Higher Order Radiosity: Using Higher Order Methods in Computer Graphics

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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 k^{th} 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

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