Non-Diffuse Effects for Point-Based Global Illumination

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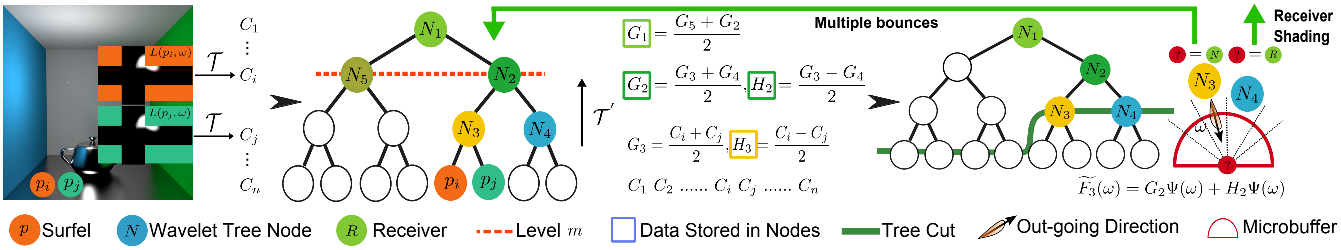

Figure 1: ***Overview.*** *At caching time, starting from a dense sampling of the scene, the outgoing radiance distribution at each point p_i is sampled in a cube map and wavelet-transformed ($\mathcal{T}$) to Haar coefficients C_i. The resulting enriched point cloud is further structured in a spatial hierarchy, with the radiance distribution of the internal nodes being propagated bottom-up using a wavelet analysis ($\mathcal{T}'$) on their children coefficients vectors. The tree can then be used either to compute multiple light bounces, by splatting it onto itself with its own nodes as receivers, or at rendering time, to shade any receiver (e.g., unprojected image pixel). In both cases, importance driven cuts are gathered from the tree for each receiver using an adaptive microbuffer.*

Context: Point-Based Global Illumination (PBGI) [2008] is a popular rendering method in special effects and motion picture productions. This algorithm provides a diffuse global illumination solution by caching radiance in a mesh-less hierarchical data structure during a pre-process, while solving for visibility over this cache, at rendering time and for each receiver, using microbuffers, which are localized depth and color buffer inspired from real time rendering environments. As a result, noise free ambient occlusion, indirect soft shadows and color bleeding effects are computed efficiently for high resolution image output and in a temporally coherent fashion. We propose an evolution of this method to address the case of non-diffuse inter-reflections and refractions using wavelets instead of spherical harmonics (see Fig. 1). We also propose a new importance-driven adaptive microbuffer model to capture accurately incoming radiance at a point. Furthermore, we evaluate outgoing radiance using a fast wavelet radiance product, containing the memory footprint by encoding hierarchically the wavelets tree.

Method: Starting from a dense point-sampling of the scene, our algorithm evaluates outgoing radiance at each point by shading the point from the scene light environment and measuring the BSDF response over the sphere, baking it for a discrete set of directions in a cube map. Then the cube map is wavelet-transformed, using the Haar basis for each of the 6 images of the cube map. This process is performed for all 3D points (or *surfels*) in the scene. At the end of the process, each surfel contains a vector of wavelet coefficients which model the outgoing radiance and which are stored in a tree structure. Then, a bounding sphere hierarchy (BSH) is built bottom-up from the surfels and internal nodes are equipped with representative attributes of their subtree (average position, size and normal cone). However, on the contrary to PBGI, we do not use spherical harmonics but compute a set of Haar coefficients to model the average outgoing radiance at a node. We further compress the hierarchy by performing a wavelet-like coding of the nodes, using the 1D parametrization of the BSH to decompose each node's radiance vector into a set of average and details coefficients. While we keep both sets for upper nodes, we only store the detail coefficients for the deeper ones. This process is performed in a post-order depth-first traversal [Buchholz and Boubekeur 2012]. As a result, our hierarchical radiance cache models indirect lighting in the scene (first bounce). In order to exploit the non-diffuse radiance response stored in this hierarchy, we substitute to the original PBGI microbuffer an adaptive, importance-driven one (AMB), which takes the form of a cube map with quad-trees as faces. The refinement of the quad-tree is tailored by an importance function which accounts for the incoming light and the BSDF. This cut is rasterized onto the AMB to estimate incoming radiance, while the AMB solves for visibility. The tree can be splatted onto itself to emulate multiple light bounces, performing radiance transfer directly in the wavelet domain, or projected onto AMBs located at the unprojected pixel positions of the final image. As a result, our algorithm, described in details in our full paper [Wang et al. 2015], can handle non-lambertian BSDFs in the light transport simulation, reproducing caustics and multiple reflections/refractions bounces with a similar quality to bidirectional path tracing in a large number of cases and for a fraction of its computation time (see Fig 2).

References

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(a) PBGI *(b) WPBGI* *(c) BPT*

Figure 2: *Compared to regular PBGI, our approach models accurately non-diffuse indirect lighting effects and appears as an efficient substitute to bidirectional path tracing, trading a moderate image degradation for up to a 10x speed-up in our experiments.*

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