

DS4200: Information Presentation and Visualization

Map

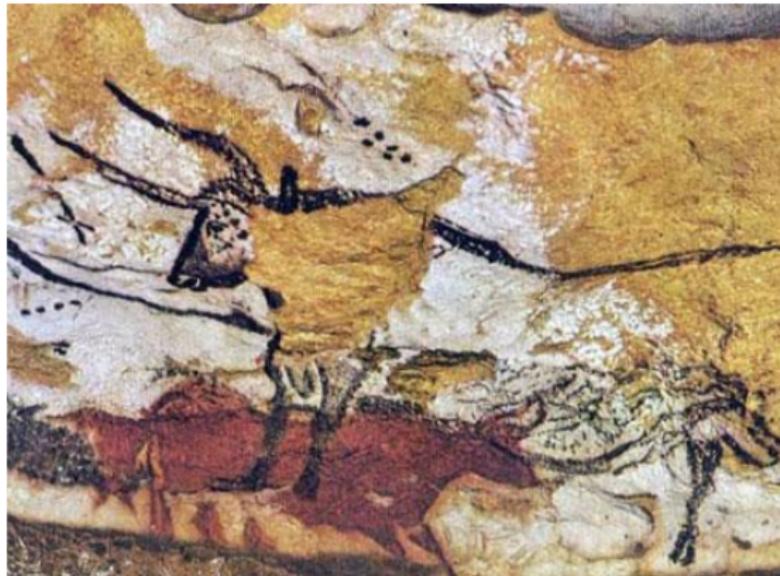
Xiaoyi Yang
Khoury College of Computer Sciences
Northeastern University

Goals for today

- Introduction to map
- Understand the map projection
- GIS
- Thematic/statistical map
- Spatial Fields encoding

Oldest map

Some of the earliest known maps date back to ancient civilizations such as the Babylonians, Egyptians, and Greeks.



Vega, Deneb, and Altair

Lascaux cave paintings - over 16,000 years old!

Oldest map

The Lascaux cave : a Prehistoric sky-map...

17,000 years ago, the Lascaux painters offered the world a peerless work of art. However, according to a new theory, some of the paintings could also be the representations of the constellations as seen in the sky by our ancestors from the Magdalenian era. Such a hypothesis, confirmed in many others Paleolithic Caves, radically transforms our conception concerning prehistoric Rock Art...

Photos by Stephane Bégin-Pascal Goergenck/LightMedia.com Text by Pedro Lina



Oldest map

Clay tablet
with map of
the Babylonian
city of Nippur
(ca. 1400 BC)



Cartography

The Greeks and Romans further developed cartography (the science and art of mapmaking) with more accurate measurements and representations of the known world.



Modern Map

Geographic Map



Geographic Map

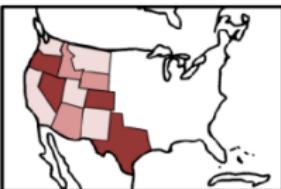
Flow Map



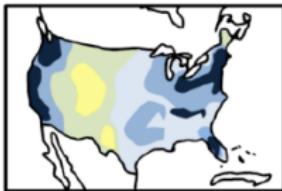
Street Map



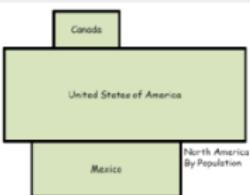
Choropleth Map



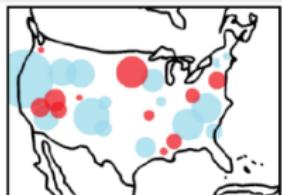
Contour Map (Isopleth)



Distorted Map (Cartogram)

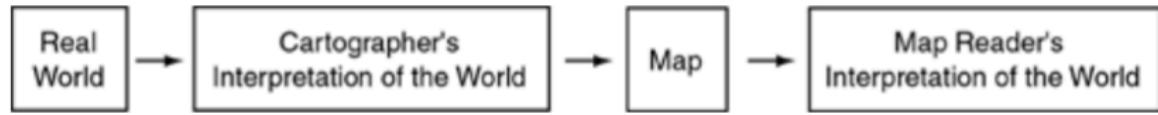


Statistical Plot Map



Geographic Map Tasks & Users

Make sure the map representation, data encodings, data plotted, and dimensionality reduction is appropriate for the viewers and their tasks.



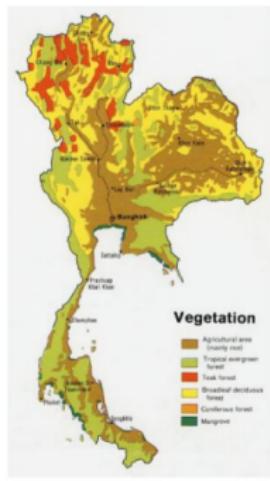
Types of Geographic Maps

THREE BROAD CATEGORIES OF MAPS:

REFERENCE MAPS



THEMATIC MAPS



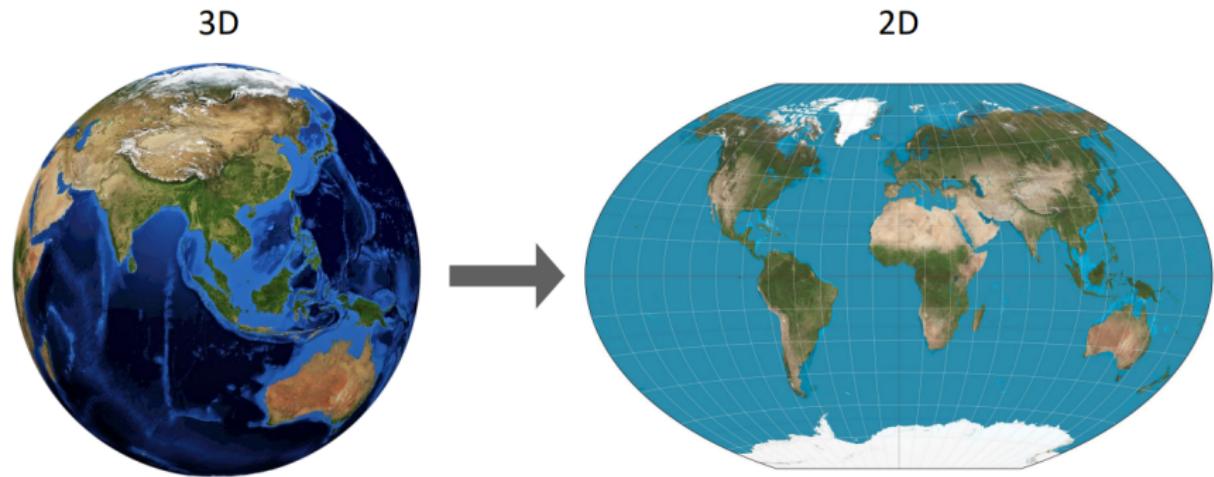
SPECIAL-PURPOSE MAPS



Types of Geographic Maps

- Reference map: A map that plots several types of spatial data without specific emphasis on one type over another
- Thematic map: A map with a specific theme or focus. Typically display attributes of features that vary spatially in a qualitative (e.g., precipitation) or nominal way (e.g., categories of land cover).
- Special-purpose map: Typically thematic maps but are task/user specific (i.e., used like reference maps but for specific tasks or specific types of data).

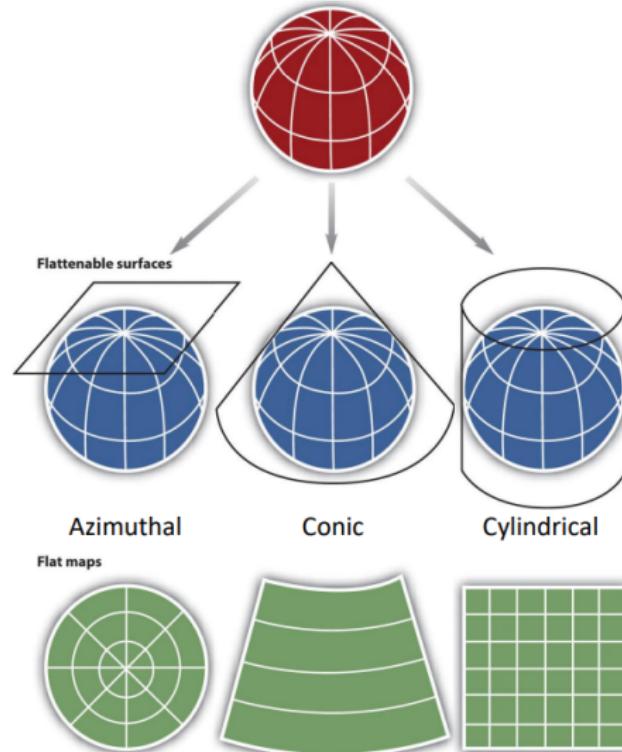
Geographic Map Projections



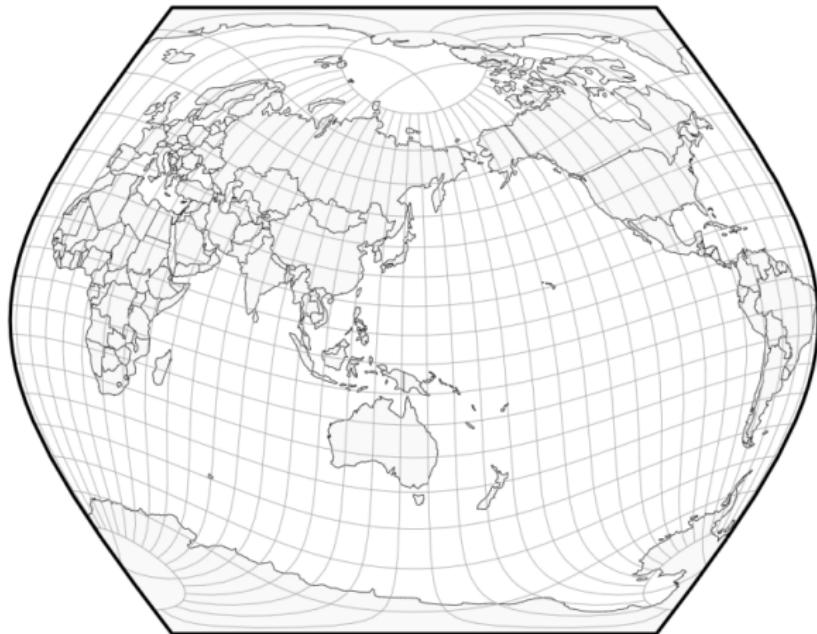
17

Dimensionality reduction

Dimensionality reduction



Map Projection Transitions



Website

Map Projection Transitions

Choose a projection (Mathematical Transformation)

- Projection Surfaces
- Center of the projection
- Minimizing Distortions
 - Conformality (preserving angles)
 - Equivalence (preserving areas)
 - Equidistance (preserving distances)
 - Azimuthal (preserving directions)

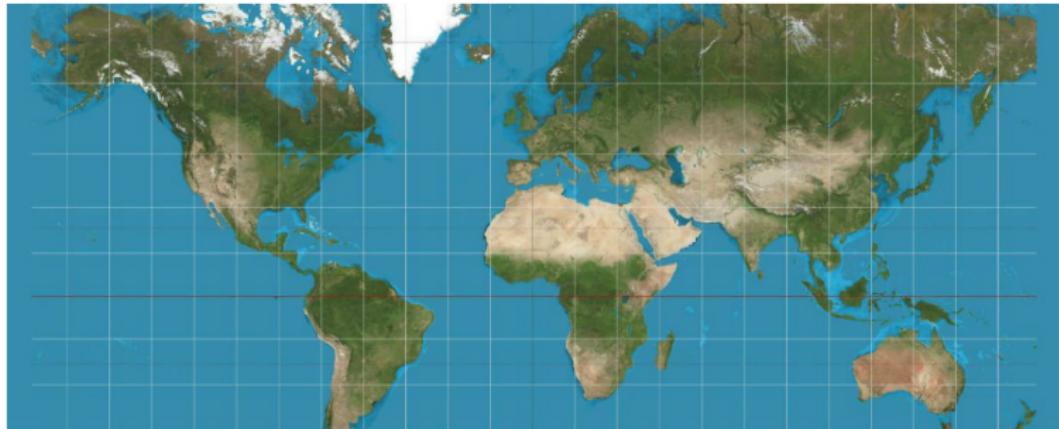
Potential map for Australian school



Maps can deceive...

It's Official: Boston's Public Schools Have Ditched This Distorted And Misleading World Map

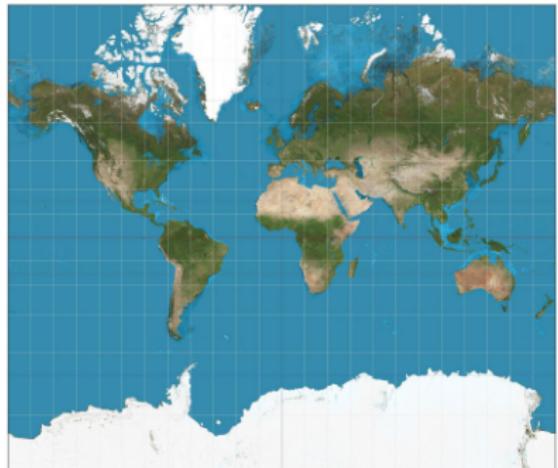
HUMANS 20 March 2017 By BEC CREW



(Mercator Projection. Credit: Strebe/Wikimedia)

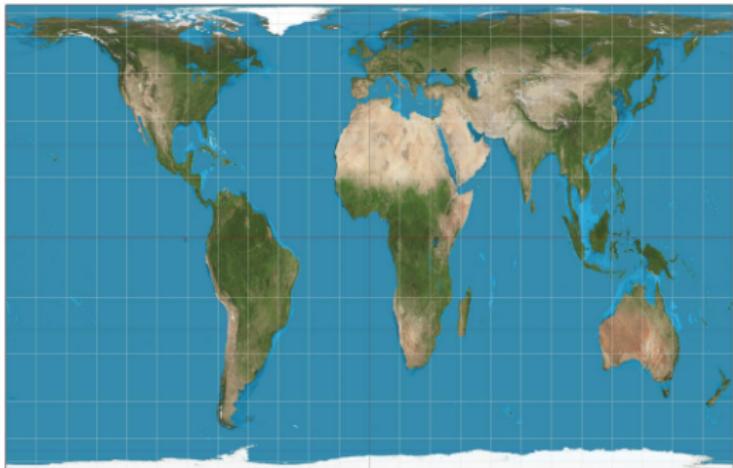
Maps can deceive...

Mercator Projection



Great for ocean navigation,
but dramatically exaggerates poles.

Gall-Peters Projection



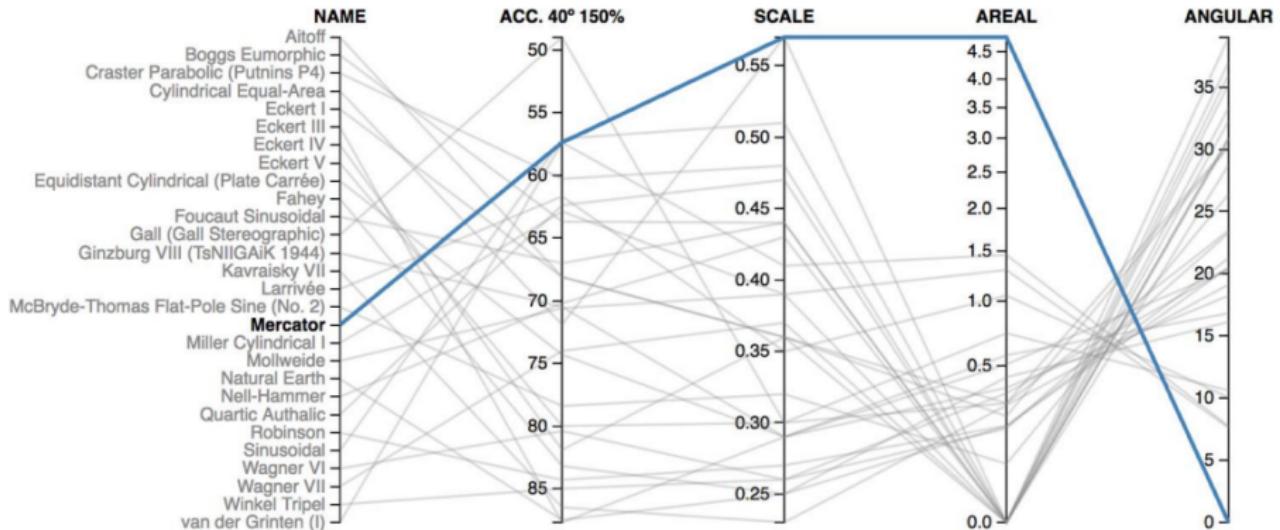
More accurate land areas.
(Officially endorsed by the UN.)

Compare map projection

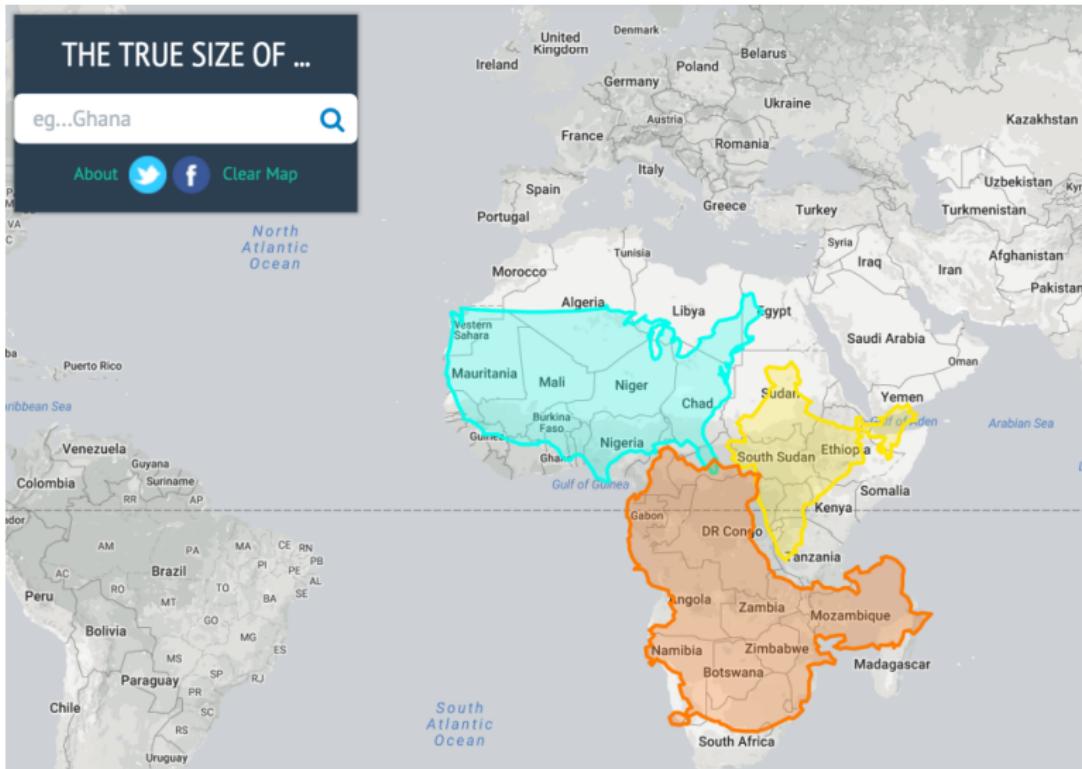
- Acc. 40° 150% – The Acceptance index is a numerical measure that summarizes overall projection distortion, in this case with a maximum angular distortion of 40° and areal distortion of up to 150%.
- Scale – The weighted mean error for overall scale distortion.
- Areal – The weighted mean error for areal distortion.
- Angular – The mean angular deformation index.

Project description

Compare map projections



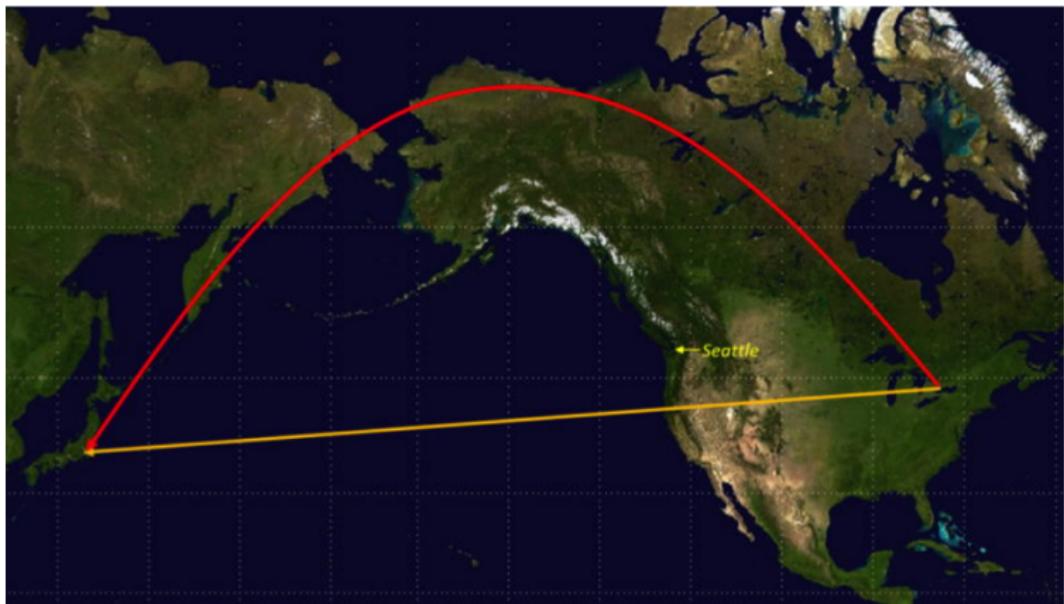
The True Size



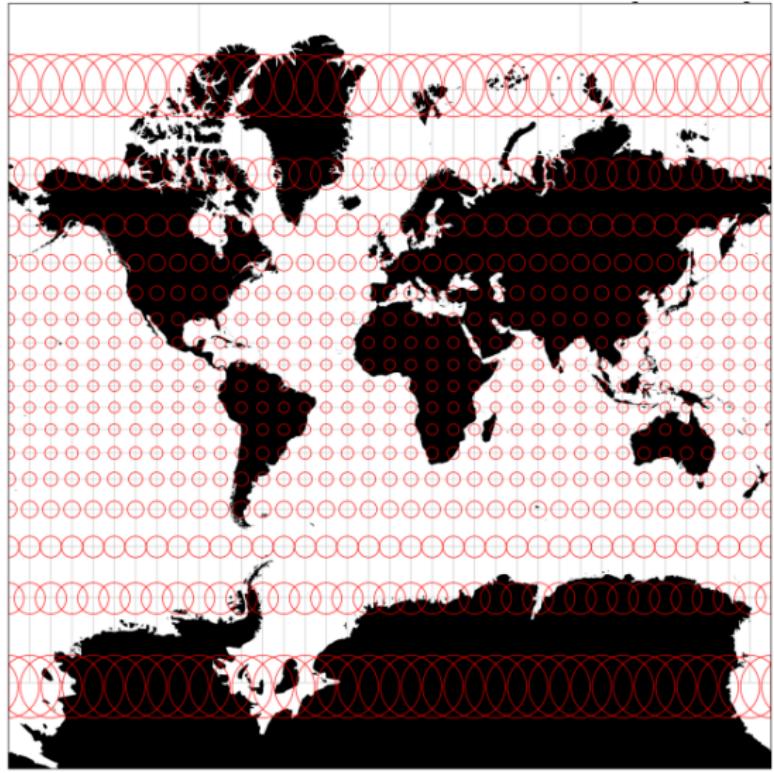
In-Class Exercise: The True Size

- Go to <https://thetruesize.com>
- Clear the map.
- Find at least two countries using the search bar.
- Position them at the equator near each other, e.g., the U.S. and Russia at the right.
- Does this match your perception of the shape and size of that country?
- Try putting your countries at other locations on the map closer to the poles. How does this affect the shape and size?
- See if you can find the worst possible distortion you can between the original map and a more accurate view at the equator.

Great Circle Routes



Tissot's Indicatrix



GIS

GIS = geographic information system. A system designed to capture, store, analyze, manage, and present spatial or geographic data.

GIS integrates various types of data: Spatio-temporal geographic information (x, y, z, t) latitude, longitude, elevation, time + other relevant attributes.

Lots of toolkits, e.g ArcGIS

Example

Key components and functionalities of GIS

- Spatial Data
- Attribute Data
- Data Capture: satellite imagery, aerial photographs, GPS (Global Positioning System) surveys, field surveys, and existing databases
- Data Storage: Common data formats used in GIS include shapefiles, geodatabases, raster datasets, and tabular data formats.
- Data Analysis: Spatial querying, spatial analysis, spatial statistics, network analysis, and geoprocessing operations.
- Visualization and Presentation
- Decision Support

Thematic/statistical map: choropleth

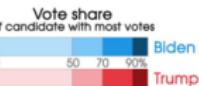
US Presidential Election 2020

Results mapped at county level showing the candidate with the largest vote share in each area

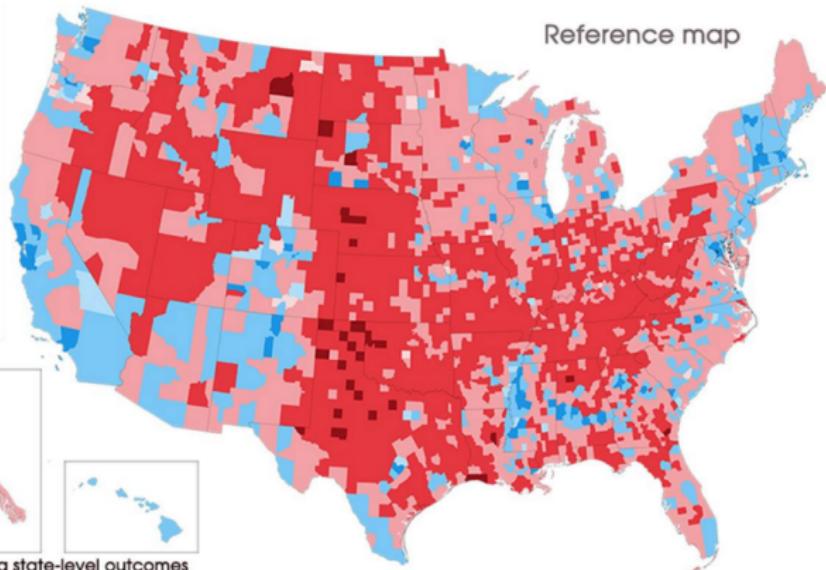
Results*

Vote share of candidate with most votes	
Biden	80,063,589 votes (51.1%)
306 electoral votes	
Trump	73,904,195 votes (47.2%)
232 electoral votes	

* preliminary results last updated 27 Nov 2020
Source: Associated Press, New York Times, The Guardian



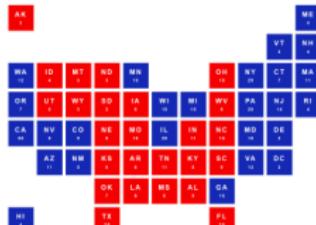
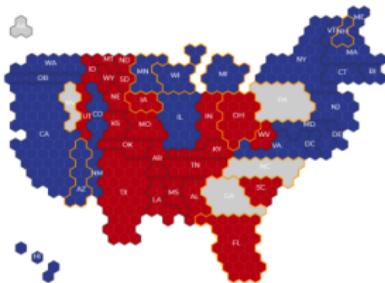
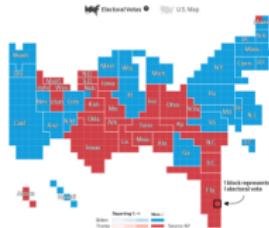
Alaska and Hawaii showing state-level outcomes



Reference map

Thematic/statistical map: cartograms

Cartograms: a thematic map in which the geometry or size of geographic regions is altered to convey information beyond traditional geographical representation



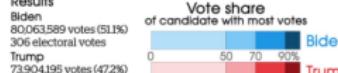
Thematic/statistical map: continuous cartograms

Use mathematical functions to smoothly and continuously transform the shapes and sizes of geographic areas based on the data being visualized.

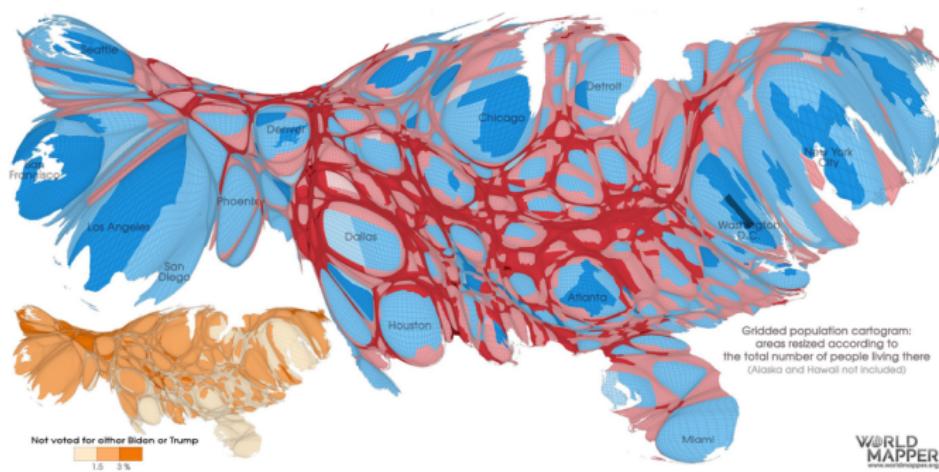
US Presidential Election 2020

Results mapped at county level showing the candidate with the largest vote share in each area

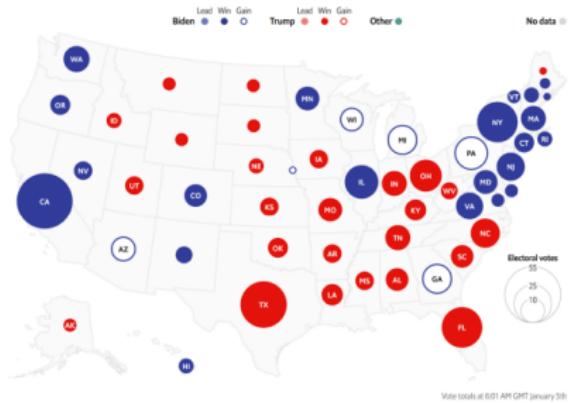
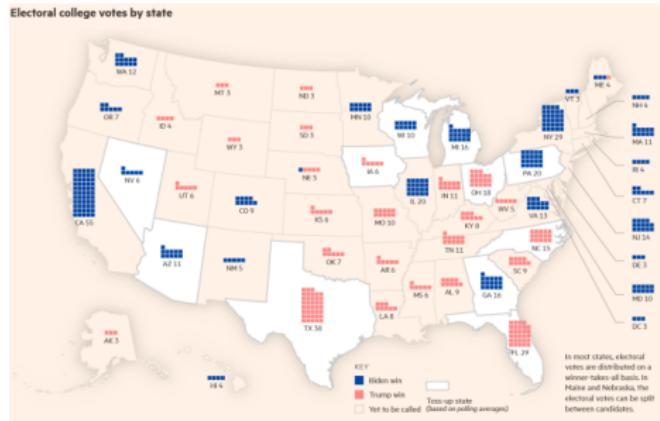
Results



* preliminary results, updated 27 Nov 2020
Source: Associated Press, The New York Times, The Guardian



Thematic/statistical map: symbol map



Interactive

Thematic/statistical map: dot density

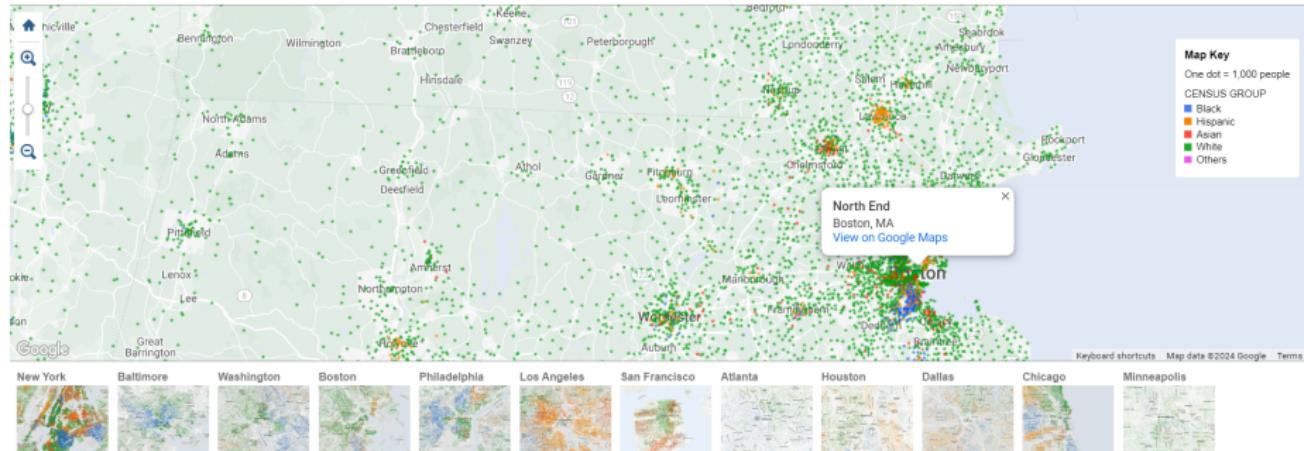
The New York Times

Published: July 8, 2015



Mapping Segregation

New government rules will require all cities and towns receiving federal housing funds to assess patterns of segregation.



Interactive

Spatial data

Arrange Spatial Data

④ 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)*

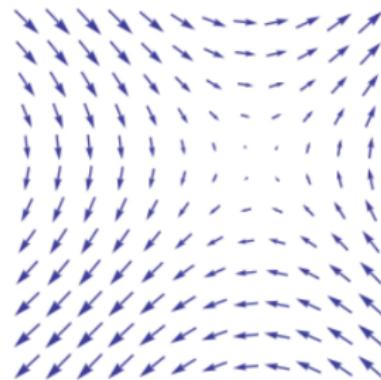
Spatial field

Scalar field = one value per cell

Vector or Tensor field = many values per cell

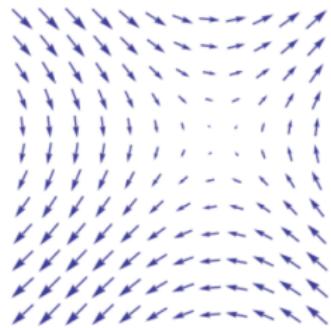
1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
7	7	5	5	6	5	5	5	8
1	1	1	1	5	6	6	6	8
2	2	2	1	5	6	6	6	8

Scalar
(magnitude)

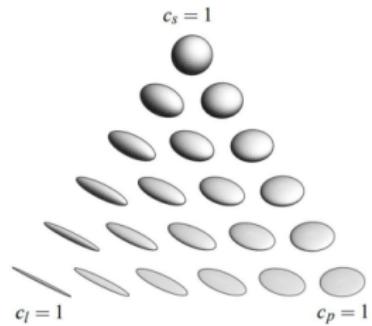


Vector
(magnitude and direction)

Spatial field

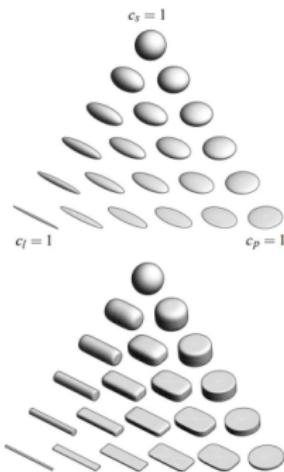


Vector
(magnitude and direction)

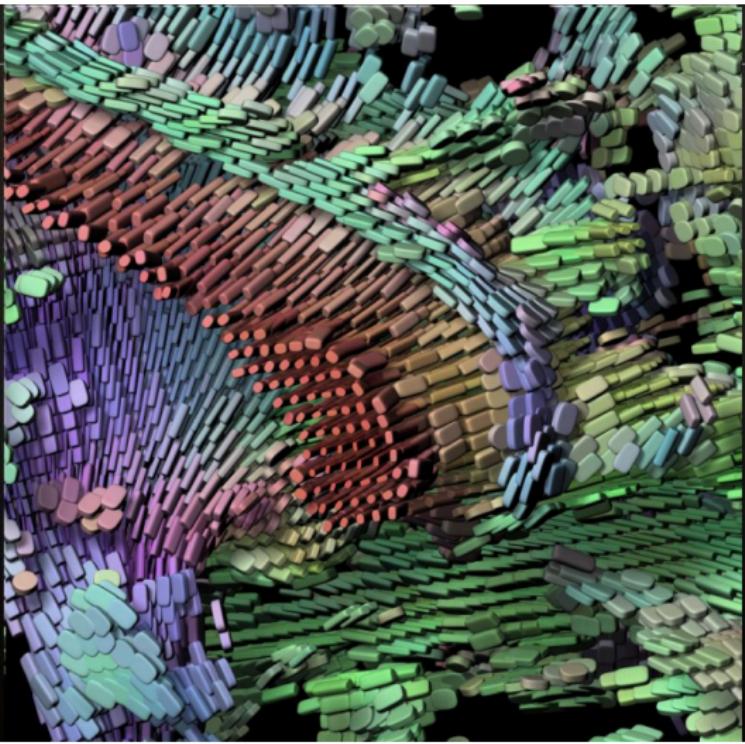
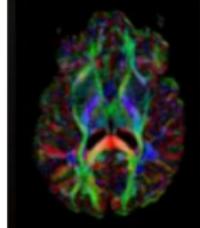
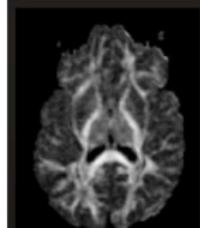


Tensor
(multiple variables with magnitude and direction)

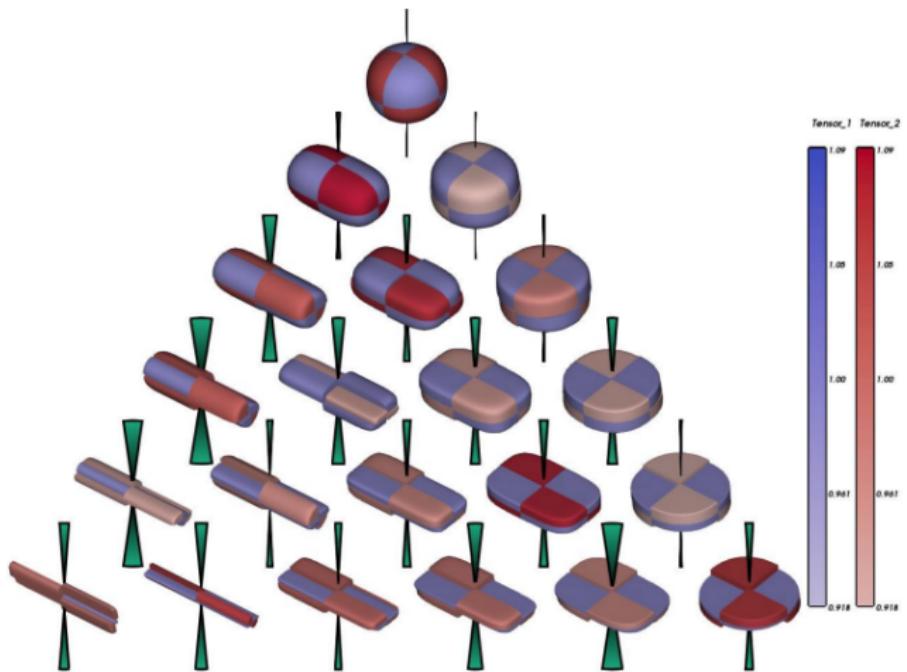
Tensor Fields



Results

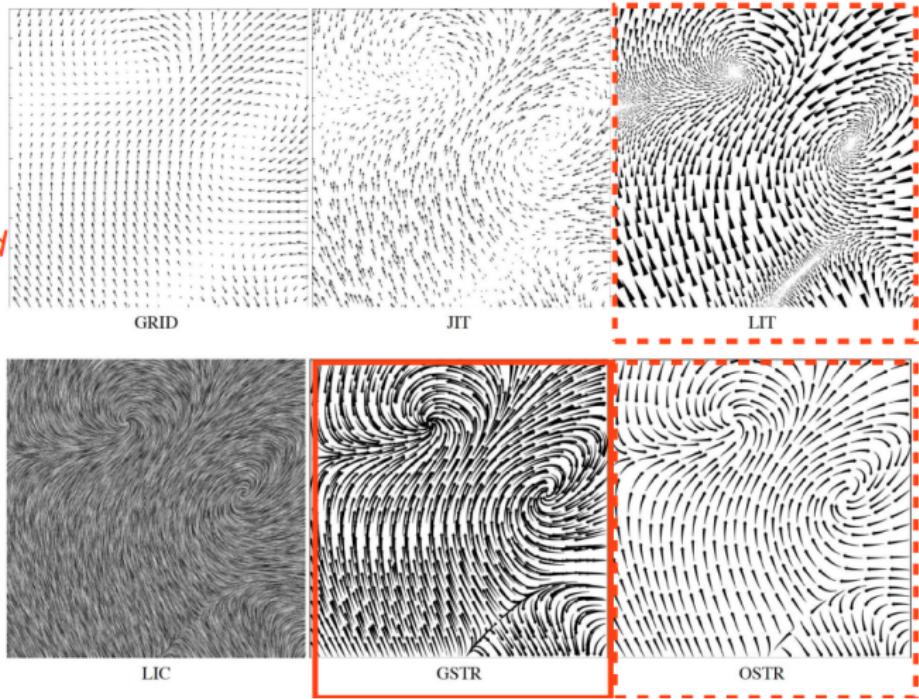


Tensor Fields



Vector Field Encoding Examples

*Most
accurate and
efficient for
certain
spatial tasks*

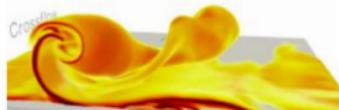


[Laidlaw, et al. 2001](#)

Example: Fluid Flow Visualization

<https://gfm.aps.org/meetings/dfd-2016>

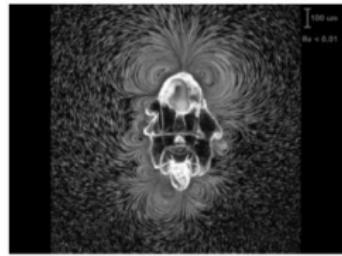
2016 APS/DFD Milton van Dyke Award Winners (Video)



V0076: Sweeping Jet from a Fluidic Oscillator in Crossflow



How does artist Holton Rower create such beautifully complex patterns with paint?
V0095: The shear joy of watching paint dry



V0055: Eat, Prey, Swim: Dynamic vortex arrays created by starfish larvae

Example: Fluid Flow Visualization

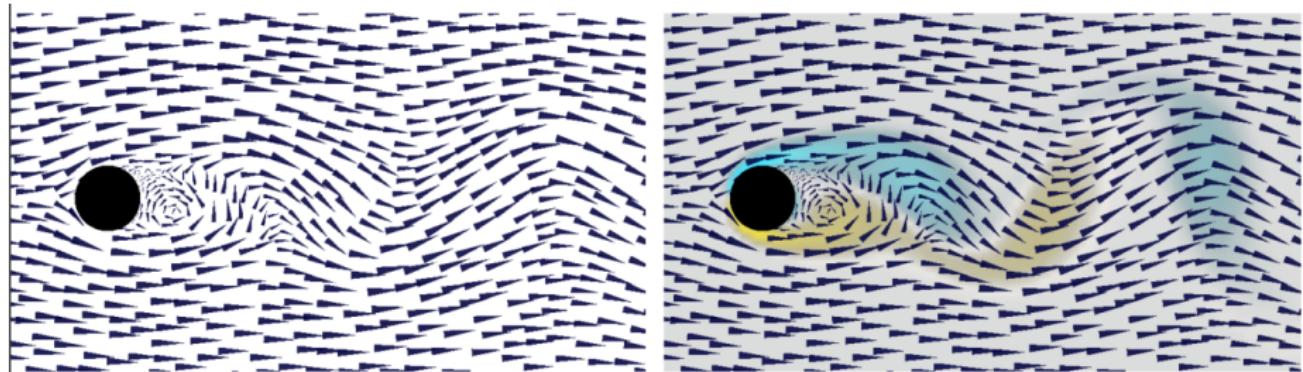
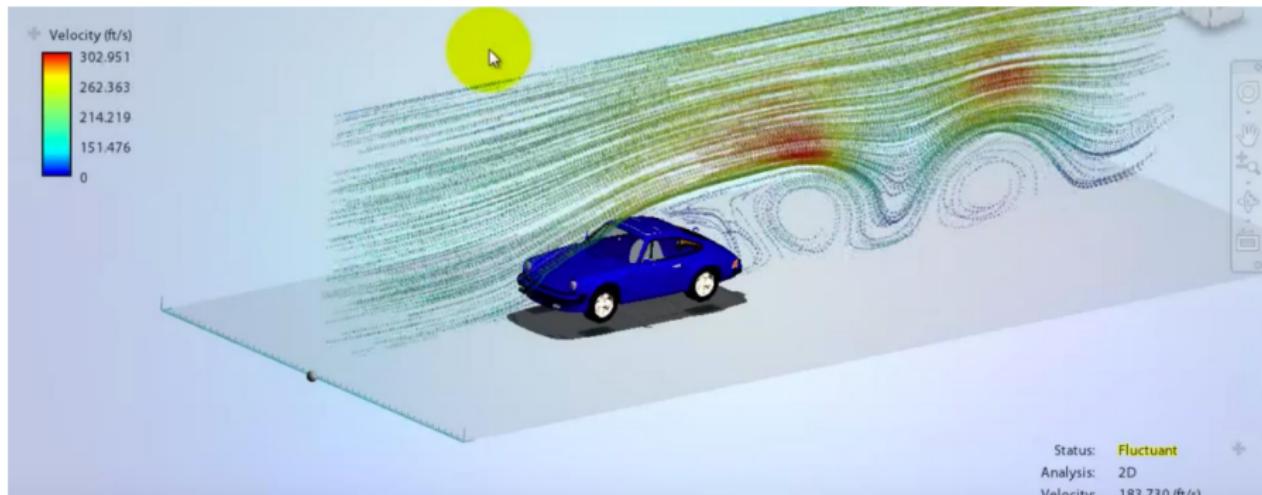


Figure 1: Typical visualization methods for 2D flow past a cylinder at Reynolds number 100. On the left, we show only the velocity field. On the right, we simultaneously show velocity and vorticity. Vorticity represents the rotational component of the flow. Clockwise vorticity is blue, counterclockwise yellow.

Example: Fluid Flow Visualization

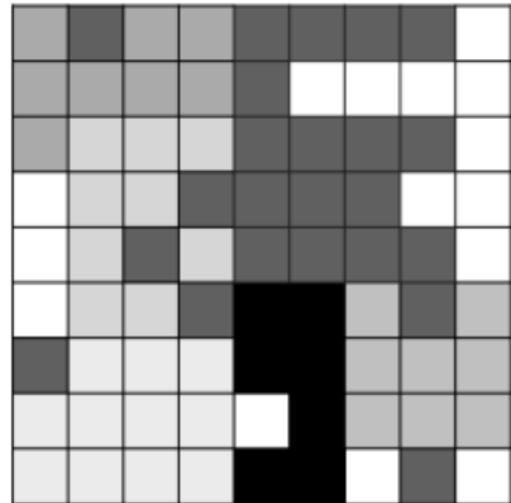


<https://www.youtube.com/watch?v=KUz0G09TGrI>

Spatial Fields

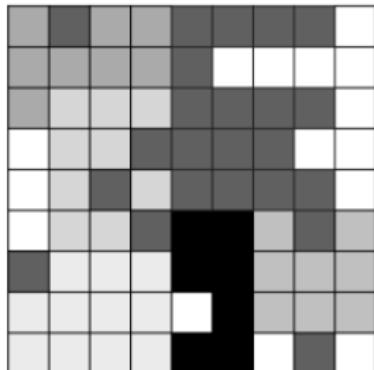
1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
1	3	4	9	4	8	8	1	0
5	6	7	8	8	8	8	8	1
9	7	5	5	5	5	5	5	8
7	7	5	5	6	5	5	5	8
1	1	1	1	5	6	6	6	8
2	2	2	1	5	6	6	6	8

Scalar
(magnitude)

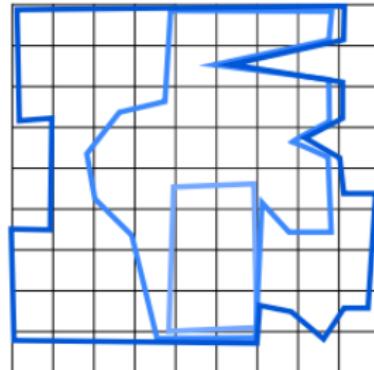


Image

Spatial Fields



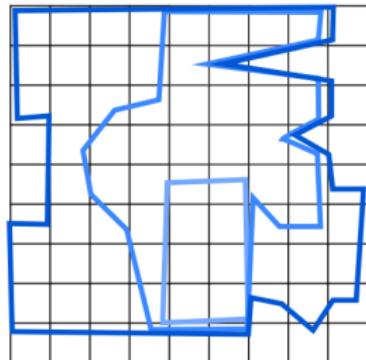
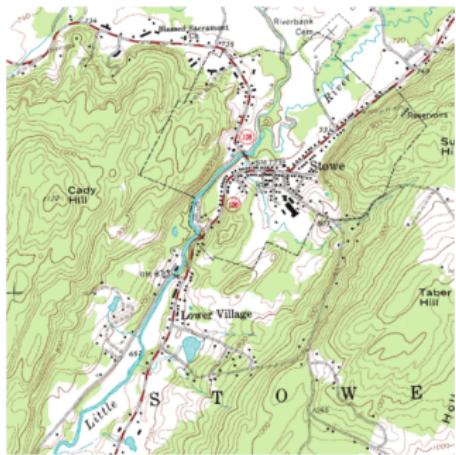
Image



Isocontours

(Contour line as single scalar threshold value)

Spatial Fields

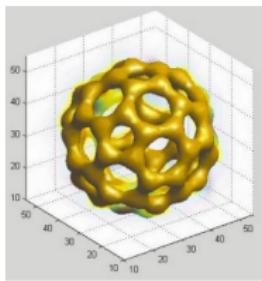


Isocontours

(Contour line as single scalar threshold value)

3D Spatial Fields

Isosurface



Surface that represents points of a constant value

Volume Rendering

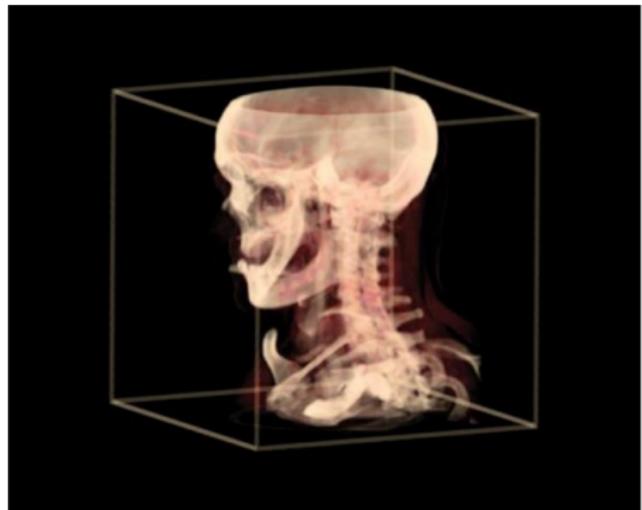


Every value is mapped to an opacity and a color via a "transfer function" 67

Isosurface vs. Volume Rendering



*distinct objects
distinct thresholds (surfaces)*



*indistinct objects
blending or transparency important*

Isosurface vs. Abstracted

