ABSTRACT

Displaying multiple graphs or graphic output on a single page is a powerful and efficient presentation tool but unfortunately is often difficult to program. This discussion addresses several aspects of the methodology and problems of image distortion associated with programming these types of graphics using SAS/GRAPH® software. Techniques presented in SAS® documentation and previous SAS Users Group International (SUGI) conferences have discussed various methods including the use of SAS procedures PROC GREPLAY, PROC GPLOT overlays, and the use of the SAS/GRAPH Annotate facility. Creating a page of multiple graphic output is especially challenging when using graphics generated from different procedures (GCHART, GPLOT, G3D, etc.).

A SAS/GRAPH graphic page can be visualized as a two-dimensional coordinate system made of X and Y positions (i.e., HPOS and VPOS attributes). Depending on page orientation (portrait or landscape) the horizontal and vertical positions (or grid resolution) can vary significantly. This becomes an important factor when a rotation or scaling change may result in symbol, label, or axis distortion. Possible methods of addressing this problem include manipulating the GREPLAY window coordinates, graphic page attributes (e.g., HPOS, VPOS, HSIZE, VSIZE, and ASPECT) as well as controlling dimensional attributes of the original graph (e.g., using LENGTH and ORIGIN options in graphic coordinate positioning).

INTRODUCTION

With the introduction of the PROC GREPLAY and the Annotate facility, programmers gained the ability to manipulate and redisplay SAS/GRAPH® output as well as to overlay almost any information (labels, symbols, and reference graphics) on the output of almost any SAS/GRAPH® procedure. In addition it became possible to take advantage of the capability of displaying multiple graphs or plots at once. Unfortunately, what can be easy to describe and visualize is often difficult and time consuming to program. The additional versatility gained by using GREPLAY also meant additional programming demands and software complexities. One specific problem associated with using GREPLAY to display multiple output on a page is distortion of an individual graphic image in a template window. This becomes especially important when an individual template is rotated or manipulated in some fashion. An alternative approach to GREPLAY is using GPLOT to overlay multiple plots at different page coordinates on a single graphic page.

THE SAS/GRAPH GRAPHIC PAGE

It is useful to understand some of the basic attributes of a graphic page in SAS/GRAPH® and how these features are hardware device dependent (terminals, plotters, laser printers, etc.). A graphic page in SAS/GRAPH® is made up of a series of rows and columns that form a grid-like pattern made of cells. Each type of graphic display device has its own default grid pattern. Regardless of the type of display device (terminal, printer, or plotter) the smallest addressable display unit is the pixel. For plotters or other devices that display vector-based images this is sometimes called the plotting unit. The combination and position of pixels on a page form the graphic image. Information about the number of pixels and the resolution of the graphic grid can be readily accessed through SAS/GRAPH® hardware interface documentation or by using the GDEVICE procedure that lists basic device attributes (Figure 1).

For this discussion we will use the Digital® LN01 laser printer, which uses Tektronix® 4014 terminal emulation for graphic display. For this printer, the default page orientation is landscape and the graphic page grid is made up of 73 columns and 35 rows (Figure 2). Each

Figure 1. GDEVICE output screen.

Figure 2. Device TEKLN01 Default graphic page grid.
column within the grid is 3,021 pixels high and each row 4095 pixels long. Looking at a closeup of an individual cell, we can calculate cell height and width in pixels. In addition, it is important to note the ratio of cell height to cell width or the "cell ratio". The attributes of the cell are calculated as:

\[ \text{XPIXELS: 4095 HPOS=73} \]
\[ \text{YPIXELS: 3120 VPOS=35} \]

Cell Height
\[ \text{Total pixels/column} = 3120 = 89.1 \text{ pixels high} \]
\[ \# \text{ of rows} \]

Cell Width
\[ \text{Total pixels/row} = 4095 = 56.1 \text{ pixels wide} \]
\[ \# \text{ of Columns} \]

\[ \frac{\text{Cell Height}}{\text{Cell Width}} = \frac{89.1}{56.1} = 1.59 \]

A cell within the default grid for this device therefore is 56.1 pixels wide and 89.1 pixels high. The cell ratio is 1.59. That is, for every pixel wide a cell is roughly 1.59 pixels high.

In SAS/GRAPH, manipulating the SAS/GRAPH graphic page (using GOPTIONS attributes) is basically addressing the grid of cells. For example, the graphic page can be adjusted by changing the following attributes:

1) HPOS and VPOS. The number of horizontal and vertical positions within the grid (controlling grid resolution).
2) ASPECT. The ratio of character height to character width.
3) HSIZE, VSIZE and GSIZE. The position and size of the graphic display.
4) GUNIT. The units by which character and symbol sizes are referenced.

SAS/GRAPH PROCEDURES AND UTILITIES

GPLOT

GPLOT and GCHART provide the ability to position the starting location (using ORIGIN) of an axis as well as axis length (using LENGTH) using the AXIS statement for each graph or plot. These attributes can be used to position plots in a variety of programmer controlled units (e.g., inches, centimeters, percent of page, or cells). This feature gives the programmer the ability to place multiple graphs onto a single page by defining the starting and ending position for each graph. Besides controlling axis position and length, the AXIS statement can also be used to control a character orientation and size using angle (A=) and height (H=) attributes. Remsburg (1986) and Carpenter (1989) provide specific details and examples for a variety of graph configurations that can be generated using this method.

ANNOTATE

The ANNOTATE facility plays an important role in adding labels, symbols and graphics to graphic output generated by SAS procedures. The versatility of ANNOTATE is its ability to address a graphic page in different combinations of coordinate systems. For example, data generated in an ANNOTATE format can be placed on a page based on the total percentage of page size (percent of grid within an X and Y coordinate system) or in the area defined by a plot's or chart's axis range. There are several excellent discussions of ANNOTATE applications from previous SUGI's (Love1, 1988; Heisel, 1989; and First, 1989).

G3D and GMAP

Unfortunately, not all SAS/GRAPH procedures offer the same versatility as GPLOT, GCHART and ANNOTATE. G3D and GMAP do not have the same flexible options as other procedures (i.e., AXIS statements and multiple overlay capabilities). However, several features of the AXIS statement such as LENGTH and ORIGIN can be simulated by using the GOPTIONS (HSIZE and VSIZE) to define graph position and size on a page. In addition, labels and symbols and graphics can be ANNOTATED onto outputs from GMAP and G3D.

GREPLAY

One of SAS/GRAPH'S most useful procedures is GREPLAY, which allows the redisplay (or replaying) of previously generated graphics stored as graphic catalogs. The power of GREPLAY is in its ability to control the attributes of the graphic page window size and graphic positioning, and to overlay multiple graphs onto a single page. This is done by using the GREPLAY interface TEMPLATE screen (Figure 3).

Figure 3. GREPLAY template screen.
GRAPHIC DISTORTION

The work associated with this discussion was started with the goal of displaying four graphs onto a single page. The individual plots (similar to Figure 4) were placed in four separate graphic windows using GREPLAY. The result was less than desirable because of the amount of graphic image distortion (Figure 5). This is particularly noticeable with axis labels, values, and symbols displayed. Most documented examples of GREPLAY use template windows that are similar (in shape) to a standard page layout (e.g., a 10" by 7" rectangle). However, when we attempt to generate windows that are not similar to a standard page rectangle or we rotate the page or label, image distortion can occur.

Further investigation into this problem indicates that such distortion results from placing a graph based on a 10" by 7" graphic page (with a grid based on HPOS=73 and VPOS=35) into a window that is 7" by 3" (Figure 6). The attributes of a cell within this grid can be calculated using the number of pixels used to display each window. In other words, a ¼ height window is 1023.7 pixels high. A cell in this "redisplayed" grid has actually been distorted to appear as a horizontal rectangle with a cell ratio of 0.68.

Figure 4. Sample plot.

Figure 5. Plots displayed using GREPLAY.

Figure 6. Default page grid as displayed in GREPLAY.
If we use this ratio to calculate a cell grid for a full size page the result would be a grid with 106 vertical positions (VPOS=106) and 96 horizontal positions (HPOS=96) (Figure 7). The GREPLAY image distortion therefore results from altering the graphic grid and cell pattern.

![Figure 7. Equivalent grid for full page display.](image)

A Suggested Solution

The following method is one alternative for correcting for the distortion of the grid pattern. This method is based on maintaining the same cell ratio (of cell height to cell width) and ASPECT ratio as the original graphic. The first step in this method is to calculate the total number of pixels per row and column. In this case the window (1/4 vertical page height) is 1023.7 pixels high and 3120 pixels wide. A corrected grid is generated using a cell ratio of 1.59 to calculate the desired number of rows.

![Table: Corrected and Revised Grid Parameters](table)

The next step is to correct for character distortion (based on the default ASPECT ratio). On any given display device, ASPECT is the ratio of character height to character width. Distorting the grid will also cause a certain amount of distortion to the display character ASPECT. The ASPECT correction factor is based on the ratio of the original pixel/cell value to the revised value. Thus in this example the value would be:

\[
\text{Corrected} = \frac{\text{Revised cell height}}{\text{Original cell height}} = \frac{29.2}{89.1} = 0.33
\]

Based on this method we can then regenerate an undistorted image using an HPOS of 170 and an ASPECT ratio of 0.33; setting GUNIT=CELL we can generate the plot in GREPLAY window with a minimum of distortion. (Figure 8).

![Figure 8. Final graphic based on revised cell grid.](image)

Note: In this example the rotated axis labels have been overlayed using ANNOTATE.

ALTERNATIVE SOLUTIONS

Other solutions that can be used to maintain cell ratio (or cell shape) include:

1. Using HSIZE and/or VSIZE to limit the area of the page where the graphic is displayed, thereby forcing the grid into a particular pattern controlling cell shape.
2) Limiting the area of the graphic display using the GREPLAY template.

Limiting the size and page area where the grid is displayed leaves a certain amount of space unused as the grid becomes compressed into a certain area. This is not necessarily a problem when the graphic page is divided into two or three windows. Unfortunately though, when we attempt to stack four or more plots onto a single page, the actual area of the page used becomes smaller for each additional plot. Eventually the result is a single central strip of graphic on the page with a substantial amount of unused space on the edges.

SUMMARY

SAS/Graph offers powerful and flexible tools for graphic display of data. However, from time to time we may have to work around problems and develop methods to complement existing features. Displaying multiple graphics on a single GREPLAY page is a good example. There are several methods for displaying multiple graphics on a page and it is recommended that the SAS user be familiar with a number of these (e.g., using GPLOT, GCHART, ANNOTATE, and GREPLAY). If the GREPLAY procedure is selected and distortion is a problem, then the following summarizes the correction approach discussed here:

1) Calculate the cell height-to-width ratio based on graphic grid attributes and cell size (in pixels).
2) Using the GREPLAY template window, calculate a revised grid pattern based on the original cell ratio and the total number of pixels/row and column of the template window.
3) Calculate an ASPECT correction based on the ratio of the revised cell height to original cell height.

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REFERENCES


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