Deducing Explicit from Implicit Visibility for Global Illumination with Antiradiance

Gregor Mückl
Carsten Dachsbacher

Utrecht University
2013 – 4 – 8

Presenters: Joeri van der Velden & Mattijs Driel

Introduction

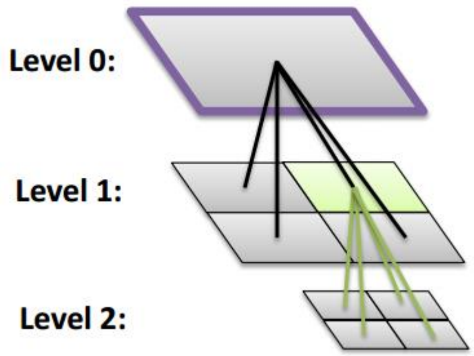
- Radiosity
- Antiradiance
- Implicit visibility
- Link mesh redundancy

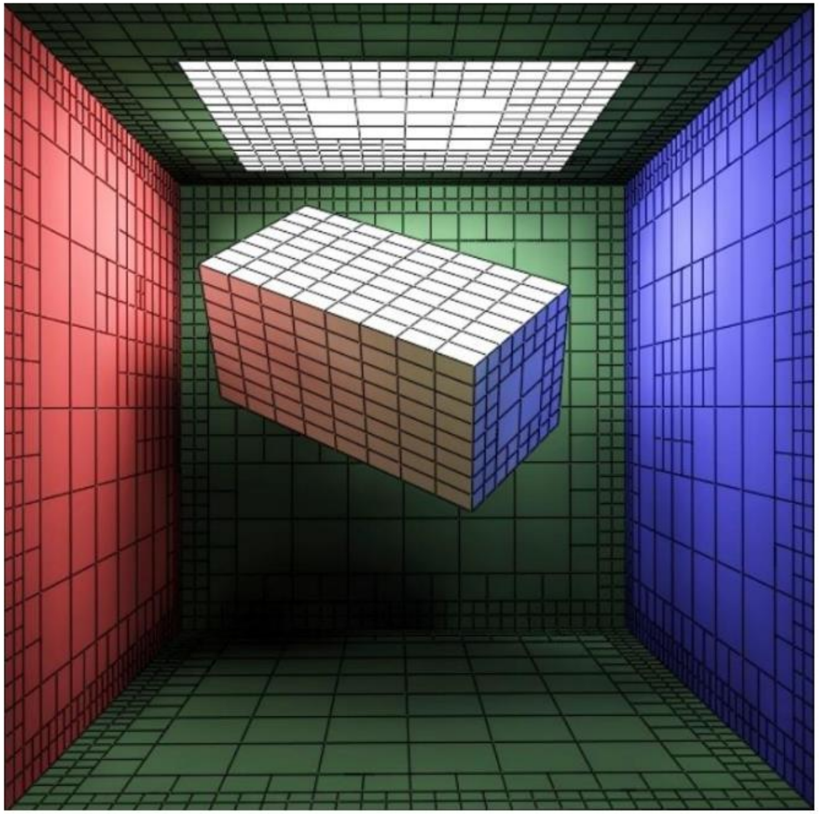
Overview

- Introduction
- Radiosity & Antiradiance Recap
- Problem statement
- Solutions
  - Removing Occluded Links
  - Heuristics
  - User-Defined link removal
- Results
- Quick mention
  - Final Shooting
- Improvements & Conclusion

Radiosity & Antiradiance Recap

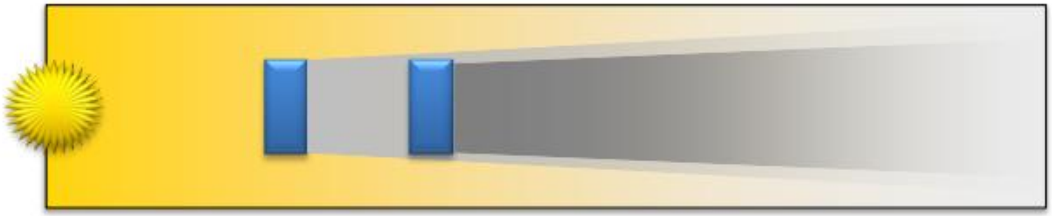
- Radiosity divides geometry into patches and creates a link mesh over them
- Propagate light over links using form factors
- Hierarchical radiosity

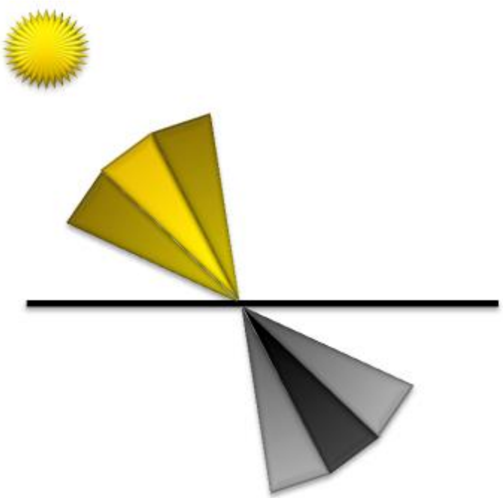


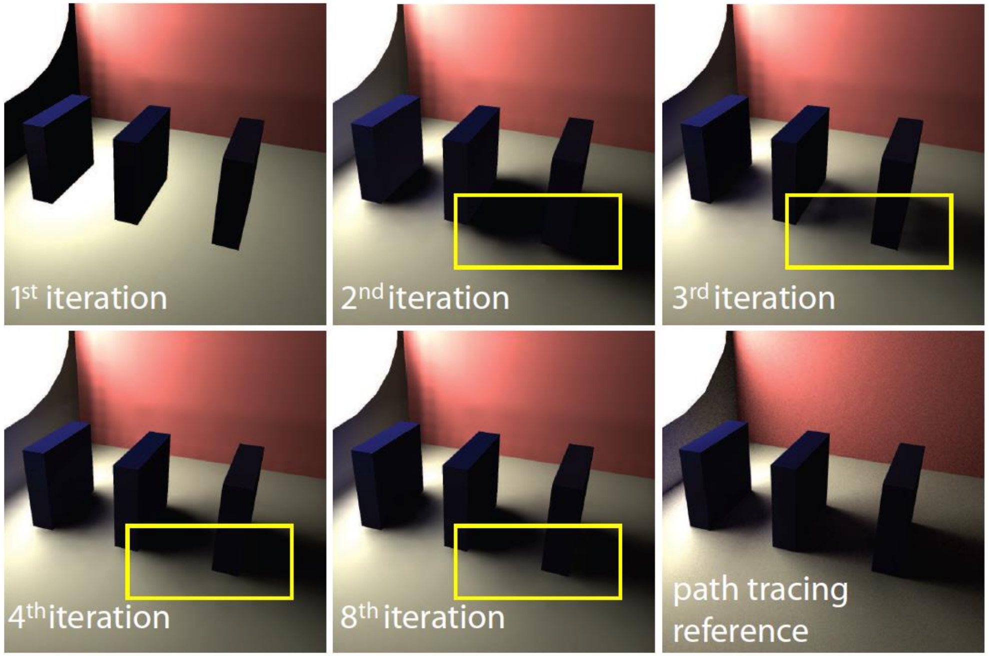


Radiosity & Antiradiance Recap

- Antiradiance: shoot negative light

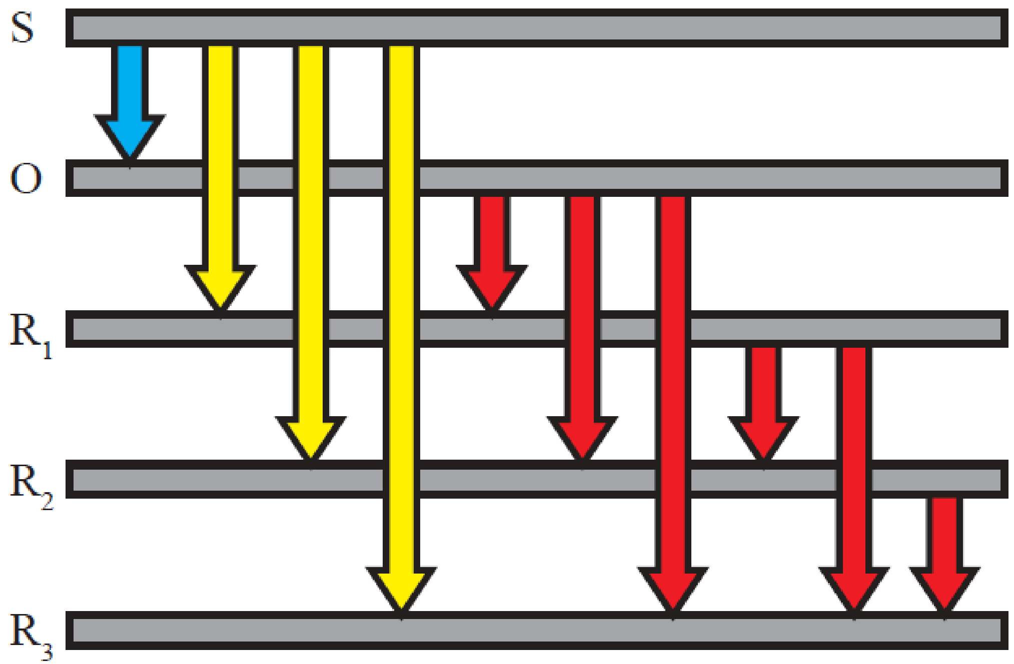






Problem Statement

Lots of redundant links in the link mesh!

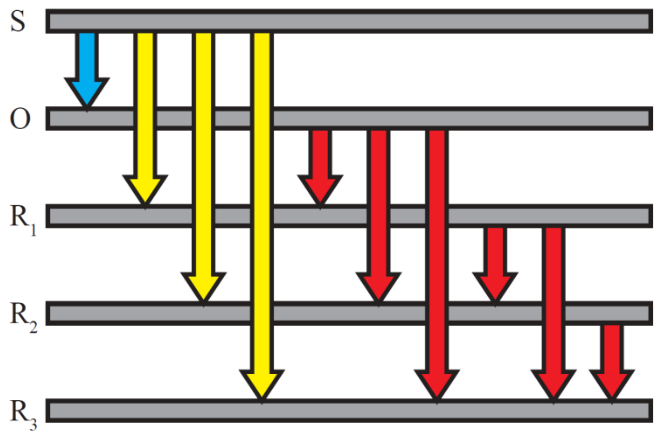


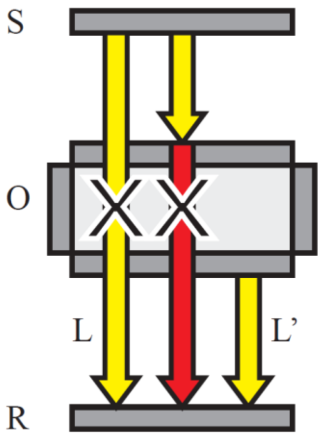
Solution – Removing Occluded Links

How do we know what links are redundant?

Define 2 rules:

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

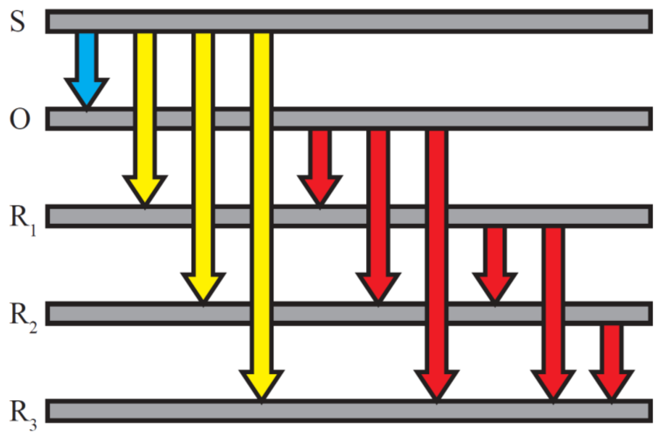


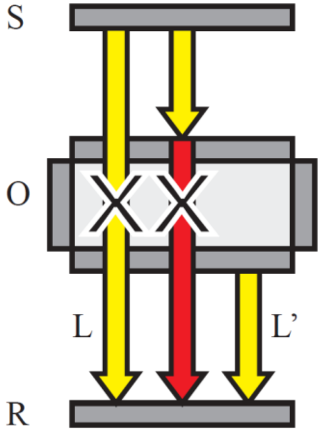


Solution – Removing Occluded Links

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

- Rule 2 only works with closed surfaces.
- This is fine, antiradiance also uses this assumption.





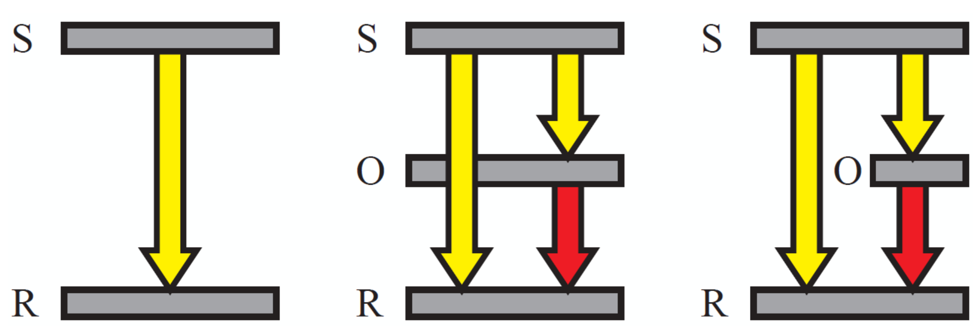
Solution – Removing Occluded Links

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

We have shown this works in simple cases.

How do these rules work in full 3D?

- Occluders can partially occlude receivers.



Solution – Heuristics

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

- We need visibility testing.
- But avoid expensive explicit testing (Ray Casting).

Deduce explicit visibility from implicit visibility, stored in the Directional Bins.

Create 2 heuristics based on the 2 rules.

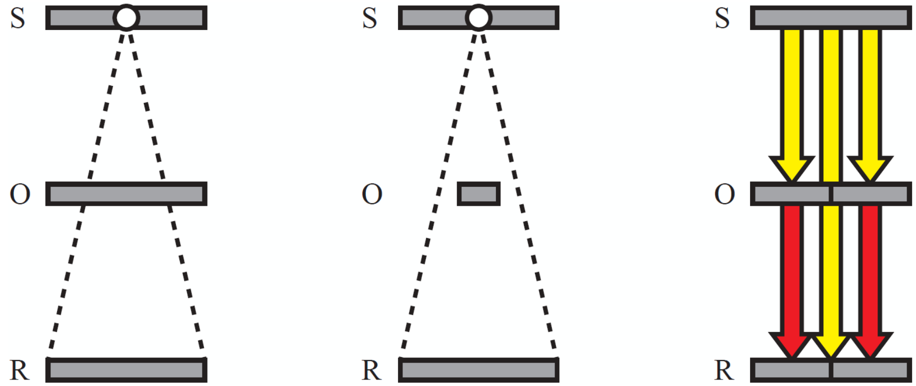
- Tests with the Directional Bins to see if the rule needs to apply.

Solution – Heuristics

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

Heuristic 1 (Algorithm 1 in the paper)

- Find an S – O – R pattern.
- Find the bins of S that store O and R.
- If O occupies the same bins as R, O must be occluding R. We then apply rule 1.

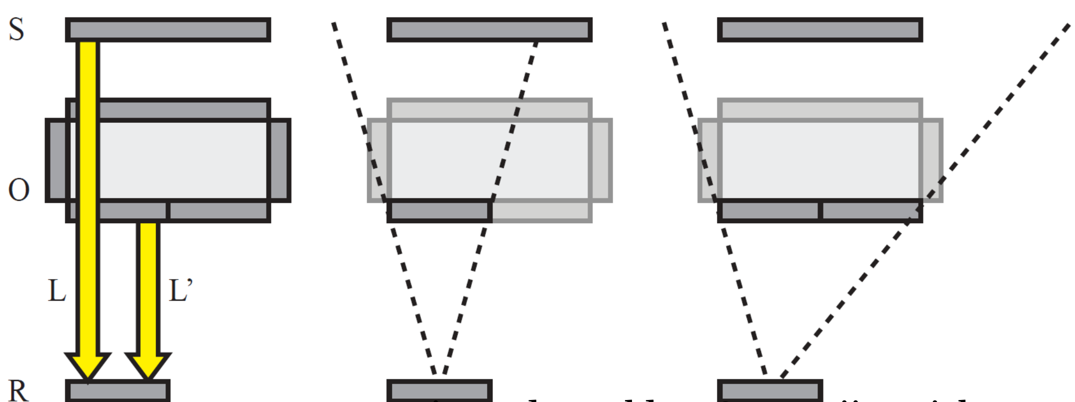


Solution – Heuristics

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

Heuristic 2 (Algorithm 2 in the paper)

- Find patch R with two incoming links sharing at least 1 bin.
- If the shorter link occupies the same bins as the longer link, there is full occlusion. We then apply rule 2 on these links.

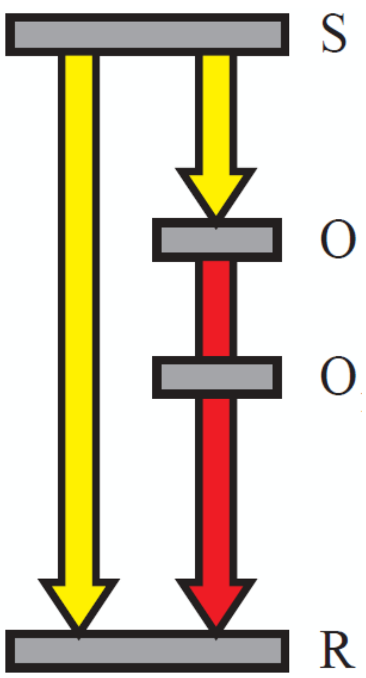


Solution – Heuristics

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

Heuristic 2 has a complication

- Antiradiance links that are indirectly required could be accidentally removed.



Use a failsafe algorithm (Algorithm 3 in the paper)

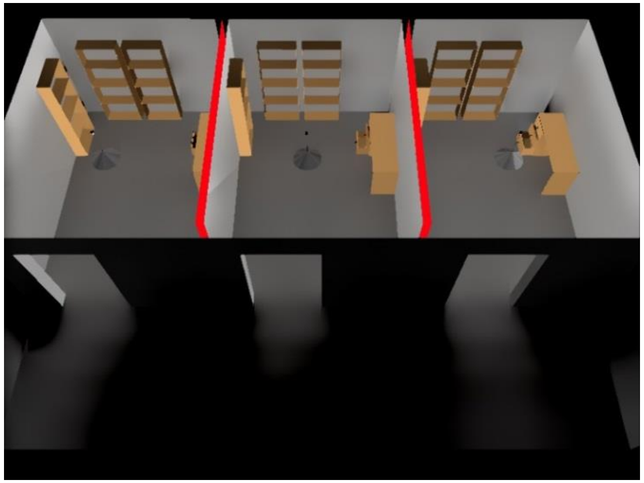
- Does additional checking.
- Will not work if Heuristic 1 has already changed the link mesh.

Solution – User-Defined Link Removal

1. Find S – O – R patterns, remove both links to R.
2. Find patches with multiple incoming links, remove all except the shortest link.

In addition to the 2 heuristics, allow the scene designer to define blocking geometry.

- Sever all links intersecting this geometry.
- Useful in scenes with multiple rooms, separated by walls.

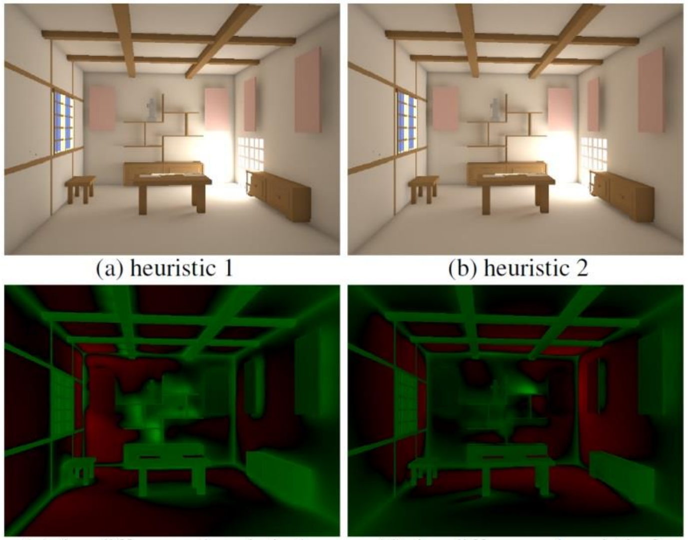


Results

scene	patches	links	heuristic 1 explicit test	heuristic 1 heuristic removal	heuristic 1 incorrect	heuristic 1 not removed	heuristic 2 explicit test	heuristic 2 heuristic removal	heuristic 2 incorrect	heuristic 2 not removed
Japan	12745	629665	157449	129313	54872 (42%)	83058 (52%)	71007	34408	11732 (34%)	48331 (68%)
Office	14246	1470440	581768	395592	124232 (31%)	310408 (53%)	260475	85075	28739 (34%)	204139 (78%)
Desks	14396	1465632	759669	280705	7752 (10%)	486716 (40%)	690145	300316	11577 (4%)	401406 (58%)
Soda Hall	25023	2774452	2076609	1621749	73998 (5%)	528858 (25%)	1888014	1016923	21026 (2%)	892117 (47%)

scene	patches	links	heuristic 1	heuristic 2
Japan	12745	629665	22.1s	26.0s
Office	14246	1470440	248.2s	224.9s
Desks	14396	1465632	80.5s	127.0s
Soda Hall	25023	2774452	87.9s	280.0s

Japan



(a) heuristic 1 (b) heuristic 2

(c) 4× difference heuristic 1 (d) 4× difference heuristic 2

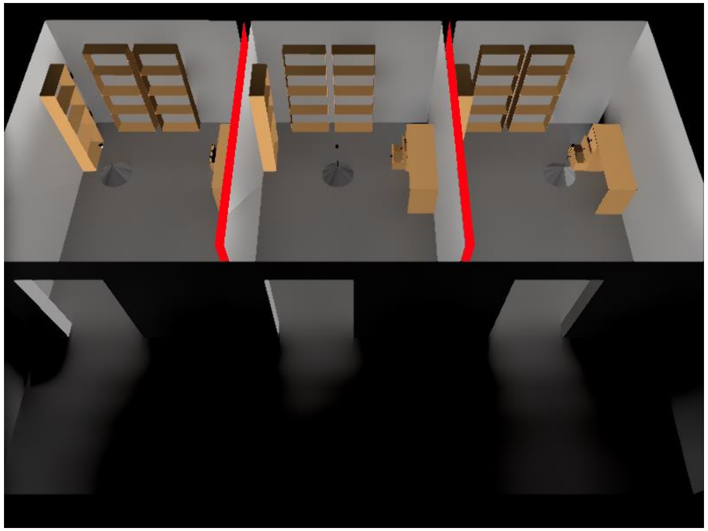
Office

Results

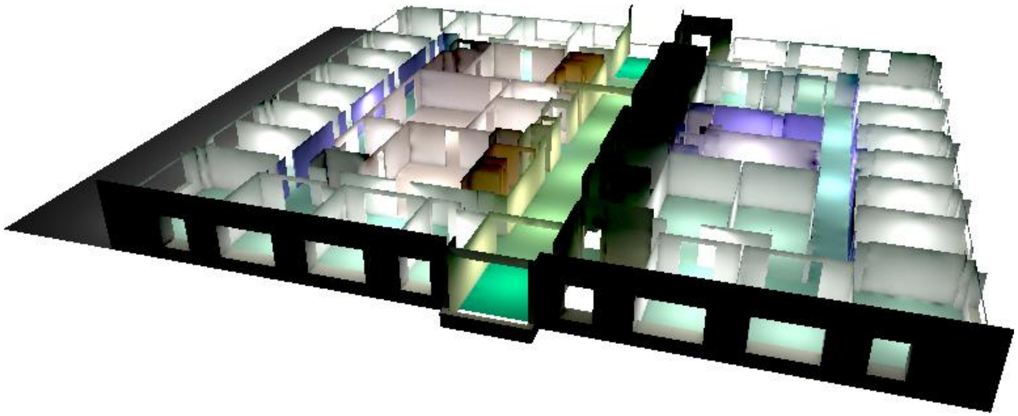
scene	patches	links	heuristic 1 explicit test	heuristic 1 heuristic removal	heuristic 1 incorrect	heuristic 1 not removed	heuristic 2 explicit test	heuristic 2 heuristic removal	heuristic 2 incorrect	heuristic 2 not removed
Japan	12745	629665	157449	129313	54872 (42%)	83058 (52%)	71007	34408	11732 (34%)	48331 (68%)
Office	14246	1470440	581768	395592	124232 (31%)	310408 (53%)	260475	85075	28739 (34%)	204139 (78%)
Desks	14396	1465632	759669	280705	7752 (10%)	486716 (40%)	690145	300316	11577 (4%)	401406 (58%)
Soda Hall	25023	2774452	2076609	1621749	73998 (5%)	528858 (25%)	1888014	1016923	21026 (2%)	892117 (47%)

scene	patches	links	heuristic 1	heuristic 2
Japan	12745	629665	22.1s	26.0s
Office	14246	1470440	248.2s	224.9s
Desks	14396	1465632	80.5s	127.0s
Soda Hall	25023	2774452	87.9s	280.0s

Desks



Soda Hall



Results

Antiradiance link mesh as input.

			heuristic 1				heuristic 2			
scene	patches	links	explicit test	heuristic removal	incorrect	not removed	explicit test	heuristic removal	incorrect	not removed
Japan	12745	629665	157449	129313	54872 (42%)	83058 (52%)	71007	34408	11732 (34%)	48331 (68%)
Office	14246	1470440	581768	395592	124232 (31%)	310408 (53%)	260475	85075	28739 (34%)	204139 (78%)
Desks	14396	1465632	759669	280705	7752 (10%)	486716 (40%)	690145	300316	11577 (4%)	401406 (58%)
Soda Hall	25023	2774452	2076609	1621749	73998 (5%)	528858 (25%)	1888014	1016923	21026 (2%)	892117 (47%)

scene	patches	links	heuristic 1	heuristic 2
Japan	12745	629665	22.1s	26.0s
Office	14246	1470440	248.2s	224.9s
Desks	14396	1465632	80.5s	127.0s
Soda Hall	25023	2774452	87.9s	280.0s

- Comparison of heuristic removal with explicit removal.
- Incorrect links mostly due to discreteness of bins.
- But, incorrect links are typically small links
- CPU implementation of heuristic removal (slow).

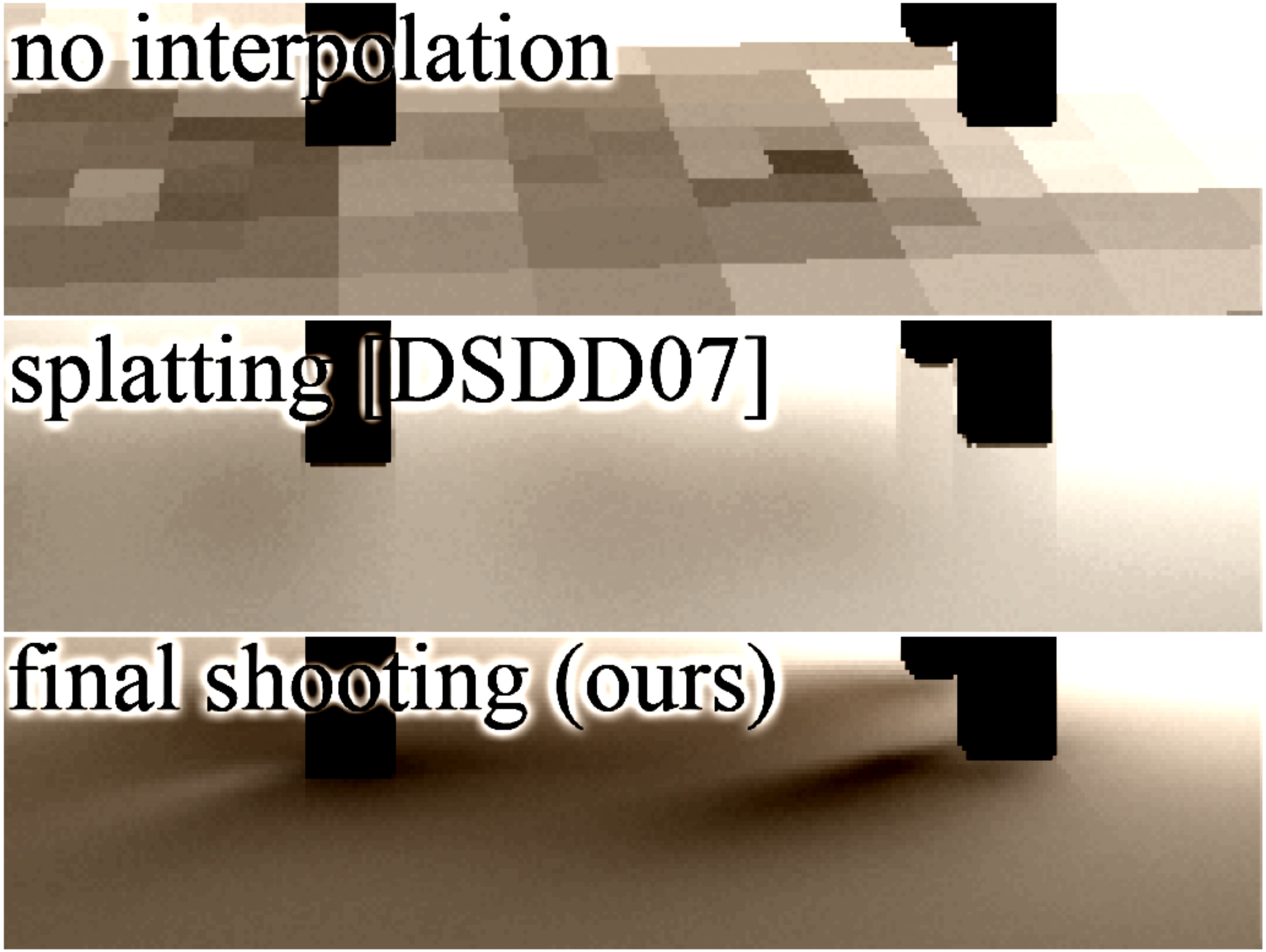
Quick mention - Final Shooting

Method to render the output of the heuristic removal.

Different approach to the original Antiradiance paper.

- Instead of splatting, use a method similar to Instant Radiosity.
- Very expensive (paper mentions 0.44 fps)
- Does manage to preserve more detail.

Final Shooting



Improvements & Conclusion

- Heuristics significantly reduce link mesh complexitity
- Speedup of light propagation in complex scenes
- Final shooting simplifies high-quality rendering

Possible improvements:

- GPU implementation would provide further speedup of link removal step
- Creating blocking geometry by analyzing scene geometry