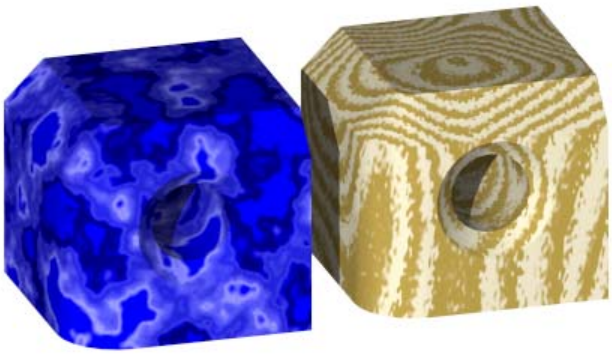
Textures and Texture Space

This document will focus on the description and use of texture space shaders within the Ashlar-Vellum line of modeling products.

There are 2 basic types of textures used by the advanced rendering engine of the Ashlar-Vellum line of modeling products. These are ***solid textures*** and ***wrapped textures***.

Solid Textures

Solid textures calculate their results based upon the shading point's position in 3-D space. Solid textures are able to generate arbitrarily complex and coherent patterns. Shaders that implement solid textures include the "**marble**" or "**simple wood**" color shaders. Solid textures create the appearance that an object has been carved out of a solid block of material. The visual appearance at any points on the object's exterior are determined by intersecting the object's surface with the solid material. Texture space shaders are not needed for and have no effect on solid textures.

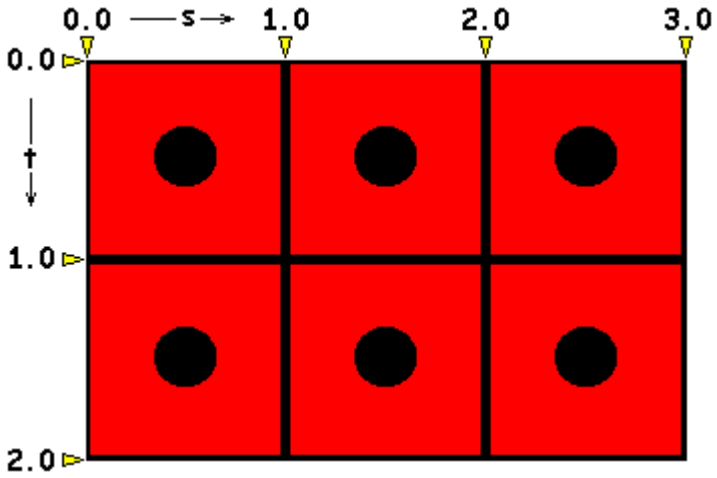


Solid textures created by the **marble** and **simple wood** color shaders

Wrapped Textures

Wrapped textures calculate their results by mapping the shading point's position in 3-D space to a 2-D coordinate system. That is, wrapped textures operate within a 2-D coordinate system known as ***texture space***. Texture space shaders handle the mapping from 3-D space (x, y, z) to 2-D texture space (s, t). There are many possible 3-D to 2-D mappings available. Hence, there are many possible texture space shaders.

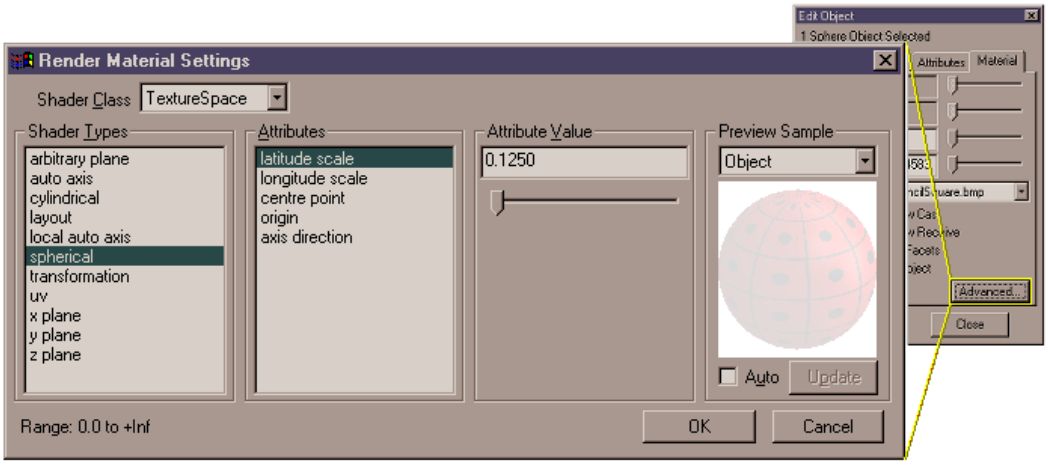
Texture space is a two-dimensional coordinate system denoted by (s, t). In general, when a texture space is applied to an object and viewed from the outside, the axes formed by the increasing s-direction, t-direction and the outward surface normal vector will form a *left-handed coordinate* system. Texture space is configured in this way so that when a pattern (such as image data) is applied, the origin of the pattern is located at its top-left corner with s increasing to the right of the image, and t to the bottom. Also, many texture space shaders operate within the unit square such that 0 <= s,t <= 1. The texture pattern will repeat outside of this range. This repeating pattern is often referred to as tiling. A sample texture pattern and its associated texture coordinate system are illustrated below:



The texture space (s, t) coordinate system

Texture Space Shaders

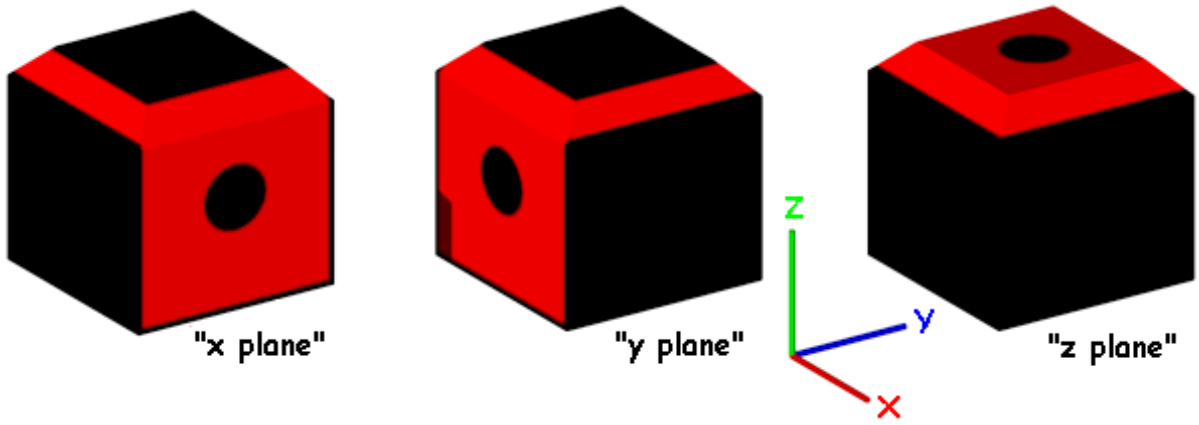
There are several common texture space shaders provided with the advanced rendering engine of the Ashlar-Vellum line of modeling products. These shaders are named "x plane", "y plane", "z plane", "auto axis", "arbitrary plane", "cylindrical" and "spherical". The applied material initially determines an object's texture space shader. This can be changed and edited at any time using the ***Render Material Settings*** dialog box. This dialog is displayed by pressing the ***Advanced…*** button on the ***Material*** page of the ***Edit Object*** dialog box.



The ***Render Material Settings*** dialog box

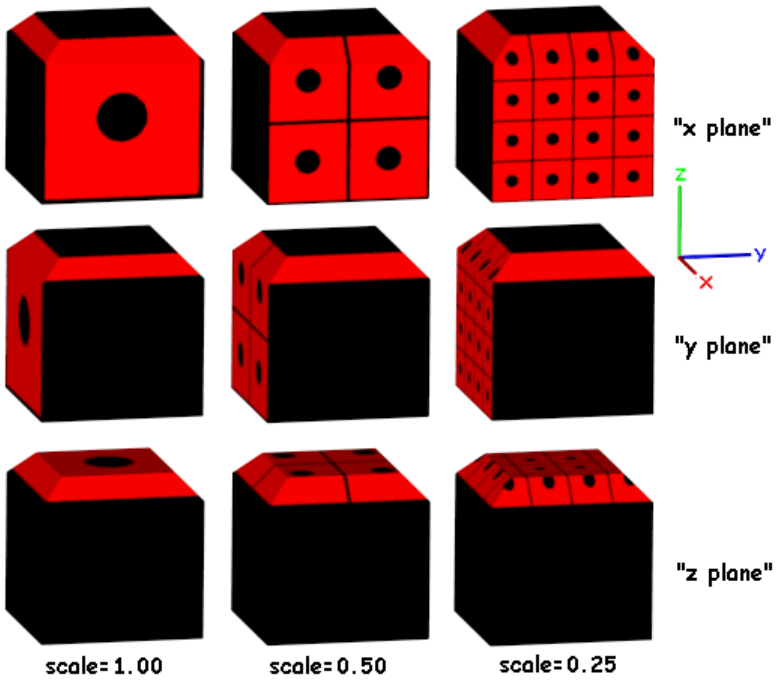
The "x plane", "y plane", "z plane" Texture Space Shaders

The "**x plane**", "**y plane**" and "**z plane**" texture space shaders are the 3 simplest shaders. They take a texture and project it along a vector parallel to the x, y, or z-axis respectively. The linear projection used by these shaders results in the pattern appearing on both "sides" of the object. The figure below demonstrates the effect of these texture space shaders when used with the "**wrapped image**" color shader.



The "**x plane**", "**y plane**" and "**z plane**" texture space shaders used with the "**wrapped image**" color shader

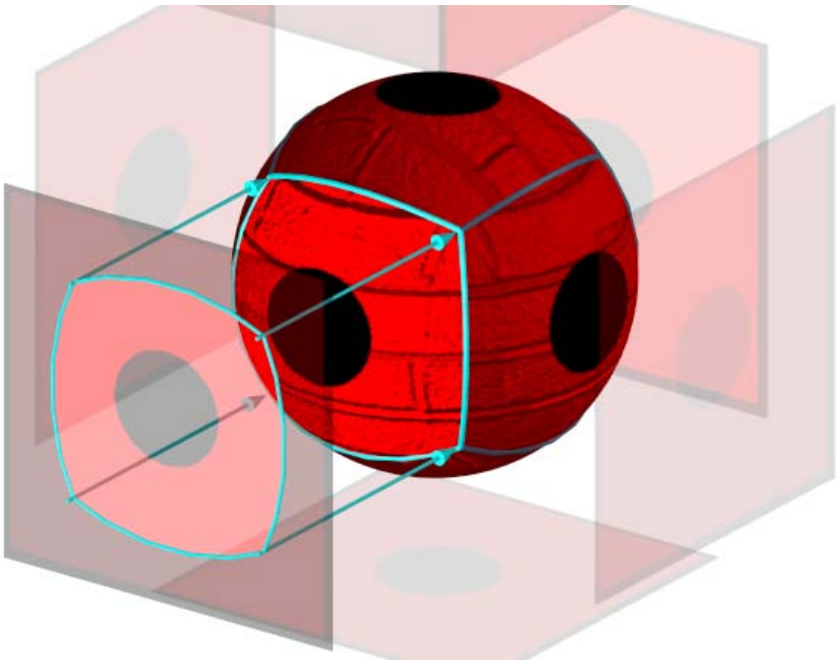
These shaders only have one attribute: **scale**. The scale controls the number of times the texture will repeat per model inch (*TilesPerInch* = 1.0/**scale**). The figure below demonstrates the effect **scale** has on the "**wrapped image**" color shader when used with the "**x plane**", "**y plane**" and "**z plane**" texture space.



The "**x plane**", "**y plane**" and "**z plane**" texture space with different **scale** values

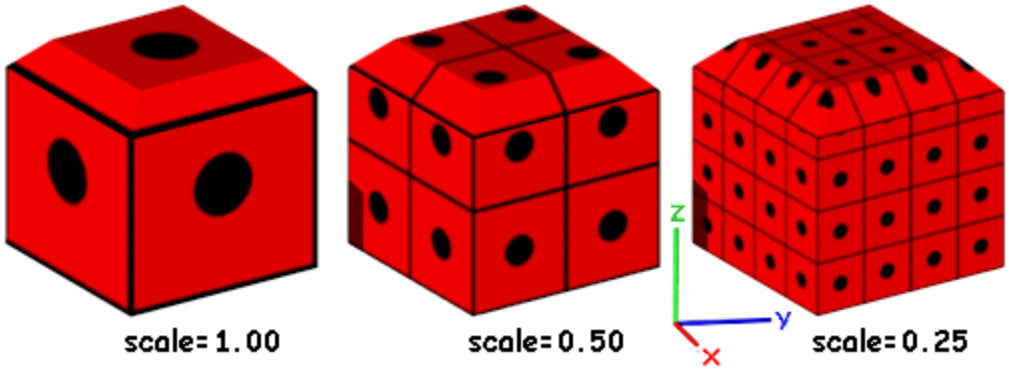
The "auto axis" Texture Space Shader

The "**auto axis**" texture space shader is a hybrid of the "**x plane**", "**y plane**", and "**z plane**" texture space shaders. This shader selects the x, y, or z plane texture space shader whose projection is most "closely aligned" to the surface normal at each evaluation point. When used on a sphere, the "**auto axis**" texture space shader produces a pattern that resembles the patches on a soccer ball.



The "**auto axis**" texture space shader mapped onto a sphere

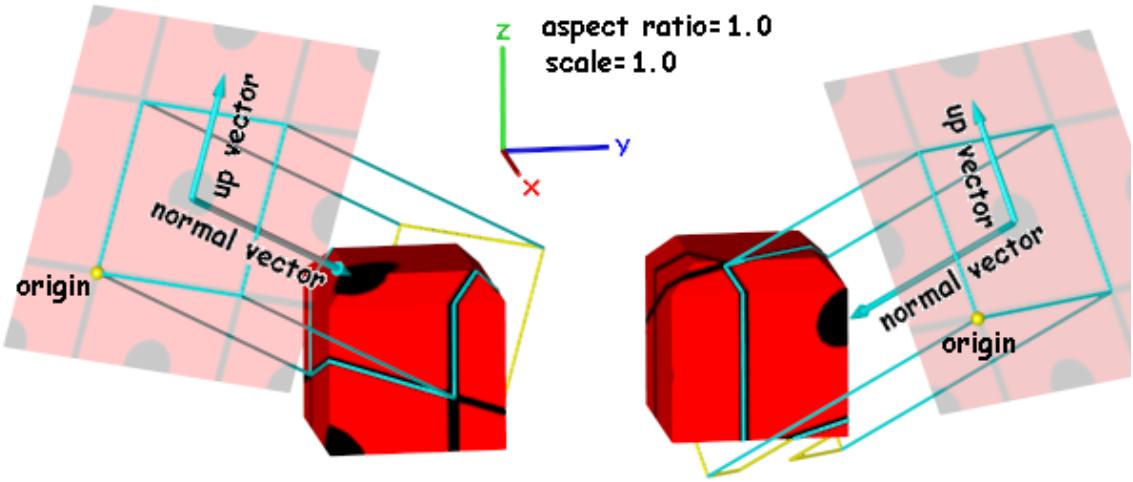
Like the xyz plane shaders, this shader only has one attribute: **scale**. The scale controls the number of times the texture will repeat per model inch (*TilesPerInch* = 1.0/**scale**). The figure below demonstrates the effect **scale** has on the "**wrapped image**" color shader when used with the "**auto axis**" texture space.



The "**auto axis**" texture space with different **scale** values

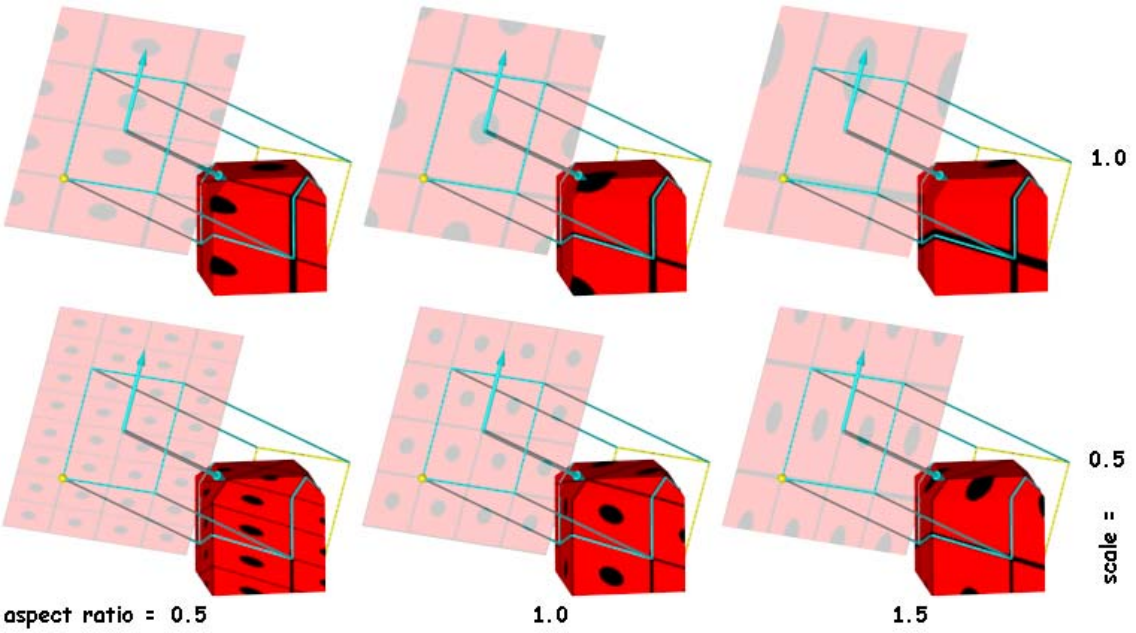
The "arbitrary plane" Texture Space Shader

The "**arbitrary plane**" texture space shader projects a texture along a user defined vector. The linear projection used by this shader results in the pattern appearing on both "sides" of the object. With the proper settings, the "**arbitrary plane**" texture space shader can be made to emulate each of the "**x plane**", "**y plane**" and "**z plane**" texture space shaders. The figure below demonstrates the effect of the "**arbitrary plane**" texture space shader when used with the "**wrapped image**" color shader.



The "**arbitrary plane**" texture space shader used with the "**wrapped image**" color shader

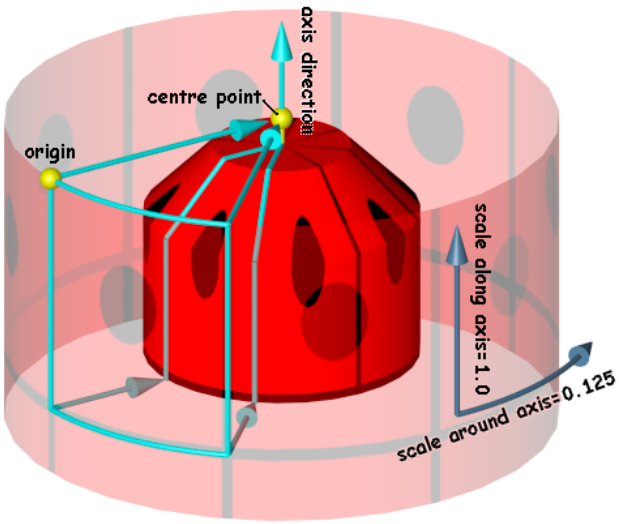
The "**arbitrary plane**" texture space shader has 5 attributes: **scale**, **aspect ratio**, **origin**, **normal vector** and **up vector**. The **scale** controls the number of times the texture will repeat in the plane per model inch (*TilesPerInch* = 1.0/**scale**). The **aspect ratio** is computed as one unit of height divided by one unit of its width. The **scale** and **aspect ratio** work together such that the horizontal scale is equal to **scale**, and the vertical scale is the product of **scale** and **aspect ratio**. The **origin** defines the corner of the applied texture image. The **normal vector** defines the plane's perpendicular direction. The **up vector** defines the textures vertical orientation within the plane. The figure below demonstrates the effect **scale** and **aspect ratio** have on the "**wrapped image**" color shader when used with the "**arbitrary plane**" texture space.



The "**arbitrary plane**" texture space with different **scale** and **aspect ratio** values

The “cylindrical” Texture Space Shader

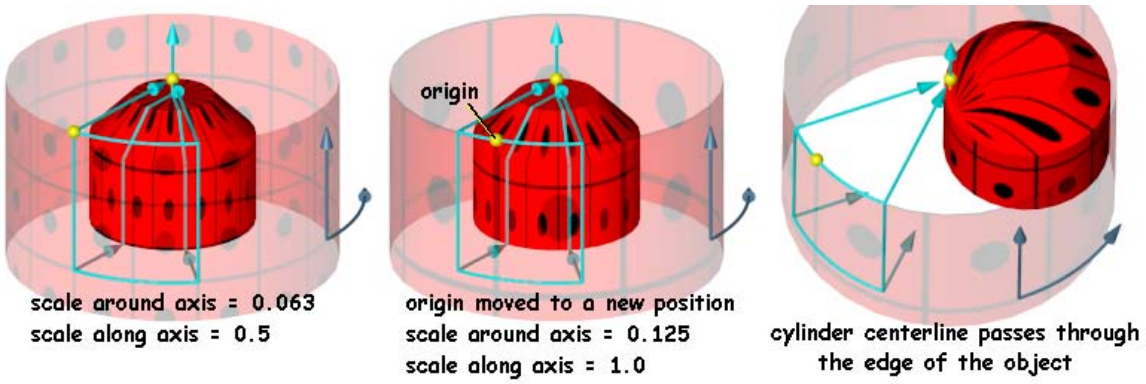
The "**cylindrical**" texture space shader projects a texture along the planar radials of an imaginary, user defined cylinder. The radial projection used by this shader causes the texture pattern to degenerate to a line as it approaches the cylinder’s centerline. This distortion is most noticeable at the top and bottom areas of the object. The figure below demonstrates the effect of the "**cylindrical**" texture space shader when used with the “**wrapped image**” color shader.



The "**cylindrical**" texture space shader used with the “**wrapped image**” color shader

The "**cylindrical**" texture space shader has 5 attributes: **scale around axis**, **scale along axis**, **center point**, **axis direction** and **origin**. The **scale around axis** controls the number of times the texture will repeat around the circumference of the cylinder per model inch. The **scale along axis** controls the number of times the texture will repeat along the height of the cylinder per model inch (*TilesPerInch* = 1.0/**scale**). The **center point** lies on the cylinder’s centerline. The **axis direction** defines the orientation of the cylinder’s centerline and the “up” direction for the texture. The **origin** lies on the surface of the cylinder and defines the corner of the applied texture image.

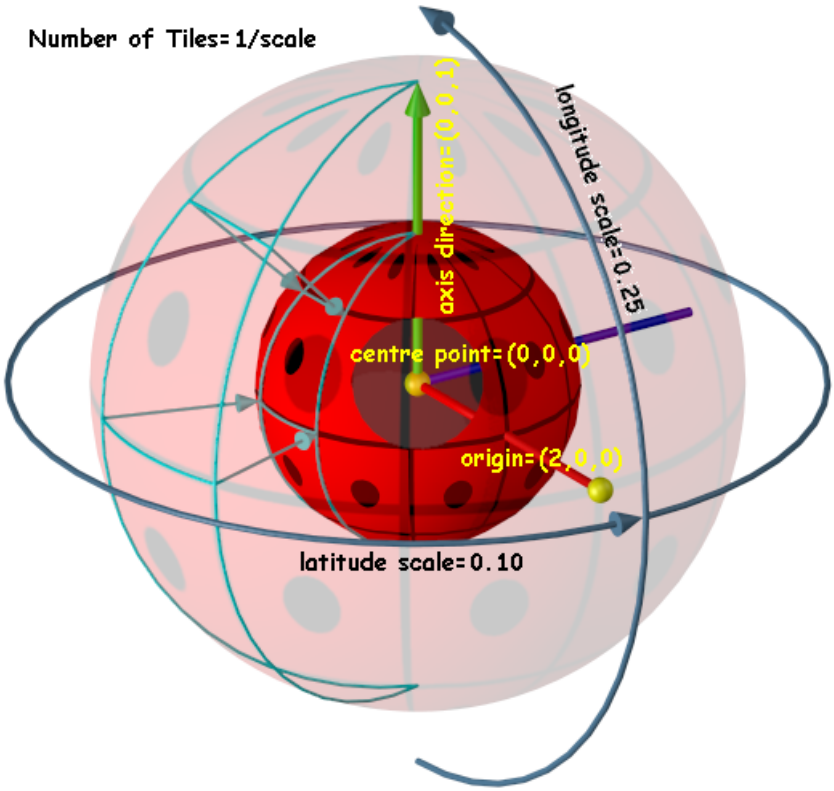
When using the "**cylindrical**" texture space shader, the distance between the **origin** and the centerline will ***not*** affect the appearance of the resulting image. Only the angular and vertical position of the **origin** relative to the centerline will affect the resulting image. The figure below demonstrates different applications the “**wrapped image**” color shader used with the "**cylindrical**" texture space.



The "**cylindrical**" texture space with different configurations

The "spherical" Texture Space Shader

The "**spherical**" texture space shader projects a texture along the radials of an imaginary, user defined sphere. The radial projection used by this shader causes the texture pattern to degenerate to a point as it approaches either the sphere's center or poles. This distortion is most noticeable at the top and bottom (polar) areas of the object. The figure below demonstrates the effect of the "**spherical**" texture space shader when used with the "**wrapped image**" color shader.

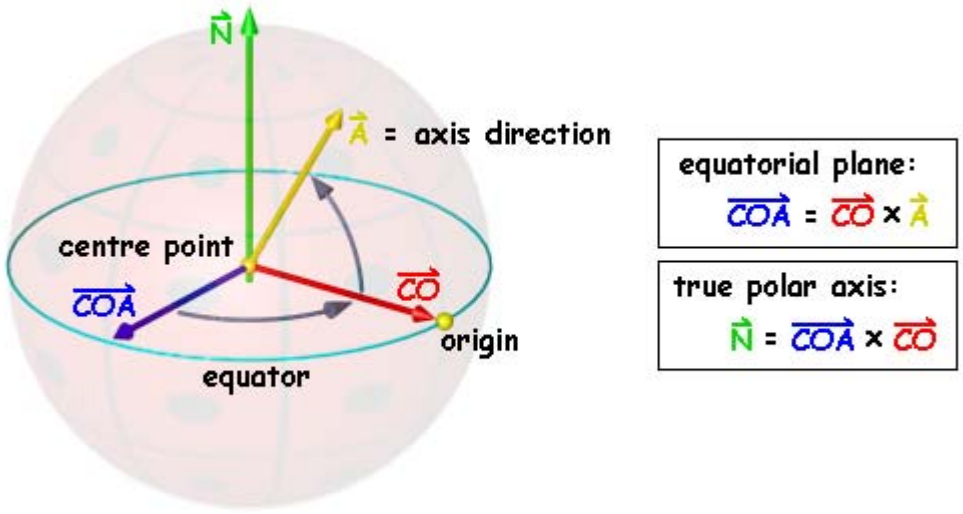


The "**spherical**" texture space shader used with the "**wrapped image**" color shader

The "**spherical**" texture space shader has 5 attributes: **latitude scale**, **longitude scale**, **center point**, **origin** and **axis direction**. The **latitude scale** controls the number of times the texture will repeat around the equator of the sphere per model inch. The **longitude**

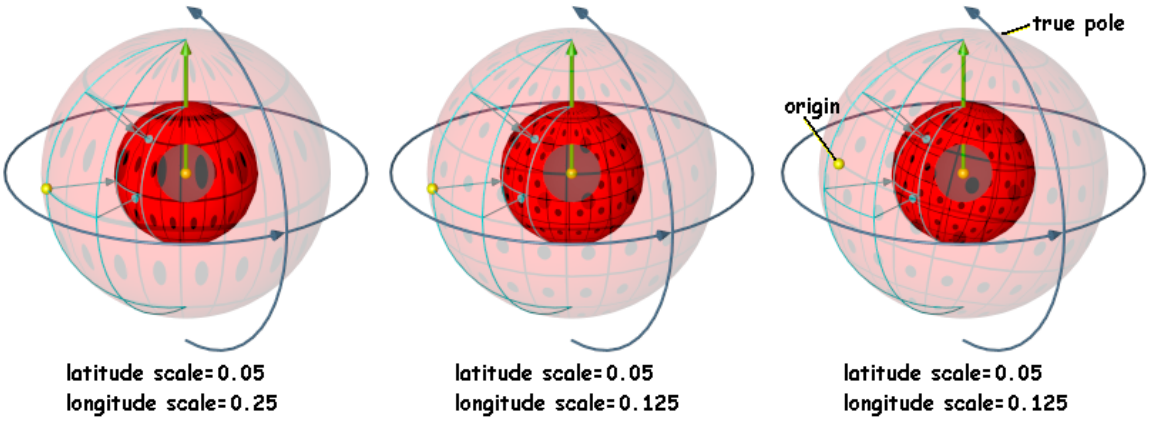
scale controls the number of times the texture will repeat from pole to pole on the sphere per model inch (*TilesPerInch* = 1.0/**scale**). The **center point** defines the location of the sphere's center. The **origin** lies on the sphere's equator and defines the corner of the applied texture. The **axis direction** defines the orientation of the sphere's "true polar axis" and the "up" direction for the texture.

When using the "**spherical**" texture space shader, the distance between the **origin** and the **center point** will ***not*** affect the appearance of the resulting image. Only the angular position of the **origin** relative to the **center point** will affect the resulting image. Also, in the general case, the **axis direction** will not be the "true polar axis". The figure below diagrams the vector equations used internally to compute the true polar axis.



Calculating the true polar axis

The equator will be perpendicular to the plane formed by the **origin, center point** vector (**CO**) and the **axis direction** (**A**). The **axis direction** is ***not*** required to be perpendicular to the vector **CO**. However, the **axis direction** must never be parallel to the vector **CO**. The figure below demonstrates different applications the "**wrapped image**" color shader used with the "**spherical**" texture space.



The "**spherical**" texture space with different configurations