Computer Graphics Report

Assignment-3

Aneesh Sambu

23/04/2024

Contents

Answers

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

Point Lights Point lights emit light uniformly in all directions from a single point in space. When using uniform hemisphere sampling, each direction on the hemisphere surrounding the point light is sampled with equal probability. However, this approach fails to accurately represent the true distribution of light emitted by the point light.

The issue arises because light intensity decreases with distance from the light source. Uniform hemisphere sampling assigns equal importance to all directions, regardless of their distance from the light source. Consequently, distant directions receive the same weight as nearby directions, leading to inaccurate rendering results.

As a consequence, if uniform sampling is used, distant directions contribute disproportionately more to the final render, while nearby directions are underestimated. This results in an incorrect portrayal of the illumination in the scene.

Directional Lights Directional lights emit parallel light rays from an infinite distance away. Unlike point lights, they have uniform intensity across all directions. Cosine-weighted sampling, which assigns probabilities based on the angle between the light direction and the surface normal, is not suitable for rendering directional lights.

The issue with cosine-weighted sampling arises because it incorrectly assumes that the intensity of light is dependent on the angle of incidence. However, directional lights emit parallel rays, so the angle between the light direction and the surface normal is constant across the entire scene. Consequently, cosine-weighted sampling introduces inaccuracies by assigning varying probabilities to directions where the light intensity is, in fact, uniform.

Summary In conclusion, the distribution of light for point and directed lights is not accurately represented by either cosine-weighted sampling or uniform hemisphere sampling. Specialised sampling methods, like importance sampling, that are adapted to the properties of these light sources can be used to produce rendering results that are accurate.

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?

Factors The noise increases for the same number of samples in the case of uniform hemisphere and cosine weighted sampling due to factors like:

- As the area light becomes smaller, the number of samples that can be taken from it decreases. This results in fewer samples to represent the light source's illumination, leading to increased noise in the rendered image.
- With a smaller area light, there's a higher likelihood that some parts of the scene receive insufficient illumination or no direct light at all. This leads to regions in the rendered image appearing darker or with more pronounced shadows, contributing to increased noise.
- Uniform hemisphere and cosine weighted sampling may not efficiently capture the distribution of light emitted by a small area light source. Due to the limited number of samples and the spatial variation of light intensity across the light source, these sampling methods may not adequately represent the true illumination pattern, resulting in increased noise.
- In smaller area lights, the variance of radiance estimation tends to be higher compared to larger area lights. This is due to the increased sensitivity of radiance estimators to variations in light intensity across the light source. As a result, the noise in the rendered image is amplified.

Summary In summary, the difficulties in precisely sampling the lighting distribution of the area light increase with its decreasing size. When employing uniform hemisphere and cosine weighted sampling techniques, this results in an increase in noise in the generated image since the small sample size and ineffective sampling methods are unable to adequately capture the subtleties of the smaller light source.

Render Timings

Q2

Image	Render Time (ms)
directional_light_1.png	915.12
directional_light_32.png	27746.20

Q3.1

Image	Render Time (ms)
scene_1_1.png	1216.41
scene_2_1.png	1232.47
scene_3_1.png	1213.18
scene_4_1.png	2203.39

Q 4.1

Image	Render Time (ms)
small-1.png	1733.80
small-10.png	16757.18
small-100.png	167353.78
small-1000.png	1671757.00
med-1.png	1751.92
med-10.png	16979.82
med-100.png	165569.63
med-1000.png	1675892.75
big-1.png	2552.45
big-10.png	17431.00
big-100.png	172068.05
big-1000.png	1686499.50
many-1.png	4042.68
many-10.png	38521.98
many-100.png	383079.88
many-1000.png	3746174.00

Q 4.2

Image	Render Time (ms)
small-1.png	1897.65
small-10.png	18919.69
small-100.png	178884.98
small-1000.png	1883273.50
med-1.png	2796.51
med-10.png	26288.69
med-100.png	223708.86
med-1000.png	1884523.38
big-1.png	2745.01
big-10.png	18329.49
big-100.png	179717.81
big-1000.png	1884523.38
many-1.png	5702.10
many-10.png	50855.21
many-100.png	430536.78
many-1000.png	3502077.70

Q 4.3

Image	Render Time (ms)
small-1.png	1611.02
small-10.png	15298.83
small-100.png	152110.64
small-1000.png	1523152.88
med-1.png	1970.96

Image	Render Time (ms)
med-10.png	16493.38
med-100.png	156690.20
med-1000.png	1551297.00
big-1.png	1661.26
big-10.png	15778.79
big-100.png	154798.83
big-1000.png	1565612.25
many-1.png	4247.58
many-10.png	34409.70
many-100.png	322174.13
many-1000.png	3242076.50