HAL
open science

Higher Order Radiosity : Using Higher Order Methods in Computer Graphics

Venceslas Biri

To cite this version:

Venceslas Biri. Higher Order Radiosity : Using Higher Order Methods in Computer Graphics. 6th International Conference on Spectral and High Order Methods (ICOSAHOM'04), Jun 2004, Brown University, France. pp.145-155. hal-00622217

HAL Id: hal-00622217

https://hal.science/hal-00622217

Submitted on 22 Mar 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Higher Order Radiosity : Using Higher Order Methods in Computer Graphics

Biri Venceslas
Gaspard Monge Institute – University of Marne-La-Vallée
6 cours du Danube – F-77700 Serris, France
biri@univ-mlv.fr

Abstract

The light ambiance of a virtual scene is the key of realistic computer generated images. But the computation of the whole light exchanges between elements of a complex scene constitutes a real challenge in computer graphics. Usually, in real-time video games for example, the modelisation of these exchanges remains quite simple. And achieve a realistic representation of lighting requires to solve the global illumination problem which means to compute all light exchanges.

The term " radiosity " gather algorithms that are able to solve the global illumination problem in the case where all light exchanges are diffuse [5]. Radiosity associates each surface to a function modeling the light energy emited per square meters in every direction. And this function is also called radiosity. Traditionnal methods [3, 10] divide surface into small patches where the radiosity is considered constant. But this approach leads to inefficient algorithms due to the high number of patches. Several algorithms [2, 11, 7, 9] allow quicker computations using progressive or hierarchical methods but they still consider constant radiosity functions.

Higher order functions bases have finally be used to represent the radiosity functions. Such higher order methods [13, 6, 12] lead to powerfull algorithms that are able, not only to compute efficiently the radiosity function [4] of all surfaces, but also give us the possibility to handle dynamic scenes [1]. For N surfaces representing the scene, the radiosity in a point x for a surface i can be written [6] :

$$B_i(x) = E_i(x) + \rho_i(x) \sum_{j=1}^{N} \iint_{S_j} K_{ij}(s,t,u,v) B_j(u,v) du\, dv \tag{1}$$

where E_i and ρ_i are the exitance (self illumination) and the reflectivity of the surface. The kernel function K is the product of a geometric term, the form factor, the differential area A and a visibility term V :

$$K_{ij}(s,t,u,v) = -\frac{(\vec{n_i}.\vec{r})(\vec{n_j}.\vec{r})}{\pi \vec{r}^4}\, V_{ij}(s,t,u,v)\, A_j(u,v) \tag{2}$$

The kernel function can be analytically computed only for very specific positions between two surfaces and usually needs a numerical computation. Then, if each function is projected over an orthonormal set of base functions $\{\Gamma_k(s,t), k = 1..N'\}$, we can project the equation (1) over the kth function of Γ which leads to the equation :

$$b_i^k = e_i^k + \rho_i \sum_{j,l} b_j^l\, K_{ij}^{kl} \tag{3}$$

where

$$K_{ij}^{kl} = \langle \iint K_{ij} \Gamma_l | \Gamma_k \rangle \tag{4}$$

The b_i^k are the coefficients of the radiosity functions and so are the unknowns we seek. All these equations, for each surface i and function k can be summarize in a system that have to be solved in order to obtain our unknowns. And this is far from being easy since matrix coefficients are difficult to compute (this is a double surface integral).

Fortunately the function base can be choose to minimize the number of “non-zero terms” (that aren’t close to zero so they can be neglected) in the matrix. Piecewise-polynomial (Galerkin) bases or wavelett bases have been used so far leading respectively to progressive or hierarchical algorithms. Moreover, as can be seen in equation (1), the illumination function (the radiosity) is separated from the geometric surface [8] assuming the surface to be parametric.

This talk will present how higher order functions bases are used in computer graphics and especially in radiosity, and why they are efficient. We will see also how they are used to handle dynamic moves in virtual scenes, taking profit of temporal coherence.

Figure 1. Two scenes lighted with radiosity using higher order functions bases

Keywords

Higher Order Methods, Dynamic Radiosity, Temporal Coherence

References

[1] V. Biri, S. Michelin, and D. Arquès. Dynamic Radiosity using Higher Order Functions Bases and Temporal Coherence. In *Journal of WSCG’03*, volume 11(1), pages 65–72, February 2003.

[2] M. Cohen, S. Chen, J. Wallace, and D. Greenberg. A Progressive Refinement Approach for Fast Radiosity Image Generation. In *Siggraph’88, Computer Graphics*, volume 22(4), pages 74–84, 1988.

[3] M. F. Cohen and D. P. Greenberg. The Hemi-Cube : A Radiosity Solution for Complex Environments. In *Siggraph’85, Computer Graphics*, volume 19(3), pages 31–40, 1985.

[4] François Cuny, Laurent Alonso, and Nicolas Holzschuch. A novel approach makes higher order wavelets really efficient for radiosity. *Computer Graphics Forum*, 19(3):C99–C108, Sep 2000. (Eurographics 2000 proceedings).

[5] C. Goral, K. Torrance, D. Greenberg, and B. Battaile. Modeling the interaction of light between diffuse surfaces. In *Siggraph’84, Computer Graphics*, volume 18(3), pages 213–222, 1984.

[6] S. J. Gortler, P. Schroder, M. F. Cohen, and P. Hanrahan. Wavelet Radiosity. In *Siggraph’93, Computer Graphics Proceedings, Annual Conference Series*, volume 27(4), pages 221–230, August 1993.

[7] P. Hanrahan, D. Salzman, and L. Aupperle. A Rapid Hierarchical Radiosity Algorithm. In *Computer Graphics (ACM SIGGRAPH ’91 Proceedings)*, volume 25(4), pages 197–206, July 1991.

[8] Nicolas Holzschuch, François Cuny, and Laurent Alonso. Wavelet radiosity on arbitrary planar surfaces. In Bernard Péroche and Holly Rushmeier, editors, *11th Eurographics Workshop on Rendering, Brno, République Tchèque*, Rendering Techniques ’00, pages 161–172, Wien, Jun 2000. Springer-Verlag.

[9] D. Lischinski, F. Tampieri, and D. P. Greenberg. Combining Hierarchical Radiosity and Discontinuity Meshing. In *Siggraph’93, Computer Graphics Proceeding*, pages 199–208, August 1993.

[10] T. Nishita and E. Nakamae. Continuous Tone Representation of Tree-Dimentional Object Taking Account of Shadows and Interreflection. In *Siggraph'85, Computer Graphics*, volume 19(3), pages 23–30, July 1985.

[11] J.R. Wallace, K.A. Elmquist, and E.A. Haines. A Ray Tracing Algorithm for Progressive Radiosity. In *Siggraph'89, Computer Graphics*, volume 23(3), pages 315–324, 1989.

[12] Y. Yizhou and P. Qunsheng. Multiresolution B-Spline Radiosity. In *Eurographics'95*, volume 14(3), pages 285–298, 1995.

[13] H. R. Zatz. Galerkin Radiosity: A Higher Order Solution Method for Global Illumination. In *Siggraph'93, Computer Graphics Proceedings, Annual Conference Series*, pages 213–220, 1993.