



*N*VIDIA™

3D Texturing

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What makes up a 3D texture?

- **A 3D array of texels**
 - Defined as a series of 2^n 2D texture slices
 - Can use same formats as 2D textures
 - Color can be compressed at 4 or 8 bits per texel
- **A set of optional mipmaps**
 - Mipmaps require 33% more memory in 2D
 - In 3D textures, they require <15% more memory
- **A filtering mode**
 - `LINEAR_MIPMAP_NEAREST` in 2D is 4-tap; 8-tap in 3D
 - `LINEAR_MIPMAP_LINEAR` in 2D is 8-tap; 16-tap in 3D
- **Additional parameters for 3rd dimension**
 - Texture coordinate R, wrap mode for R

What are 3D textures used for?

- **Solid textures**
- **Volumetric data visualization**
- **Non-linear color space conversion**
- **Attenuation maps**
- **Video loops**
- **View independent billboards**



Solid Textures

Materials such as marble, wood, granite are stored in 3D texture

Pros:

- **Arbitrary shapes have realistic appearance (more so than applying 2D texture)**

Cons:

- **Poor utilization of precious texture memory**
- **Better to render offline with procedural solid texture and extract 2D surface to use in realtime**
See: Lapped Textures, SIGGRAPH 2000



Volumetric Data Visualization

Store CT/MRI, geophysical, atmospheric or illumination data in 3D texture

Render in slices orthogonal to viewing vector, using blending to provide transparency

Pros:

- **Best for medical imaging, oil/gas research**

Cons:

- **Volumes are huge, using lots of texture memory**
- **Many slices necessary for good final image**
- **All slices are blended, using lots of bandwidth**



Non-linear Color Space Conversion

Map RGB to CMYK or other color space via a 3D texture lookup (with interpolation)

Pros:

- **Allows good quality with high performance**

Cons:

- **Dependent 3D texture lookup requires all 4 texture units (3 dot products + dependent lookup)**
- **Could fake “pixel texture” by supplying vertices representing pixel positions, but this would overwhelm the transform engine quickly**



Attenuation Maps

**Store per-pixel lighting attenuation in a 3D texture
(could be $1-x^2-y^2-z^2$, exponential or other)**

Pros:

- **Uses only 1 texture unit**
- **Can encapsulate a completely arbitrary falloff
(need not be radially or cylindrically symmetric)**

Cons:

- **Quality not great with small volumes ($32^3 = 32\text{KB}$)**
- **High quality requires large texture ($128^3 = 2\text{MB}$)**



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Video Loops

Each slice of a 3D texture represents a frame of a video loop – the R coordinate represents time

Pros:

- **Allows frames to be “tweened” for free**
- **At the end of the loop, texture wrapping allows the last frame to be blended with the first frame**

Cons:

- **Must have 2^n number of reference frames (loop can filtered to accommodate this restriction)**



View Independent Billboards

Encapsulate various views of a given object in slices of the 3D texture

Viewpoints may rotate around an object or represent views differing in elevation

Pros:

- **Free tweening**
- **Fast way to draw what looks like lots of geometry**

Cons:

- **Requires object symmetry or viewing restrictions**



Performance Considerations

- **3D textures are very large and can evict other textures used in your scene – use judiciously and ensure you have space for them**
- **Use mipmaps to increase texture cache hits (and they don't take much more space)**
- **Use texture compression where feasible**
- **3D texturing is slower than 2D texturing**



Questions?

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