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)

4,097 deaths

**Age**

<table>
<thead>
<tr>
<th>Age</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>54%</td>
</tr>
<tr>
<td>25-34</td>
<td>33%</td>
</tr>
<tr>
<td>35-44</td>
<td>10%</td>
</tr>
<tr>
<td>45+</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Branch of Military**

<table>
<thead>
<tr>
<th>Branch</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force</td>
<td>1%</td>
</tr>
<tr>
<td>Army</td>
<td>72%</td>
</tr>
<tr>
<td>Marine Corps</td>
<td>24%</td>
</tr>
<tr>
<td>Navy</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Race**

<table>
<thead>
<tr>
<th>Race</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>9%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>10%</td>
</tr>
<tr>
<td>White</td>
<td>71%</td>
</tr>
<tr>
<td>Other</td>
<td>5%</td>
</tr>
<tr>
<td>Unknown</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Type of Duty**

<table>
<thead>
<tr>
<th>Type of Duty</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Guard</td>
<td>11%</td>
</tr>
<tr>
<td>Regular</td>
<td>77%</td>
</tr>
<tr>
<td>Reserve</td>
<td>7%</td>
</tr>
<tr>
<td>Unknown</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Location of Death**

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

- Texas
- Alaska
- California
- Gulf of Mexico
- North Dakota

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.

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**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")
The Mercator projection is available as d3.geo.mercator.
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>Location</th>
<th>'00</th>
<th>'12</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Diego</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>El Centro</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Yuma</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Tucson</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>El Paso</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Big Bend</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Del Rio</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Laredo</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Rio Grande Valley</td>
<td>3.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Satellite Projection, NY Times
ADAPTIVE COMPOSITE MAP PROJECTIONS
What your favorite map projection says about you:

Mercator:

You're not really into maps.

Van der Grinten:

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 a circle. You like circles. Today is gonna be a good day!
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
You can drag the map with your mouse, and use the +/- buttons to zoom. The circle in the center will always indicate North for that point, and when you stop dragging the map will re-orient itself automatically. Read more about this on my blog.
Scale
This is not “scale”
Scale is an idea imported from print

<table>
<thead>
<tr>
<th>Scale Mapping</th>
<th>Scale Mapping</th>
<th>Scale Mapping</th>
<th>Scale Mapping</th>
<th>Scale Mapping</th>
<th>Scale Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1,000,000</td>
<td>1:625,000</td>
<td>1:250,000</td>
<td>1:50,000</td>
<td>1:25,000</td>
<td>1:10,000</td>
</tr>
</tbody>
</table>
Choose the right content at different scales
Four maps, same area
What shows at different scales?
Shapes change at different scales.
Mapping
Visualizing Geospatial Data
Symbol Maps
Dots can be symbols
Guess the crime
Dots 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

Chinatown

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
Three dimensions shown by color (?)
One dimension, shown by hue
Let patterns emerge
Continuous Data
Don’t hide the context
Uber Wait Times, 2011

Expected Wait Times in San Francisco

Latitude

Longitude

Expected wait time (seconds)

http://sta.mn/6x27
Try smooth gradations?
Break data into buckets

CRIMESPOTTING

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 CrimeStoppers, a community website, to show the gaps between crimes at a given intersection: white is high-crime; darker areas are safer. staman.com

KEY
Colours show how recently a crime was reported in a given part of Oakland.

- A week ago
- Two weeks ago
- A month ago
- Two months ago
- Three months ago
- Four months ago
- Five months ago
Meaningful buckets
“Iso” means “same”

Isolines for elevation
Isochrones are isolines for time.
Choropleth Maps
1826(?) Illiteracy in France, Pierre Charles Dupin
Five quantiles
Generic names for Soft Drinks by county

"pop" "soda" "coke" other?

Survey data courtesy of Alan McConchie
Visit www.popvssoda.com to participate.

Map by Matthew T. Campbell
Spatial Graphics and Analysis Lab
Department of Cartography and Geography
East Central University (Oklahoma)

Map Template courtesy of www.mymaps.com

Respondents through March 1, 2003
Choose colors well
Focus on the foreground
What is obscured?
Regions -> Symbols
Cartograms
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
Minard 1869: Napoleon's march
1864 British Coal Exports, Charles Minard
Flow Map Layout
Phan et al. 2005
Migration from California, 95-00

Tobler 1987

Phan et al. 2005

Verbeek et al. 2011

Cui et al. 2008

Holten & van Wijk 2009
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
Harry Beck’s London tube diagram
**Principle**: Straighten lines to emphasize stop sequence

Technique used to emphasize/de-emphasize information
People *love* the tube map
Tube map + isochrones
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
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/