Color Graphics Terminals at SEP

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This article summarizes our early experiences with color graphics terminals at SEP. Another article in this SEP report by Claerbout explains how we got involved in color graphics. The most exciting feature of such terminals is the generation of real time movie sequences of seismic data. Many people in SEP have written software for our terminals including Jon Claerbout, Rob Clayton, Alfonso Gonzalez, Dave Hale, Rick Ottolini, Chuck Sword, and Jeff Thorson.

Uses of Color Graphics Terminals

We find the following uses for color graphics terminals:

(1) The ability to view seismic sections and other graphical data at remote terminals.

(2) Savings from not having to run off hard copies of every intermediate result.

(3) Using the color attribute in seismic sections to increase resolution and types of information plotted.

(4) Using animation as a diagnostic tool such as displaying data along slowing changing coordinates (e.g. offset) or processing steps (e.g. downward continuation). Certain features may be detected which would not be seen otherwise.

(5) Generating color slides and movies for presentations and educational purposes.

(6) Digitizing and interactive data processing.

(7) Games.

Terminal Characteristics

So far we have purchased nine DEC GIGI terminals (@$3000) for use primarily as ordinary CRT terminals. We have also bought one high performance Advanced Electronics Design (AED) terminal (@$15,000) for color graphics research. We have had on loan a Tektronix 4027 terminal. The table below compares major terminal characteristics.

Brand	Simultaneous Colors	Picture Element Grid	Comments
GIGI	8	384 x 240	built in BASIC
Tektronix	8	640 x 420	
AED	256	512 x 512	parallel I/O, pan, zoom, blink, memory mask, raster load

The color display capacity varies between different terminals. One measure of color capacity is the number of simultaneously displayable different colors. In many cases this quantity is far less than the number of *possible* colors.

Both the Tektronix and AED use a color index scheme. Each display point is stored in screen memory as an index to a short color table. Then each color table entry is assigned to a specific color. Color tables may be loaded by the computer much faster (1 sec) than the whole display memory (5 min). One benefit is the ability to rapidly change the overall color scheme. A clever use of this feature is to alter the gain scheme of a seismgram.

Color resolution and graphical resolution are not necessarily the same in a given terminal. The GIGI restricts six adjacent picture elements to the same color. The AED allows a tradeoff in color resolution and screen size. To double the number of grid points, the number of different colors is reduced by a factor of four per doubling.

All terminals attach to the host computer over relatively slow serial data lines (5 min to load screen memory). The AED has a parallel interface (20 sec) and direct-memory-access (1 sec).

All terminals double as ordinary alphanumeric terminals. All have digitizers and cursors. All have a vector plotting language with options for color selection, interior fill, etc. However, the language syntax is different for each brand.

Vector plot commands are useful for reducing the amount of information which must be sent across serial interfaces. However, they are too verbose and slow for plotting seismic sections where the color may change from point to point. Therefore, the ability of the AED to directly load raster data is very useful for plotting seismic sections.

Color in Seismogram Plots

Color can increase the amount of information in a seismic section plot, compress size, and improve clarity. We usually plot amplitude as a function of color. On terminals with a small color menu we make variable area plots with one color for positive amplitudes and another for negative amplitudes. On the AED, which can plot fine gradations in color, we have dispensed with variable area altogether. There is one screen raster to a data point. We use a three color spectrum with the endpoints maximum negative, zero, and maximum positive. Favorite schemes are black-grey-white, red-black-blue, and orange-white-green. Setting zero to a bright color tends to emphasize weak events while setting zero to black tends to emphasize the strong events.

Color may be used to plot other attributes of seismic data such as in the work pioneered by Seiscom Delta. Color can be used to plot overlay two different datasets, for example, one processed and the other unprocessed.

Gain

Gain schemes are important in utilizing the dynamic range of color graphics terminals for plotting seismic sections. Dynamic range is either increased or decreased on color graphics terminals as compared to conventional electrostatic plotters. When we must use variable area plots, the dynamic range is decreased, because the display screen size is relatively coarse. On the other hand, dynamic range is increased in terminals which can simultaneously display a large number of different colors. A rough comparison of distinguishable states is about 6 on a GIGI color graphics terminal, 16 on a Gould electrostatic plot, and 32 on the AED color graphics terminal.

A partial logarithmic gain of the data of about the .5 power (square root) improves our ability to distinguish weak events in the data (Claerbout SEP-25). The best choice of power is data dependent. We compute a satisfactory default by sorting a 25,000 point subset of the *entire* gather or section into percentiles. Then we chose the power to fit unity at the 99th percentile and .5 at the 85th percentile.

Gain can be applied before or after plotting the seismic section. Before plotting we rescale each data sample. Then amplitudes are converted to color indexes as they are sent to the graphics terminal. We assign default colors to the color index table by a linear gradation between the colors representing maximum negative, zero, and maximum positive amplitudes. However, we can quickly change the gain scheme *after* plotting by reloading the color index table with a non-linear gradation.

Zoom

The AED terminal permits instantaneous expansion of any portion of the display screen. The expansion factor may be different in the vertical and horizontal directions. Weak or aliased events sometimes appear and disappear depending upon the zoom factor. This feature is not unlike viewing a seismic section edge on.

Animation

The most exciting feature of our color graphics setup is the ability to quickly produce and display movies of seismic data. It takes from 5 to 20 minutes to convert the floating point data of an average length movie into color index bytes which can be directly loaded into AED memory. Then individual frames of the movie may be displayed as fast as a twentieth of a second apart using the animation schemes described below.

We have two different seismic data animation schemes. The first is for the slower serial and parallel interfaces. In this situation the time to fill the display memory of a color graphics terminal is significantly longer than the time interval between frames of a movie. First the screen is divided into up to several dozen display panels. Next the zoom feature is used so that a single panel fills the entire screen. Then the screen can be made to pan from panel to panel at a certain time rate to appear as a movie. Satisfied with the result, the movie can be directly recorded on a videotape machine. The length of the movie and size of each panel are restricted by the AED's quarter megabyte core memory. Thus this scheme usually restricts us to displaying gathers or synthetics.

The second scheme uses the lightning fast direct-memory-access interface to directly dump the host computer's core memory into the graphics terminal. The core memory in VAX computer is 16 times larger than the AED memory. Therefore, we are able to run significantly longer and larger movies such as that of real data midpoint sections.

Some movie examples include:

(1) The propagation of point disturbances in an elastic media with space variable

properties [Clayton]. They look like expanding soap bubbles.

(2) Downward continuation focusing of a linear moved out gather [Gonzalez]. Aliased energy seems to move in strange directions.

(3) A string of adjacent shot profiles [Morley]. Lateral changes in reflection coefficients and dipping reflectors appear as movement. Differential geophone gains appear as persistent vertical streaks during the movie.

(4) Wave propagation through a focus and prism [Gonzalez]. These are the classics Claerbout and Estevez put into a Super 8 movie and FGDP.

(5) Time slices sequences through a set of adjacent moved out shot profiles [Sword]. Shot or geophone consistent features appear as vertical and horizontal streaks. Midpoint or offset consistent features line up with one or the other diagonals. These phenomena were first noticed by Kjartansson (SEP-22).

(6) Migrated and unmigrated Snell trace midpoint sections across different Snell parameters [Ottolini]. Changes in reflector intensity demonstrate angle dependent reflectivities.

(7) Migrated linear moved out gathers through different p values [Gonzalez]. Events focus along Snell trace trajectories. As the p value increases, the Snell trace "bright spots" sweep from low to high offsets.

Videotapes of some of these examples are being prepared for viewing by our sponsors.

Rick Ottolini, Jeff Thorson, and Alfonso Gonzalez wrote the movie software. Chuck Sword wrote the parallel and direct-memory-access interfaces.

Computer Plotting Languages

Each of the half-dozen different graphics terminals and hard copy plotters has a different command language. Different standardization strategies have been chosen for vector plotting and seismic section plotting routines. All vector plot requests issued by programs are made in a concise intermediate plot language. (For example, $m\ x\ y$ means move to coordinates x and y.) These commands are then sent through a "filter" program tailored for each plot device. On the other hand, seismic section plotting programs are written specifically for each plot device. However, the input parameter format is the same for all seismic section programs.

Rob Clayton and Jon Claerbout wrote the vector plotting software. Rick Ottolini and Jeff Thorson wrote the raster seismogram plotting programs.

Other Applications

Dave Hale has written a command system to perform time series processing on seismic traces for his research and a course lab. Color graphics terminals provide a quick and easy way to see intermediate results. Final results can be plotted on a hard copy terminal.

Rob Clayton and Jeff Thorson modified a seismic data plot program to provide stereographic 3-D views of amplitudes. The result looked like flags hanging on a wire where the tilt of the flag was amplitude dependent. This suggests using several different plot attributes- color, variable area, 3-D to display several different data attributes such as amplitude, phase, velocity, etc.

Vlastislav Cerveny plots earth models, raypaths, and synthetic seismograms on color graphics terminals. Color is used to identify different interfaces and wave types.

Rick Ottolini has written programs for manipulating and displaying landsat satellite data. Three of the four landsat channels are assigned to blue, green, and red. Twenty-six bits of color information per picture element must be compressed into eight bits. The results are not bad.

Jeff Thorson wrote a plotting program for displaying integrated circuit designs. 256 color indexes permit identification of all possible intersections of up to eight fabrication layers.

Rick Ottolini has used the character re-definition feature to simulate a Mediterranean fruit fly bouncing about the display screen. Several fly poses are defined as new characters. Then the characters are displayed and erased in different positions to simulate motion.

Jeff Thorson wrote a program to trace the trajectory of a point object in a central force field. The distance attenuation law can be arbitrarily chosen. A joystick is used to change the velocity of the object.