Adaptive Ray-bundle Tracing with Memory Usage Prediction:
Efficient Global Illumination in Large Scenes

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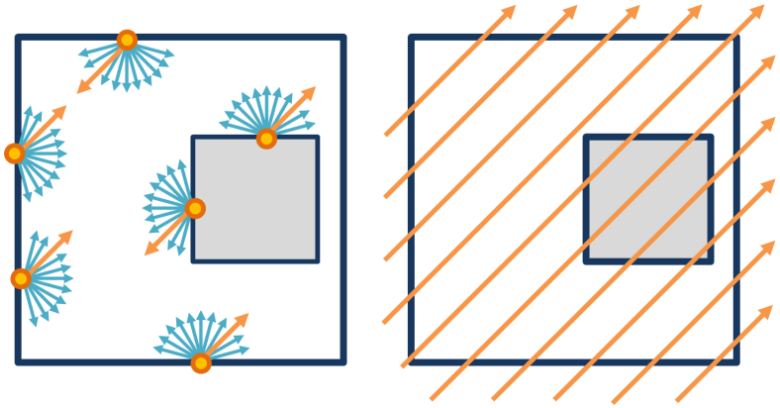
Light Maps for Large Scenes

45.3 M texel light maps
Scene with 4.9 km in diameter (3.7 M triangles)
Computation time: 1396 secs (2000 sample directions)
(GPU: NVIDIA GeForce GTX 580 1.5GB memory)

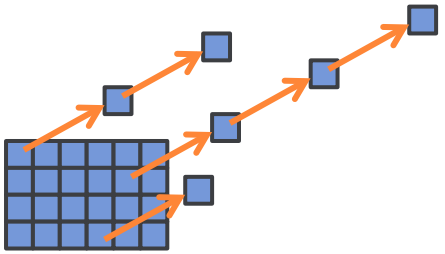
Introduction

1. Introduction
2. Adaptive Tiling for Ray-bundles
3. Experimental Results & Future Work

Ray-bundle Tracing

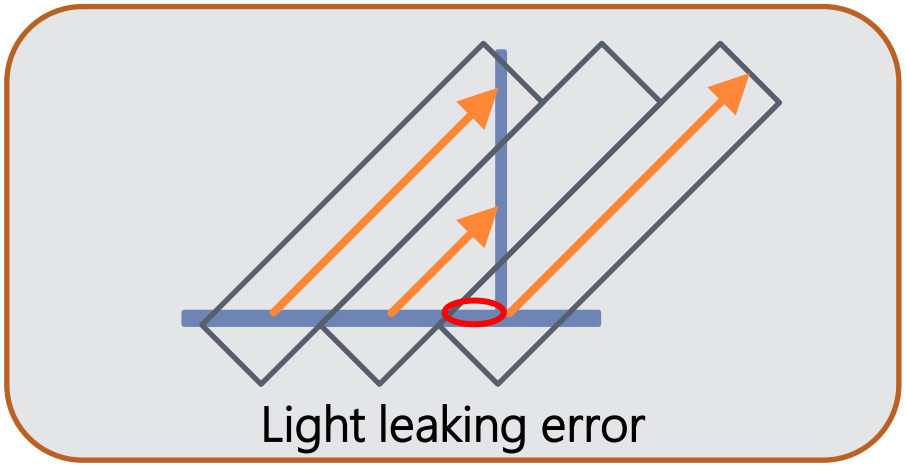


- Set of parallel rays for a sample direction [Sbert96]
- Implemented with GPU rasterization [Szirmay-Kalos98, Hachisuka05]
  - Benefits: HW acceleration, tessellation etc.
- Multi-fragment problem is identical to OIT
  - Per-pixel linked-list [Yang10]



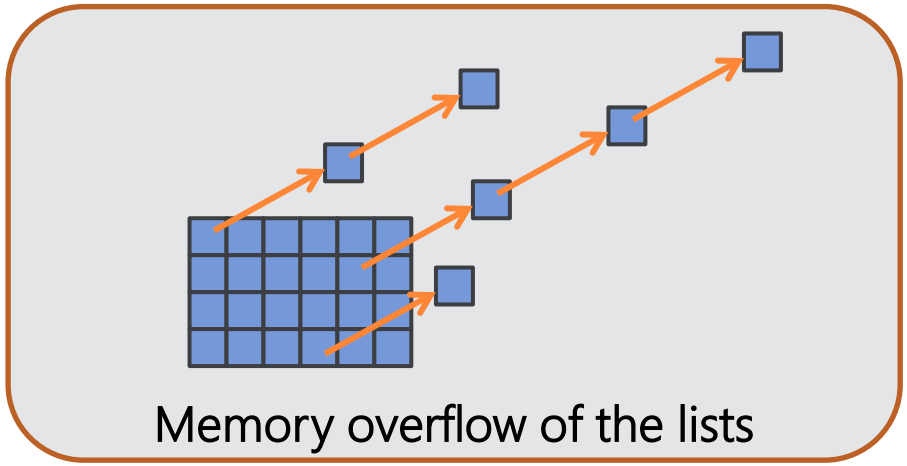
Limited Memory Capacity of GPUs

Ray-bundle tracing is weak in large scenes



Light leaking error

- Uniformly distributed rays
- Inhomogeneous light map density
- High-resolution ray-bundle buffer is required

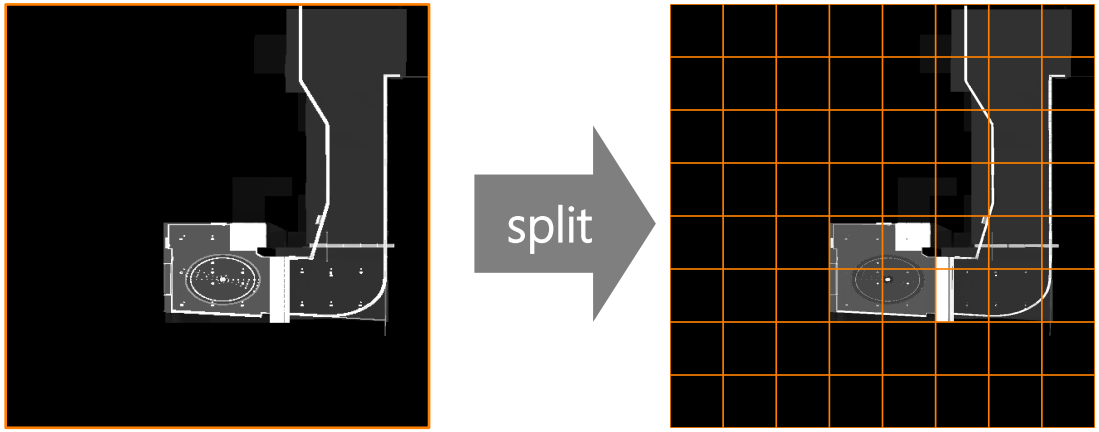


Memory overflow of the lists

- Memory usage is unknown before rendering
- Excessive memory has to be allocated

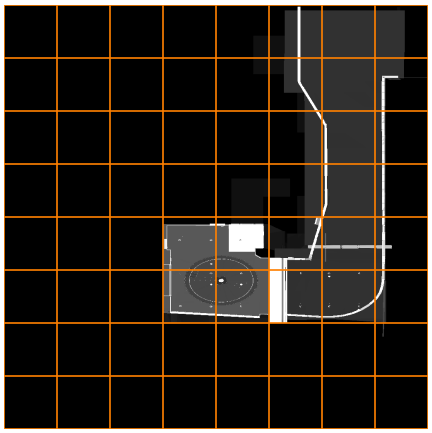
Uniform Tiling [Thibieroz11]

- Proposed for real-time linked-list OIT
  - Split a render target into smaller tiled regions
  - Each tile is rendered separately
- Unsuitable for off-line rendering
  - Overflow is still unpredictable
  - Scene-dependent parameter tuning

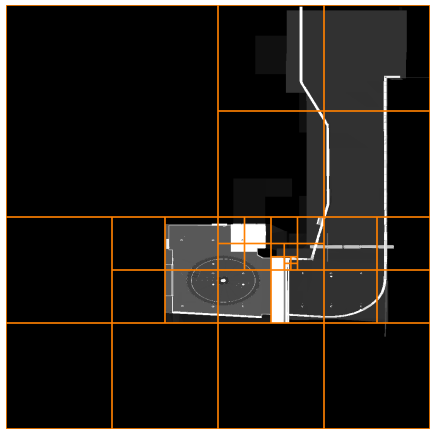


Our Contributions

- Memory usage prediction for linked-list ray-bundles
- Adaptive tile subdivision using the above prediction
  - Reduce the risk of memory overflow & light leaking error
  - Avoid over-splitting
  - Less parameter tuning



Uniform tiling



Our adaptive tiling

Adaptive Tiling for Ray-bundles

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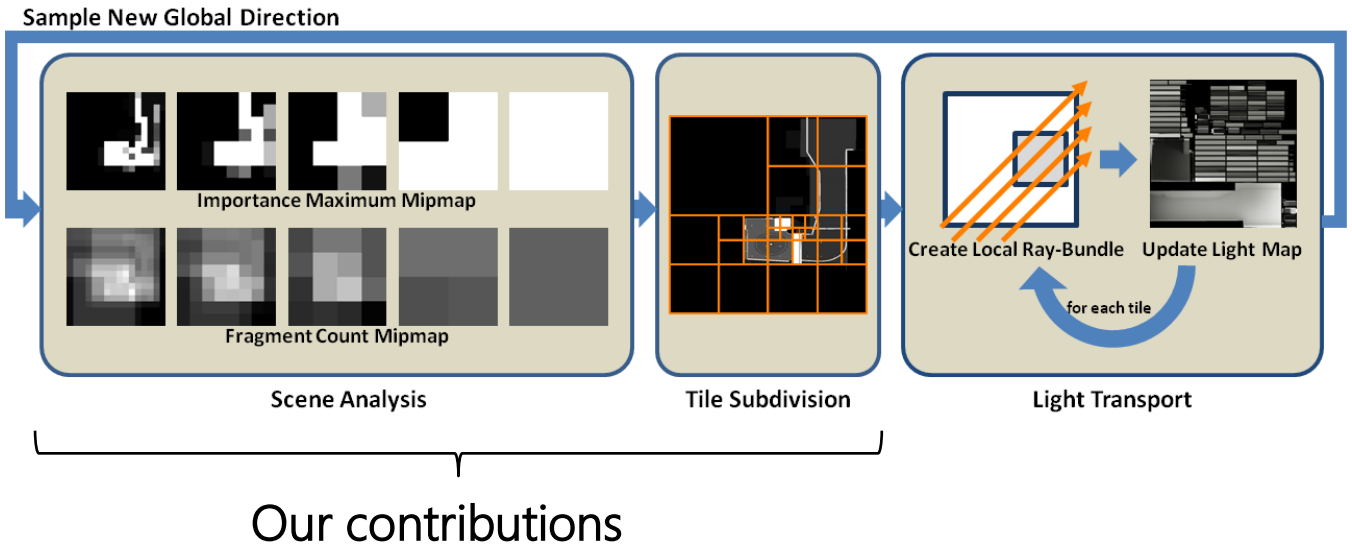
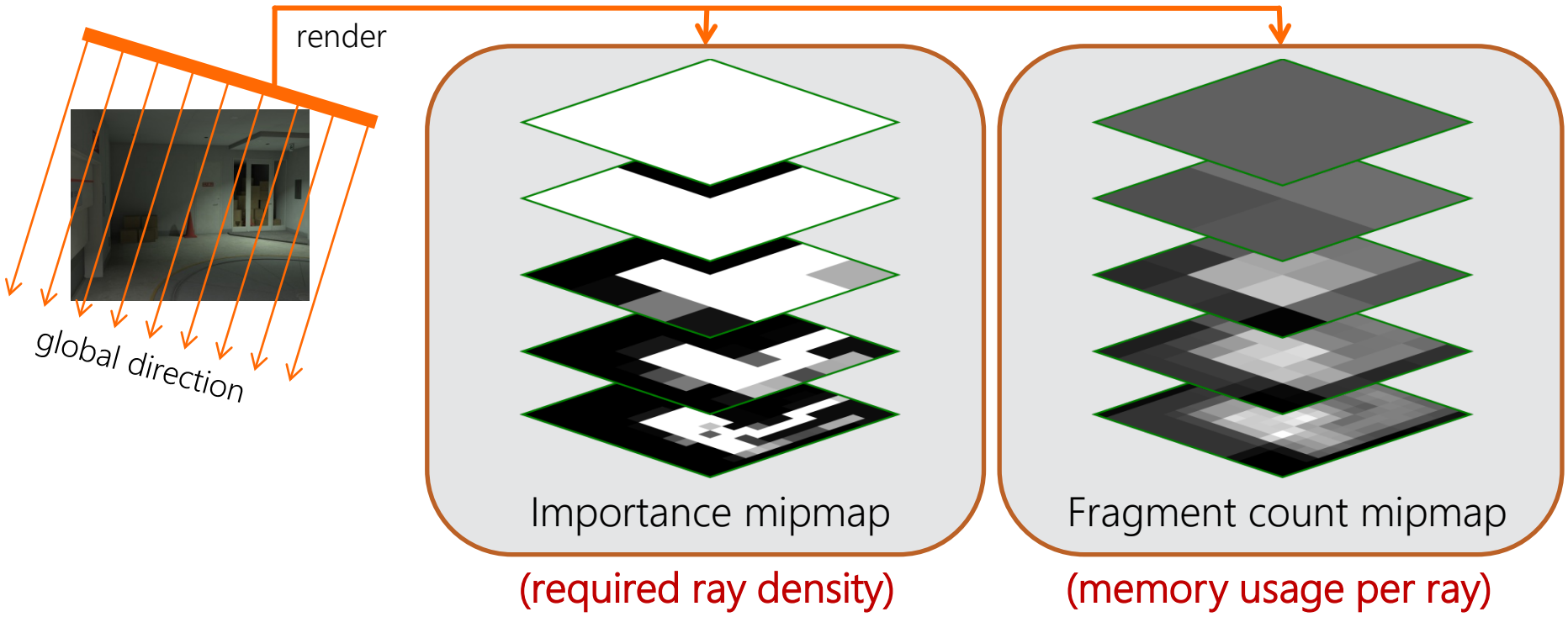
Adaptive Tiling

- Based on adaptive shadow mapping [Fernando01]
  - Quadtree-based tile subdivision
  - According to a low-resolution scene analysis
- Analysis for memory usage prediction is also added
  - The overflow risk is reduced dramatically
    - It is not completely eliminated, however



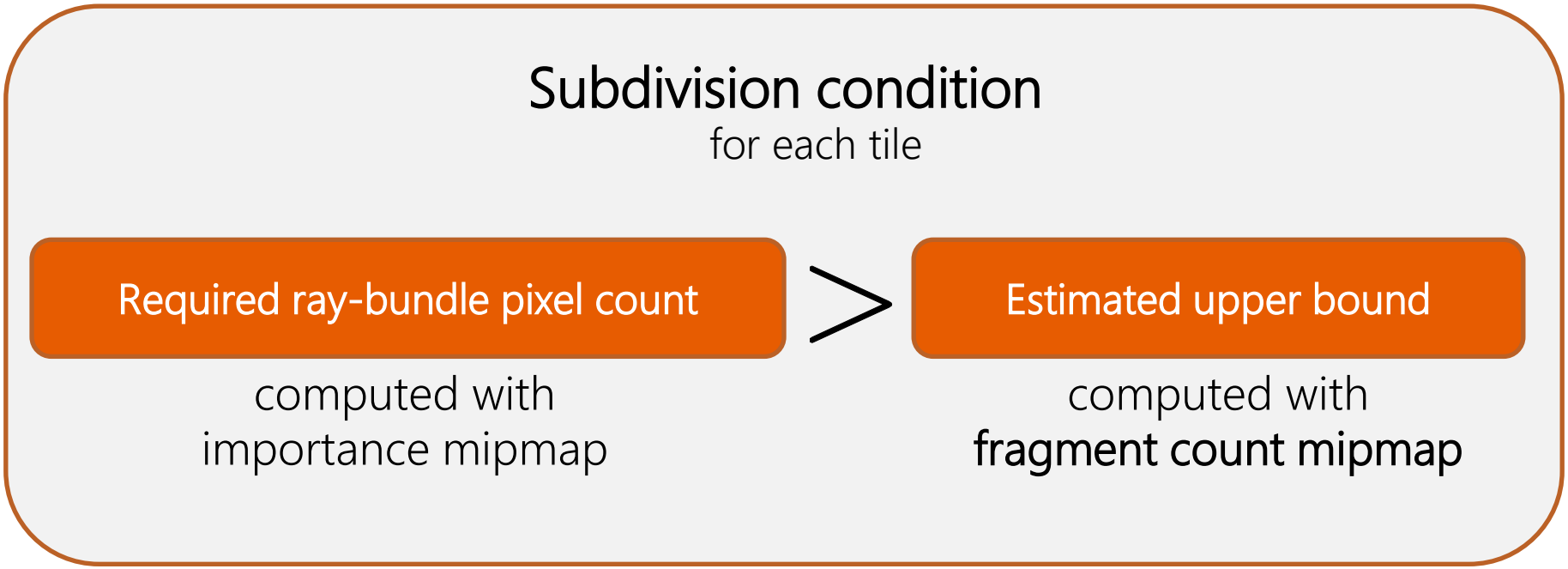
Importance & Fragment Count Analysis

- Render two mipmaps from the ray-bundle direction
- Pixels as quadtree nodes (resolution: 2^n)



Recursive Tile Subdivision

- Start from the top mip level (root of the quadtree)
- A tile is subdivided when overflow is predicted



Experimental Results & Conclusions

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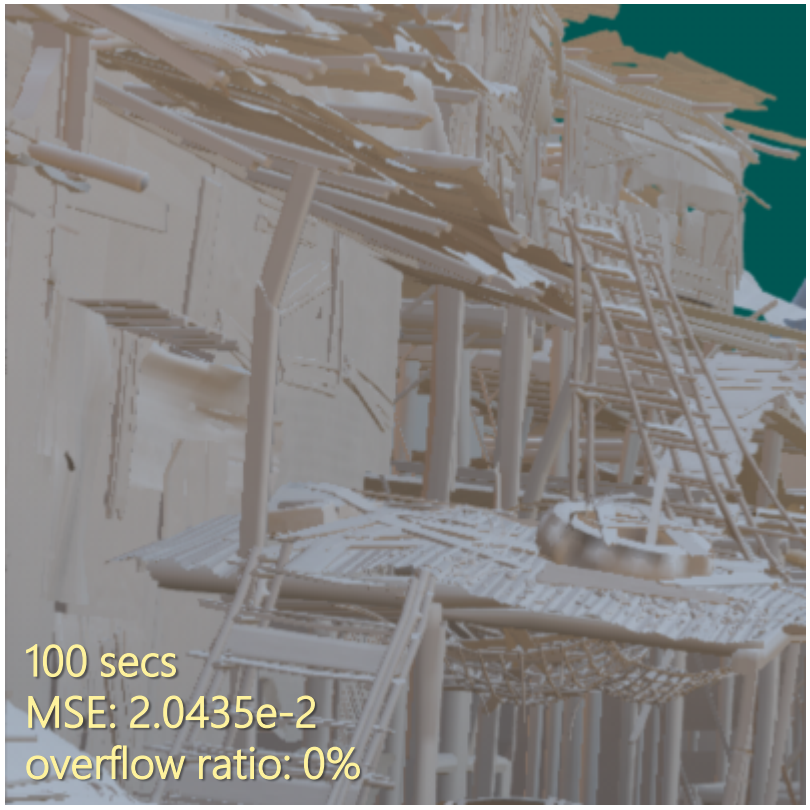
No Tiling

2000 sample directions
Ray-bundle resolution: 1024^2
Node buffer size: 5M nodes
Analysis resolution: 1024^2



GPU: NVIDIA GeForce GTX 580 with 1.5GB memory

35x35 Uniform Tiling

2000 sample directions
Ray-bundle resolution: 1024^2
Node buffer size: 5M nodes
Analysis resolution: 1024^2

GPU: NVIDIA GeForce GTX 580 with 1.5GB memory

Our Adaptive Tiling

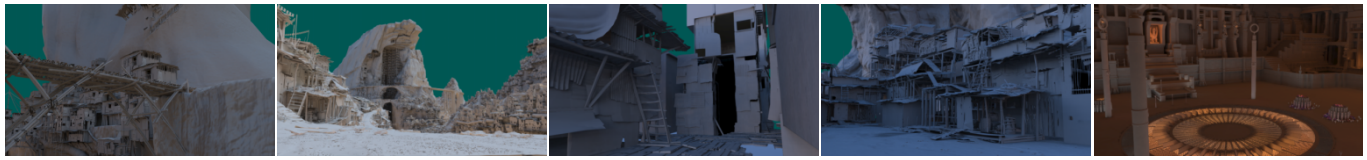
(172.7 tiles / direction)

2000 sample directions
Ray-bundle resolution: 1024^2
Node buffer size: 5M nodes
Analysis resolution: 1024^2

GPU: NVIDIA GeForce GTX 580 with 1.5GB memory

Computation Times per Sample Direction

2% overhead



Analysis Rendering	7.9	13.3	2.4	7.5	12.5
Mipmapping	0.3	0.5	0.3	0.2	0.3
Tile Subdivision	0.3	0.2	0.3	0.4	0.4
GPU-CPU Data Copy	0.7	0.8	0.6	0.8	0.7
Ray-bundle Creation	291.6	405.7	69.9	269.8	418.9
Light Map Update	180.3	274.7	63.8	217.4	286.9

(ms)

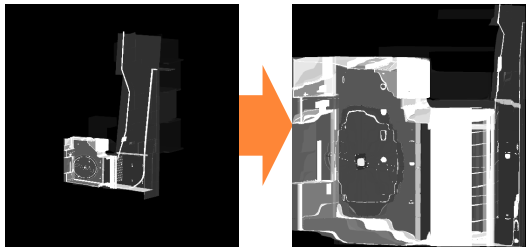
GPU: NVIDIA GeForce GTX 580 with 1.5GB memory

Conclusions

- Adaptive tiling for linked-list ray-bundles
  - A tiles is subdivided when overflow is predicted
  - The risk of memory overflow is reduced dramatically
  - Less parameter tuning
- Memory usage prediction
  - Using the fragment count mipmap
- Demonstrated baking light maps of large scenes
  - With a limited memory capacity

Future Work

- Improving the analysis accuracy
  - Supersampling
  - Conservative rasterization [Hasselgren05]
- Ray-bundle warping
  - Rectilinear texture warping [Rosen12]
- Real-time linked-list OIT
  - For an arbitrary node buffer size



Warping

Thank You