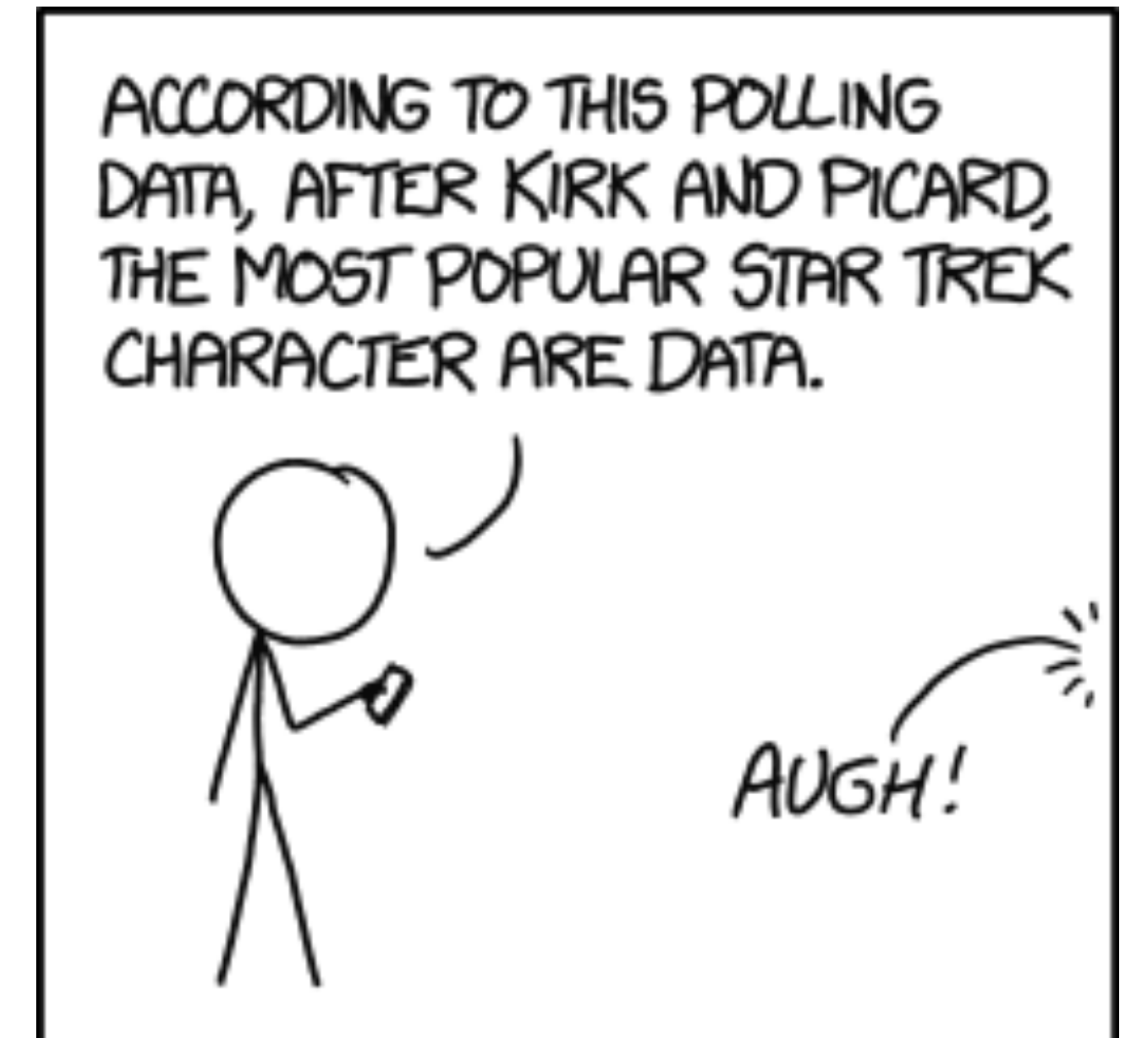


CS-5630 / CS-6630

Visualization for Data Science

Data

Alexander Lex
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ANNOY GRAMMAR PEDANTS ON ALL SIDES BY MAKING "DATA" SINGULAR *EXCEPT* WHEN REFERRING TO THE ANDROID.

This Week

Thursday: Visualization Alphabet

Mandatory Reading: Crowdsourcing graphical perception: using mechanical turk to assess visualization design.
Jeff Heer, Mike Bostock

CHI 2010: Visualization

April 10–15, 2010, Atlanta, GA, USA

Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design

Jeffrey Heer and Michael Bostock
Computer Science Department
Stanford University
{jheer, mbostock}@cs.stanford.edu

ABSTRACT

Understanding perception is critical to effective visualization design. With its low cost and scalability, crowdsourcing presents an attractive option for evaluating the large design space of visualizations; however, it first requires validation. In this paper, we assess the viability of Amazon's Mechanical Turk as a platform for graphical perception experiments. We replicate previous studies of spatial encoding and luminance contrast and compare our results. We also conduct new experiments on rectangular area perception (as in treemaps or cartograms) and on chart size and gridline spacing. Our results demonstrate that crowdsourced perception experiments are viable and contribute new insights for visualization design. Lastly, we report cost and performance data from our experiments and distill recommendations for the design of crowdsourced studies.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces—Evaluation/Methodology

General Terms: Experimentation, Human Factors.

Keywords: Information visualization, graphical perception, user study, evaluation, Mechanical Turk, crowdsourcing.

INTRODUCTION

“Crowdsourcing” is a relatively new phenomenon in which web workers complete one or more small tasks, often for micro-payments on the order of \$0.01 to \$0.10 per task.

for ecological validity. Crowdsourced experiments may also substantially reduce both the cost and time to result.

Unfortunately, crowdsourcing introduces new concerns to be addressed before it is credible. Some concerns, such as ecological validity, subject motivation and expertise, apply to any study and have been previously investigated [13, 14, 23]; others, such as display configuration and viewing environment, are specific to visual perception. Crowdsourced perception experiments lack control over many experimental conditions, including display type and size, lighting, and subjects' viewing distance and angle. This loss of control inevitably limits the scope of experiments that reliably can be run. However, there likely remains a substantial subclass of perception experiments for which crowdsourcing can provide reliable empirical data to inform visualization design.

In this work, we investigate if crowdsourced experiments insensitive to environmental context are an adequate tool for graphical perception research. We assess the feasibility of using Amazon's Mechanical Turk to evaluate visualizations and then use these methods to gain new insights into visualization design. We make three primary contributions:

- We replicate prior laboratory studies on spatial data encodings and luminance contrast using crowdsourcing techniques. Our new results match previous work, are consistent with theoretical predictions [21], and suggest that

Terms

Dataset Types

what can be visualized?

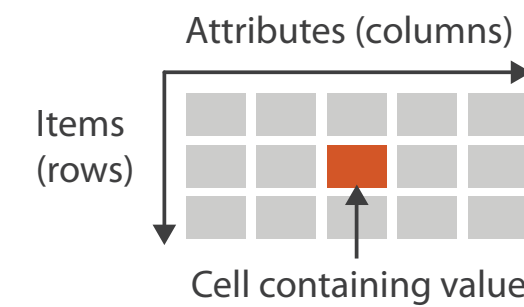
Data Types

fundamental units

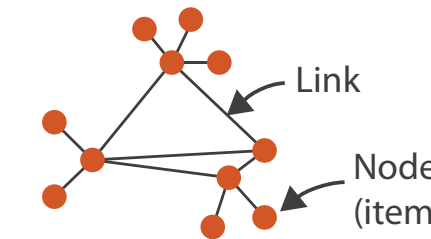
combinations make up Dataset Types

→ Dataset Types

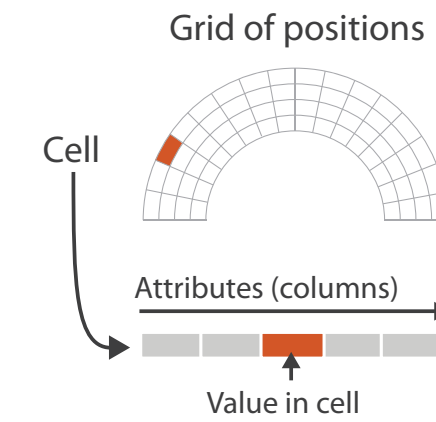
→ Tables



→ Networks



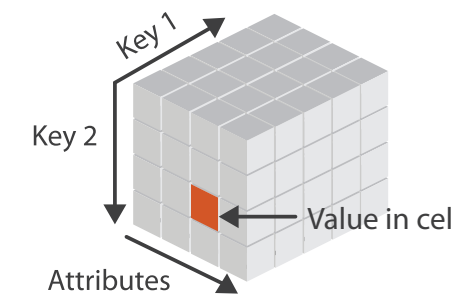
→ Fields (Continuous)



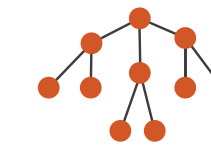
→ Geometry (Spatial)



→ Multidimensional Table



→ Trees



→ Data Types

→ Items

→ Attributes

→ Links

→ Positions

→ Grids

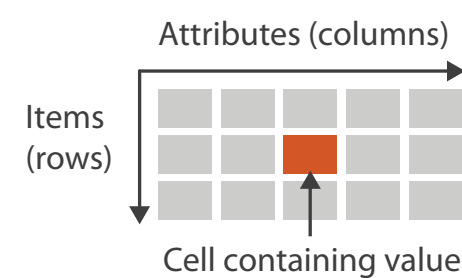
Structure

Structured Data

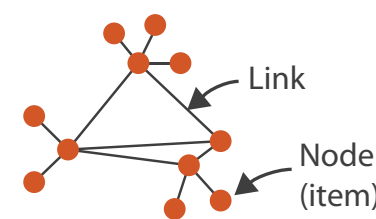
known data types, semantics

Dataset Types

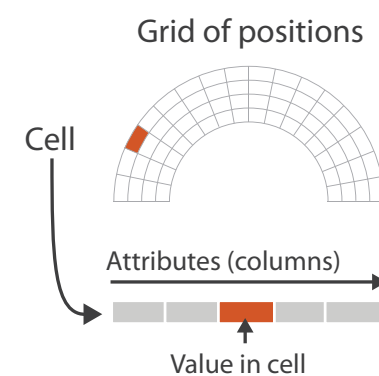
→ Tables



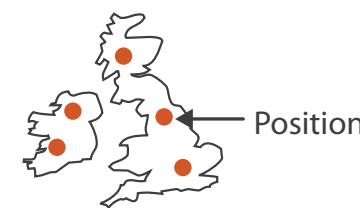
→ Networks



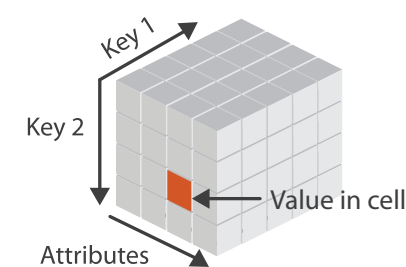
→ Fields (Continuous)



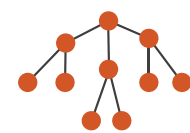
→ Geometry (Spatial)



→ Multidimensional Table



→ Trees



Unstructured Data

no predefined data model

text-heavy, interspersed with facts (dates, times, locations)

video, images

Translate into structured data

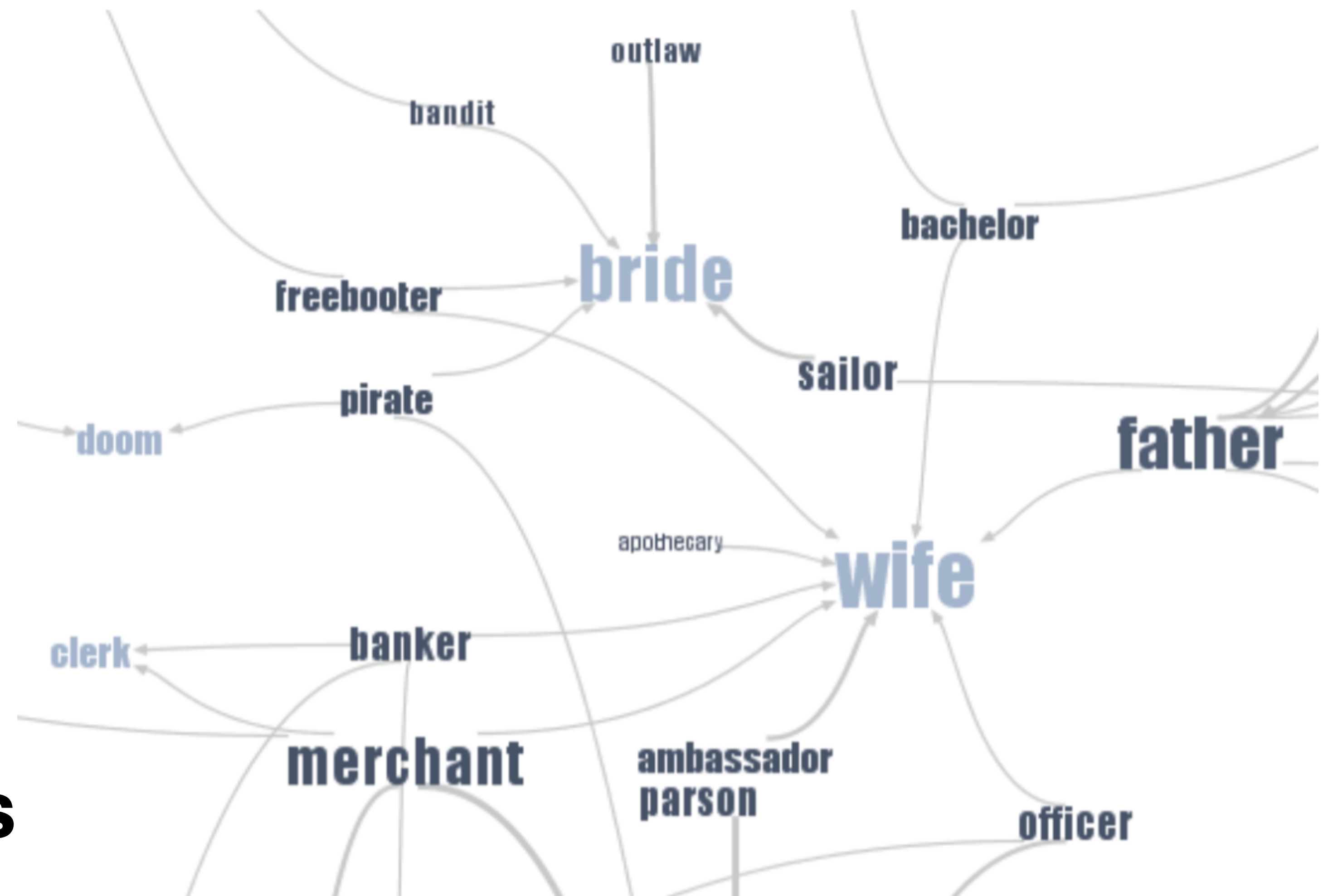
Natural Language Processing, Text mining (sentiment, keywords, concepts, categories)

Object Recognition, Tracking

Example: Phrase Net

Pattern: “X’s Y”

18th & 19th century
novels



More in Lecture
Text & Document Vis

Data Semantics

ID	Name	Age	Shirt Size	Favorite Fruit
1	Amy	8	S	Apple
2	Basil	7	S	Pear
3	Clara	9	M	Durian
4	Desmond	13	L	Elderberry
5	Ernest	12	L	Peach
6	Fanny	10	S	Lychee
7	George	9	M	Orange
8	Hector	8	L	Loquat
9	Ida	10	M	Pear
10	Amy	12	M	Orange

Basil, 7, S, Pear

What does it mean?

Semantics: real world meaning

Name? City? Fruit? Height? Age? Day of Month?

Metadata

Data Types

structural or mathematical interpretation of data

Item, Link, Attribute, Position, Grid

Different from data types in programming!

Items & Attributes

Item: individual entity, discrete

e.g., Patient, Car, Stock, City

“independent variable”

Attribute: measured, observed,
logged property

e.g., Patient: height, blood pressure

Car: horsepower, make

“dependent variable”

Item: Person Attributes

ID	Name	Age	Shirt Size	Favorite Fruit
1	Amy	8	S	Apple
2	Basil	7	S	Pear
3	Clara	9	M	Durian
4	Desmond	13	L	Elderberry
5	Ernest	12	L	Peach
6	Fanny	10	S	Lychee
7	George	9	M	Orange
8	Hector	8	L	Loquat
9	Ida	10	M	Pear
10	Amy	12	M	Orange

Cell



Other Data Types

Links

Express relationship between two items

Friendship on Facebook, Interaction between proteins

Positions

Spatial data -> location in 2D or 3D

Pixels in photo, Voxels in MRI scan, latitude/longitude

Grids

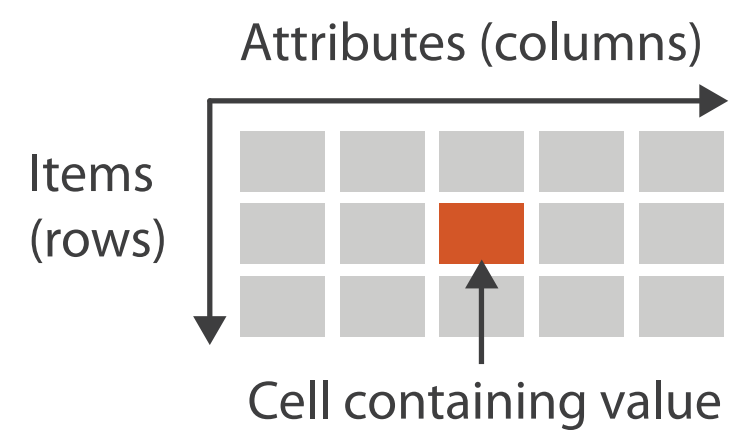
Sampling strategy for continuous data

How many Voxels in MRI scan, positions of weather stations in the US

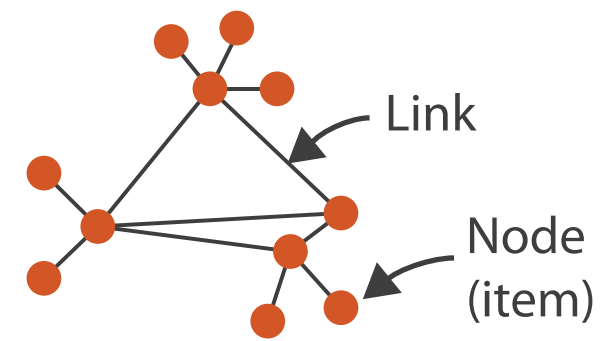
Dataset Types

→ Dataset Types

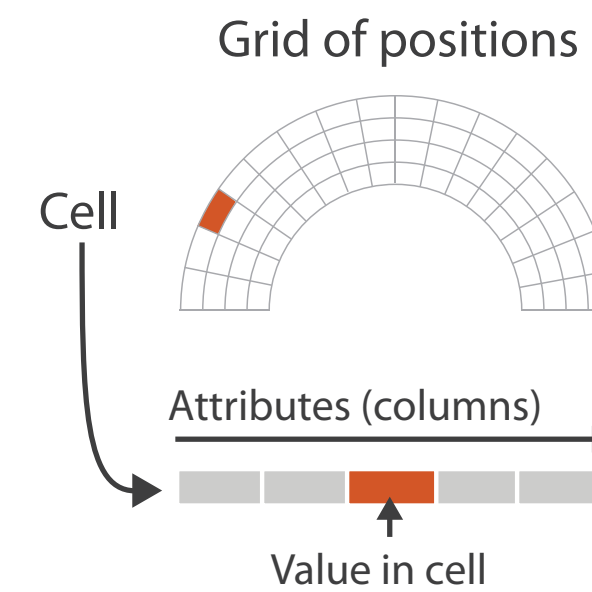
→ Tables



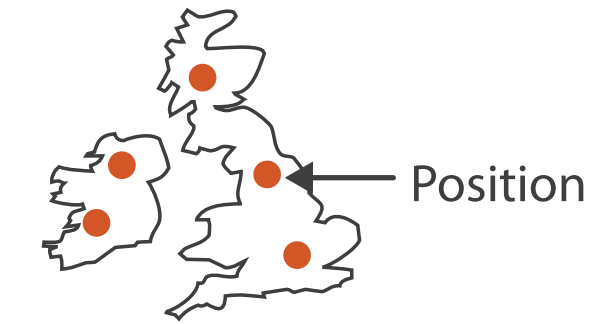
→ Networks



→ Fields (Continuous)



→ Geometry (Spatial)



Tables

Flat Table

one item per row

each column is attribute

unique (implicit) **key**

no duplicates

Multidimensional Table

indexing based on multiple keys

	Keys		Attributes		
	ID	Name	Age	Shirt Size	Favorite Fruit
Item	1	Amy	8	S	Apple
	2	Basil	7	S	Pear
	3	Clara	9	M	Durian
	4	Desmond	13	L	Elderberry
	5	Ernest	12	L	Peach
	6	Fanny	10	S	Lychee
	7	George	9	M	Orange
	8	Hector	8	L	Loquat
	9	Ida	10	M	Pear
	10	Amy	12	M	Orange

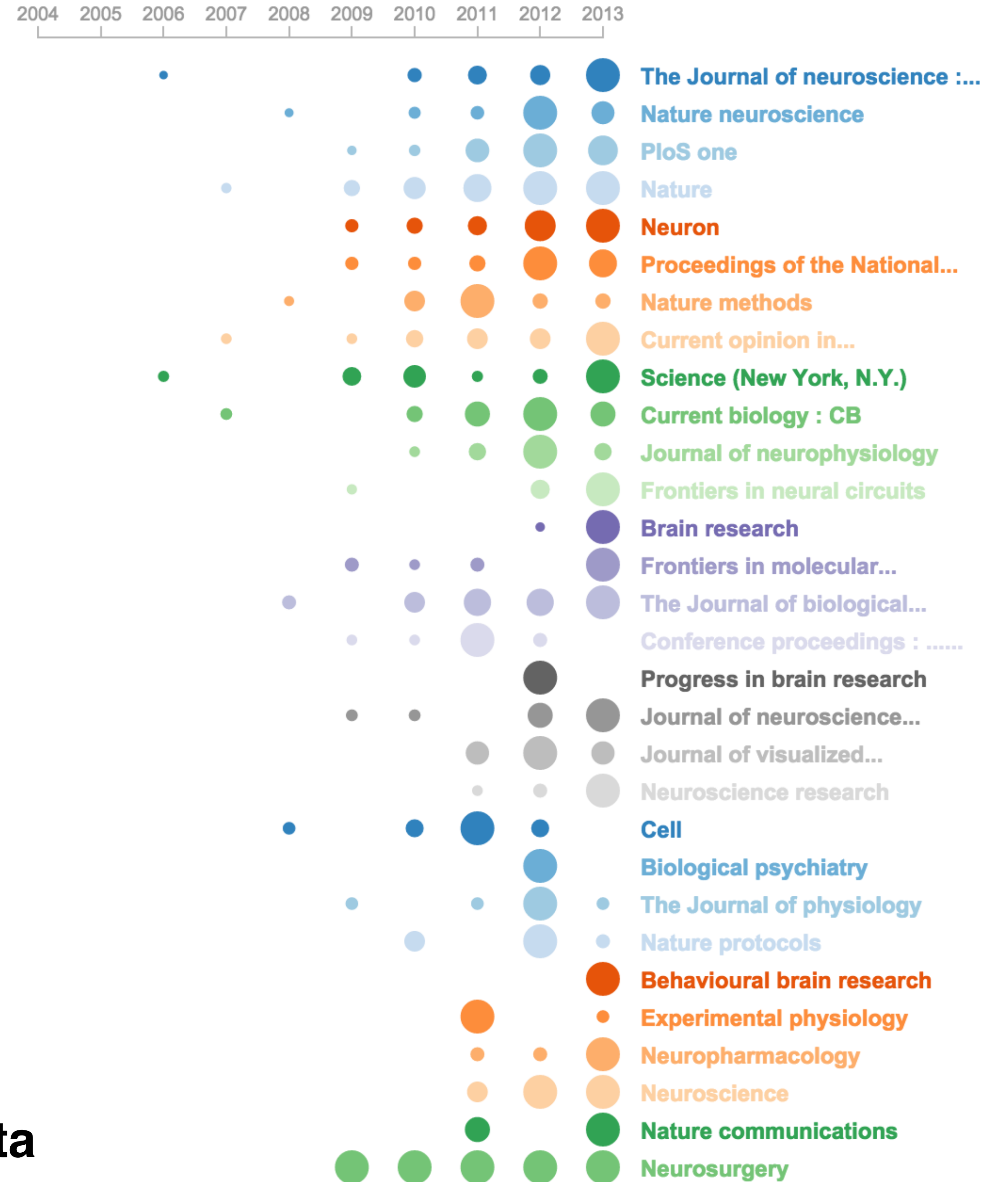
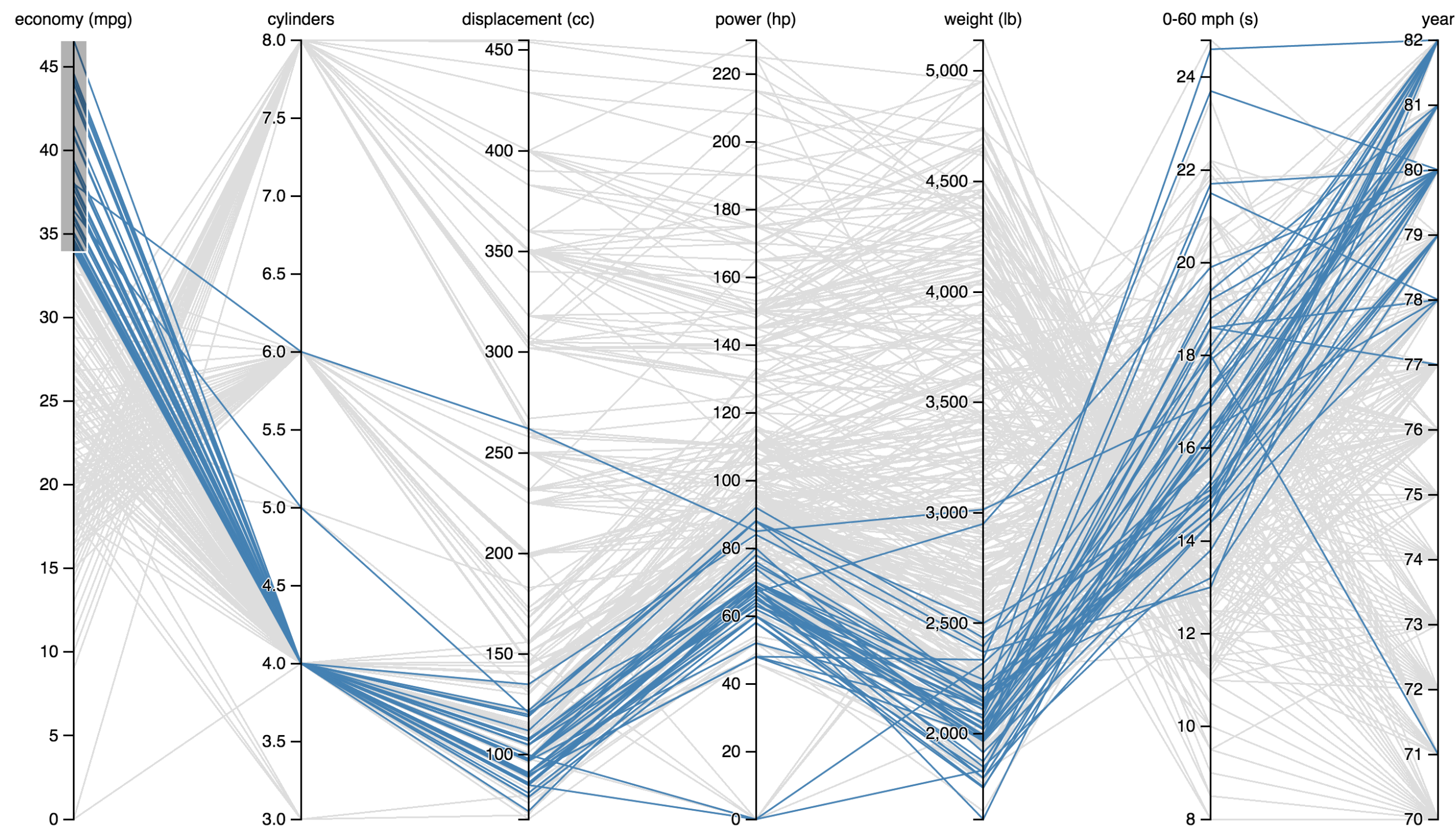
Multidimensional Tables

Keys: Genes

	A	B	C	D	E
1	#				
2	1	#			
3	2	1	#		
4	3	2	1	#1.2	
5	4	3	2	1500	529
6	5	4	3	GeneName	DESCRIPTION
7	6	5	4	LTF	LTF
8	7	6	5	POSTN	POSTN
9	8	7	6	TMSL8	TMSL8
10	9	8	7	HLA-DQA1	HLA-DQA1
11	10	9	8	RP11-35N6.1	RP11-35N6.1
12	11	10	9	STMN2	STMN2
13	12	11	10	DCX	DCX
14	13	12	11	AGXT2L1	AGXT2L1
15	14	13	12	IL13RA2	IL13RA2
16	15	14	13	SLN	SLN
17	16	15	14	MEOX2	MEOX2
18	17	16	15	COL11A1	COL11A1
19	18	17	16	NNMT	NNMT
20	19	18	17	F13A1	F13A1
21	20	19	18	CXCL14	CXCL14
22	21	20	19	MBP	MBP
	22	21	20	TF	TF
		22	21	KCND2	KCND2

Patients

Visualizing Tables



More in Lecture on Tables & High-Dimensional Data

Collections

How we group items

Sets

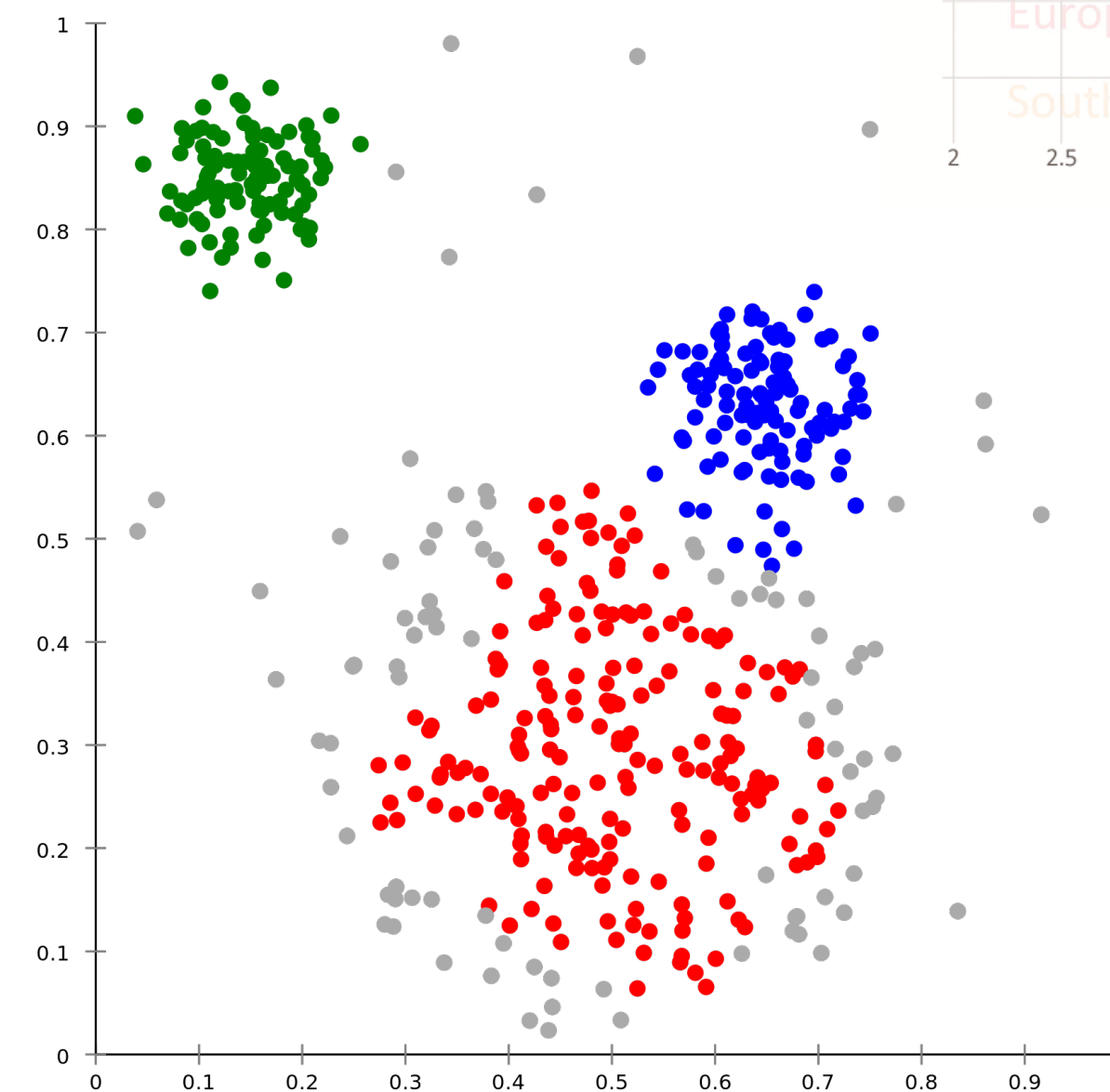
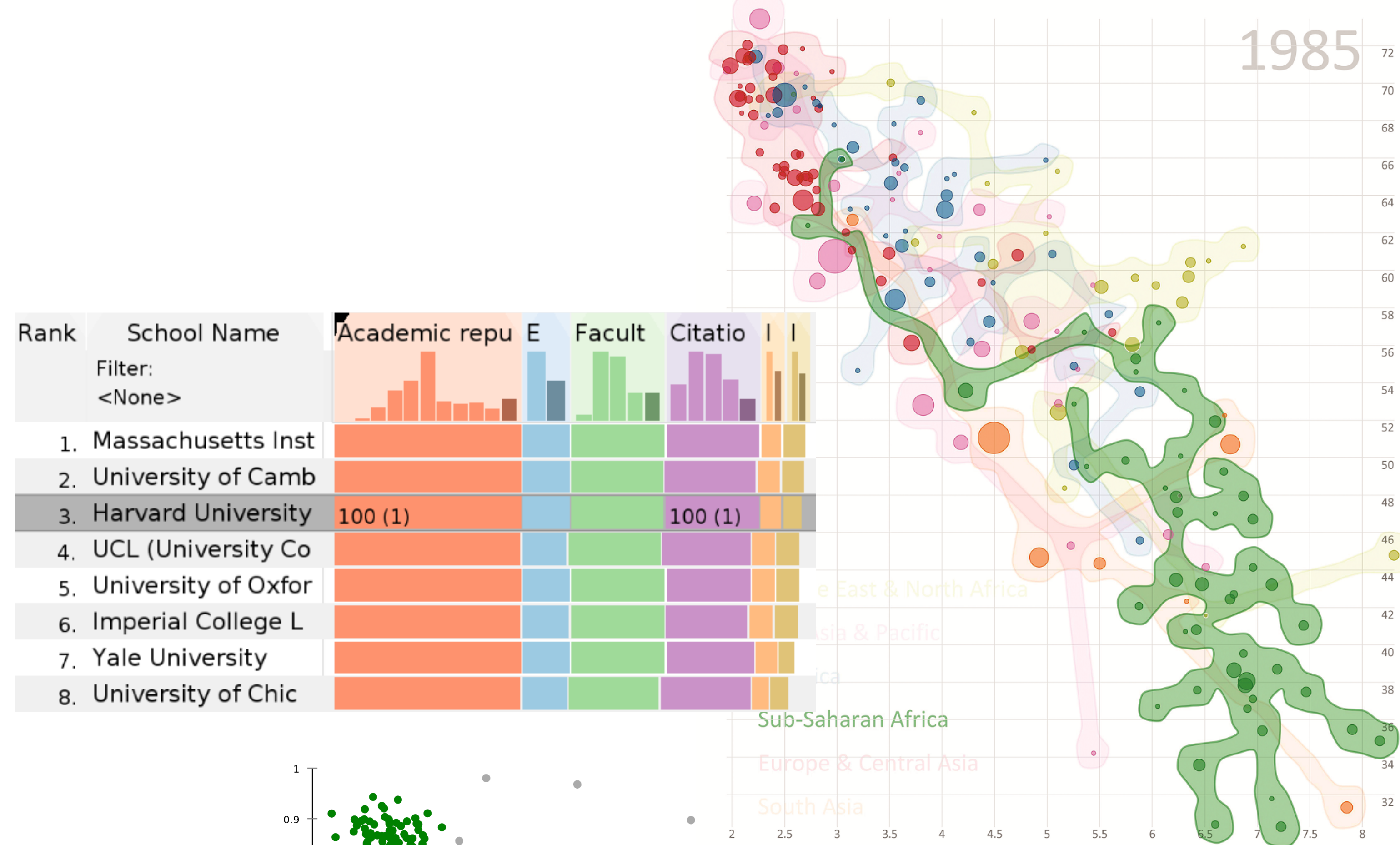
Unique items, unordered

Lists

Ordered, duplicates allowed

Clusters

Groups of similar items



Graphs/Networks

Items (nodes) are connected with links.

Examples: Social networks, power grids, road networks, computer chips, ...

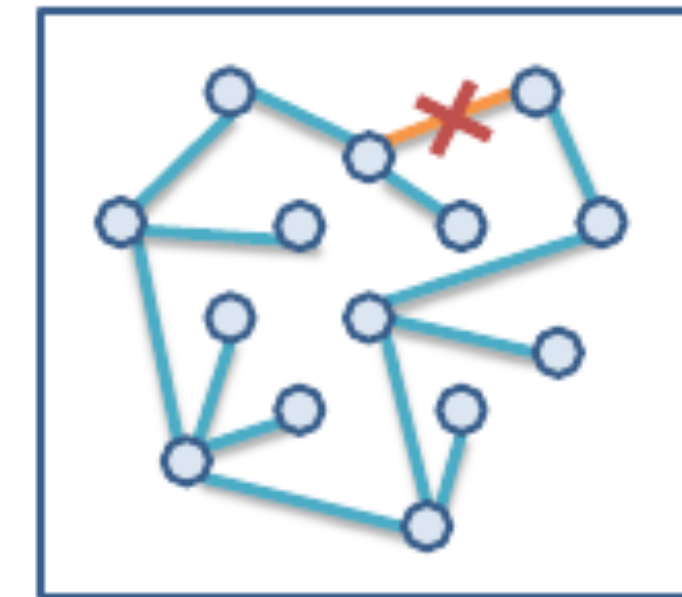


Diagrammatic Example

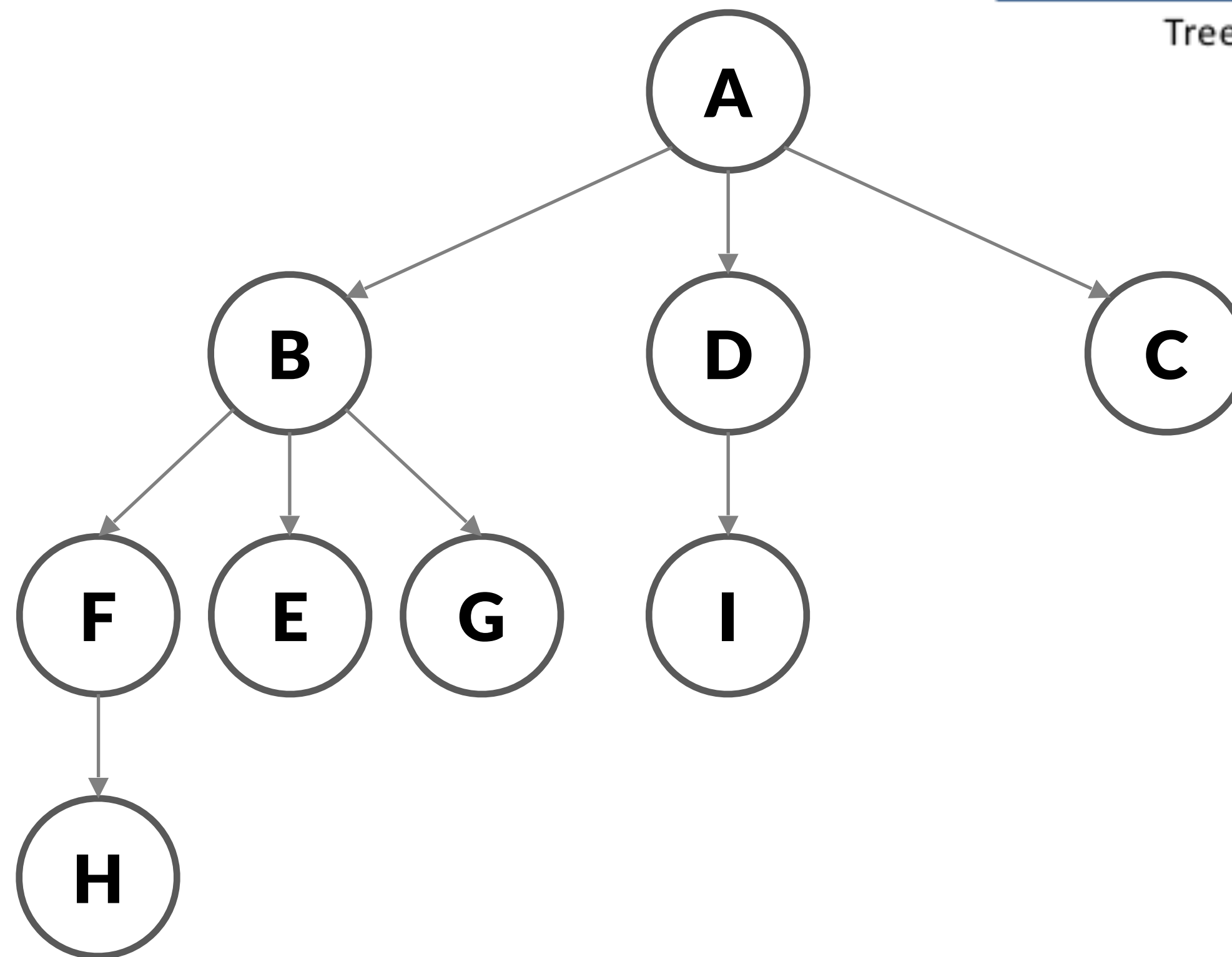
Trees

A **tree** is a graph with *no cycles*

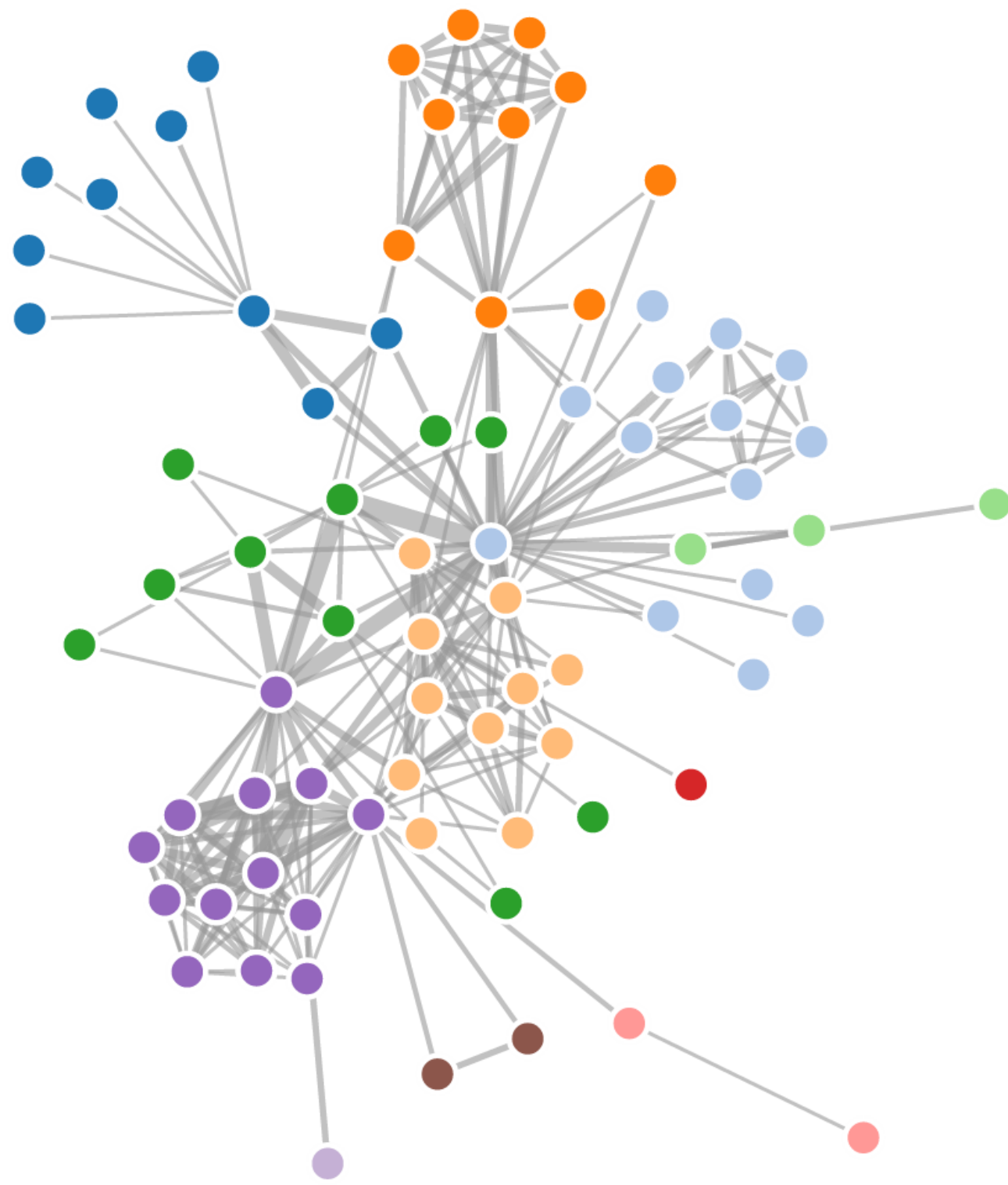
Trees often also have roots and are directed



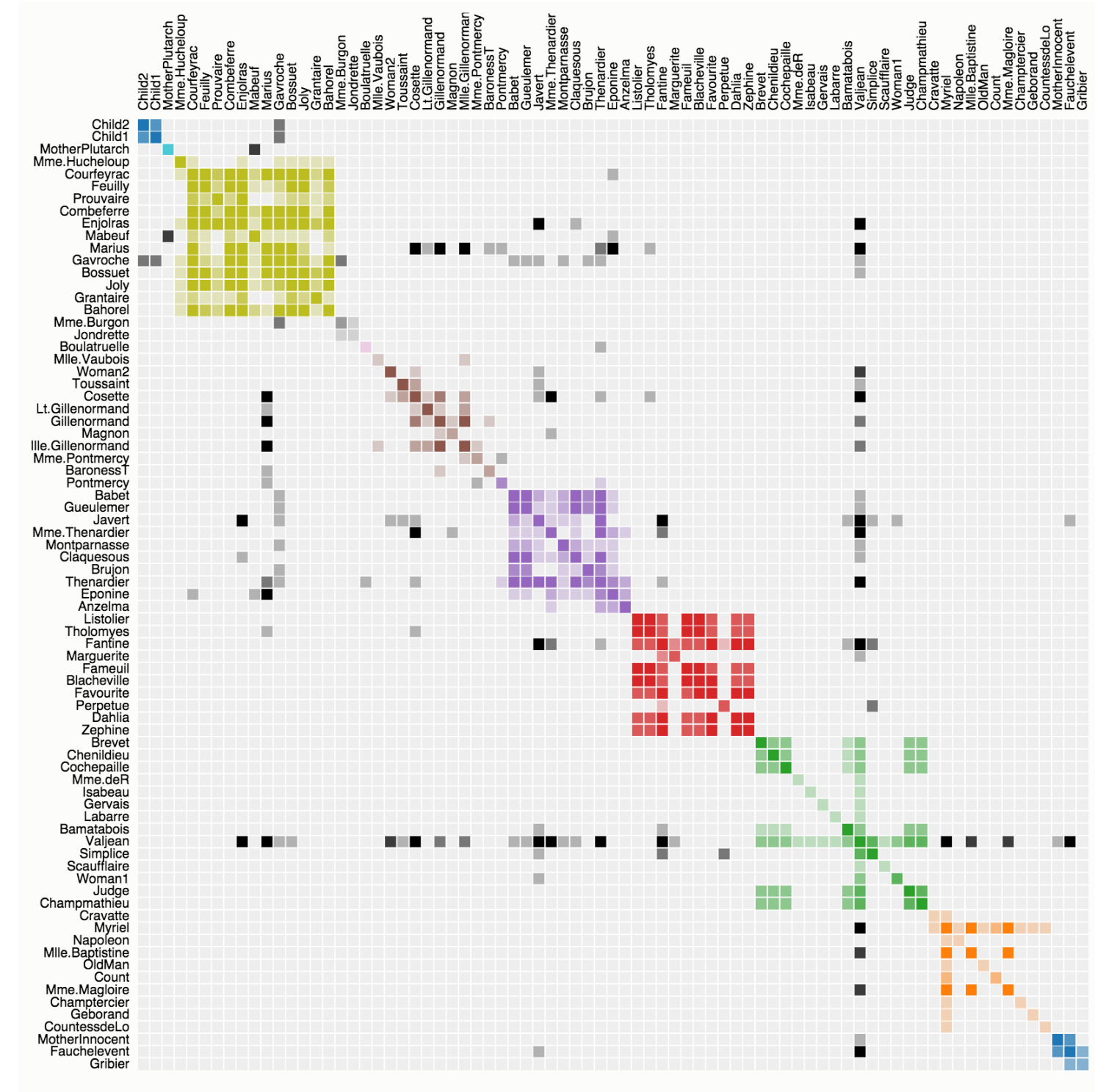
Tree



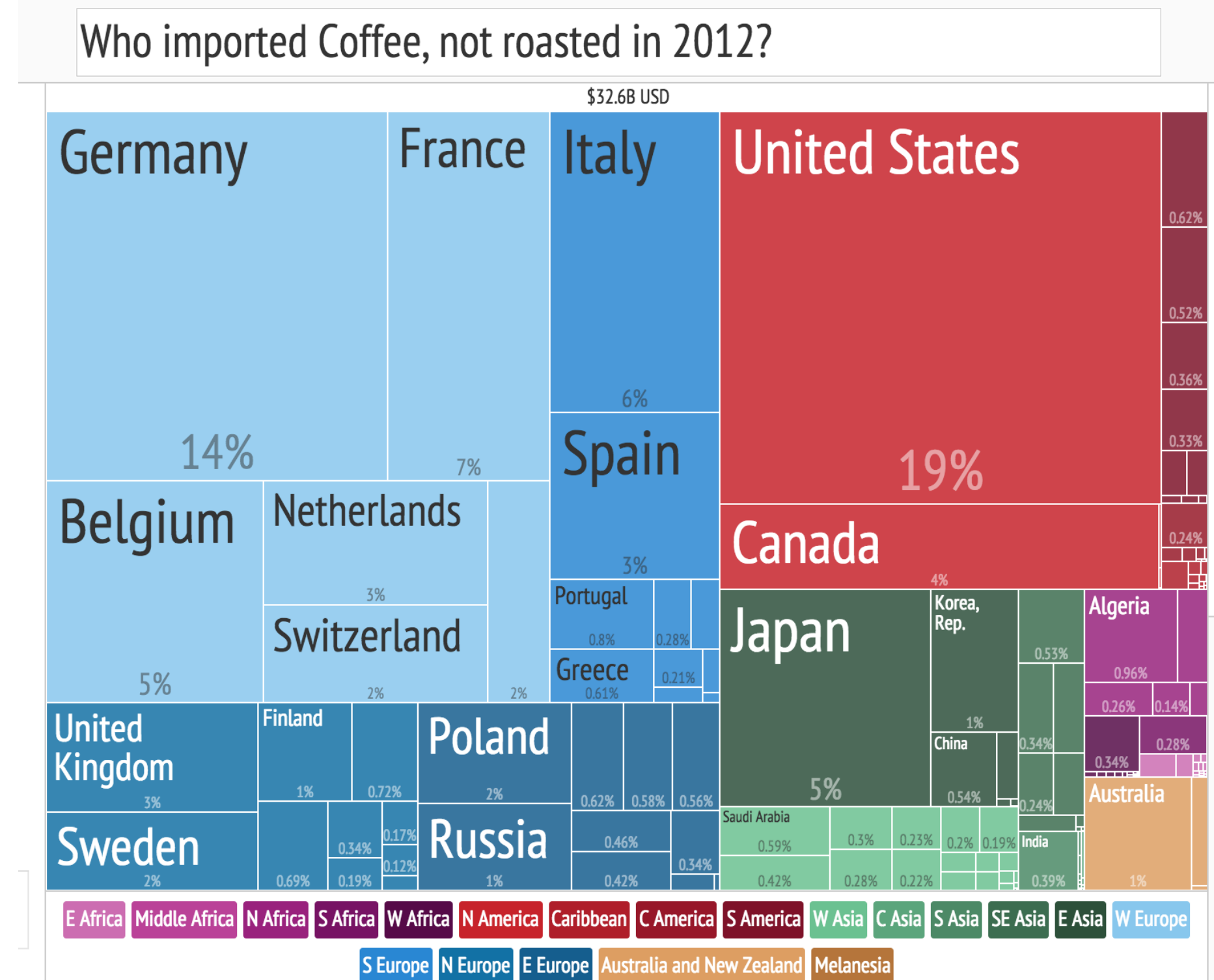
Visualizing Graphs



Node-Link Diagram



Matrix



Treemap (Implicit Tree Visualization)

More in Lecture on Graphs & Trees

Fields

Attribute values associated with cells

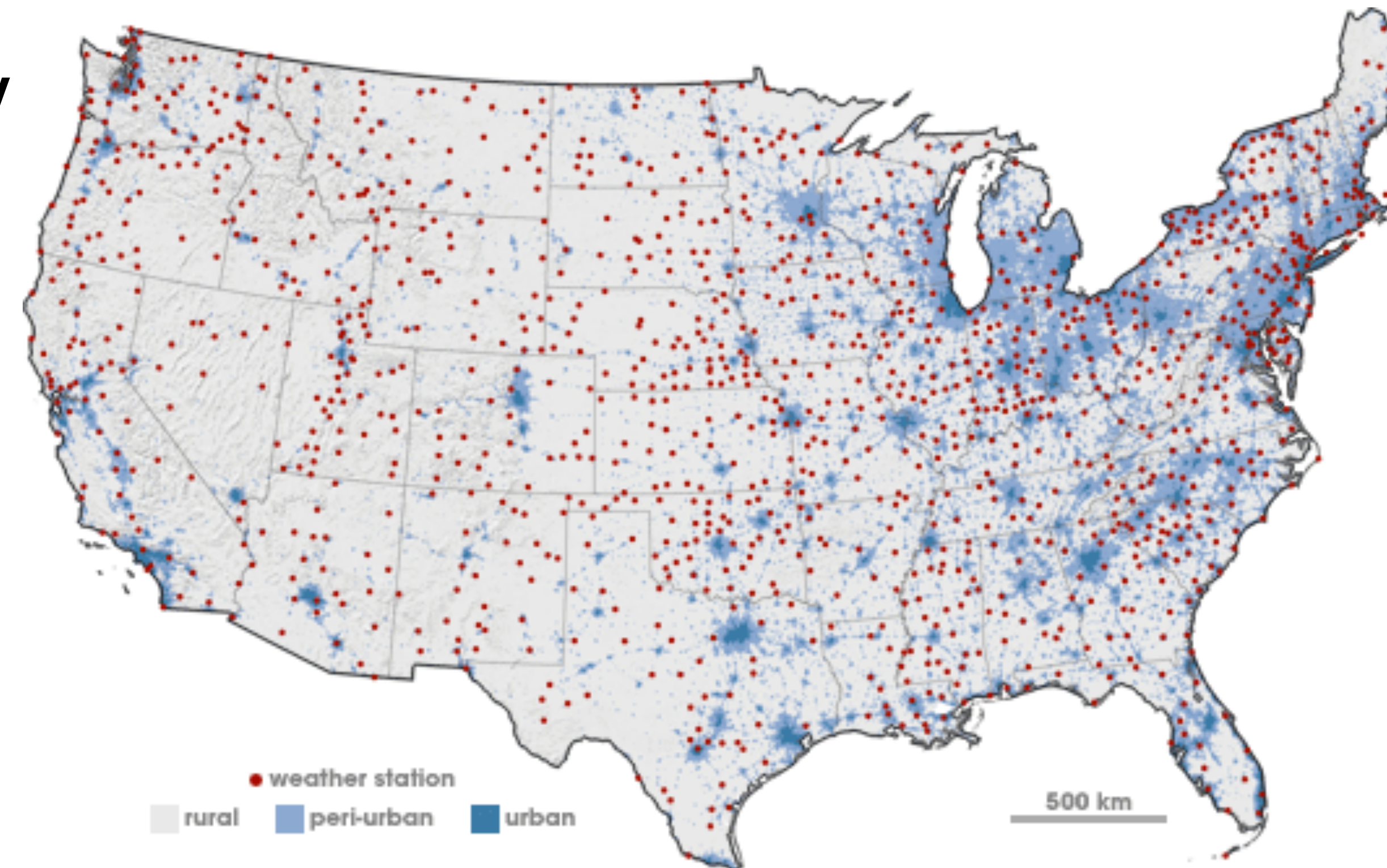
Cell contains data from continuous domain

Temperature, pressure, wind velocity

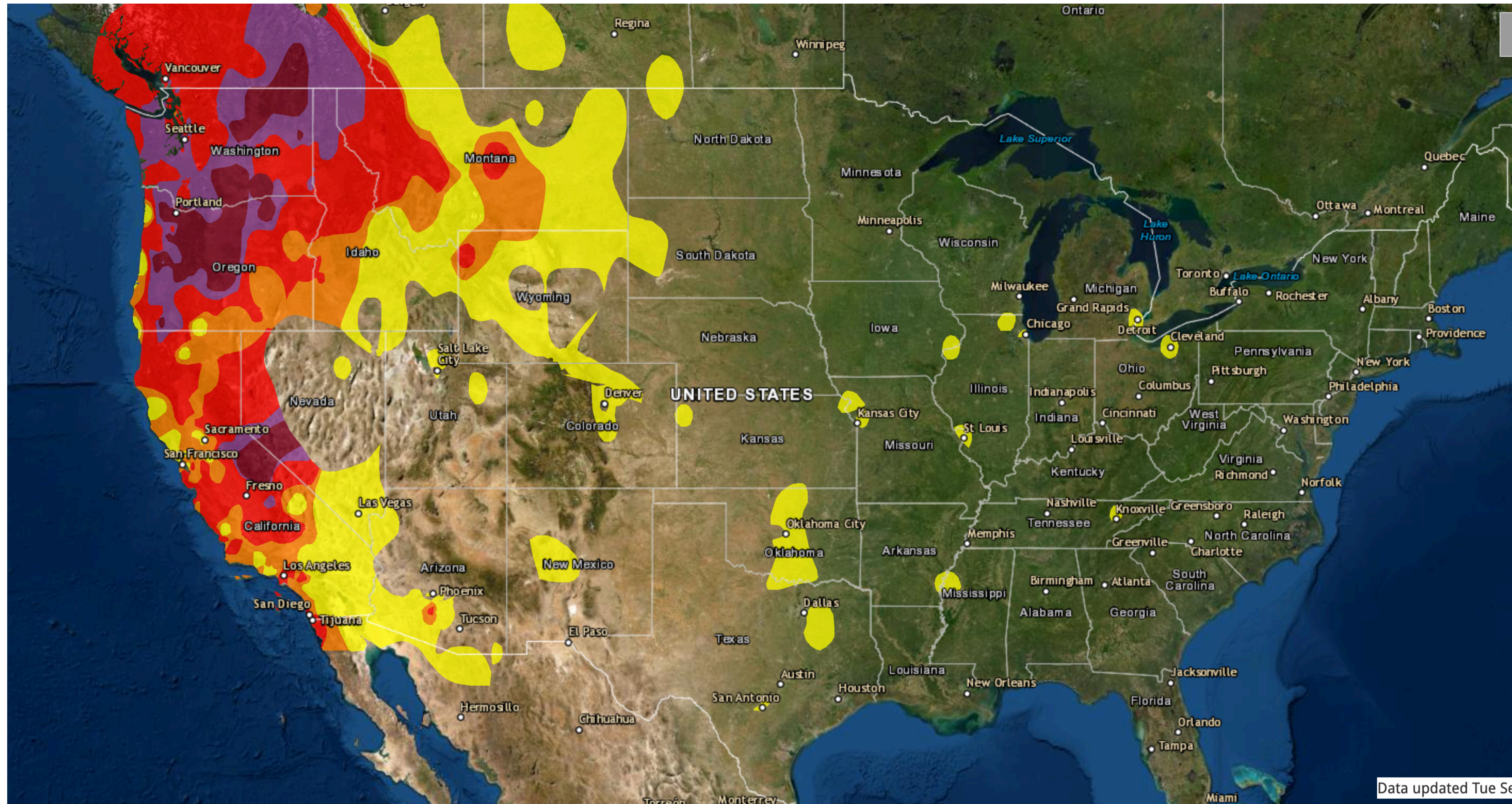
Measured or simulated

Sampling & Interpolation

Signal processing & stats



Field Example: Air Quality



Fields: Grid Types

Uniform Grid

Geometry & topology can be computed

Rectilinear Grid

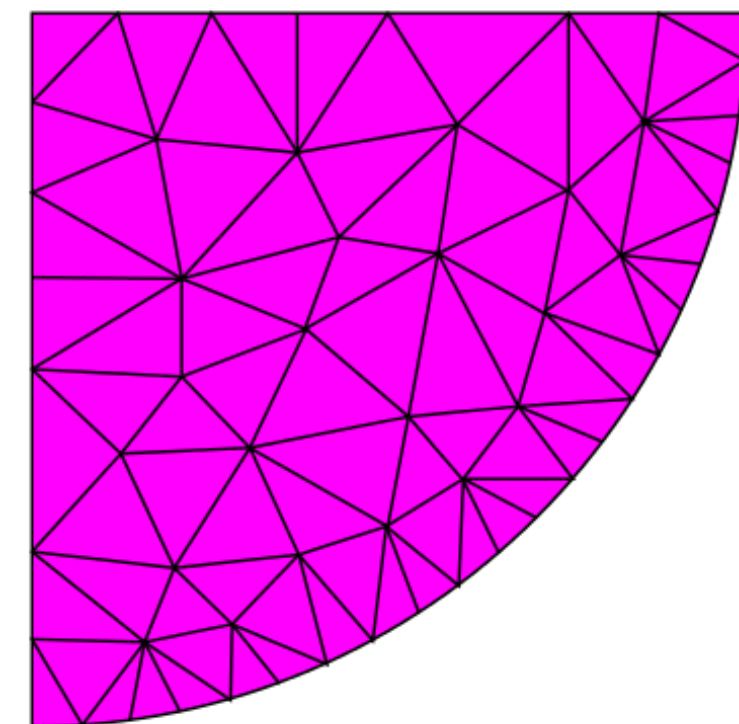
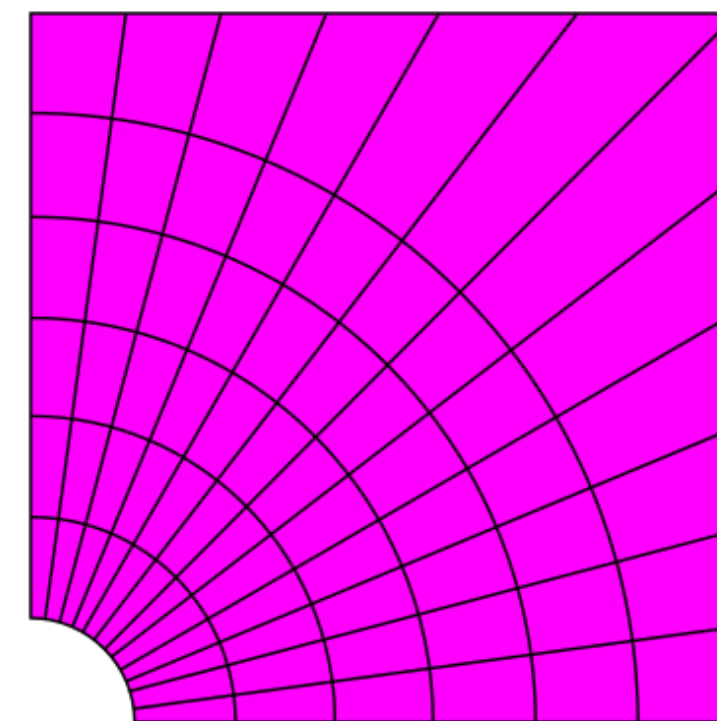
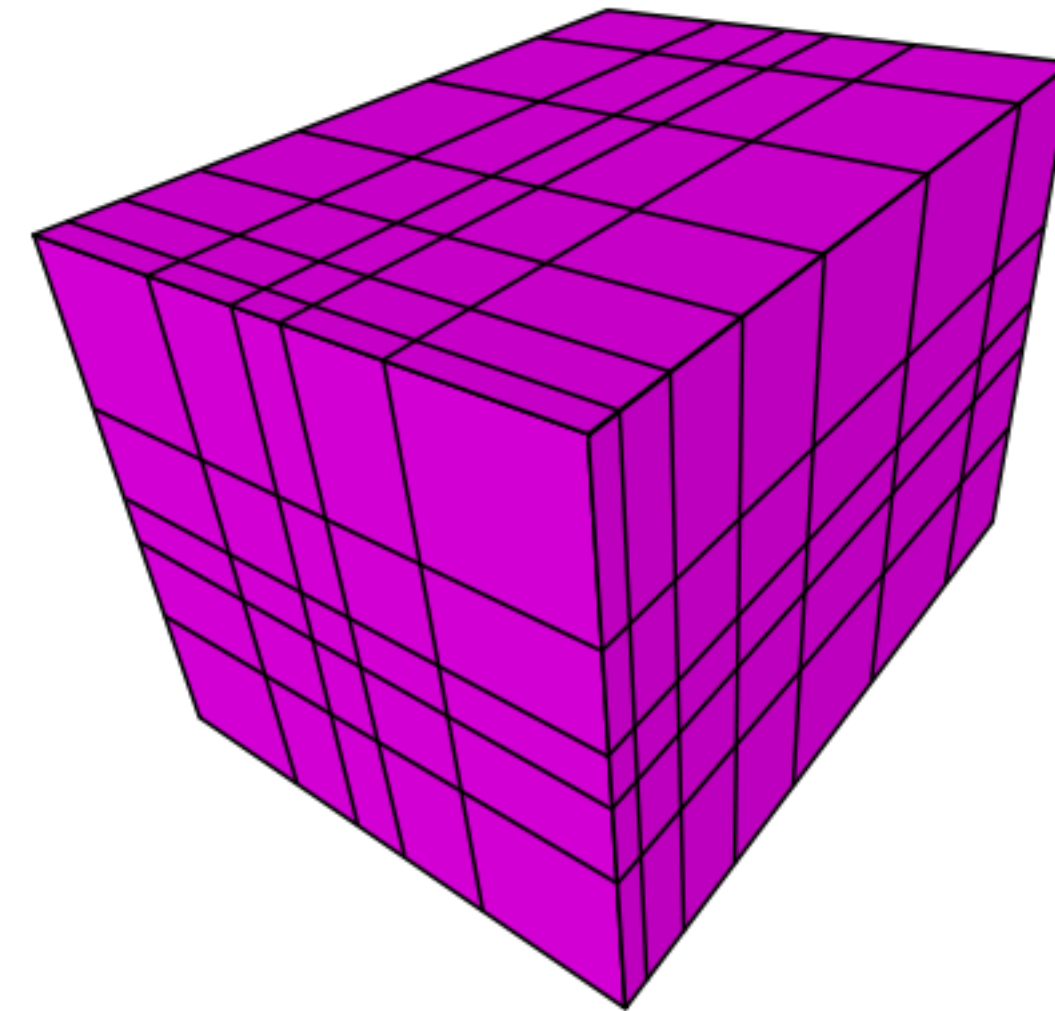
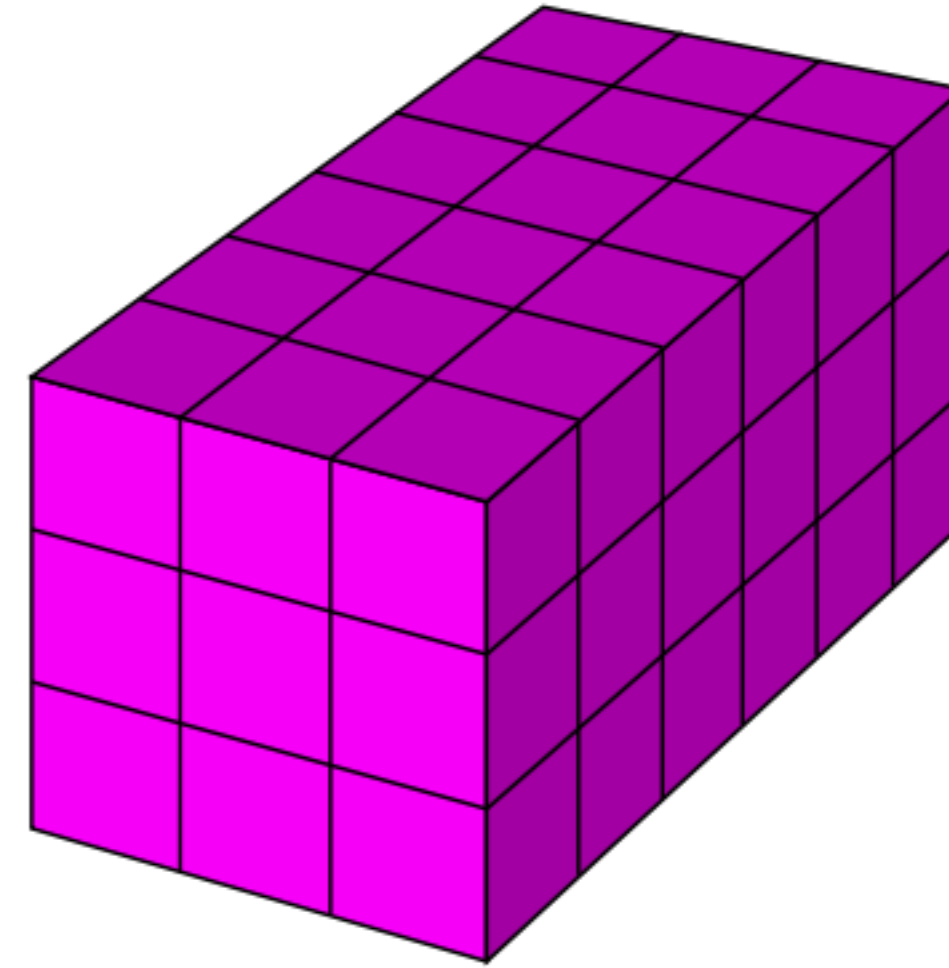
Nonuniform sampling

Structured Grid

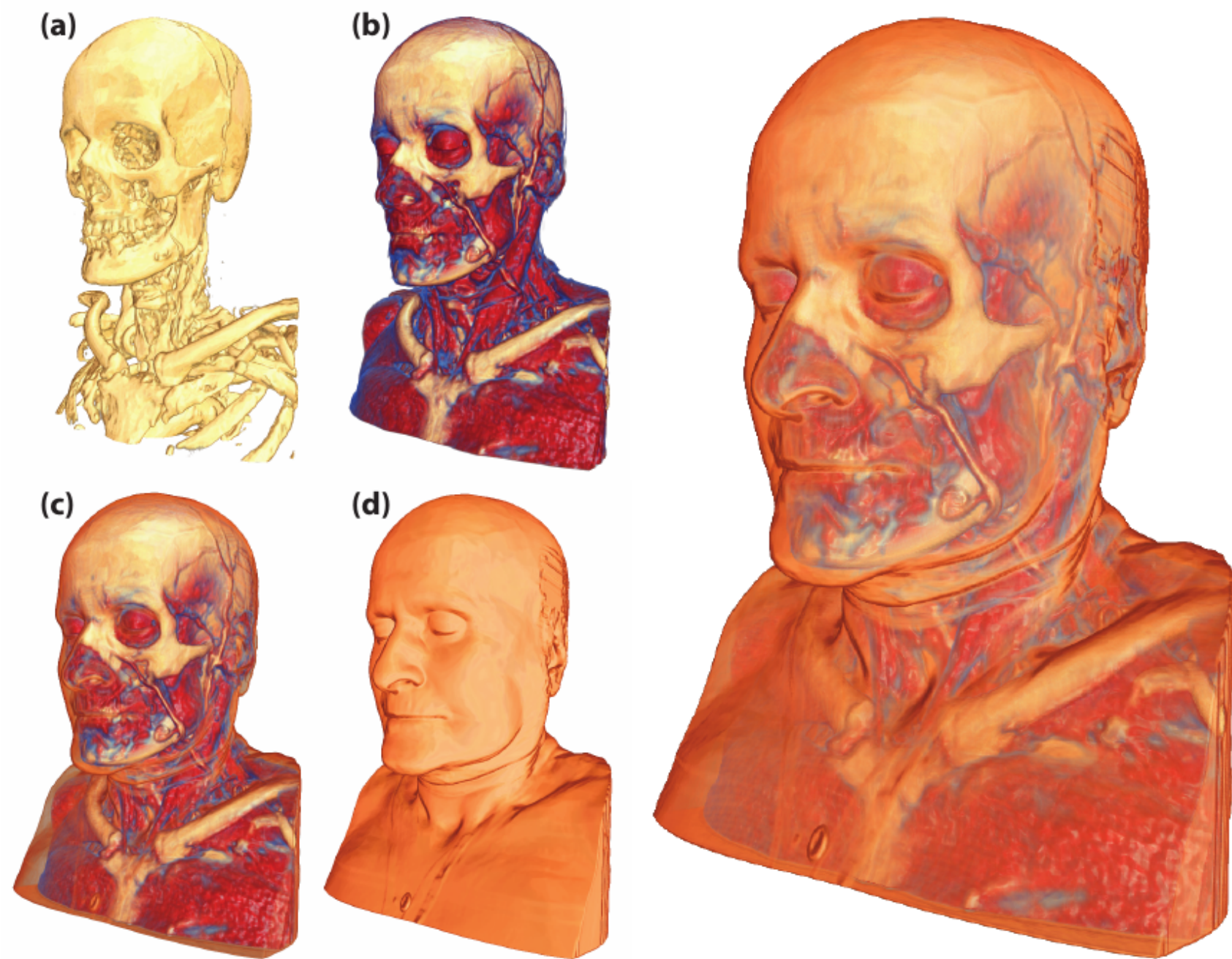
allows curvilinear grids

Unstructured Grid

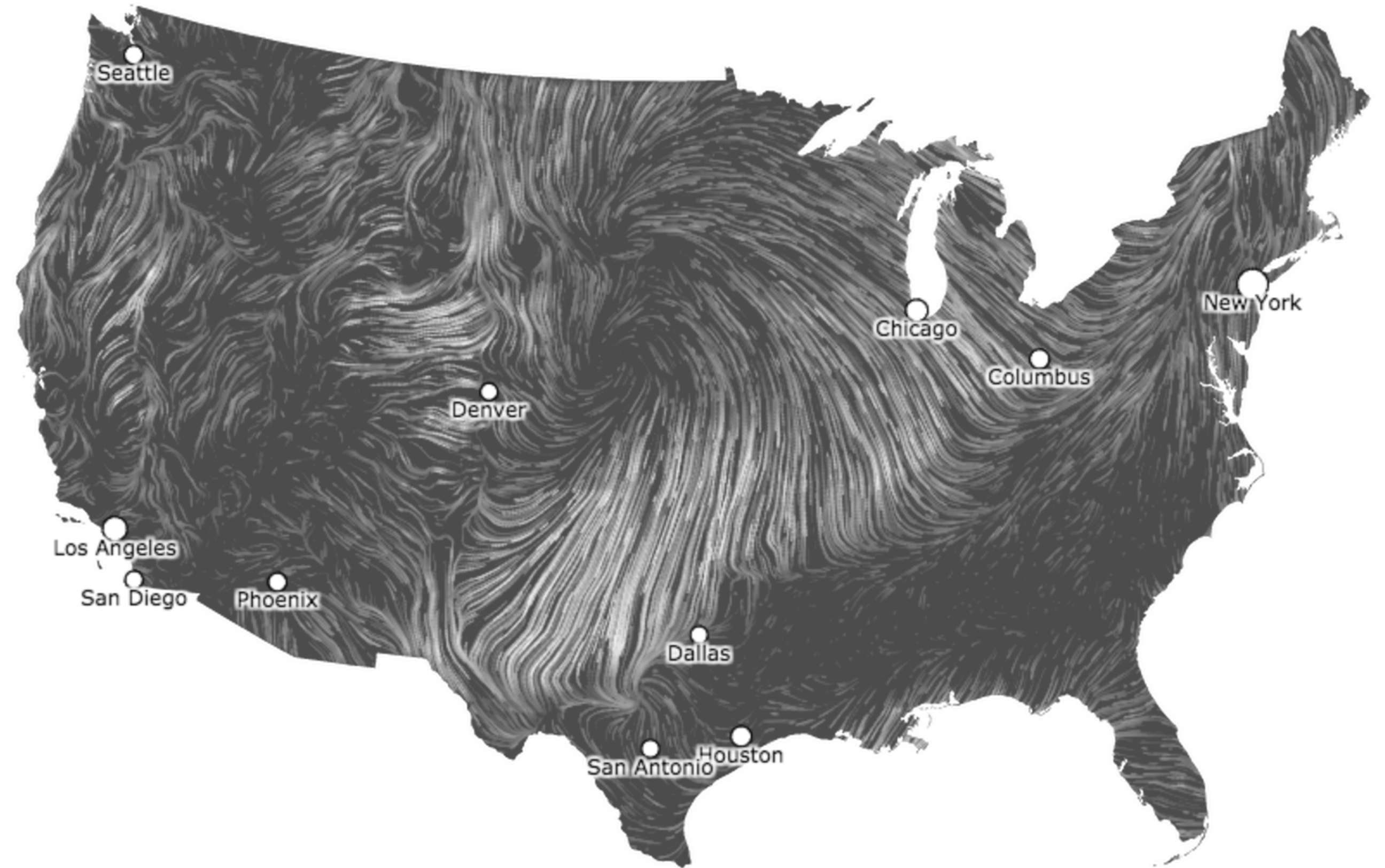
full flexibility, store position and connection



Visualizing Fields



[Bruckner 2007]



More in Maps, CS 5635 / 6635 - Visualization for Scientific Data

Side Note: Academic Subfields

Information Vis

“Abstract Data”

Tables, Graphs,
Maps

Free to choose
spatial layout

Perception
Research

Visual Analytics

InfoVis + Stats +
Machine learning

Applied Work

Systems

Funding buzzword

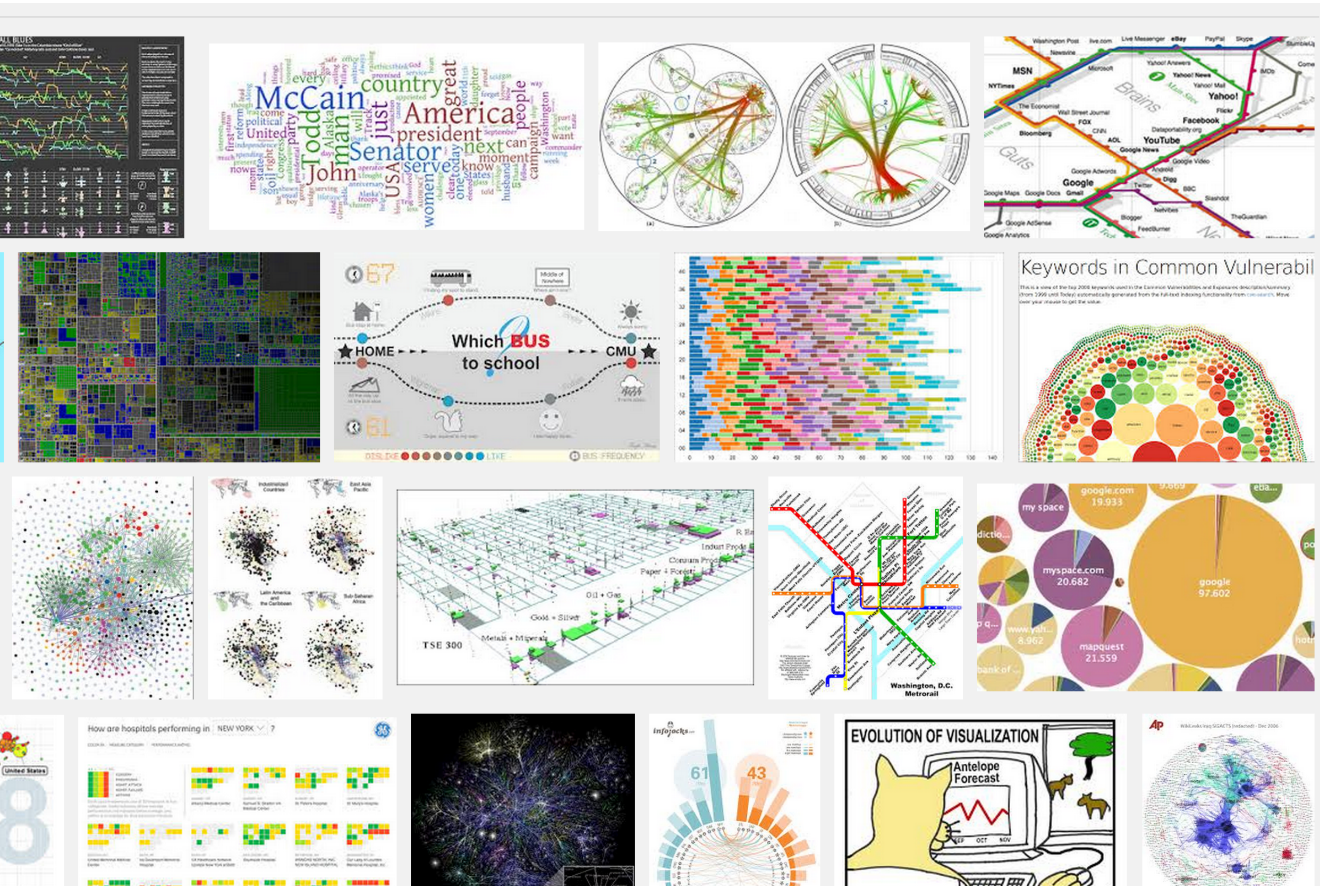
Scientific Vis

“Spatial
Data” (Fields)

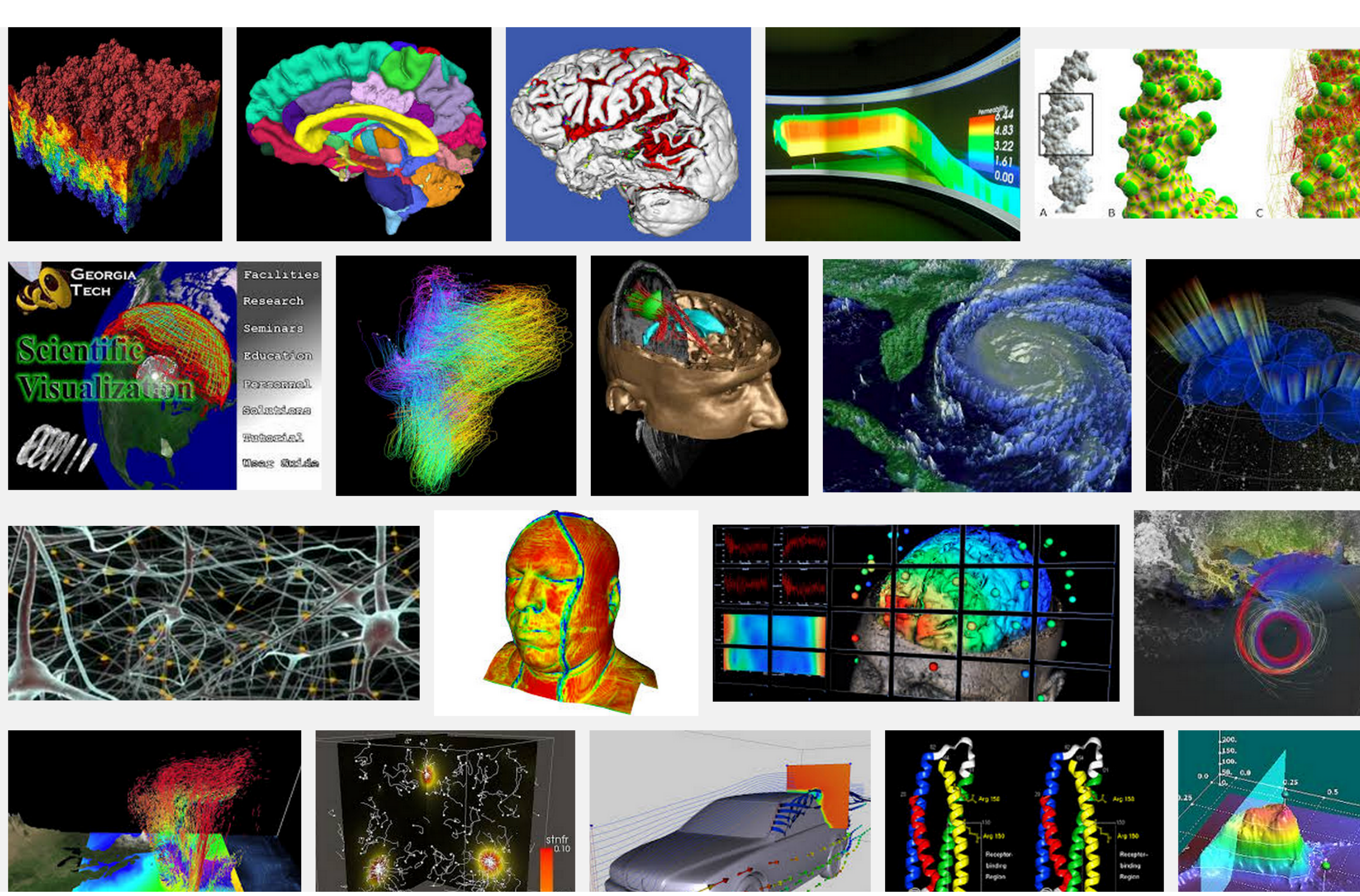
Not free to choose
spatial layout

Find best way to
depict reality

InfoVis or SciVis?



InfoVis: White Background



SciVis: Black Background

Geometry

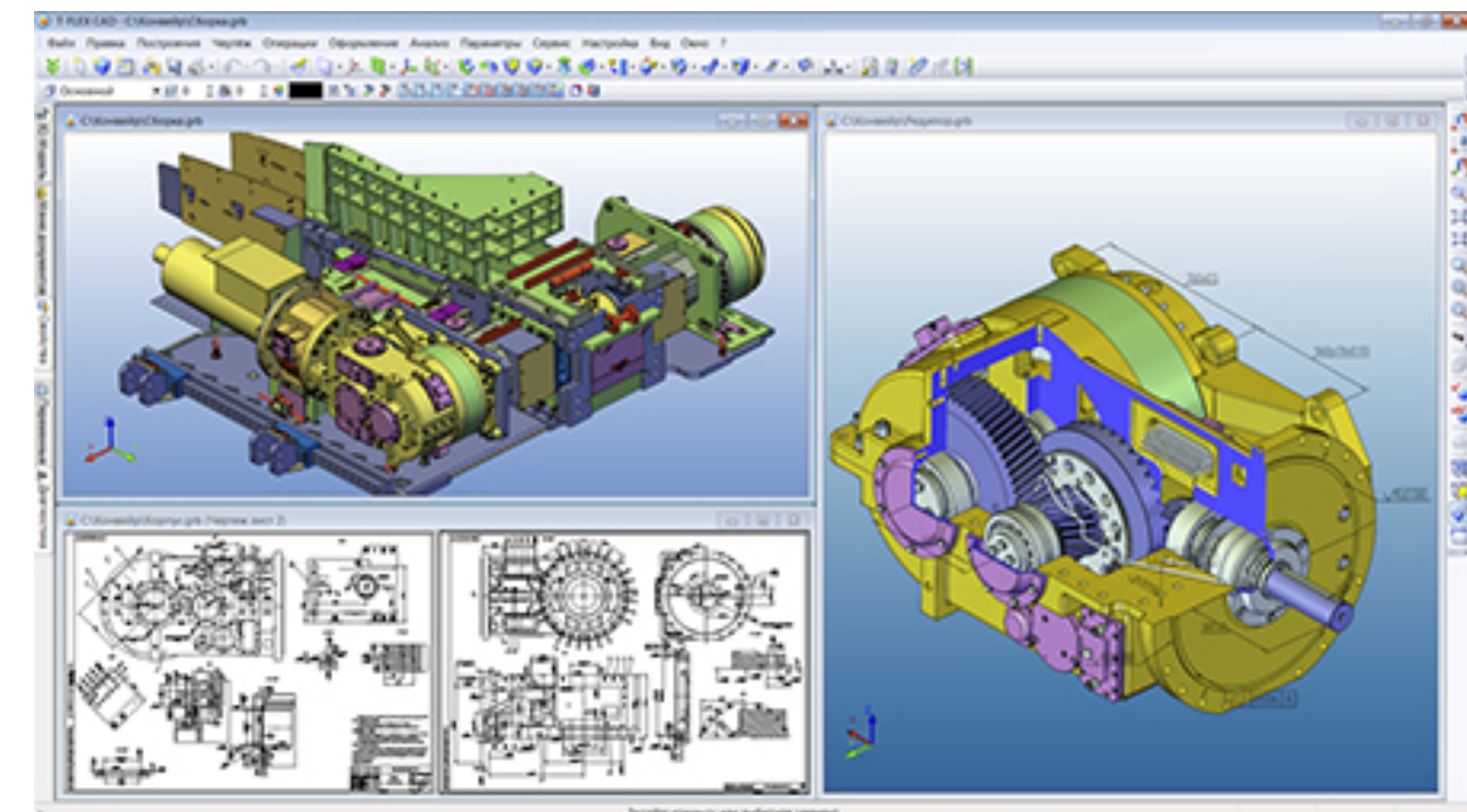
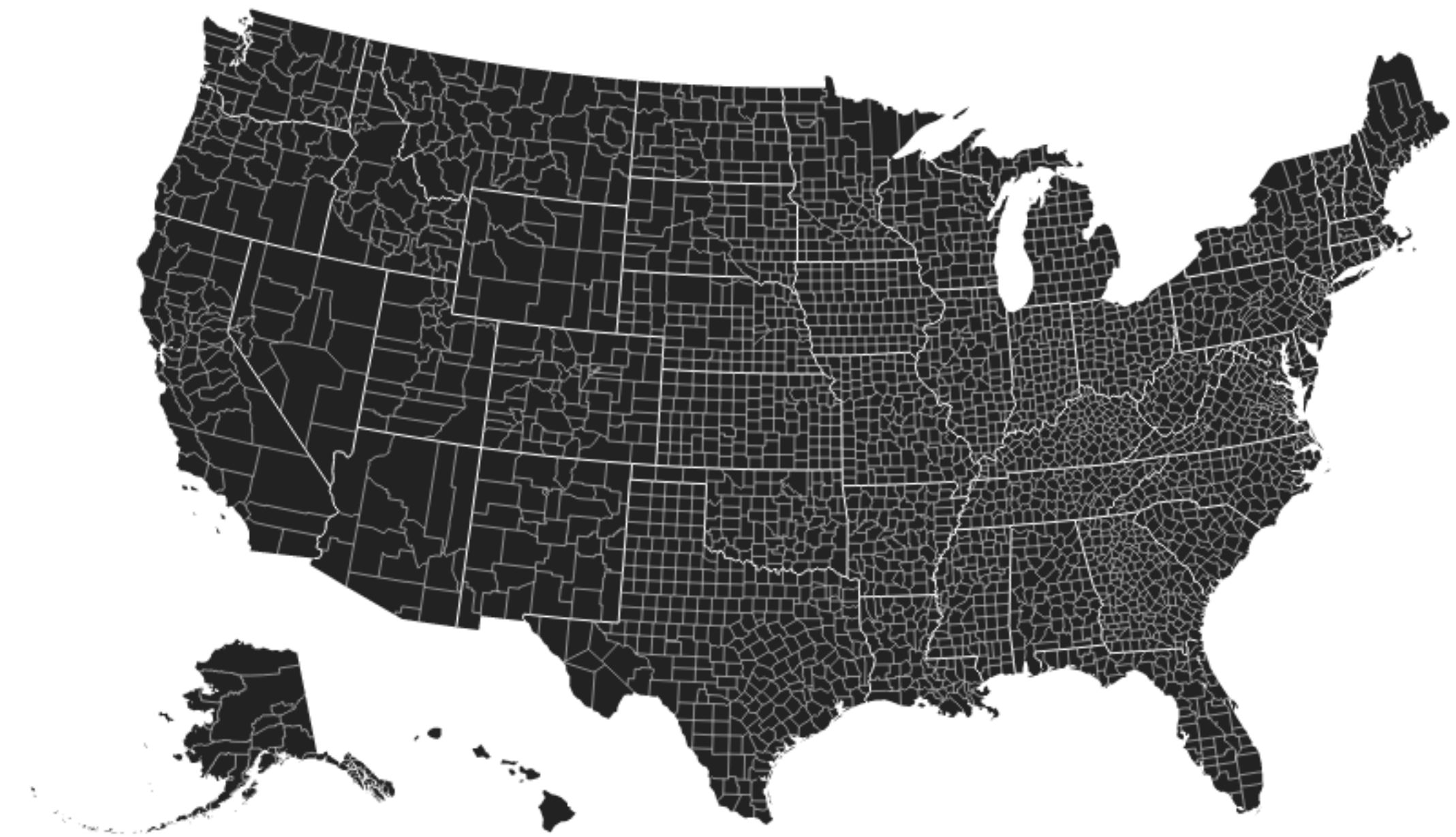
Shape of items

Explicit spatial positions

Points, lines, curves, surfaces, regions, volumes

Important in Computer Graphics, CAD, ...

Not a core Vis topic



Attribute Types

Attribute Types

Which classes of values & measurements are there?

Categorical (nominal)

Compare equality

Fruit, Gender, Movie Genres, File Types

Ordered

Ordinal

Great/Less than defined

Shirt size, Rankings, Car classes

Quantitative

Arithmetic possible

Length, Weight, Count, Temperature

→ Categorical

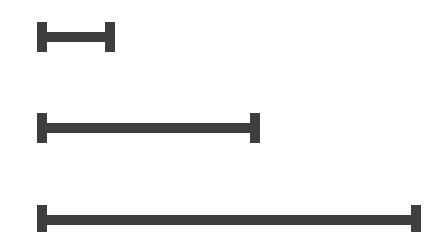


→ Ordered

→ Ordinal



→ Quantitative



Quantitative Data Type: Interval

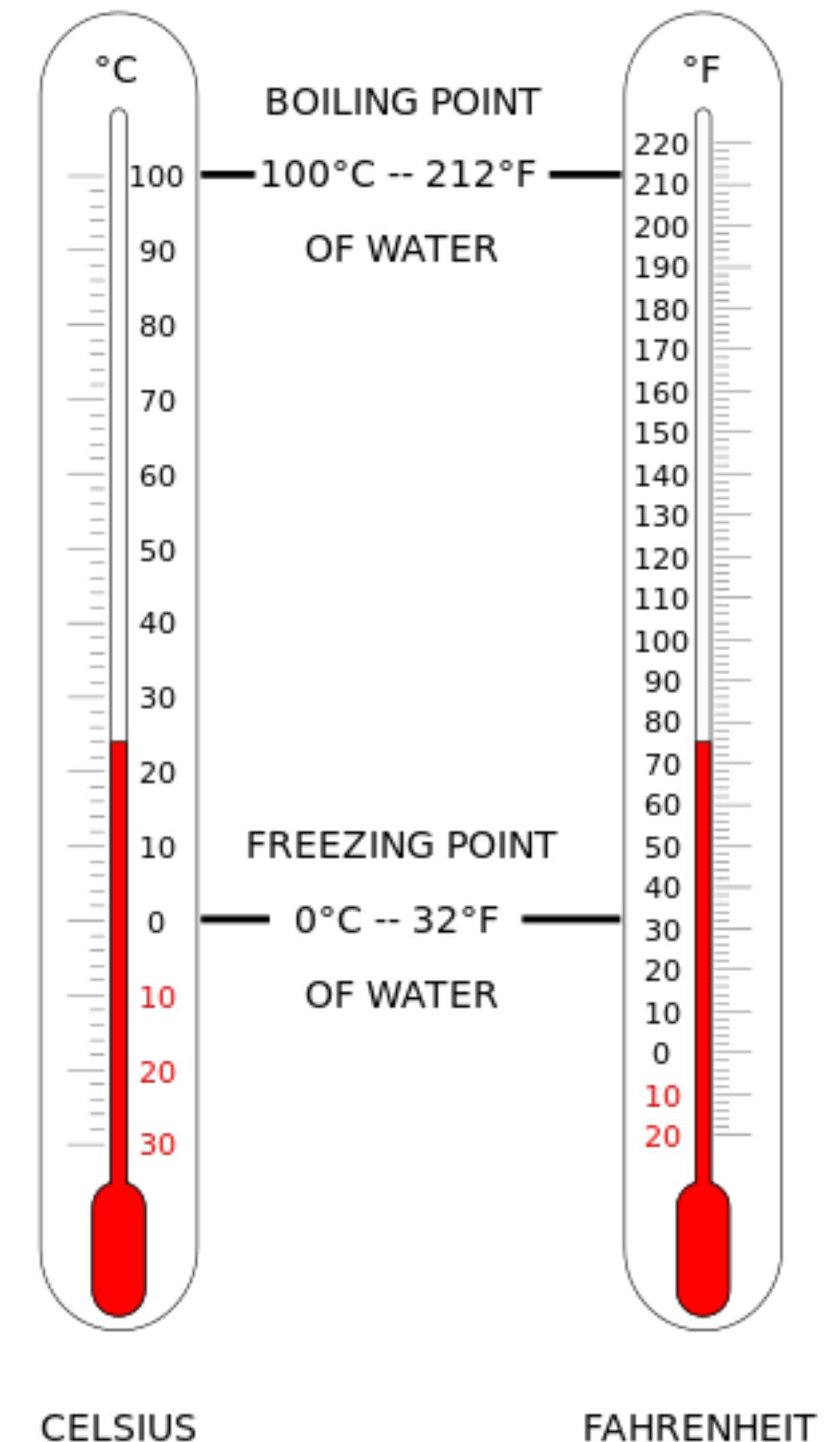
There are equal differences between successive points on the scale but the position of zero is arbitrary.

Question to ask: does zero mean none?

Dates: Jan 19; Location: (Lat, Long)

Cannot compare directly. Temp in Celsius & Fahrenheit

Only differences (i.e., intervals) can be compared



Quantitative Data Types: Ratio

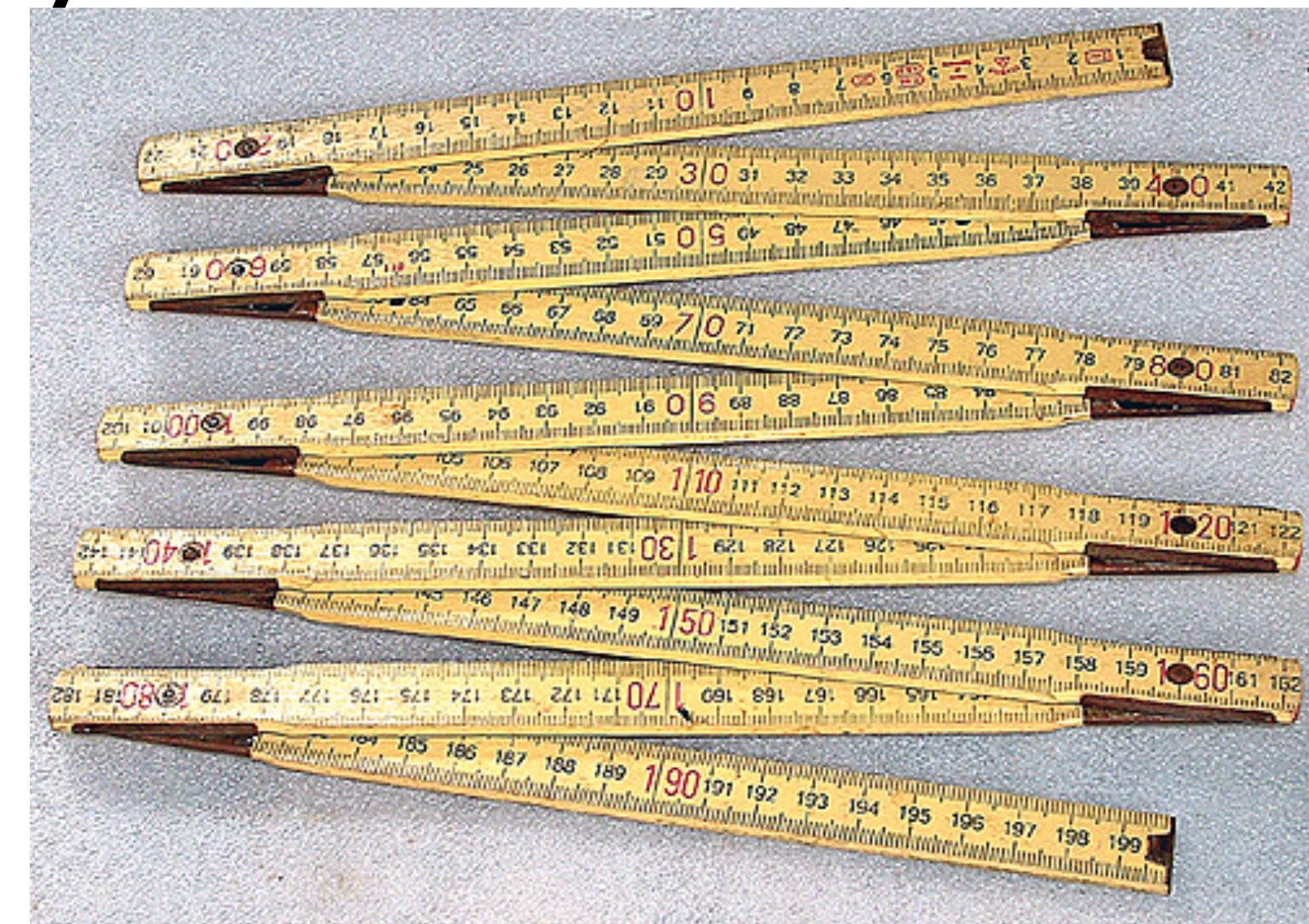
The relative magnitudes of scores and the differences between them matter.

The position of zero is fixed.

Zero: there is nothing of the measured entity observed

Measurements: Length, Mass, Age, Weight, Speed

Can measure ratios & proportions



Data Types

Nominal (categories, labels)

Operations: =, \neq

Ordinal (ordered)

Operations: =, \neq , $>$, $<$

Interval (location of zero arbitrary)

Operations: =, \neq , $>$, $<$, +, - (distance)

Ratio (zero fixed)

Operations: =, \neq , $>$, $<$, +, -, \times , \div (proportions)

Quiz!

What type of variable (Nominal, Ordinal, Interval, or Ratio) are the following:

1. 50 meter race times
2. College major
3. Amazon rating for a product
4. IQ Score
5. Product Name

Sequential & Diverging Data

Sequential:

homogeneous from min to max

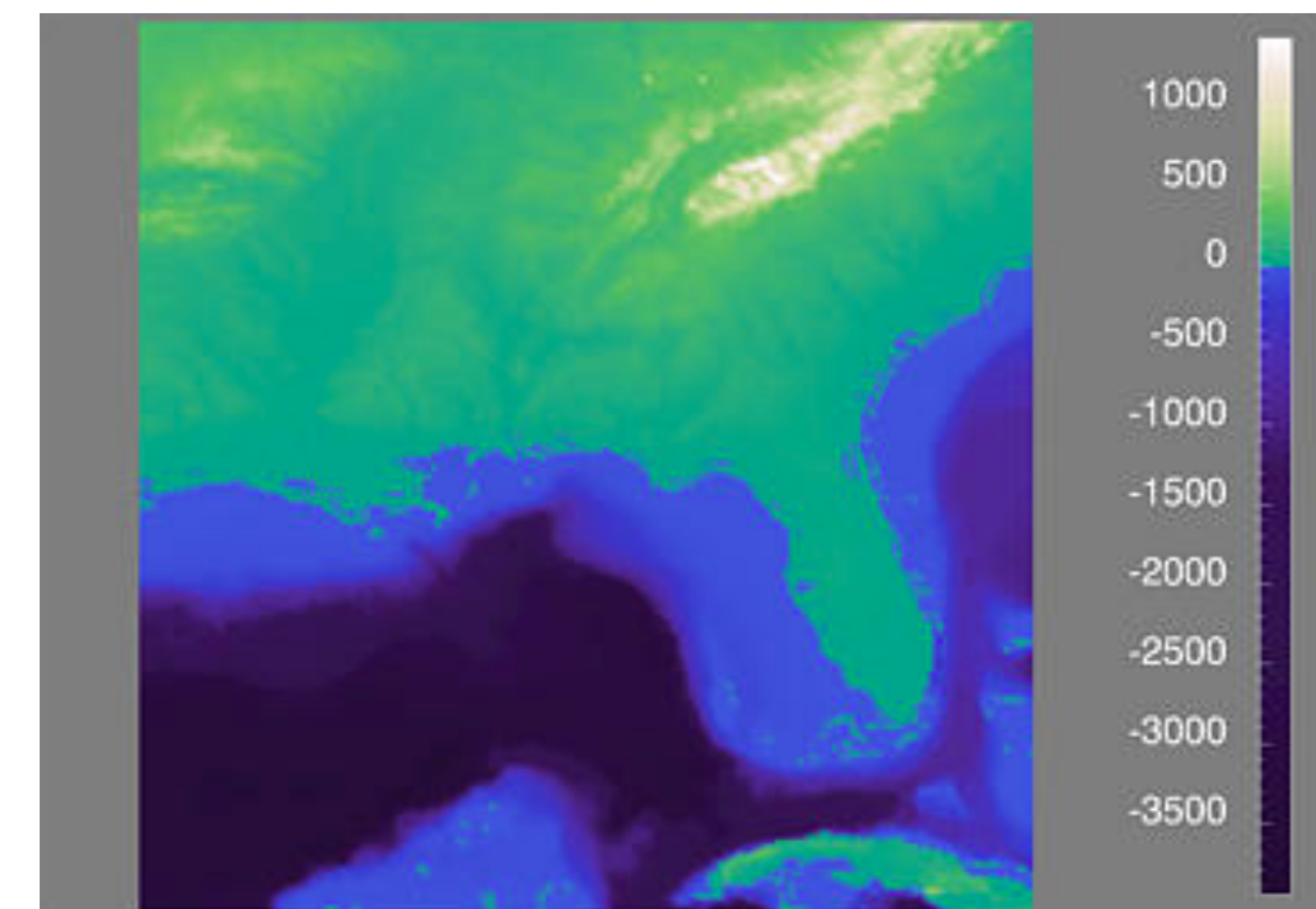
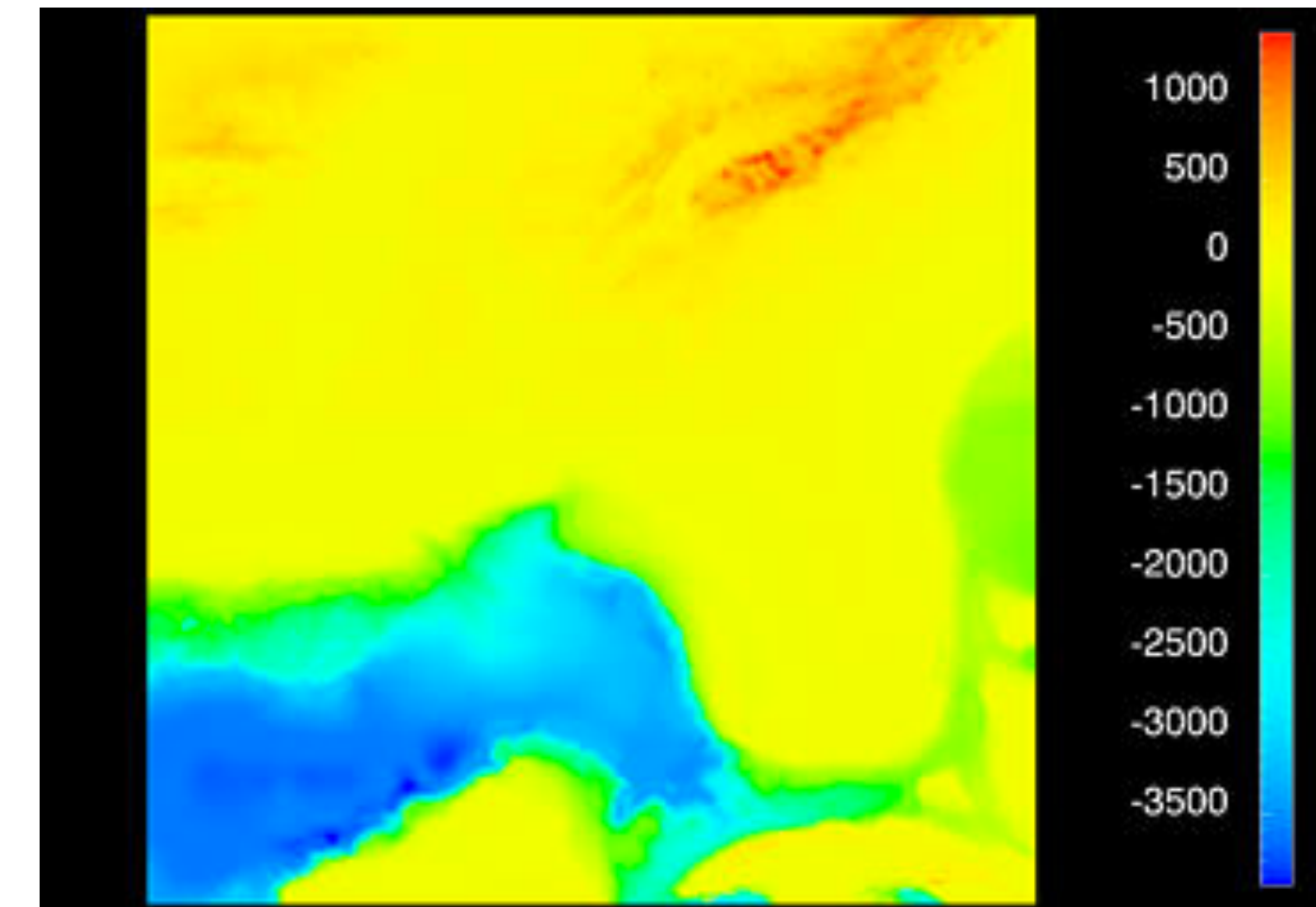
people in countries

Diverging:

two or multiple sequences that meet

Elevation dataset: above sea level
& below sea level

Temperature of water: below or above
freezing / boiling



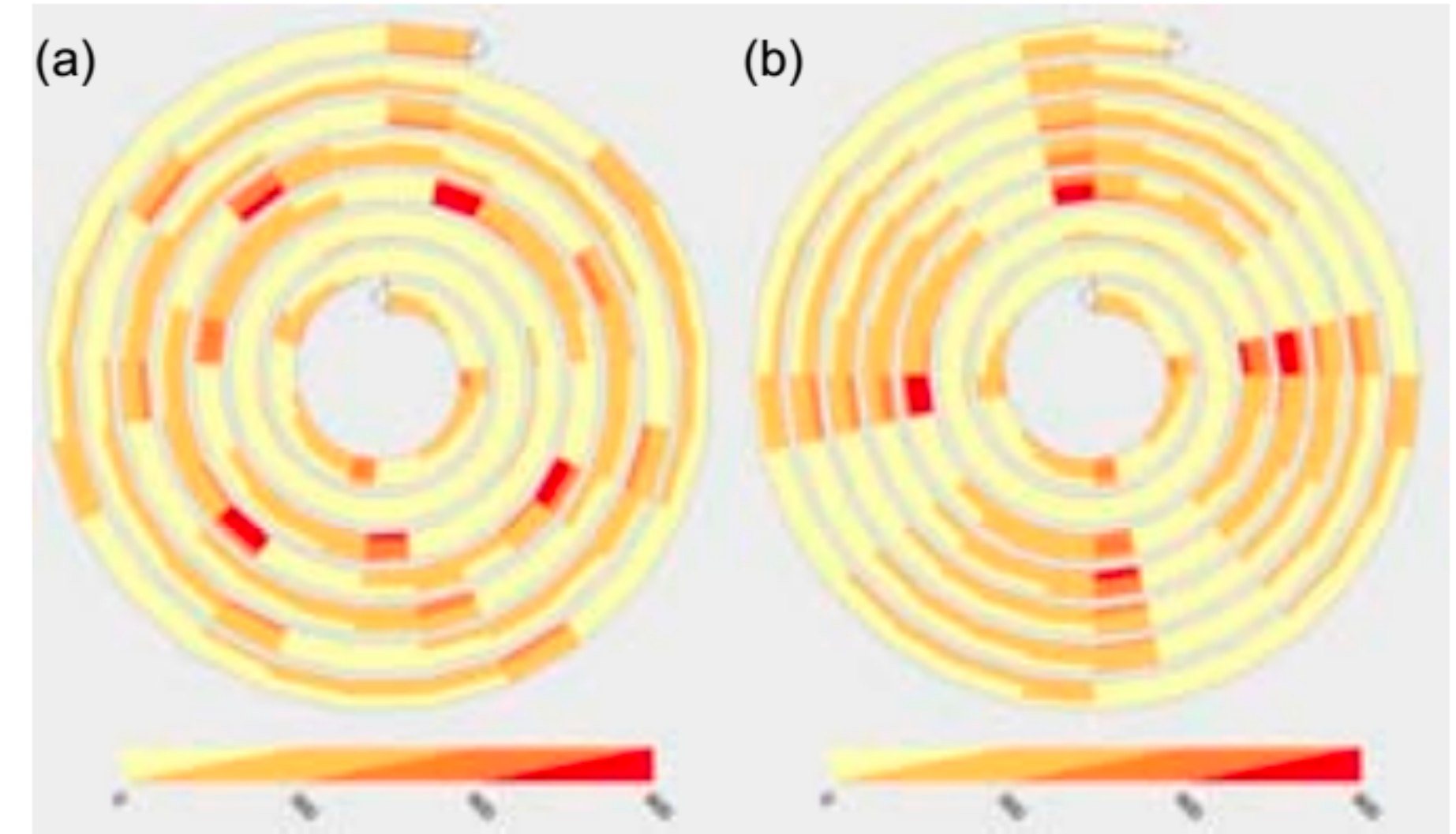
Other Structure

Cyclic data

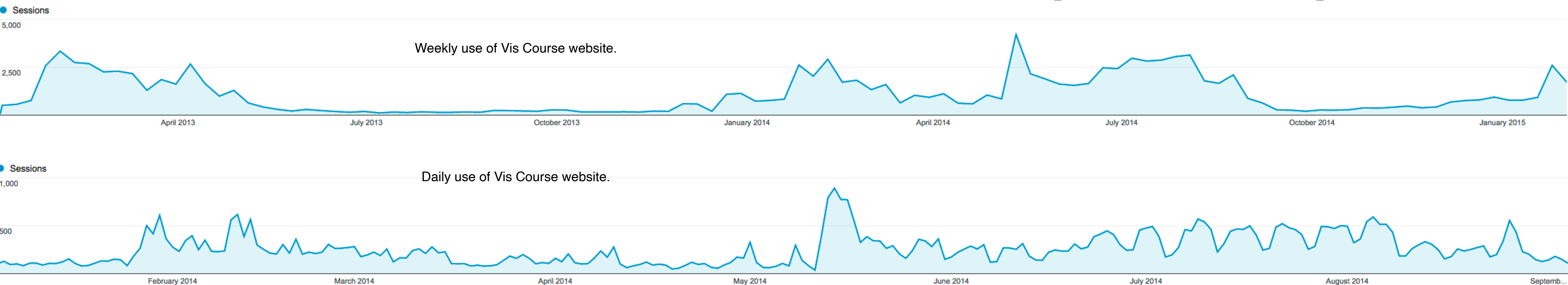
time (hours, week, month, year)

Aggregation

might be patterns on multiple levels



Respiratory disease cases.
Left: 25 day pattern
Right: 28 day pattern
[Tominski 2008]



	A	B	C	S	T	U
1	Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
2	3	10/14/06	5-Low	Large Box	0.8	10/21/06
3	6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
4	32	7/16/07	2-High	Small Pack	0.79	7/17/07
5	32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
6	32	7/16/07	2-High	Medium Box	0.6	7/18/07
7	32	7/16/07	2-High	Medium Box	0.65	7/18/07
8	35	10/23/07	4-Not Specified	Wrap Bag		10/24/07
9	35	10/23/07	4-Not Specified	Small Box		10/25/07
10	36	11/3/07	1-Urgent	Small Box		11/3/07
11	65	3/18/07	1-Urgent	Small Pack		3/19/07
12	66	1/20/05	5-Low	Wrap Bag		1/20/05
13	69	6/4/05	4-Not Specified	Small Pack		6/6/05
14	69	6/4/05	4-Not Specified	Wrap Bag		6/6/05
15	70	12/18/06	5-Low	Small Box		12/23/06
16	70	12/18/06	5-Low	Wrap Bag		12/23/06
17	96	4/17/05	2-High	Small Box	0.55	4/19/05
18	97	1/29/06	3-Medium	Small Box	0.38	1/30/06
19	129	11/19/08	5-Low	Small Box	0.37	11/28/08
20	130	5/8/08	2-High	Small Box	0.37	5/9/08
21	130	5/8/08	2-High	Medium Box	0.38	5/10/08
22	130	5/8/08	2-High	Small Box	0.6	5/11/08
23	132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
24	132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
25	134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
26	135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
27	166	9/12/07	2-High	Small Box	0.55	9/14/07
28	193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
29	194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

**Item/Element/
(Independent)
Variable**

	A	B	C	S	T	U
1	Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
2	3	10/14/06	5-Low	Large Box	0.8	10/21/06
3	6	2/21/08	4-Not Specified	Small Pack		2/22/08
4	32	7/16/07	2-High	Small Pack		7/17/07
5	32	7/16/07	2-High	Jumbo Box		7/17/07
6	32	7/16/07	2-High	Medium Box		7/18/07
7	32	7/16/07	2-High	Medium Box		7/18/07
8	35	10/23/07	4-Not Specified	Wrap Bag		10/24/07
9	35	10/23/07	4-Not Specified	Small Box		10/25/07
10	36	11/3/07	1-Urgent	Small Box		11/3/07
11	65	3/18/07	1-Urgent	Small Pack		3/19/07
12	66	1/20/05	5-Low	Wrap Bag		1/20/05
13	69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
14	69	6/4/05	4-Not Specified	Wrap Bag	0.6	6/6/05
15	70	12/18/06	5-Low	Small Box	0.59	12/23/06
16	70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
17	96	4/17/05	2-High	Small Box	0.55	4/19/05
18	97	1/29/06	3-Medium	Small Box	0.38	1/30/06
19	129	11/19/08	5-Low	Small Box	0.37	11/28/08
20	130	5/8/08	2-High	Small Box	0.37	5/9/08
21	130	5/8/08	2-High	Medium Box	0.38	5/10/08
22	130	5/8/08	2-High	Small Box	0.6	5/11/08
23	132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
24	132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
25	134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
26	135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
27	166	9/12/07	2-High	Small Box	0.55	9/14/07
28	193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
29	194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

**Attribute/
Dimension/
(Dependent)
Variable/
Feature**

	A	B	C	S	T	U
1	Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
2	3	10/14/06	5-Low	Large Box	0.9	10/21/06
3	6	2/21/08	4-Not Specified	Small Pack	0.5	2/22/08
4	32	7/16/07	2-High	Small Pack	0.9	7/17/07
5	32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
6	32	7/16/07	2-High	Medium Box	0.6	7/18/07
7	32	7/16/07	2-High	Medium Box	0.65	7/18/07
8	35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
9	35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
10	36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
11	65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
12	66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
13	69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
14	69	6/4/05	4-Not Specified	Wrap Bag	0.6	6/6/05
15	70	12/18/06	5-Low	Small Box	0.59	12/23/06
16	70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
17	96	4/17/05	2-High	Small Box	0.55	4/19/05
18	97	1/29/06	3-Medium	Small Box	0.38	1/30/06
19	129	11/19/08	5-Low	Small Box	0.37	11/28/08
20	130	5/8/08	2-High	Small Box	0.37	5/9/08
21	130	5/8/08	2-High	Medium Box	0.38	5/10/08
22	130	5/8/08	2-High	Small Box	0.6	5/11/08
23	132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
24	132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
25	134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
26	135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
27	166	9/12/07	2-High	Small Box	0.55	9/14/07
28	193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
29	194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

Semantics

	A	B	C	S	T	U
1	Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
2	3	10/14/06	5-Low	Large Box	0.8	10/21/06
3	6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
4	32	7/16/07	2-High	Small Pack	0.79	7/17/07
5	32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
6	32	7/16/07	2-High	Medium Box	0.6	7/18/07
7	32	7/16/07	2-High	Medium Box		7/18/07
8	35	10/23/07	4-Not Specified	Wrap Bag		10/24/07
9	35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
10	36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
11	65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
12	66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
13	69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
14	69	6/4/05	4-Not Specified	Wrap Bag	0.6	6/6/05
15	70	12/18/06	5-Low	Small Box	0.59	12/23/06
16	70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
17	96	4/17/05	2-High	Small Box	0.55	4/19/05
18	97	1/29/06	3-Medium	Small Box	0.38	1/30/06
19	129	11/19/08	5-Low	Small Box	0.37	11/28/08
20	130	5/8/08	2-High	Small Box	0.37	5/9/08
21	130	5/8/08	2-High	Medium Box	0.38	5/10/08
22	130	5/8/08	2-High	Small Box	0.6	5/11/08
23	132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
24	132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
25	134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
26	135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
27	166	9/12/07	2-High	Small Box	0.55	9/14/07
28	193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
29	194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

Keys?

	A	B	C	S	T	U
◇	Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
1	3	10/14/06	5-Low	Large Box	0.8	10/21/06
2	6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
3	32	7/16/07	2-High	Small Pack	0.79	7/17/07
4	32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
5	32	7/16/07	2-High	Medium Box	0.6	7/18/07
6	32	7/16/07	2-High	Medium Box	0.65	7/18/07
7	35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
8	35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
9	36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
10	65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
11	66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
12	69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
13	69	6/4/05	4-Not Specified	Wrap Bag	0.6	6/6/05
14	70	12/18/06	5-Low	Small Box	0.59	12/23/06
15	70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
16	96	4/17/05	2-High	Small Box	0.55	4/19/05
17	97	1/29/06	3-Medium	Small Box	0.38	1/30/06
18	129	11/19/08	5-Low	Small Box	0.37	11/28/08
19	130	5/8/08	2-High	Small Box	0.37	5/9/08
20	130	5/8/08	2-High	Medium Box	0.38	5/10/08
21	130	5/8/08	2-High	Small Box		5/11/08
22	132	6/11/06	3-Medium	Medium Box		6/12/06
23	132	6/11/06	3-Medium	Jumbo Box		6/14/06
24	134	5/1/08	4-Not Specified	Large Box		5/3/08
25	135	10/21/07	4-Not Specified	Small Pack	0.55	10/23/07
26	166	9/12/07	2-High	Small Box	0.55	9/14/07
27	193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
28	194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08
29						

**Attribute
Types?**

◇	A	B	C	S	T	U
1	Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
2	3	10/14/06	5-Low	Large Box	0.8	10/21/06
3	6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
4	32	7/16/07	2-High	Small Pack	0.79	7/17/07
5	32	7/16/07	2-High	Jumbo Box	0.72	7/17/07
6	32	7/16/07	2-High	Medium Box	0.6	7/18/07
7	32	7/16/07	2-High	Medium Box	0.65	7/18/07
8	35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
9	35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
10	36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
11	65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
12	66	1/20/05	5-Low	Wrap Bag	0.56	1/20/05
13	69	6/4/05	4-Not Specified	Small Pack	0.44	6/6/05
14	69	6/4/05	4-Not Specified	Wrap Bag	0.6	6/6/05
15	70	12/18/06	5-Low	Small Box	0.59	12/23/06
16	70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
17	96	4/17/05	2-High	Small Box	0.55	4/19/05
18	97	1/29/06	3-Medium	Small Box	0.38	1/30/06
19	129	11/19/08	5-Low	Small Box	0.37	11/28/08
20	130	5/8/08	2-High	Small Box	0.37	5/9/08
21	130	5/8/08	2-High	Medium Box	0.38	5/10/08
22	130	5/8/08	2-High	Small Box	0.6	5/11/08
23	132	6/11/06	3-Medium	Medium Box		
24	132	6/11/06	3-Medium	Jumbo Box		
25	134	5/1/08	4-Not Specified	Large Box		
26	135	10/21/07	4-Not Specified	Small Pack		
27	166	9/12/07	2-High	Small Box		
28	193	8/8/06	1-Urgent	Medium Box		
29	194	4/5/08	3-Medium	Wrap Bag		
30	194	4/5/08	3-Medium	Wrap Bag		

Categorical
Ordinal
Quantitative

Data vs. Conceptual Model

Data Model: Low-level description of the data

Set with operations, e.g., floats with +, -, /, *

Conceptual Model: Mental construction

Includes semantics, supports reasoning

Data	Conceptual
1D floats	temperature
3D vector of floats	space

Data vs. Conceptual Model

From data model...

32.5, 54.0, -17.3, ... (floats)

using conceptual model...

Temperature

to data type

Continuous to 4 significant digits (Q)

Hot, warm, cold (O)

Burned vs. Not burned (N)

Combinations, Derived Data

Networks can have attributes

Attributes have hierarchies

Data types can be transformed

Real life is complicated...