UNIT 17 - GRAPHIC OUTPUT DESIGN ISSUES

UNIT 17 - GRAPHIC OUTPUT DESIGN ISSUES

This unit introduces some fundamental concepts of graphic design. If you wish to do a more thorough job of this, consider combining this unit with the material in Unit 49.

UNIT 17 - GRAPHIC OUTPUT DESIGN ISSUES

A. INTRODUCTION

- previous unit described technical aspects of GIS output
- much GIS output is in the form of hard copy maps or graphic displays
- design of graphic output is critical if information is to be conveyed effectively to the user

    - graphic output from GIS is often poorly designed
        - e.g. colors used randomly without appropriate scaling
        - conventional scale of colors used to display elevation on standard atlas maps has been optimized over centuries of cartographic experience

- design can benefit from principles of cartographic design developed in cartography
    - screen display introduces a new set of issues because of greater capabilities compared with paper maps

- also see more general treatment of visualization of spatial data in Unit 49

Topics covered

- technical issues of label placement

- general principles of graphical excellence

- introduction to principles of map design

B. LABEL PLACEMENT

- features shown on maps and displays can be differentiated and identified in various ways:
    - symbols, e.g. church, bridge
    - colors
    - sizes
    - labels

- labels provide the greatest flexibility to attach descriptions to point, line and area features
    - names of administrative divisions, lakes, rivers etc.
    - elevations of contours, spot heights
    - highway numbers

- in cartography, positioning labels is a complex and sophisticated process
    - there have been few attempts to write down the rules used (Imhof, 1975 is a well-known exception)
    - it has proven difficult to emulate these rules in automated map production or GIS
    - positioning labels on screen displays is especially difficult because of low resolution (e.g. 640 by 480 pixels), and the importance of speed
        - by comparison, a plotted map may have an effective resolution of 300 dots per inch, and an hour computing time may be acceptable

Imhof's basic rules

- names on maps should:
    - be legible
    - be easily associated with the features they describe
    - not overlap other map contents

    - be placed so as to show the extent of the feature
    - reflect the hierarchy of features by the use of different font sizes
    - not be densely clustered nor evenly dispersed

- it may not be possible to satisfy all of these rules perfectly

- the best solution will balance conflicting objectives, e.g. need to associate name with feature vs. need to avoid overlap of contents

- label placement is a complex problem because of the vast number of possible positions that have to be searched and the number of conflicting objectives

- two labelling problems are particularly significant in automated mapping and GIS:

Overposting

- when features are densely packed on a map or screen, it is difficult to keep labels separated
    - labels may overlap (overposting)
    - labels must be positioned to avoid overposting, but without destroying the eye's ability to associate labels with appropriate features

- e.g. point features
    - optimum position for a label is above and to the right
    - below and to the right is less acceptable
    - least acceptable positions are to the left
    - label can be turned (non-horizontal) if necessary, but only by a small amount

- overposting is a problem because the computer must search a vast number of possible positions
    - in practice, must limit the number of positions somehow
    - some solutions define a fixed number of possible absolute positions, like a raster
    - other solutions define a fixed number of positions relative to the feature

  diagram

Polygon labeling

- labelling polygons has become notorious within automated mapping as a difficult and challenging programming problem

- the label should be central to the feature, may be reoriented or curved to fit the feature

  diagram

- in some cases the label may be connected with the feature by an arrow

  diagram

Some simple methods

1. label centered on the polygon centroid

   - problems:
     - centroid may lie outside the polygon
     - a long label may have to be multi-line to fit inside
     - solution fails to meet Imhof's criterion of showing the extent of the feature

2. variable rectangle positioned inside the polygon
   - search for feasible positions for a rectangle wholly enclosed within the polygon
   - ratio of width to height should be as high as possible
   - solution will not curve the label to fit the feature
   - largest enclosed rectangle may be in an inappropriate part of the polygon

diagram

3. Skeleton

   - shrink the polygon by moving its edges inward at a uniform rate
   - the vertices trace out a network known as the skeleton (discussed in more detail in Unit 33)

diagram

   - position the label along the central part of the skeleton
   - best for polygons like Florida which require curved labels

- practical labeling methods use combinations of rules for different shapes, sizes of polygons

- many developers have used the term expert system to describe label placement software
  - an expert system works with complex sets of rules in a rule base
  - the objective of the expert system is to emulate the complex decision process of a cartographer

C. PRINCIPLES OF GRAPHICAL EXCELLENCE

- some very broad principles apply to the design of graphic output in general (includes graphics and charts)

- the following discussion relies heavily on Tufte (1983)

Graphical excellence

- gives the viewer the greatest number of ideas, in the shortest time, with the least ink, in the smallest place
  - maximize the data/ink ratio
  - erase non-data ink

erase redundant data-ink
    - revise and edit the graphic
        - it is difficult to get a good graphic first time around
    - mobilize every graphical element, perhaps several times over, to show the data
    - maximize data density and the number of data entries shown, within reason

- if the nature of the data suggests the shape of the graphic, follow that suggestion - otherwise, move toward horizontal graphics about 50% wider than tall

D. DESIGN OF GRAPHIC OUTPUT

- for GIS, graphic output must show:
    - features appropriately symbolized or labeled
    - objects computed by the GIS, e.g. buffer zones
    - relationships

- it may be difficult to display the results of some forms of GIS data analysis because of the constraints of 2D display, e.g.:
    - 3D data
    - interaction data (migration, flows of goods)
    - global data

Scale

- the scale of output should be consistent with input scale
    - e.g. inappropriate to digitize from 1:1,000,000 map, display at 1:24,000 because data will not be sufficiently accurate
    - also inappropriate to digitize at 1:24,000, display at 1:1,000,000 without adequate generalization features will be too dense, too detailed
    - scale on a CRT screen is as important as on a plotted map

- in principle a spatial database is "scale-free", but in practice scale is a crude indicator of data accuracy
    - GISs should record and track scale in the database, but do not

Base map

- to be useful, a map must include information for visual locational reference
    - output of computed information alone is rarely useful need base map features as well
    - e.g. map of cuttable forest stands
        - needs to show locations of roads, watersheds, streams and lakes, besides cuttable stands, so user can locate stands on the ground, make decisions based on correct spatial context
    - particularly important in raster systems
        - display of a single layer is rarely useful without some form of basemap for locational reference
        - basemap information will normally be vector, or at higher resolution than the raster

        - this will be difficult if the raster system does not have vector capabilities

- input of basemap information can be expensive
    - difficult to justify digitizing of data just to support interpretation of graphic output

- can plot output on top of pre-printed base map
    - avoids need to digitize base map information
    - base map must be accurately registered
        - some GIS support this function

General graphic design

- often desirable to create good-looking finished product
    - e.g. as part of professional report, presentation
    - undesirable to have map look "computer-produced", excessively abstract or schematic

- high cost of providing cosmetic output functions in GIS
    - e.g. map border neatlines, symbols, north arrows, legends
    - complexity of programming for these features may be much greater than for analytic functions
    - time to plot these features may be high, particularly for pen plotters

- some GIS map products are now almost indistinguishable in quality from manual cartography

- is appearance really important in a map drawn to support decision-making?
    - GIS output maps are to be used directly, not destined for walls or map libraries
    - should GIS products be simple, schematic, avoid high cost of manual cartographic quality?
    - marketplace seems to say "no"

Screen display

- issues are different here because screen is:
    - smaller, lower resolution than a printed or plotted map
    - more flexible
        - zoom, pan, interaction with user, animation, use of color

- principles of design of screen displays are still poorly developed
    - black background or white?
        - affects perception of color
        - tradition (PC and mainframe terminals) is black background, Mac and many workstations use white

- hard copy map must display as much information as possible to satisfy possible user requirements
    - because system is interactive, screen can display limited information but provide for access to more

- e.g. user "clicks" on or "picks" an object with a mouse, accesses lengthy text description
- access to an object's attributes is not limited by constraints of static display

Scene generation

- maps show geographic variation using symbols, objects, other abstractions of reality
- GISs do not have to do this - why not show a picture of the reality? - artist's impression?
- scene generation is set of techniques for simulating real physical appearance
  - e.g. GIS is used to plan a ski area on a mountain which is currently forested
  - plan could be shown as a map, with contours, green tint for remaining forest, line objects for ski lifts
  - scene generation would show oblique perspective view, cover hill with trees of varying height
  - current technology allows appearance of trees to be varied depending on species, age
  - we are still some way from having hardware fast enough to do this in "real time"

REFERENCES

Freeman, H. and J. Ahn, 1984. "AUTONAP - an expert system for automatic map name placement," Proceedings, First International Symposium on Spatial Data Handling, Zurich.

Imhof, E., 1975. "Positioning names on maps," The American Cartographer 2(2):128-44.

Robinson, A.H., R.D. Sale, J.L. Morrison and P.C. Muehrcke, 1984. Elements of Cartography, 5th edition, Wiley, New York. Excellent source of map design principles.

Tufte, E.R., 1983. The Visual Display of Quantitative Information, Graphics Press, Cheshire, CT. Contains numerous examples of graphical excellence (and its opposite) in map design.

Zoraster, S., 1986. "Integer programming applied to the map label placement problem," Cartographica 23(3):16-27

A session on automatic names placement at AutoCarto 9, Baltimore, April, 1989 provides several reviews of the use of expert systems for map design:

Doerschler, J.S., and H. Freeman, "An expert system for dense- map name placement," pp. 215-224.

Ebinger, L.R., and A.M. Goulette, "Automated names placement in a non-interactive environment," pp. 205-214.

Johnson, D.S., and U. Basoglu, "The use of artificial intelligence in the automated placement of cartographic names," pp. 225-230.

Jones, C.B., and A.C. Cook, "Ruled-based cartographic name placement with Prolog," pp. 231-240.

EXAM AND DISCUSSION QUESTIONS

1. "Map output is essential to GIS, yet GIS designers have ignored or failed to implement many of the well-known principles of map design". Discuss.

2. Examine and discuss a collection of GIS output maps, such as the ARC/INFO Maps volume produced annually by Environmental Systems Research Institute, Redlands, CA, or the slides supplied with Unit 53. How effectively do they implement principles of map design?

3. Discuss the differences in graphic design principles as applied to manually produced maps, GIS hard copy output and screen displays.

4. Review the Cartographic Design chapter of Elements of Cartography, and discuss its contents in the context of GIS output.

Last Updated: August 30, 1997.