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Efficient Point based Global Illumination on Intel MIC Architecture

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Abstract

Point-Based Global Illumination (PBGI) is a popular rendering method in special effects and motion picture productions. The tree-cut computation is in general the most time consuming part of this algorithm, but it can be formulated for efficient parallel execution, in particular regarding wide-SIMD hardware. In this context, we propose several vectorization schemes, namely single, packet and hybrid, to maximize the utilization of modern CPU architectures. While for the single scheme, 16 nodes from the hierarchy are processed for a single receiver in parallel, the packet scheme handles one node for 16 receivers. These two schemes work well for scenes having smooth geometry and diffuse material. When the scene contains high frequency bumps maps and glossy reflections, we use a hybrid vectorization method. We conduct experiments on an Intel Many Integrated Core architecture and report preliminary results on several scenes, showing that up to a 3x speedup can be achieved when compared with non-vectorized execution.

1. Context

PBGI [Chr08] has been introduced to compute diffuse global illumination effects efficiently. At the heart of the algorithm, the scene is represented by a shaded-hierarchical point structure that acts as a multi-resolution radiance cache. A cut is gathered from this tree using a top-down traversal to shade every single receiver (e.g., pixel) using a splatting procedure which solves for visibility using a local variant of the Z-Buffer algorithm. In practice, the traversing process represents a large portion of the rendering time. In this paper we focus on the mapping of the PBGI tree traversal onto a wide-SIMD architecture, which has been previously used successfully to accelerate global illumination. In particular we address the case of the 16-wide SIMD Intel MIC architecture [Int10](MIC).

CPU Parallelism. A number of approaches have been proposed to exploit CPU vectorization for ray tracing, including packet-based ray tracing [BEL*07], the combination of single and packet-ray [BWW*12] and a low level kernel to maximize CPU usage [WWB*14].

2. Related Work

PBGI. PBGI was first proposed by Christensen [Chr08] to evaluate diffuse light transport. Ritschel et al. [REG*09] and Holländer et al. [HREB11] both have provided efficient GPU implementations. A number of subsequent approaches have been proposed to improve PBGI, including tree-cut/microbuffers factorization based on spatial coherence [WHB*13], and a wavelet-based model to simulate non-diffuse light transport [WMB15]

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Hybrid Vectorization The high SIMD utilization of the packet scheme relies on the coherency of the tree-cuts for nearby receivers. When it comes to high frequency variations in the cut, such as with bump maps or glossy reflections, this SIMD performance diminishes drastically. To handle this problem, we propose a hybrid vectorization scheme, combining the single scheme and the packet scheme. Starting from the packet scheme, we trace the count of the active receivers, and when this number is less than a given threshold, we save the traversal state and switch to the single scheme for the last stages of the traversal. The initial traversal queue for a receiver is obtained from the traversal queue and the mask queue of the packet stage. Each receiver traverses one by one independently. While still at its earliest development stage, this technique is expected to bring more speedup than the packet one for such complex scenes.

4. Results

We implemented our algorithm in the Mitsuba Renderer [Jak10]. We compare (i) thread parallel execution (Thread), (ii) single vectorization (Single), (iii) packet vectorization (Packet) and (iv) path tracing solution (PTS), which we consider as ground truth for quality comparison, (shown in Fig.1). Performances (see Tab. 1) are measured on 1.1 GHz Intel Xeon Phi Coprocessor 7110P (61 core) with 8GB memory. The others in Tab. 1 includes the time for splatting and convolving.

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