Variance Minimization light probe sampling

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ABSTRACT We present a technique for sampling the light probe image using variance minimization. The technique modifies median cut algorithm for light probe sampling [Debevec 2005] so that the variance of each region is minimized. The algorithm is fast, efficient, and easy to implement.

Introduction The median cut algorithm for light probe sampling does not behave optimally, when a region contains two main unequal intensity light sources. The median cut algorithm tends to cut through the brighter light source, so the sampled lights are not placed at the right places. To solve this, a variance in a region is taken into account. This was done before with BRDF in a two stage importance sampling technique [Cline et al. 2006]. Therefore, this work attempts to minimize the variance of sub-region so that the lights are grouped as much as possible.

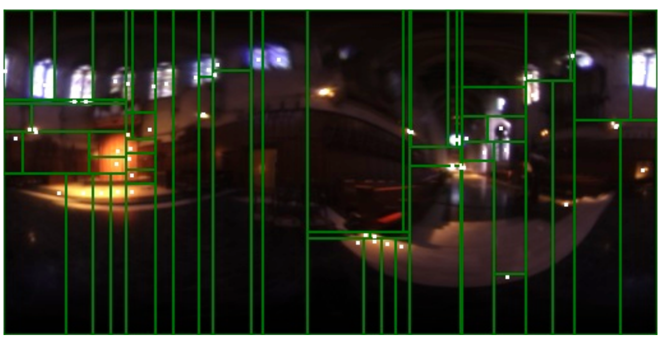


Figure 1: The Grace Cathedral light probe is divided into 64 regions using the variance minimization light probe sampling algorithm.

Algorithm The algorithm divides the entire light probe image into 2^n regions as follows:

1. Add the entire light probe image to the region list as a single region.
2. For each region in the list, subdivide such that the maximum of two sub-region's variances is minimized.
3. If the number of iterations is less than n, return to step 2.
4. Place a light source at the centroid of each region, and set the light source color to the sum of the pixel values within the region.

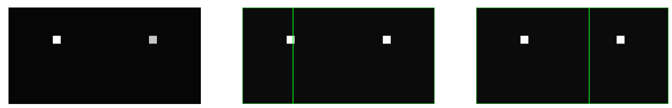
The variance of each region r can be calculated from the following equation:

$$Variance = \sqrt{\sum_{p \in r} L_p d_p^{\,2}}$$

L_p is the light energy weighting factor of p
d_p is the distance from p to the centriod of r

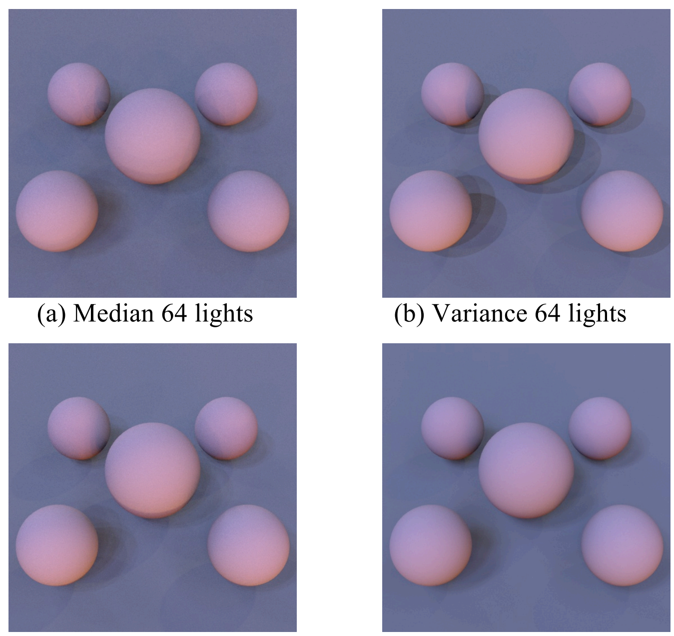
Implementation The calculation of variance of each region can be accelerated by using 5 summed area tables.

Results Fig. 1 shows the 64 lights sampled from the Grace Cathedral lighting environment. Fig.2 shows the case that median cut algorithm does not behave optimally but variance minimization does. Fig.3 shows the diffuse scene rendered with different numbers of sampled light from the Grace Cathedral light probe. Using 256 sampled lights produces a close result to the Monte-Carlo solution.



(a) Source (b) Median (c) Variance

Figure 2: (a) the environment with two main different intensity light sources. (b) Cut made by median cut approach (c) Result from variance minimization approach



(a) Median 64 lights (b) Variance 64 lights
(c) Variance 256 lights (d) Monte Carlo rendering

Figure 3: (a) – (c) Renderings of Grace Cathedral lighting environment using different approaches and numbers of lights. (d) A Monte-Carlo solution considered as a ground truth image

Reference

DEBEVEC, P. 2005. A Median Cut Algorithm for Light Probe Sampling *(SIGGRAPH Poster 2005)*

CLINE, D., EGBERT, P. K., TALBOT, J. F., AND CARDON, D. L. 2006. Two Stage Importance Sampling for Direct Lighting *(EGSR 2006)*