Real Time Multi-Scale Sand Rendering

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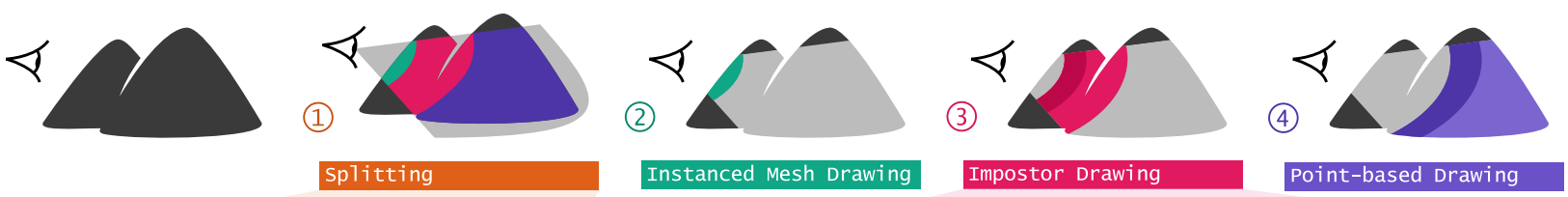
Abstract

Rendering dense dynamic stackings, frequent in natural phenomena, induces high frequencies which are hard to reproduce under real time constraints. Sand is an extreme such example with challenging appearance level-of-details at any given scale. In this paper, we study the problem of real time sand rendering, from the scale of individual grains to the one of wide sand tracts. As mesh-based level-of-details approaches fail on such fine complex geometric elements, we propose a model based on rich spherical impostors able to combine precomputed as well as dynamic procedural data, and offering seamless transitions from close instanced meshes to distant surfels. We show that our method extends beyond sand with several distributions of non-trivial dynamic geometric elements rendered in real-time on a standard graphics processor.

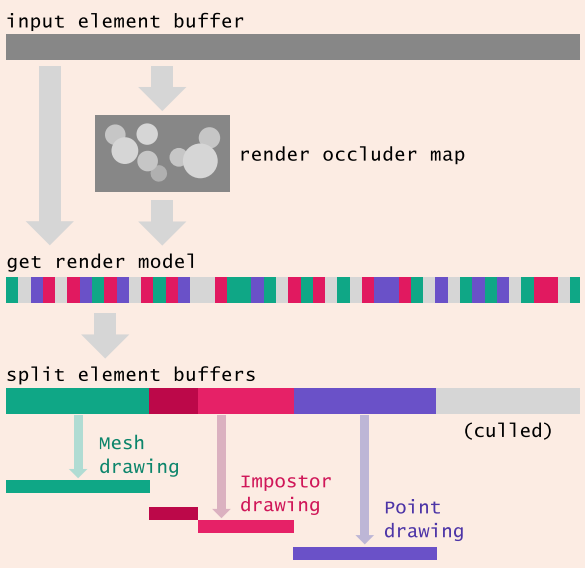
Overview



« *Anatomy of a multi-scale sand rendering sequence. We focus on splitting and transitional impostor-based model.*

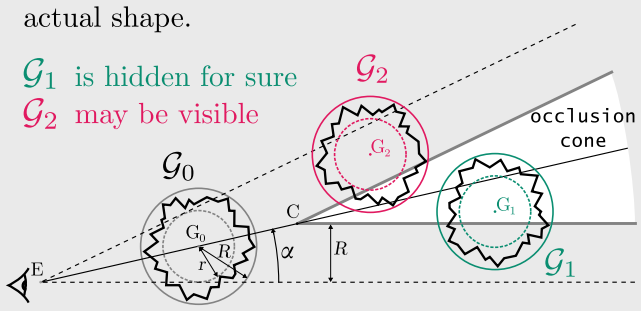
Splitting
to build per-scale element buffers

The element buffer **dynamically reordered** to group grains for subsequent draw calls. This step also performs occlusion culling.



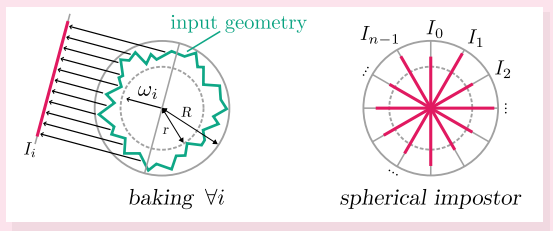
Occlusion Culling
to discard invisible grains

Inner radius r and outer radius R are used to cull some grains prior to querying their actual shape.



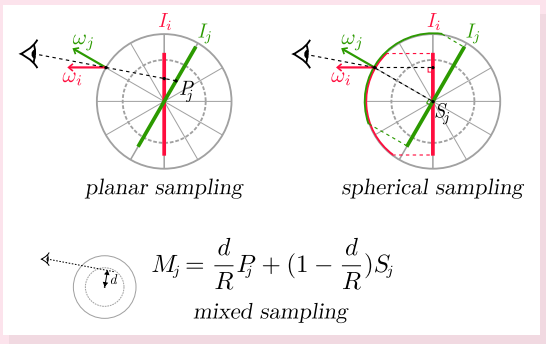
Impostors
to draw mid-scale grains

Precomputing (usually <1s)



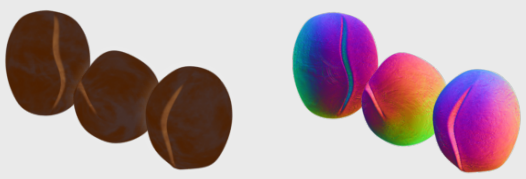
Rendering G-buffer maps (albedo, normal, etc.) from many directions.

Runtime



(a) Find closest directions i, j, k, l
(b) Sample one texel from each plane
(c) Blend responses

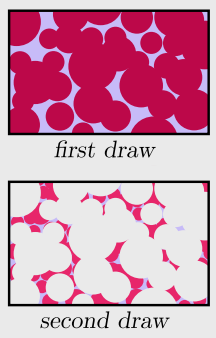
Atlas of G-Buffers



In memory, the impostor is an atlas of per-view g-buffers.

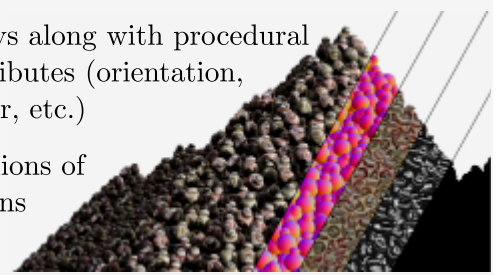
Double Draw
to foster early-Z rejection

During the second draw call any fragment in a pixel filled during the first draw is **automatically early-Z rejected**.



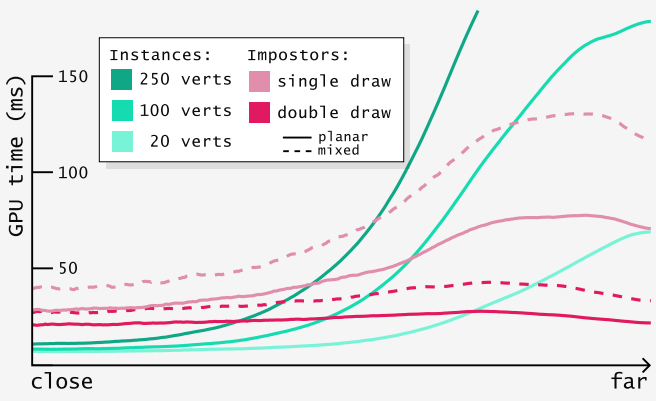
Properties

- Apply to many other granular materials
- Fit in **deferred-shading** pipelines
- Plays along with procedural attributes (orientation, color, etc.)
- Millions of grains

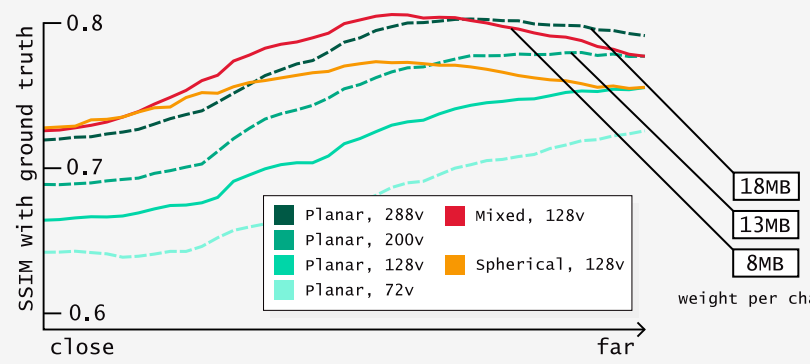


Performances
impostors vs. instanced meshes

Mesh-based rendering is **vertex bounded** and depends of the grain's complexity, so it gets outperformed by instance rendering when the number of visible grains is large.



Visual Loss
comparing impostor sampling strategies



Our mixed sampling provide a comparable visual accuracy at lower memory requirement.

References

[0] Michel, Élie and Boubekeur, Tamy. *Real Time Multiscale Rendering of Dense Dynamic Stackings*. (full paper to appear).

[1] Todt, Severin, Rezk-Salama, Christof, Kolb, Andreas and Kuhnert, KD. *Fast (spherical) light field rendering with per-pixel depth*. Tech rep. Univ. of Siegen, Germany, 2007.

[2] Bruneton, Éric and Neyret, Fabrice. *Real-time Realistic Rendering and Lighting of Forests*. Computer Graphics Forum 31.2pt1 (2012), 373-382.