Raytracing Prefiltered Occlusion for Aggregate Geometry

Chasing Performance

- Faster hardware
- Faster single-ray intersection
- Fewer samples
  - Importance sampling
  - Prefiltering
Soft Shadows (2M tris)

- Standard, 4 rays: 112 seconds
- Prefiltered, 9 rays: 74 seconds
- Standard, 25 rays: 704 seconds
Bounding Volume Hierarchy

- $O(\log N)$ ray intersection
- $O(N)$ update
Early Ray Termination
Early Termination (opaque boxes)

Triangles

Opaque boxes
Bottom-up Prefiltering
Bottom-Up Prefiltering
Correlation Height

\[
\begin{array}{ccc}
\text{OVER} & \text{OVER} & = \text{OVER} \\
0.5 & 0.5 & 1.0
\end{array}
\]
Correlation Height

\[
\begin{array}{ccc}
\text{OVER} & \rightarrow & \text{0.5} \\
\text{0.5} & == & \text{0.5}
\end{array}
\]
Correlation Height

\[
\begin{array}{c}
\text{OVER} \\
0.5 \\
\end{array}
\quad = \quad
\begin{array}{c}
0.5 \\
0.75 \\
\end{array}
\]
Early Termination (opaque boxes)

Triangles

Opaque boxes
Early Termination (prefiltered boxes)

Triangles  

Prefiltered boxes
Prefiltered (converged), 81 rays
Regular, 81 rays, 3x slower
Regular, 169 rays, 6x slower
Variance Measurement

![Image of variance measurement with plots showing different types of BVH boxes and their variances compared to triangles.](image-url)
Cost of Transparency
Soft Shadows (5M tris)

- Standard, 9 rays: 64 seconds
- Prefiltered, 9 rays: 87 seconds
- Standard, 49 rays: 339 seconds
Ambient Occl. (3.8M triangles)

- Standard, 9 rays: 106 seconds
- Prefiltered, 9 rays: 66 seconds
- Standard, 36 rays: 420 seconds
When to Update?

- Whenever BVH is updated
- Independent of lights
- No update for instances
Memory Usage per Node
Total Mem. Usage (GB)
3x3 Cubemap per Node

<table>
<thead>
<tr>
<th></th>
<th>Original</th>
<th>Prefiltered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bush (2M)</td>
<td>0.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Tentacles (3.8M)</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Bamboo (5M)</td>
<td>2.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Reference
3x3 Cubemap
DC (average of 3x3 cubemap)
DC (ortho average)
Ad-hoc
12x12 Cubemap
DC (average of 12x12 cubemap)
Conclusion

- Simple to implement
- Two runtime speedups:
  - Stop descending early
  - Less noise ==> Fewer rays
- $O(N)$ update
- DC average often suffices
Short-Term Future Work

- Faster prefiltering
- Quantization
- Out of core scenes
- Indirect diffuse
Longer-Term Future Work

Automatically classify geometry:

- Nice mesh [Razor]
- Aggregate and random [current paper]
  - Determine “correlation height”
- Aggregate but not random [R-LOD?]
  - Buildings, vehicles, etc.