Cartography or Geospatial

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23-Nov-2009

The Space-Time Cube Revisited from a Geo-Visualization Perspective

Menno Jan Kraak
International Cartographic Conference, 2003

Previous Work

'60s Hägerstrand's space-time model:
- Space-Time Path(STP) – limited by capability constraints, coupling and authority constraints
- Terms –stations, activity bundles, path footprint,
- Space-Time Prism – Potential Path Space (PPS), PPA
- Space-Time cube – 3 dimensions, geography along x-y axis, time along z axis

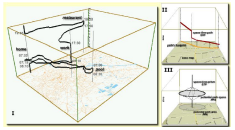


Figure 1 : Authors day at the city of Enschede

Automation and Multiple Views

An interactive visual environment with alternative graphics connected to the cube via multiple linked views

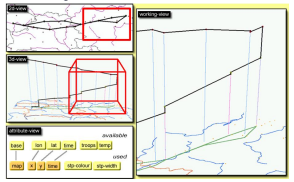
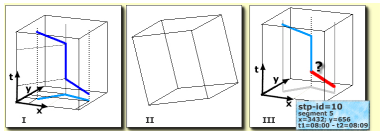


Figure 2 : Napoleon's 1812 march into Russia

Axis Rotation and Measurement

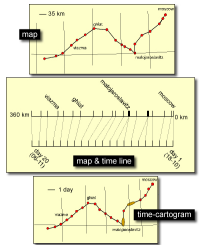


Applications and Extended Functionalities

- Orienteering run, fitness run – terrain and it's effect, reconstruct participant's trajectory
- Archaeology – spread of civilization, interesting location

Using Additional Views

Figure : Napoleon's retreat



Critique

Pros:
- Strong tool, can associate axis with other variable
- Scaling along axis possible

Cons:
- Space and time have to be associated to two of the axis
- Need additional views even for basic space concepts like distance

Questions on usability aspects of the cube's viewing environment:
1. How many views can the user handle?
2. Can multiple STPs be shown?
3. How should the interface look like?

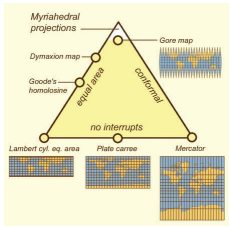
Unfolding the Earth : Myriahedral Projections

Jarke J. Van Wijk
The Cartographic Journal, Feb 2008

Distortion in Map Projection

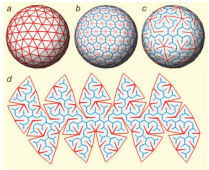
Terms :
- Myriahedron
- Parallels and meridians
- Graticulated mesh
- Tissot indicatrix
- Conformal projection
- Equal area projection
- terra incognita projection

Factors leading to different requirements
1) intended use of the map
2) the available technology
3) the area or aspect



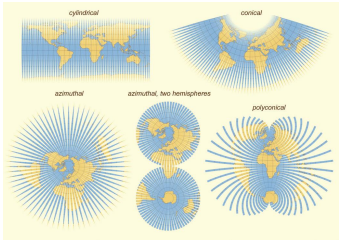
Graticulated Mesh Conditions

- Triangular faces with small area as node and edges as edge of graph G
- foldout connected and can be flattened implies H_f is a spanning tree
- G_c is a spanning tree
- no fold-overs

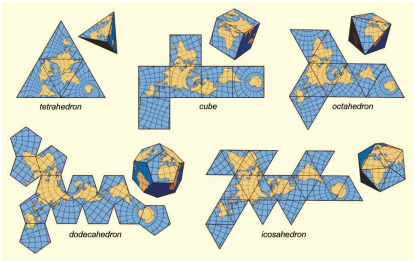


Algorithm to generate myriahedral:
1. Generate a mesh
2. Assign weights to all edges
3. Calculate a maximal spanning tree H_f using Prim's algorithm $O(|E| + |V| \log |V|)$
4. Unfold the mesh
5. Render the unfolded mesh

Unfolding mesh

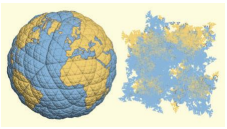


Projections on Platonic Solids



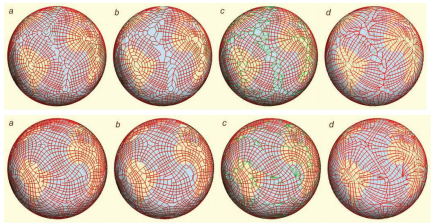
Defining Mesh

a. Generate mesh lines along and perpendicular to contours of f with the algorithm of Jobard and Lefer;
b. Calculate intersections of these sets of lines, and derive polygons;
c. Tesselate polygons with more than four edges; and finally
d. Use the standard approach to decide on folds and cuts.

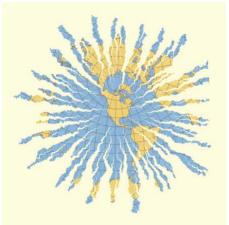


Alternate Mesh Definition

Based on vector fields and tensor fields:



Pretty Maps!



Azimuthal projection, random weights added, 81 920 polygons

Critique

Pros:
- Methodologically interesting in Computer Science perspective
- Can use different weight factors according to presentation target

Cons:
- fold-over rare but not restricted
- Most resultant maps unusual and unusable
- High computational complexity
- Cuts are more disturbing than distortions to most users

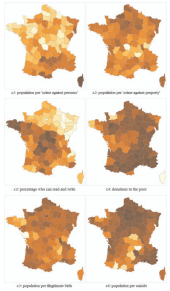
Geographically Weighted Visualization: Interactive Graphics for Scale-Varying Exploratory Analysis

Jason Dykes and Chris Brunsdon
IEEE Transactions on Visualization and Computer Graphics, 2007

Context

André-Michel Guerry on Moral statistics:
- Dataset – related data for the departments of France in the early 19th century
- View – uni-variate choropleth maps to identify trends and outliers

Friendly proved some of Guerry's hypothesis wrong using regression



Summary Statistics

Weighted Mean, $M(u, h) = \frac{\sum x_i w_i(u)}{\sum w_i(u)}$

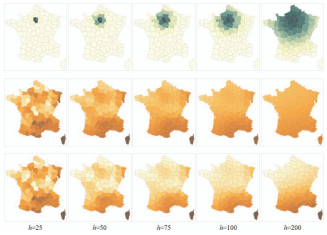
Gaussian decay function, $w_i(u) = \exp\left(-\frac{|u-u_i|^2}{2h}\right)$

Redefining weight function as $W_i(u) = \frac{w_i(u)}{\sum w_i(u)}$

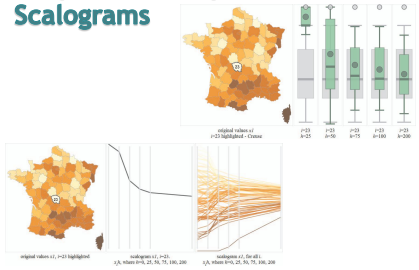
Then $M(u, h) = \sum x_i W_i(u)$

Discrete set of value, probability pairs $L = \{ x_i, W_i \}$

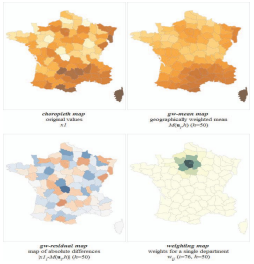
Weight Maps and Their Effects



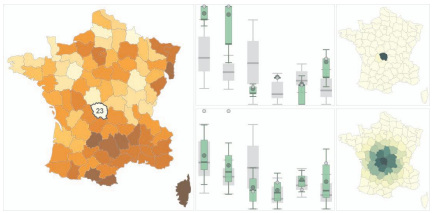
Boxplots, Choropleths and Scalograms



Spatial Views



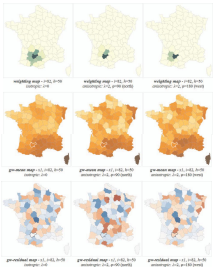
Linked Views



Directed Geographic Weighting

Take $w_i = w_i \exp\ (-\lambda \cos(\theta - \varphi))$

Directed GW statistics at clock points to reduce computation time.



Critique

Pros:
- Can compare at different scales (different values of h and θ)
- Moving window approach overcomes the abruptness of aggregation based on regional administrative hierarchy
- Ability to strum the set of scalograms

Cons:
- Computationally expensive and hard to search for trends at large number of scales
- Large number of views

Questions?

Thank You