

THE CARTOGRAPHIC POTENTIAL OF LOW-COST COLOR
COMPUTER GRAPHICS SYSTEMS

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For most cartographers the direct view storage tube (DVST), as in the Tektronix 4010 family of terminals, is the basic unit of graphic display. The storage tube displays only monochromatic vectors and shades or tones can only be created by drawing patterns of lines. The resolution of these tubes is usually 760 by 1024 addressable positions which has become accepted as the standard of graphics quality. Because the screen displays everything written on it, a display cannot be erased selectively. Displays can be documented with hardcopies using special photocopiers or plotters. A variety of storage tube systems are now available from simple terminals to integrated graphic systems with multiple work stations. Prices range from \$4,000 upward into six figures. A sizeable body of software is available, including many mapping programs and subroutines.

Now another form of graphic display has been developed as an alternative or complement to the DVST. The world of microprocessors has led to the development of the low-cost, color CRT display, which in its cheapest form sells for less than \$2,000. Some of these low-cost color systems are employed as intelligent terminals while other systems are self-contained microprocessors with more than 40K of memory and peripheral storage devices. Pictures are refreshed (recreated) at least 30 times a second so that displays can be modified or selectively erased as desired. The

resolution of the system and the number of colors and shades that can be created is related to the memory dedicated to refreshing the image and thus to the cost.

To date, three low-cost, low-resolution color CRT systems are known to the author, but other systems may and probably do exist. The Cromemco Dazzler is a microprocessor that displays a 64 by 64 pixel array in 15 colors on a TV set. The 8 basic colors are shown in either low-intensity and high-intensity: black, white, red, blue, green, magenta, cyan, and yellow. The low and high intensity blacks are the same, thus the 15 colors. The Apple II is advertised as a personal computer and is marketed primarily to those who want to use it as a stand alone microprocessor system. This system can generate a 40 by 48 pixel array in the same colors on a TV set. It can also be used at a higher resolution to generate a 280 by 192 pixel array in 4 colors. The third unit is called the CompuColor when packaged as the personal computer and is known as an Intecolor when configured as a business/scientific package. These units can display the basic 8 colors at one intensity in a 25 by 80 or a 48 by 80 array and can be operated at a higher resolution in 8 colors in a 100 by 160 array or a 192 by 160 array.

Perhaps the newest development is the announcement by Texas Instruments of a color video graphics chip to plug into a microprocessor to generate a 15-color display at 256 by 192 levels of resolution. The chip will sell for under \$50 in batches of 100 units. (1) ABW Corporation has come out with a chip to let the Apple II emulate a Tektronix terminal, but at a much lower level of resolution. Announcements of this type will probably become more common in the next couple of years. What is really missing at this time is software--programs to do something useful with the color systems. However, software will be forthcoming and we will soon see organizations devoted to the sharing of programs of all types. Certainly, some of these programs will be cartographically oriented.

What can these low-cost, low-resolution systems do for cartography? The low resolution of these systems makes them quite limited for line-drawing. Their strength lies in the ability to produce a variety of tones, or colors, which can be quite dramatic. For the most part, these systems are comparable to the image

processing systems used by our colleagues in remote sensing. The refresh nature of the tube permits the image to be changed and modified in real time. This attribute should permit the development of dynamic cartography, where a series of map patterns evolve before our eyes. A real disadvantage of these low-cost color systems is that there is no convenient way to make colored hard copies, other than taking a photograph of the screen. But even if you could get a colored hard copy, what can you do with it? If you want slides you are in good shape, but the costs of printing color makes it unlikely that colored maps will soon be reproduced in most journals or books. The photographs in this paper illustrate this problem. In spite of the problems of getting hardcopies and the lower resolutions, some new dimensions in thematic cartography are opened with these systems.

The Intecolor Experience

Four years ago my department purchased an Intecolor CRT intelligence terminal, a forerunner of today's low-cost color systems. The unit is a 25 line by 80 column alphanumeric terminal with the graphics option to break each alphanumeric cell up into a 2 by 4 array of smaller cells so that an array of 100 by 160 cells can be addressed and displayed in a saturated color. Another option allows the full range of 8 colors to be displayed as foreground or background. The display screen is a 19-inch TV tube. The terminal is connected to a DEC10 with a KL10 processor by a 300 baud dial-up modem.

We soon found that using the terminal in the graphics mode with the 100 by 160 cells was of no benefit to our mapping applications. This resolution was too coarse to use for line drawings. Where detailed lines were required to enhance a map we found they could be added by inking on an acetate overlay and attaching it to the screen. Further, in the graphics mode the terminal is limited in the number of colors that can be combined. A red line drawn to cross over a blue line on a white background will result in part of the blue line being changed to red. This characteristic kept us from using the terminal for dot maps because the color of a dot might be determined by the sequence of plotting rather than by its value. The problem also makes it

impractical to use this terminal for the processing of remote sensing imagery.

The strength of this terminal lies in the ability to display a broad palette of rather brilliant colors. By writing any alphanumeric character in one color on a different background color, combinations of colors may be created. In this way graded series can be constructed as: solid red, yellow colon on red, yellow X on red, red X on yellow, red colon on yellow, solid yellow. This sequence could be expanded or contracted as well as be continued by going from yellow into blue or black. Such color sequences are appropriate for map situations where the data have a numerical range, be it ordinal, interval or ratio data. If the data being mapped are nominal values, then the color terminal provides enough distinct hues to distinguish between a number of non-related classes.

On the 25-line terminal the alphanumeric display cells are much taller than they are wide. Text can be written horizontally for titles and legends but is limited to one size. Because of the very low resolution (25 by 100) and the non-square nature of the cells, it seemed practical to base the mapping programs on the scan-line algorithm used in CMAP (2). In CMAP a map of a fixed size and scale is defined line by line. Each line is specified in terms of how many display positions are allocated to each polygon or choropleth area. Text or titles are assigned to particular rows and columns. This technique works well for choropleth maps on the color CRT and was incorporated into other mapping programs. In a contour program the data points are specified as row and column positions on the screen, the outlines of the study area are specified row by row and the map is at a fixed scale. With the low resolution no attempt has been made to incorporate variable scaling into the programs.

Last year my colleagues in engineering purchased a 48 line by 80 column Intecolor terminal with a floppy disk drive. Because of my experience with the 25 line unit, I was called in to help develop some programs for mapping data output from a simulation study. Although this terminal was a more advanced intelligent terminal with BASIC and usable memory, it was used as a display device attached to the DEC10.

Four basic mapping programs and a set of utility subroutines have been written at Tennessee for use on the Intecolor terminals. Each program is unique to one of the terminals and the mapping problem. Listings of the programs and subroutines are available from the author. All programs are written in FORTRAN IV for a DEC10.

A choropleth mapping program designed around a scan-deck for the counties of Tennessee gets the most use. Interactively, the user has to select the data set to be mapped, set the number of class intervals and the class limits, specify the colors for the highest class, lowest class, the background area and the titles and give a title. Colors for intermediate classes are put together in the program by combining the colors from the highest and lowest classes. The characters forming the symbols are fixed within the program. A variation of the Tennessee choropleth map employs two variables for a cross-correlation display, similar to the maps from the U.S. Bureau of the Census (3).

In a study of the changing patterns of moisture conditions in the southeastern United States, the author designed an isoline mapping program specific to the task but containing subroutines that could be adapted easily to other mapping situations (Fig. 1). Data for the program consist of values for 54 climatic divisions. A 25 x 80 grid of the character blocks was overlaid on an outline map of the southeastern United States and the centers of the climatic divisions were selected as data points specified in terms of character block coordinates. The outline of the study separating it from the surrounding land and ocean was specified as a scan-deck file similar to that used in the choropleth program. Values for display positions in the study area are determined by interpolation.

Thirteen classes are displayed in a graded series ranging through three colors. A good color combination was found to be red-yellow-blue, where red is used for the lowest class (dry), yellow for the intermediate class, and blue for the highest class (wet); shadings for the second through sixth lower classes employ yellow characters on a red background and the second through sixth higher classes are displayed as yellow characters on blue. Cyan identifies the Atlantic and Gulf of Mexico, and green for the outside land areas,

and heat from power plants into water bodies (5). Input data were matrices of concentration values. In a preprocessing program the values were transformed into a matrix of color patches and symbols. This matrix was then fed to the display program where the rectangular set of values is centered on the screen. A white outline was drawn around the study area, tick marks and scaling were added to the outline and the title and legend were printed. The white outlines and tick marks on these maps are the only use in all of the programs of the graphics mode. After making a particularly revealing map, the terminal was put into local mode, the map was enhanced with embellishments like a blinking X at the site of the discharge, and the image was transferred to a floppy disk. Images stored on a disk can be recreated in seconds.

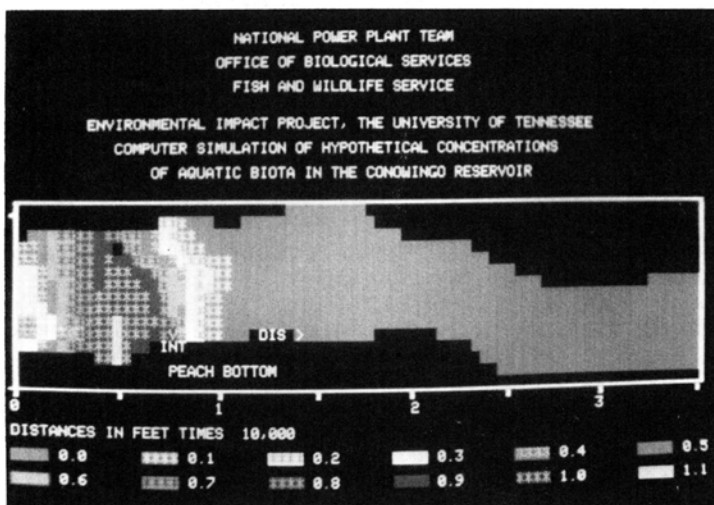


Fig. 2-Simulated concentrations of biota in the Conowingo Reservoir displayed on a 48-line Intecolor terminal. This black and white copy was made from a color print in which the central point is magenta and the colors grade from magenta-red-yellow-green cyan-blue. The outline and tick marks are drawn with the graphic plot mode. Data are a matrix of values for every print position.

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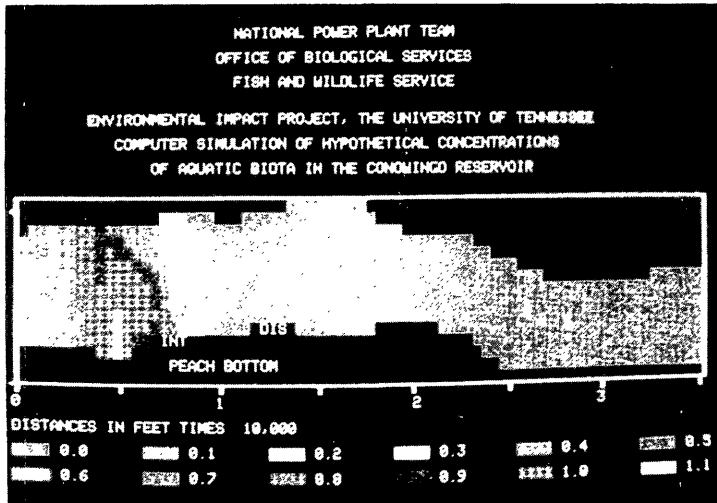


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The present and future

Low-resolution color CRT terminals cannot produce the detailed drawings we normally look for in cartography, but these terminals can be used to make some rather dramatic and effective maps. Coarseness need not be of much concern; of all of the people I have observed using the choropleth mapping program for Tennessee, no one has really complained about the coarse resolution used to define the counties.

What can be done with low-resolution color? Not much if you need multiple copies at a low price, but if you can live with slides, videotapes, a few color prints or a temporary picture on a CRT, these graphic systems may be of great service to you.

As interactive color systems proliferate, our concern should be that good cartographic design is incorporated into software we develop. Just because we can display 3, 8, 16, or 64 colors does not mean we should do it. Numerical data that are to be displayed in a gradation from low to high should be assigned colors that convey that trend. With the ability to select a number of colors with the push of a button, we must make people aware that color on a map is a symbol and conveys meaning by itself and in combination with other colors. The availability of colors extends our range of options but it also extends our responsibilities.

Footnotes

1. Minicomputer News, Aug 30, 1979, p. 12.
2. Scriptor, M. W., "Choropleth Maps on Small Computers," Proc., Assoc. Am. Geogr, Vol 1 (1969), pp. 133-136.
3. Meyer, M.A., F. R. Broome and R. H. Schweitzer, Jr., "Color Statistical Mapping by the U. S. Bureau of the Census," Am. Cart., Vol 2, No 2 (Oct 1975), pp. 100-117
4. Johnson, P. E., "The Diffusion of Commercial Fertilizer in the Corn Belt," M.S. Thesis, Geog. Dept., Univ. of Tennessee, June 1978.
5. Eraslan, Arsev, "Environmental Impact Project," for the U. S. Department of the Interior, Univ. of Tennessee, Eng. Sci. and Mech. Dept.