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Data Cubes and Maps:

A Richer Metaphor for Diagrams and Thematic Maps[1]

Dr. Andrew U. Frank
Associate Professor, Department of Surveying Engineering
Associate Director
National Center for Geographic Information and Analysis
University of Maine
Orono ME 04469
(207) 581-2174 (Fax: (207) 581-2206)
FRANK@MECAN1.bitnet

ABSTRACT

Geographic Information Systems and computer cartography use an extensive set of programmed operations to produce maps and diagrams, mostly with traditional command line interfaces. We propose here an enrichment of the desktop metaphor to cover geographic data sets and mapping operations. The novel idea is to show (two) different icons that stand for data sets and maps - stressing a conceptual difference - and provide direct manipulation operations beyond the 'double click for open', that translate into complex operations on these: data cubes can be rotated to change direction of projection, combined and dragged over maps to be graphically rendered. Maps are overlaid by dragging one over the other. - The adequacy of these visualizations will be shown by a analysis of the algebraic specifications of both source and visualization domain of the metaphor.

Topic Area: Domain specific designs

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Summary

The desktop metaphor is a widely accepted and successful method. It is based on a few simple concepts and equally few operations, all ground in our common experience of office work, and it has been possible to extend it beyond the realm of 'paper documents'. It is tempting to apply the same metaphor (or a closely related one) to the management of geographic data, as collected in Geographic Information Systems. Traditionally, planners and cartographers draw maps on transparent material and then combine the data by physically overlaying one above the other. Assuming appropriate selection of colors and patterns, this allows them to see boolean combinations of the data. Often it is necessary to draw the resulting maps to communicate better or to be used in a further overlay operation (Tomlin 1983, Tomlin 1989). Computerized GIS offer such operations with much more flexibility and speed than in manual operations, but lack currently convincing graphical user-interfaces.

Borrowing this metaphor - maps on a desk and physical overlay operations - enriches the desktop with an additional, map specific operation: dragging one map over another results in an overlay of the two. Familiar double-clicking will open the result for viewing. There are a number of 'hidden' improvements over the manual operations:

- the two maps are automatically registered so corresponding points are aligned properly,
- the colors used for showing the map can be adjusted (at least as a best effort) to communicate map contents.

Once the overlaid map is shown, the user has the regular tools of such systems to adjust the display methods (which need also extensions and better human interfaces), store the result etc.

Maps are typically colorful documents and people recognize them by their overall color and major shapes shown. In lieu of using a standard 'file' icon a reduced small preview of the map with a title underneath is probably very helpful and not encountering the same concept for text files (Nielson 1990).

Some problems remain with this approach, which will lead to a number of dialog boxes (to select the specific operation to be performed for the overlay (Dorenbeck 1991)), to menus (to change the display), to active map legends and to overview windows to support pan and zoom (Kuhn and Jackson 1990). These are known problems with partial solutions. A more fundamental shortcoming is the selection of maps as the unique type of objects.

Cartographers use many kinds of data, often in tabular form or shown graphically in maps, to produce new maps. They conceptually separate data from the rendered graphics - the numbers in the spreadsheet are different from the diagram. The current programs do not separate these two classes sufficiently and the above user interface goes one step further to obfuscate the difference.

To enrich the metaphor further, using the often used block diagrams that visualize a function from a point in the plane (x, y) to a data value, e.g. the height of the surface. A block diagram is a good source for an icon, which may stand for the generalized concept of a data set. Data sets can be combined by visually joining them along a common axis (overlay operation) and data sets, or combinations of data sets can be projected onto maps - visualized as dragging the data set onto a map icon. It is possible to change the direction of the projection by turning the map cube around.

This is clearly an enrichment of the desktop metaphor - not only introducing two new types of documents, but empowering them with specialized operations which have meaningful visual expressions. How to further develop this concept and assure a realization that is consistent in all detail? The method we have used successfully before and applied to this problem so far is based on algebraic specification of objects and operations for both the source and the visualization domain of the metaphor: here the operation cartographers conceptually and

manually apply to data set, maps and diagrams form the source of the metaphor and the data cube and map icons with the corresponding operations are the visualization domain. We assume that a metaphor works well, if it matches well with its source, as seen in the closeness of the morphism, that maps between the two algebras. As next steps, we will analyses the operations and write algebraic specifications to see how closely they match. We will also draw an extended series of thumbnail sketches to illustrate the visual operations. Both these documents will be extremely helpful during implementation on top of one of the standard map overlay packages.

REFERENCES

C. Dorenbeck. 1991. Formalization of map algebra. Dipl. inf. thesis (unpublished, forthcoming) thesis, University of Bremen.

W. Kuhn and J. Jackson. 1990. *Metaphors for Interaction with Geographic Information Systems.* Report : University of Maine.

J. Nielson. 1990. Traditional Dialogue Design Applied to Modern User Interfaces. *Communications of the ACM* 33 (10) : 109 - 118.

C. D. Tomlin. 1983. "A Map Algebra". In *Harvard Computer Graphics Conference.* Cambridge, MA:

C. D. Tomlin. 1989. *Geographic Information System and Cartographic Modeling.* New York: Prentice Hall.