



Module #3b: **Visual Variables**



The Designer's Role

- Your job as a visualization designer
 - Design an interpretable visual representation
 - Define the mapping function to algorithmically convert data to geometry
- The algorithmic requirement is important
 - Not a “one time design”
 - Repeatable for a defined class of data
 - What types of data? What prerequisites are there?
 - What are the “edge cases” that need to work?
 - How would the appearance of outliers impact the design?
 - How will it scale to larger volumes of data?
 - This is what makes mapping challenging

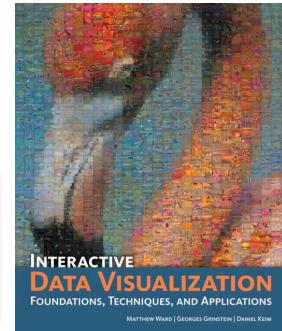


The Visual Variables

- **Eight “visual variables”** that can be controlled during the mapping process

1. Position
2. Mark
3. Size
4. Brightness
5. Color
6. Orientation
7. Texture
8. Motion

"Interactive Data Visualization"
by Matthew Ward, Georges Grinstein and Daniel Keim



Position

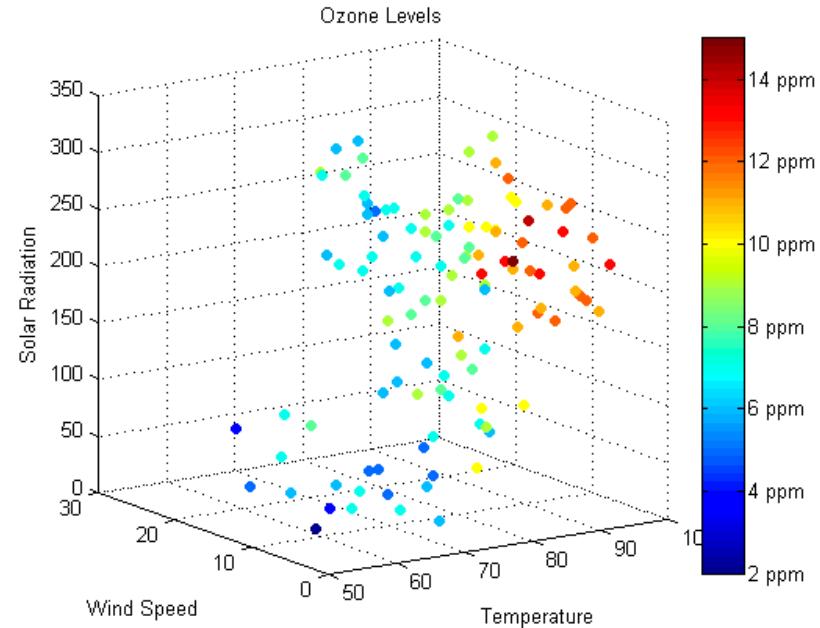
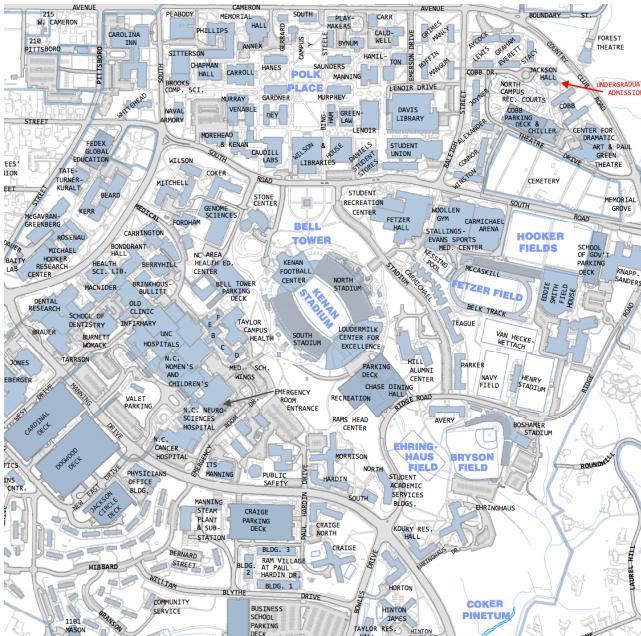
- The location of a visual object

- 1D



- 2D

- 3D (use rarely...)



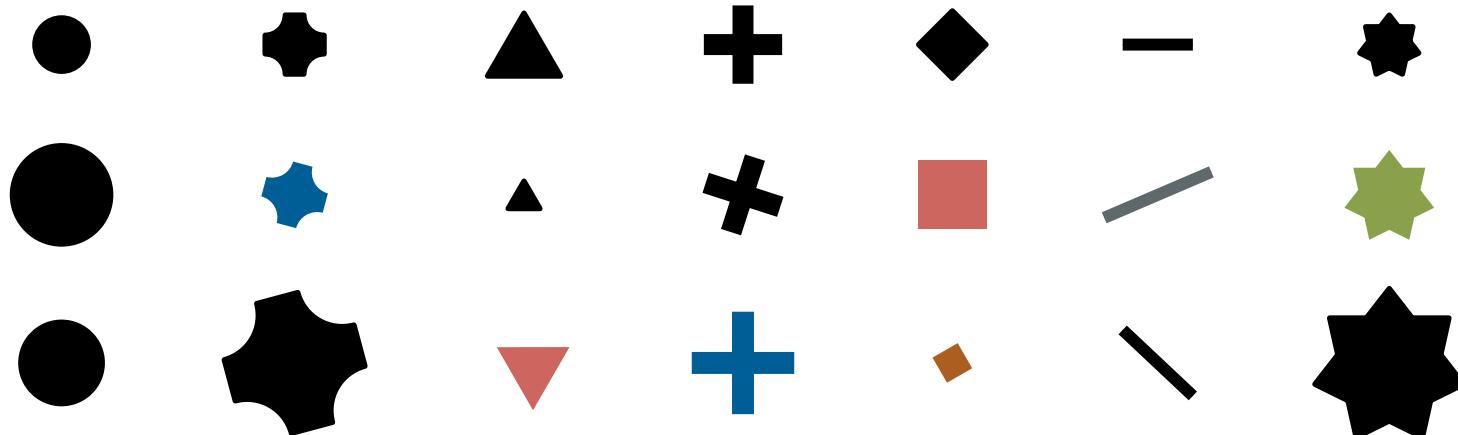


Marks

- A mark is an atomic graphical primitive

- Often called a “glyph” or “symbol”
- Embodied by the **shape** of a graphical object
 - A distinct composition of lines, areas, volumes
 - **Scale, orientation, color/shade are NOT considered**

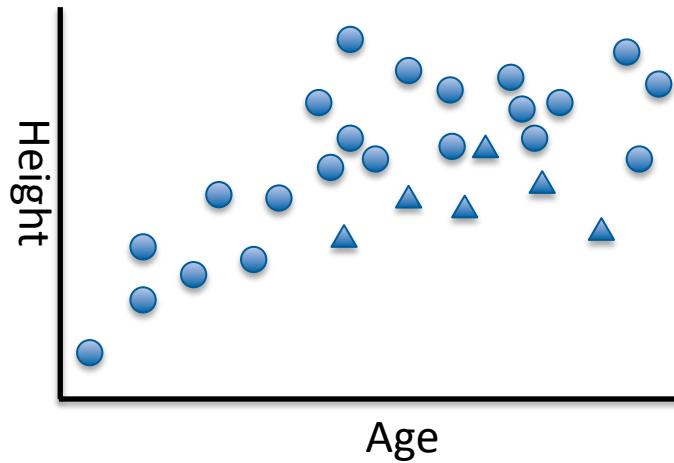
- Example marks:





Required: Position and Marks

- Both **position** and **marks** are required to define a visualization.
 - This is the minimum: **a mark drawn at a particular spot**
 - Without either, there is nothing to see

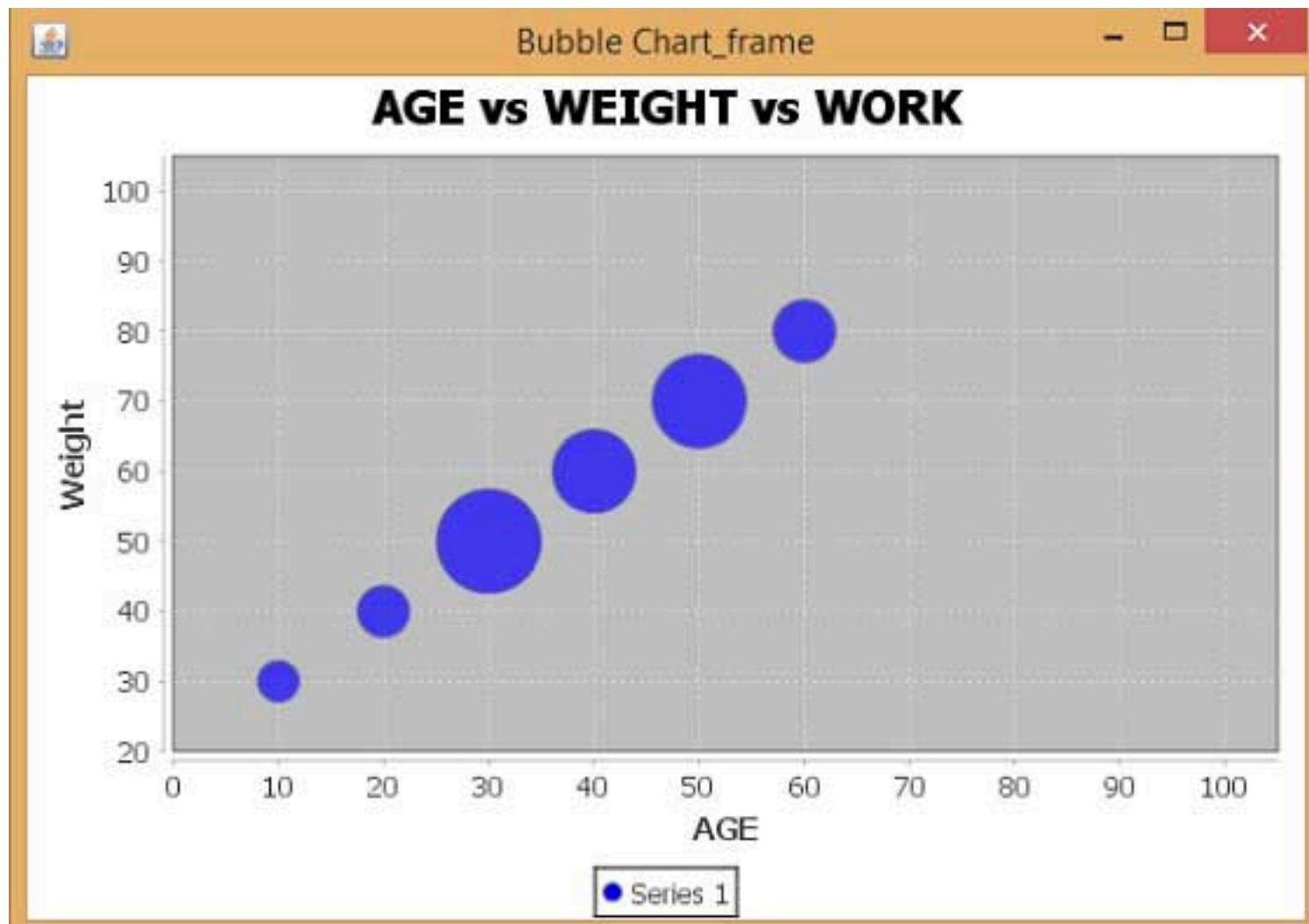




Size

- Marks can be drawn with varied size
 - 1D: length
 - 2D: area
 - 3D: volume

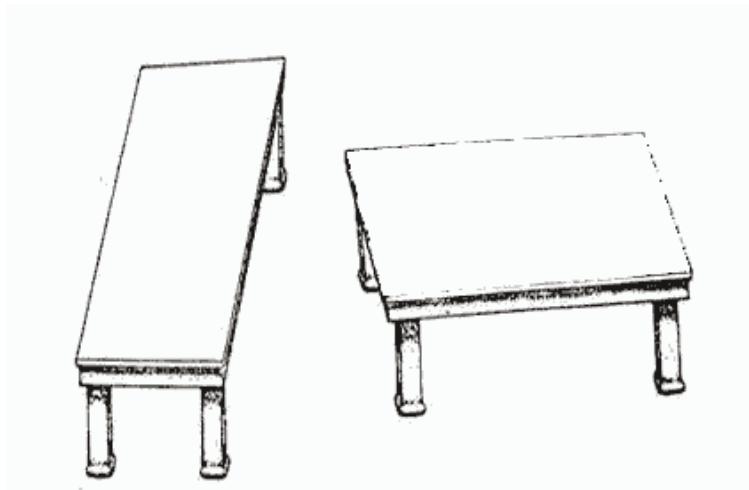
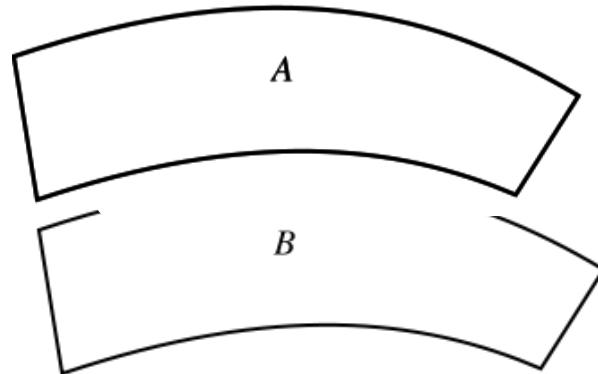
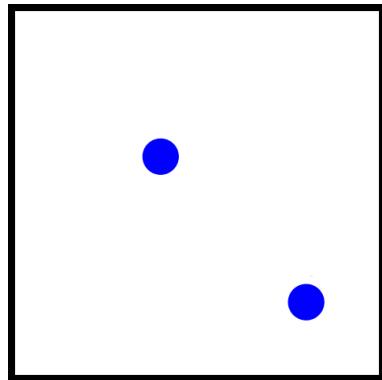






Beware Perception of Size

- Our ability to judge size is easily confused:

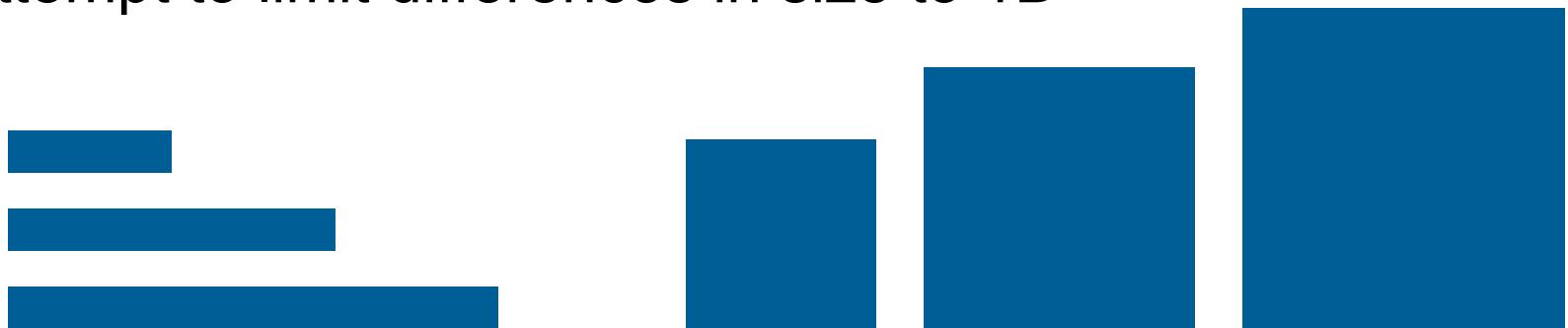




Suggestions For Effective Size Comparison

When possible...

- Attempt to limit differences in size to 1D



- Use position to align shapes





Brightness

- Like size, **brightness** (aka luminance) can be used to distinguish marks
 - Perception of brightness less precise than size.
 - **Hard to estimate magnitude of differences**
 - Sorting objects easier than magnitude of differences
 - **Small differences may be imperceptible**
- Compare brightness to size:



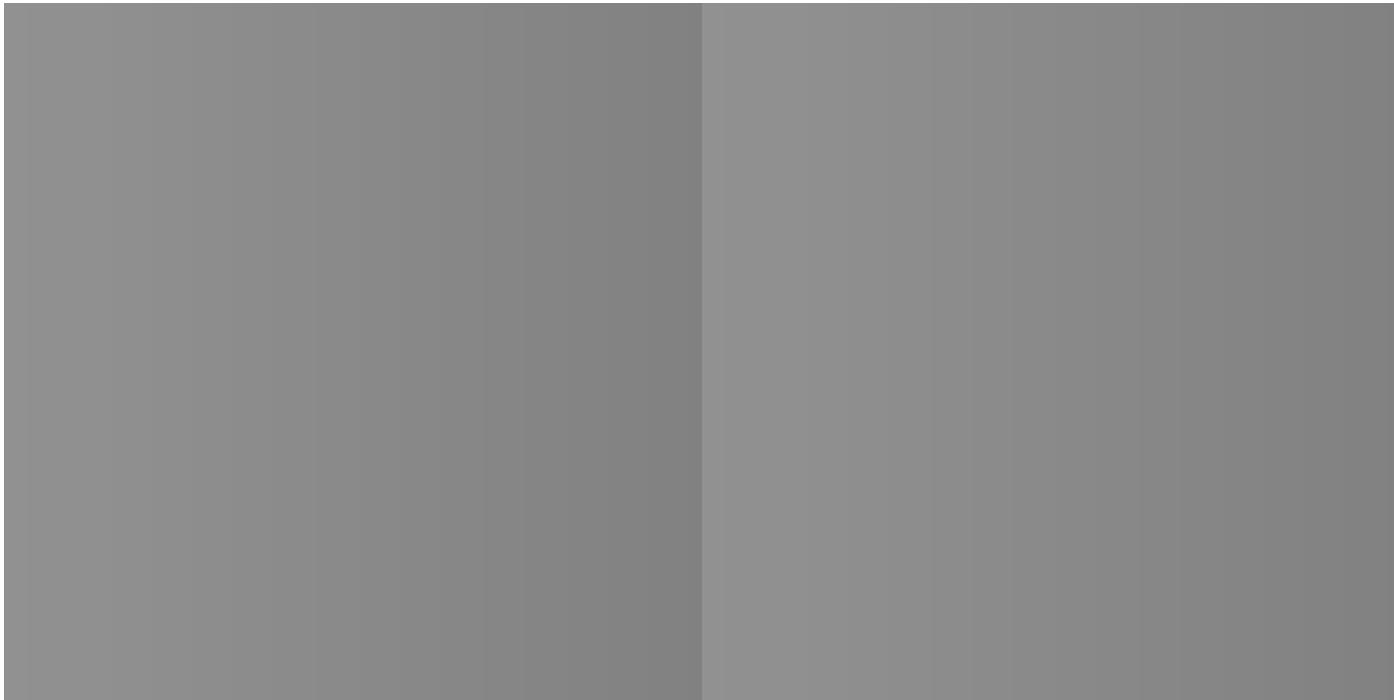
Line length with 5% difference



The right square has 5% less brightness



Beware “Fancy” Shading With Gradients

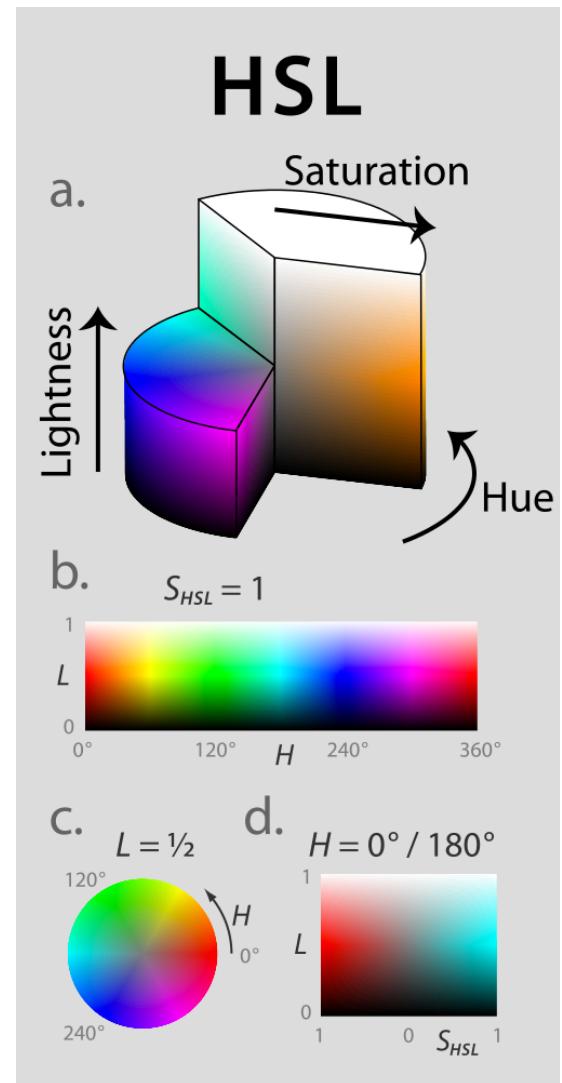


The Gradient Illusion



Color

- Brightness is part of color
 - Maps to the **lightness** (or darkness) of a color
- Other aspects of color
 - **Hue** is the primary wavelength (color)
 - **Saturation** is amount of color vs. gray

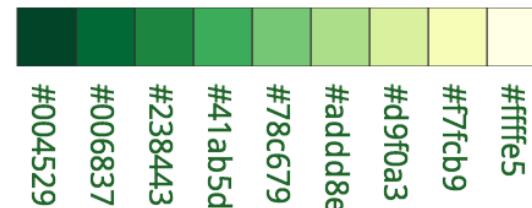


Colormaps

- Colormaps provide mapping between a variable's value and color
- Can be discrete or continuous
 - Gradients for continuous ratio values

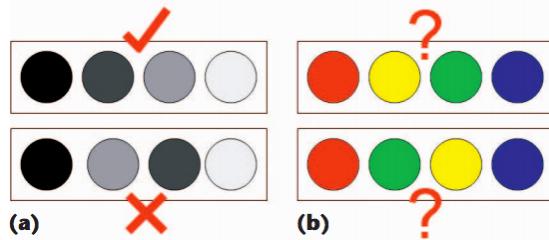


- Discrete, ordinal, or categorical data use palettes



Suggestions for the Effective Use of Color

- Avoid “rainbow” color maps



IEEE Computer Graphics

Rainbow Color Map (Still) Considered Harmful

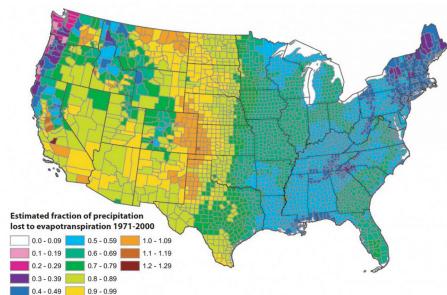
March/April 2007 (vol. 27 no. 2)

pp. 14-17

David Borland, University of North Carolina at Chapel Hill

Russell M. Taylor II, University of North Carolina at Chapel Hill

DOI Bookmark: <http://doi.ieeecomputersociety.org/10.1109/MCG.2007.46>



- Be aware of color blindness
 - 1 in 12 men (8%)
 - 1 in 200 women (0.5%)
- Color theory has much to say about designing good colormaps.
Seek advice...
 - <http://colorbrewer2.org/>



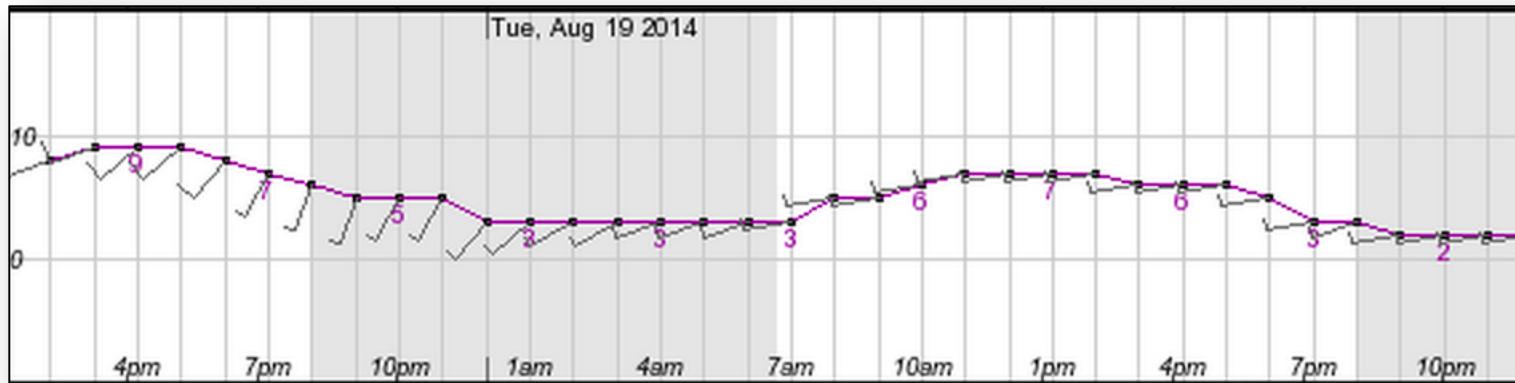
Orientation

- Marks can have an ***orientation***
 - Map attribute value to angle of rotation





Orientation Example

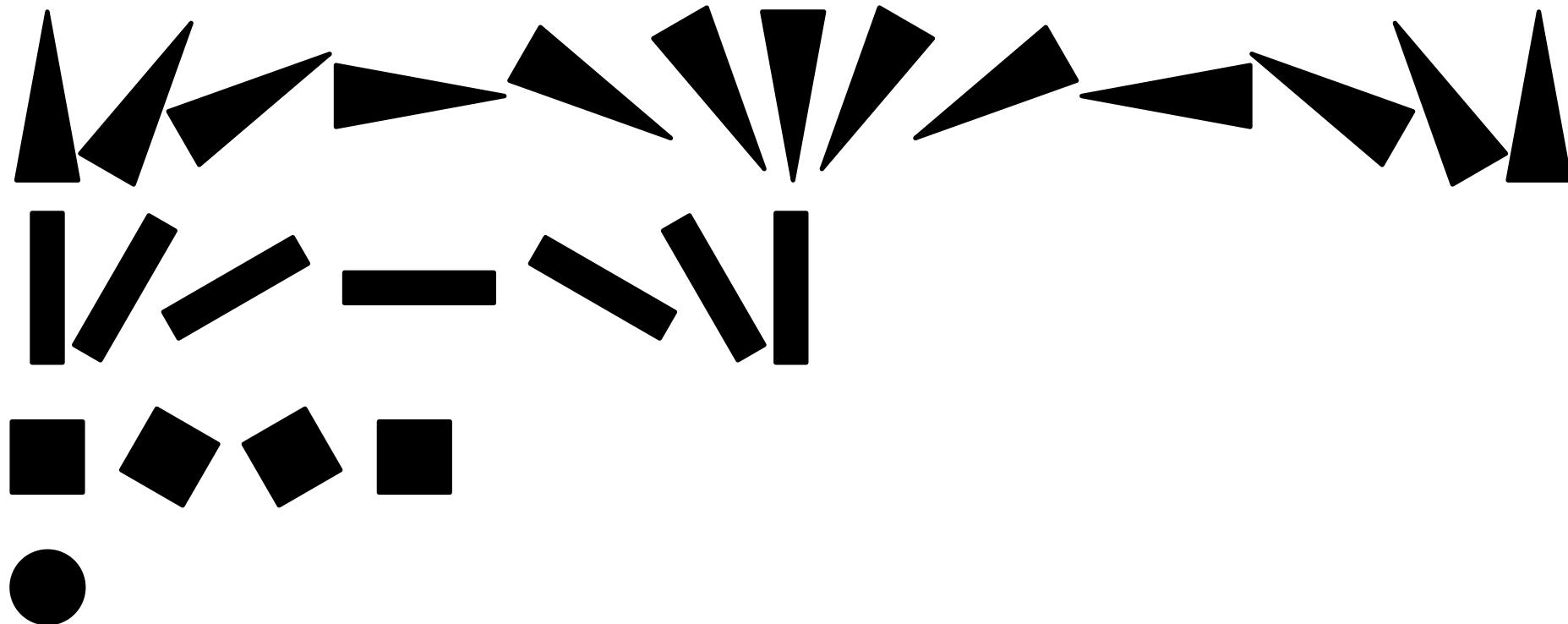


- Visualization of wind speed from NOAA
 - Position shows time of prediction
 - Orientation shows forecast wind direction
- **Question:** Why L-shaped marks?



Orientation and Mark Symmetry

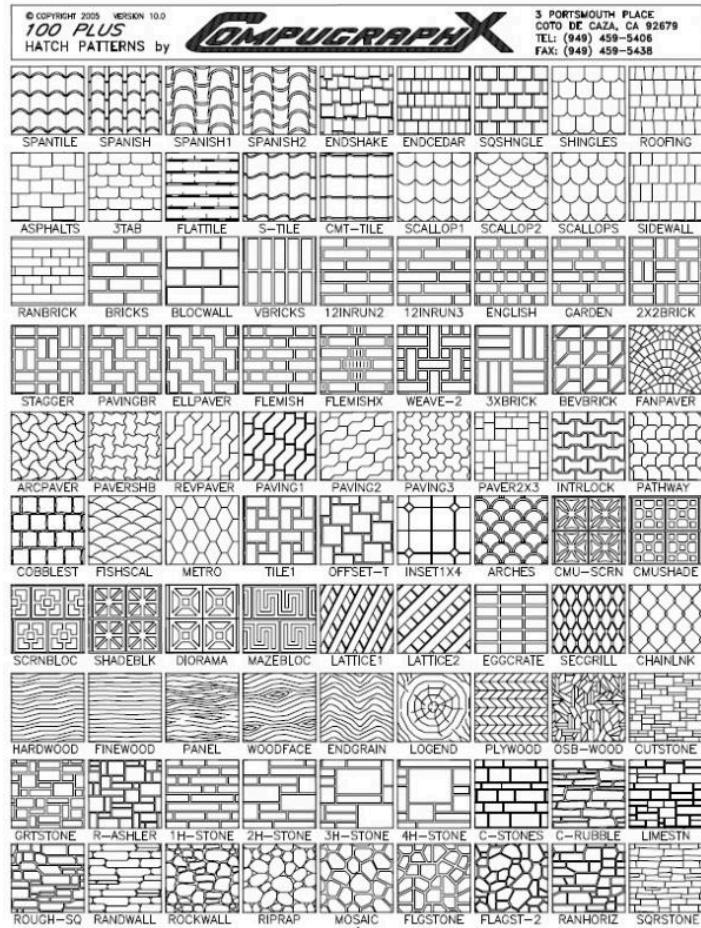
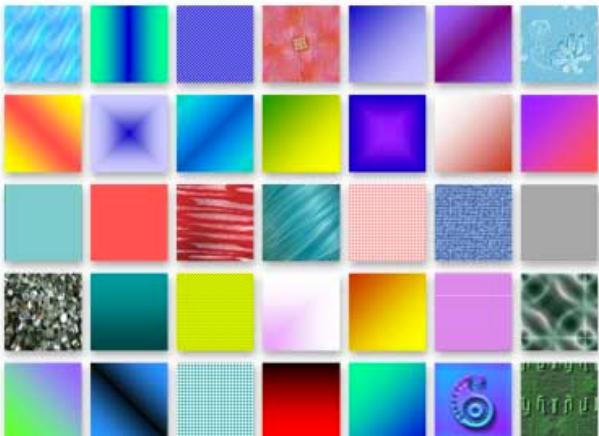
- Marks can have an ***orientation***
 - Map attribute value to angle of rotation
 - Range of angle values depends on mark symmetry





Texture

- **Texture**
 - Color gradients
 - Hatching
 - Marks within a mark
- **Not common.** Most often in black-and-white graphics where color is not an option



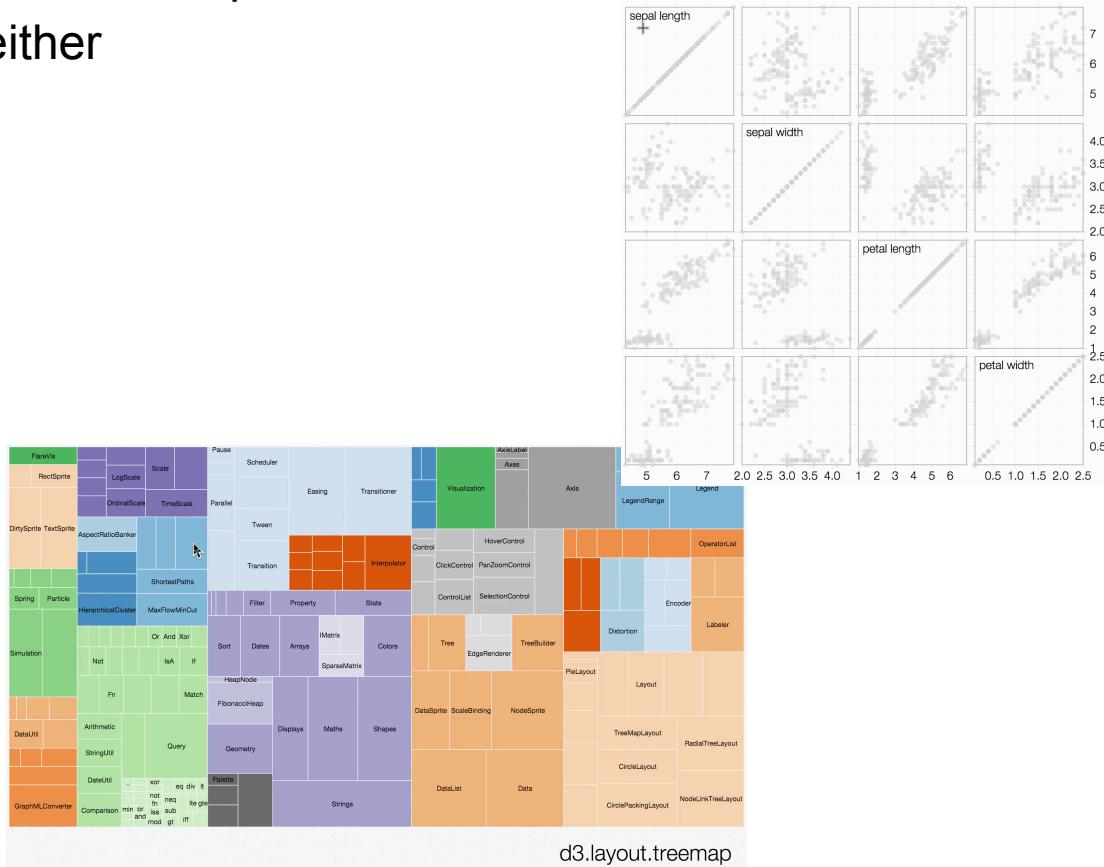
<http://www.archblocks.com/archblocks-cad-blocks-and-products-previews/autocad-hatch-patterns>

<http://www.indezine.com/products/powerpoint/ppezine/048.html>

Motion

- A **change** to any of the other seven properties
 - **Animation** can be used used to interpolate between values
 - Typically associated with either
 - Interaction
 - Dynamic data

- **Use judiciously!**
 - Show corresponding datapoints
 - Across a transition
 - Across views





The Visual Variables

- Eight “visual variables”
 - Position
 - Mark
 - Size
 - Brightness
 - Color
 - Orientation
 - Texture
 - Motion
- During mapping, we convert attribute values to these visual properties



JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

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