



**CS 563 Advanced Topics in  
Computer Graphics**  
*Texturing Part 1*

by Peter Lohrmann



## What is Texturing?

- Texture is the look and feel of an object
- Mapping of a function or 2D image to a 3D object
- In Graphics
  - Complex coloring to surfaces
  - Surface imperfections
  - Lighting details



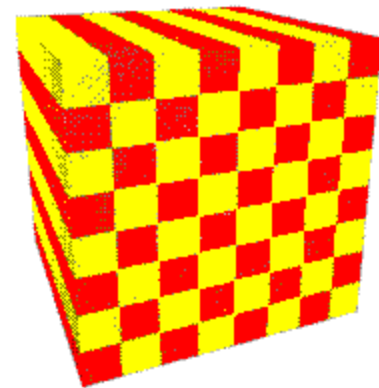
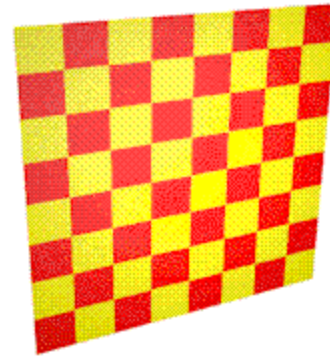
## Outline

- General information on texture application
- Complex objects and textures
- Common problems ...
- ... and their solutions
- Addressing speed issues
- Animated textures

# Texture Projections

- Spherical
- Cylindrical
- Planar
- Natural

(images by: Microsoft)

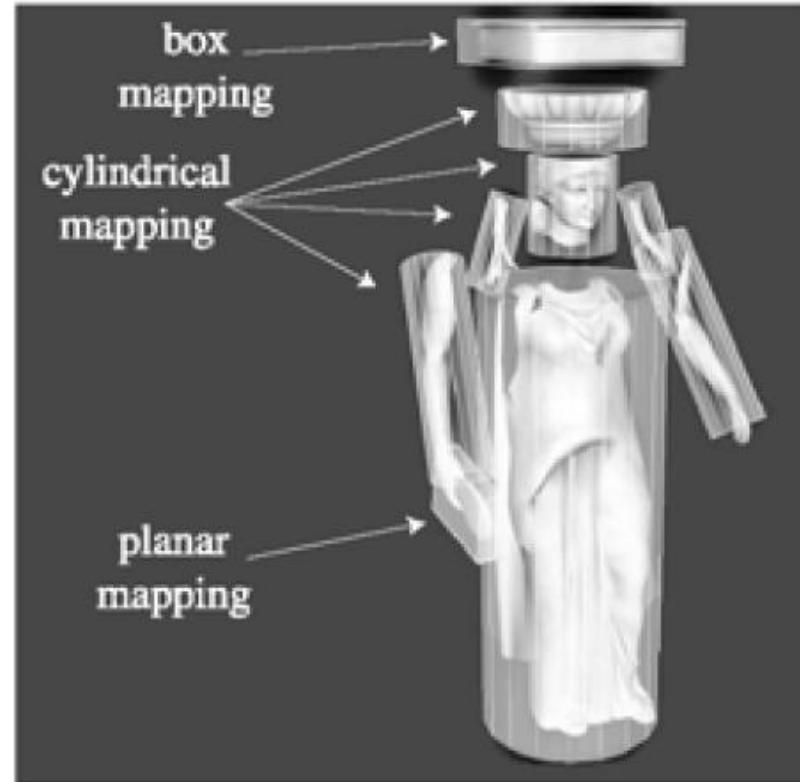


# Wrapping Modes

- Wrap / Repeat / Tile
- Mirror
- Clamp / Clamp to edge
- Border / Clamp to border

# Complex Objects

- Break apart into “simple” shapes
  - Each shape gets its own texture
  - Looks right as a whole



(Images by: Tito Pagan)

# Examples



(image: [www.isner.com](http://www.isner.com))

## 3D Textures

- Also called “procedural textures”
- Function or algorithm determines surface color
- Realistic, continuous surfaces
  - Wood
  - Marble



(Image from:  
Ohio State)



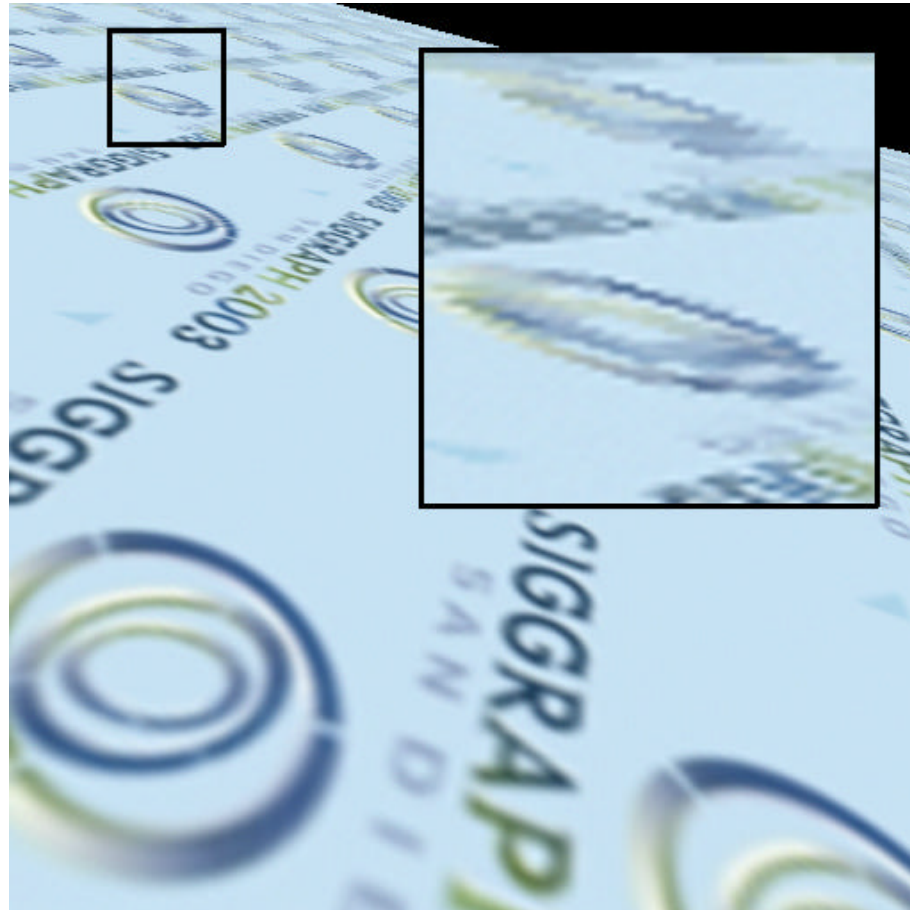


## Common Problems

- Magnification
  - Texture is smaller than surface
  - Aliasing
- Minification
  - Texture is larger than surface
  - Quality loss
- <http://www.ds.arch.tue.nl/General/Staff/joran/wup/Default.menu?menu=6>
- <http://www.vrvis.at/vis/research/hq-hw-mipmap/>

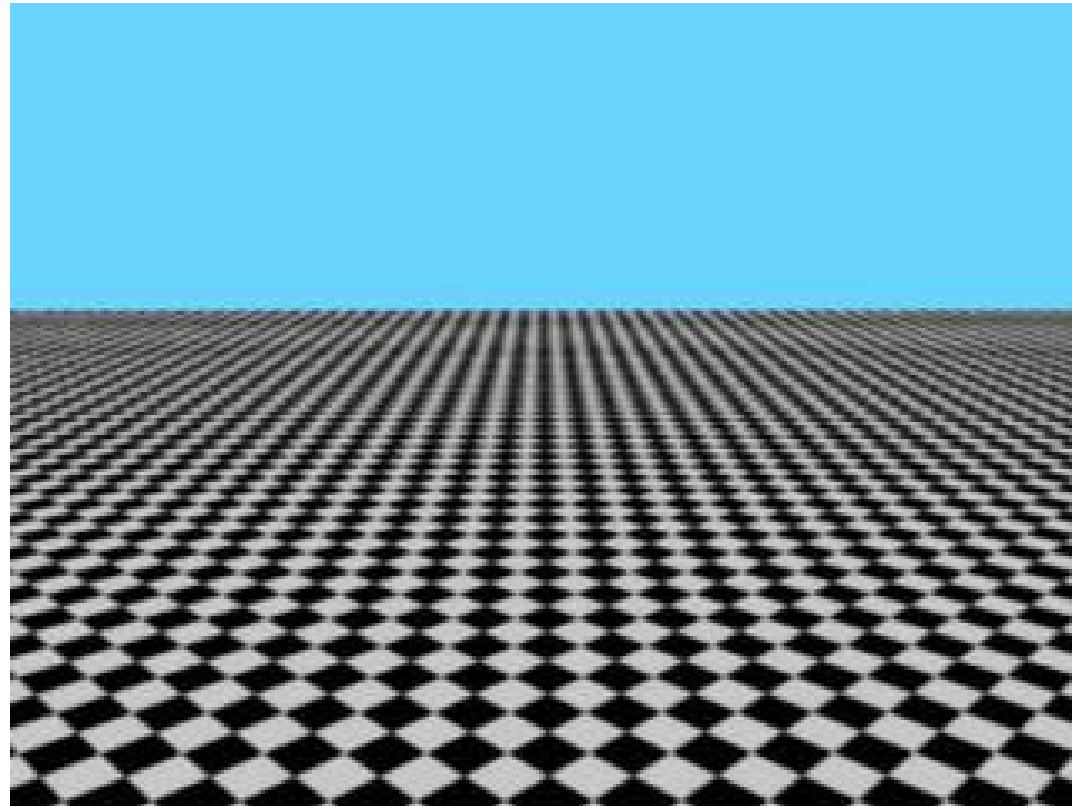
# Magnification

- More pixels than texels assign colors to
  - Aliasing problems
  - Intermediate pixels have to be calculated



## Minification

- More texels than pixels that need color
  - Could be big loss of texture quality
  - Sampling of texels determines pixel color



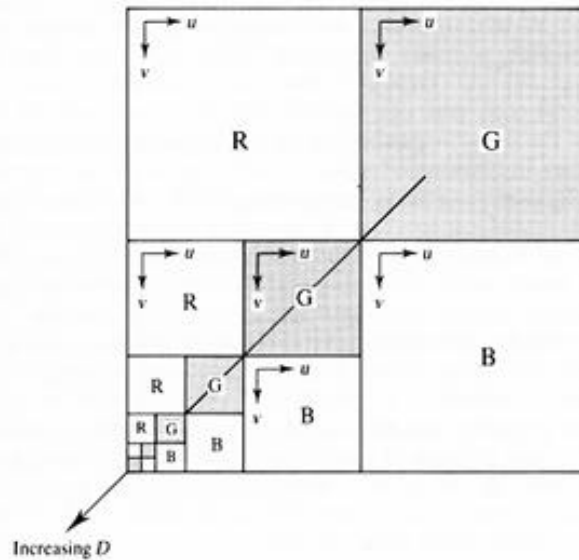


## Common Solutions

- Mipmapping
- Ripmapping
- Summed-Area Table
- Unconstrained Anisotropic Filtering

# Mipmapping

- Solves minification (image from [accad.osu.edu](http://accad.osu.edu))
  - Generates subtextures
    - Averages 2x2 texel square into 1 texel
    - Recursively shrinks texture by 25% until it is 1 texel big
  - Uses about 133% of memory of original texture





## Ripmapping

- Similar to mipmapping
  - Solves problem of viewing from near the surface
  - Recursively halves each dimension of the texture
  - Uses about 400% of memory of original texture
- Provides tall, wide, and proportional versions of the original texture



## Summed-Area Table

- Back-projection of pixel onto texture
  - Averages texel values below pixel projection
    - Overblurring when viewed along the diagonal
  - Uses about 300% of memory of original texture
- Not currently implemented in hardware



## Unconstrained Anisotropic Filtering

- Utilizes the mipmapping hardware
- Samples from several layers of mipmaps
- Line of anisotropy
  - Parallel to longer side of the quad
  - Through middle of quad
  - Samples taken along this line



## Comparison



*Stars, I have seen them  
Fall, but when they drop and  
Die, no star is lost at  
II, from all the star-sown  
y. The toil of all that  
helps not the primal  
; it rains into the  
nd still the sea is*



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## Texture Caching

- Far away textures have small mipmaps loaded
  - As object gets closer, bigger mipmaps are loaded
- Least recently used
  - Based on load time
  - May cause thrashing
- Most recently used
  - If texture was used in last frame, keep it around
  - Unload the most recently loaded texture
- Flight simulators
  - Several mipmaps loaded due to view



## Compression

- Fixed-rate compression
  - Requires less texture memory and bandwidth
  - Allows higher quality at same performance cost
- DXTC (DirectX Texture Compression)
  - Stores 16 pixel values in 64 bits (vs. 256-385 bits)
  - 4:1 to 6:1 compression ratio
- Efficient and fast, but lossy



## Multipass Texture Rendering

- Computing additional parts of lighting equation in several passes
  - Motion blur
  - Depth of field
  - Antialiasing
  - Soft shadows
  - Reflections
  - Etc



## Multipass Texture Rendering Cont'd

- Quake III had a 10 pass design
  - Could be minimized to 2 for slower machines
  - 1-4: accumulate bump map
  - 5: diffuse lighting
  - 6: base texture
  - 7: specular lighting
  - 8: emissive lighting
  - 9: volumetric / atmospheric effects
  - 10: screen flashes



## Multitexturing

- Allows multiple textures to be applied to one object
  - Textures are applied serially
    - Complex texture combinations that multipass can't do
- <http://www.delphigl.de/tutorials/multitex.htm>  
!
- <http://www.nvnews.net/previews/geforce3/multitexturing.shtml>



## Animated Textures

- Textures can also be video clips
  - They are computed for every frame anyways
  - Televisions
  - Windows
- Texture can also be moved along the surface
  - Water flowing
  - Clouds moving
- Blending
  - Making statues come to life



## References

- Akenine-Moller, Tomas. Real-Time Rendering. Second Edition. 2002. AK Peters, Ltd.
- [http://msdn.microsoft.com/archive/default.asp?url=/archive/en-us/dnardir3d/html/msdn\\_wrapfun.asp](http://msdn.microsoft.com/archive/default.asp?url=/archive/en-us/dnardir3d/html/msdn_wrapfun.asp)
- [http://www.cs.cornell.edu/courses/cs665/2004fa/Lectures/Lec15\\_Hardware\\_web\\_6page.pdf](http://www.cs.cornell.edu/courses/cs665/2004fa/Lectures/Lec15_Hardware_web_6page.pdf)
- [http://www.isner.com/tutorials/texture\\_primer.htm](http://www.isner.com/tutorials/texture_primer.htm)
- <http://www.cse.ohio-state.edu/~yootai/cis782/lab-2/marble.html>
- [http://accad.osu.edu/~midori/Materials/texture\\_mapping.htm](http://accad.osu.edu/~midori/Materials/texture_mapping.htm)