Review

- **Terrain representation:**
  - Vector: Point samples (regular and irregular) and Contours
  - Raster: DEM, DTM, DSM
  - TIN
  - Others: Voxels and 3D point cloud

- **Terrain analysis:**
  - Slope and aspect
  - Hillshade
  - Elevation profile
  - Intervisibility and viewshed
  - Curvature
  - Flow accumulation
Lecture 15: Making Maps with GIS

(chapter 8)

Rui Zhu
Three views of GIS
Map is often the output of GIS

After you have done all **analysis, a map** can be used to summarize the result of your work

- As a paper map
- As part of your poster (e.g., your GEOG 176C course)
- Be included in a digital report
Recall: What is a map?

“A graphic depiction of all or part of a geographic realm in which the real-world features have been replaced by symbols in their correct spatial location at a reduced scale”
Cartographer’s paradox

- A map is a combination of **science** and **art**
- One side: scientific accuracy & completeness
  - Position
  - Attribute
  - Timely
- The other side: easy to interpret and aesthetic design
  - Provide effective communication
  - Intuitive and hard to misread
  - Should simply look nice
Elements of a map (1)

A map consists of the following elements:

- Title
- North arrow
- Symbols (points, lines, polygons)
- Text
- Scale bar
- Legend
Elements of a map (2)

- Border (boundary of the medium)
- Neat line
Elements of a map (3)

- Graticule / Grid (show lat and lng on a projected flat map)
- Coordinate system (geographic / projected)
- Sources (where do your data come from?)
- Credits (who have contributed to this map?)
Elements of a map (4)

- Insets (zoom in or zoom out)
A map can be on different mediums

- Paper
- T-shirt
- Tie
- Cake
- ...
Different types of maps

What is the geometric type of features?

● Points
  ○ Dot map, picture map, graduated symbol map
● Lines
  ○ Network map, flow map
● Areas
  ○ Choropleth map, area qualitative map, cartogram
● Volume (e.f., terrains)
  ○ Isoline map, hypsometric map, gridded fishnet, hillshade
Different types of maps

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● Points
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● Lines
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● Volume (data has elevation values)
  ○ Isoline map, hypsometric map, gridded fishnet, hillshade
Maps based on points

- Dot map: each feature is represented as a small dot
  - E.g., locations where hurricane has occurred
Maps based on points

- Picture symbol map: each feature is represented using pictures
  - Pictures are intuitive and easy to be understood
Maps based on points

- Graduated symbol map: different features are represented with **different sizes** of symbols
Different types of maps

What is the geometric type of features?

● **Points**
  ○ Dot map, picture map, graduated symbol map

● **Lines**
  ○ Network map, flow map

● **Areas**
  ○ Choropleth map, area qualitative map, cartogram

● **Volume (data has elevation values)**
  ○ Isoline map, hypsometric map, gridded fishnet, hillshade
Maps based on lines

- Network map: visualize the **structure** of line features
  - E.g., subway map
Maps based on lines

- Flow map: emphasize the **amount** of flows
Maps based on lines

- Flow map: emphasize the **destinations** of the flow
Different types of maps

What is the geometric type of features?

- **Points**
  - Dot map, picture map, graduated symbol map
- **Lines**
  - Network map, flow map
- **Areas**
  - Choropleth map, area qualitative map, stepped statistical surface, cartogram
- **Volume (data has elevation values)**
  - Isoline map, hypsometric map, gridded fishnet, hillshade
Maps based on areas

- Choropleth maps: use gradually changing colors to represent different quantities

Health Facilities per Square Kilometer
Afghanistan 2006

Health Facilities per Square Kilometer

- 0
- 0 - 0.001
- 0.001 - 0.002
- 0.002 - 0.004
- 0.004 - 0.233
Maps based on areas

- Area qualitative maps: use different colors to represent different categories
Maps based on areas

- Stepped statistical surface: extrude (fake) elevations using an attribute value
Maps based on areas

- Cartogram: distort (shrink or enlarge) the shapes of the polygon to reflect their attribute values
Different types of maps

What is the geometric type of features?

- **Points**
  - Dot map, picture map, graduated symbol map

- **Lines**
  - Network map, flow map

- **Areas**
  - Choropleth map, area qualitative map, stepped statistical surface, cartogram

- **Volume (data has elevation values)**
  - Isoline map, hypsometric map, gridded fishnet, hillshade
Maps based on volume

- Contour map (isoline): use contours to represent elevation
Maps based on volume

- Hypsometric map: use different color to represent elevation
Maps based on volume

- 3D fishnet: grids with elevations
Maps based on volume

- Hillshade map: simulate lights and shadows on a terrain
Maps can contain points, lines, areas simultaneously

- Reference map: provide some general reference on countries and major cities
Maps can contain points, lines, areas simultaneously

- Topographic map: benchmarks (points), contours (lines) and regions (areas)
Maps in time series

- Multiple maps focusing on the same area and the same theme can be generated in different years
- Animation can be created to vividly show the dynamic changes
Maps in time series

- Urbanization:
  https://www.youtube.com/watch?v=yKJYXujJ7sU

- Air traffic:
  https://www.youtube.com/watch?v=oR00_uLfGVE

- Living city project:
  https://www.youtube.com/watch?v=lJ8R8Kn8Ovs
Spatialization

- Using the cartographic approach to visualize non-spatial data
- Visualizing keywords from research papers
Choose a suitable map type

- A lot of geographic contents can be represented using different types of maps
  - E.g. terrain can be represented as either contours or irregular sample points
- What do you want to communicate?
  - Vivid images or quantitative numbers
  - Or both?
- Avoid some typical cartographic errors
  - Continuous data $\rightarrow$ gradually changing colors
  - Categorical data $\rightarrow$ different colors that are in contrast
A bad example

Any critics?
A bad example

- Title is too small
- Legend too big
- Color schema varies hue, but not saturation and value
- Data are not normalized by area
- No scale or reference graticule
- …
Human cognition in map design

- Maps are eventually used by humans
- Good maps should be easy to read and understand
- Designing a good map requires a cartographer to have basic understanding on human cognition
Visual center

- Human’s visual center is generally 5% above the geometric center
Eye tracking

- How could we scientifically find out where people generally look at when seeing a map?
Eye tracking

- The same strategy has been used to design GIS interface
Texts matter

- The same map with different titles
  - USA: Employment Distribution 2010
  - **USA: Employment Distribution 2010**
  - America at Work
  - Where the Jobs are Today?
  - America’s Great Recession
Layout matters

- A more balanced layout is generally preferred
- Not too much empty space

V.S.
Layout matters

- Align your map elements
Color matters

- Color is a complex visual variable and is specified by RGB or sometimes HSV/HSI/HSL.
Color matters

- HSV
  - **Hue**: specifies the hue (color) to which the color will be set
  - **Saturation**: specifies the intensity of saturation to which the color will be set
  - **Value**: specifies the intensity of white in the color
Color matters

ArcMap Symbology Tab:
Color matters

- Color design assistance: ColorBrewer [http://colorbrewer2.org/]
Lie with maps

**Fig. 2.** Crude birth rates, 2000, by state, based on equal-intervals cut-points and plotted on a visibility base map.

**Fig. 3.** Crude birth rates, 2000, by state, based on quantile cut-points and plotted on a visibility base map.

**Fig. 5.** Crude birth rates, 2000, by state, categorized to suggest dangerously low rates overall.

**Fig. 6.** Crude birth rates, 2000, by state, categorized to suggest dangerously high rates overall.
Tools

- Mapbox
- HERE data lens
- OpenLayers
- Mapzen
- Google Maps API
- ...

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