A COLOR SYSTEM FOR COMPUTER GENERATED CARTOGRAPHY

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## ABSTRACT

Color is being used more often as a technique to represent entities within a Cartographic representation. Color, in the context of a map, if understood and properly manipulated, enhances and clarifies the portrayal of that information.
This being the age of the comupter and advancing technology, there arises new applications for fundamental theories. In this study basic color theory is applied in the developing of a color system for computer qenerated cartography.
The color is derived systematically through a numerical process. By using this system, the colors, once established can be repeated and reproduced through a computer driven 35mm matrix camera. The perceptual difference between color are achieved by visually selecting a series of color palettes. With numerical coding the colors can then be matched and displayed ina map format for testing. This presentation demonstrates the application of basic color theory concepts using this approach.

Geographic Data Base

    The Cartographic Display Process begins with the establishment of the geographic data base. A multi-faceted geographic data base is established for storage and retrieval of cartographic information. Initially, cartographic data is entered by means of a digitizing table and cursor, or by a direct image transfer, and stored in digital form. The information is recorded in polygon strings of X-Y coordinates. It is then organized and edited through the computer and temporarily stored on a removable magnetic disk. The digital information stored on the disk is encoded through the graphic display unit. The peripheral memory unit, which is attached to the cpmputer, transforms the infor mation to a visual graphic image. This image is projected through the black and white display module. An image can remain in black and white or it can be transferred to the color monitor, which displays the grey tones in color. The image displayed, can be reproduced through the matrix camera in black and white or color.

**Cartographic Display Process**



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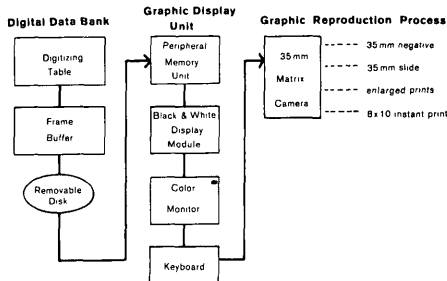
## Graphic Reproduction Process

The matrix camera is a 35mm camera mounted on a light-tight box which houses a computer driven CRT Monitor. This CRT monitor is used to pick up the graphic image, displayed in raster form, in grey tone values. Through a mirroring projection system the CRT image is composited through sequential red, green and blue filter exposures and copied by the 35mm camera or the single sheet film magazine mounted on the front and top, respectively, of the light-tight box. The image can be reproduced in color or black and white on different materials: 35mm film, positive and negative; paper print enlargments can be made from the negatives; or individual sheet film can be used in the single sheet film magazine for an 8x10 instant paper print.

## Basic Color Theory

To understand the process of producing color on the color monitor, one must also understand the concepts of color theory.

The physics of light demonstrates that white light projected through a prism can be broken into the color spectrum. Color theory demonstrates that there are basically two methods of producing and mixing colors, the subtractive and additive methods.

The subtractive method of producing color begins with a source of white light which contains all colors of the spectrum. Through absorbing particular colors, those colors absorbed are subtracted from the spectrum, allowing for the remaining color to be transmitted.
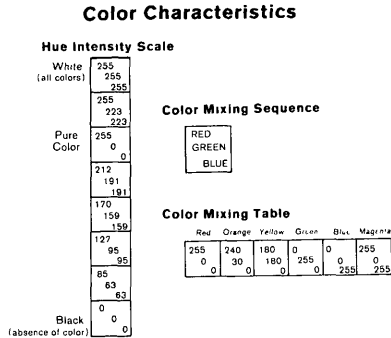
Subtractive primary mixing colors are: Yellow, (Slide #2) Cyan, (Slide #3) and Magenta. (Slide #4) Through the mixing of these primary colors, secondary colors are produced. Yellow and Cyan combine to produce Green; Cyan and Magenta produce Blue; Magenta and Yellow produce Red. All colors combined produce Black.

This method of color mixing is used in offset lithographic printing. The mixing of color pigments is achieved through over printing of the primary colors. Cartographers use this method of color mixing for map reproduction.

The opposite of this is the additive method which starts with the absence of light, blackness. Color is achieved by means of projecting the pure color. Although there are different ways of projecting color, the most common is by projecting white light through a colored filter. The additive color mixing method uses the primary color: Red, (Slide #5) Green, (Slide #6) and Blue, (Slide #7) which in color theory, are the subtractive secondary colors. The mixing of the primary colors produce the additive secondary colors. The mixing of the primary colors produce the additive secondary colors: Red and Green produce Yellow; Green and Blue produce Cyan; and Blue and Red are combined to produce Magenta. These secondary colors are the subtractive primary colors. All colors combined produce white light. This method of color mixing is used in electronically projected color, for example, CRT monitors and T.V.

The color monitor used for viewing the display employ's the additive process of producing color. Pure colors, Red, Green and Blue are electronically transmitted and the monitor is calibrated to incorporate specific color charateristics. The intensity of a pure color is calibrated by assigning a numerical value range of 0 to 255, with zero being no color and 255 the greatest luminosity of the hue.

This calibration is equivalent to screen printing, with 255 equalling 100% of a saturated hue. Primary colors in their purest state are transmitted by individual color channels on the color monitor at an in intensity value of 255, and through a color mixing proceedure, all other colors are derived.

**Color Characteristics**

**Hue Intensity Scale**

| White (all colors) | 255 255 255 |
|---|---|
| | 255 223 223 |
| Pure Color | 255 0 0 |
| | 212 191 191 |
| | 170 159 159 |
| | 127 95 95 |
| | 85 63 63 |
| Black (absence of color) | 0 0 0 |

**Color Mixing Sequence**

| RED |
|---|
| GREEN |
| BLUE |

**Color Mixing Table**

| | Red | Orange | Yellow | Green | Blue | Magenta |
|---|---|---|---|---|---|---|
| | 255 0 0 | 240 30 0 | 180 180 0 | 0 255 0 | 0 0 255 | 255 0 255 |

An eight step Hue Intensity scale was established to demonstrate the progression of tints and shades. The scale shows the numerical values of a single color  intensity range. The pure color was placed in step three,  then other primary colors were added or subtracted for a color range from black to white. To produce a desired color there are two controlling variables; the intensity of a color and the mixing of colors.

Once the primary colors are established a numerical interpolation is calculated to produce secondary and all other colors. The color mixing table shows the additive process of mixing primary colors, to achieve additional colors for example, to produce Magenta, equal parts of Red and Blue are combined; Yellow is produced by a mixture of Red and Green; and a greater value of Red is used to produce an Orange.

Through this process a logarithmic interpolation between primary colors was set up to produce a 30 step color spectrum. (Slide #9 Color Spectrum)

## Selection of Usable Color Palettes

The next step was to establish a color value spectrum. An 8x8 grid was displayed on the color monitor. The color mixing array appears on the X axis and the Y axis represents the color intensity scale. With this display the task of recording color combinations was possible. The colors were  reproduced and preserved on color slide film, in positive form. Usable color palettes were selected from numerous amounts of color swatches, by using a trail and error process.

Although there can conceivably be hundreds of different color combinations produced, one must choose colors which can be perceptually distingushable. To achieve this the series of color palettes were visually selected through a masking technique. With this method each color could be isolated from the next. A series of eight colors were chosen for each palette and once a color was visually chosen it was then matched up numerically.

## Establishing of Color Palettes

The color palettes were selected and coded. The following are the initial color palettes which were established: <u>Series of Grey's</u> (Slide #10) here the initial 32 step color run was calculated; a second 8 color run (Slide #11) was selected by pulling every other fourth color. <u>Saturated Hues</u> (Slide #12) light, Medium, (Slide #13) and Dark. (Slide #14) The three palettes displayed together (Slide #15) demonstrate the progression from light to dark these palettes contain colors having the same intensity value, yet saturated in their hue.

<u>Pastel Hues</u> Light, (Slide #16) Medium, (Slide #17) and Dark (Slide # # 18) The Comparative series (Slide #19) showing all three color palettes were developed next. These palettes have colors containing a large quantity of white light. Also developed are a <u>Series of Brown's</u> (Slide #20) 16 color run, 8 color run (Slide #21) and a 4 color run. (Slide #22) Also displayed is the Comparative series. (Slide #23)

## Color Application and the Process of the Color Display

Once the color palettes were established, they could be applied in a map format. (Slide #24 Digital grey scale map with 32 step grey series palette) First the digital graphic image is brought up on the color monitor in grey tone values with a selected palette appearing with the graphic image. (Slide #25 Grey scale map with series of Brown palette) The color palettes are located along the top or the bottom of the image frame. (Slied #26 Grey scale map with color spectrum) Through a pointing technique, color can be assigned to the areas within the body of the map.

With keyboard at hand for the input, one simply points with the joy stick, to the color desired in the palette, keys in a return then points to the polygon to be colored, and keys in another return. (Slide #27 color map with palette display) The selected color then appears in that polygon and all other polygons having the same value.

It then becomes a quick task to compose a color map which is a suitable representation of the information. If after the map is composed one is not satisified with those colors used, the colors may be changed through the same process. Once a fully composed color map is established and is deemed satisfactory, it can be preserved by the different reproduction techniques of the matrix camera.

## Conclusion

The field of Cartography is expanding rapidly and influencing disciplines such as Computer Technology, Mathematics, Psychology, and the Graphic Arts, are being applied to Cartographic techniques. It is no longer sufficient to have training in only one area. Through the study and practical use of cartography, one must incorporate the many diverse disciplines. As computer technology advances there are new applications for fundemental concepts. This documentation demonstrates one study of Color Theory Concepts as they can be applied to computer enhanced Cartographic Techniques.

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