A Shadow Culling Algorithm for Interactive Ray Tracing

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Abstract
We present a novel shadow culling algorithm in ray tracing. For interactive ray tracing, our approach exploits frame-to-frame coherence instead of preprocessing of building shadow data. In this algorithm, shadow results are stored to each primitive and used in the next frames. We also present a novel occlusion testing method to guarantee exact shadows. In experiments with BART scenes, our algorithm shows 7-19 percent reduction in cost of traversal and 9-24 percent reduction in cost of intersection test.

KEYWORDS: Ray tracing, real-time rendering, shadow algorithm

Overall Flow of the Shadow Culling Algorithm

- Why this occlusion testing is needed?
  - Updating shadow results is valid if and only if the primitive is not occluded on the viewpoint.
- Algorithm details
  1. Compare primitives between the current pixel and two reference pixels.
  2. If the primitives are different, an intersection test is executed between the current primary ray and the primitive on the reference pixel.
  3. If the hit result is true, the primitive on the reference pixel is partially occluded by the primitive on the current pixel.
- Example
  - The current pixel: 5
  - Reference pixels: 2 and 4
  - Result: The faint blue triangle is partially occluded

Required Addition Information
- An occlusion mode (2 bit)
- A shadow mode (2 bit * light sources)

Benchmark Results

<table>
<thead>
<tr>
<th>Scene</th>
<th>Cost reduction ratio of shadow ray traversal</th>
<th>Cost reduction ratio of shadow ray/primitive intersection test</th>
<th>Additional intersection tests for occlusion testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>19.8</td>
<td>59.5</td>
<td>24.5</td>
</tr>
<tr>
<td>Robot</td>
<td>7.4</td>
<td>19.5</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Future Works
- Apply shadow caching – reduce the calculation of partially occluded primitives
- Apply triangle subdivision – reduce the ratio of primitives which have partial shadows
- Support soft shadows

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