Many Thanks to

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[skod]
Principles

Special type of Spatial Data

Use maps when spatial relationships are paramount

Map Tasks:

Find Location / Feature (county, country, city, street)

Find Route

Identify attribute associated with location (elevation, land/water, GDP)

Compare attributes between Locations/Features
Map Projections
Why projections?

Earth is a (flattened) Sphere

Need to project or “unfold” the hull of the sphere to fit onto paper/screens

Relevant attributes:
- Area, Shape, Direction,
- Bearing, Distance, Scale
Mercartor Projection

Gerardus Mercator, 1569
Projection onto a cylinder wrapped around the globe conformal map projection; that is, angles are preserved.
All lines of constant bearing are straight lines.
Constant bearing means constant compass heading - developed for sailors
Mercator Projection
Mercator Projection of Mars

Circular craters map to circles

Based on slide from Hanrahan
Mercator Projection

Mercator works really great if you’re, say, Ferdinand Magellan looking for a compass bearing that will take you around Cape Horn, because all of the latitude and longitude lines and angles in between lay out nice and straight on the map like we experience them in real life. It also works well if you’re Google and you want a map image that you can neatly slice up into little squares that your server sends to a customer’s browser. North is always up, your hometown doesn’t look squished or slanted when you zoom in to it, and everybody’s happy.

http://giscollective.org/slippy-map-projections-explained/
Latitude-Longitude

Does not preserve angles

Does not preserve areas

Things are squashed at the top and bottom

Snyder, “Flattening the Earth”
Based on slide from Hanrahan
Azimuthal Projections

Projection onto a plane tangent to the Earth

angles are correct around the center point

Great circles through the center are straight lines

Radii correspond to true distances

Sometimes see this in airline magazine centered around the hub
Azimuthal Equidistant
Winkel Tripel Projection

Modified azimuthal map projection
averaged to cylindrical projection

Minimizing three kinds of distortion:
  area
  direction
  distance

Considered good projection for world maps, endorsed by National Geographic Society, used in Textbooks
Albers Equal-Area

Shows areas correctly
Distorts distances and shapes
AFRICA IN PERSPECTIVE

United States of America
9,372,180 sq km

India
3,166,830 sq km

Argentina
2,766,889 sq km

Western Europe
4,939,927 sq km

Africa:
30,301,596 sq km

Other named countries:
29,843,826 sq km

China
9,597,000 sq km

Composite Projections

Bernhard Jenny
Fixing the Mercator Projection for the Internet Age

Raghu Nachiraju, Ohio State University


John Holdorf, in his delightful work The Shipmakers (Peacham, 2002), traces the adventures and memories of shipmakers and cartographers over the centuries. It is a fascinating story still unfolding in this age of the internet. Mapmaking has undergone many changes, with demands on both ends of the user spectrum, from the precise maps required to chart the cruise lines and surfaces of planets to the more general and adaptable maps employed to navigate the streets and waterscapes of our cities and towns.

Today’s maps are viewed on a plethora of devices and browsers of every imaginable form and function, all made available through the embrace of various Web-based mapping services. The staple of map-displaying methods is still the equirectangular projection of Mercator. However, there’s a problem that this master cartographer could have never anticipated: the Mercator projection is a poor choice for maps of the globe in an entity of its own or for large landscapes on digital displays. The higher latitudes suffer from excessive distortion and convey a false sense of proximity to the same, while the polar latitudes are completely missing in the Web-based Mercator projection. Is there an alternative?

Raghu Nachiraju of Ohio State University offers a well-crafted solution called Adaptive Composite Map Projection, which creates algorithimic and user-preferred principles of information visualization design. "Adaptive Composite Map Projections," IEEE Data Visualization and Computer Graphics, vol. 18, no. 13, 2012, pp. 2055-2062. doi: 10.1109 TVCG.2012.192. Map scale, the pan- ter, geospatial, the agent ratio, and measures of particular cartographic visualization impact the final display of regional features and outlines. Jenny’s compact projection combines several information-relevant proportions and adaptively and smoothly maps the map space under scrutiny as the user changes scale or the region of interest. It also adapts the underlying geometry to scale, to the map’s aspect ratio, and to the display area’s quadrant.

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Projections in D3

Many projections included:


https://github.com/d3/d3-geo-projection/
Unfolding The Earth

Idea: use small patches
flatten them out
Jarke van Wijk

http://www.win.tue.nl/~vanwijk/myriahedral/
Texture

- Materials need parameters to describe properties.

- Spatially varying

- Textures model spatial variations.

- Texture is a function mapping points between domains
Texture Zoo
Texture Mapping
Anything Goes …
Texture maps

• How is a texture mapped to the surface?
  – Dimensionality: 1D, 2D, 3D
  – Texture coordinates (s,t)
    • Surface parameters (u,v)
    • Projection: spherical, cylindrical, planar
    • Reparameterization

• What can a texture control?
  – Surface color and transparency
  – Illumination: environment maps, shadow maps
  – Reflection function: reflectance maps
  – Geometry: displacement and bump maps
Map Software / Navigation
Mapping Software

Open StreetMap

Google Maps
D3 Maps

1) get TopoJSON / GeoJSON file
https://github.com/mbostock/topojson/wiki

2) Map Values to Geolocations contained in JSON file

3) Map Values to Channel
Landmarks & Paths

Based on slide from B. Tversky
LineDrive, 2001

Straighten wiggly lines
Turn directions to right angles
Expand regions with turns
Contract long straight roads
Label carefully to avoid clutter
Maintain overall orientation
Choropleth Maps
Principle

Area are shaded or patterned in proportion to measurement
Each spatial unit is filled with a uniform color or pattern
Early Choropleth Map

Illiteracy in France

Charles Dupin, 1826
Kerry vs. Bush, 2004
2004 Popular Vote

- Bush: 62 million votes
- Kerry: 59 million votes

Amount of red and blue shown on map

- Bush: 2,500,000 mi²
- Kerry: 525,000 mi²
The deep red down the center of this map highlights the president's support in sparsely populated areas.
This map removes mostly uninhabited areas, revealing Mr. Bush’s suburban and rural support in the East and South.

Matthew Ericson, NY Times
In 3D!

Matthew Ericson, NY Times
Rich Blocks, Poor Blocks

A map of income and rent in every neighborhood in every city in America

Enter a city name or address and pick a state -- or just a pick a state from the dropdown. (I'm colorblind)

(boston)

Massachusetts

Income

Search

Change Map Size

(Note: Loading taking long? Zoom in or out. No map? Reload, or choose another browser. And if you want more economic details, click any part of the map after you click "Search.")

Source on all data: 2007-2011 American Community Survey. For more info, see the ACS' definitions for income and rent. All map boundaries are Census Tracts.
Mapping the Nation’s Well-Being

For the last three years, Gallup has called 1,000 randomly selected American adults each day and asked them about indicators of their quality of life. Responses are converted to the Gallup-Healthways Well-Being Index. Here are the 2010 results, sorted by Congressional districts. Related Article »

Have you ever been told by a physician or nurse that you have diabetes?

Note: The survey was conducted over the course of a year from Jan. 2 to Dec. 30, 2010. The number of people surveyed in each district varies, and ranges from 300 to 2,000 people. A sample size of 300 corresponds to a margin of sampling error of ±5.7%. A sample size of 2,000 corresponds to a margin of sampling error of ±2.2%.

By MATTHEW BLOCH and BILL MARSH | Send Feedback

Source: Gallup-Healthways Well-Being Index
Where We Live...

Unlike many developed countries, the U.S. keeps growing. We are also moving south and west. But compared with China or India, the nation is a vast prairie.

80% of the U.S. population lives in a metropolitan area.

The entire state of Wyoming (pop. 509,300) has fewer people than the Hamburg, Pa., metro area.

Our families are getting smaller—with one vital exception. Compared with those of Europe and Japan, the U.S. population is younger and more colorful because of the continued arrival of immigrants and their higher-than-average birthrates. Of the 100 million Americans who will join us in the next 37 years, half will be immigrants or their children. In the next few decades, 95% of the world's population growth will occur in the developing world; the U.S. is the largest developed country in the world that is still growing at a healthy clip. That matters, strategically, economically.

1. New York City metro area
   (pop. 18,747,300)

2. Los Angeles metro area
   (pop. 12,923,500)

3. Chicago metro area
   (pop. 9,443,400)

4. Philadelphia metro area
   (pop. 5,823,200)

5. Dallas-Fort Worth metro area
   (pop. 5,819,500)

Ala.: Pussum Trot, Ky.; or Lonelyville, N.Y. But they are all probably close to someone's idea of paradise. —By Nancy Gibbs

Sources: U.S. Census Bureau; LandScan2000, V.F. Rebbete, LLC

Alexia is the most sparsely populated state, with 1 person per square mile.

New Jersey is the most densely populated state, with 1,134 people per square mile.
Robert Kosara  February 22nd, 2014 at 4:13 am

The problem here is not that it could be interesting to see population density, but that the claim is that something other than population density is revealed, which is simply not true. Why not make a chart of population density instead? This incredible map shows you where 50% of the people in the U.S. live!

If this were really about GDP, it would be per capita. That would be interesting. Income per capita is certainly higher in New York City than in Dallas, for example. But how do NYC and L.A. compare? What about other areas? And how does income compare to cost of living? Etc.

The reason this is getting any attention at all is because it’s a map. If it were a bar chart or similar, people would just ignore it. But no matter how simple or obvious your data, once it’s shown on a map, people find it interesting.

http://www.thefunctionalart.com/2014/02/the-incredible-gdp-map-that-shows-that.html

Alberto Cairo  February 22, 2014 at 7:43 AM

Another analogy: Simplistic graphics like this (only one or two data points; no nuances, exceptions, details) are the equivalent of writing just a headline when you should be writing that headline PLUS a complete news story to provide background information.

Reply

Stephen Few  February 22, 2014 at 9:44 AM

In our modern world of news aggregators, few people read beyond the headlines. Knowing a few sound bytes and bullet points is what passes for being informed. Few take time to think beyond a superficial level. Most producers of infographics encourage this through their designs, in part because they embody this in their own thinking.

Reply
The map does not make false claims but it leads readers to the conclusion that the orange areas are much more important than the blue region (equal economic activity but much smaller area). The first problem is that the types of economic activities are vastly different between those regions, and this significant factor is ignored.

The second problem is that the designer over-aggregated the data. All counties (or zip codes) are classified into two groups (“split in half”) when in fact, the level of economic activity at the level of counties (or zip codes) is a gradient. Imagine plotting the economic activity index by county, ordered from the highest to the lowest. Do we see a dramatic drop-off after counting out half the counties (i.e., the pattern shown on the left chart below)? Or are we more likely to see the pattern shown on the right? If you see a distribution like the one shown on the right, would you summarize that with just two segments?

![Graph](http://junkcharts.typepad.com/numbersruleyourworld/2014/02/numbersonse-and-true-lies.html)
Data Driven Maps
Data Driven Maps

Idea: don’t use a map to render on top
Let the data make up the map
ZipDecode
Census Dotmap

What's all this?
This is a map of every person counted by the 2010 US and 2011 Canadian censuses. The map has 341,817,095 dots - one for each person.

Why?
I wanted an image of human settlement patterns unmediated by proxies like city boundaries, arterial roads, state lines, &c. Also, it was an interesting challenge.

Who is responsible for this?
The US and Canadian censuses, mostly. I made the map. I'm Brandon Martin-Anderson. Kieran Higgins came to the rescue with spare server capacity and technical advice once this took off.

How?
I wrote a Python script to generate points from US Census block-level counts, and then generated the tiles with Processing. Here's more detail for the interested.
ZipScribble
Amsterdam RealTime
SandDance

Arrange Particles
to create visualizations

Thematic Maps
One hour in front of the TV

Map by The Bumblebee
http://www.flickr.com/photos/the_bumblebee/2229041742
NEW SIMPLIFIED MAP OF LONDON

RIVER

LOSERS

VERY RICH

LOSERS

From Memory (was: Maps from Memory)
http://www.flickr.com/groups/46079190@N00/
Contour (Isopleth) Maps
Early Contour Map

Halley’s lines of equal magnetic declination, 1701
Early Weather Map

Halley’s wind map, 1686
Wind Map
Cartograms
Scale Distance by Data

Figure 1.8  Airlines’ view of the United States.
Maps can be scaled to units other than distance. In this case, airline fares are used instead of miles or other linear units.
(Map copyright by the author.)

From Atlanta, Georgia

Airlines’ View of the United States

Compiled from advertised one-way coach airfares in the Atlanta/Journal Constitution from Atlanta to various American cities, American Airlines, September 24, 1987.

Dent. "Cartography"
Based on slide from Hanrahan
Scale Area by Data

Elvis Concerts
Attendance per State, 1970 - 1977


© 1995 Andrew Dent and Linda Turnbull

Dent. "Cartography" Based on slide from Hanrahan
The World
Population

Mark Newman, Univ. Michigan
GDP
Child Mortality
Greenhouse Emissions

Mark Newman, Univ. Michigan
Rectangular Cartograms

World Population Cartogram Poster
Drawn by Hand
Bush vs. Kerry, 2004

Heilman, Keim, Panse, Sips, “RecMap: Rectangular Map Approximations”
Based on image from Keim
Heilman, Keim, Panse, Sips, "RecMap: Rectangular Map Approximations"
Based on image from Keim
What Your Global Neighbors Are Buying

How people spend their discretionary income — the cash that goes to clothing, electronics, recreation, household goods, alcohol — depends a lot on where they live. People in Greece spend almost 13 times more money on clothing as they do on electronics. People living in Japan spend more on recreation than they do on clothing, electronics and household goods combined. Americans spend a lot of money on everything. Related Article

Boxes represent selected countries and are scaled according to total spending in 2007.

Roll over countries to see spending figures.
Proportional Symbol Maps
Taken together, the five counties that make up New York City have a margin for Kerry of +1,556,430 votes.

Matthew Ericson, NY Times
Katrina’s Diaspora

The victims of Hurricane Katrina have filed for assistance from FEMA from every state. This map shows the distribution and number of the 1.38 million individual assistance applications as of Sept. 25.

There are scattered through all 48 states, the District of Columbia and Puerto Rico—except for Guam, the Virgin Islands and the Northern Mariana Islands. They are clustered by the large metropolitan areas of the Southern cities like Houston, Dallas, Atlanta and Memphis, and by hub cities in the South such as Miami, Fort Lauderdale, Austin and Tampa. There are also large numbers of applications from the Gulf Coast among the hardest-hit areas in Texas, Alabama, Mississippi, and Louisiana.

Residents of New Orleans, a city that was submerged by the storm, have been filing applications for assistance. More than 20% of the population of New Orleans is still not back home. Applications from New Orleans are spread across the state of Louisiana, but also to other states in the region, such as Mississippi and Texas. The map shows the distribution of applications by state, with Louisiana having the highest number of applications, followed by Texas and Mississippi.

There are also applications from other states, such as Florida, Georgia, and California, with more than 1,000 applications each. The map also shows the distance of applications from New Orleans, with the majority of applications coming from within a 100-mile radius of the city.

M. Ericson, NY Times
For both sides, the top ZIP code in the nation for contributions was 10021, on the Upper East Side. Mr. Kerry's appeal, however, was greater throughout much of the rest of Manhattan, bringing in more money than Mr. Bush and the R.N.C. in areas like the Upper West Side, Greenwich Village and SoHo.
Killer circles threaten America

- No sides
- Area equal to $\pi r^2$
- Extremely round
- Often fatal
- North Dakota, New Mexico, Colorado remain circle-free

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How are Americans reacting to the growing geometric menace?

<table>
<thead>
<tr>
<th>Don't care</th>
<th>Unsure</th>
<th>Scared of circles</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td>14%</td>
<td>80%</td>
</tr>
</tbody>
</table>
What’s in a Surname?

America is a nation of Smiths, Johnsons, and Sullivans—but also of Garcías and Nguyêns. Zoom in on the map below to see what surnames proliferate in your part of the country.
FatFonts

http://fatfonts.org/
Mapping America: Every City, Every Block

Browse local data from the Census Bureau’s American Community Survey, based on samples from 2005 to 2009. Because these figures are based on samples, they are subject to a margin of error, particularly in places with a low population, and are best regarded as estimates.

Distribution of racial and ethnic groups

NYT, 2010
Visualizing Addresses of Gun Owners

Published after Connecticut school killings

What are the ethics of visualization?

Data is public: is making it accessible problematic?

Flow Maps
Early Flow Map

Transportation of Passengers in Ireland
Henry Drury Harness, 1837
Carte figurative des pertes successives de l'Armée française dans la campagne de Russie 1812-1813.

C. Minard, 1869
Effect of US Civil War on Cotton Trade

Before

After

Milestones Project
Plymouth County (Brockton), Mass.

Population (2005): 486,292
Inbound income per cap. (2010): $32,500
Outbound income per cap. (2010): $29,300
Non-migrant income per cap. (2010): $33,000

Enter a county or major city:
Non-spatial Representation