Data Maps
Location-Based Data Visualizations

IT 7113 Data Visualization
http://idi.kennesaw.edu/it7113/

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Overview

Location intelligence is an analytical capability that relates to geographic or other types of locational contexts of business data. The analysis based on this data can provide an additional aspect of business insights. Naturally, visualizing this data in a location-based context (map) has also gained popularity in many analytics and data exploration scenarios.

In this module, we will cover the following main points:

- Location intelligence and map
- Basics of data maps: three major elements
  - Location data
  - Base map
  - Data representation (layers)
- General data map types

Location Intelligence

- Spatial information, commonly known as “location", relates to the nature of “where”.

- Location intelligence (LI) is a business intelligence (BI) and analytics capability that relates geographic and location contexts to business data.
  - Location Intelligence organizes business and geographically referenced data to reveal the relationship of location to people, events, transactions, facilities, and assets.
  - http://searchbusinessanalytics.techtarget.com/definition/location-intelligence-LI

- Like business intelligence, location intelligence supports analysis and decision making. But for the past 20 years, these two data-centric disciplines have forged independent but parallel paths. Only now are they beginning to converge. The explosion of mobile and IoT devices facilitates the integration of business and location intelligence.
  - The first step toward converging location and business intelligence is plotting business metrics on a map.
  - The next step is the interactive process of location driven visual analytics, utilizing more sophisticated mapping layers and data presentation (even on three-dimensional surface, with the help of VR/AR technologies). https://www.youtube.com/watch?v=oQpBUn0nFq0
  - Also used for real time monitoring https://www.youtube.com/watch?v=Ri5HyHp5-_I
  - https://www.esri.com/news/arcuser/1012/files/morethanamap.pdf

- Location-based analysis
  - Coverage analysis, distance analysis, space time analysis

- Location based visualization (map) is the base for location intelligence and also plays an important role in data visualization.

Location Intelligence Market

- The global location intelligence market size was valued at USD 10.6 billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 15.2% over the forecast period.
- Growth factors
  - portable navigation devices, web-mapping services, and smartphone applications
  - Increasing investments in IoT, growing penetration of smart devices, and network infrastructure (e.g. 5G)

https://www.grandviewresearch.com/industry-analysis/location-intelligence-market

Location-based Visualizations

- Location-based visualizations, or commonly referred to as data maps, has been growing in the data visualization applications.
  - All of the leading front-end BI tools support interactive maps.
  - A 2015 survey http://sandhill.com/article/iot-and-the-growing-use-of-location-features-in-business-intelligence-software/
    - finds “map-based visualization of information as the top priority, and more than 95 percent of respondents rank it as at least somewhat important.”
    - more than 60 percent report that the functionality for layered visualizations is “very important” or “critical” for their organization.

- Why maps
  - Visualizations are strong in integrating multiple aspects of elements, including background and supplemental context, and provide an overall perception.
  - Location as a context is visualized as familiar maps or areas, and corresponding data items are mapped to the space.
  - Map is a major way to provide background and context information related to locations. Maps provide context … Quickly associate data with familiar position/location – added familiarity increase comprehension. (Tableau “The Power of Where” https://www.tableau.com/learn/whitepapers/government-mapping)
  - Maps are widely recognized and understood—even by nontechnical professionals—which helps make the data represented more accessible and understood. (Forbes “The Power of Place” https://www.forbes.com/forbesinsights/pitney_bowes_power_of_place/)

Compare These Two Visualizations

Bar charts for states can quickly identify the magnitude of the values, but lack of sense of location.

The map can give a sense of location context and show regional patterns.

Map Usages

- Maps are widely applicable in many industries, such as retail, logistics, hospital, government, public service, weather, sports, fleet management, delivery and logistics, flights, rides share, public transportation etc.
  - Environment
    - https://insights.sustainability.google/
  - City planning/management
    - http://boston.maps.arcgis.com/home/index.html
  - Election
    - https://trends.google.com/trends/story/election2016
  - Explore the city and region
    - https://opendata.atlantaregional.com/
    - https://neighborhoodnexus.org/maps-and-data/maps/
    - https://citygeographics.org/
  - Sports analytics
    - https://grantland.com/features/kirk-goldsberry-introduces-new-way-understand-nba-best-scorers/
  - Space management: seating, parking, room/building
    - https://public.tableau.com/profile/osmguy#!/vizhome/2015WorldSeriesTicketPrices/2015WorldSeriesTicketPrices
- Maps are also used in real time event monitoring and forecasting
  - Crisis management: https://www.crisisready.io/
  - Natural phenomenon like storm, hurricane, flood, etc. https://ai.googleblog.com/2020/09/the-technology-behind-our-recent.html
  - Transportation, delivery, logistics tracking
- See more examples of data with maps
  - http://metrocosm.com
  - https://www.tableau.com/learn/articles/interactive-map-and-data-visualization-examples

Geographic Information Systems (GIS)

- The idea of mapping data isn't new. Geographic information systems (GIS) have been around for decades, but they existed for a particularly limited scope.
- They required special training and were rarely used by mainstream companies because they lacked a clear-cut business case and workers needed expertise.
- http://searchbusinessanalytics.techtarget.com/feature/Bringing-location-intelligence-software-to-the-masses

Data Visualization with Maps

There are three major elements in map-based data visualization:

1. Types of location data
2. Base map (background map)
3. Data representations on the map (as map layers)

- Two broad categories of data maps based on these three elements
  - Geo data map
    - Geo location
    - Geo base map
    - Data associated with geo location
  - Contextual data map
    - Contextual location
    - Contextual base map
    - Data associated with contextual location

1. Types of Location Data

- Most common business uses of spatial information deal with locations on the earth, but spatial is not constrained to a geographic location.

- There are basically four types of location data
  1. Direct/precise geo location coordinates
  2. Logical geo location data
  3. Contextual (relative) location data
  4. Abstract location (position) data
     - Illustrational representation of a logical space, using X,Y coordinates
     - Examples: process, network, structure, etc.

Abstract location data is not our focus in this module or this class.

Geo Location Coordinates

- Geo location coordinates, or GPS coordinates, are a pair of numbers based on longitude and latitude values.
- Example

  Kennesaw, GA 30156, United States of America

  Latitude: 34.023434 | **Longitude:** -84.61549

- See more details at https://gisgeography.com/latitude-longitude-coordinates
- Get coordinates at https://www.gps-coordinates.net

A data map with data items mapped as pins.
Image from Map Marker https://maps.co

Logical Geo Location Data

- Locations are based on geo space, but they do not use GPS coordinates, but use names or labels that can be mapped.

- These locations need to be translated into the GPS coordinates system, or other types of coordinates of an illustrational map.
  - A visualization tool may be aware of these locations and map them automatically (with geo code mapping built-in).
  - Or use external tools or services

- Examples
  - Address (Tableau cannot map this level see https://kb.tableau.com/articles/howto/address-level-mapping)
  - Standard geo areas
    - Continent, island, river, lake, etc.
    - Country, state, zip, city, school district, voting region, etc.
  - Custom grouping of standard areas
  - Non-standard
    - Community, land use zones
    - Parking lot
    - Land regions (park, airport, campus)
    - Road, path, railway

http://www.270towin.com

https://fivethirtyeight.com/features/where-your-state-gets-its-money/

Tableau supported location types

How do organizations use geo location data?

Where to get location data?

Q6: With respect to collecting location data, which of the following challenges does your organization face? Select all that apply.

ENSURING DATA QUALITY AND ACCURACY	49%
GATHERING DATA REAL TIME	40%
EXTRACTING DATA FROM EXISTING SYSTEMS IN A USABLE WAY	39%
STORING AND SECURING THE DATA COLLECTED	36%
NORMALIZING AND CLEANING THE DATA	35%
MANEUVERING LOCATION PRIVACY ISSUES	32%
KNOWING WHERE TO FIND THE DATA YOU'RE LOOKING FOR	32%
IDENTIFYING THE SOURCES OF DATA	31%
HAVING THE APPROPRIATE TECHNOLOGY TO COLLECT DATA	28%
HAVING SUFFICIENT PERSONNEL RESOURCES TO COLLECT DATA	26%
MAINTAINING THE HEALTH OF DATA SYSTEM	24%
HAVING ADEPT PERSONNEL TO COLLECT DATA	23%
OTHER	0%

Q7: With respect to analyzing location data, which of the following challenges does your organization face? Select all that apply.

EXTRACTING, CLEANING, AND TRANSFORMING THE DATA INTO WORKABLE FORMAT	41%
ENSURING SUFFICIENT DATA IS AVAILABLE FOR ACTIONABLE ANALYTICS	38%
MAKING SENSE OF THE DATA	37%
HAVING STAFF WHO ARE PROFICIENT TO RUN THE ANALYSIS	36%
ENSURING THE LOCATION DATA IS UP-TO-DATE	33%
DETERMINING THE ACCURACY OF GEOCODING	32%
HAVING THE APPROPRIATE ANALYTICAL TOOLS	32%
DRAWING INSIGHTFUL FINDINGS FROM THE DATA	31%
ACCESSING DATA COLLECTED BY OTHER DEPARTMENTS	30%
HAVING ADEQUATE TIME AND/OR PERSONNEL RESOURCES TO PERFORM ANALYSIS	29%
OVERCOMING TECHNICAL DIFFICULTIES WHEN USING THE ANALYTICAL TOOLS	26%
OTHER	0%
I DON'T KNOW / NOT SURE	5%

Contextual Location Data

- Contextual location data is based on relative positions in a limited confined region
  - usually independent of the geo space
- These data are usually visualized in map-like illustrations.
- Locations are often coded as X,Y coordinates for the mapping process
  - Mappings need to provided by the designer or a third party.
- Examples:
  - building, room, shelf, stadium, court, fields, body,
  - vision (a space with real world context of what a human or device sees. Often used in Augmented Reality).

https://public.tableau.com/en-us/s/gallery/seasons-nba-shots

2. Base Map

- Base map is the underlying background layer that provides the location context.
  - A base map should provide enough contextual information about the space/location but does not interfere with the thematic data layer
- Types of location context (base map)

Base map type	Map construction	Location data	Description
Geospatial map (geo map)	Geo map	Geo coordinates or logical geo data	• Visualize geo location related data directly on real world maps, utilizing GPS coordinates, or relying on a system to translate GPS coordinates.
Geo chart (geo shape map)	Illustrational diagram, shape	Logical geo data	• These are conceptually related to geo location but presented in more abstract shapes, rather than accurate geo locations. • Sometimes they can even go symbolic: tile grid map
Tile grid map	Illustrational diagram with standard size and shape	Logical geo data or non geo data	• The base map is made of symbolic areas (usually regular shapes like square, circle, hexagon, etc.) that abstractly represent locations.
Contextual map	Real spatial or object image; or illustrational diagram	Non geo data	• Any data relevant to the positioning in a particular confined context or space, e.g., building, campus, mall, stadium, keyboard, or just a logical space (like a batting/hitting area) etc. • Again, these maps can be real-world imaging based or illustrational diagram based.

Geo Map

- Geo maps use realistic world images
- Some commonly used sub-types of geo maps
  - basic landform, topographic map, terrain, political, transportation view, and satellite image.
- The projection of sphere images onto a 2D space needs some techniques.
  - different ways of earth projection on 2D https://observablehq.com/collection/@d3/d3-geo-projection

https://communityhealthmaps.nlm.nih.gov/2017/10/23/mapping-south-floridas-king-tides/

Geo map base map can also have satellite image layer to provide more and richer contexts.

Geo Map Styles/Layers

Geo map base map can be just a plain map with minimum landform features. In this example, basically land/water lines.

http://luminocity3d.org/WorldCity

Geo map base map can also provide basic political regions (borders, etc.) as contexts.

http://qonnections2016-charts.qlikcloud.com/57279cd9c22f280100294eaa/chart.html

Geo Charts

- A geo chart basically resembles a geo map, but it is not based on geo location coordinates.
  - Continents, countries, or other types of regions are represented by shapes, with varied level of details. To certain extreme, the shapes may even utilize standard one-size shapes – see the tile grid map.
- The generation of this kind of base map does not need special GIS software
  - It may use a shape definition file, language, a just a static image.
- The mapping of data is more based on custom coordinates mapping instead of direct geo coordinates mapping

http://www.citylab.com/politics/2014/04/2-very-different-migrations-driving-growth-us-cities/8873/

https://developers.google.com/chart/interactive/docs/gallery/geochart

Cartogram

- A **cartogram** is a map/chart that is reshaped or resized to represent data such as population demographics, business data, or natural phenomena. In the map below, for example, the sizes of the states represent the total number of African Americans.

Image from https://www.caliper.com/glossary/what-is-a-thematic-map.htm

Tile Grid Map

- Tile grid maps abstractly use simplified symbols (tiles) to represent geo regions
  - just like geo charts, but even more abstract and less accurate.
  - Purely representational, least accurate
- Common use cases
  - Eliminate the Alaska effect on US maps
  - Need to standardize places of irregular shape and different sizes
  - Provide a more modern look
- Not ideal when
  - Geographical precision is important

Key readings about tiled grid map:

- https://forumone.com/ideas/good-data-visualization-practice-tile-grid-maps-0
- http://blog.apps.npr.org/2015/05/11/hex-tile-maps.html

https://fivethirtyeight.com/features/where-your-state-gets-its-money/

Why Tiles?

- Map project distortion
  - https://en.wikipedia.org/wiki/Map_projection
  - https://observablehq.com/collection/@d3/d3-geo-projection
- Tiny states are hard to be visualized

Alaska effect in Mercator projection

States are now represented in shapes with equal sizes

https://www.tableau.com/about/blog/2017/1/viz-whiz-hex-tile-maps-64713

Tile Grid Map Variations

See more details about tile grid maps in module 7.

http://blog.apps.npr.org/2015/05/11/hex-tile-maps.html

http://afterthefloood.co/projects/london-squared-map

https://www.dailykos.com/stories/2013/7/9/1220127/-Daily-Kos-Elections-2012-election-results-by-congressional-and-legislative-districts

http://bfongdata.blogspot.com/2015/11/periodic-table-map.html

Contextual Map

- Contextual maps do not use geo location data and the area is smaller or confined in a specific place.
- Examples of local contextual spaces
  - Sports playing court/field
    - Especially used in sports, like tennis, basketball, soccer, etc.
    - https://www.espn.com/nba/story/_/id/27587041/the-absolute-best-shooters-nba-decade
  - Space/seating utilization
    - Building, mall, park, stadium (https://public.tableau.com/profile/stanke#!/vizhome/HackyourMNTwinsTickets/TicketHack), hospital, classroom, airplane, parking
  - Space or layout of smaller objects like keyboards, screens, etc.
  - Open air space like bat hitting areas
- Contextual base maps can have two styles
  - Abstract diagrams (illustrational map): Illustrational maps simplify map details and use symbols to represent map objects. The goal is to illustrate relative positioning rather than accuracy.
  - More realistic, based on actual photo or image

This lecture focuses on geo maps. See more details about contextual map in module 7.

Originally from http://fatalities.safer63and881.com/#highway

http://public.tableau.com/profile/datavizard#!/vizhome/MLBBatterHotColdZones/BatterHotCold

https://www.espn.com/tennis/story/_/id/16954858/how-andy-murray-took-milos-raonic-become-wimbledon-champion

3. Data Representations

- There are basically three basic forms of visual elements on a map
  - Point: the data value is associated with point on the map
  - Area: the data value is associated with a polygon that covers a region
  - Line/flow: the data value is associated with a path connecting more than one point
- These elements are associated with selected measures to represent values, using common visual properties such as size, color, etc. (see SCOPeS visual properties), or even a secondary chart.
- Visual elements can be arranged in layers (overlapped, or toggled to show/hide independently)

Key reading: https://www.qlik.com/blog/data-visualization-foundations-mapping

Point Based Mapping

- Locations are represented as points on the map, based on geo coordinates
  - Usually represents smaller but many locations
  - Data values are represented by properties associated with the point
  - Can use more visual variables for more data dimensions, like shape, color, size, texture, etc. – size: proportional symbol map
  - Sometimes points are charts themselves

http://luminocity3d.org/WorldCity

- Major types of point-based map
  - ***Proportional symbol map (bubble map)***
  - ***Dot density map***
  - 3D prism map
  - Clustered point - a point representing a larger area

- Further reading: https://www.qlik.com/blog/data-visualization-foundations-mapping-point-data

Proportional Symbol Map

- Proportional symbol maps, or bubble maps, scale the size of simple symbols (usually a circle/bubble) proportionally to the data value associated with that location.
- Reference
  - https://www.axismaps.com/guide/proportional-symbols

Classic bubble map. Use size (number of people) and color (in-flow or out-flow) to code two variables.

http://www.citylab.com/politics/2014/04/2-very-different-migrations-driving-growth-us-cities/8873/

Arrow is the symbol here. Two measures are encoded with the symbol using three visual properties: orientation (direction) and color represent change; its length represents magnitude (although not continuous).

https://www.nytimes.com/interactive/2021/08/12/us/2020-census-race-ethnicity.html

Dot Density Map

- A dot density map uses dots or other symbols on the map to show the values of one or more numeric data fields.
  - Each dot on a dot-density map represents some amount of data.
  - In a dot-density map, areas with many dots indicate high concentrations of values for the chosen field and fewer dots indicate lower concentrations.
  - Dots are typically of the same size, and do not use size to code a measure.
  - It is similar to a scatter plot but based on location data
  - Dot Density Maps visualize a large quantity of data points. They can provide a perception of density (pattern) but are also difficulty to browse.
  - Example: http://racialdotmap.demographics.coopercenter.org/

- Usage
  - Population density

- Alternative designs
  - Dynamic cluster map: dynamically cluster higher concentrated locations into clusters
    - https://www.arcgis.com/apps/Cascade/index.html?appid=4eff1f0e80344639b918cbd99b8523ff
    - https://blog.mapbox.com/clustering-millions-of-points-on-a-map-with-supercluster-272046ec5c97
  - Isopleth grid map: If individual points are not the focus: Heat map - turn points into areas, using color coding for density

- Also used in motion maps
  - https://www.patreon.com/posts/united-states-of-20329634

Change dot density into isopleth grid map

https://www.sirvizalot.com/2016/05/how-to-density-maps-using-hexbins-in.html

Area Based Mapping

- There are basically two types of areas: predefined and dynamic

1. Choropleth map (Area Filled Map)
   - Defined areas, based on the map context
   - Predefined geo regions like country, state, city, zip code
   - Predefined non-geo regions like parts of a football field
2. Isopleth map
   - Dynamic area (heat map), based on data
   - Heat maps (isopleth maps) differ from choropleth maps in that the data is not grouped to a pre-defined unit like a city district.

Choropleth Map (Area Filled Map)

- Data is represented using polygons corresponding to defined geo regions
  - Can only use color or texture to visualize data.
  - https://en.wikipedia.org/wiki/Choropleth_map
- The layer is divided into different regions, and data will be mapped to the regions as units
  - Common types of regions include pollical areas like country, state, county, or other defined by businesses like postal (https://www.gasbuddy.com/GasPriceMap), phone code, school district, or marketing/sales area.
  - Regions generally correspond to geo locations, but they may be less detailed and accurate.
- Usage
  - Politics
  - Land use
- "Choropleth maps are sometimes incorrectly referred to as heat maps. A choropleth map features different shading or patterns within geographic boundaries to show the proportion of a variable of interest, whereas the coloration a heat map (in a map context) does not correspond to geographic boundaries"
  - see http://blog.gretchenpeterson.com/archives/2694

https://googletrends.github.io/search-election-election-night/

http://www.270towin.com

http://www.unfpa.org/world-population-dashboard

Isopleth Map (Heatmap on Maps)

- Isopleth maps show areas with continuous distribution.
  - An isopleth differs from a choropleth because the regions are determined by the data (dynamically formed) rather than conforming to a predefined area, such as a city and state.

- Usage
  - Isopleth maps are ideal for showing gradual change over space and avoids the abrupt changes which boundary lines produce on choropleth maps.
  - Isopleth maps may use lines to show areas where elevation, temperature, rainfall, or some other quality is the same; values between lines can be interpolated.
  - Isopleths may also use color to show regions where some quality is the same; for example, a map that use shades from red to blue to indicate temperature ranges. Temperature, for example, is a phenomenon that should be mapped using isoplething, since temperature exists at every point (is continuous), yet does not change abruptly at any point (like population density may do as you cross into another census zone).
  - Used in weather, climate

- Examples
  - Geo heat map https://www.maptive.com/feature/heat-mapping-tool/
  - Grouped regions (binned) https://www.sirvizalot.com/2016/05/how-to-density-maps-using-hexbins-in.html
  - Heat map on a keyboard: https://www.patrick-wied.at/projects/heatmap-keyboard/
  - Heat map on a web page: https://www.hotjar.com/heatmaps

- Variation
  - Hex binning grid map: small bins give some levels of ordered boundaries.

Hex binning grid map

https://www.sirvizalot.com/2016/05/how-to-density-maps-using-hexbins-in.html

Granularity of Areas

- On Choropleth maps, granularity of regions are also predefined, such as the hierarchy of country → state → county
- On isopleth maps, granularity of regions can be more arbitrary depending on data availability.

This is a more granular level of areas

https://public.tableau.com/app/profile/datavizard/viz/PITCHfxheatmap/PITCHfx

http://public.tableau.com/profile/datavizard#!/vizhome/MLBBatterHotColdZones/BatterHotCold

How are points and areas mapped to base map?

- Automatic translation
  - Most mapping services provide built-in features to translate common geo locations and areas, like address, city, state, zip, etc.
- Custom map based on geo codes
  - Non-standard places or areas can be defined by external geo coordinates as part of the data source

Line/Path Mapping (flow/network map)

- Using lines to represent relationships and paths - some kind of network graph in a location context
- Use scenario
  - Transportation/traffic lines, rides/travel
  - Moving path
- Visual variables
  - Thickness of the line
  - Color
- Variations
  - Line map
  - Flow map
- Usually for illustrating a path that consists of different locations in an order
  - Can use more visual variables for more data dimensions, like shape, color, size, texture, etc.
  - https://blog.qlik.com/data-visualization-foundations-mapping-flow-data

http://qonnections2016-charts.qlikcloud.com/57279cd9c22f280100294eaa/chart.html

https://twitter.com/RK_Stimp/status/734054780172144641
https://public.tableau.com/profile/publish/NewPassingViz/Dashboard1#!/publish-confirm

Path Map

Size/thickness represents traffic volume.

A line layer of highways with a size theme on the value of vehicle flow. Highways with more traffic are shown wider than those with less traffic.

https://www.caliper.com/glossary/what-is-a-thematic-map.htm

Color represents distance.

https://public.tableau.com/app/profile/grecian/viz/UKParaglidingXCLeague/Flightbrowser

Flow map

- Flow maps are often used to visualize origin-destination flow data. The origin and destination can be points or surfaces. The interaction data between the origin and the destination is usually expressed by a line that connects the geometric center of gravity of the space unit. The width or color of the line indicates the flow direction value between the origin and the destination. Each spatial location can be either a origin or a destination.

- Use scenarios: inter-regional trade, traffic flow, population migration, shopping consumption behavior, communication information flow, aviation routes, etc.

https://www.superdatascience.com/blogs/art-using-tableau-custom-maps

https://towardsdatascience.com/top-10-map-types-in-data-visualization-b3a80898ea70

3D Map

- Prism map utilizes the height property to represent a variable in regions.
- Very useful in a virtual 3D or immersive environment.
  - https://vcg.seas.harvard.edu/publications/tilt-map-interactive-transitions-between-choropleth-map-prism-map-and-bar-chart-in-immersive-environments

https://www.caliper.com/glossary/what-is-a-thematic-map.htm

https://towardsdatascience.com/top-10-map-types-in-data-visualization-b3a80898ea70

+ Charts on Map

- Use a chart (not just a dot or symbol) to represent a data point
  - Pie/waffle charts
    - https://onlinehelp.tableau.com/current/pro/desktop/en-us/maps_howto_filledpiechart.html
    - https://policyviz.com/2017/09/20/tile-grid-waffle-chart-map-in-excel
  - Bar charts
    - http://datavizproject.com/data-type/map-bar-chart/
    - https://www.dataplusscience.com/BarChartMaps.html
  - Line/area charts
    - https://www.sirvizalot.com/2016/05/how-to-small-multiple-tile-map-in.html
    - https://public.tableau.com/profile/matt.chambers#!/vizhome/MostVisitedNationalParksbyState2006-2016/MostVisitedNationalParksbyState2006-2016
    - https://coronavirus.jhu.edu/data/new-cases-50-states

https://homes.cs.washington.edu/~jheer//files/zoo/ex/maps/symbol.html

https://public.tableau.com/app/profile/matt.chambers/viz/MostVisitedNationalParksbyState2006-2016/MostVisitedNationalParksbyState2006-2016

A bird-eye view of various election data map styles: can you recognize the map types and identify the three elements?

Image from https://www.anychart.com/blog/2020/11/06/election-maps-us-vote-live-results/

Multi-Layer Map

- Maps can support multiple layers of base maps and data representation layers. These layers can be turn on/off interactively depending on user needs.
- Sometimes, more than one form data representations can be layered on the same base map.
- Example (dual axis map in Tableau):
  - Point + area dual layer map
    - https://help.tableau.com/current/pro/desktop/en-us/maps_dualaxis.htm
    - https://blog.databender.net/2014/06/23/points-and-polygons/
  - Area + area (different area definitions)
    - dual axis maps in Tableau https://www.youtube.com/watch?v=KymI5cC4ug0

Visual Variables Applied to Data Representation on Maps

- Position is inherent in all location related visualizations.
- How about orientation?

Shapes are used more often as symbols on maps

Often used.

https://www.slideshare.net/tillnagel/nagel-unfolding-thecityworkshops

Animated/Motion Map

- Added animation to show changes or movements
- Motion (changes) along the timeline
  - https://www.gapminder.org/tools/#$chart-type=map
  - http://tableau7.wordpress.com/2014/01/12/motion-map-chart/
  - https://www.patreon.com/posts/arms-sales-usa-21015616
- Motion (movements) indicating direction and speed
  - http://metrocosm.com/global-immigration-map/
  - https://googledataorg.cartodb.com/u/googledata/viz/bf595f4c-7381-11e5-9ec5-42010a14800c/public_map

This class does not focus on motion maps.
Students may conduct a research in this topic.

Map-Driven Data Exploration and Analysis

- Map-driven apps and dashboards for event monitoring, data exploration, and analysis
  - These kind of apps and dashboards use a big map (often the complete screen) as the basis for data visualization and user interaction.
  - Sometimes evolves 3D spaces.

- Examples
  - Data exploration
    - http://luminocity3d.org
    - https://oerworldmap.org/resource/?view=map&size=20
    - https://www.globalforestwatch.org/map
  - Dashboard
    - JHU CCOVID-19 Dashboard https://www.arcgis.com/apps/dashboards/bda7594740fd40299423467b48e9ecf6
    - https://www.youtube.com/watch?v=Ri5HyHp5-_I
    - https://resourcewatch.org/data/explore
    - See more in the dashboard learning module.
  - Information exploration
    - http://www.healthmap.org/en/
    - http://www.sightsmap.com

This class does not focus on this kind of applications, but it is a very good research topic for class project.

Mapping Tools and Solutions

- Major location intelligence vendors
  - CARTO https://carto.com
  - Esri https://www.esri.com/en-us/location-intelligence
  - Pitney Bowes https://www.pitneybowes.com/us/location-intelligence.html
  - Galigeo, MapLarge, Near, Ubimo, etc.

- Web based tools
  - http://www.mapinseconds.com/
  - https://mangomap.com/
  - https://flourish.studio/visualisations/maps/
  - https://maps.co

- Most self-service BI tools provide mapping support
  - Tableau, Power BI, Qlik, FineReport

- Programming library and API (most visualization libraries provide support for geo charts)
  - http://datamaps.github.io
  - Google GeoChart https://developers.google.com/chart/interactive/docs/gallery/geochart
  - Google Map https://developers.google.com/chart/interactive/docs/gallery/map
  - https://mapsplatform.google.com
  - https://leafmap.org/maps/

- More information
  - https://www.g2.com/categories/location-intelligence
  - https://flatlogic.com/blog/top-mapping-and-maps-api/
  - http://oedb.org/ilibrarian/do-it-yourself-gis-20-free-tools-data-sources-for-creating-data-maps/

Location Platform Ratings

- https://www.counterpointresearch.com/maintains-location-platform-leadership-ahead-google-tomtom/

Key Resources

- Location Intelligence Is More Than a Map
  https://www.esri.com/news/arcuser/1012/files/morethanamap.pdf
- 12 Methods for Visualizing Geospatial Data on a Map
  https://www.safegraph.com/guides/visualizing-geospatial-data
- Map types by data encoding forms (point, area, flow):
  https://blog.qlik.com/data-visualization-foundations-mapping
- Tile Grid Map:
  - https://forumone.com/ideas/good-data-visualization-practice-tile-grid-maps-0
  - http://blog.apps.npr.org/2015/05/11/hex-tile-maps.html
- Mapping concepts in Tableau:
  https://help.tableau.com/current/pro/desktop/en-us/maps_build.htm

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Additional Good Resources

- https://www.perceptualedge.com/articles/visual_business_intelligence/geographical_data_visualization.pdf
- https://towardsdatascience.com/an-introduction-to-geographical-data-visualization-3486959cd4b8
- https://www.forbes.com/sites/forbesinsights/2017/01/19/location-intelligence-mapping-the-opportunities-in-the-data-landscape/
- https://carto.com/blog/really-good-guide-location-intelligence-implementation/
- Mapping example collections
  - https://citygeographics.org
  - http://metrocosm.com
  - https://vividmaps.com
  - https://flowingdata.com/category/visualization/mapping/
  - http://googlemapsmania.blogspot.com
  - https://carto.com/blog/eighty-data-visualizations-examples-using-location-data-maps/
- Books
  - https://go.carto.com/get-location-intelligence-for-dummies
- Concepts
  - https://en.wikipedia.org/wiki/Map_projection
- Maps for fun
  - https://www.youtube.com/watch?v=YH2sAbXv7p4
  - https://carto.com/blog/eighty-data-visualizations-examples-using-location-data-maps/

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