COLOR GRAPHICS HARDWARE: REVIEW

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One of the most talked about and written about subjects of 1980 in the computer industry was color. The emergence of color as a useful tool will continue in coming years. The use of color display terminals and color hard-copy output will become commonplace.

As IBM states in one of their brochures, color can provide us with important information. This is a succinct reason for color use and its benefits. The reasons, of course, can be expanded, but color is important if it provides information.

VISUAL PERCEPTION

It has been calculated on the basis of neurological measurements that about 38% of all human sensory input is delivered through the visual mechanism. We obviously use our visual mechanism to receive and recognize data, even graphical data, differentiating objects by their size, shape, texture, etc. On computer displays, we differentiate items by blinking, underlining, font changes, reverse video, etc. It is natural then to add color to this visual input. Work by psychologists and others involved in perceptual experience into the proper use and psychological effects of color, indicate that color is a common experience descriptor. Similar descriptors include shape, size, position, texture, function, etc. Color is just one of the many descriptors we use to differentiate objects in our environment.

While it is generally accepted that color images are more pleasing to the eye, are more rapidly understood, and are capable of providing more information, there is an increasing need for more work to be done relating the use of color to business graphs and the decision making process. Color leaves a lasting and definite impression regardless of the accuracy of the data presented. A 1975 study by Richard E. Crist of the Department of Psychology at New Mexico State University concluded that color may be a very effective performance factor under some conditions, but that it can be detrimental under others.

Color can be used to elicit responses both of a rational and emotional nature. Inappropriate use of color can distort perception and lead to erroneous interpretation. Since color increases the amount of information supplied, it must be used wisely, and not over used. How color graphic information is displayed determines whether the information is easier to understand and assimilate. Consider what is the most important information to be communicated and select colors in such a relationship that the necessary information is more quickly recognized. Certain color combinations can hamper legibility and distract the viewer. Given two squares of equal size, one bright red and one bright green, the red square will tend to be judged as larger. Certain colors such as blue, for which there is low visual acuity, may cause recognition problems when used for small textual data.

USES OF COLOR

Color is important in that it has a principal motivation effect: it causes attentiveness. Proper use and understanding can turn this effect into great advantage. The basic uses of color are three-fold. Color can be used as a signal, color can convey meaning, and color can be used as a parameter of differentiation or discrimination. In the first instance color can draw attention to or aid in locating a particular symbol or item. It can be used as a cue or alarm to alert an operator, making critical or dangerous conditions stand out.

In the second instance, the color of an object can itself convey certain data and provide information. Additional meaning can be given by using color as a coding mechanism to separate categories of information. Enhancing pictures by the addition of color makes pictures more understandable, at least to someone trained in the recognition of those colors and their meaning. While it is possible to differentiate items by size, shape, etc. adding different colors to these sizes and shapes permits easier recognition. A distribution of heat of a body of land, ranging from red for hot to blue for cold would be an example of this use. If, for example, color is used to distinguish red objects from green objects from blue objects, it may also be used to indicate a specific piece of information about objects of the same size or shape. Given an added dimension by varying their colors, a blue triangle may have a different meaning than a red triangle, yet the blue square and blue triangle share something. In such an instance the discrimination factor is increased as well as providing significant information about the object or what it represents. For example, consider the computer printout. By adding color to a certain column, it can be identified quicker.

The financial analyst will certainly
know which column lists accounts receivable over 90 days due and can search for that column. If that column, however, appeared in some color, location and recognition would be faster. If the color of an item is unique and that color is known in advance, the color aids in the search and identification task.

Thirdly, color can be used to distinguish items or fields of data for further investigation and interpretation. The same color applied to different areas links those particular areas of information. This feature occurs in thematic mapping.

While color can be very effective in improving performances and productivity there are certain instances were color can be detrimental. Color must be used selectively otherwise it doesn’t increase operator efficiency. Colors must be tied to a meaningful relationship and not chosen at random, just for effect. Color can be successfully used to reinforce information but if one uses it just to liven up the screen it may not help. It may in fact, hinder the operator understanding of what he is supposed to learn.

The computer printout allows us to create an instance of where color can be used detrimentally. If concern is only to locate accounts receivable items over 90 days overdue, try to put only that item in color. If, for purpose of visual effect, or for the mere purpose of exercising the hardware and software, all columns were printed in a variety of colors, the irrelevance of color or redundancy of colors might cause a decrease in the search time for the particular item.

**NON-GRAPHICS**

Although the true benefit of color is in the presentation of graphic images, and the interest in these two capabilities has occurred almost simultaneously, color can benefit the presentation of alphanumeric data. We can divorce the terms color and graphics although that is not too often done in the text on the subject, but it is possible. We are all familiar with the standard tabular printouts. Delving through the information to find those items of interest is time consuming and tedious. A color display and color hardcopy output make it easy to accentuate and locate specific information. Referring to the accounts receivable example, it is very easy to color code those accounts which are outstanding for a certain period of days. This is a simple way to begin using and benefiting from color.

**GRAPHICS**

We absorb information through verbal and non-verbal recognition processes. An example of a non-verbal recognition process is the recognition of a familiar face or a scene. A verbal description to communicate this information to another, even another familiar with that face or object would be irrelevant, distracting and may not even convey the proper message.

The purpose of a graph is to compress and telegraph a specific idea. If the visual information is unclear or too cluttered, it will distract from the information learning process. Graphics convey more information more rapidly due to a process called pre-attentive perception, however, the brain must comprehend text or numerals in a more laborious one at a time fashion.

By summarizing masses of data in an easy to read format, graphics such as pie charts, line charts, bar charts and shaded maps allow managers to analyze, digest and act on more information more rapidly than before, when data came in the form of fixed stacks of computer printouts. Printouts provide an over-abundance of irrelevant information, causing managers to spend too much time studying details to see how business is going.

Scientists and engineers are trained in the use of graphs and it is from this area that much of the development in color graphic hardware and software originated. The predominant growth in color usage, however, will be in the presentation of graphic information. As management is educated in their use in absorbing information, color graphics will become more a part of the decision making process.

Business management has a way to go to catch up with present technology, and corporations and universities are beginning to educate managers.

The reasons for graphics are to increase productivity on the part of the user, require less time to accomplish a given task, more effective problem solving, and improve communication in relating results to other individuals. Remember that the vast market for potential users of computer graphics is not among computer or scientific professionals, but managers.

Business graphics create efficient communication channels between man and the computer. Whereas, color computer graphics were originally used only to highlight or represent data, as their use and understanding increases and businessmen are able to interpolate
beyond the graph, they will be utilized more as decision making tools. Managers are interested in magnitude and direction of quantities and statistics, relationships that can easily be described in graphical presentation as opposed to textual presentation. Often change or rate of change are more important than absolute values.

A manager usually needs to digest large amounts of information quickly to develop an overall model and understanding of a particular situation. To understand trends, patterns, and inter-relationships between various factors, it is easier to use graphical representation than to abstract this data from a tabular format of alphanumeric information.

Charts and graphs are used to examine comparisons, relationships, variations and distributions, not specific details. A good chart can convey this information even without scales. The object of graphs is to convey useful information, even interpretation, not to impress with the volume of data, novelty of design, or number of colors.

Consider some of the common charts. The Pie Chart gives the impression of being total, of 100%. It highlights the relative magnitude of comparative data. Designers recommend starting the most important data at the 12 o'clock, ordering by size, and limiting to five or six fields.

The Bar Chart emphasizes deviations from standards or previous years by comparing and ranking. Sequencing by magnitude creates one effect, randomly another.

The Curve (Line), or Column Chart emphasizes trends and patterns overtime by showing quantitative variations. Color graphics systems increase personal productivity by reducing the medium of wading through written reports, replacing it with an activity of understanding and interaction with the data and concepts represented. The important part is that a color graphics system can provide information that is really needed. The relationships and trends produced by statistical tools such as smoothing functions, regression, curve fitting, trendlines, etc. can help the executive isolate and view more clearly the information exhibited in the display. Color graphics will enable the executive to spot trends more readily and increase complete information throughput, by spotting trends and exceptions rather than all the data. Absorption and interpretations of numbers can be a problem because they are abstract baring no physical relationship to what they represent. Graphic representation on the other hand adds to the quantitative data physical and spatial relationships. This latter type of information is much easier to absorb and interpret. When exact figures are not necessarily required, decisions can be made quicker through the use of graphics. Graphics of course, is a tool which enables the decision maker to see performance variables quickly, perhaps even in one page.

Graphic presentations must be produced honestly and well or they can be deceptive. The manager using graphics must be supplied with something he needs rather than something that just looks nice. Pictorial or graphical representations should convey actual and relevant information. Given that the information is accurate, the impact created by graphics, coupled with the additional impact created by color, requires care in the presentation format and in developing and maintaining a consistency of that format. A consistent approach to displaying graphic information makes information easier to read, yields confidence in graphic format and color, and stimulates the need to know.

DISPLAYS

Most manufacturers of computer and display equipment have either introduced their own color graphics CRT or are using color graphics CRTs produced by others. Color CRTs are available at all cost/performance levels from both new and established companies. There are low cost versions for the personal computer market to offerings from large mainframe manufacturers. Color is available in a variety of resolutions, from 128 by 128 bits to 1,024 by 1,024 bits, with prices proportional to the increase in resolution. Most color displays are readily interfaced to existing user's systems. Color displays range from small self contained desk-top units to peripheral terminals, both intelligent and dumb. There are applications and needs for both types and those in between. Lagging behind was the development of software. However, many companies are actively engaged in producing packages to enable the user to adapt easily and readily to displaying information in color.

HARD COPY

The experience of the past year has shown the constant need for hard copy. This presented a problem for color display manufacturers, but in the past 18 months there have been introduced a number of devices providing color hard copy, of various quality, at various speeds, and, at various prices. Companies ranging from large manufacturers such as IBM and Xerox to small newcomers such as Trilog and Dunn Instru-
ments have produced color output devices. The most common method for generating color hard copy from a color graphics display has been direct screen photography, where a camera is positioned in front of the CRT and a picture taken. This procedure is not optimal because stringent precautions need to be taken to reduce display screen glare, the curved surface of the tube produces distortion, the camera must be made steady, and colors are desaturated.

The second most common means for generating color hard copy though it may or may not involve a system with a color display, is the use of line drawing plotters. Line drawing, or vector plotters, have been available for many years, even with multiple pens, but these units require long times (even hours) to produce color copy. They are mostly limited to four colors, with a singular advantage of being able to produce large drawings. Plotter prices range from under $1K to $30K, with a low cost/copy. Printers from Trilog, Ramtek and IBM are dot matrix type printers using multi-color ribbons to produce images on plain printer paper. They have a resolution of one hundred dots per inch and are priced in the $10-12K range. While the Trilog and Ramtek units interface to many CRTs, the IBM unit requires additional IBM hardware. Images are produced in about four minutes at a low cost/copy.

The Xerox 6500 Color Graphics Printer uses laser xerography to produce color copy on plain bond paper. The Xerox device uses seven colors: red, green, blue, black, cyan, magenta and yellow. Halftoning produces additional colors. The Xerox printer is designed to interface to a host CPU or to terminals such as Ramtek and Tektronix. The Xerox unit will print in sizes up to 6.4 inches by 13.75 inches at a rate of up to 192 per hour, at a moderate cost/copy. Resolution is 100 points per inch and purchase price is $28,000.

Color cameras from Dunn Instruments, Matrix Instruments, and Image Resource yield highest quality images using a three-step procedure to consecutively expose red, green, and blue, using corresponding color filters, from a monochromatic CRT onto Polaroid instant color films or conventional photographic film. These units interface to CRTs having RGB output conforming to RS-170 protocol standards, and have the capability of accepting NTSC video signals. Prices for hardware range from $3K to $20K, with cost/copy of $.50 to $6.00.

Ink-jet printers from Applicon and Printacolor produce color images by shooting fine dots of cyan, yellow and magenta onto the paper. The Applicon unit has a resolution of 100 dots per inch and produces copy up to 12 inches by 34 inches. The Applicon unit is expensive, costing $55,000 yet per image cost is low. It takes about 12 minutes to produce a copy. A smaller, lower cost version has been demonstrated privately. The Printacolor unit, just introduced at $6,000.00, uses special printer paper to absorb the wet ink. With a low hardware cost and low per copy cost, this unit bears watching.

The proper hard copy device for a particular application must be determined from user established criteria regarding speed, quality, and price. Those requiring copy that is to be reproduced in annual reports may want that device which produces the highest quality output. Those applications in which the user is concerned now with quality, but with quick data verification, speed and cost per image may be more appropriate considerations.

In the next few years:

1. Computer and display manufacturers will produce output devices with greater flexibility, such as allowing one unit to service many displays.

2. Prices for hardware and per copy cost will decrease.

3. The availability of more and better graphics software will stimulate the use of color graphic displays and the need for color hard copy.

4. There will be multi-unit installations, with printer, camera, and laser xerographic device available for diverse output needs. Flexibility will be key as user output needs differ. Converting from one medium to another will be necessary.

Precise economic justification of color graphics is difficult. Offered in support of color graphics use is the fact that DP departments of large corporations have already spent millions of dollars to set up elaborate methods of generating highly sophisticated reports. The problem with this is that they are presenting too much data to managers. The incremental cost of adding graphics capability is low, when compared with the investment already made, to allow it to be justified both in reduced paper flow and improved speed of decision making.

It is evident that the fields of color graphics will occupy manufacturers, suppliers, and users and will exhibit rapid maturation as all three groups adapt to each other's needs. But, successful growth will require better communication among the system designer, programmer and user. Too often systems are designed in isolation of the user.
It is for the user to state what information is needed and to define the word "friendly".