CSE 442 - Data Visualization

Mapping & Cartography

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(with significant material from Michal Migurski)
Rail Passengers and Freight from Paris 1884
Casualties of War

Use the slider below to investigate the demographics and military status of U.S. service members who died during the war in Iraq.

MARCH 16, 2003  JULY 5, 2008  (277 WEEKS)

4,997 deaths

Age
- 18-24: 54%
- 25-34: 33%
- 35-44: 10%
- 45+: 2%

Branch of Military
- Air Force: 1%
- Army: 72%
- Marine Corps: 24%
- Navy: 2%

Race
- Black: 9%
- Hispanic: 10%
- White: 71%
- Other: 5%
- Unknown: 5%

Type of Duty
- National Guard: 11%
- Regular: 77%
- Reserve: 7%
- Unknown: 5%

Location of death
Circles sized according to percentage of deaths in each Iraqi province.

Show all  Initial invasion  First invasion of Falluja  Second invasion of Falluja  Since troop buildup began

Show home
Texas oil boom is visible from space

Lighting and natural gas flares from drilling on the 400-mile-long Eagle Ford shale formation can be seen from space in this image.

The new formation has helped make Texas the No. 1 oil-producing state in the nation.

Oil production from different U.S. regions (in thousands of barrels per day)

Source: Energy Information Administration
Ramadi: The Government Provides an Opening for ISIS

Tensions between this city’s residents, who are mostly Sunni, and the central government had been brewing here for at least a year. Then in December, Iraq’s prime minister, Nuri Kamal al-Maliki, ordered security forces to dismantle a protest camp — an outlet for disenchanted Sunnis angered at their treatment by the Shiite-dominated government. The action ignited days of violence and created the opening ISIS needed to seize parts of the city, the provincial capital.

Falluja: A Symbolic Fall

Just days after the raid on the camp in Ramadi, ISIS fighters destroyed the Police Headquarters and mayor’s office here, planted their flag on government buildings and decreed the city to be theirs. Ten years earlier, American forces had captured this city from Qaeda-style insurgents at a considerable cost of American lives.
Cartography
The Making of Maps
Projections
Latitude, Longitude

P = 40°N, 60°W

Point

Center

Equator
Exploring Projections…

https://vega.github.io/vega/examples/world-map/
A sphere tears when you flatten it
Three example ways to categorize projections...
Azimuthal
Preserve direction / distance from center
Azimuthal Equidistant

The azimuthal equidistant projection is available as d3.geo.azimuthalEquidistant.
Equal-Area

Preserve area
The Albers equal-area conic projection is available as d3.geo.albers. See also the interactive version.
Conformal
Preserve local angles ("shape")
Tissot’s Indicatrix
Spherical Mercator is ubiquitous on the web—why?
Web Mercator

\[ x = \frac{128}{\pi} 2^{\text{zoom level}} (\lambda + \pi) \text{ pixels} \]
\[ y = \frac{128}{\pi} 2^{\text{zoom level}} (\pi - \ln \left[ \tan \left( \frac{\pi}{4} + \frac{\varphi}{2} \right) \right]) \text{ pixels} \]

World coordinates adjusted to map to 256 x 256 pixels.

**Latitude cut-offs** at 85.051129 degrees: the exact point at which the projection frames the world in a square.
The Earth as a Square
The Peirce quincuncial projection is implemented as d3.geo.peirceQuincuncial in the geo.projection D3 plugin. It is derived from the Guyou projection.
Projections usually have a home
Increased Border Enforcement, With Varying Results

There are now more agents along the 1,954 mile-long border than ever before...

Border agents per sector.

<table>
<thead>
<tr>
<th>SAN DIEGO</th>
<th>EL CENTRO</th>
<th>YUMA</th>
<th>TUCSON</th>
<th>EL PASO</th>
<th>BIG BEND</th>
<th>DEL RIO</th>
<th>LAREDO</th>
<th>RIO GRANDE VALLEY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,000</td>
<td>1,000</td>
<td>1,200</td>
<td>1,200</td>
<td>2,000</td>
<td>3,000</td>
<td>1,000</td>
<td>2,000</td>
<td>4,000</td>
</tr>
</tbody>
</table>

Satellite Projection, NY Times
WHAT YOUR FAVORITE MAP PROJECTION SAYS ABOUT YOU

MERCATOR

YOU'RE NOT REALLY INTO MAPS.

YOU'RE NOT A COMPLICATED PERSON. YOU LOVE THE MERCATOR PROJECTION; YOU JUST WISH IT WEREN'T SQUARE. THE EARTH'S NOT A SQUARE, IT'S AIRCLE. YOU LIKE CIRCLES. TODAY IS GONNA BE A GOOD DAY!

VAN DER GRINTEN
YOU THINK THAT WHEN WE LOOK AT A MAP, WHAT WE REALLY SEE IS OURSELVES. AFTER YOU FIRST SAW "INCEPTION," YOU SAT SILENT IN THE THEATER FOR SIX HOURS. IT FREAKS YOU OUT TO REALIZE THAT EVERYONE AROUND YOU HAS A SKELETON INSIDE THEM. YOU HAVE REALLY LOOKED AT YOUR HANDS.
There are interesting ways to tear spheres
One notable interesting way to tear a sphere
ADAPTIVE COMPOSITE MAP PROJECTIONS
Scale
This is not “scale”
Scale is an idea imported from print.
Choose the right content at different scales
Four maps, same area
What shows at different scales?
Shapes change at different scales

Figure 11. Fragmentation of a river into polygons and lines with different thresholds leading to different results (c, d, e).
Mapping
Visualizing Geospatial Data
Symbol Maps
Dots can be symbols
Guess the crime
Dots can can be good symbols
Dots can include data
Dots are ubiquitous
“Red Dot Fever”
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

By MATTHEW BLOCH, SHAN CARTER and ALAN McLEAN | Source: 2005-9 American Community Survey, Census Bureau; socialexplorer.com

Note: Dots are evenly distributed across each Census tract or county. Dollar amounts are adjusted for inflation.
This map is counting many small things

the black lines show Chicago’s official community areas.

each dot represents twenty-five people. Here, Hispanic is exclusive of other categories.

block-level data from the U.S. Census.

scale 1:200,000
Clustering, grouping
Let patterns emerge
Continuous Data
Binning
Don’t hide the context
Break data into buckets

The brazen 2007 murder of journalist Chauncey Bailey in Oakland, California, led Stamen partner Mike Migurski to make the city’s crime data more accessible. This heat map of downtown uses data from CrimeMapping.com, a community website, to show the gaps between crimes at a given intersection: white is high-crime; darker areas are safer. sta.mn/4w
Meaningful buckets
"Iso" means "same".

Isolines for elevation.
Isochrones are isolines for time.
Choropleth Maps
1826(?) Illiteracy in France, Pierre Charles Dupin
Five quantiles

Unemployment
Choose colors well
Focus on the foreground
What is obscured?
Cartograms
New York Times ratings


Click on a district below to learn more.

Each box represents a House district.
Obesity Map (Dorling Cartogram)  Vadim Ogievetsky
Obesity Map (Dorling Cartogram)  Vadim Ogievetsky
China Still Dominates, but Some Manufacturers Look Elsewhere

While China maintains its overwhelming dominance in manufacturing, multinational companies are looking for ways to limit their reliance on factories there. Related Article »

Economic Output

In this map, geography is distorted so that each country is sized according to its economic output in 2012. The countries are colored by their rate of growth; more established economies tend to grow more slowly.

China is both highly productive and growing rapidly. Considering individual provinces conveys its impressive scale: Guangdong, just one of 31 Chinese provinces, has an economic output greater than Indonesia.

Japan and South Korea have large economic output, but growth has slowed as they have caught up with the West and innovation becomes more difficult.

Rising wages and risk in China are encouraging businesses to consider alternatives, including Cambodia, Vietnam and the Philippines.

New York shown for comparison.
Major distortions can stay recognizable
Flow Maps
1864 British Coal Exports, Charles Minard
Migration from California, 95-00

Tobler 1987

Phan et al. 2005

Verbeek et al. 2011

Cui et al. 2008

Holten & van Wijk 2009
wind map

February 19, 2014
11:55 am EST
(time of forecast download)

top speed: 35.3 mph
average: 11.6 mph
Romney’s Shift Wasn’t Enough

Most of the nation shifted to the right in Tuesday’s vote, but not far enough to secure a win for Mitt Romney.
Generalization
1864 British Coal Exports, Charles Minard
Harry Beck’s London tube diagram
**London Underground [Beck 33]**

**Geographic version of map**

**Principle:** Straighten lines to emphasize stop sequence

**Technique used to emphasize/de-emphasize information**
People *love* the tube map
Time to Travel from Arnos Grove

Tube map + isochrones
Route Maps: Bellevue to Seattle
Map Design via Optimization [Agrawala ‘01]

Set of graphic elements
  Roads, labels, cross-streets, …

Choose visual attributes
  Position, orientation, size, …
  Distortions increase flexibility

Develop constraints based on design principles

Simulated annealing
  Perturb: Form a layout
  Score: Evaluate quality
  Minimize score
Road Layout Constraints [Agrawala ’01]

**Length**
Ensure all roads visible
Maintain ordering by length

**Orientation**
Maintain original orientation

**Topological errors**
Prevent false
Prevent missing
Ensure separation

**Overall route shape**
Maintain endpoint direction
Maintain endpoint distance

\[
((L_{\text{min}} - l(r_i))/L_{\text{min}})^2 \times W_{\text{small}}
\]

\[
W_{\text{shuffle}}
\]

\[
|\alpha_{\text{curr}}(r_i) - \alpha_{\text{orig}}(r_i)| \times W_{\text{orient}}
\]

\[
\min(d_{\text{origin}}, d_{\text{dest}}) \times W_{\text{false}}
\]

\[
d \times W_{\text{missing}}
\]

\[
\min(d_{\text{ext}}, E) \times \text{Ext}
\]

\[
|\alpha_{\text{curr}}(v) - \alpha_{\text{orig}}(v)| \times W_{\text{enddir}}
\]

\[
|d_{\text{curr}}(v) - d_{\text{orig}}(v)| \times W_{\text{enddist}}
\]
Tools
Software Tools

Web Tools

d3.geo: projections, paths and more
GeoJSON: JSON format for geo data
TopoJSON: topology -> compressed GeoJSON
Leaflet: open-source, customizable map tile system

Other

PostGIS: Postgres DB extensions for geo data
Mapnik: Render your own map tiles!
Data Resources

Natural Earth Data
naturalearthdata.com

OpenStreetMap
openstreetmap.org

U.S. Government
nationalatlas.gov, census.gov, usgs.gov
Tutorials

Let’s Make a Map!
http://bost.ocks.org/mike/map/

How to Infer Topology
http://bost.ocks.org/mike/topology/