Abstract

We describe how the radiosity method can be used to compute the global illumination of a static scene with dynamic lights. A transfer function that maps the direct illumination to the global illumination is precalculated. Real-time performance is reached for simple scenes.

Keywords: global illumination, radiosity, real-time, precomputed radiance transfer

1 Introduction

The radiosity method can be used to compute the global illumination, direct and indirect lighting, of a scene that consists of ideal diffuse surfaces. The surfaces are first divided into patches. The radiosity equation system describes the relation between the global illumination of all patches \( B = (B_1, \ldots, B_n)^T \) and the emission of all patches \( E = (E_1, \ldots, E_n)^T \) [Hanrahan et al. 1991]:

\[ MB = E \]

The matrix \( M \) depends on the geometric relation between the patches (form factors) and the patches’ colors (diffuse reflectance). For our purposes we may consider \( E \) to be the direct illumination of the patches. The direct illumination of each patch can be computed in real-time using standard methods like shadow mapping [Akenine-Moller and Haines 2002]. The inverse of \( M \) describes the linear mapping from direct illumination to global illumination:

\[ B = M^{-1} E \]

It holds coefficients that tell how much light that travels from one patch to another after an infinite number of bounces in the scene. The matrix \( M \) is very expensive to compute but if the geometry and textures of the scene are static, \( M \) remains static as well. \( M^{-1} \) may thus be precomputed and used as a transfer function that maps arbitrary direct illumination to global illumination. The process of computing the global illumination can thus be performed with a large matrix-vector multiplication. That is, for each patch that we want to illuminate globally, we sum over all other patches and accumulate their contribution. Illuminating all patches thus results in a time complexity of \( O(n^2) \), where \( n \) is the number of patches.

2 Compressing the Matrix

For larger scenes a time complexity of \( O(n^2) \) is not manageable. [Hanrahan et al. 1991] reduces the number of interactions, described by \( M \), by clustering of small interactions. This method can be modified and used for \( M^{-1} \) as well. It however only clusters neighbouring patches lying in the same plane. For scenes consisting of large planar surfaces the time complexity is reduced to \( O(n) \).

[Willmott et al. 1999] describe a method that extends clustering to patches that are just approximately planar. They use it for the radiosity equation system described by \( M \). Extending it to \( M^{-1} \) is not as straightforward as the planar clusters first mentioned. This and other techniques are discussed by [Lehtinen et al. 2008]. It should also be noted that it is just necessary to update the interactions between patches visible on screen and those illuminated directly.

3 Conclusion

It is today possible to do real-time global illumination of simple static scenes with dynamic lights. There exist promising ideas and if they are all incorporated in an implementation, preferably accelerated by graphics hardware, real-time performance will probably also be possible for more complex scenes.

References


