New Developments in SAS® Three Dimensional Visualization

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ABSTRACT

In this paper, we present some of the current three-dimensional visualization development efforts of the computer graphics division at SAS Institute. We will discuss the current functionality in SAS/SPECTRAVIEW™ and SAS/NVISION® software. We also discuss a new product, Visual Space™ as well as ideas for their future directions and applications. Although it is in the R&D stage, we have included it in this paper to provide a feel for some of the avenues we are exploring in this ever-growing area of three-dimensional computer graphics.

INTRODUCTION

Traditional methods of data visualization have produced information in the form of text reports. With text reports, relationships between the data are difficult to see in the letters and numbers. However, with the advent of graphing packages like SAS/GRAPH® software, an overall picture of the data is available to the user in a much clearer format. Overall trends in the data are visible in the maps, plots, and charts. Consider Table 1 and Figure 1:

The SAS System

OBS	MONTH	SALES
1	Jan	12.4
2	Feb	13.3
3	Mar	14.0
4	Apr	15.6
5	May	15.3
6	Jun	15.2
7	Jul	15.9
8	Aug	16.0
9	Sep	16.5
10	Oct	17.0
11	Nov	18.0
12	Dec	18.9

Table 1 - PROC PRINT output of sales data

As the amount of data grew, the need for more graphics processing became more apparent. Consider Table 2 and Figure 2:

Currently, most organizations have enormous quantities of data that simply cannot be comprehended in a text-based form. This is especially true for data with more than two dimensions.

In many cases, static pictures are incapable of conveying the true nature of the data. What you need to do is interact with the displayed information. For example, rotating a SAS/INSIGHT® scatter plot often clarifies particular clusters in the data. Similarly, interactively setting the color, size, and shape of particular points in a scatter plot adds a level of clarity to the data that is frequently unattainable with static graphs.

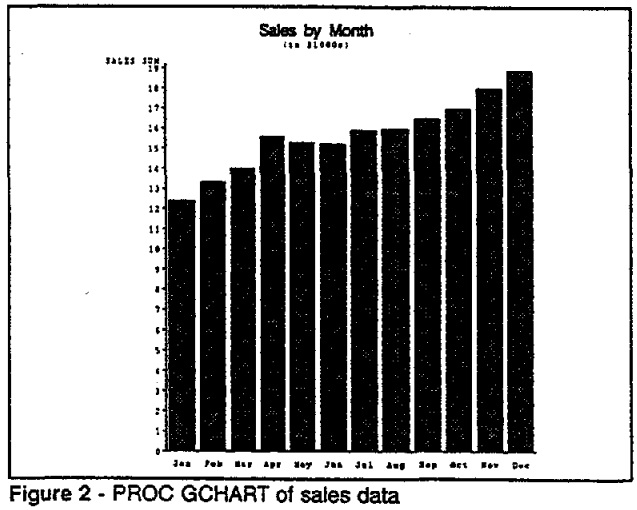

Figure 2 - PROC GCHART of sales data

The SAS System

OBS	STCODE	STATE	SALES
1	AL	1	1642.67
2	AZ	4	1370.67
3	AR	5	1636.67
4	CA	6	1052.00
...			
44	VA	51	1466.67
45	WA	53	1153.33
46	WV	54	1473.33
47	WI	55	1274.67
48	WY	56	1156.67

Table 2 - PROC PRINT output for sales by state

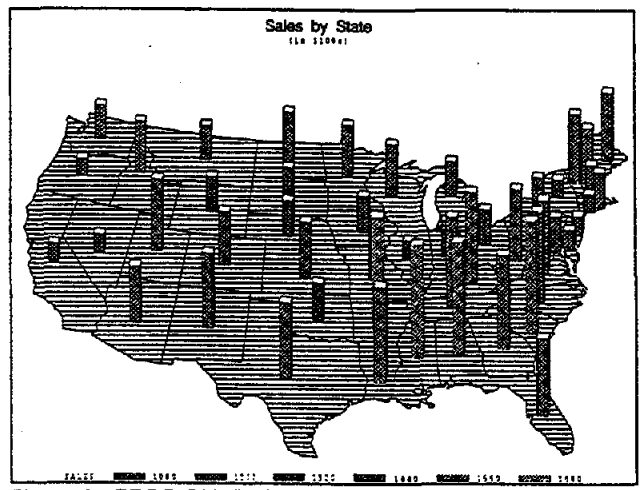

Figure 1 - PROC GMAP of sales data for each state

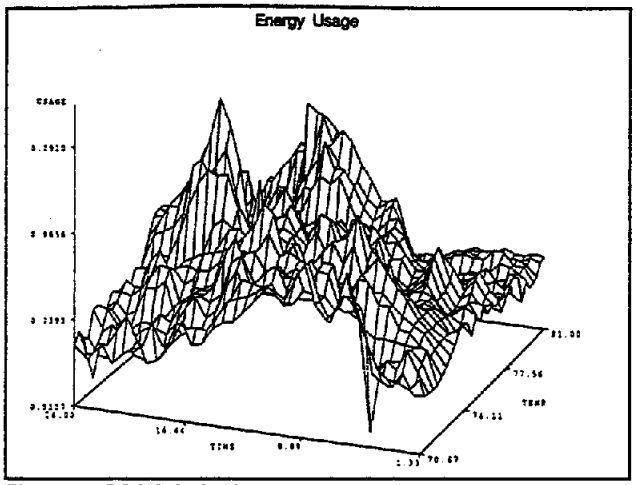

Figure 3 - PROC G3D of energy usage over time and temperature

In addition to the need for clearer graphical representations, more interesting data presentation has been required. Tables of data on an overhead projector, have given way to color slides with 3D effects. In many cases, the ANNOTATE facility can add depth and shading to graphs.

With the acquisition of NeoVisuals® software in 1988, the Institute stated its intentions to explore cutting-edge 3D graphics technologies. Although the high-end modeling, rendering, and animation capabilities of NeoVisuals were not immediately evident in the SAS System, many of the newest SAS products have begun taking advantage of this technology. SAS/NVISION is the direct result of rewriting NeoVisuals with a more intuitive user interface and immediate 3D shaded feedback. SAS/SPECTRAVIEW takes some of the advanced algorithms and techniques from SAS/NVISION and applies them to multidimensional data visualization. Visual Space™ uses and extends some dynamic camera movement functions initially derived from SAS/NVISION to provide a free-form tool for visualizing 3D models.

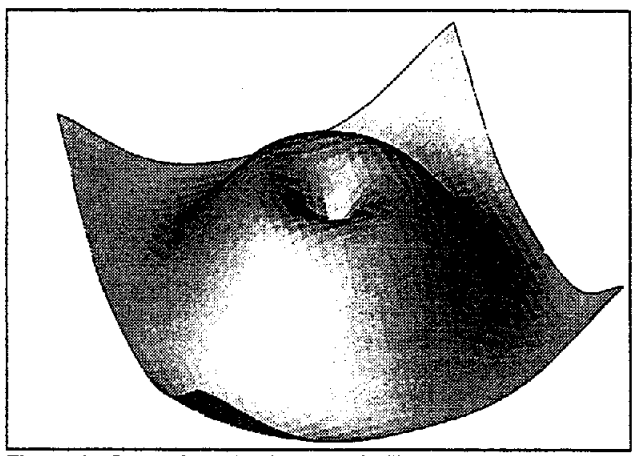

Figure 4 - Output from the Annotate facility

SAS/SPECTRAVIEW

New for Release 6.09 of the SAS System, SAS/SPECTRAVIEW provides real- time, multidimensional data visualization functionality with a complete menu-driven interface. This software has possible uses in a variety of applications, including environmental sciences, oil exploration, medical imaging, pharmaceutical studies, and financial analysis.

You can include up to five variables in a single analysis. The variables correspond to:

- X-axis variable
- Y-axis variable
- Z-axis variable
- Response variable
- BY variable

One of the strengths of this software is its ability to visualize very large data sets. Subtle patterns and changes in the data are clearly visible using custom color palettes and 3D structures viewed from any angle. The interactivity of SAS/SPECTRAVIEW allows you to rotate the model in real-time, stopping to zoom in on areas of interest. In addition, you can:

- Modify the colors while viewing the model to highlight particular densities or values.
- Make slices through the data using contour planes.
- Display contour planes as a block or line contour.
- Extract the peaks and valleys of a contour into 3D space much like a surface plot in G3D. The difference is that the SPECTRAVIEW surface is color-coded based on the response value.

In all, these contours and surfaces can be displayed with sixteen different variations. The entire volume of data can be viewed at once with its perimeter cut away or rendered with transparency to reveal internal structures.

The data points in a user-specified range can be subsetted and displayed in a variety of shapes and sizes. Once you find an interesting data range, you can request an iso-surface to be displayed at a given response value. The iso-surface is a 3D geometric representation of all data corresponding to the requested value. In medical imaging, this might be a 3D model of the skull from an MRI scan. In environmental science, the iso-surface might represent a potentially toxic level of air pollution. If the pollution data are collected over a period of time, it is possible to animate the analysis using time as the BY variable. This animation clearly distinguishes trends in the pollution levels. Further, you can pass a probe through the data to retrieve exact location and response value information. If the initial data contains anomalies (often present in medical images), several types of prebuilt filters can be used to process the data. The filters are a 3x3x3 matrix of values that operate on the input data set to smooth or sharpen contrasts in the data. You also have the option to define and use a custom filter on the data. Once you have performed the data analysis, you can add interactive annotations to the model. Axis labels, titles, and legends can be added to the model with the final results written to a TIFF file.

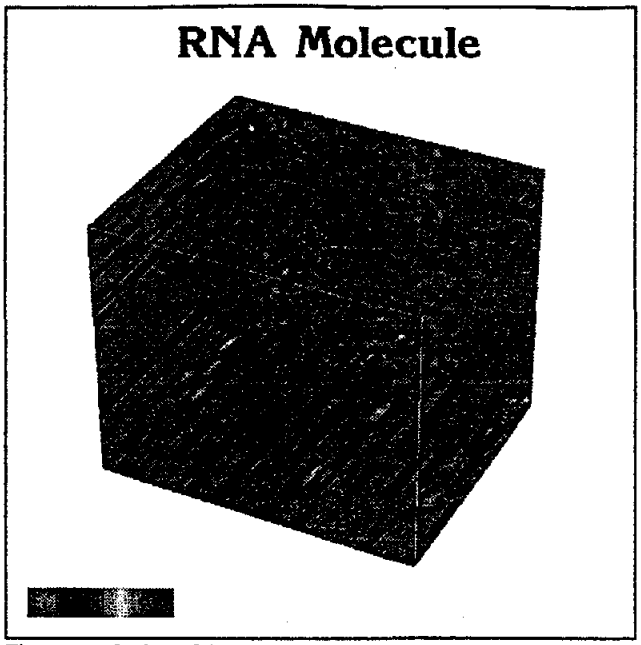

Figure 5 - SAS/SPECTRAVIEW output

SAS/NVISION

SAS/NVISION is the Institute's 3D modeling, rendering and animation package. The Institute has used it extensively to produce slides (in fact most of the slides produced for the Institute presentations were produced using SAS/NVISION) and computer animations (for example. all the computer animations at the SUGI19 opening session). It consists of three different parts: a free-form modeler, a renderer, and an animator.

Modeler

The modeler actually performs of three tasks: geometry modeling, attribute assignments, and scene construction.

To create the geometry, you can model with either the polygon modeler or the spline modeler. With the polygon modeler each entity consists of one polygon to make figures and, one or more figures make an object. Combining figures into objects gives the advantage of referring a collection of figures through a single name. In the *figure editor* lines, arcs, circles and various splines can be used to create polygons. Once saved each polygon becomes a collection of lines. Editing the figures consists of transforming vertices, which can be done either one at a time or a group at a time.

In the *object editor*, you can either group figures to make an object or you ca apply some transformation to a figure or an other object (for example, extrusion, connecting revolving around on axis). Once the objects are created, you can apply several transformations to the objects (for example, scaling, shearing, bending). In the *polygon modeler* there also exists a text editor, which you can use to create either legends in two-dimensions or text that can be converted to a series of figures in 3D.

The spline modeler, a NURBS (Non Uniform Rational B-Spline) modeler in turn describes its entities as a series of parametric equations. A one-dimensional set of equations describes a 3D curve; a 2D matrix of equations describes a 3D surface. All of this is hidden from the user's point of view. The software constructs all of this from the control points entered from the menu.

Attribute Assignments

The Attribute module of the modeler specifies numerous surface properties for the model. it also specifies the method of rendering. It is possible to specify 255 graduations of red, green, and blue or a hue, saturation, and lightness for the color. Other attributes include transparency, reflectivity, specularity, polish, and roll off. If you want scan line rendering (a method that evaluates each pixel against the model), specify the appropriate options (for example, Gouraud shading, Phong shading, ray tracing). Also, if you want to map images on the polygons while scan rendering, it should be applied here. Four mapping methods exists in SAS/NVISION software texture, transparency, reflection, and bump mapping. Texture mapping is used when an image is mapped on a an entity. Transparency and reflection mapping effects would be like etched glass and mirror, where transparency or reflectivity is desired in a pattern specified by the image. Use bump mapping when you want the effect of a non-smooth surface.

Scene Construction

In the scene construction portion of the modeler lights, cameras, background maps or environment maps are specified. Several different kinds of lights care available (globe lights spot lights, bar lights). Several different camera options exist (for example, field of view, type of projection, near and far planes, eye and focal points). The areas of the display that are not occupied by the model can be filled with the background. Use environment mapping when you want the effect of the environment on the model (sky, distant buildings that you do not want to model, for example).

Rendering and Animation

The renderer processes everything specified so far and produces a picture. The *renderer* can produce wire-frame, depth-sorted, or scan-line rendered images. As we mentioned earlier, several shading techniques can be applied as specified for scan-line renderings.

The animation portion of the package creates a sequence of images to produce an animation. Here the software constructs functions to be applied to the transformations. Later these transformations are to be applied either to the cameras, pieces of the model, or the lights. The functions are created when a location, orientation or some other property is marked at desired times. The software constructs the functions to evaluate the values of the transformations in between the frames.

Recent Enhancements

- Tracing around an image: You can bring in an image to SAS/NVISION and using the mouse give a loose region of interest. The software snaps to the contrasting parts producing a contour.
- Beveling: You can take a figure extrude in the direction of its axis and scale in the plane perpendicular to the normal to get the desired bevelling.
- Bounding box deformations: Once you put a bounding box around the section of the model. The geometry inside the box will deform as you deform the bounding box.

- 3D morphs: When you define a source and a target geometry. The source will be transformed into the shape of the destination in the specified interval.
- New environment mapping algorithm: The algorithm allows the environment to be mapped on the surfaces of a cube.
- Interactive Texture Mapping: A new interface to the texture mapping functions eases the application of textures onto surfaces.

Visual Space

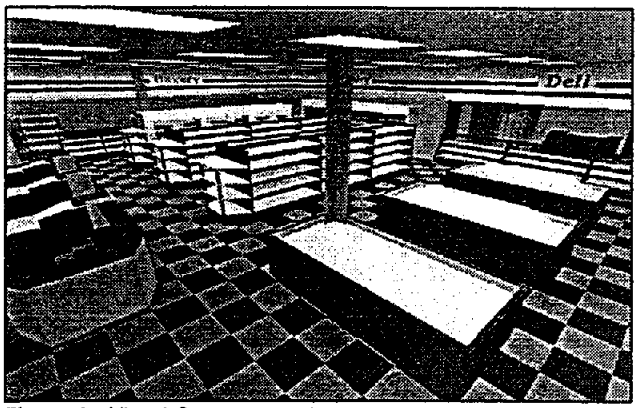

Figure 6 - Visual Space example

Visual Space represents one of the avenues the Institute is pursuing to explore new and more intuitive ways of navigating through three dimensional data.

The most traditional way of visualizing three-dimensional data on a two dimensional display has been taking isometric snapshots from the primary axes to produce engineering drawings.

The biggest shortcoming of the three-view approach is that it requires a trained eye and o back and forth between the three views to visualize the geometry in our minds. Nevertheless it still is one of the most accurate ways of describing a 3-D geometry.

Another way of visualizing 3-D data is through perspective projections. This way we have a way of looking at the data in a single window. However, using this method some of the detail of the data is no longer visible or distorted. For example in Figure 7 the notch on the corner of the cube cannot be seen at its full detail on the perspective window

You can alleviate most of these problems by moving the model or looking at different views. With today's computer hardware, some software does this by specifying panning, orbiting, tilting, or dollying. Moving the model or changing views has several advantages. Since all these motions can easily be described by a mathematical function, the exact location and orientation of the eye point can be generated. The only shortcoming is that humans do not move around the world that way. They mostly move with many different freedom of motions at the same time. So in order to navigate around 3D data a more relaxed way of navigation is needed.

Visual Space is the first attempt at this. Visual Space takes a very basic approach to 3D movement. Most of the time when humans walk, they look into the direction of interest and move toward it. In Visual Space the mouse movements move the focal point of the

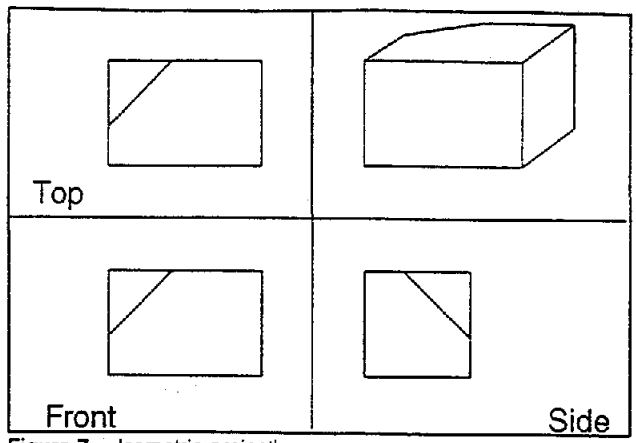

Figure 7 - Isometric projections

scene. The movement is accomplished by giving a speed to the eye point, and moving the focal and eye points in the direction of the established vector.

Applications of Visual Space

• Walking through architectural data (Building plans, remodeling projects)
Wanting to walk through proposed buildings was probably the earliest cause for such technology to be developed: the prospective owner of the building could walk through the building and ask for a change in plans or do it as he or she is walking through it. Without knowing how to read blue prints , and at a time where it is much easier to change plans than in the middle of construction. Figures 6 and 8 show some examples of Visual Space's use in the field of architecture.

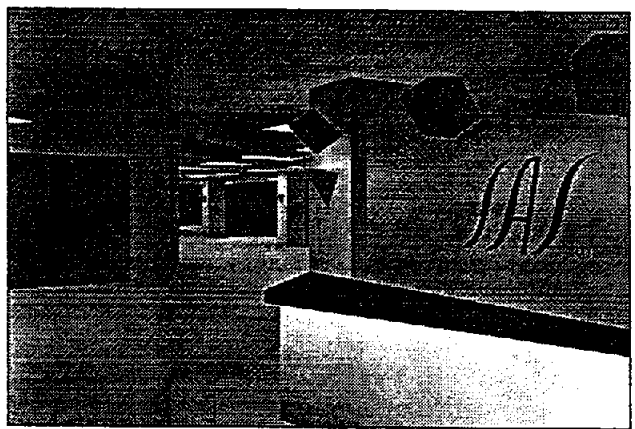

Figure 8 - Example of walking through Architectural data

Several different venues developed over the last few years. Movie directors started set designs and planned camera movements of a shoot very early on.

• Walking through scientific data
Investigating 3D scientific data may also benefit from such a

scheme. Probably the first applications of walking through scientific data come from the medical imaging community in which where medical personnel want to investigate the results of a CT scan generated surface from SAS/SPECTRAVIEW. For example, it is possible to examine a fracture closely before an attempt is made to repair it.

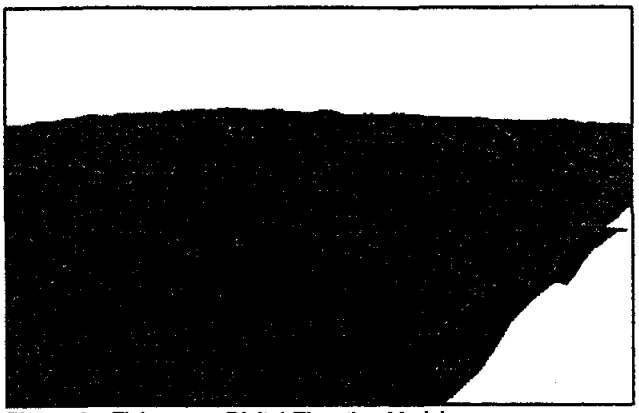

Figure 9 - Flying over Digital Elevation Models

• Walking (Flying over) surface data (Maps, plots)
Here Visual Space can be used to fly over digitized maps and elevation models. For example, a land developer may want to examine various sites around the country to look for a suitable piece of land. He or she can look at the incline of the land, the position of the sun in respect to the land, potential drainage problems. An example of this can be seen on figure 9.

Adding More Realism

As you can imagine, examples in this paper need to be represented as close as possible to they are seen in real life, and not as a 3D set of points in space. The biggest help to realistic simulations is the radiosity solver also being developed at the Institute. Radiosity is one of the newest technologies used in 3D visualization. Unlike the traditional lighting algorithms, it produces a view-independent solution. This reduces the computing effort required to produce real-time realistic motion.

Radiosity creates the lighted scene by solving the energy equation on the scene. Where the light sources emit energy into the scene. The other entities in the scene reflect some part of this energy back in the scene and absorb the rest of it. From the results of this procedure the colors for each of the vertices of the polygons is assigned (for example, the corner of a blue polygon which is closest would be a brighter shade of blue than the corner farther away).

CONCLUSION

The area of 3D computer graphics as applied to data visualization has grown dramatically over the past three years. This growth will continue at an even faster pace as businesses, scientists, researchers, and educators look for better understanding and clearer pictures from their data. Currently, much of the computer industry's work in visualization relies on expensive hardware and custom-built peripherals. The challenge is to implement these novel visualization techniques and to make them available to users on a wide variety of commonly available platforms.

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