

# Data Visualization (CSCI 627/490)

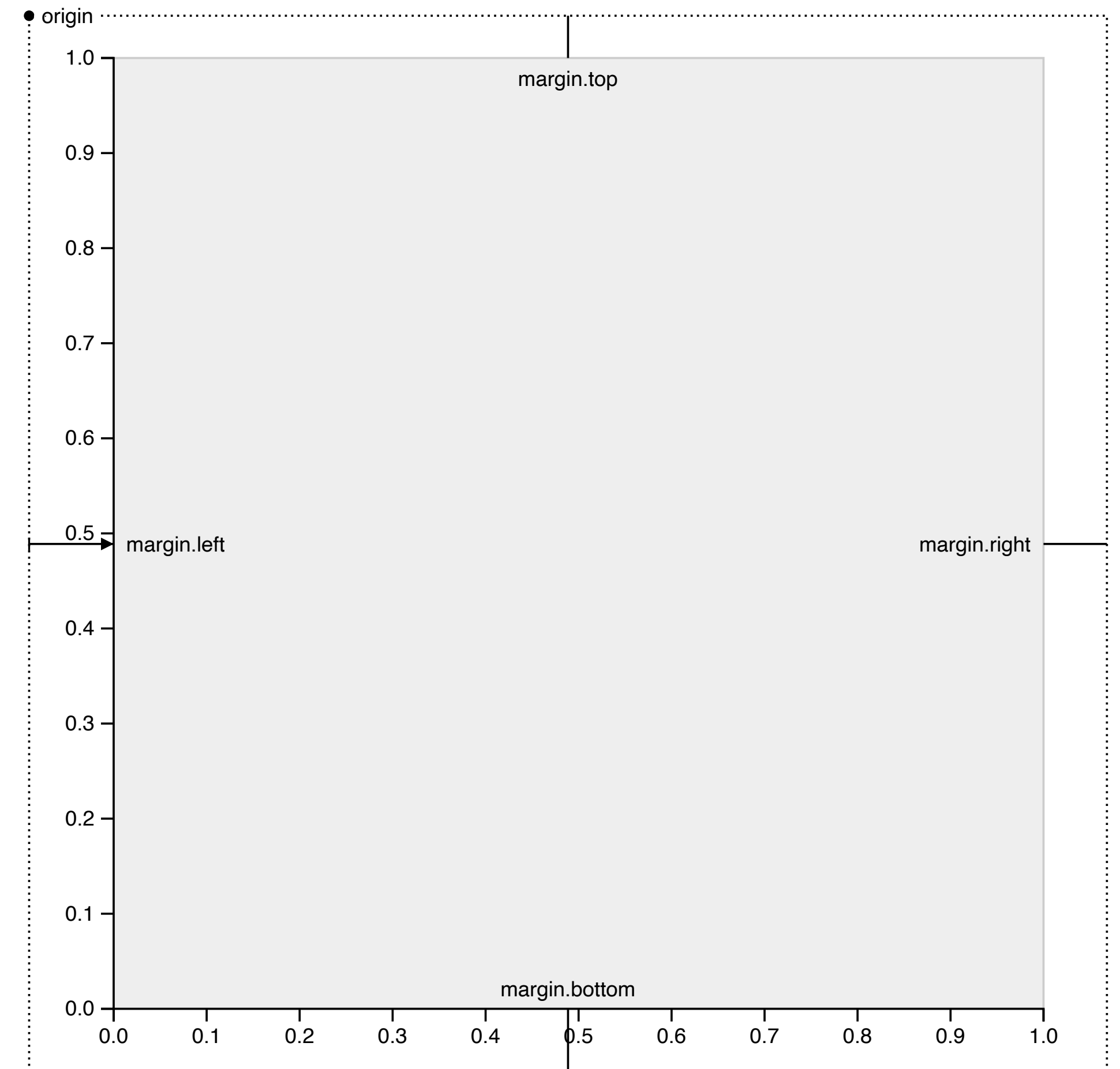
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## Marks and Channels

Dr. David Koop

# D3 Margin Convention

- Observable Notebook
- Three Bar Charts:
  - Similar Solution
  - With Axes and Scales
  - With Objects and Margin Convention
- More on Margin Convention:
  - <https://observablehq.com/@d3/margin-convention>



[M. Bostock]

# Toward Reusable Charts

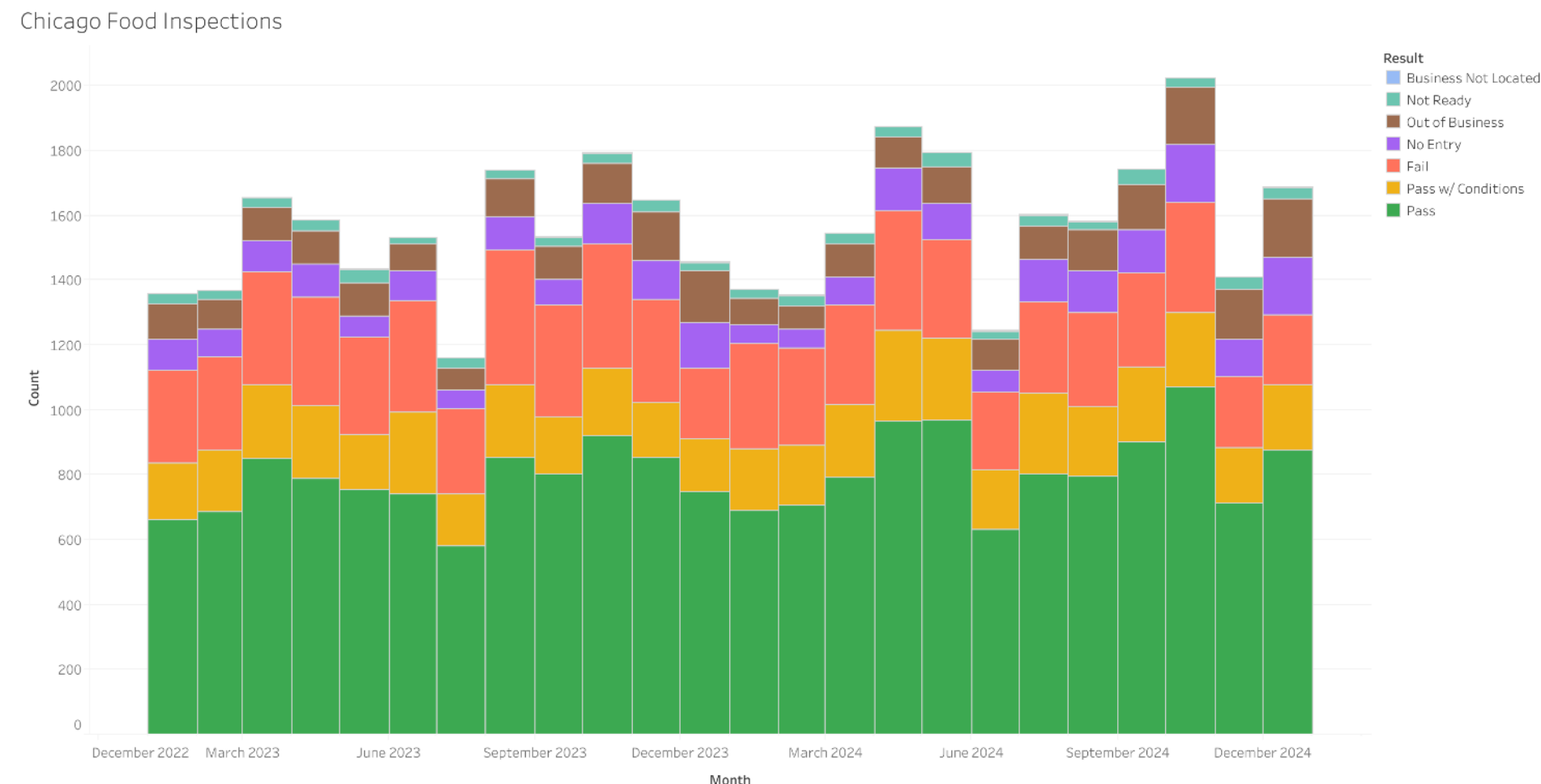
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- D3 does not provide "standard" charts
- E.g. there is no barchart method
- What is a standard chart?
  - "Should you expose the underlying scales and axes, or encapsulate them with chart-specific representations?"
  - "Should your chart support interaction and animation automatically?"
  - "Should the user be able to reach into your chart and tweak some aspect of its behavior?"

[Towards Reusable Charts, M. Bostock, 2012]



# Assignment 3



- Food Inspections Data
- Create the same stacked bar chart using
  - Tableau Public
  - Observable Plot
  - D3
- D3 Stacked Bar Chart:
  - Required for CSCI 627 students
  - CSCI 490 students need not stack

# Project

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- Start thinking about project dataset and questions
- Working on posting some example datasets
- Goal: Less explored datasets (more opportunity for design/questions)
- If you are doing research and can tie this project in, please talk with me

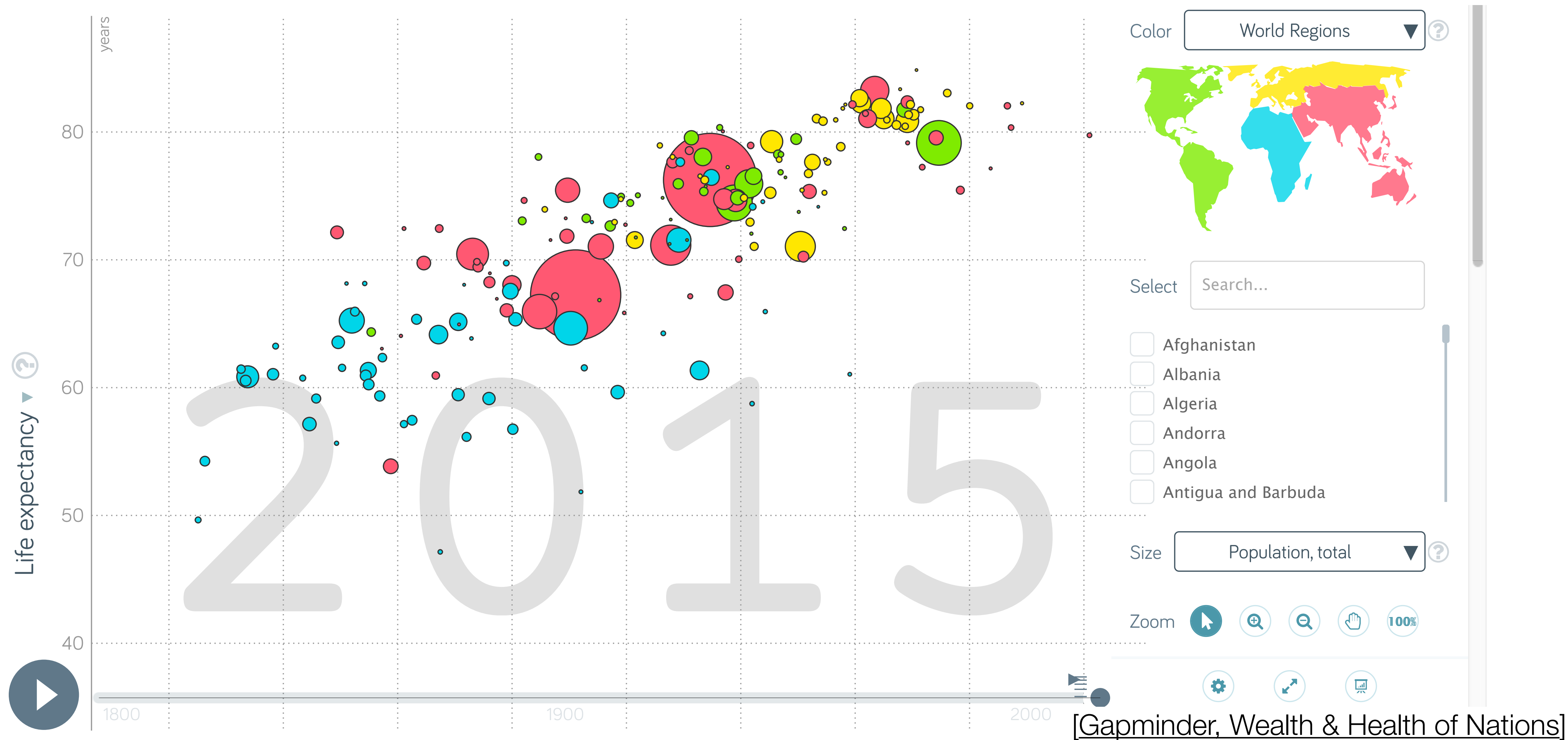
# Visual Encoding

- How should we visualize this data?

| Name          | Region                | Population | Life Expectancy | Income   |
|---------------|-----------------------|------------|-----------------|----------|
| China         | East Asia & Pacific   | 1335029250 | 73.28           | 7226.07  |
| India         | South Asia            | 1140340245 | 64.01           | 2731     |
| United States | America               | 306509345  | 79.43           | 41256.08 |
| Indonesia     | East Asia & Pacific   | 228721000  | 71.17           | 3818.08  |
| Brazil        | America               | 193806549  | 72.68           | 9569.78  |
| Pakistan      | South Asia            | 176191165  | 66.84           | 2603     |
| Bangladesh    | South Asia            | 156645463  | 66.56           | 1492     |
| Nigeria       | Sub-Saharan Africa    | 141535316  | 48.17           | 2158.98  |
| Japan         | East Asia & Pacific   | 127383472  | 82.98           | 29680.68 |
| Mexico        | America               | 111209909  | 76.47           | 11250.37 |
| Philippines   | East Asia & Pacific   | 94285619   | 72.1            | 3203.97  |
| Vietnam       | East Asia & Pacific   | 86970762   | 74.7            | 2679.34  |
| Germany       | Europe & Central Asia | 82338100   | 80.08           | 31191.15 |
| Ethiopia      | Sub-Saharan Africa    | 79996293   | 55.69           | 812.16   |
| Turkey        | Europe & Central Asia | 72626967   | 72.06           | 8040.78  |

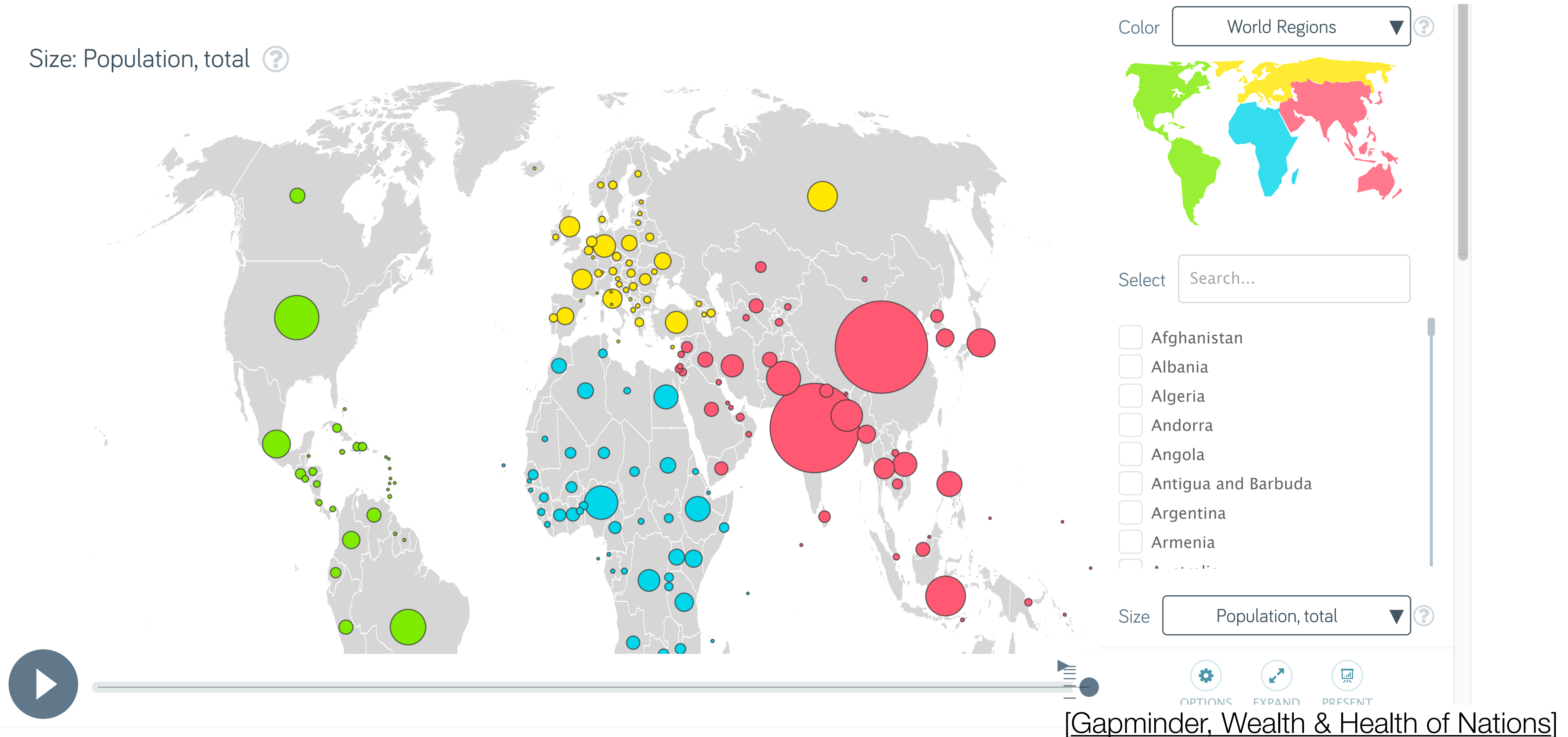


# Potential Solution





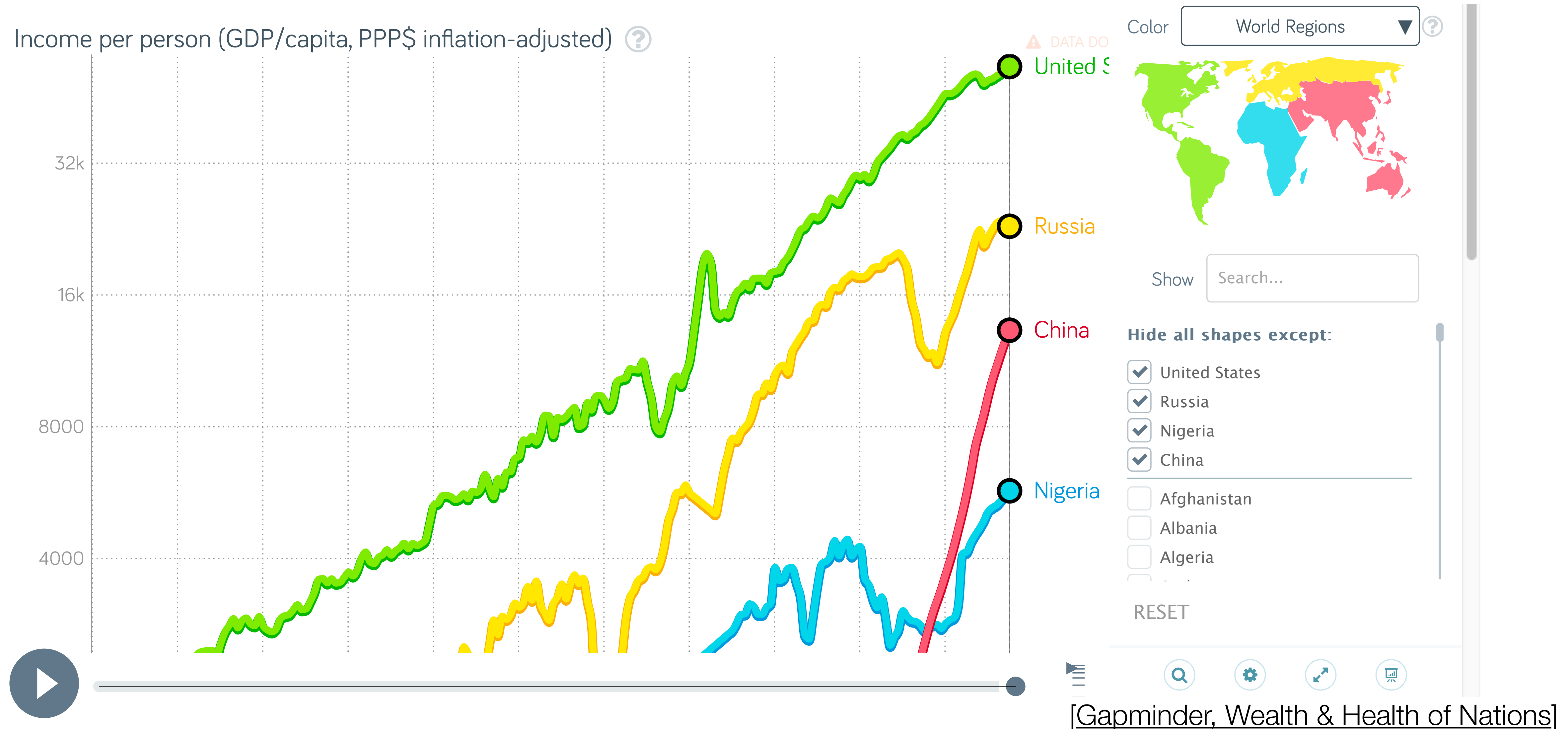
# Another Solution





What about change over years?

# Another Solution showing trends over time

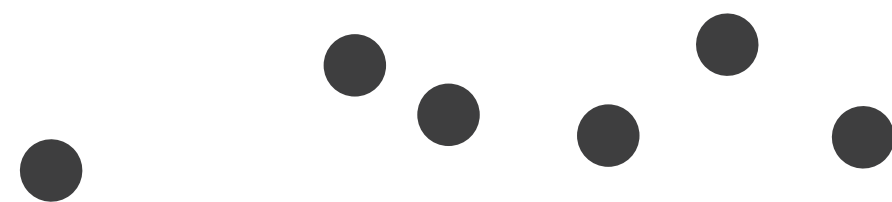


# Visual Encoding

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- How do we encode data visually?
  - **Marks** are the basic graphical elements in a visualization
  - **Channels** are ways to control the appearance of the marks
- Marks classified by dimensionality:

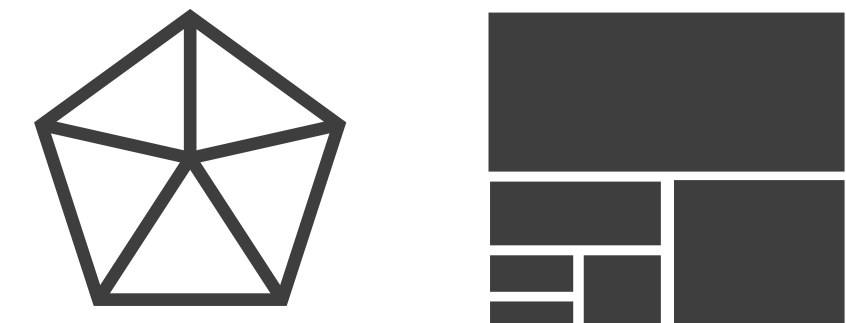
➞ **Points**



➞ **Lines**



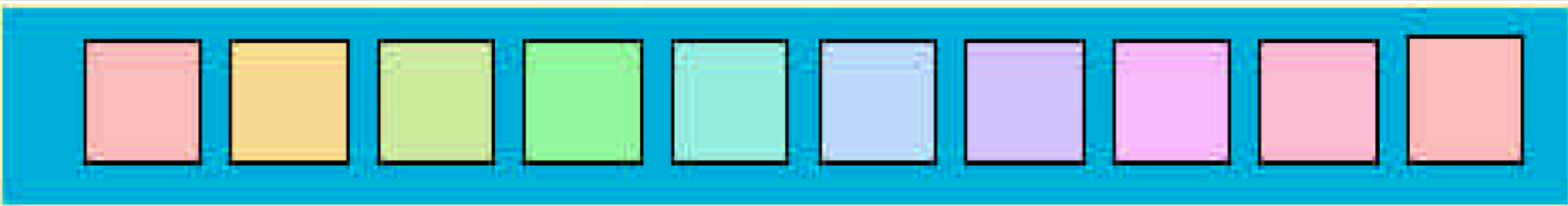
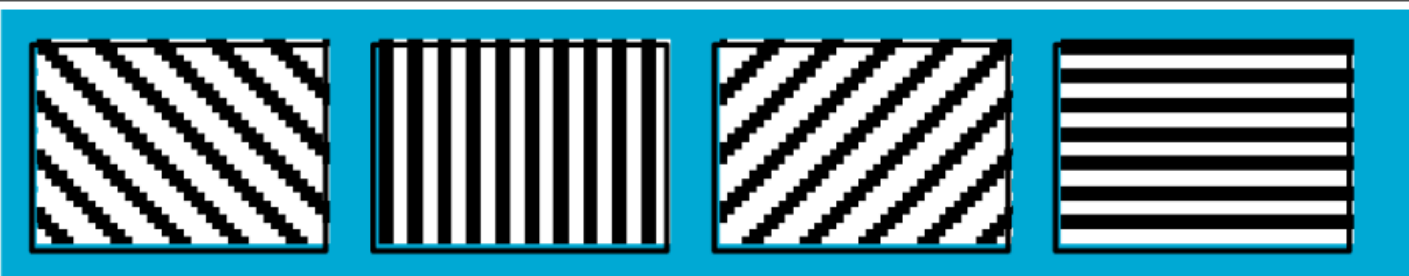
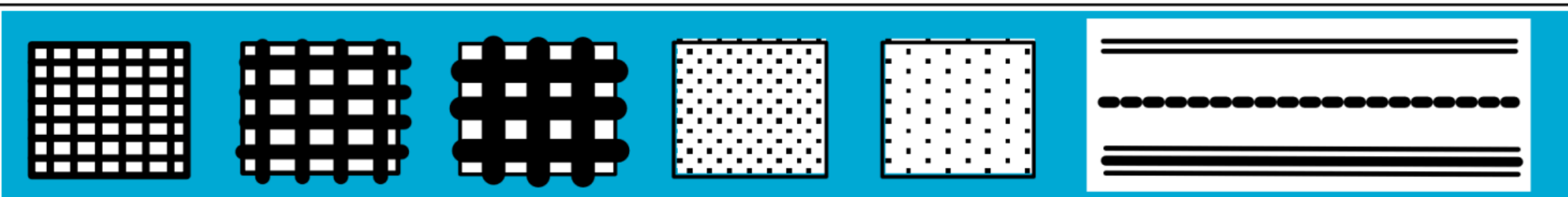
➞ **Areas**



- Also can have surfaces, volumes
- Think of marks as a mathematical definition, or if familiar with tools like Adobe Illustrator or Inkscape, the path & point definitions



# Bertin - Visual Variables

| Bertin's Original Visual Variables               |                                                                                       |
|--------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Position</b><br>changes in the x, y location  |    |
| <b>Size</b> change in length, area or repetition |    |
| <b>Shape</b><br>infinite number of shapes        |    |
| <b>Value</b><br>changes from light to dark       |   |
| <b>Colour</b><br>changes in hue at a given value |  |
| <b>Orientation</b><br>changes in alignment       |  |
| <b>Texture</b><br>variation in 'grain'           |  |

# Visual Channels

## ➔ Position

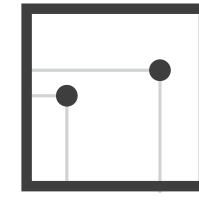
➔ Horizontal



➔ Vertical



➔ Both



## ➔ Color



## ➔ Shape



## ➔ Tilt

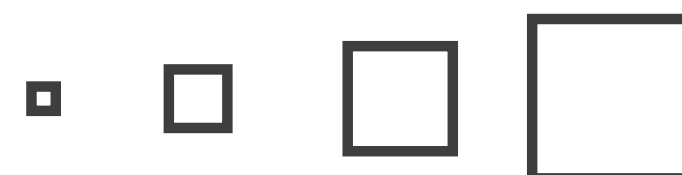


## ➔ Size

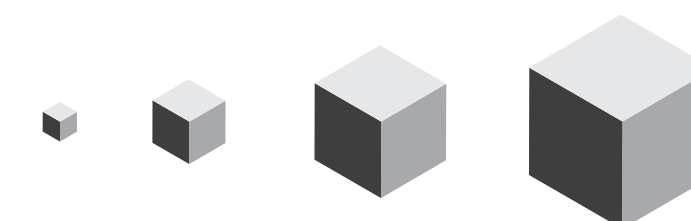
➔ Length



➔ Area



➔ Volume



[Munzner (ill. Maguire), 2014]



# Visual Attributes Survey

| Table of Visual Attributes<br>Richard Brath<br>v. Sept 2013 |                  | Information Visualization Researchers |                |                |                 |                |           |            |                |                    | Vision Rsch             | Shape Rsch      |
|-------------------------------------------------------------|------------------|---------------------------------------|----------------|----------------|-----------------|----------------|-----------|------------|----------------|--------------------|-------------------------|-----------------|
|                                                             |                  | Bertin 1967                           | Cleveland 1985 | MacKinlay 1986 | MacEachren 1995 | Wilkinson 1999 | Ware 2000 | Mazza 2009 | Illiinsky 2012 | Chen, Floridi 2013 | Preattentive Perception | Brath 2009/2011 |
| Trans-form                                                  | Position         | X                                     | X              | X              | X               | X              | X         | X          | X              | X                  |                         |                 |
|                                                             | Length           |                                       | X              | X              |                 |                | X         | X          | X              | X                  | X                       |                 |
|                                                             | Size (Area)      | X                                     | X              | X              | X               | X              | X         | X          | X              | X                  | X                       |                 |
|                                                             | Orientation      | X                                     |                | X              | X               | X              | X         | X          | X              | X                  | X                       |                 |
|                                                             | Volume           |                                       | X              | X              |                 |                | X         |            |                |                    |                         |                 |
| Shape                                                       | Shape            | X                                     |                | X              | X               | X              | X         | X          | X              | X                  |                         | X               |
|                                                             | Angle            |                                       | X              | X              |                 |                |           |            |                | X                  |                         | X               |
|                                                             | Curvature        |                                       |                |                |                 |                |           |            |                |                    | X                       | X               |
|                                                             | Mark             |                                       |                |                |                 |                |           |            |                |                    | X                       | X               |
|                                                             | Line Ending      |                                       |                |                |                 |                |           | X          | X              | 3                  | X                       | X               |
|                                                             | Closure          |                                       |                |                |                 |                |           |            |                | X                  | X                       | X               |
|                                                             | Local Warp       |                                       |                |                |                 |                |           |            |                |                    |                         | X               |
|                                                             | Edge Type        |                                       |                |                |                 |                |           |            |                | 1,2                |                         | X               |
|                                                             | Corner Type      |                                       |                |                |                 |                |           |            |                | 3                  |                         | X               |
|                                                             | Icon, glyph, etc |                                       |                |                |                 |                |           |            |                | 4                  |                         |                 |
| Colour                                                      | Brightness       | X                                     |                | X              | X               | X              | X         | X          | X              | X                  | X                       |                 |
|                                                             | Hue              | X                                     | X              | X              | X               | X              | X         | X          | X              | X                  | X                       |                 |
|                                                             | Saturation       |                                       |                | X              | X               | X              | X         | X          | X              | X                  |                         |                 |

[R. Brath]



# More Visual Attributes

| Table of Visual Attributes<br>Richard Brath<br>v. Sept 2013 |                   | Information Visualization Researchers |                |                |                 |                |           |            |                |                    |   | Vision Rsch             | Shape Rsch      |
|-------------------------------------------------------------|-------------------|---------------------------------------|----------------|----------------|-----------------|----------------|-----------|------------|----------------|--------------------|---|-------------------------|-----------------|
|                                                             |                   | Bertin 1967                           | Cleveland 1985 | MacKinlay 1986 | MacEachren 1995 | Wilkinson 1999 | Ware 2000 | Mazza 2009 | Illiinsky 2012 | Chen, Floridi 2013 |   | Preattentive Perception | Brath 2009/2011 |
| Texture                                                     | Granularity       | X                                     |                | X              | X               | X              | X         | X          | X              | X                  |   |                         |                 |
|                                                             | Pattern           |                                       |                |                |                 | X              | X         | X          | X              |                    |   |                         |                 |
|                                                             | Orientation       |                                       |                |                |                 | X              | X         |            |                |                    |   |                         |                 |
| Relation                                                    | Connection        |                                       |                | X              |                 |                |           | X          | X              | X                  |   |                         |                 |
|                                                             | Containment       |                                       |                | X              |                 |                |           | X          | X              |                    |   |                         |                 |
| Optics                                                      | Blur              |                                       |                |                | X               | X              |           |            |                | X                  |   |                         |                 |
|                                                             | Transparency      |                                       |                |                | X               | X              |           |            |                | X                  |   |                         |                 |
|                                                             | Stereo Depth      |                                       |                |                |                 |                |           |            |                |                    | X |                         |                 |
|                                                             | Concavity         |                                       |                |                |                 |                |           |            |                | X                  | X |                         |                 |
|                                                             | Light Direction   |                                       |                |                |                 |                |           |            |                | X                  | X |                         |                 |
|                                                             | Shadow            |                                       |                |                |                 |                |           |            |                | X                  |   |                         |                 |
|                                                             | Partial occlusion |                                       |                |                |                 |                |           |            |                | X                  |   |                         |                 |
|                                                             |                   |                                       |                |                |                 |                |           |            |                |                    |   |                         |                 |
| Move-<br>ment                                               | Flicker           |                                       |                |                |                 |                | X         |            |                | X                  | X |                         |                 |
|                                                             | Speed             |                                       |                |                |                 |                | X         |            |                | X                  | X |                         |                 |
|                                                             | Direction         |                                       |                |                |                 |                |           |            |                | X                  | X |                         |                 |
| Misc                                                        | Numerosity        |                                       |                |                |                 |                |           |            |                | X                  | X |                         |                 |
|                                                             | Spatial Grouping  |                                       |                |                |                 |                |           |            |                | X                  | X |                         |                 |
|                                                             | Arrangement       |                                       |                |                | X               |                |           |            |                |                    |   |                         |                 |
|                                                             | Resolution        |                                       |                |                | X               |                |           |            |                |                    |   |                         |                 |
|                                                             | Artistic Effects  |                                       |                |                |                 |                |           |            |                |                    | X |                         |                 |
|                                                             |                   |                                       |                |                |                 |                |           |            |                |                    |   |                         |                 |
|                                                             | Text Labels       |                                       |                |                |                 |                |           | X          | X              | X                  |   |                         |                 |

[R. Brath]

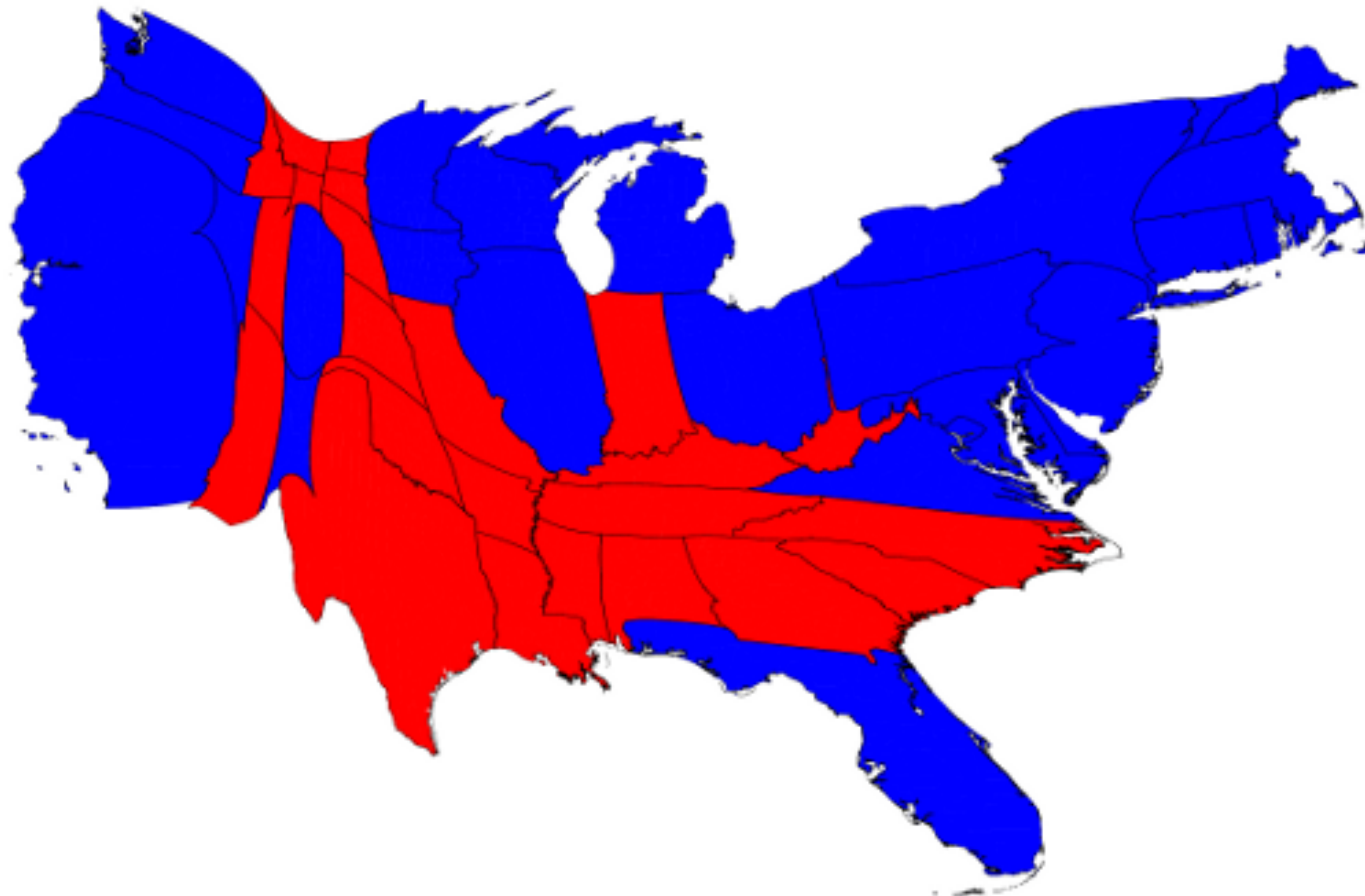
# Channels

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- Usually map an attribute to a single channel
  - Could use multiple channels but...
  - **Limited** number of channels
- Restrictions on size and shape
  - Points are nothing but location so size and shape are ok
  - Lines have a length, cannot easily encode attribute as length
  - Maps with boundaries have area, changing size can be problematic

# Cartograms

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[Election Results by Population, M. Newman, 2012]



# Channel Types

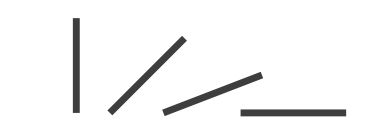
- Identity => what or where, Magnitude => how much

## ➔ **Magnitude** Channels: **Ordered** Attributes

Position on common scale 

Position on unaligned scale 

Length (1D size) 

Tilt/angle 

Area (2D size) 

Depth (3D position) 

Color luminance 

Color saturation 

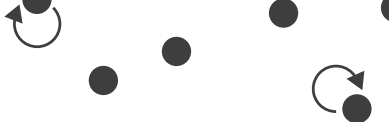
Curvature 

Volume (3D size) 

## ➔ **Identity** Channels: **Categorical** Attributes

Spatial region 

Color hue 

Motion 

Shape 

[Munzner (ill. Maguire), 2014]