Scale and Resolution

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Tobler: Measuring Spatial Resolution

http://www.geog.ucsb.edu/~tobler/
Tobler: Measuring Spatial Resolution

- Spatial resolution is defined as:
  \[(\text{Domain/ # of Observations})^{(1/\text{Dimension})}\]
- This formula measures the average influence region of each observation
- The size of the smallest detectable feature is twice that of the resolution
The usefulness of GIS is constrained by its spatial resolution.

Systems with the same resolution can be compared.
Tobler: Measuring Spatial Resolution

- Since this document dates back to 1987, how has the idea of spatial resolution changed in relation to the approach Tobler takes?
- Let's keep this in mind in discussing the following readings (Goodchild)
Mandelbrot

- Study of complexity
- Rectifiable curves vs. the infinite
- Opposite of regularity → roughness
- Traces of order in that roughness
- Statistical self-similarity
- Quantifying degrees of complication
“Reduced Scale of Image of the Whole”
Mandelbrot’s Measurement $D$

- An exponent of statistical self-similarity
- Possesses many properties of a dimension
- Range of dimension from 0 to infinity
- “Practical measure of roughness”
- $D = - \log \frac{N}{\log r(N)}$
- Calculated for general figures or in parts deduced from the whole
Fractals and Cartography

- Coastlines: unrectifiable?
- "Measured with increased precision..lengths ten, hundreds or even thousand times as great as the length read off the school map"

Mandelbrot's re-expression of length

\[ r = \left( \frac{1}{N} \right) \frac{1}{D} \]

\( D > 1.0 \) for lines

\( r = \) increase in total length
\( N = \) unit of measure

How long are the "lakesides" in these pure fractal forgeries? What about the coast of Britain? Fractals can span the range from surfaces of well-defined area to surfaces that fill space – like the lung.

\( D = 1.17 \)

\( D = 1.33 \)

\( D \) is a practical measure of roughness. ©1982
Dimension: Point of View and Roughness
Scale Bars and RF are “Legacy” ideas of paper cartography

- Geographic data is almost infinitely complex and generalization is always required
- Generalization is subjective. Coarse Vs. Fine. (Village example)
- Limitations of detail (Pen-Pixel Size, Visual Clutter, data size and cost)

Two Alternative Measures

Object Models and Field Based Models

- Object Models - Points, Lines and Areas.
- Field Based Models - Points have value. DEM
Object Models

- The selection of Icons determines the level of geographic detail.
  - ex. Points represent entire cities
- This model may represent scale inaccurately.
  - ex. Cities are bigger than dots and roads are more narrow in the real world
- Digitally this level of detail may change when zoomed.

Field Models

- Selection of Pixel size determines geographic area of detail.
  - ex. A Pixel representing 1m has more detail than a pixel representing 1Km
- Geographic data smaller than the MMU will be merged and lost.

In either model the cartographer must clearly define the level of geographic detail and establish suitable metaphors.
Analog Scale

This map does well to show the complexities of scale and geographic detail.

Scale on this map is not finite, instead the cartographer attempted to use a sliding scale much like what the observer on the hill would see, while still preserving geographic detail.
3 Main Focuses:

- Extend the original fractal algorithm to “include measurement of surfaces that are not strictly self-similar” - p.135
- Interactive mode of algorithm, allows user to experiment with different parameters that result in different dimension values
- Using fractal-generated surfaces to test various algorithms
Drawbacks to the Original Fractal Model

- Oversimplification is easy when using a “single fractal dimension index” -p.136
- Fractals and scale are inseparable because self-similarity is only apparent at certain scales
- “…inconsistency of measurement results” -p.136

Extensions of fractal measurements to surfaces: raster models

- Measuring texture
- Efficient way of measuring human impact on landscapes, change in land use
Do all four readings talk about scale and resolution in the same way? How do the approaches differ?

**LIMITATIONS imposed by SCALE**

**Goodchild**: the “legacy” definition of scale is not prohibitive in our digital interfaces, but we now have edges and limits to our data sets because of limitations of old data collection. (Data availability)

**Tobler**: The size of the smallest detectable object is twice the resolution. (RASTER sensitivity)

**PROBLEMS WITH SCALE**

**Mandelbrot**: Patterns that repeat at certain scales. Scale-bound.

**Shelberg et al.**: Changing scale is willy-nilly is problematic because it changes the outcome of the measurements you are trying to take. (VECTOR)
What advantages and disadvantages are provided by eliminating scale and resolution into data? By incorporating it?

Eliminate scale.
**Goodchild**: Representative fraction is no longer valid because we can digitally zoom into our maps. Do away with edges and tracts.

Incorporate Scale
**Goodchild**: take the data you need, not all the data you possibly can have.

**Shelberg/Mandelbrot**: The way you simplify depends on scale, and it’s possible to generalize out fractal patterns. You need to fix your scale if you’re doing any sort of analysis.
The concept of self-similarity has generated a lot of debate. What is the criticism, and is it valid for geographic data?

**Tobler**: Depending on the scale/resolution at which you took your raster data, you might not be able to detect self-similar trends.

**Shelberg et al.**: Self-similarity is not a useful tool to consider at the in-between scales, and can be washed away by over-simplification.

**Shelberg et al.**: Self similarity is used to simplify modeling. More accurate models are made when breaking strict self-similarity.
Cheers!