

CS7.302: Assignment 3

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1 Pixel Subsampling for Anti-aliasing

1.1 Timings

Scene	SPP	Render Time (ms)
CornellBox: Directional Light	1	1037.84
	32	31507.78

Table 1: Time taken for rendering models

1.2 Rendered Images

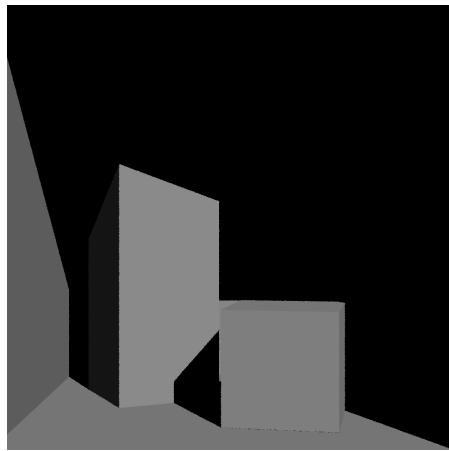


Figure 1: Rendering of CornellBox, at 1 SPP

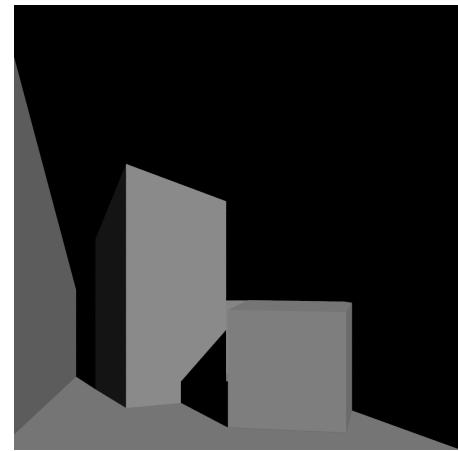


Figure 2: Rendering of CornellBox, at 32 SPP

2 Area Light Support

2.1 Timings

Scene	Render Time (ms)
Scene 1	2966.52
Scene 2	2564.13
Scene 3	2788.72
Scene 4	3544.12

Table 2: Time taken for rendering models, with Area Light Support, at 32 SPP

2.2 Rendered Images



Figure 3: Rendering of Scene 1

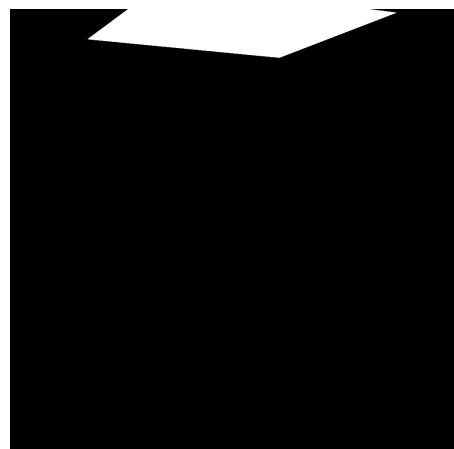


Figure 4: Rendering of Scene 2



Figure 5: Rendering of Scene 3

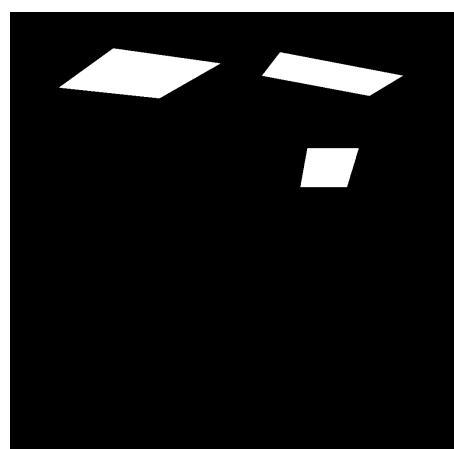


Figure 6: Rendering of Scene 4

3 Monte-Carlo & Importance Sampling

3.1 Uniform Hemisphere Sampling

3.1.1 Timings

Scene	SPP	Render Time (ms)
Small Area Light	10	6022.58
	100	59144.16
	1000	589168.56
Medium Area Light	10	6124.01
	100	60336.18
	1000	604133.56
Big Area Light	10	6682.72
	100	65333.00
	1000	651757.00
Many Area Lights	10	8851.31
	100	87987.65
	1000	874781.50

Table 3: Time taken for rendering models, with Uniform Hemisphere Sampling

3.1.2 Rendered Images

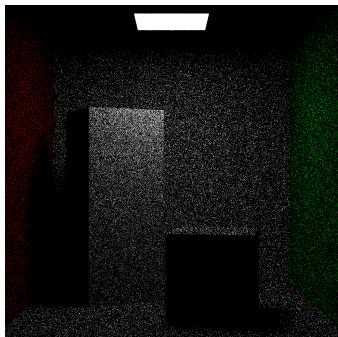


Figure 7: Rendering of Small Area Light, at 10 SPP

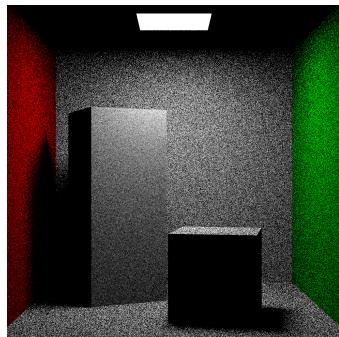


Figure 8: Rendering of Small Area Light, at 100 SPP

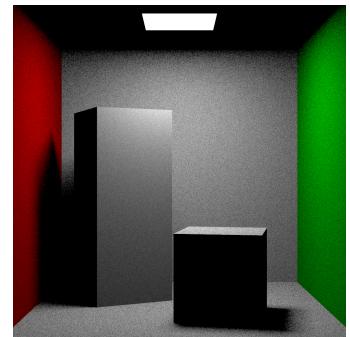


Figure 9: Rendering of Small Area Light, at 1000 SPP

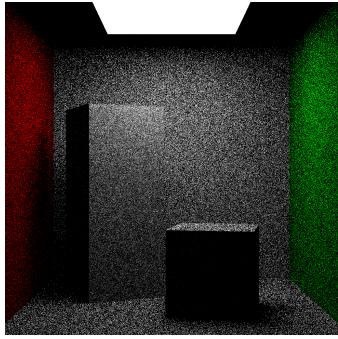


Figure 10: Rendering of Medium Area Light, at 10 SPP

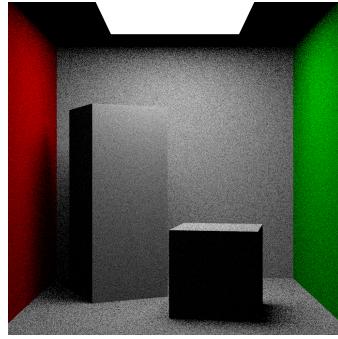


Figure 11: Rendering of Medium Area Light, at 100 SPP

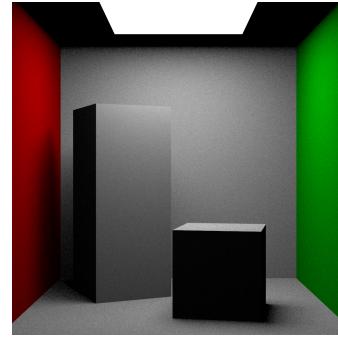


Figure 12: Rendering of Medium Area Light, at 1000 SPP

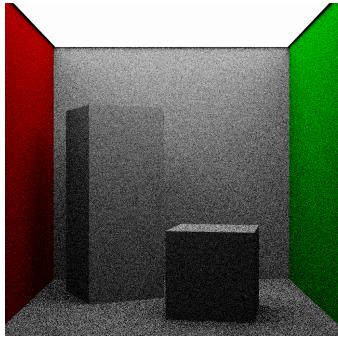


Figure 13: Rendering of Big Area Light, at 10 SPP

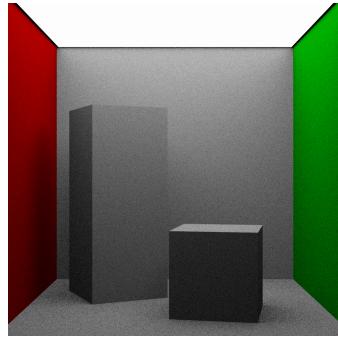


Figure 14: Rendering of Big Area Light, at 100 SPP

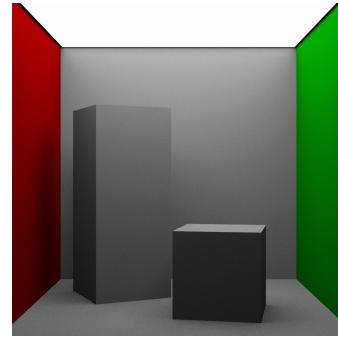


Figure 15: Rendering of Big Area Light, at 1000 SPP

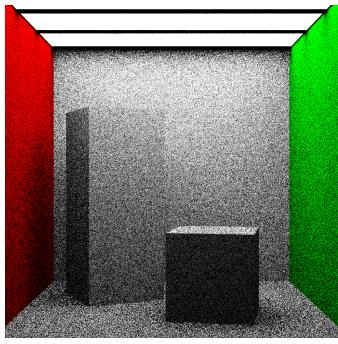


Figure 16: Rendering of Many Area Lights, at 10 SPP

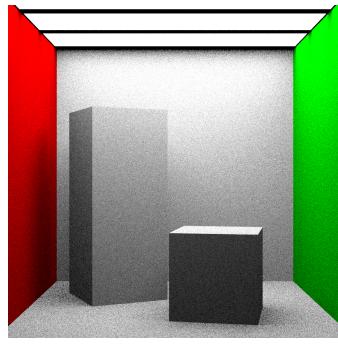


Figure 17: Rendering of Many Area Lights, at 100 SPP

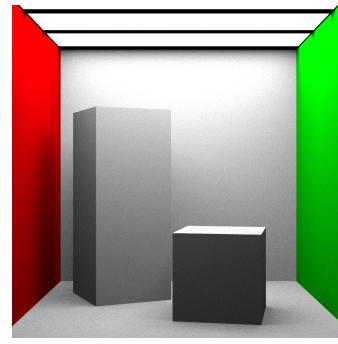


Figure 18: Rendering of Many Area Lights, at 1000 SPP

3.2 Cosine Weighted Sampling

3.2.1 Timings

Scene	SPP	Render Time (ms)
Small Area Light	10	6036.33
	100	59582.02
	1000	592307.38
Medium Area Light	10	6207.46
	100	60797.05
	1000	605032.50
Big Area Light	10	6633.85
	100	65366.50
	1000	651788.44
Many Area Lights	10	8912.70
	100	90106.61
	1000	888110.00

Table 4: Time taken for rendering models, with Cosine Weighted Sampling

3.2.2 Rendered Images

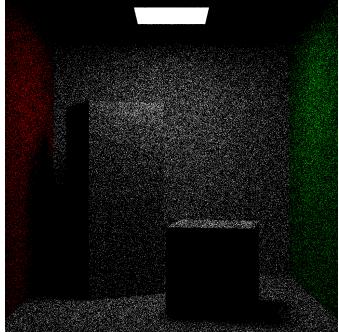


Figure 19: Rendering of Small Area Light, at 10 SPP

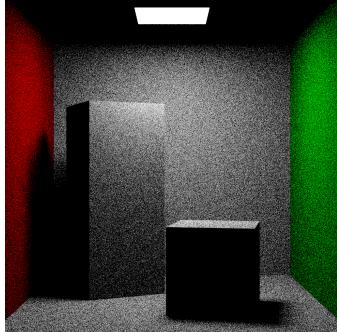


Figure 20: Rendering of Small Area Light, at 100 SPP

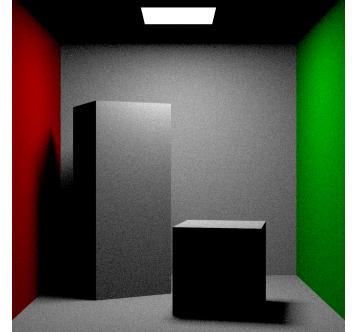


Figure 21: Rendering of Small Area Light, at 1000 SPP

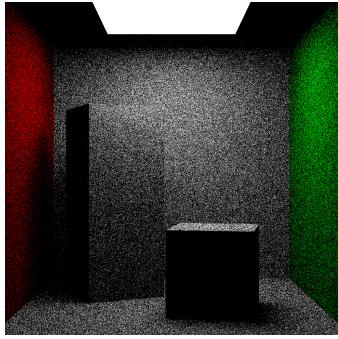


Figure 22: Rendering of Medium Area Light, at 10 SPP

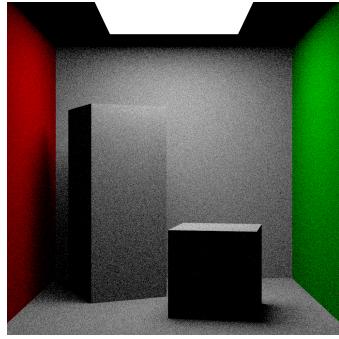


Figure 23: Rendering of Medium Area Light, at 100 SPP

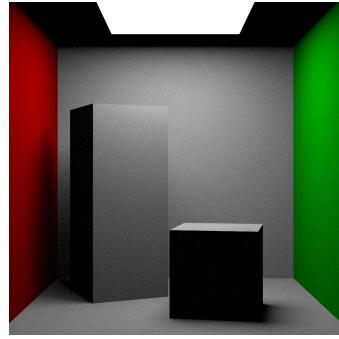


Figure 24: Rendering of Medium Area Light, at 1000 SPP

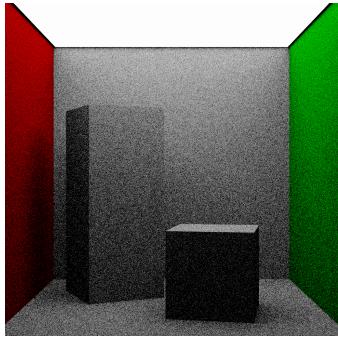


Figure 25: Rendering of Big Area Light, at 10 SPP

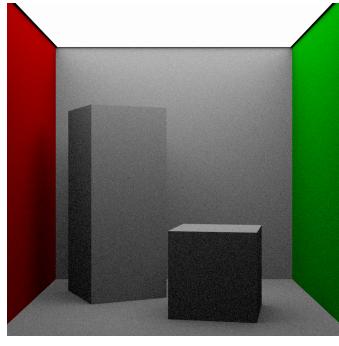


Figure 26: Rendering of Big Area Light, at 100 SPP

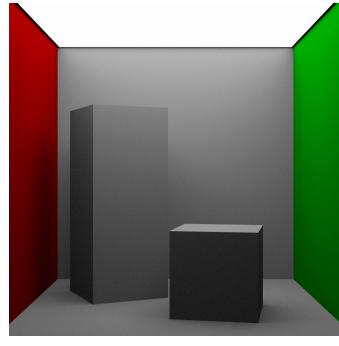


Figure 27: Rendering of Big Area Light, at 1000 SPP

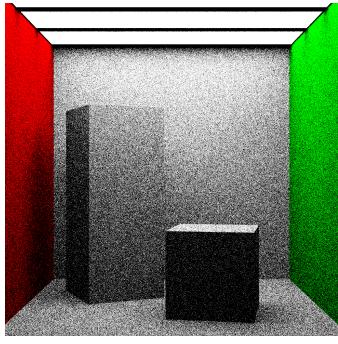


Figure 28: Rendering of Many Area Lights, at 10 SPP

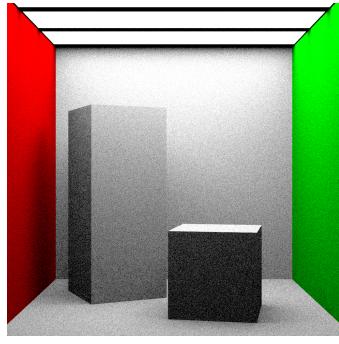


Figure 29: Rendering of Many Area Lights, at 100 SPP

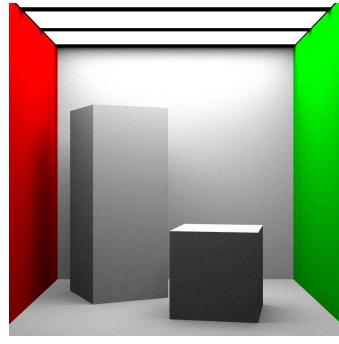


Figure 30: Rendering of Many Area Lights, at 1000 SPP

3.3 Light Sampling

3.3.1 Timings

Scene	SPP	Render Time (ms)
Small Area Light	10	9806.28
	100	97156.87
	1000	971337.81
Medium Area Light	10	9932.09
	100	98510.02
	1000	983582.56
Big Area Light	10	10076.54
	100	99681.77
	1000	996459.94
Many Area Lights	10	20799.39
	100	205285.19
	1000	2048712.50

Table 5: Time taken for rendering models, with Light Sampling

3.3.2 Rendered Images

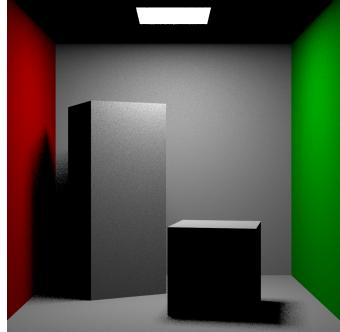


Figure 31: Rendering of Small Area Light, at 10 SPP

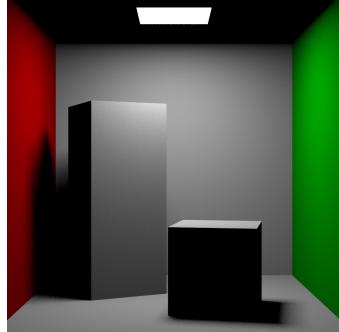


Figure 32: Rendering of Small Area Light, at 100 SPP

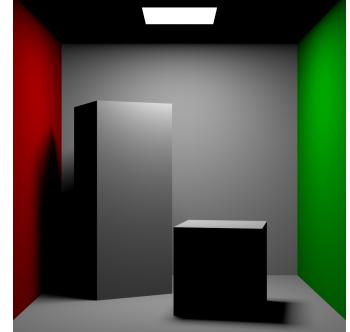


Figure 33: Rendering of Small Area Light, at 1000 SPP

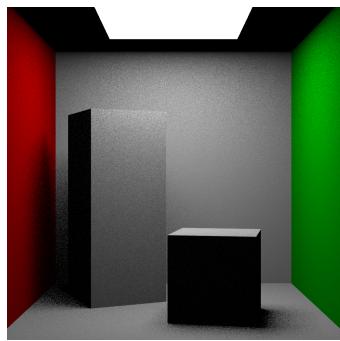


Figure 34: Rendering of Medium Area Light, at 10 SPP

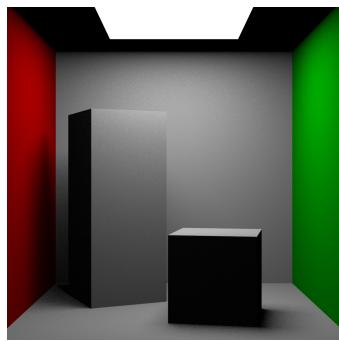


Figure 35: Rendering of Medium Area Light, at 100 SPP

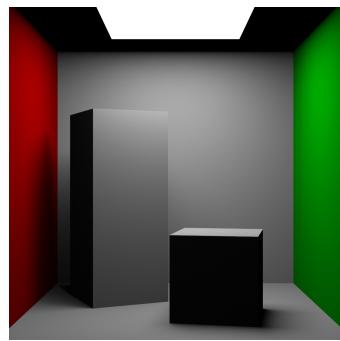


Figure 36: Rendering of Medium Area Light, at 1000 SPP

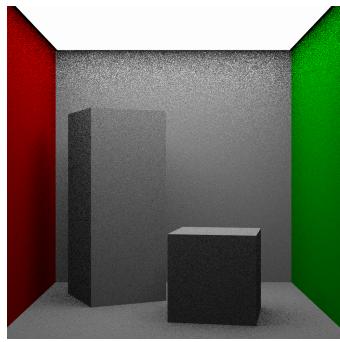


Figure 37: Rendering of Big Area Light, at 10 SPP

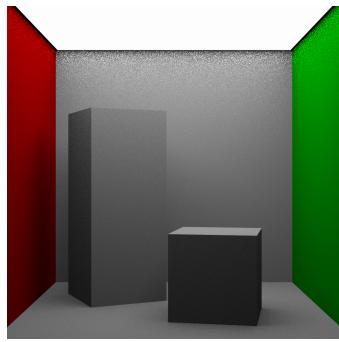


Figure 38: Rendering of Big Area Light, at 100 SPP

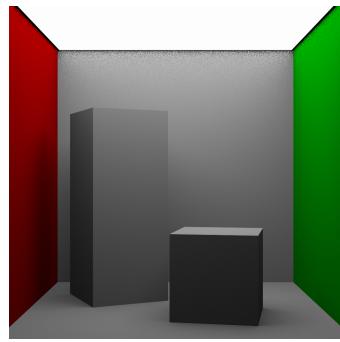


Figure 39: Rendering of Big Area Light, at 1000 SPP

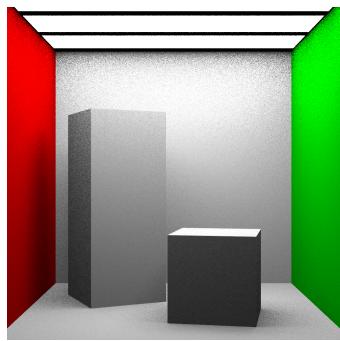


Figure 40: Rendering of Many Area Lights, at 10 SPP

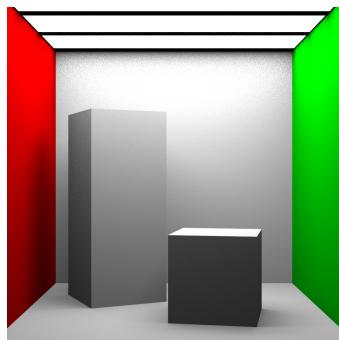


Figure 41: Rendering of Many Area Lights, at 100 SPP

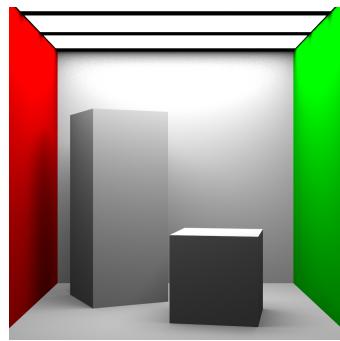


Figure 42: Rendering of Many Area Lights, at 1000 SPP

4 Follow-Up Questions

4.1 Why can't we render point and directional lights with uniform hemisphere sampling or cosine weighted sampling?

Suppose for the sake of contradiction, we could use uniform hemisphere or cosine weighted sampling, for shading with point and directional lights. This would require us to sample a direction ω_i , such that $V(\mathbf{x}, \omega_i) = 1$. We know that for point and directional lights, there can exist only a unique value of ω_i , that satisfies this constraint for any given \mathbf{x} , in particular $p' - \mathbf{x}$, and $-\omega'$ respectively (as per the notation used in slides). The probability of sampling this unique direction from a continuous distribution is zero. Thus, our rendering may never converge to the ground truth, with any arbitrary number of samples.

4.2 Why does the noise increase for the same number of samples in the case of uniform hemisphere and cosine weighted sampling as the size of the area light decreases?

The sampling distribution in both the cases depends only on the normal at the intersection point, which defines the upper hemisphere at the intersection. Evidently, it is independent of the size of the concerned area lights. As the size of the area light decreases, the probability of these independently sampled directions ω_i intersecting the area light, i.e. $V(\mathbf{x}, \omega_i) = 1$, decreases. Thus, we require more number of samples to locate the area light for proper shading, and converge to the ground truth. Failure to do so leaves us with the perception of noise in the rendering.