

GPU-Accelerated High-Quality Hidden Surface Removal

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Requirements

Comparable quality to CPU-only renderers:

- Depth of field and motion blur
- Transparency
- Filters with wide support
- Robustness for real production scenes
- Occlusion culling to avoid excess shading
- Spectral opacity and arbitrary outputs
- Complete feature set (shadows, GI, RT...)

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Requirements

Using hardware to accelerate computations:

- Commodity hardware
- Hide *all* hardware limitations
- No loss in precision (fp32 everywhere)

→ *Not the best mode for most GPUs!*

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Hider Architectural Overview

- REYES-style geometry processing
- Supersampling for anti-aliasing
- Accumulation buffer for MB & DOF
- Enhanced depth peeling for transparency
- Two-pass downsampling for filtering
- Occlusion query for culling

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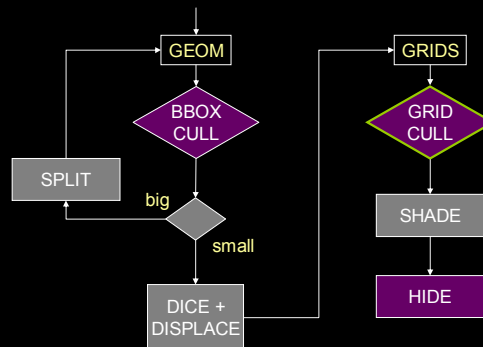
Prior Work

- Accumulation Buffer [Haeberli, Akeley '90]
- Depth Peeling [Mammen '89, Everitt '01]
- REYES [Cook, Carpenter, Catmull '87], [Apodaca, Gritz '99]
- Two-Pass Filtered Downsampling [Wexler, Enderton '05]

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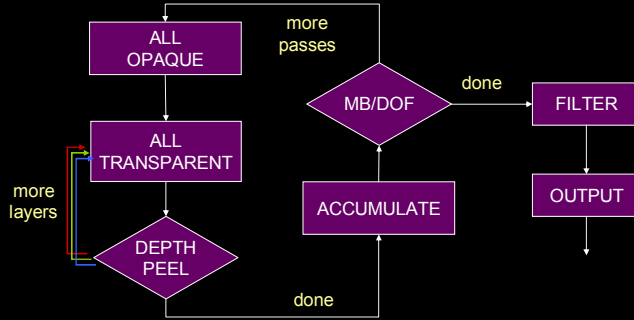
REYES Algorithm



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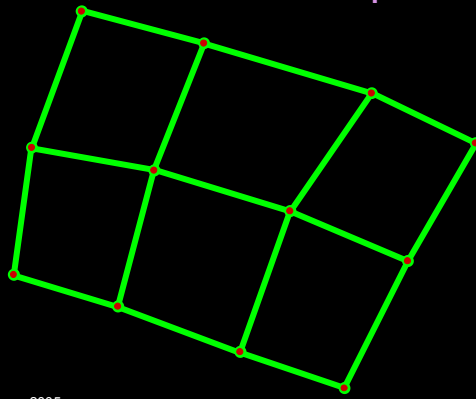
GPU Hiding Algorithm



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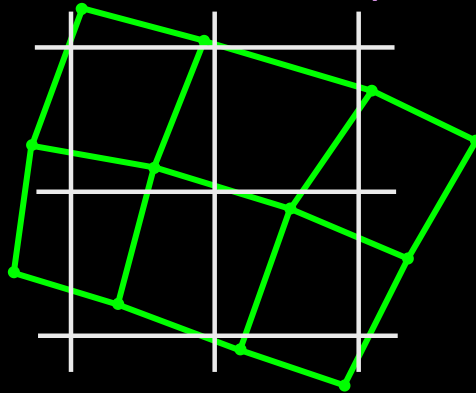
Grids, Pixels & Samples



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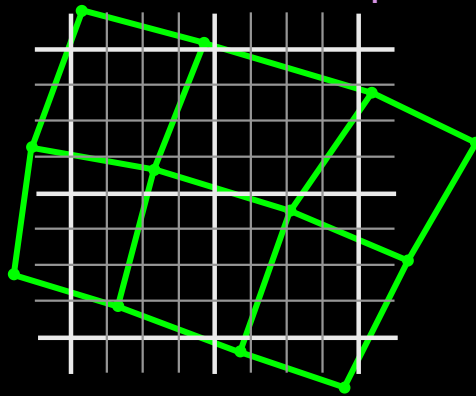
Grids, Pixels & Samples



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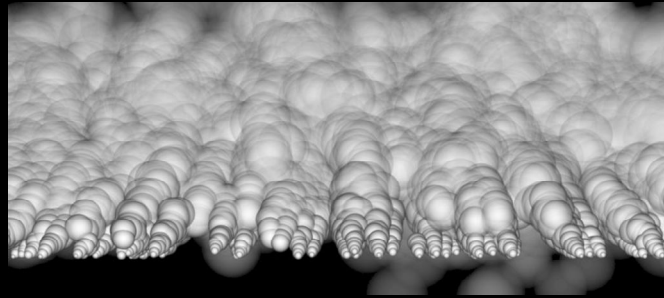
Grids, Pixels & Samples



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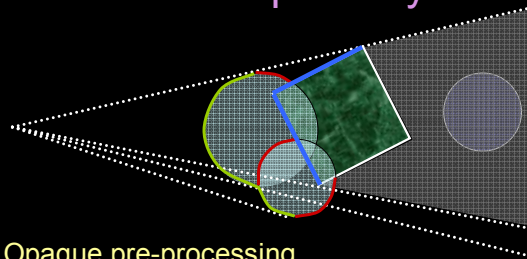
Transparency



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Transparency

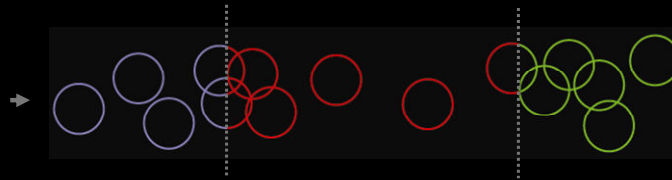


- Opaque pre-processing
 - One additional texture-z test
 - Reduces number of depth peeling passes
 - Occlusion culling remove hidden surfaces

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Z-Batches

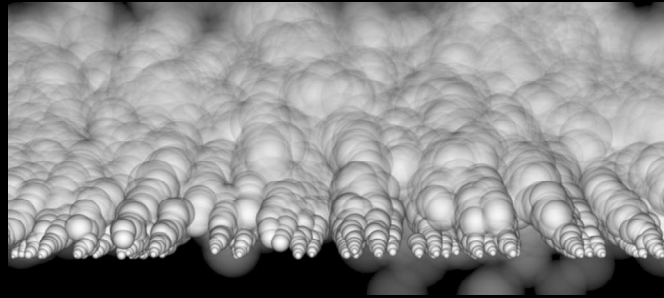


- For N grids processed in batches of B grids:
 $O((N/B)B^2) = O(BN) = O(N)$
- Problem: grids overlap into multiple batches
- Opacity thresholding between batches

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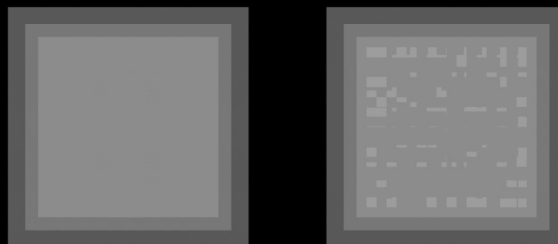
Transparency



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Transparency Artifacts



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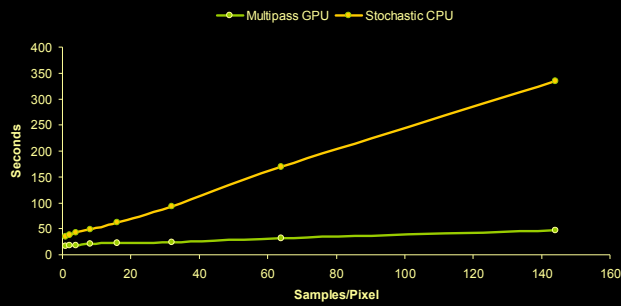
Performance



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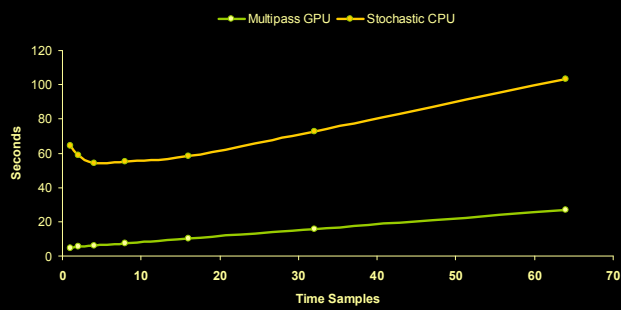
Spatial Samples



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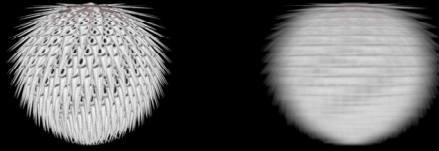
Temporal Samples



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Poor Performance Cases



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Extensions

- Two-pass depth peel for average-z
- Volumetric shadow map generation
- Multiple camera (stereo) rendering
- Workqueue-based latency hiding
- Adaptive motion and DOF sampling

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Challenges

- Hiding Latency
 - Occlusion Query
 - Orthogonal computations
- Hybrid Algorithms
 - Batch size vs. excessive computation
 - Starving and Readback
- Programming Environment
 - Debugging and profiling
 - Support and stability

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Thank You



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