Volume Data: A Definition
A volume is a 3D discretely sampled data set where the size of the voxels have been expanded to occupy the space to the neighboring voxels.

Why Do We Care About Volume Visualization?
- Medical: CAT, MRI, 3D ultrasound
- Science and engineering: CFD, stress, thermal, molecular
- Volumes are normally very difficult to comprehend

Montreal Neurological Institute at McGill University
Researchers used a tool called a microtome to cut a brain into slices 20 micrometers thick.

Understanding Volume Data Usually Involves a Compromise
- Point Clouds: All values everywhere, hard to see very much, distracting artifacts
- Interpolated-colors cutting planes: All values in a single plane
- Contours cutting plane: Discrete values in a single plane
- Isosurfaces: A single value everywhere

Because of these compromises, these are all considered to be indirect ways to visualize volume data

Direct Volume Rendering
Composite the colors and alpha of the voxels
Transfer Function

Voxel Compositing

Recall this color blending equation from the OpenGL Transparency notes:

\[ C' = \alpha C_{\text{new}} + (1 - \alpha) C_{\text{old}} \]

In “Voxel World”, things work the same way:

**Cropping the Volume based on Data Value**

**Cropping the Volume based on Spatial Location**

Voxel Compositing Example

You are compositing back-to-front through the volume. At this moment, the running values of RGB are \((0., 1., 1.)\). The next voxel you encounter has a \(T\) value of 33.33.

1. What is the color of just this voxel?
2. What is the opacity of just this voxel?
3. What will the new running RGB values be when you are done compositing this voxel with the old running RGB values?
"Magic Lens" to Selectively Look Inside Volume Data

Display Parameters #1

Display Parameters #2

One Display

Volume Rendering with Parallel Texture Planes

Volume Rendering with Parallel Texture Planes

In Display 

Sets the global variables Major, Xside, Yside, and Zside

In Display II:

In a callback that is called whenever the opacity transfer function changes:

\[
\vec{n} = \frac{\partial S}{\partial x} \frac{\partial S}{\partial y} \frac{\partial S}{\partial z} = \nabla S
\]
To be manufactureable, there must be finite material between two isosurfaces.
Putting the Tools Together: Modeling and Making Anabolic Aortic Aneurysms

CAT scans from the UCSD VA Hospital

OSU vx (Volume Explorer)

Fabricated