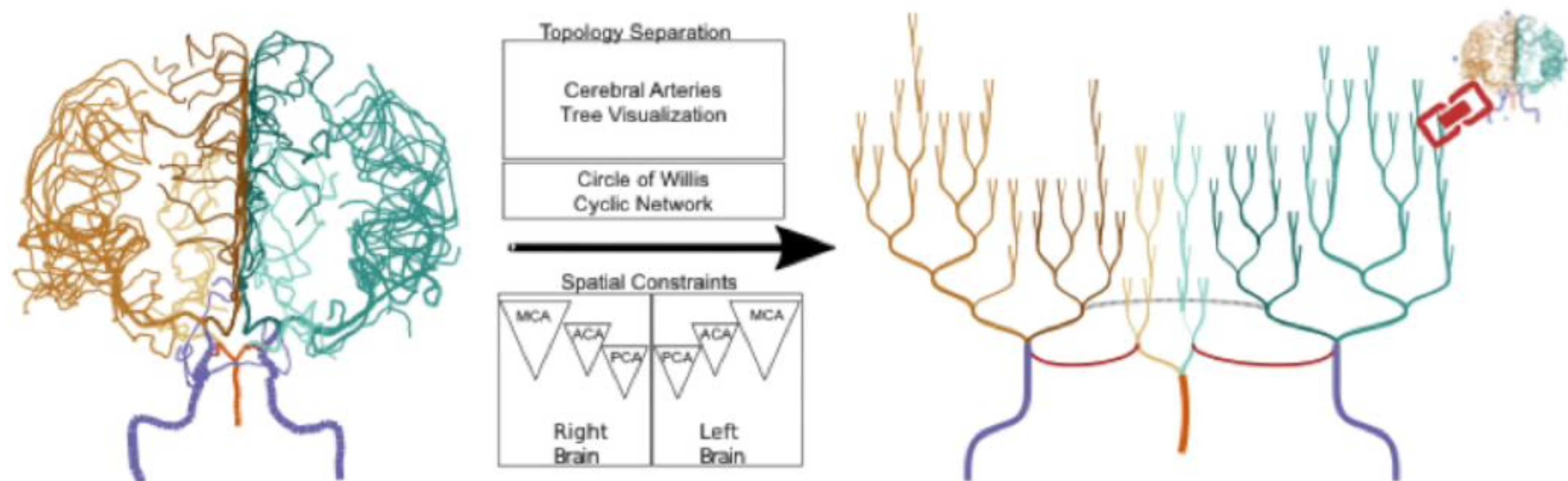
In this paper we first offer a novel framing of cerebral arteries using network theory. Next, we characterize the domain goals and present them as network analysis tasks. In an iterative user-centered design with

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- Geoffrey S. Young, Amir A. Zamani, Liangge Hsu, and Raymond Huang are with Brigham and Women’s Hospital. E-mail: {gyoung@bwh.harvard.edu, azamani@bwh.harvard.edu, lhsu1@bwh.harvard.edu, ryhuang@bwh.harvard.edu}
- Lei Qin is with the Dana-Farber Cancer Institute. E-mail: lqin2@partners.org

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CS 7260 FALL 2017:
VISUALIZATION FOR
NETWORK SCIENCE

CerebroVis: Designing an Abstract yet Spatially Contextualized Cerebral Artery Network Visualization



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Northeastern University

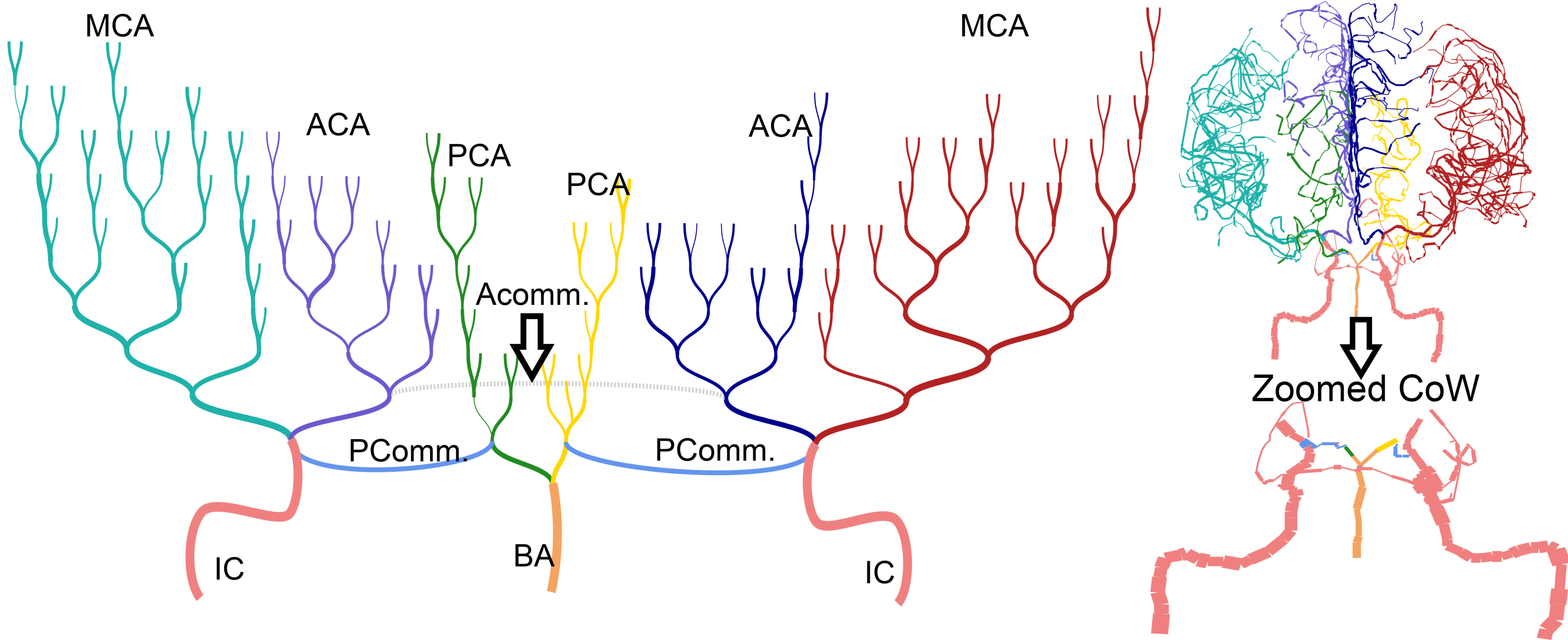


HARVARD MEDICAL SCHOOL AND
BRIGHAM AND WOMEN'S HOSPITAL



DANA-FARBER
CANCER INSTITUTE

PROJECT EXAMPLE — CEREBROVIS



Upcoming Assignments & Communication

Look at the upcoming assignments and deadlines regularly!

- Textbook, Readings, & Reading Quizzes — Variable days
- In-Class Activities — 11:59pm same day as class
 - F: Lecture, T: Lecture, F: Project Testing, Feedback
- Assignments & Projects— Generally due **R 11:59pm**
 - R (2 days): Project 7 — Sprint 2 & Paper Draft
 - Next R (9 days): Project 8 — Sprint 3 & Prep for Usability Testing
 - Next F (10 days): In-Class Usability Testing
 - Next-Next R (16 days): Project 9 — Presentation and Video
 - Next-Next F (17 days): In-Class Project Presentations

Use Canvas Discussions for general questions, email the TAs/S-LTA/instructor for questions specific to you: codydunne-and-tas@ccs.neu.edu. Include links!

If you're emailing about a particular assignment, please **include the URL of the Submission Details page**. ([Canvas documentation](#).)

If you have a project question, **give us your group number**. E.g., include: `Group ## — Topic` with `##` replaced by your group number and `Topic` replaced by your topic.

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