CS 563 Advanced Topics in Computer Graphics

Texture Sampling & antialiasing - Basic Texturing (Ch. 8)

Physically Based Rendering

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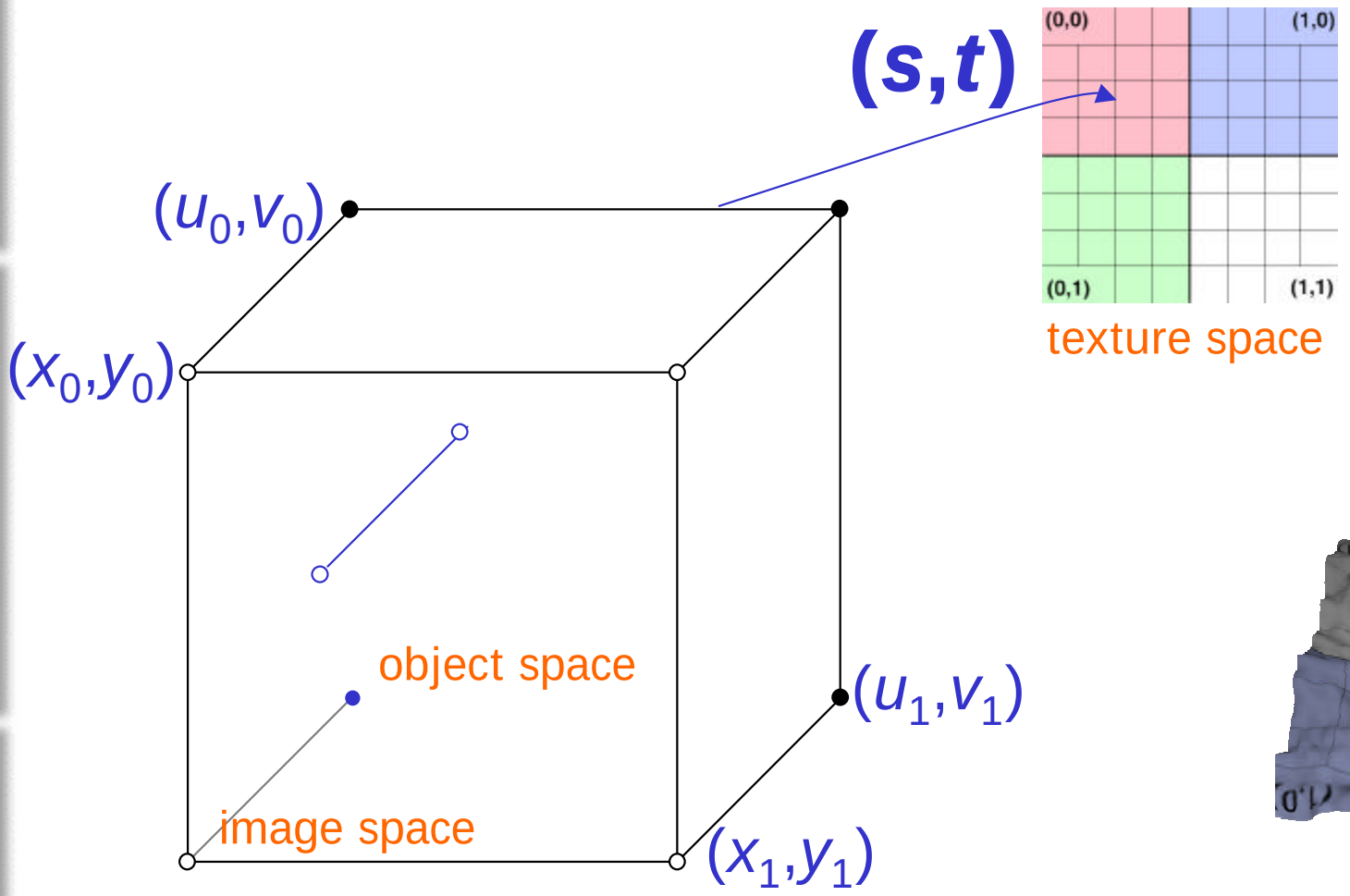
Outline

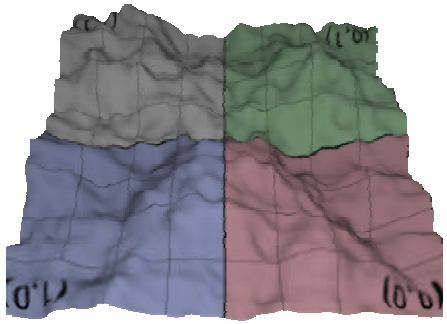
- Texture Space Sampling Rate
- Aliasing associated with Texture
- Refracted and Reflected Rays

Two Core Challenges for removing Texture Aliasing

- Sampling Rate
  - Must be computed in Texture space as opposed to screen space
  - Must determine rate which the texture function is being sampled
- Sampling Theory
  - Given the sampling rate we need to remove excess frequencies beyond the Nyquist limit from the texture function

Texture Sampling Rate





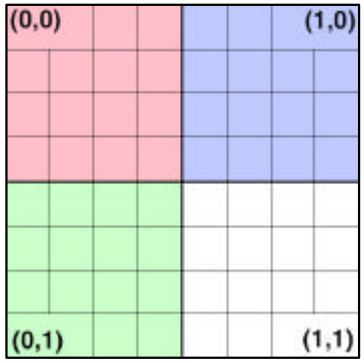
PBRT Texture coordinates are (S,T):

- **Commonly used industry Apps often use (u,v)**
- **PBRT uses (u,v) as a shapes "parametric description" coordinates**

p=f(u,v)

Simple Example: Finding Texture Sampling Rate

Image Space, Object Space & Texture Space perfectly aligned



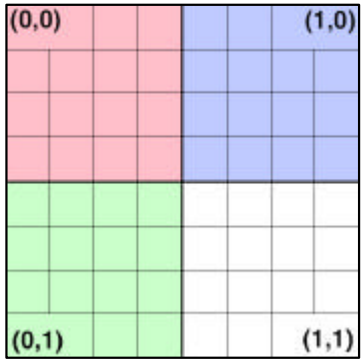
$$s = P_x \qquad t = P_y$$

$$s = \frac{x}{x_r} \qquad t = \frac{y}{y_r}$$

thus given a sample spacing of 1 pixel in the image plane the sample spacing in (s,t) texture space is $(1/x_r, 1/y_r)$

Simple Example: Finding Texture Sampling Rate

Image Space, Object Space & Texture Space perfectly aligned

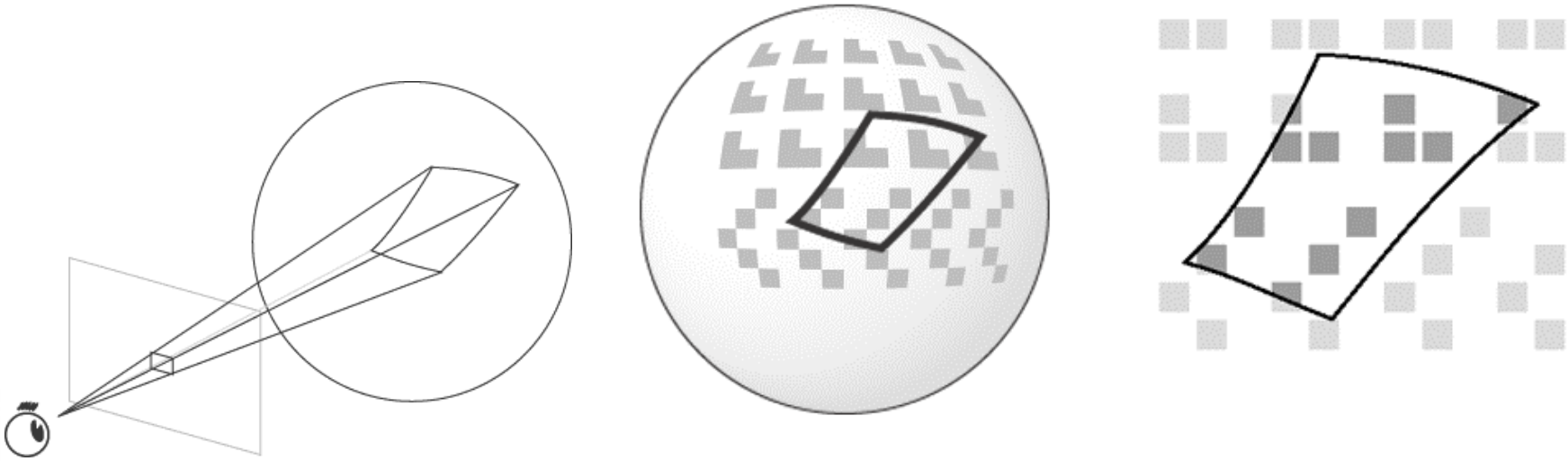


$$f(x',y') \approx f(x,y) + (x'-x)\frac{\partial f}{\partial x} + (y'-y)\frac{\partial f}{\partial y}$$

$$\frac{\partial s}{\partial x} = \frac{1}{x_r} \qquad \frac{\partial t}{\partial x} = 0$$

$$\frac{\partial s}{\partial y} = 0 \qquad \frac{\partial t}{\partial y} = \frac{1}{y_r}$$

Texture Aliasing

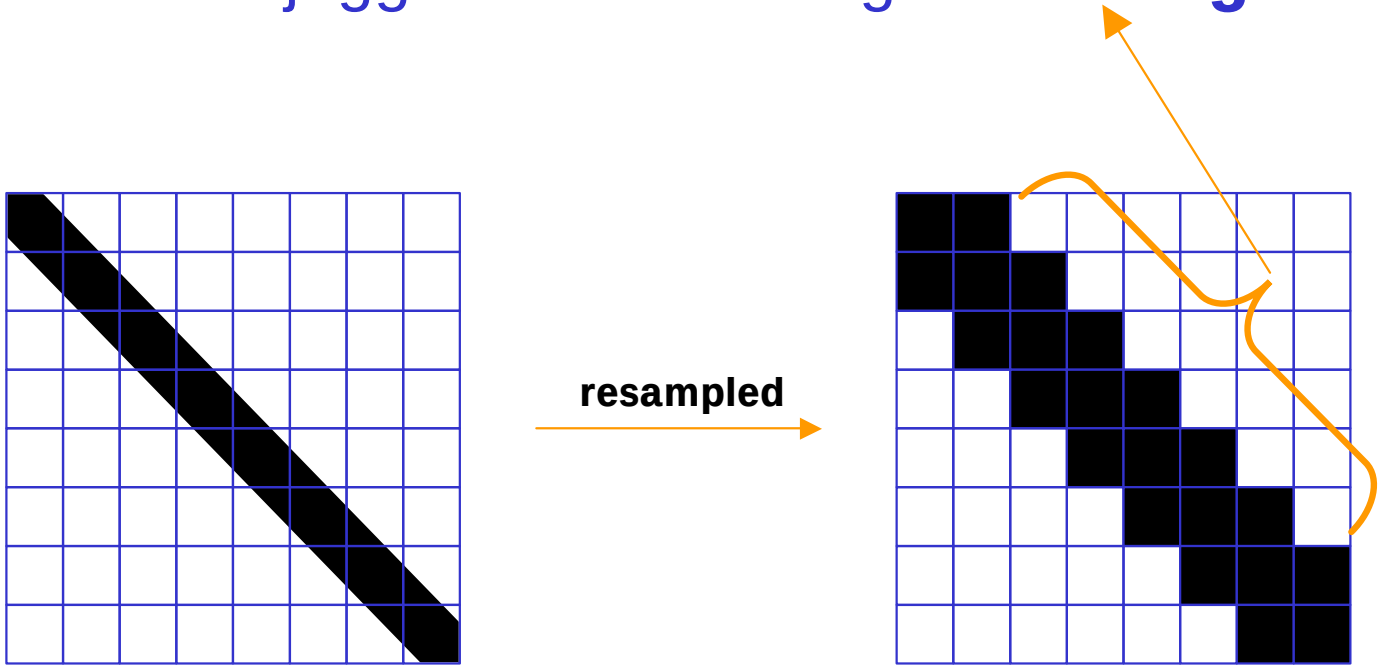


- The previous example was purposely kept overly simple:
- The following realities all lend to more complex but common scenarios:
  - Object Visibility
  - Object Shape
  - Perspective
  - Shadowing
  - Texture Frequency Variance

Finding Texture Sampling Rate

Aliasing Review

jaggies = staircasing = **aliasing**

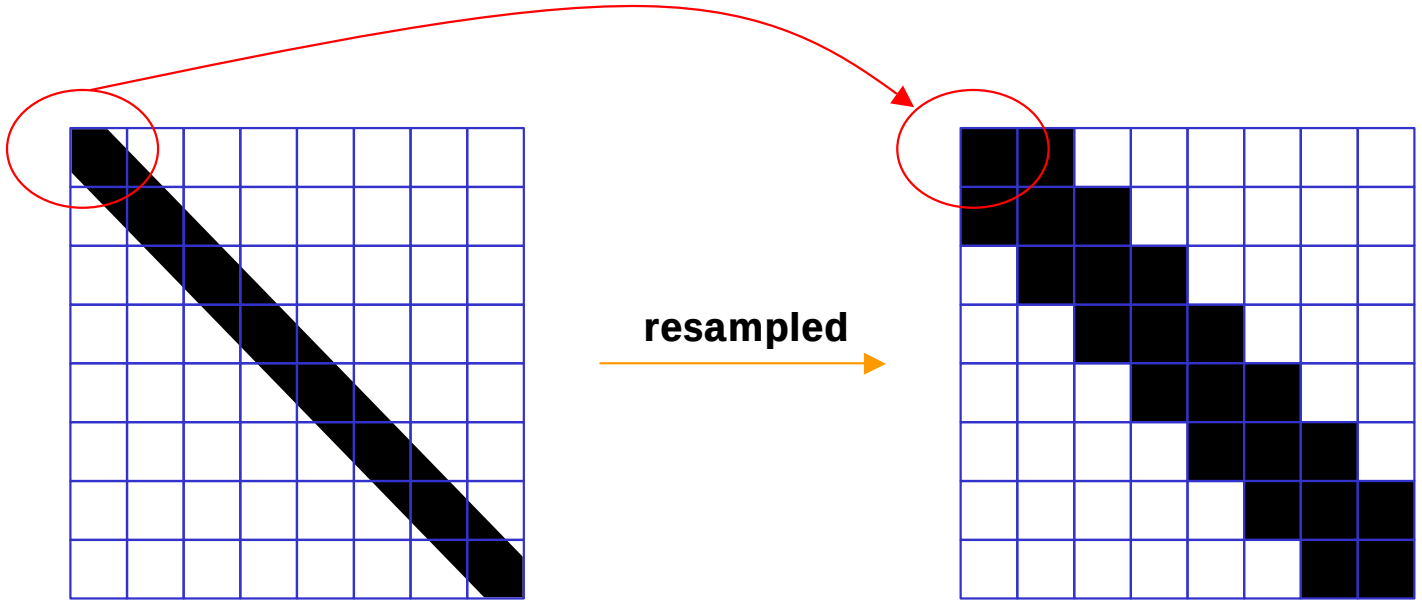


Ideal Line on Low Resolution Grid

Aliased

Aliasing Review

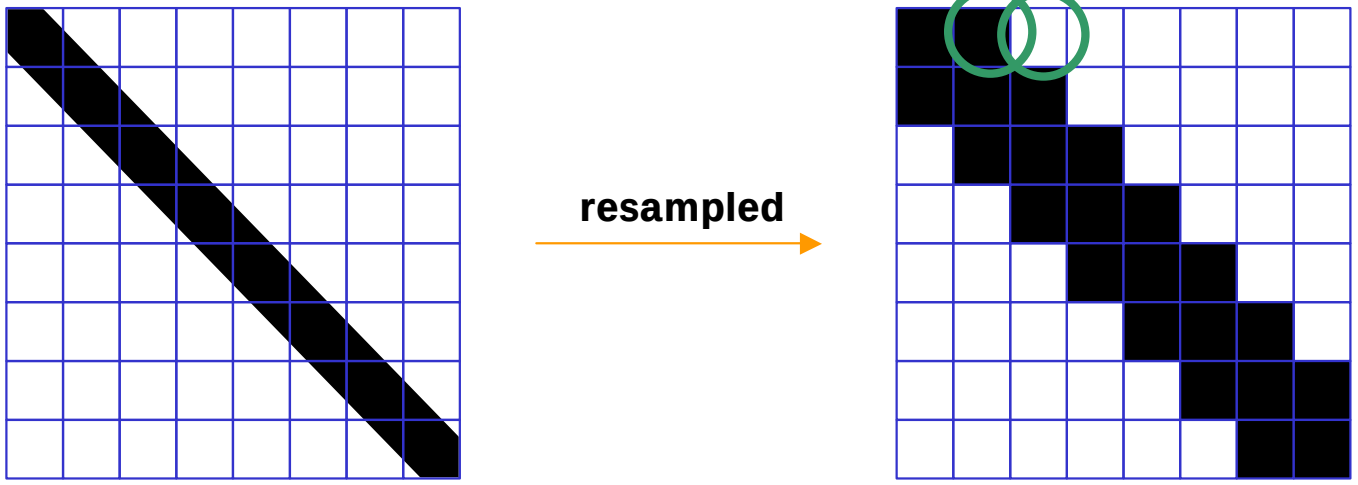
IF (Line_Is_Inside_Pixel) = black



Ideal Line on Low Resolution Grid

Aliased

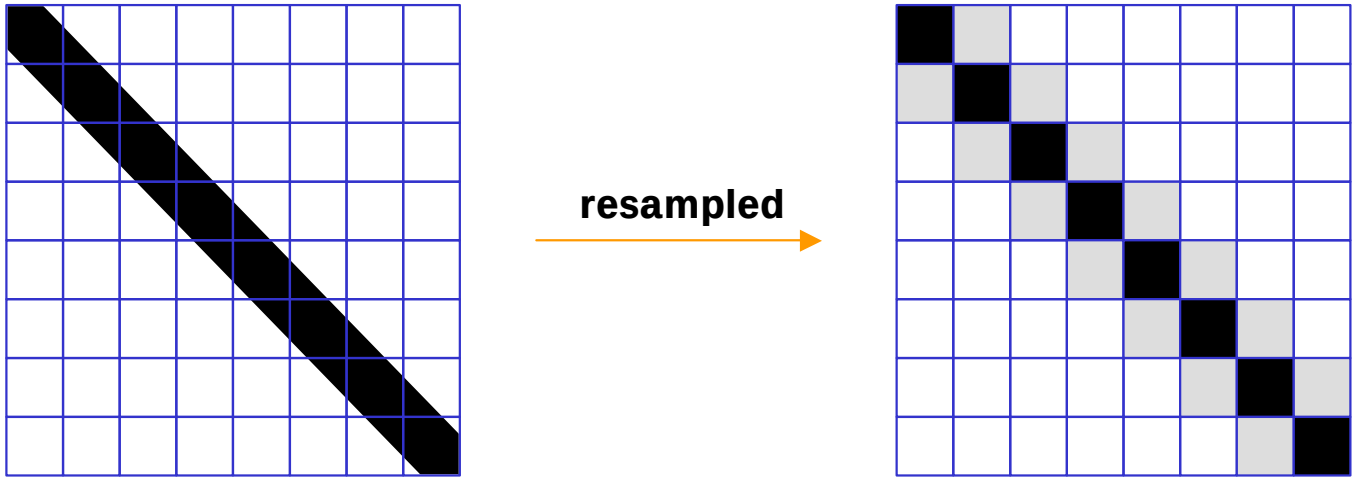
Aliasing Review



Ideal Line on Low Resolution Grid

Aliased

Aliasing Review



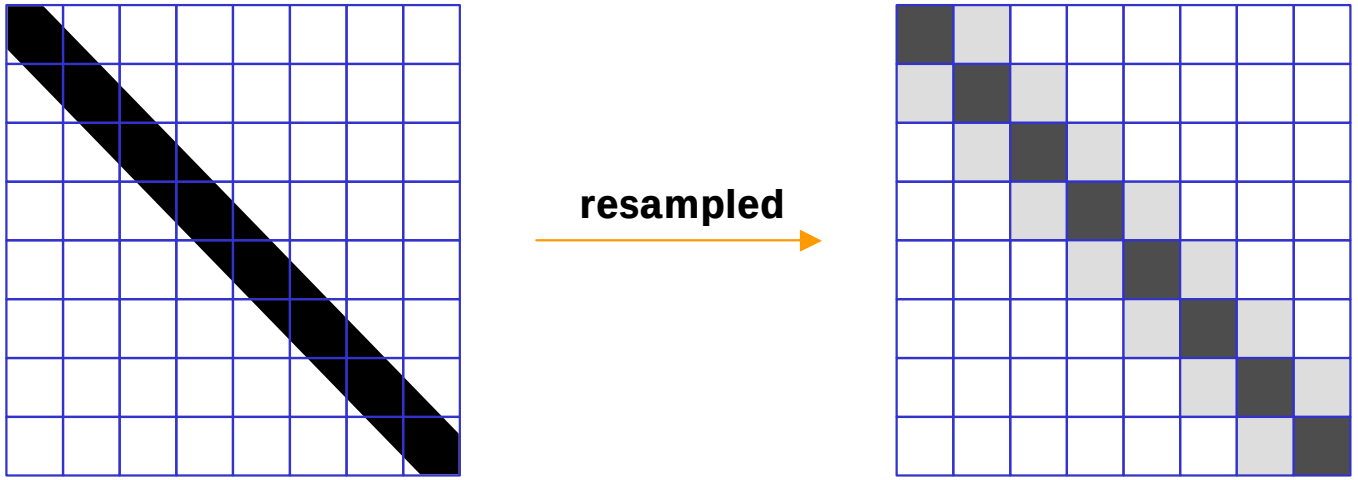
Ideal Line on Low Resolution Grid

Anti-Aliased

Unweighted Area Sampling

Three Properties of Unweighted area sampling:

1) Intensity of the pixel intersected by a line edge decreases as the distance between the pixel center and the edge increases
2) Non-intersected pixels are not influenced
3) Only the total amount of overlapped area matters (not weighted based on orientation towards the center of the pixel)

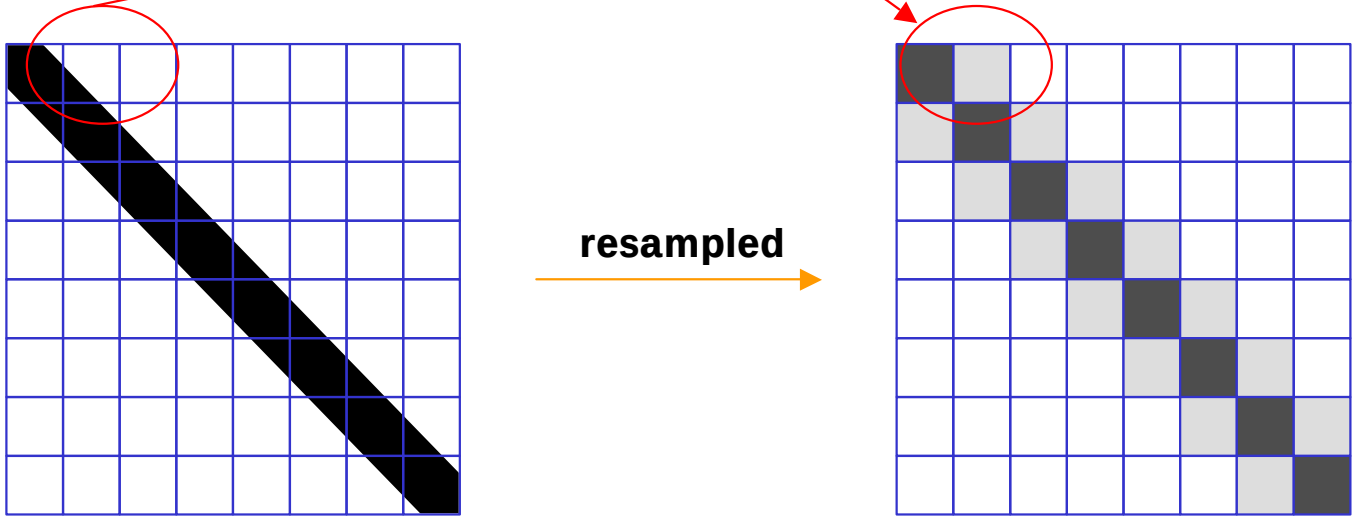


Ideal Line on Low Resolution Grid

Anti-Aliased

Unweighted Area Sampling

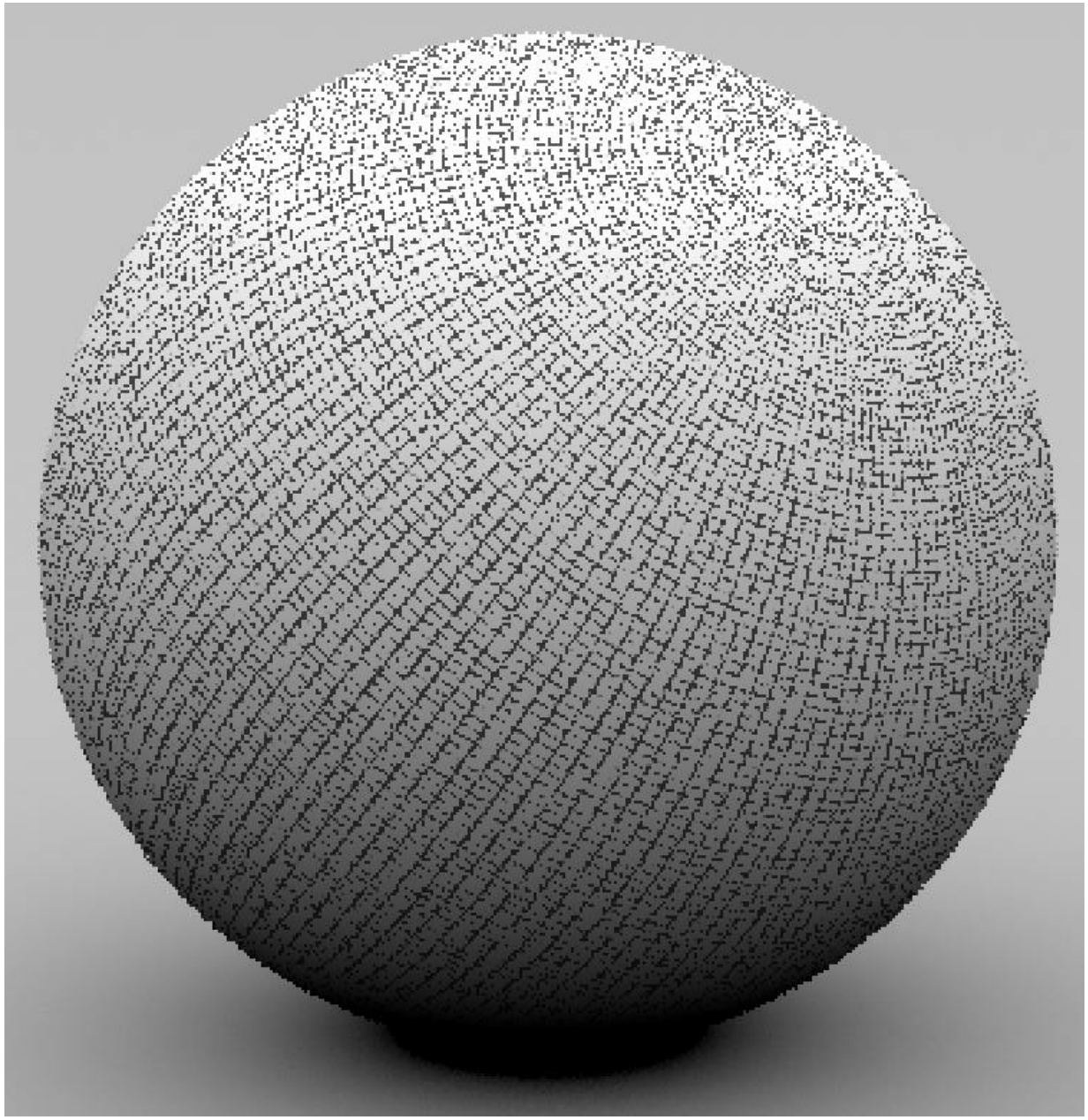
Accounting for contributions of original
-> result is % of BLACK (light Gray)



Ideal Line on Low Resolution Grid

Anti-Aliased

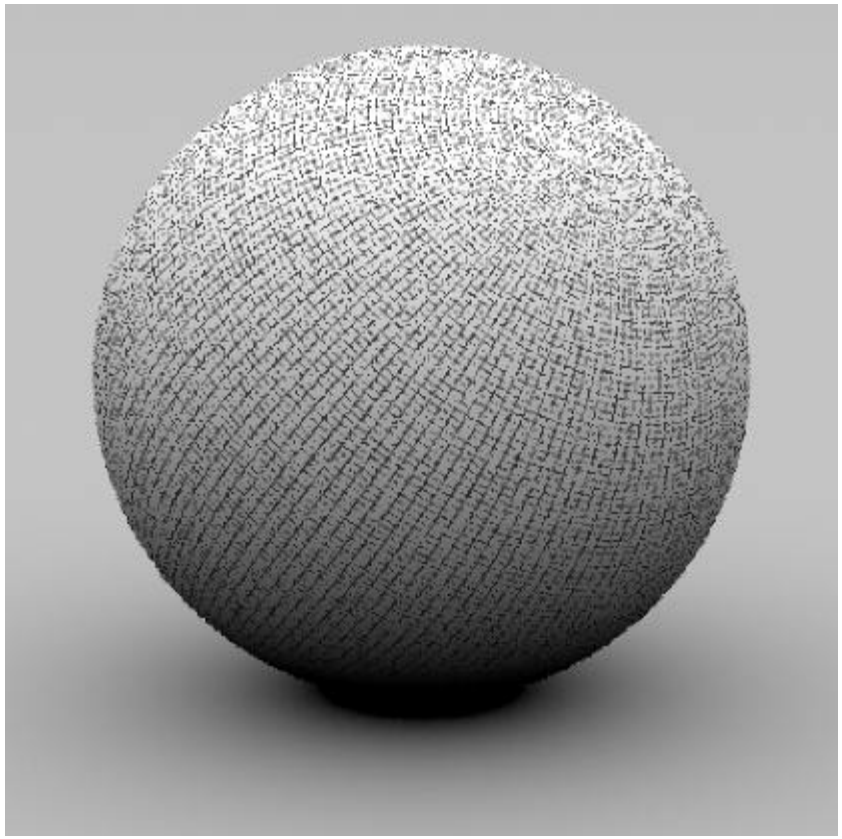
p. 496 Fig. 11.5 (a) ./images/11F05A.png



Grid texture on sphere w/ 1 sample per pixel

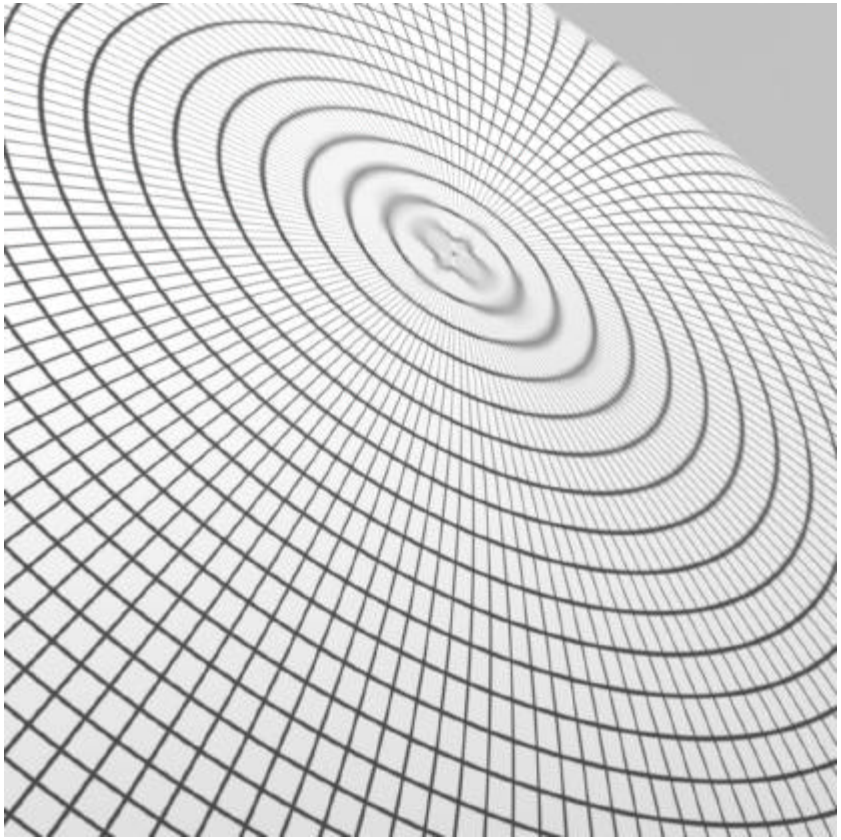
Texture Aliasing

p. 486 Fig. 11.1 (a) ./images/11F01A.png



Severe aliasing artifacts

p. 486 Fig. 11.1 (b) ./images/11F01B.png

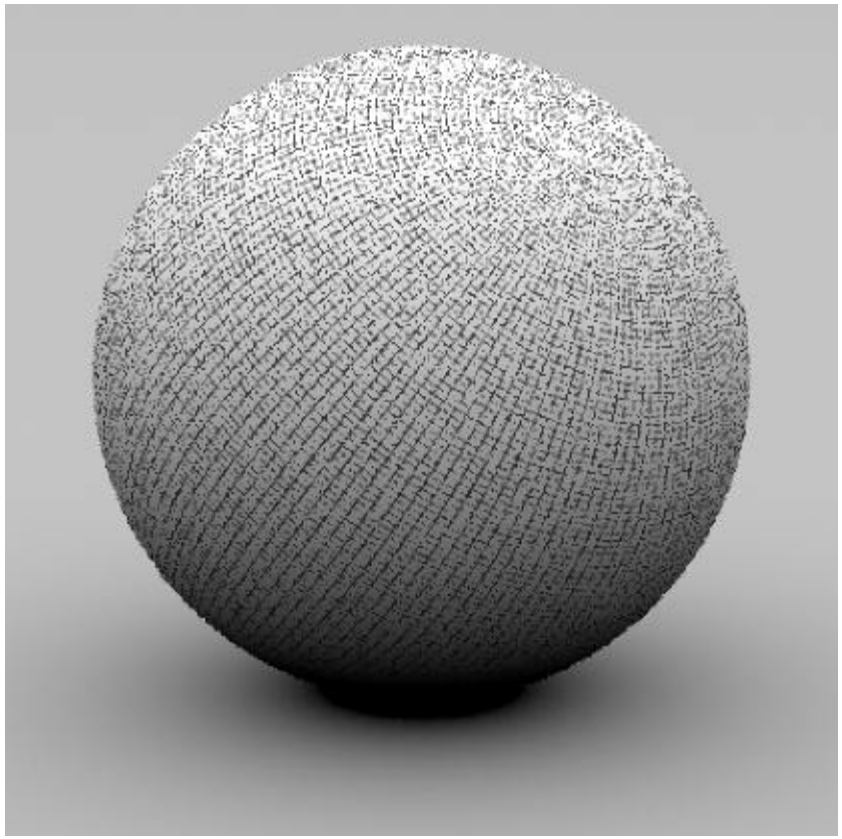


Zoom-In of sphere from left

Notice High-Frequency detail is present

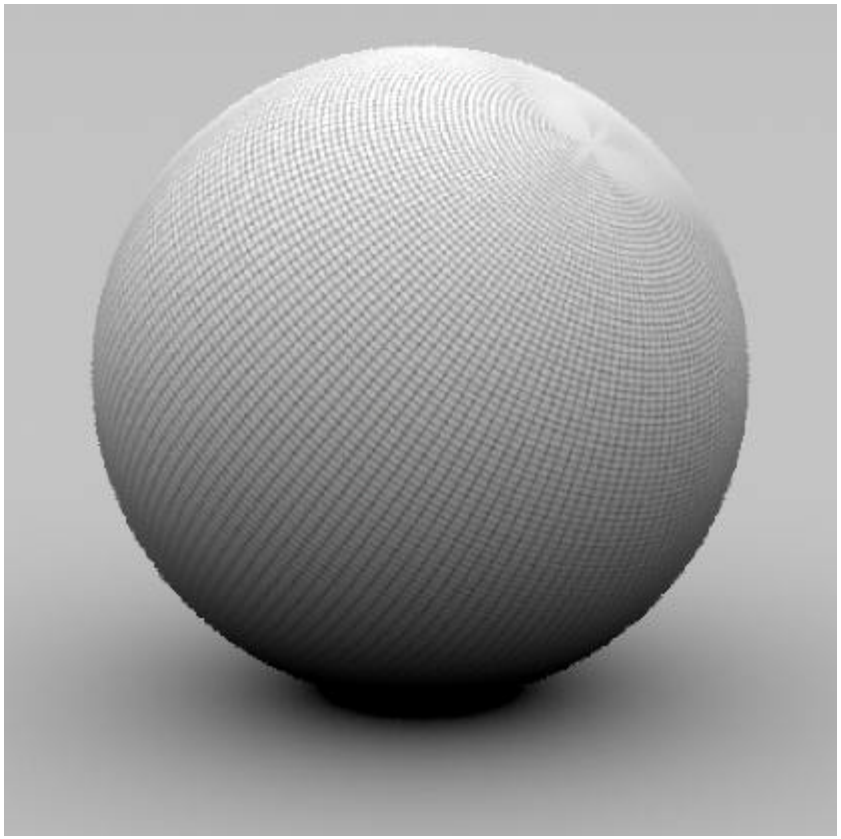
Texture Aliasing

p. 486 Fig. 11.1 (a) ./images/11F01A.png



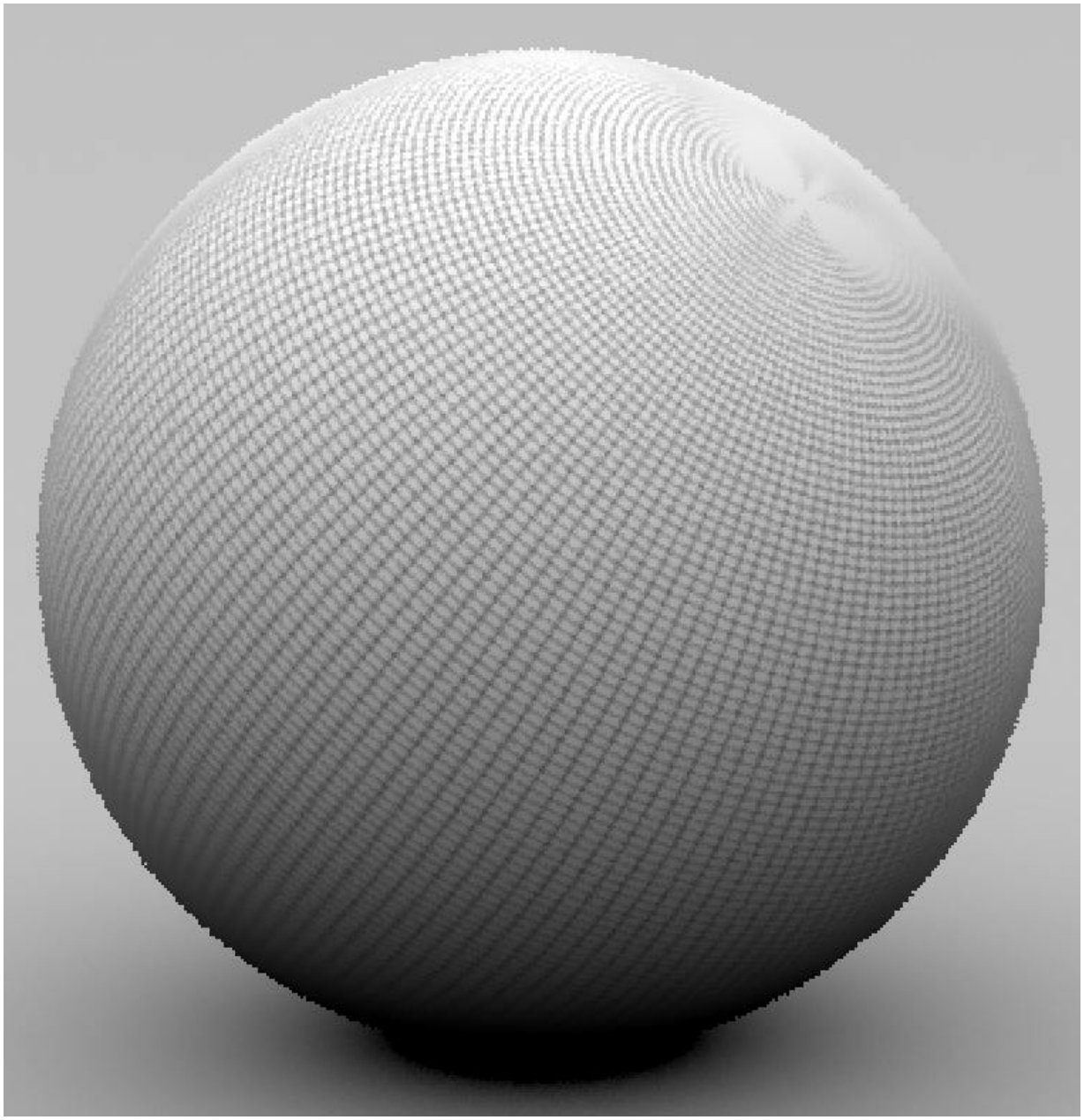
Severe aliasing artifacts

p. 486 Fig. 11.1 (c) ./images/11F01C.png



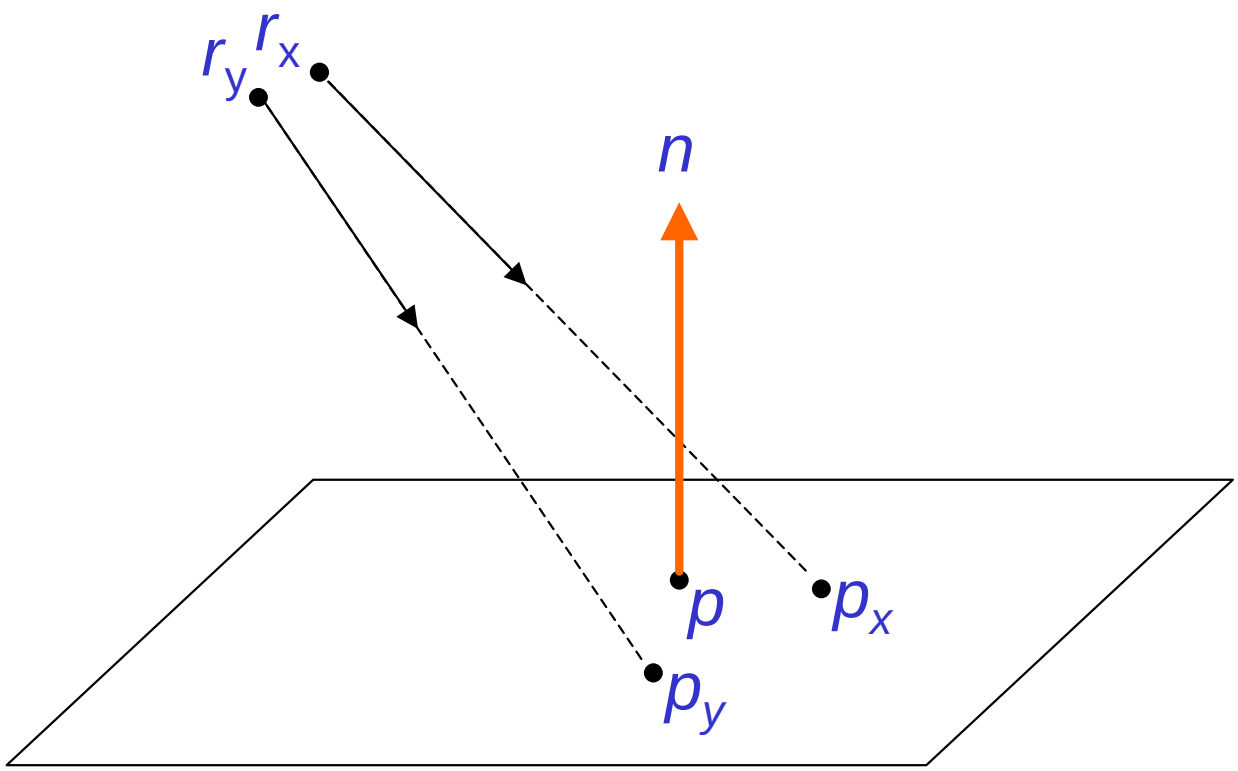
Texture function applied

p. 496 Fig. 11.5 (c) ./images/11F05C.png

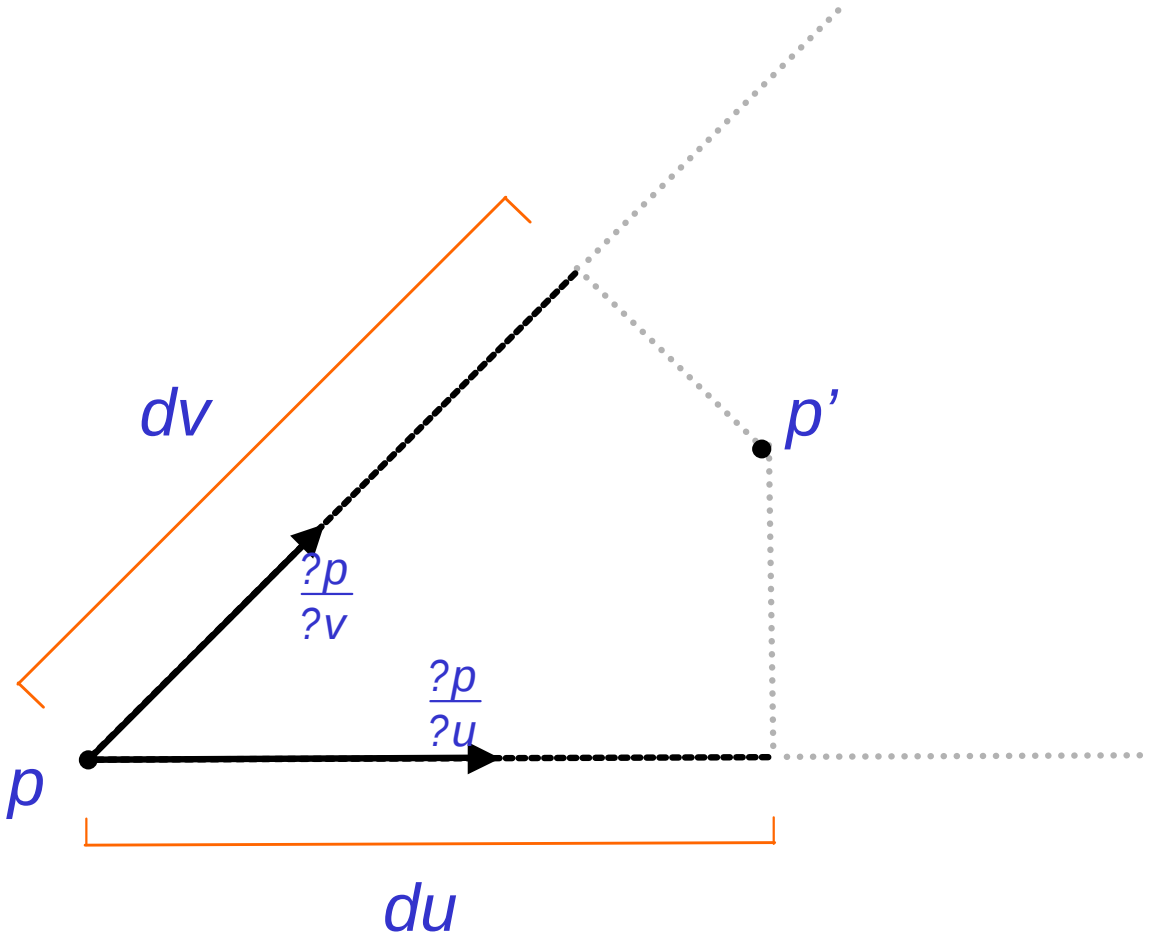


antialiased image, even with a single sample per pixel

Texture Sampling Rate



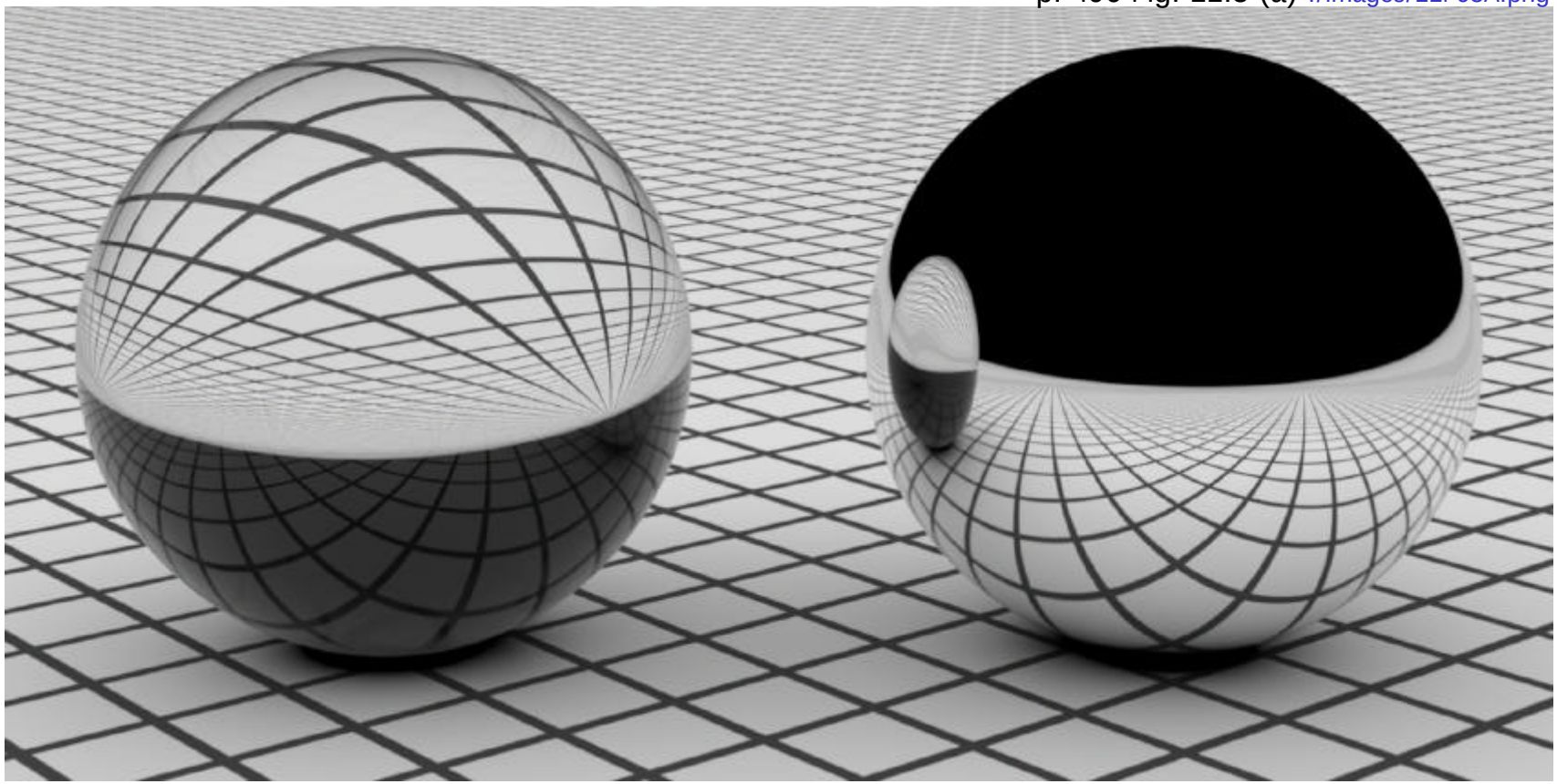
(u,v) parameterization



p. 492 Fig. 11.4

Reflected & Refracted Rays

p. 496 Fig. 11.5 (a) ./images/11F05A.png



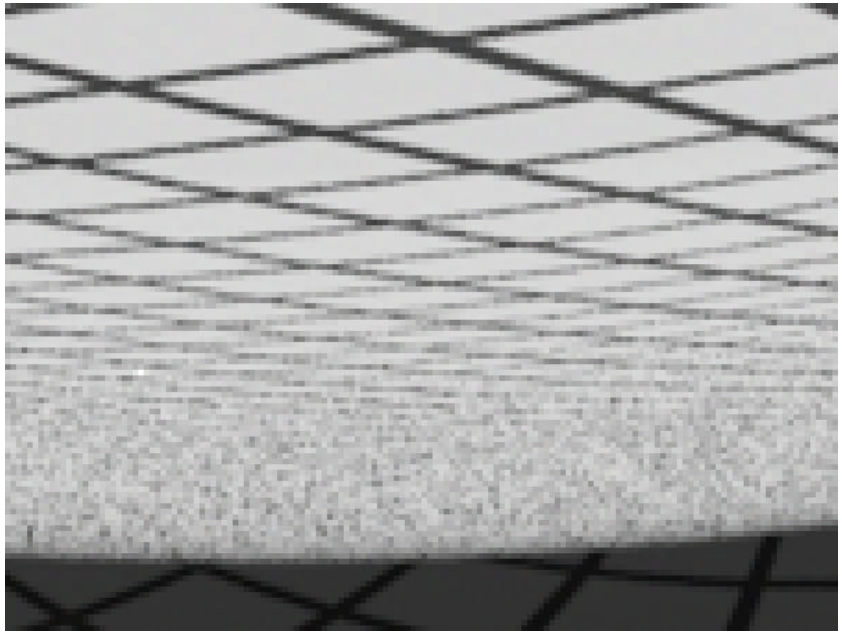
Tracking ray differentials

Left is glass (reflection & refraction)

Right is Mirror (reflection)

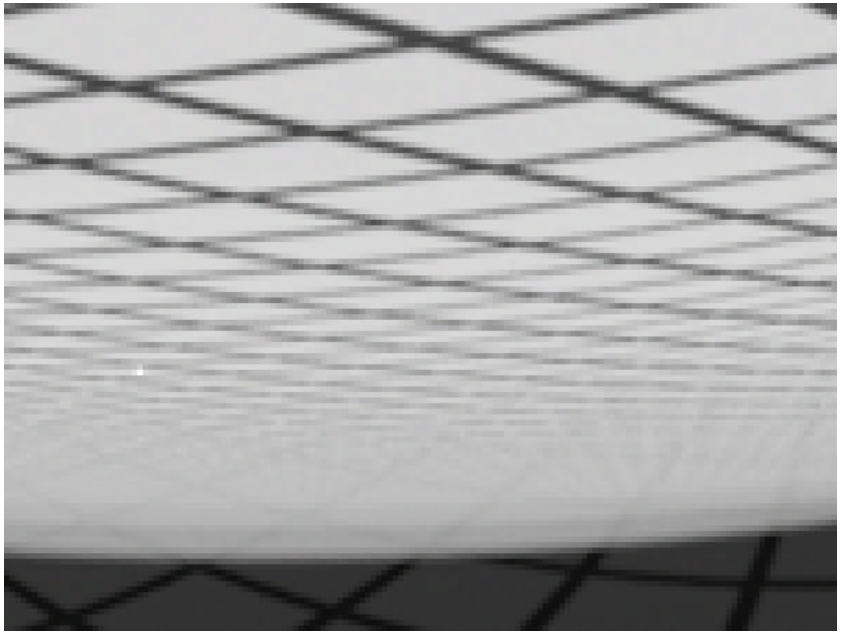
Tracking Ray Differentials

p. 496 Fig. 11.5 (b) ./images/11F05B.png



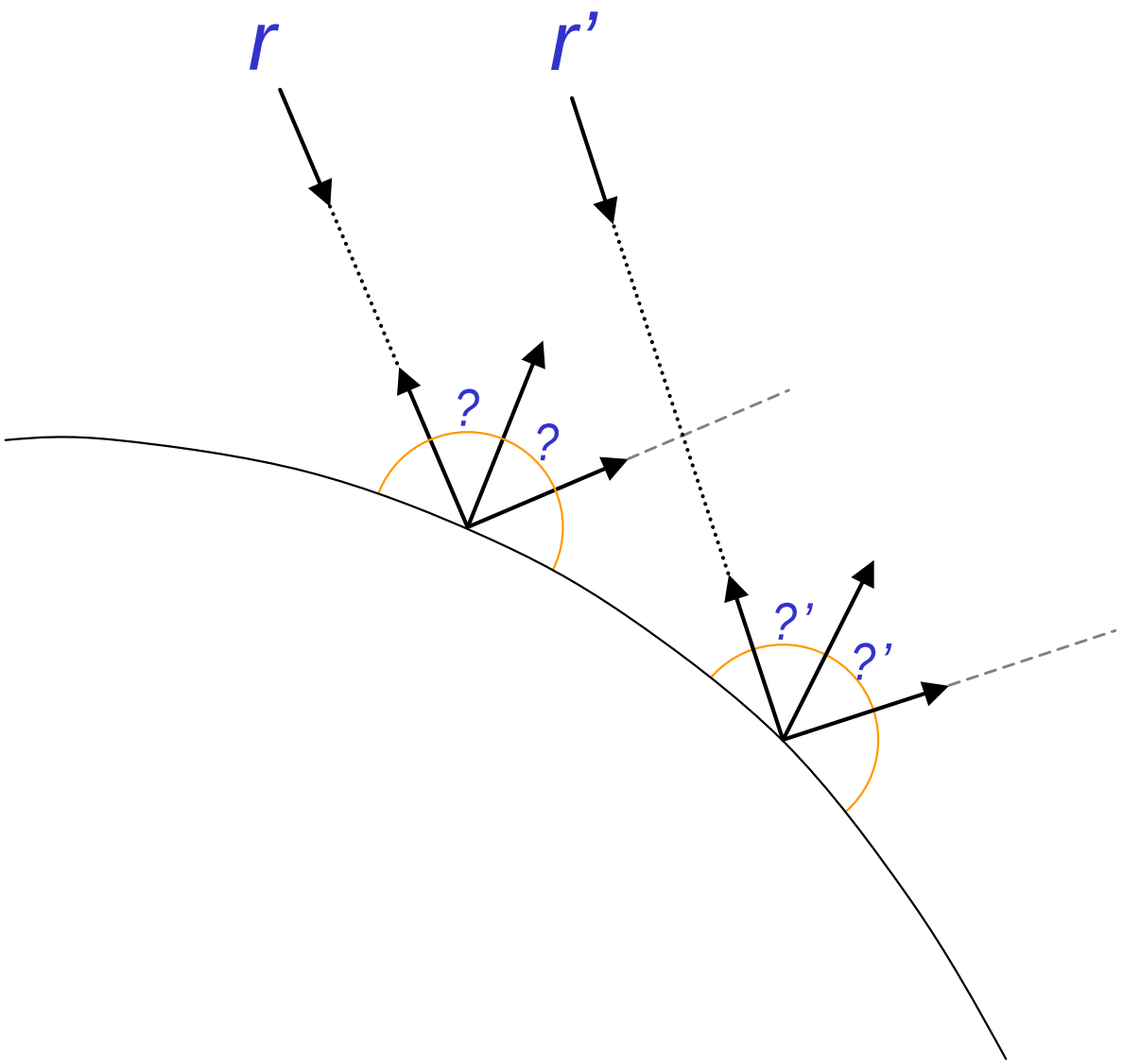
aliasing artifacts

p. 496 Fig. 11.5 (c) ./images/11F05C.png



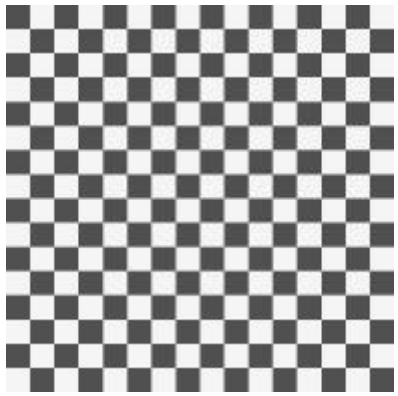
antialiasing w/ ray differentials

Specular Reflection

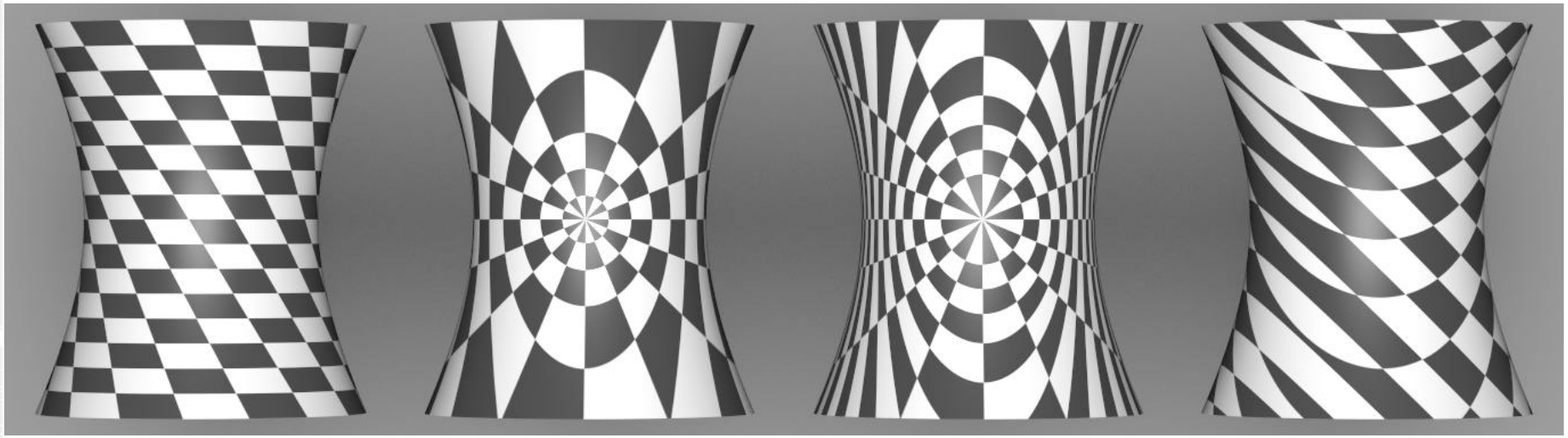


Reflected & Refracted Rays

(*s*,*t*)



p. 499 Fig. 11.7 ./images/11F05A.png



(*u*,*v*) Spherical Cylindrical Planer

Different texture coordinate generation techniques

Checkerboard texture applied to a hyperboloid

References

"Physically Based Rendering" by Gregg Humphreys & Matt Pharr

- All Images Obtained from "Physically Based Rendering" CD-ROM
- Figures recreated by tgrant from figures cited in "Physically Based Rendering" textbook

Daylon Graphics – Leveller Documentation

- Raytracer Texturing

www.cambridgeincolour.com (Sean T. Mchugh)

- Digital Image Interpolation

"Computer Graphics: Principles & Practice" by Foley, van Dam, Feiner, Hughes

"What We Need Around Here is More Aliasing" by Blinn, J.F.

"Return of the Jaggy" by Blinn, J.F.

"The Aliasing Problem in Computer-Generated Shaded Images" by Crow, F.

"A Comparison of Antialiasing Techniques" by Crow, F.

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