08. Anti-aliasing, texturing

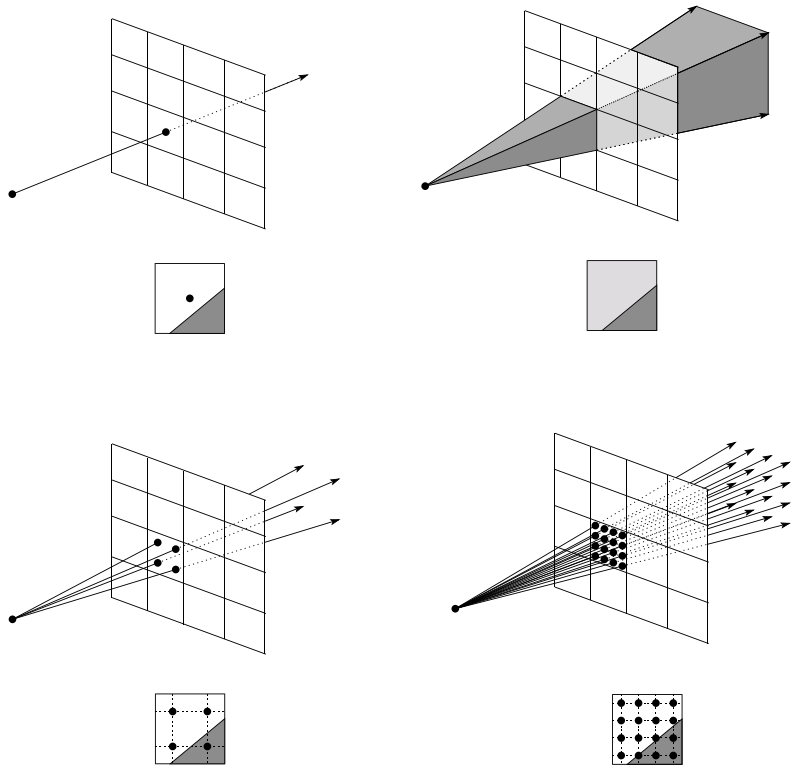
Reading

Recommended:

- Foley, et al, Sections 15.10.4, 16.2.14, 16.3.

Antialiasing

When casting one ray per pixel, we are likely to have aliasing artifacts.



To reduce aliasing, we can cast more rays per pixel and average the resulting rays.

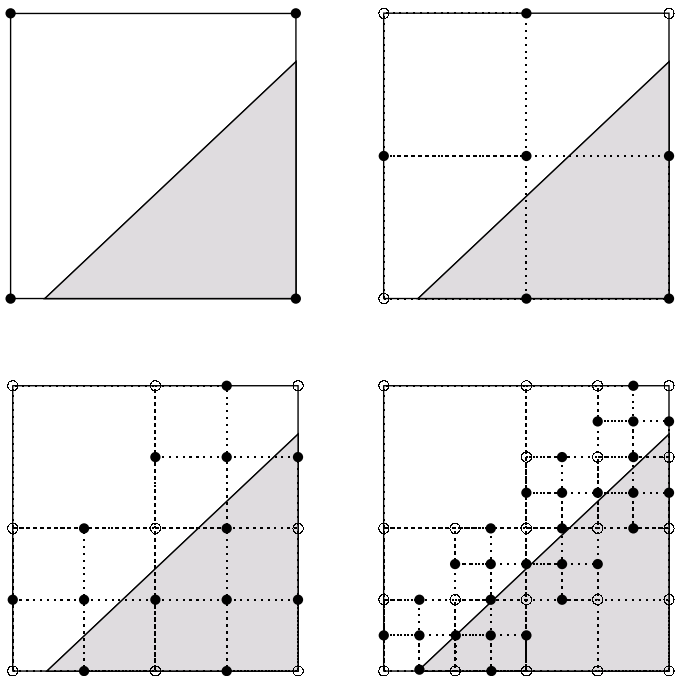
This is called "super-sampling and averaging down."

Antialiasing by adaptive sampling

Casting many rays per pixel can be unnecessarily costly.

For example, if their are no rapid changes in intensity at the pixel, maybe only a few samples are needed.

Solution: adaptive sampling.



Q: When do we decide to cast more rays in a particular area?

Stochastic sampling

Under photopic lighting conditions, the cones provide our image of the world.

In the fovea: densely packed in a regular pattern (kind of like a hexagonal CCD).

In the periphery: sparse, irregular spacing.

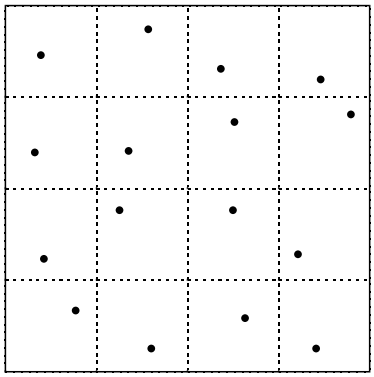
Yet, in the periphery we do not complain of aliasing ... inspiration for a sampling algorithm!

Stochastic sampling patterns

The distribution of cones in the periphery follows a Poisson disk pattern.

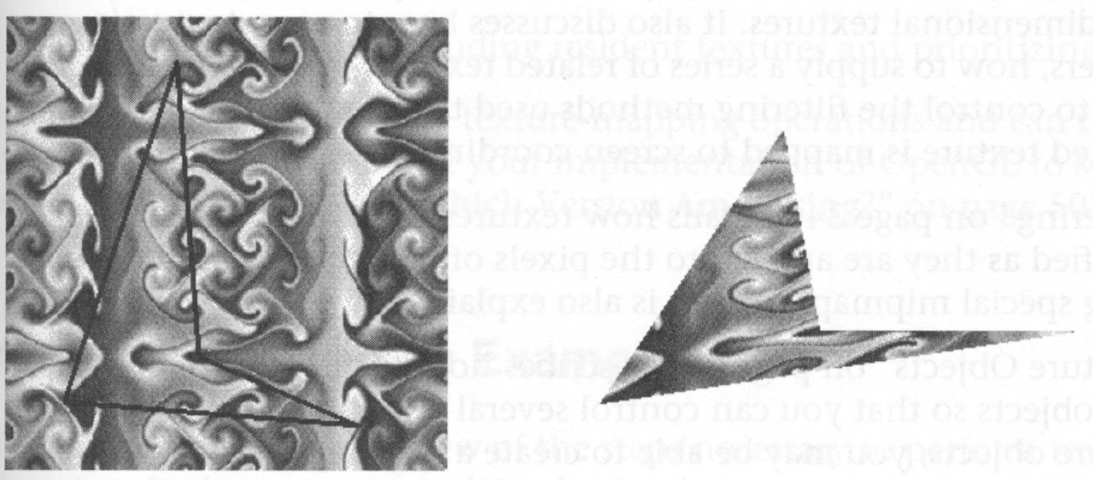
Poisson disk: random, uniform spatial distribution with the restriction that no two samples are within d of each other.

A simpler alternative that yields reasonable results is jittered sampling.



Stochastic sampling trades regular aliasing artifacts for high frequency noise.

Texture mapping

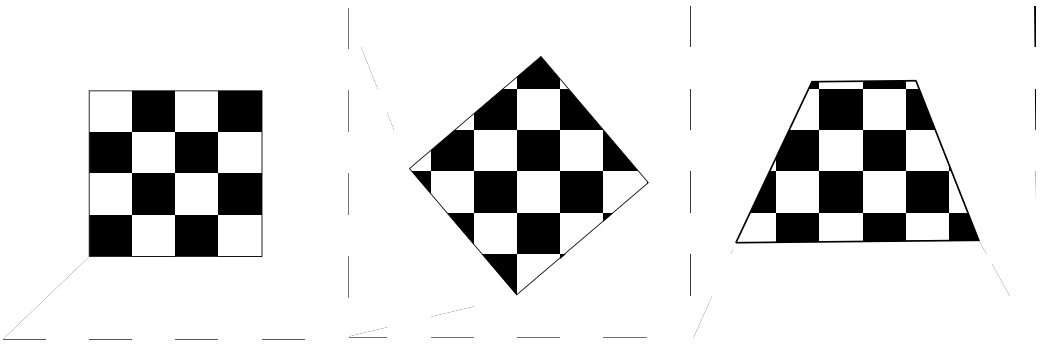


Texture mapping (Woo et al., fig 9-1)

Texture mapping allows you to take a simple polygon and give it the appearance of something much more complex.

- Due to Ed Catmull, PhD thesis, 1974
- Refined by Blinn & Newell, 1976

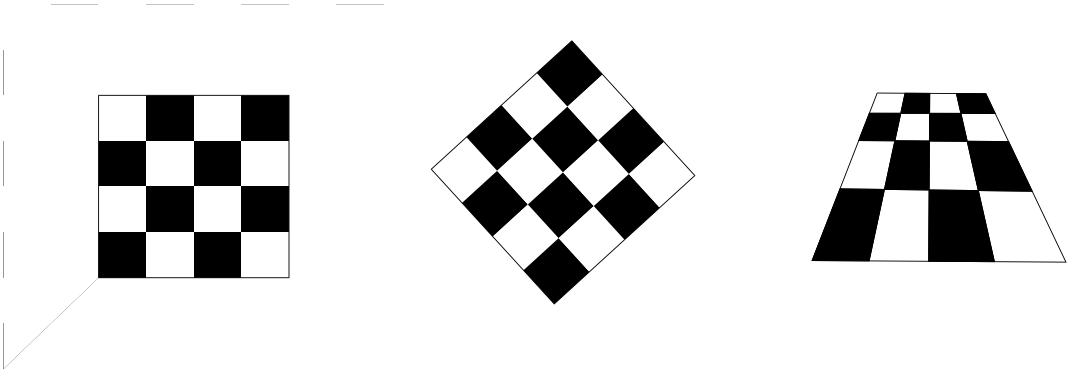
Non-parametric texture mapping



With "non-parametric texture mapping":

- Texture size and orientation are fixed
- They are unrelated to size and orientation of polygon
- Gives cookie-cutter effect

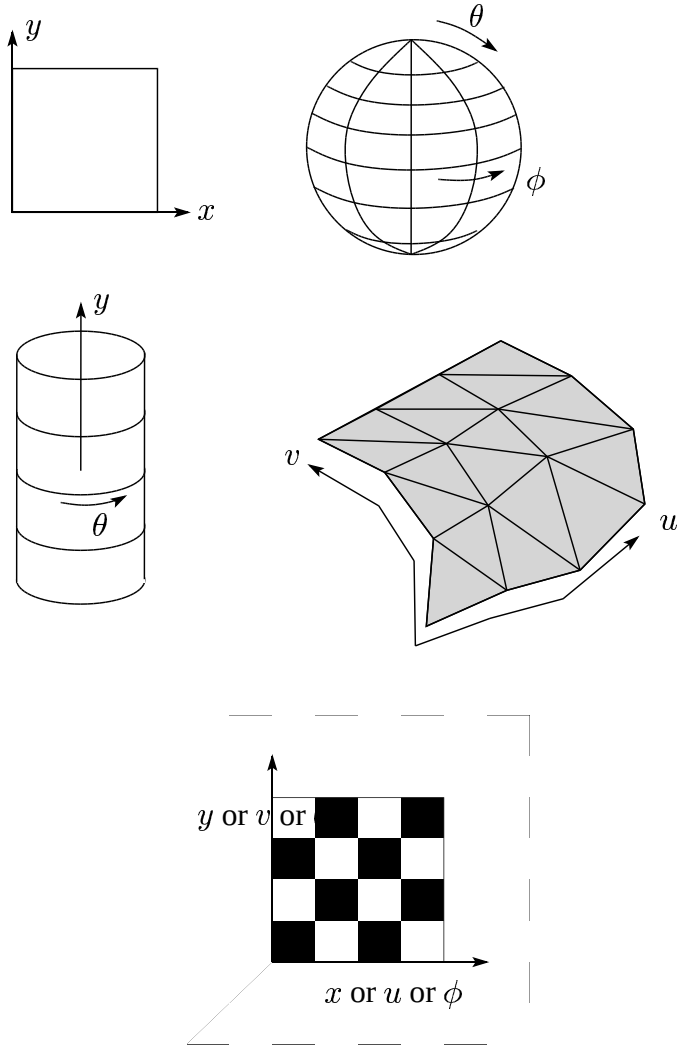
Parametric texture mapping



With "parametric texture mapping," texture size and orientation are tied to the polygon.

Implementing texture mapping

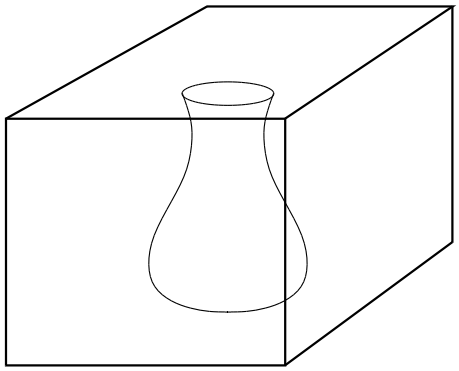
Textures can be wrapped around many different surfaces:



Computing texture coordinates in a ray tracer is fairly straightforward.

Solid textures

Q: What kinds of artifacts might you see from using a marble veneer instead of real marble?



One solution is to use "solid textures":

- Use model-space coordinates to index into a 3D texture
- Like "carving" the object from the material

One difficulty of solid texturing is coming up with the textures. . . .

Solid textures, cont'd

Here's an example for a vase cut from a solid marble texture:

Solid marble texture by Ken Perlin, (Foley, IV-21)

Bump mapping

Textures can be used for more than just color.

In "bump mapping," a texture is used to perturb the normal:

- The normal is perturbed in each parametric direction according to the partial derivates of the texture:

- These bumps "animate" with the surface

Q: What artifacts in the images would reveal that bump mapping is a fake?

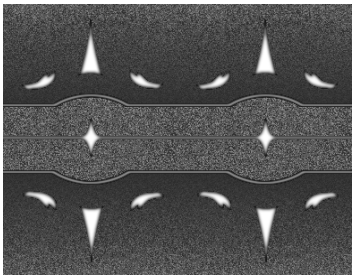
Displacement mapping

In "displacement mapping," a texture is used to perturb the surface geometry itself:

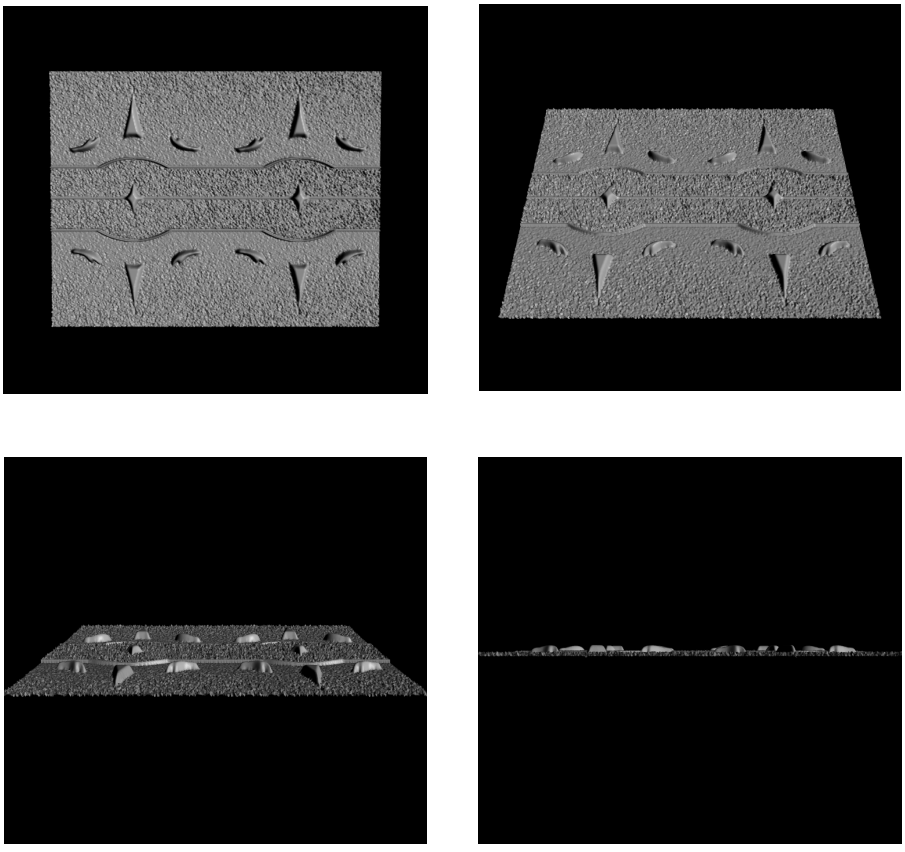
- Silhouettes are correct
- Requires doing additional hidden surface calculations

Displacement vs. bump mapping

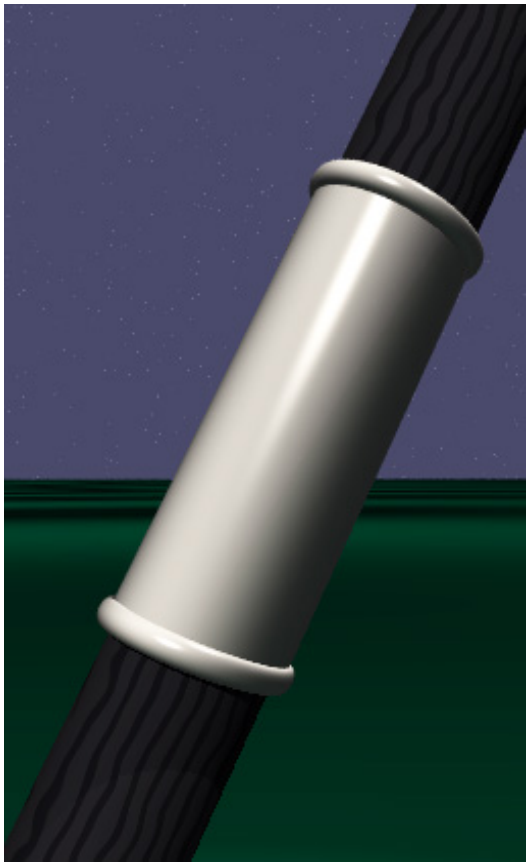
Input texture



Rendered as displacement map over a rectangular surface



Displacement vs. bump mapping, cont'd

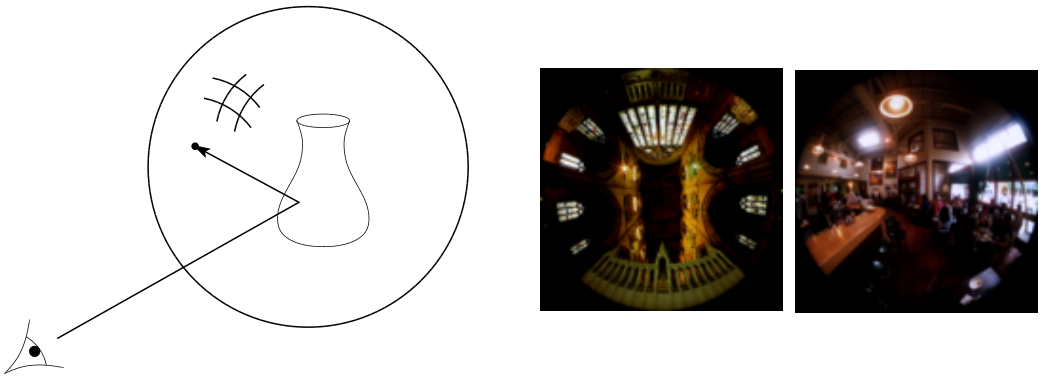


Original rendering

Rendering with bump map wrapped around a cylinder

Bump map and rendering by Wyvern Aldinger

Environment mapping



In "environment mapping" (also known as "reflection mapping"), a texture is used to model an object's environment:

- Rays are bounced off objects into environment
- Color of the environment used to determine color of the illumination
- Really, a simplified form of ray tracing
- Environment mapping works well when there is just a single object — or in conjunction with ray tracing

Under simplifying assumptions, environment mapping can be implemented in hardware.

With a ray tracer, the concept is easily extended to handle refraction as well as reflection.

Constructing texture maps

How do we construct a texture map?

- Scan in a photograph (texture CD's)
- Procedural methods – generate texture algorithmically
  - Checkerboards
  - Perlin's marble
- Hybrid: texture analysis/synthesis
  - Use a procedure generate an arbitrary amount of texture from a scanned sample.
  - Adresses the tiling problem.