AVS

AVS GEOMETRY and GRAPH VIEWERS TUTORIAL GUIDE

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GEOMETRY VIEWER TUTORIAL

CHAPTER ONE

Introduction

This tutorial walks you through several sessions with the AVS Geometry Viewer application. We start with the simplest case — working with a single, simple object. Then, we move on to creating a ''scene'' out of more than one object. We add lights to the scene, then add another ''camera'' (that is, another window to view the same scene from a different angle).

This tutorial uses a ''movie studio'' metaphor in describing the Geometry Viewer. The viewing application really does enable you to accomplish many of the same tasks as a movie director — you specify objects and compose them into scenes; you adjust the lighting; you shoot the scene from one or more camera angles.

The viewing application itself adopts the movie studio metaphor in its menu structure, which includes such choices as *Lights*, *Camera*, and *Action*.

We assume that you (or someone at your site) have installed the Application Visualization System tape according to the instructions in the *AVS Installation and Release Note*. If not, you may have to address operating system issues, such as adjusting your **PATH** variable.

Session 1: Working with a Single Object

To get ready to run AVS, simply sign onto the system, just as you always do. There is no need to change to a special directory first. To start the program, type this command:

```
avs
```

Within a couple of seconds, the main AVS menu appears. Select the Geometry Viewer subsystem. An empty window appears on the screen, along with a control panel along the left edge:

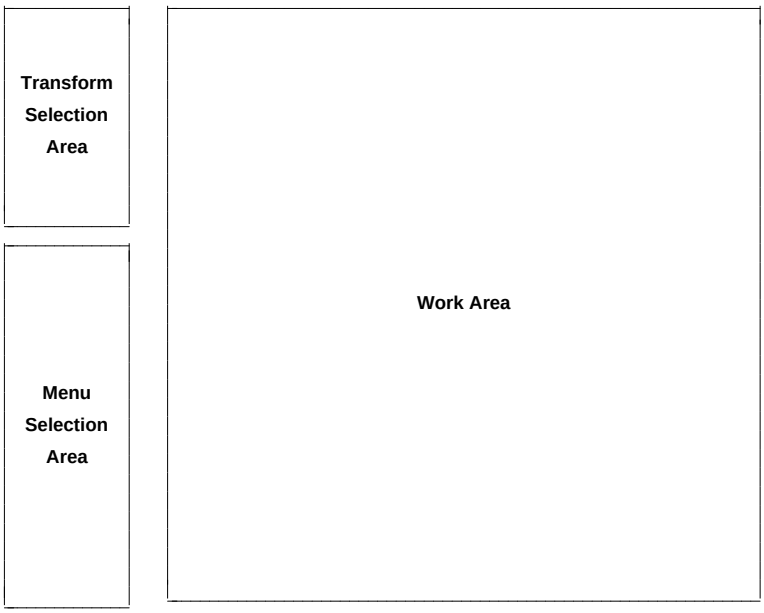

Figure 1-1. Initial Geometry Viewer Screen

The empty window is the viewing area. Think of it as a ''scene'' in which no objects have yet been placed. The control panel has two main areas:

- The *Transform Selection* area allows you to control the way in which the mouse works. At any point during a session, the mouse is in control of an object, a light, or a camera.
- The *Menu Selection* area is where you invoke most of AVS's functions: retrieving and storing data, specifying colors and lighting, etc.

The menu selection area always displays the following options:

```
Objects
Lights
Cameras
Labels
Action
```

Note the red ball that indicates **Objects** is the current menu selection. Accordingly, the lower part of the Menu Selection area shows the various **Objects** menu choices.

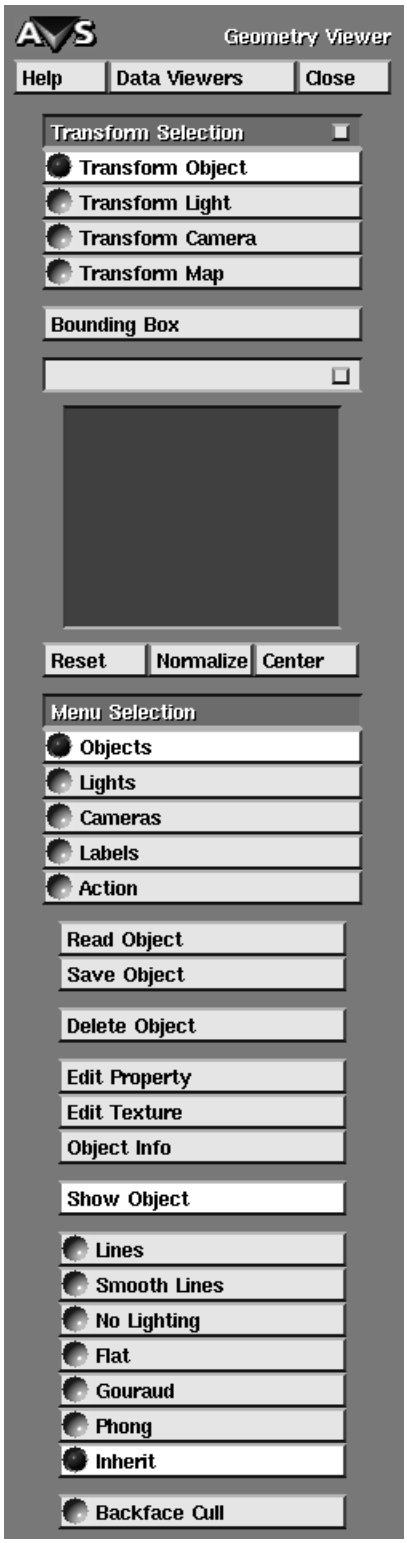

Figure 1-2. Transformation and Selection Menus

Reading in an Object

Let's bring an object into the work area. You'll note that the **Objects** menu selection is activated automatically at the beginning of the session. Thus, a variety of object-related options are listed in the menu selection area.

Click on **Read Object**.

A new window, the **File Browser**, pops up, listing the files in the current directory that describe objects AVS can display. At the top of this window is the name of the current directory (initially, *data*).

Click on *teapot.geom*.

You can add your own objects to this list, as well; we'll do that later on. We'll also explain the File Browser's file naming conventions, and how to access data in other subdirectories.

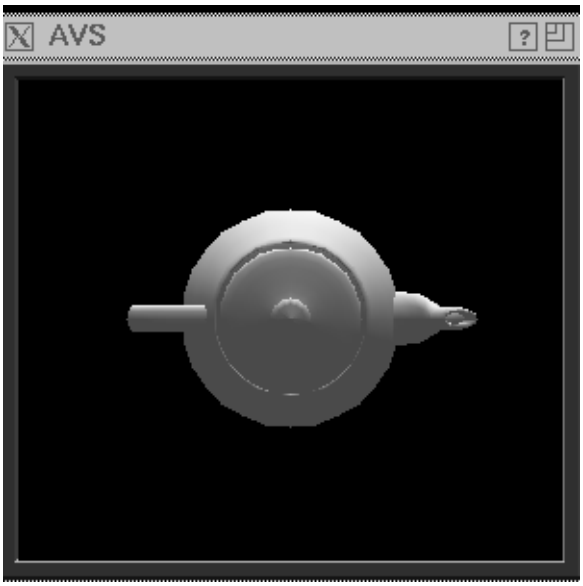

Figure 1-3. A Teapot

Note that the File Browser window remains onscreen. This makes it easy for you to bring several objects into a scene at once. For now, however, the teapot is enough, so click **Close** at the bottom of this window to remove the File Browser from the screen.

Manipulating an Object

Now, let's move the object around. There are three basic ways to manipulate an object: *translation*, *rotation*, and *scaling*. Using the mouse, you can accomplish all of these:

- *Translation:* When you place the mouse pointer on the teapot and hold down the right mouse button, you can drag the teapot around the window. You can even move the teapot completely out of sight. If you do,

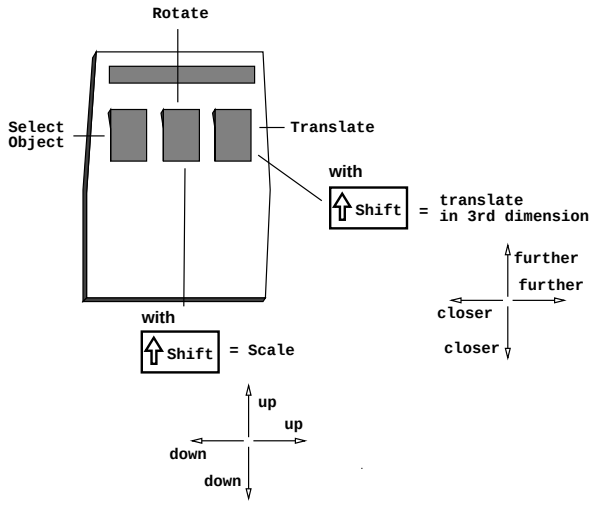

Figure 1-4. Functions of the Mouse Buttons

click the **Reset** choice at the bottom of the Transformation Selection area; this returns an object to its original position, in the middle of the window.

So far, you've translated the teapot only within a single plane. (It's the ''X-Y plane'' or the ''Z=0'' plane. By default, the positive Z axis comes directly out of the screen.) To translate the teapot in the third dimension, hold down the **Shift** key on the keyboard while dragging with the right mouse button. This may take a little while to get used to. Dragging downward or to the left moves the object closer to you; dragging upward or to the right moves it further away.

Note that you can make the teapot disappear by translating it too close or too far away. This is because AVS displays only a finite *view volume*. As an object passes though the near or far *clipping plane*, more and more of the object disappears. When it is entirely beyond the clipping plane, it vanishes completely. (If you lose an object, use the **Reset** button in the Transform Selection area to bring it back.)

- *Rotation:* When you place the mouse pointer on the teapot and hold down the middle mouse button, you can rotate the teapot in three dimensions. (It always rotates around its own center, rather than around some fixed point in the scene.) Try it, using the spout as the place where you ''grab'' the teapot.

  To understand how this works, imagine that a trackball device is embedded in the display screen. The mouse cursor is, in effect, attached to the surface of this ''virtual trackball''.

With a little practice, you can get the teapot ''rolling'', so that it continues to rotate by itself. To do this, release the middle mouse button while you are still moving the mouse. To stop a spinning object, just click the middle mouse button.

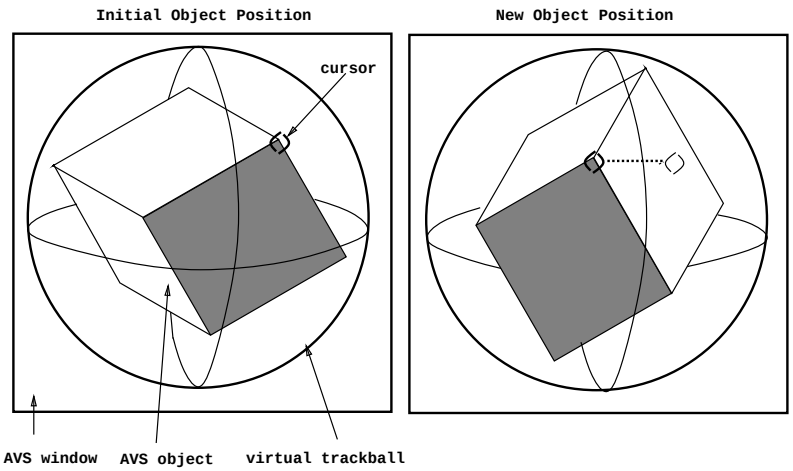

Figure 1-5. Rotating an Object with the Virtual Trackball

- *Scaling:* To make the teapot grow or shrink, hold down the **Shift** key on the keyboard while dragging with the middle mouse button. Dragging to the right makes the object larger; dragging to the left makes it smaller.

  If you make an object too large, all its surfaces fall outside the finite view volume, and the object disappears. As before, remember the **Reset** choice.

In general, you make a menu choice in the control panel by clicking once with any mouse button. You can click anywhere within a menu-choice rectangle — AVS confirms the click.

Bounding Box

The **Bounding Box** button at the bottom of the Transformation Selection menu changes the way that object manipulation works. Click on **Bounding Box** to turn it on. Now, repeat the mouse button manipulations for translation, rotation, and scaling that you experimented with in the previous section.

When you press a mouse button to transform an object, **Bounding Box** surrounds the object with a wireframe box. As you move the mouse, the *wireframe box* moves, but the object does not. Only when you release the mouse button at the end of the manipulation is the object re-rendered at its new location or scale.

Bounding Box is useful when you are using AVS from a less-powerful workstation such as an "X terminal" to reduce the amount of computational effort (and therefore time) required to render objects.

Precise Transformations

The Transformation Selection menu bar has a "dimple." Clicking any mouse button on this dimple brings up the **Transformation Options Panel**. The Transformation Options Panel gives you precise control over object transformations.

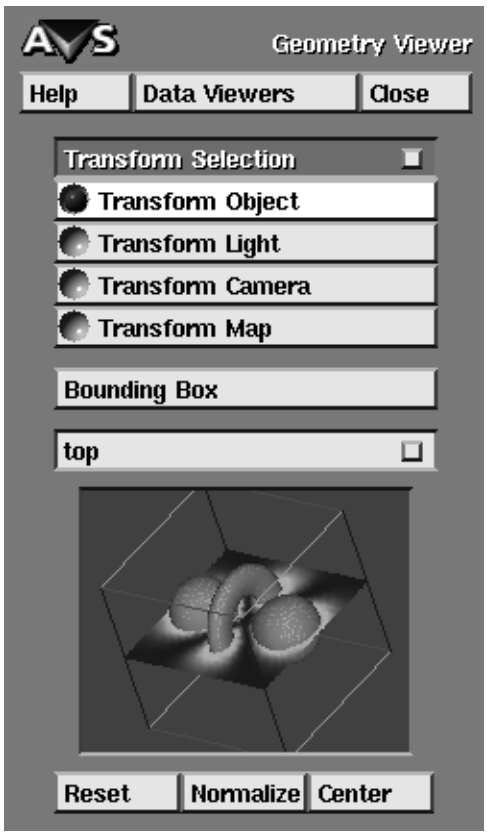

Figure 1-6. Transformation Selection Area

Select an object to be the current object and leave the mouse cursor in the geometry display window. Now, start pressing the four arrow keys on your keyboard. The object rotates about its center by the number of degrees shown in the Degree of Rotation typein at the top of the Transformation Options Panel. The default is 45 degrees. (Note: this may not work if your window manager defines the arrow keys for other purposes.)

The right/left arrow keys rotate the object about the Y axis, up/down about the X axis, and if you hold a shift key held down while pressing the right/left arrow keys, the object rotates about the Z axis. You can change the degree of rotation by moving the mouse cursor into the typein box, deleting 45.0 with **Ctrl-U**, then typing a new rotation value.

The other Transformation Options Panel typeins give you precise control over object translations either **Relative** to the object's current position in space, or to an **Absolute** location in space. Not all transformations work

with all transformable objects.

To update the **Absolute** display, you must click on **Relative**, then click back on **Absolute**.

Changing the Properties of an Object

While moving the teapot around the screen, you've no doubt noticed various aspects of its appearance. The entire teapot is a single color, but this color is subtly shaded rather than being uniform. The shading at a particular point depends on the shape, and on the angle between the surface and the light source. There are specular highlights resulting from a light source located directly in front of the screen.

AVS allows you to control all these aspects of an object's appearance:

- The apparent color of an object depends on its actual color, but also depends on the way the surface reflects light. You can set these ''surface properties'' (or ''material properties'') for the teapot by selecting **Edit Property** under the Object menu selection.

  The apparent color also depends on the color of the light(s) which illuminate the object. We work with lights in the next session of the tutorial.

- The appearance of specular highlights on an object depends both on its surface properties and on the available light(s). In this session, we'll manipulate the surface properties only — we defer changing the lighting until the next session.

- The degree of realism in an object's image depends on the *rendering method* used to draw it. Under the Object menu selection, there are several rendering-method choices: **Lines**, **Smooth Lines**, **Flat**, and so on.

Let's start by changing the surface properties of the teapot. Click on **Edit Property** to ope n a window that contains slider controls for various surface properties:

Before we start working with the Edit Property window, remember that AVS can handle multiple objects. When you set about altering the properties of an object, be sure that you know exactly ***which*** object you're currently working with. In our situation, there are actually two slightly different objects:

- The ''top-level'' object, which hierarchically includes all the objects that you've read into the scene. At this point, ''all the objects'' is just the single teapot.

- The teapot itself, as an individual object.

If you specify a change in the color of the top-level object, it may have no effect on the image. That's because the teapot itself can have a color, which overrides the color setting at the top level. Each object's color can be either set explicitly or inherited from its parent object. Explicit settings at lower (more specific) levels in the hierarchy override settings at higher levels.

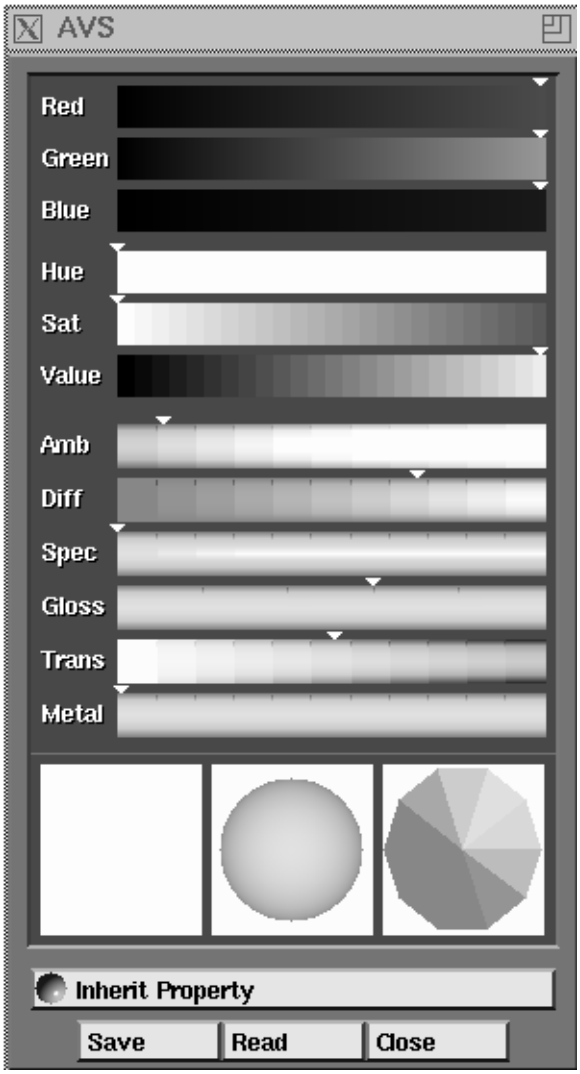

Figure 1-7. The Edit Property Window

To make sure that the teapot as an individual object is selected, click on the teapot repeatedly with the left mouse button, and watch the **Current Object Indicator** in the Transform Selection area.

Figure 1-8. Current Object Indicator Showing Top Object

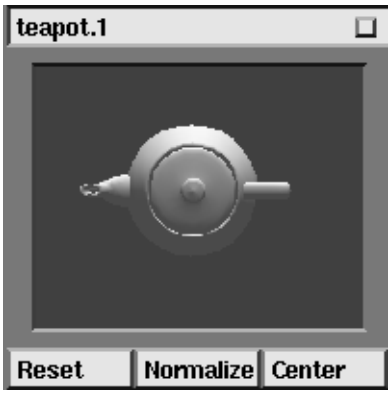

Figure 1-9. Current Object Indicator Showing Child Object

Each time you click, you move to a different level in the scene's object hierarchy. The label above the Current Object Indicator also helps you to keep track:

`top` Indicates that the top-level object is currently selected

`teapot.1` Indicates that the teapot as an individual object is currently selected (AVS adds a numeric suffix to help you keep track of objects. If you read in the same object twice, the instances are assigned two different numeric suffixes.)

Stop clicking when you are sure that the teapot itself is selected. You may notice that each time you click, the Edit Property window changes to show the settings of the current object.

We'll examine object hierarchy and its implications for attribute setting more closely in the third session of this tutorial.

The first six sliders control the surface color of an object. You can specify the color in two ways:

- The first three sliders adjust the Red-Green-Blue (RGB) components of the color.

- The second three sliders also adjust the color, by specifying its Hue-Saturation-Value (HSV) components.

You can use any mouse button to adjust a slider. Just click where you want the slider to move to. (Alternatively, drag the slider from its current location to a new one.)

When you adjust a color-control slider, the teapot's color changes as soon as you release the mouse button. Also note that the HSV sliders automatically adjust if you change the RGB specification, and vice versa. There's only one current color, but you can specify it in two different ways.

Below the color-control sliders is a group of reflectance-control sliders.

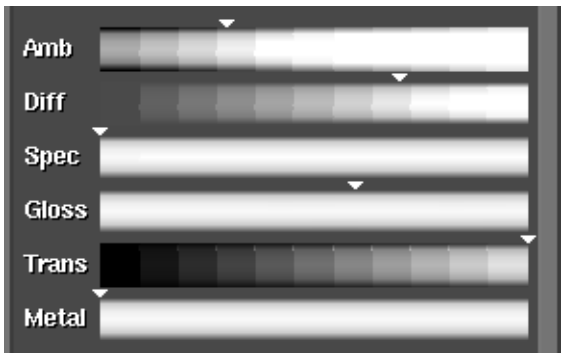

Figure 1-10. Material Properties Sliders

The first two reflectance-control sliders set the percentage of ambient and diffuse light reflected by an object.

- The fraction of **ambient** (uniform, directionless, background) light that the object reflects. Move the slider to the right to make the teapot appear brighter.
- The fraction of **diffuse** light (non-ambient light — from directional, point, and spot light sources) that the object reflects diffusely (dependent on the angle between the light source and the surface). As above, moving the slider to the right makes the teapot appear brighter.

You can also control the amount and type of light that actually exists in a scene. This is independent of each object's ability to reflect the various types of light. We'll adjust lighting in the next session.

Three sliders control the appearance of specular highlights on an object. Such highlights depend on the angles between the light source, the surface, and the eye.

- Move the **specular** slider to the right to make the specular highlight on the teapot brighter.
- Move the **gloss** (specular sharpness) slider to the right to increase the glossiness of the highlight.

- AVS constrains the color of specular highlights — move the **metal** (specular color) slider to vary the color between that of the light source (to the left) and that of the object (to the right). In our default-lighting situation, the color of the light that produces the specular highlight is white.

The **trans** slider controls the transparency of the object. Moving this slider to the left causes the teapot to fade away. Note that as it fades, you can see the back of the teapot through its increasingly transparent surface.

The best way to get the feeling for surface properties is to play with all these sliders. See how closely you can match the various teapot images that follow.

Figure 1-11. Teapot with Metallic Surface and Specular Highlights

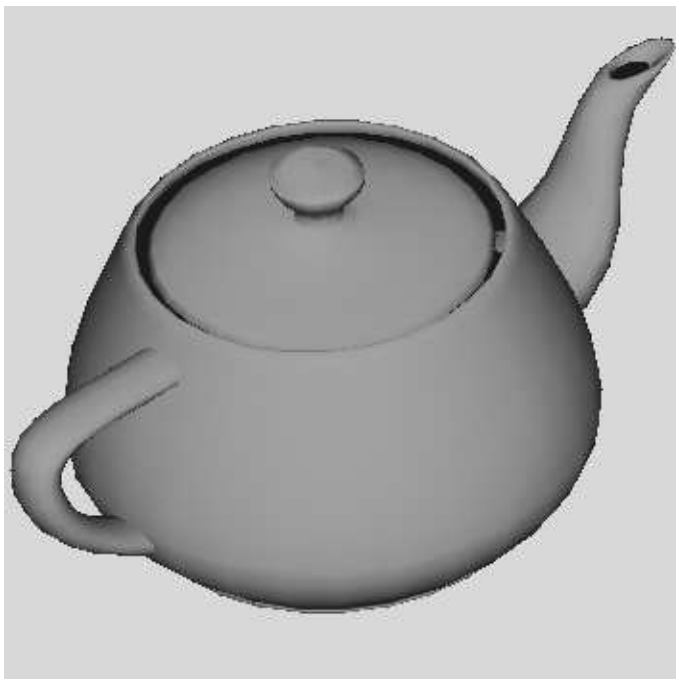

Figure 1-12. Teapot with Clay Surface

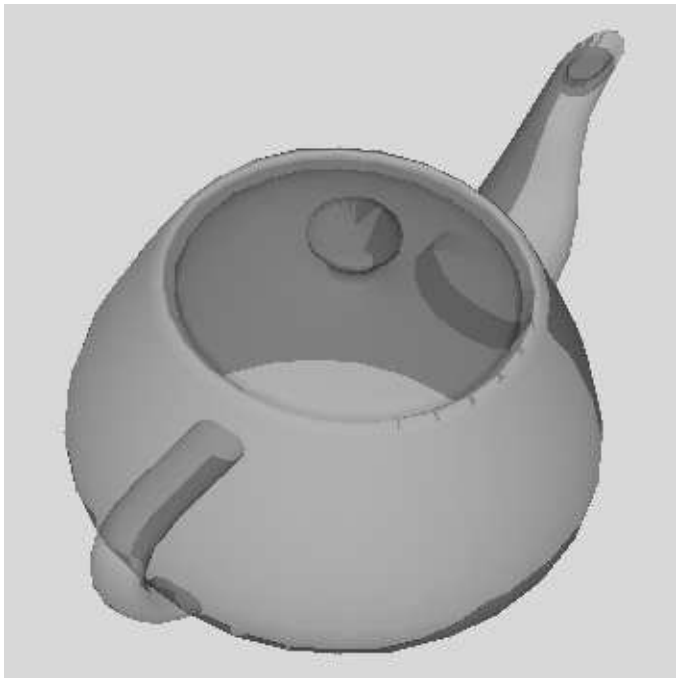

Figure 1-13. Teapot with Semi-Transparent Surface

At any time, you can close the Edit Property window by clicking on **Close** at the bottom of the window.

Changing the Rendering Method

Besides being able to control the surface properties of objects, you can control the *rendering method* that AVS uses to create images. Different objects can be rendered using different methods.

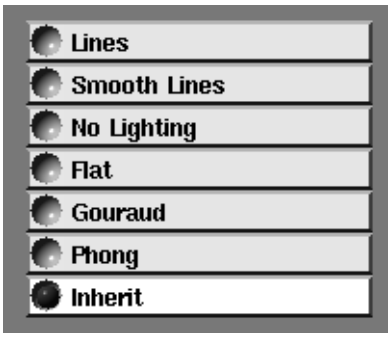

Figure 1-14. Rendering Methods

Click on each of the rendering-method choices, and note the effects on the teapot image. The most realistic method offered by AVS is *Phong* shading. In combination with specular highlighting, it provides excellent image fidelity.

The following paragraphs describe the differences between the rendering methods. Several of the methods address the way in which the facets of a solid object are colored. A typical object is defined as a collection of tens, hundreds, or even thousands of facets (usually triangles).

Points
An image in which only vertices are plotted; no connections are made between these points. However, AVS does allow you to apply lighting to these points.

Lines
A ''wireframe'' image, consisting of vertices and lines connecting them.

Smooth Lines
A wireframe image in which the lines connecting the vertices are anti-aliases (smoothed). The anti-aliasing process requires extra computation; for complex scenes, there may be a slight performance cost with this method vis-a-vis **Lines**.

No Lighting
A solid image in which only the color you assign to the object is used. Any lights in the scene are ignored; no shading computations are performed.

If an object has colors assigned to each of its vertices, these colors are linearly interpolated across the facets of the object. For example, a finite element analysis model might represent stress values as colors for the

various points in a support beam.

Flat
A solid image in which each facet of a polygon is drawn with a single, constant color. This depends on the object's color, along with the color and angle of the light(s) shining on the facet. Different facets can have different colors.

Outline Gouraud
A Gouraud shaded image with a (white lined) wireframe image superimposed on it.

Gouraud
A solid image in which each facet of a polygon is shaded (different pixels are drawn with different colors) using the *Gouraud shading* algorithm. In this algorithm, a color is computed for each vertex that defines a facet. The computation takes into account the color assigned to the vertex (or to the entire facet), the ''vertex normal'' vector, and the available light(s). When color values have been computed for all vertices, the values are linearly interpolated to produce color values for the pixels in the interior of the facet.

Phong
A solid image in which each facet of a polygon is shaded (different pixels are drawn with different colors) using the *Phong* shading algorithm. This algorithm interpolates the vertex normals, rather than the computed vertex colors. A separate lighting calculation then takes place for each pixel in the facet, producing greater accuracy at the expense of more computation.

Inherit
Causes the rendering method of the object's parent to be used.

In some cases, you may notice performance differences among the surface-rendering methods. The following table suggests why these differences exist:

Rendering Method	**Lighting Calculations**
No lighting	none
Flat	one per facet
Gouraud	one per vertex
Phong	one per pixel

Saving Your Work

Continue experimenting with the Edit Property window and the rendering methods choices until you have a teapot you are proud of. Then, select **Save Object** under the Object menu selection. Type in a filename for your teapot in the popup window that appears. Be sure that the mouse cursor is in the filename entry area before you start typing. Finish by pressing **RETURN** or by clicking the **OK** box in the popup window. AVS automatically adds a *.obj* filename extension to the name you enter (unless you type the extension yourself).

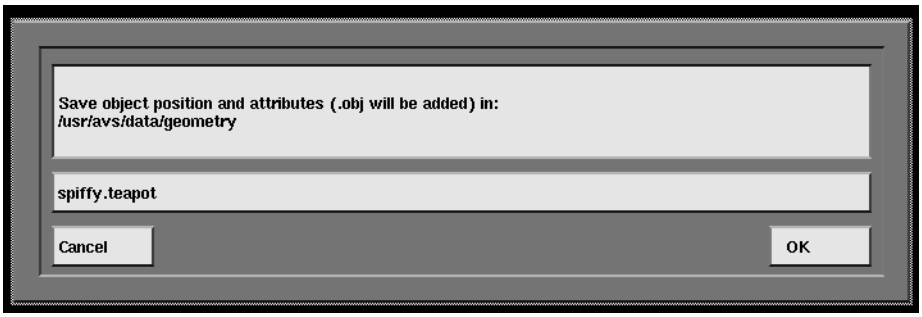

Figure 1-15. Saving an Object

To verify that your object was saved correctly, follow these steps:

- Select **Delete Object** to remove the teapot from the scene.
- Select **Read Object** to bring up the File Browser, and click on the filename you just entered. You may need to scroll the filenames. Scrolling works the same way in AVS as it does in the **xterm**(1) terminal emulator program: — the right mouse buttons scrolls toward the end of the list; the left mouse buttons scrolls toward the beginning of the list. Scrolling proceeds page-at-a-time unless the mouse cursor is in the little box at the top (or bottom) of the scroll bar. In that case, scrolling proceeds line-at-a-time.

The teapot should reappear, exactly as you saved it.

Figure 1-16. Scrolling Through the File Browser

Exiting the Geometry Viewer

That's enough for one session with the Geometry Viewer. To exit the program, select **Exit** at the very top of the control panel. To exit AVS, select **Exit AVS**, then click **OK** in the pop-up window that appears.

Session 2: Working with Lights

In the preceding session, we worked with a single object, changing its position, its surface properties, and the rendering method used to draw it. In this session, we'll leave the object alone and concentrate on another aspect of the scene — the lighting.

First, start AVS and enter the Geometry Viewer as described in Session 1.

Once again, the **Object** menu selection is chosen automatically. Select **Read Object**, and click on the customized teapot object that you created in the preceding session. After you've read in the object, close the File Browser window.

To get a feeling for the default lighting, rotate the teapot again. (Use the middle mouse button.) It's clear from the specular highlights that there is a light source located directly in front of the screen. Now, let's work with that light source.

The Lighting Panel

Select the **Lights** menu selection in the control panel. The various object-related menu choices disappear and are replaced by lighting-related choices.

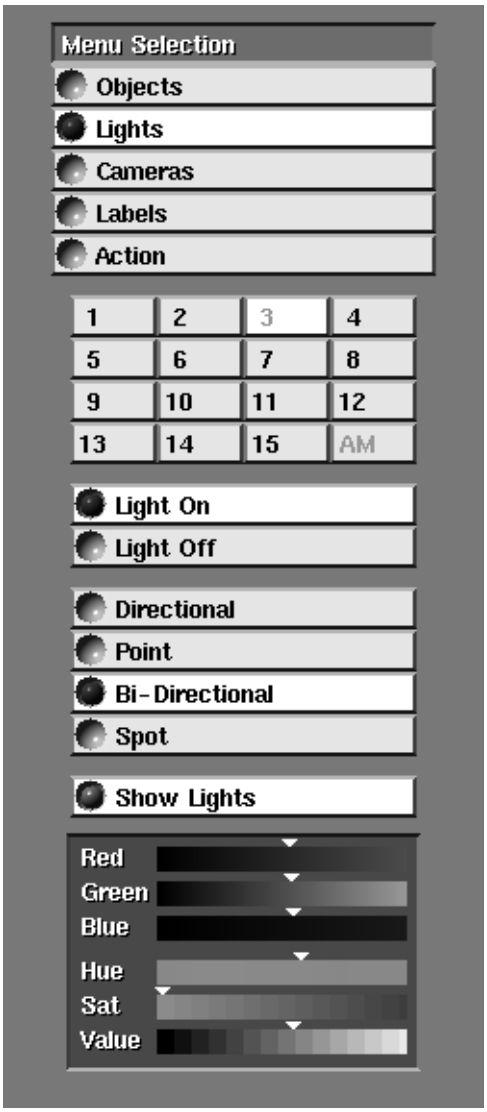

Figure 1-17. The Lights Menu Selections

The bank of numbers is a *lighting panel*, which allows you to create and control up to 16 lights. Each of the first 15 lights can be any of the following types:

- Directional
- Point

- Bi-Directional
- Spot

The last one, **AM**, is the ambient (non-directional) light for the scene.

Note that the **1** and the **AM** are illuminated, indicating that light number 1 and the ambient light are currently turned on. Below the lighting panel are control/indicator buttons that you can use to turn particular lights on and off and to change the type of each light. Click on the various buttons in the lighting panel to verify that all lights (except number 16) are initially directional, and all but light number1 are initially turned off.

At this point, make sure you also select **Transform Light** in the Transform Selection part of the control panel. This causes the mouse to be ''attached'' to the lights.

As you become more familiar with the Geometry Viewer, you may find it convenient to ''mix-n-match'' the transformation selection setting and the menu selection setting. For instance, you might choose the Object menu selection to read new objects, but at the same time choose the **Transform Light** selection to move the lights around the new objects. At the beginning, however, we recommend that that you keep the menu selection and the transform selection synchronized.

Manipulating Lights

Just as you have used the middle mouse button to rotate objects, you can now use this button to rotate the directional light. Give it a try. The specular highlights on the teapot give a clear indication that the light direction is, indeed, moving.

To help you work with lighting, there is a **Show Lights** menu selection. Make this selection, and an arrow appears in the scene, indicating the direction of the light. As you rotate the light, this arrow changes its angle accordingly.

The right mouse button controls translation of the light source parallel to the plane of the display screen, just as it did for objects. (And along with the **Shift** key, it can also control translation perpendicular to the screen.) If you try this, however, you won't see any change it the lighting. That's because translating a *directional* light source makes no difference.

To test the translation facility, change the light source from *directional* to *point* by clicking the **Point** menu selection. (A point light source, such as a light bulb, has a specific position.) The appearance of the teapot changes slightly, showing the difference between point lighting and directional lighting. And now, you can use the right mouse (with and without **Shift**) to move the location of the point light. As before, the middle mouse button rotates the light.

Note that for point lights, **Show Lights** causes a location marker to appear, rather than a directional arrow. This marker is depth-cued to show its location along the axis perpendicular to the screen.

Be sure to test the **Reset** button with the light. As with objects, it returns the light to its original position (and direction).

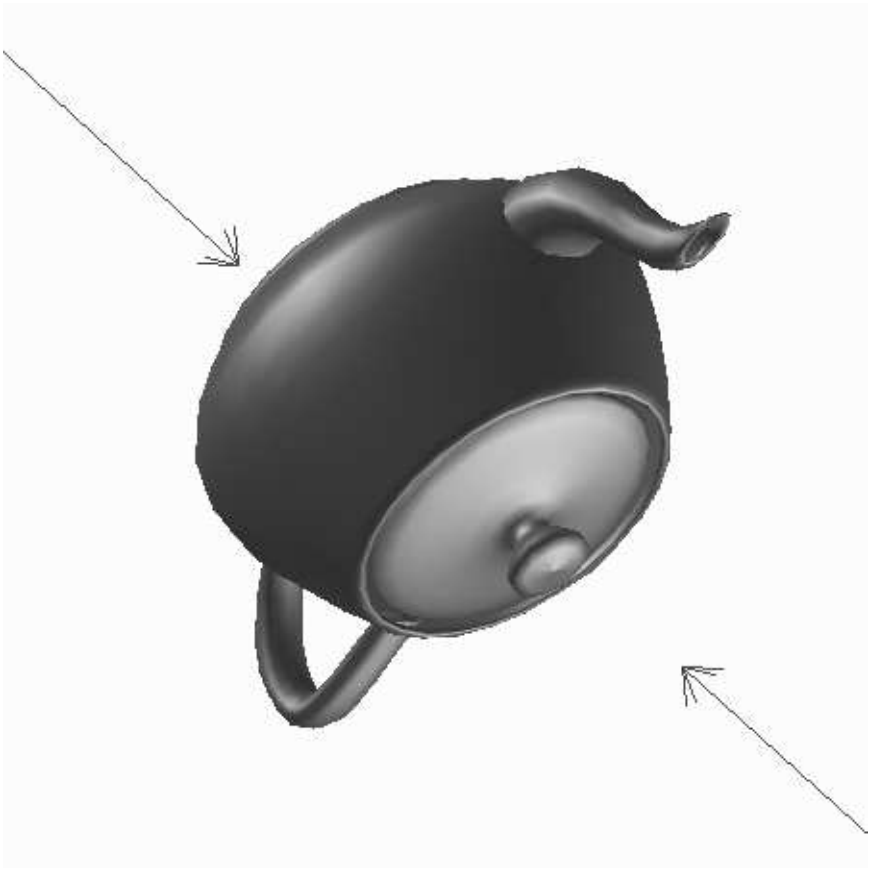

Figure 1-18. Using 'Show Lights'

Creating Additional Lights

So far, we've been working with just one light. Let's create another one. Click **2** on the lighting panel, then turn the light on by clicking **Light On**. Assuming that you still have **Show Lights** selected, another arrow appears in the scene.

As you switch back and forth between Light number 1 and Light number 2 on the lighting panel, note that the label above the Current Object Indicator also changes, indicating which light is currently under mouse control. As long as **Transform Light** is the transform selection, the mouse is ''attached'' to the currently-selected light on the lighting panel.

Try moving and translating both lights, making sure that you can see the effect of each light on the teapot. To facilitate differentiating the lights, try changing the color of one (or both) of them. At the bottom of the control panel is a miniature set of color controls, just like the ones in the Edit Property window for objects. Moving these sliders controls the color of the currently selected light.

Additional Light Types

AVS also supports *bi-directional* lights and *spot* lights. Try making light number 2 bi-directional. Note that light number 10 is turned on automatically. That's because this type of light is actually two directional lights, pointing in opposite directions. When **Show Lights** is selected, a bi-directional light is represented by two arrows.

A spot light is similar to a point light, but has a restricted ''cone'' of influence. (If a point light is like a naked light bulb, a spot light is like a well-focused flashlight.) When **Show Lights** is selected, the symbol for a spot light shows the cone. The angle of this cone is fixed in AVS — you cannot change it.

Be sure you also work with the ambient light (**AM** on the lighting panel). Using the mouse won't make any difference, since ambient light has no position or direction. But you can change the brightness and the color of this light using the sliders.

That's all for this session. Note that there is no ''Save'' menu selection under **Lights**. There is no way to save a particular lighting configuration independently from the scene in which they exist. In the next session, we'll save and retrieve an entire scene.

To end the Geometry Viewer session, select **Exit** at the top of the control panel. To exit AVS, select **Exit AVS**, then click **OK** to verify your choice.

Session 3: Creating Composite Objects

So far, we have worked with a single object, a teapot, changing its properties and changing the way it is lighted. In this session, we explore one of AVS's more sophisticated capabilities — maintaining hierarchies of objects and attributes.

The Geometry Viewer allows you to define complex object hierarchies. For instance, a model of a building might feature an office unit, which contains rooms, which contain desks, which have built-in clocks, which have hands.

The viewing application itself does not create multi-level hierarchies in ordinary, interactive usage. Each *scene* you create consists of a top-level object, which is initially empty. Each time you bring an object into the scene using **Read Object**, the new object becomes a direct descendant of the top-level

object:

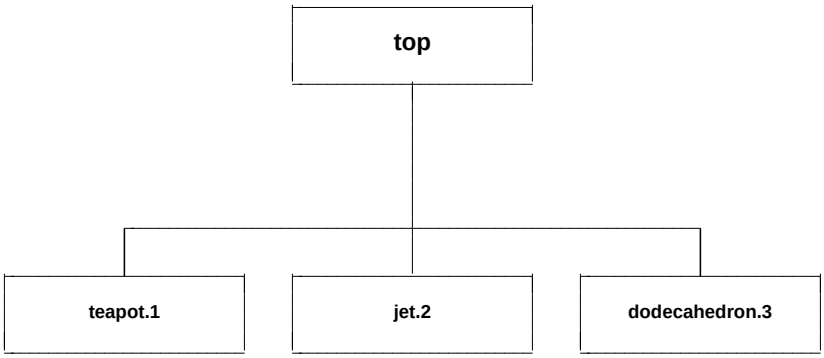

Figure 1-19. Object Hierarchy

NOTE
Actually, AVS is capable of handling deeper hierarchies. Some of the supplied objects are themselves hierarchical. In addition, you can use the AVS Script Language to define multi-level object hierarchies. This language is described in the *AVS User's Guide*.

Using the Edit Property window and the rendering-method selections (as we did in Session 1), you can set the attributes of the top-level object, or of any of its children. If a child has its attributes set, they override the settings of its parent, the top-level object. Alternatively, you can specify that the child is to *inherit* the attributes of its parent. You can also save the current state of the Edit Property window in a *.prop* file, then retrieve the attributes later, applying them to the same object (or a different one).

Changing the Current Object

Let's see how it all works. Start the AVS program and then start the Geometry Viewer subsystem, select **Read Object**, and (once again) click on the customized teapot object that you created in the first session. This time, however, don't close the File Browser. Instead, select another object to read into the scene: *dodec.geom*. This is a dodecahedron (a twelve-faced platonic solid whose principal occurrence in nature is in the form of calendar paperweights).

The simplest way to explore the object hierarchy is to rotate and translate objects. First, make sure that **Transform Object** is the current Transform Selection. Now, click the left mouse button at various locations in the window. Watch the current object indicator in the Transform Selection area as you do so:

- Clicking on either the teapot or the dodecahedron makes it the current object.
- Clicking on the background makes the top-level object current — this includes both the teapot *and* the dodecahedron.

Note that the Current Object Indicator always shows the currently selected object. In addition, the label above this indicator shows you where you are in the hierarchy:

```
top                 top-level object is current
teapot.1            teapot is current
dodec.3             dodecahedron is current
```

Verify that a particular object is selected by moving it with the right mouse button, or rotating it with the middle mouse button. When the top-level

object is selected, the teapot-dodecahedron pair move as a unit.

There are a couple of additional ways to navigate the object hierarchy:

- Clicking on the same object multiple times cycles you through the hierarchy — the first click selects the object itself (the bottom level); the second moves up one level to the parent (in many cases, this is the top-level object); and so on. Continuing to click after you've reached the top level returns you to the individual object level.
- Clicking on the current object indicator window cycles through all the single and composite objects in the scene.

Try these methods, too, and verify them by moving and rotating the object you select.

Hierarchy and Property Editing

Now, let's explore the way in which you can use hierarchy in editing object attributes. Make the teapot the current object. Then select **Edit Property** under the Object menu selection. The sliders in the Edit Property window reflect the ''customization'' you performed on the teapot in the first session. Suppose you want to these same settings to apply to both the teapot and the dodecahedron. There are two ways to accomplish this:

- Apply the teapot properties directly to the dodecahedron.
- Apply the teapot properties to the top-level object, then have both the teapot and the dodecahedron *inherit* these properties from the top-level object.

Let's try both methods.

Saving and Retrieving Properties

Click **Save** at the bottom of the Edit Property window. Then enter a filename under which to save the properties. AVS automatically adds a *.prop* extension to the name you type (unless you type the extension yourself).

Now make the dodecahedron the current object by clicking on it with the left mouse button. The sliders in the Edit Property window change to indicate the current settings for the dodecahedron. Click on **Read** at the bottom of this window, bringing up the File Browser. Then click on the name of the *.prop* file you just created. This copies the saved properties onto the dodecahedron.

The Geometry Viewer subsystem doesn't try to keep the properties of the two objects synchronized. Both objects have the same color now, but if you change the color of the teapot, the dodecahedron *won't* change too.

Inheritance of Properties

Applying the properties to the top-level object *will* keep the teapot and dodecahedron synchronized. Make the teapot the current object, then click **Inherit** at the bottom of the Edit Property window. Do the same for the

dodecahedron.

Now select the top-level object (e.g. by clicking with the left mouse button in the background of the window). Click on **Read** at the bottom of this window and, as before, click on the name of the *.prop* file you created. These saved properties now pertain to the top-level object and, through inheritance, to both the teapot and the dodecahedron. If you change the color of the top-level object, it affects both objects at the lower level.

That's all for this session. Exit from the Geometry Viewer and AVS as usual.

Session 4: Creating Multiple Views

In this session, we explore AVS's ability to show the same scene from different points of view. Continuing the use of the movie studio metaphor, each view is associated with its own *camera*. Each camera's view appears in a separate window, which you can move and resize using any X Window System window manager. You can change the position of cameras in much the same way as you change the position of objects and lights. You can also access such features as depth-cueing and Z-buffering.

Collectively, all the views on a particular collection of objects, along with a set of lights, is called a *scene*. (Thus far, we've been using the term *scene* more loosely, referring to a group of objects.) We'll also see in this session how the Geometry Viewer lets you work with multiple scenes concurrently.

First, recreate the situation of the previous lesson: start AVS and the Geometry Viewer and read in both the teapot and dodecahedron objects.

Now, bring up the **Camera** menu selections in the control panel.

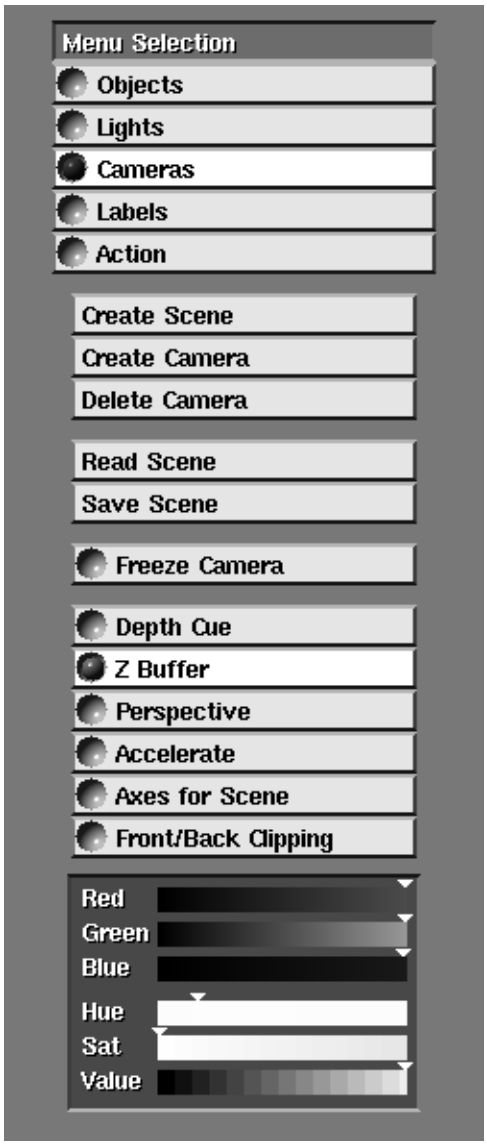

Figure 1-20. Cameras Menu Selections

Creating and Resizing a Window

Select **Create Camera** to create a new window that shows the same scene — that is, the same pair of objects. You may want to use the window manager to rearrange and/or resize the windows more to your liking.

The initial position of the new camera is the same as the initial position of the original camera, so both views may be the same. The two cameras are independent, however. To see how this works, click **Transform Camera** in the Transform Selection area. Now use the right mouse button (with and without **Shift**) to change the position of the newly created camera. Also try using the middle mouse button to rotate the new camera.

It's easy to move the camera to the other window. As soon as you click (e.g. with the middle mouse button) in the other window, the mouse becomes ''attached'' to that window's camera.

Relating Cameras to Lights and Objects

To gain a better understanding of how cameras work, try moving the light and the objects in either window. Remember to change the Transform Selection to **Transform Light** or **Transform Object** before you try to manipulate them with the mouse.

You'll notice that as you manipulate the light(s) in one window, the lighting also changes in the other window. That's because, conceptually, a single scene with a single set of lights is being viewed in both windows.

Similarly, when you move an object in one window, it also moves in the other — there is one set of objects, being viewed in two different ways.

Adjusting the Camera Lens

Several of the menu selections under **Camera** allow you to "adjust the lens" of the current camera. These adjustments provide access to several features of the underlying graphics software:

- You can switch back and forth between an *orthogonal* view (the default) and a *perspective* view. Moving the camera or an object perpendicular to the screen produces quite different effects, depending on which type of view is currently selected.
- You can turn on and off the Z-buffering of lines and the depth-cueing of lines and spheres.
- You can turn on and off the display of the X-Y-Z coordinate axes. This can help you keep track of the orientation of the object(s) as you work with one or more camera views.

Try each of these adjustments by clicking the menu choices. Keep in mind that each selection is applied to the current camera (window). You may need to click in a particular window (with any mouse button) before making the **Camera** menu choice.

The Accelerate Feature

The Geometry Viewer includes a performance acceleration feature that is quite useful when your scene includes a large number of objects, or a few very complex objects. When you select **Accelerate**, only the current object is rendered repeatedly as you move it around the screen. All other objects and the window background are saved in a *virtual pixel map*. Parts of this pixel map are copied into display memory (the frame buffer) as needed while you perform object manipulations. Since copying pixels is faster than rendering, the result is a performance acceleration.

Freezing a View

There may be times when the view provided by one of the cameras is ''just right''. You can temporarily freeze the image with the **Freeze Camera** menu selection. You can still manipulate the lights and/or objects in the scene, but the changes won't be shown in the frozen window until you unfreeze it by clicking (with any mouse button) in that window.

Saving an Entire Scene

The **Save Scene** menu selection causes the entire current scene to be saved in a *.scene* file. You supply a filename, just as you do when saving objects and Edit Property attributes. The saved scene includes all the objects and their attributes, all the lights, and all the cameras/windows that you've created for the scene.

To test this, first save the scene with **Save Scene**, then delete each of its windows with **Delete Camera**. Now, select **Read Scene** and click on your scene's name in the File Browser. All the windows defined for the scene return to the screen.

Creating a New Scene

The Geometry Viewer lets you create as many windows as you want on the current scene, using **Create Camera**. You can also create an entirely new scene with **Create Scene**. The new scene is an empty window, into which you can read one or more objects, adjust the lighting, and create additional cameras, just as you did with the original scene.

If you have two or more scenes onscreen at the same time, be sure you know which is the current window when you use **Create Camera**. This function creates a new camera for the scene to which the current window belongs. To get what you want, you may need to click in a particular window (using any mouse button) before selecting **Create Camera**.

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GRAPH VIEWER TUTORIAL

CHAPTER TWO

Introduction

This tutorial provides a step-by-step approach to using the AVS Graph Viewer. It explains how to read data from a file, how to create a plot title and labels, and how to save or print the plot. It also discusses using the network to obtain data.

Each step has two parts — an action you perform and the explanation of what happens. You should read the explanation before performing the action so that you know what to expect.

Before starting this tutorial you need to read the "Graph Viewer Subsystem" chapter in the *AVS User's Guide*, at least through the section, "Read Data."

Starting the Graph Viewer

To use the Graph Viewer, follow these steps:

1. Start AVS by typing `avs` and then pressing **Return**.

   The AVS program takes several moments to display the menu. You can select menu items in AVS by placing the mouse pointer on the menu item and clicking any mouse button.

2. Select **Graph Viewer** on the menu.

Reading In a File

The **Option Selection** menu appears with **Read Data** already selected to read in a file.

Use the **File Type** menu to choose the type of file (ASCII, AVS Plot, AVS Field.or Ximage) you want to read. ASCII files are often the output of another program, AVS Plot files are plots previously saved, and AVS Field files are output from another AVS module. The Ximage files are used for background images.

Begin by reading an ASCII file:

1. Select **Read ASCII File** in the **File Type** menu. The **Data Format** menu appears for choosing how the Graph Viewer should interpret the input data.

2. Select **Plot as XY Data** in the **Data Format** menu. The default data format specifies column one of the input file as the X Axis and column two as the Y Axis. Color Column is set to column zero (no input) so it is not used. The default setting for the type of plot is Simple Line.

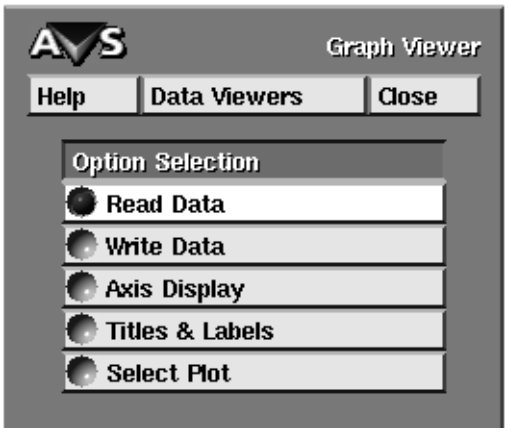

Figure 2-1. Read Data in the Option Selection Menu

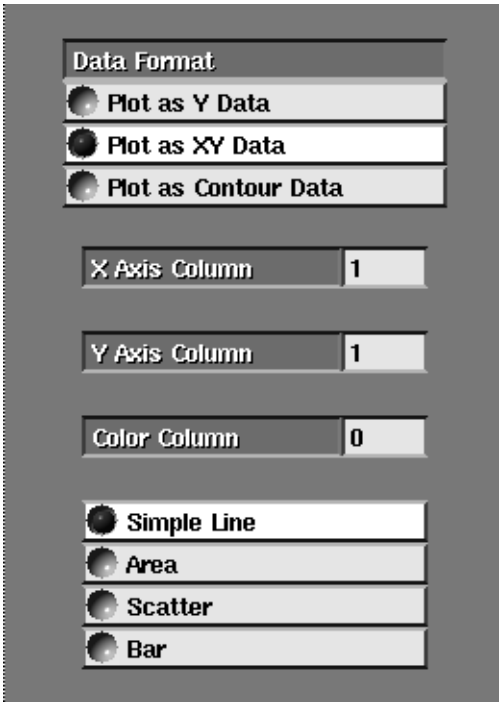

Figure 2-2. Two Column-Linear in the Data Format Menu

A File Browser window pops up listing files and directories in the current directory. Near the top of the window the current directory is displayed (e.g. */usr/avs/data*).

3. Select the red *graph* subdirectory entry to see the listing of available files.

   When the listing of files appear, select the file *growth.dat* as the ASCII input file. AVS reads the file and the plot appears on your screen.

4. Select **Close** on the File Browser window to remove the File Browser.

   So far you have read in the ASCII file *growth.dat* which uses columns one and two as the XY values for a Line plot.

Setting the Title and Axis Labels

This sections discusses how to create titles and axis labels.

1. Select **Titles & Labels** on the **Option Selection** menu. This enables you to create or change the plot's title and axis labels. After you select **Titles & Labels** several menus appear.

   - **Label Display menu.** Chooses which of the plot labels you are working on. The default is the Plot Title.
   - **Current Label.** Displays the text for the option selected in the **Label Display** menu (e.g. the Plot title). If blank, then there is no existing text for the option.
   - **Label Menu Selection.** Chooses either **Label Attributes** (position and color) or **Font Selection** (style and height) for the label. The following figure illustrates this:

2. Place the mouse pointer in the **Current Label** data area (it will highlight). If a Title exists, it is displayed in the **Current Label** data area. If no Title exists the data area is blank.
3. Type in a plot Title of your choice and press **Return**. The typed Title appears at the top and center of the plot. Center is the default Title position.
4. Select **Left** position to change the Title location. You can change the Title from Center position to Left or Right or back to Center. Select each setting so you can view its effect.
5. Adjust the colorbar sliders to change the Title color. You can change the color by placing the mouse pointer on one of the colorbars and clicking any mouse button. The colorbar setting moves to the mouse pointer position and the Title changes color. Or, you can hold the mouse button down and drag the pointer to a location — when you release the button the Title changes color.

   The six colorbar sliders are divided into two sets of three bars. You can use one set or the other to adjust color.

   The top three colorbar sliders adjust the Red-Green-Blue (RGB) components of the color.

   The bottom three colorbar sliders adjust the Hue-Saturation-Value (HSV) components of the color.

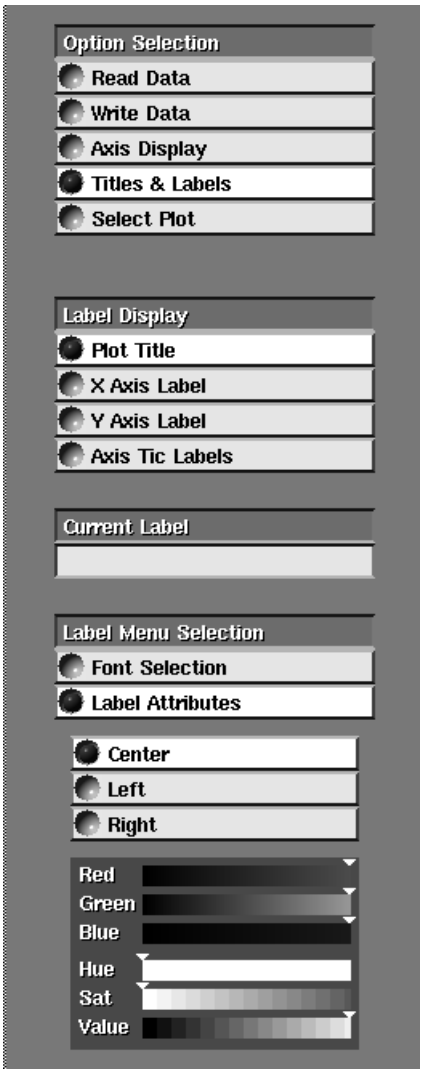

Figure 2-3. Label Menu Selection

As you adjust the RGB sliders the HSV colorbars change color to display the changes. As you adjust the HSV sliders the RGB colorbars change color to display the changes.

6. Select **Font Selection** in the **Label Menu Selection** menu. You can change the font style, attributes and height of the Title. The default font style is Helvetica with a height of 24 points. The next figure illustrates this. (**Note:** fonts may vary from platform to platform.)

7. Select **New-Century** (or any different font) as the Title's font style. The Title font style changes to the selected font. Select each font to view the results on the Title text.

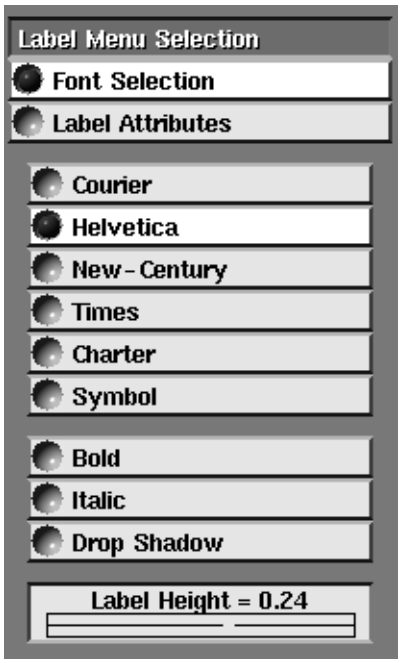

Figure 2-4. Font Selection in the Label Menu Selection Menu

8. Select **Bold** as an option. The Title text changes to become bold. Select **Bold** again to remove it as an option. Then select **Italic**, view its effect, and reselect to remove its effect. Then select **Drop Shadow**, view its effect, and reselect to remove its effect.

   You can also select **Bold**, **Italic** and **Drop Shadow** in combinations. Select **Bold** with **Italic**, **Bold** with **Drop Shadow**, and so on to view the different combination effects.

9. Adjust the **Label Height** slider to change Title size. You can change the Title size by placing the mouse pointer on the Label Height slider and clicking any mouse button. Or, you can hold the mouse button down and drag the pointer to the size location you want. When you release the button the Title changes size.

   The numerical value in the **Label Height** menu indicates relative size. Note that the actual size displayed depends upon the X-Windows font sizes installed for your system. The size printed on PostScript printers is in actual point size.

10. Select **X Axis Label** in the **Label Display** menu. This enables you to work with the X Axis Label and all its attributes (positioning, coloring, style, height).

11. Place the mouse pointer in the **Current Label** data area (it will highlight). If an X Axis Label exists it is displayed in the **Current Label** data area. If no X Axis Label exists the data area is blank.

12. Type in an X Axis Label of your choice and press **Return**. The typed X Axis Label appears at the bottom and center of the plot.

    All of the controls described in Steps 4 through 9 affect the X Axis

NOTE
If your PostScript printer does not have the selected font then it uses its default font.

Label exactly the same as they did the Title. You can change some or all of the controls (with X Axis Label selected) to view the results upon the X Axis Label. Then proceed to the next Step in this tutorial.

13. Select **Y Axis Label** in the **Label Display** menu. This enables you to work with the Y Axis Label and all its attributes (position, color, style, height).

14. Place the mouse pointer in the **Current Label** data area (it will highlight). If a Y Axis Label exists, it is displayed in the **Current Label** data area. If no Y Axis Label exists the data area is blank.

15. Type in a Y Axis Label of your choice and press **Return**. The typed Y Axis Label appears at the left side and center of the plot.

16. All of the controls described in Steps 4 through 9 affect the Y Axis Label exactly the same as they did the X Axis and the Title. You can change some or all of the controls (with Y Axis Label selected) to view the results upon the Y Axis Label. Then proceed to the next Step in this tutorial.

17. Select **Axis Tic Labels** in the **Label Display** menu. This enables you to work with the Axis Tic Labels and all their attributes (position, color, style, height). (Axis borders and ranges are handled in the **Axis Display** menu.)

NOTE
Axis Tic Labels are generated automatically and therefore nothing is displayed in the **Current Label** data area.

All of the controls described in Steps 4 through 9 affect the Axis Tic Labels exactly the same as they did the X or Y Axis and the Title. You can change some or all of the controls (with **Axis Tic Labels** selected) to view the results upon the Axis Tic Labels.

You have now set the Title and Axis Labels for the plot.

Setting the Axis Display

Select **Axis Display** in the **Option Selection** menu. This enables you to set X and Y Axis options. The following menus appear:

Border Display
Sets the border on the plot.

Axis Selection
Chooses the X or Y Axis for the lower menus.

Axis Scale
Sets Linear or Log scaling.

Axis Range
Sets axis range between the **From** and **To** values.

Axis Tic Marks
Sets axis tic marks.

1. Select **Left & Bottom** on the **Border Display** menu. The border is now displayed only on the left and bottom sides of the plot.

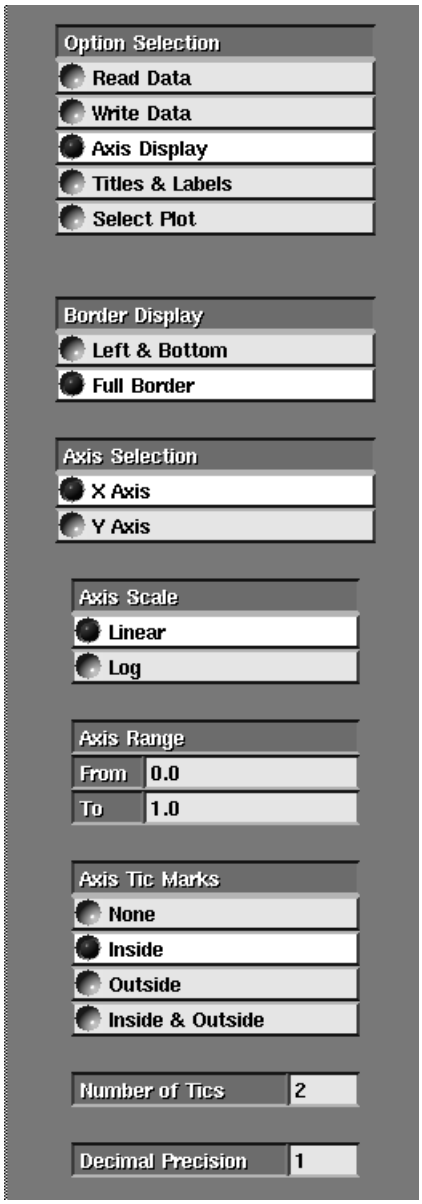

Figure 2-5. Axis Display in the Option Selection Menu

2. Select **Y Axis** on the **Axis Selection** menu. This chooses the Y Axis for the lower menu operations.

   If the Y Axis is selected all changes made affect only the Y Axis. If the X Axis is selected all changes made affect only the X Axis.

3. Change the **Axis Range** for the Y Axis. This menu sets the low and high values of the axis range. The default settings are the

lowest (**From**) and highest (**To**) values of the axis dataset.

4. Place the mouse pointer in the **From** data area (it will highlight) in the **Axis Range** menu. Press **Backspace** one or more times to delete the existing entry (or use **Ctrl U** to clear the field). Type in the value 25 and press **Return**. The Y Axis displays the new range.

5. Place the mouse pointer in the **To** data area (it will highlight) in the **Axis Range** menu. Press **Backspace** to delete the existing entry. Type in the value 75 and press **Return**. The Y Axis displays the new range.

6. Return the Y Axis range to the original values by typing in 0 for the **From** data area and 95 for the **To** data area.

7. Select **Outside** in the **Axis Tic Marks** menu. This menu sets the location of tic marks on the axis. The tic marks move from the inside position (the default) to the outside position. Select each of the menu choices (**None**, **Inside & Outside**) to view the effect upon the axis tic marks.

NOTE
The Axis Range values do not change their decimal precision immediately. You need to select another menu in the **Option Selection** or **Axis Selection** menu, to update the values.

8. Change the **Number of Tics** value. This menu sets the number of tic marks displayed on the axis. Place the mouse pointer in the **Number of Tics** data area (it will highlight). Press **Backspace** to delete the existing entry (2 is the default value). Type in the value 5 and press **Return**. The plot axis displays the new number of tic marks.

NOTE
The number of tic marks displayed between the axis origin and end point includes the end point as a tic mark. The axis origin is not included as a tic mark. For example, four tic marks are on the axis line and the fifth tic mark is located at the axis end point.

9. Change the **Decimal Precision** value. This menu sets the decimal precision value used in the **Axis Range** menu and the axis itself. Place the mouse pointer in the **Decimal Precision** data area (it will highlight). Press **Backspace** to delete the existing entry (the default is one decimal position). Type in the value 2 and press **Return**.

10. Select **X Axis** on the **Axis Selection** menu. This chooses the X Axis for the lower menu options. Repeat steps 3 through 9 in order to modify the X Axis.

Choosing Select Plot

This section discusses how to select a point within the plot display, choose a dataset, change line type, and change plot type.

1. Choose **Select Plot** in the **Option Selection** menu. The following menus appear:

   - **Display Crosshair**. Displays or removes a crosshair at the mouse pointer.

   - **Plot Attributes**. Plot type (**Simple Line**, **Area**, **Scatter**, **Bar**), line thickness line type (**Solid**, **Dash**, **Dot**, **Dot-Dash**) and color.

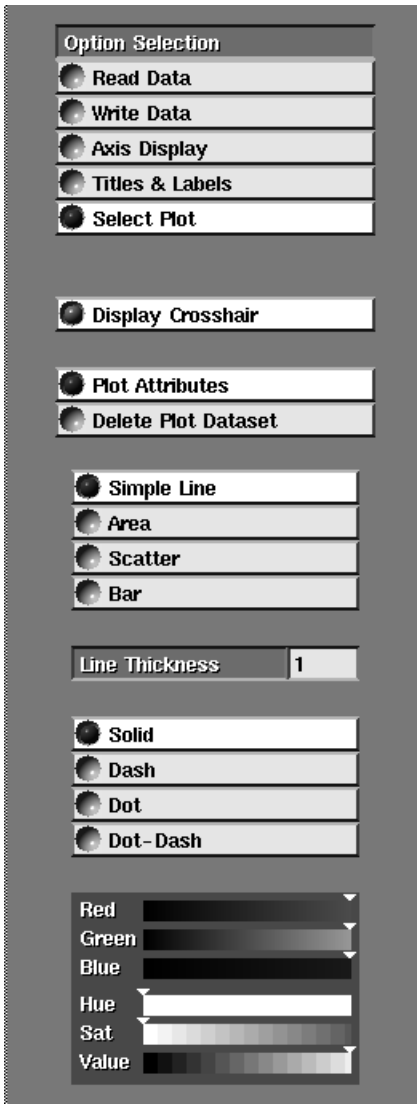

Figure 2-6. Select Plot Options

2. Move the mouse pointer inside the plot area. The crosshair provides an easy-to-see display of the mouse pointer location within the plot area. To remove the crosshair click any mouse button on the **Display Crosshair** menu.

   The **Cursor Position** (near the bottom) shows your exact location within the plot area. The displayed values are the X Axis (on the left) and Y Axis (on the right) coordinates.

   The **Selected Point** is updated to display the X and Y coordinate values of the mouse pointer whenever you click any mouse button.

3. Select the dataset within the plot. Click a mouse button while the mouse pointer is on or near the dataset in the plot. The dataset is

Choosing Select Plot (continued)

highlighted in white to indicate it has been selected. A circle is also displayed at the point within the plot that is closest to the point selected.

After you have selected a plot, you can delete it with the **Delete Plot Dataset** menu item. (Do not delete the dataset at this time.)

NOTE
You must select the dataset before you can alter its characteristics (color, plot style).

4. Change the **Line Thickness**. You can change the line thickness by placing the mouse pointer in the **Line Thickness** data area (it will highlight). Press **Backspace** to delete the existing entry. Type in the value 3 and press **Return**. The new line thickness is displayed in the plot.
5. Change the **Line** type. Choose each of the Line types to see what they look like. Place the mouse pointer on each of the line types (**Dash**, **Dot**, etc.) and click any mouse button to view the result.
6. Change the plot color. You can change the plot color by clicking on the colorbars (see Step 5 of "Setting The Title & Axis Labels" for details on manipulating colorbars).
7. Change the plot type. You can change the plot type at any time by clicking on the type of plot you want (**Area**, **Scatter**, etc.). Note that colorbar changes made on a plot type affect only that type and not others. Select each plot type to see the resulting plot.

Using Write Data

This section describes how to save and print a plot.

1. Select **Write Data** in the **Option Selection** menu as illustrated in the figure, "Write Data in the Option Selection Menu".
2. Select **Write AVS Plot Data** in the **File Type** menu. The File Browser window pops up. Select the **New File** button on the File Browser. Type in a new directory to save your plot file (e.g. */home/bob*). Now, you can select the **New File** option at the File Browser window bottom and type in the file name *graph1* (the filename extension *.plt* is added automatically). Or, you can select an existing filename and overwrite it by clicking on the existing filename.

   The other menu options are as follows:

   - **Write PostScript**. Enables you to save the plot to a file (with the extension .ps) so that you can print your plot on a PostScript printer.
   - **Write ASCII XY Data**. Enables you to save only the data itself.
   - **Write AVS Geometry Data**. Enables you to work with the plot within another AVS module.

You have now saved the plot with Title and Label information from the ASCII file *growth.dat*.

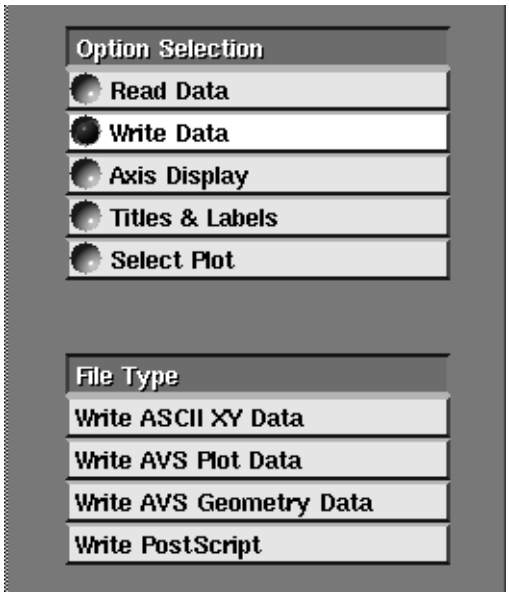

Figure 2-7. Write Data in the Option Selection Menu

Using Multiple Datasets in a Single Window

This section describes how to display and delete multiple datasets within the same plot window.

1. Select **Read Data** in the **Option Selection** menu.
2. Select **Read ASCII File** in the **File Type** menu.
3. Select **Add to Current Plot** in the **Plot Control** menu.
4. Select **Plot as XY Data** in the **Data Format** menu.
5. Set the **X Axis Column** to column one and the **Y Axis Column** to column two. Set **Color Column** to column zero, indicating it is not used.
6. In the preceding example ("Using Write Data"), you may have saved your data into a new directory. If you did, you need to change the directory that the File Browser is currently listing. Select the **New File** button on the File Browser. Type in the directory */usr/avs/data/graph*. Now, you can select the file *growth2.dat* from the File Browser window.
7. Choose **Select Plot** in the **Option Selection** menu.
8. Select *growth2.dat*. Move the mouse pointer to *growth2.dat* and click any mouse button to select the dataset. The dataset highlights in white to indicate it has been selected.
9. Delete *growth2.dat*. Select **Delete Plot Dataset** to remove *growth2.dat* from the plot window. Move the mouse pointer to the **Confirm Delete** option and click any mouse button to perform the delete. The dataset is removed from the plot window.

In this section, you read in the ASCII file *growth2.dat* into an existing plot window and removed it after comparing it with dataset, *growth.dat*.

Using Datasets in Multiple Windows

This section of the tutorial describes how to display and delete multiple windows.

Currently you should have the ASCII file *growth.dat* displayed as a line plot in a single window. (If you are using another type of plot you need to change to a line plot for this section. Choose the **Select Plot** option, click the mouse pointer on the plot dataset, and select **Simple Line** under the **Plot Attributes** option.)

1. Select **Read Data** in the **Option Selection** menu.
2. Select the **Create New Plot** option in the **Plot Control** menu. Now, when you read in a new plot, it goes into a new window.
3. Select **Read ASCII File** in **File Type** menu.
4. Select the **Bar** plot style. The default plot style is **Simple Line**.
5. The file, *growth.dat*, automatically appears in the new window as a bar plot. You can create as many windows as needed and read files to create plots. You can read the same file and use different plot types or use different files in each window.
6. Delete plot window two. Selecting the **Delete Plot Window** option deletes the active window (window two in this exercise). AVS does **not** ask for confirmation before deleting. Once a window is deleted it is gone forever.
7. Delete plot window one. After window two is deleted the red border returns to window one, showing it is the active window. Select the **Delete Plot Window** option to delete it.

You have now created and deleted multiple window plots.

Plotting a Single Column of Data

This section of the tutorial describes how to read in a single column of data from a file for a plot.

1. Select **Read Data** in the **Option Selection** menu.
2. Select **Replace Current Plot** in the **Plot Control** menu.
3. Select **Read ASCII File** in **File Type** menu. The File Browser window appears.
4. Select **Plot as Y Data** in **Data Format** menu.
5. Set **Y Axis Column** to 1. The Y Axis is plotted using the selected data column read from the file. The X Axis is automatically supplied. The Graph Viewer counts the number of Y Axis items and sets the X Axis to the same number of items in interval units of 10. The X Axis Intervals can be changed from 10 to any value you need.

6. Select **Simple Line** as the plot type.
7. Select *sine.dat* file. The data column is read and plotted as the Y Axis in the plot window.
8. Delete the plot window. Select the **Delete Plot Window** option to remove the plot window.

You have now read a single column of data as a plot and deleted the plot.

Using Data for Color Control

This section of the tutorial describes how to use a column of data to control the coloring of the plot.

1. Select **Read Data** in the **Option Selection** menu.
2. Select **Read ASCII File** in the **File Type** menu.
3. Select **Plot as XY Data** in the **Data Format** menu.
4. Set **X Axis Column** to column one, **Y Axis Column** to column two. This selects the data columns for the plot's X and Y axis.
5. Set **Color Column** to column three. This chooses data in column three of the file to control coloring in the plot. The data is used as Hue control in a range of 0 - 499 (five hundred values). If a number greater than 499 is used it wraps around to the beginning value of 0. For example, 500 wraps to 0, 501 wraps to 1, 502 wraps to 2, and so on.
6. Select **Area** as the type of plot.
7. Select *growth.dat* from the File Browser. The plot is displayed with the Hue coloring controlled by values in column three of the file.
8. Select **Delete Plot Window** to remove the plot.

You have now read a file using one column to control color and then deleted the plot.

Generating Data for a Contour Plot

This section of the tutorial describes how to display a contour plot. It also gives an example of using the **graph viewer** module in a network. In order to understand the following instructions, it is assumed that you are familiar with the use of the Network Editor. If not, see the "Network Editor Subsystem" chapter in the *AVS User's Guide*.

You will be constructing the following network:

The basic operations you'll use to construct this network are the following:

- Scroll the module Palette by putting the mouse in the column title box (e.g. Data Output); then type in the first two or three characters of the module name you're looking for. The column scrolls automatically, locating the module. Use the **Backspace** key to reset to the top of the column.

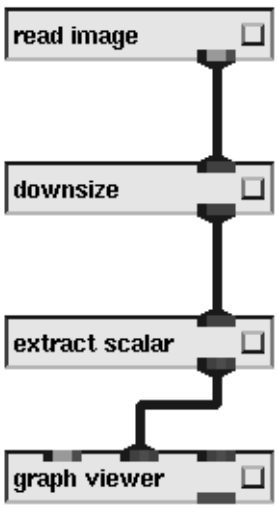

Figure 2-8. Network with Graph Viewer Module

- You drag icons out of the module palette and into the Workspace with the **left** mouse button.
- Connect modules together with the **middle** mouse button. Where there are multiple possible pathways, keep the mouse button held down and "follow" the path you want. When it is highlighted, release the mouse button.
- Break module connections with the **right** mouse button.

Use the following steps to build this network:

1. Select the **Close** button at the top of the Graph Viewer's control panel. You now see the AVS main menu.
2. Select **Network Editor** on the menu.
3. Drag the **read image** module from the palette into the workspace.
4. Drag the **downsize** module from the palette into the workspace and connect the **read image** module's output to the **downsize** module's input. Also, change the value on the **downsize** dial in the control panel from its current setting of 1 to the new setting of 10.
5. Drag the **extract scalar** module from the palette into the workspace and connect the **downsize** module's output to the **extract scalar** module's input.
6. Drag the **graph viewer** module from the palette into the workspace and connect the **extract scalar** module's output to the **graph viewer** module's *middle* input port.
7. Display the **read image** module's file browser by pressing on the **read image** module's dimple with the left mouse button.
8. Select the red *image* subdirectory entry for available files. When the listing appears, select the file *mandrill.x*.

9. Wait while the network executes. When it completes firing, display the **extract scalar** module's control panel by pressing on the **extract scalar** module's dimple with the left mouse button.

10. Select the *red* color channel from the control panel. You'll see a contour plot generated in the **graph Viewer's** plot window. Now that a contour plot is being displayed, it is possible to look at different contour levels for the same data. In order to do this, the **graph Viewer's** menu must be visible.

11. Go to the **Graph Viewer** by pressing down and holding the left mouse button over the **Data Viewer**'s button. Drag the mouse while holding the left mouse button down and select the **Graph Viewer** button. The new menu then appears.

12. Select **Read AVS Field File** in the File Type menu. The File Browser pops up. Do not select a file from this browser.

13. Select **Plot as Contour Data** in the Data Format menu.

14. Select **Hue Range** in the Color Selection menu.

    Color Selection chooses between **Monochrome** (plotting in a single color only) or **Hue Range** (different coloring for each value).

15. Contour Level Selection menu chooses between **Automatic**, **Value Range** and **User Specified**.

    - **Automatic**. Accepts all data values from the lowest to the highest. The plot displays all data points occurring at the contour levels. The number of Contour Levels is divided between the lowest and highest value.
    - **Value Range**. Accepts all data values from the specified Start Value to the specified End Value. The number of contour levels is divided between the Start and End values.
    - **User Specified**. Enables you to specify the contour level data points explicitly by value. Select **Value Range** in the **Contour Level Selection** menu. This performs the same way as **Automatic** except that you specify a starting and ending threshold for the input file.

16. Type in 10 as the **Start Value** This allows only values ≥ 10 from the file being read.

17. Type in 250 as the **End Value**. This allows only values ≤ 250 from the file to be read.

18. Type in 7 as the number of **Contour Levels**. This places contour levels at the following values: 10, 50, 90, 130, 170, 210 and 250.

    You have now generated a contour plot by plotting 8 contour levels between the specified Start and End values in the dataset and deleted the plot.

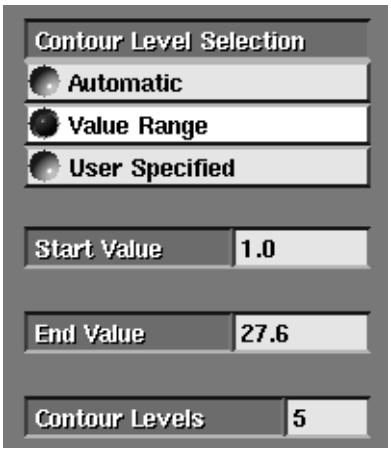

Figure 2-9. Value Range in the Contour Level Selection Menu

You can also explicitly specify the values to be plotted by using the **User Specified** option in the Contour Level Selection menu.

19. Select **User Specified** in the Contour Level Selection menu. A window appears prompting you to enter Contour Levels. You can type in values and separate them by typing a space character or a comma.

20. Type in the values 20, 135, 245. Press **Return** or click on the OK in the window. The plot appears with the specified values.

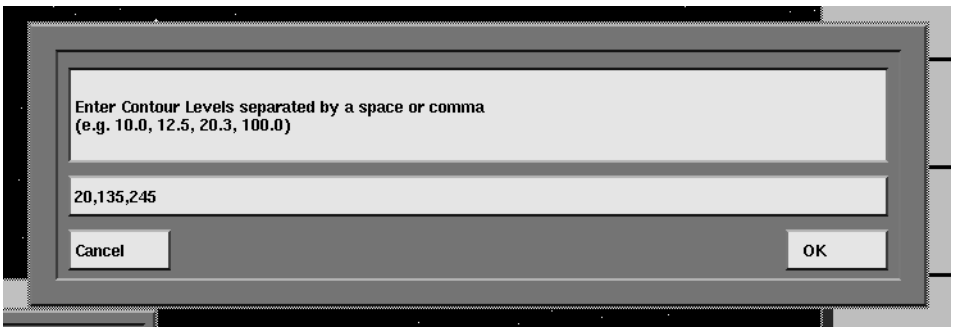

Figure 2-10. User Specified in the Contour Level Selection Menu