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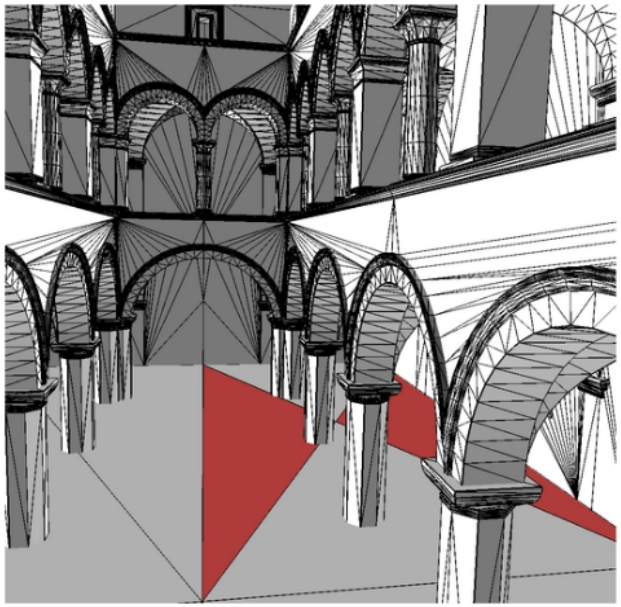
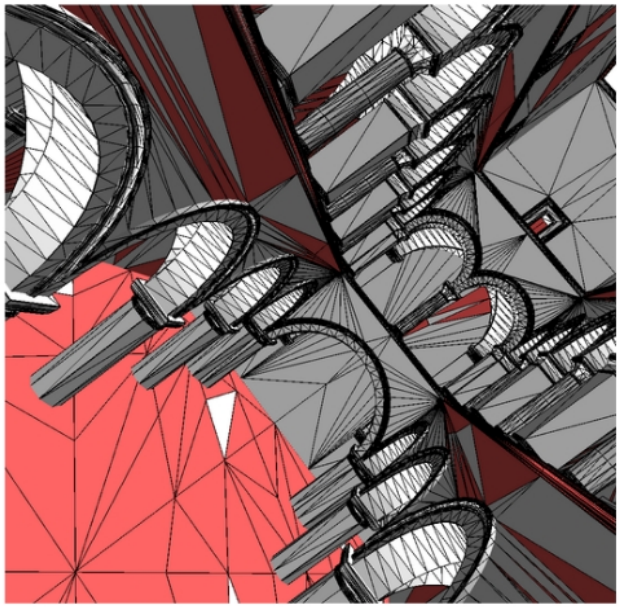
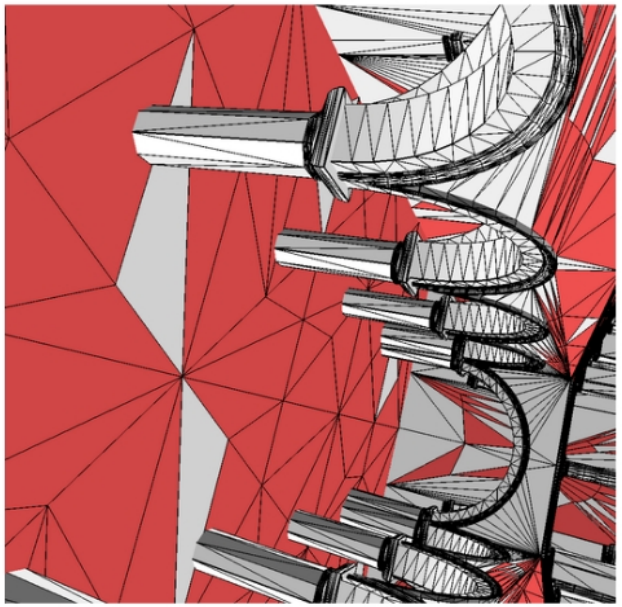






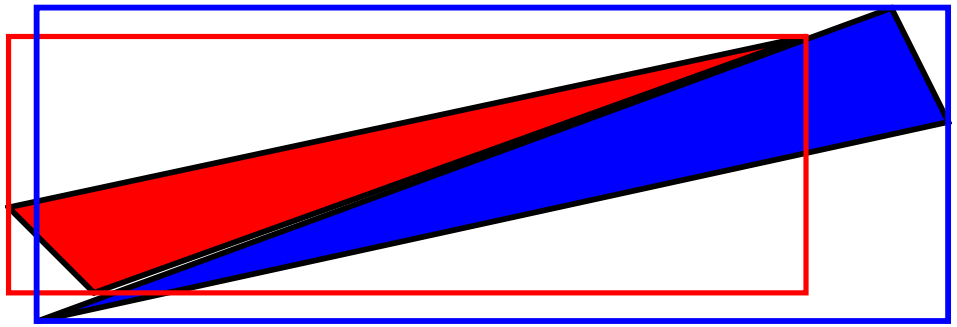
The Edge Volume Heuristic
Robust Triangle Subdivision for Improved BVH Performance

Holger Dammertz, Alexander Keller

Introduction

Disadvantage of Object Partioning using Bounding Volumes

- Bounding volume does not pack primitives perfectly
- Primitves are of varying size
- The result is overlap of tree nodes and children wasting traversal time



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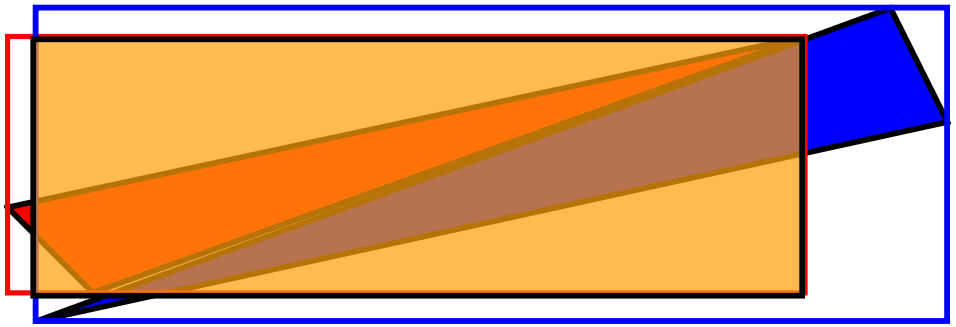

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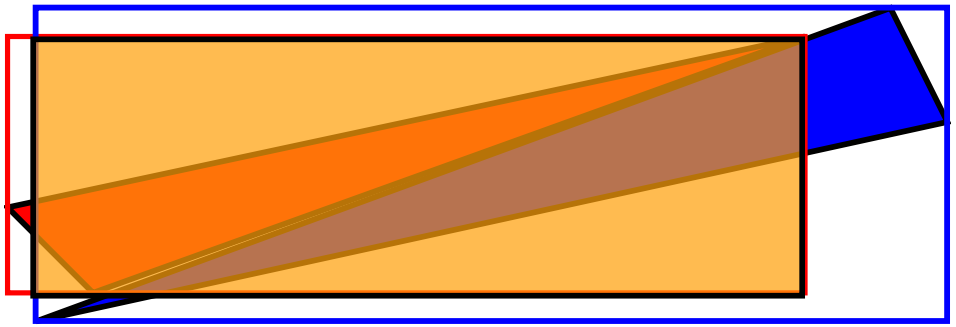

Advantage of Bounding Volume Hierachies

- Easy and fast traversal
- Memory behaviour deterministic and controllable
- Very small acceleration structures possible

Splitting

Early Split Clipping Approach

- Presented last year on RT07
- Based on surface area of triangles
- Split each triangle at axis aligned plane
- Good performance with correct parameters

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" by `ingenious` - OMPF Forum

There is no good global early clipping heuristic.
Try presplitting the triangles in Soda Hall - unless you're a magician and just guess the correct splitting threshold, you'll end up with out of memory exception during tree building :D

Hand Tweaking may be difficult

Problems of Early Split Clipping

- Memory consumption unpredictable
- Clipping against planes may introduce numerical problems
- May split many triangles without any speed improvement

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- Many different shots
- Scene complexity may change during a shot

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Advantages of creating smaller triangles

Basic principle similar to *k*d reference duplication

- Controllable which triangles to split
- Preprocess before tree construction

Our Approach

Preserve advantage of BVH

- Small memory consumption - split only really bad triangles
- Numerically robust and consistent
- Fast
- Automatic for normal scenes

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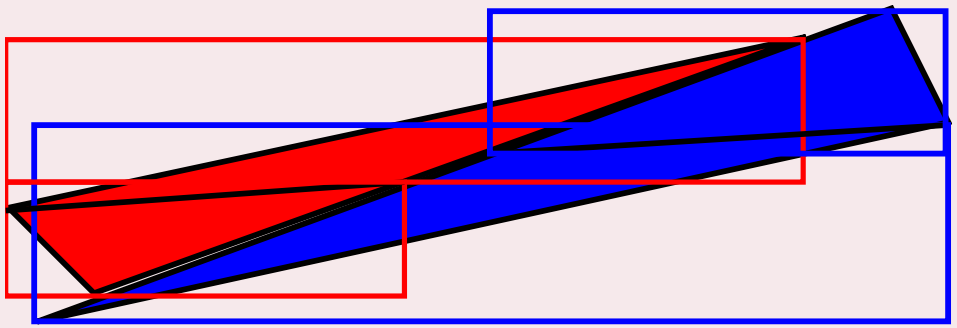
Observation

- Not all large triangles are bad,
  espacially in architectural scenes
- Large triangles are often axis aligned and form quads
- These triangles are no huge problem in SAH based tree construction

Subdivision

Reduce overlap

- Triangle Subdivision at edge midpoint also reduces overlap



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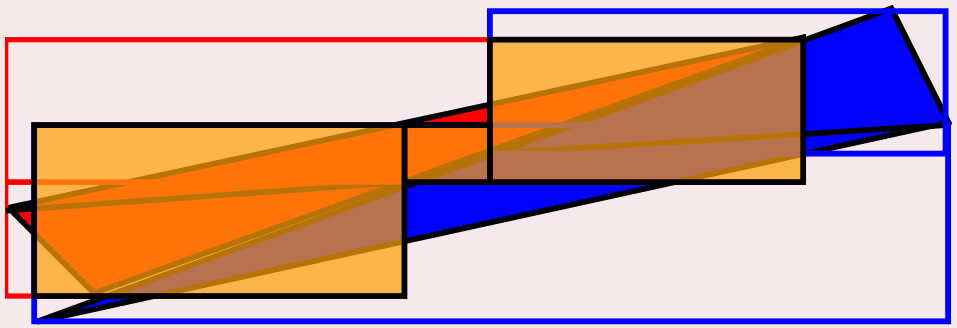

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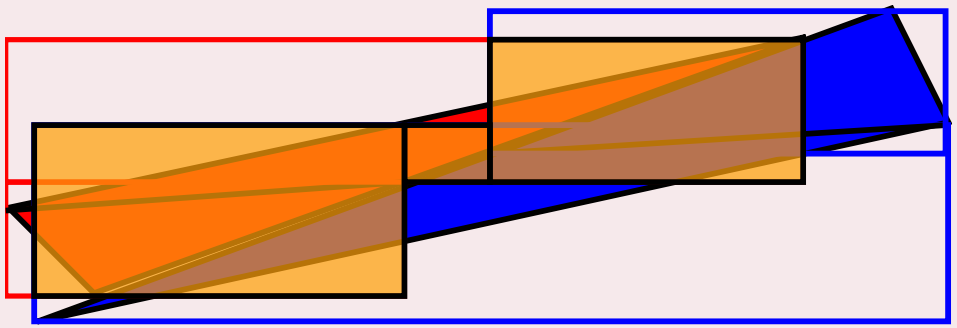

Edge Volume Heuristic

- Split a triangle if volume of AABB of a triangle **edge** exceeds threshold $\varepsilon_v(t)$.
- Use midpoint of edge for split
  - $\frac{A+B}{2}$ is numerically very robust
  - Adjacent triangles sharing an edge are split at the same point
  - Watertight Subdivision: a consistent mesh stays consistent
  - Each triangle is independent

Subdivision

Edge AABB Volume

- Axis aligned edges have no AABB volume
- Very economic splitting: only very bad triangles are split

Choice of Threshold

- Global Threshold based on full scene AABB volume V

$$\varepsilon_v(t) := \frac{V}{2^t}$$

- Use $t = 14$ as default value.
  - Over a broad range of scenes a very good default value
  - Less than 1% of reference duplication in already fast scenes

Implementation Details

Preprocess

Before ray tracing by scene exporter

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On demand

- Compute only bounding boxes prior to tree construction
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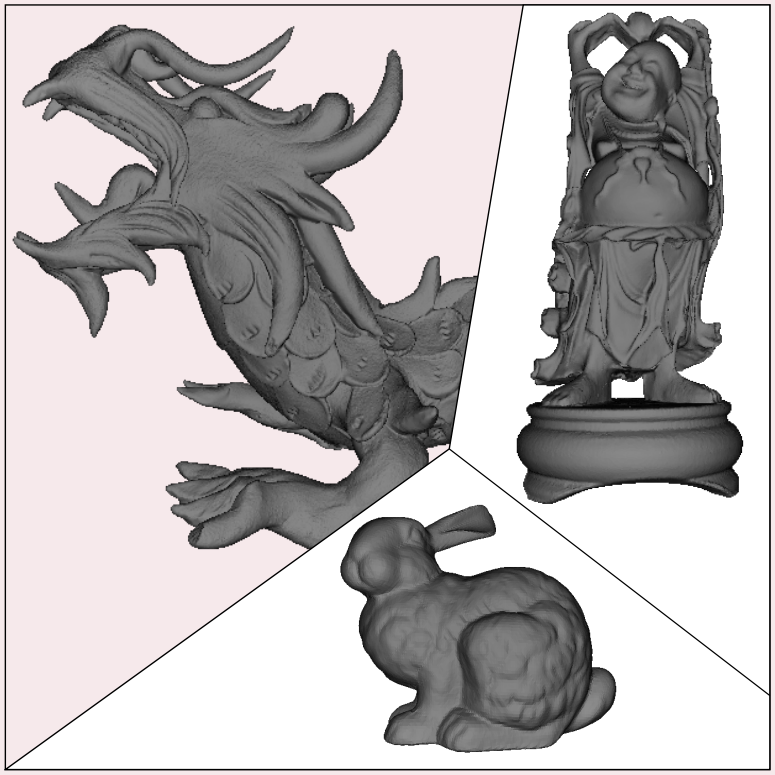
Additional optimization

- BVH has usually more than one triangle per leaf
- Remove duplicates

Results - Static Scenes

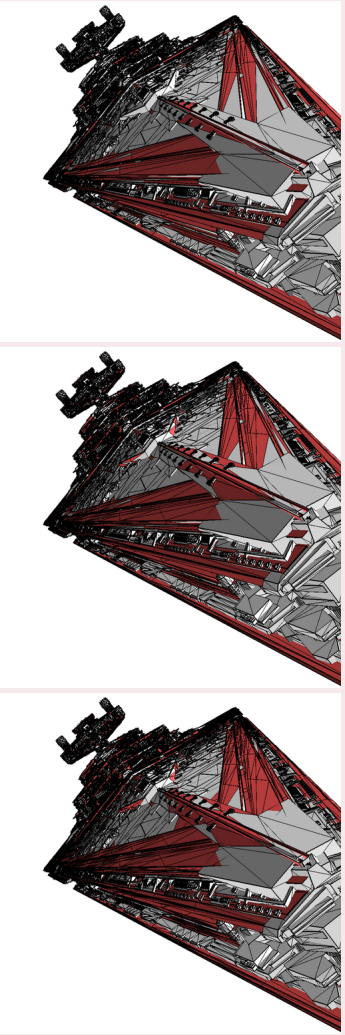
Bunny, Buddha, Dragon...

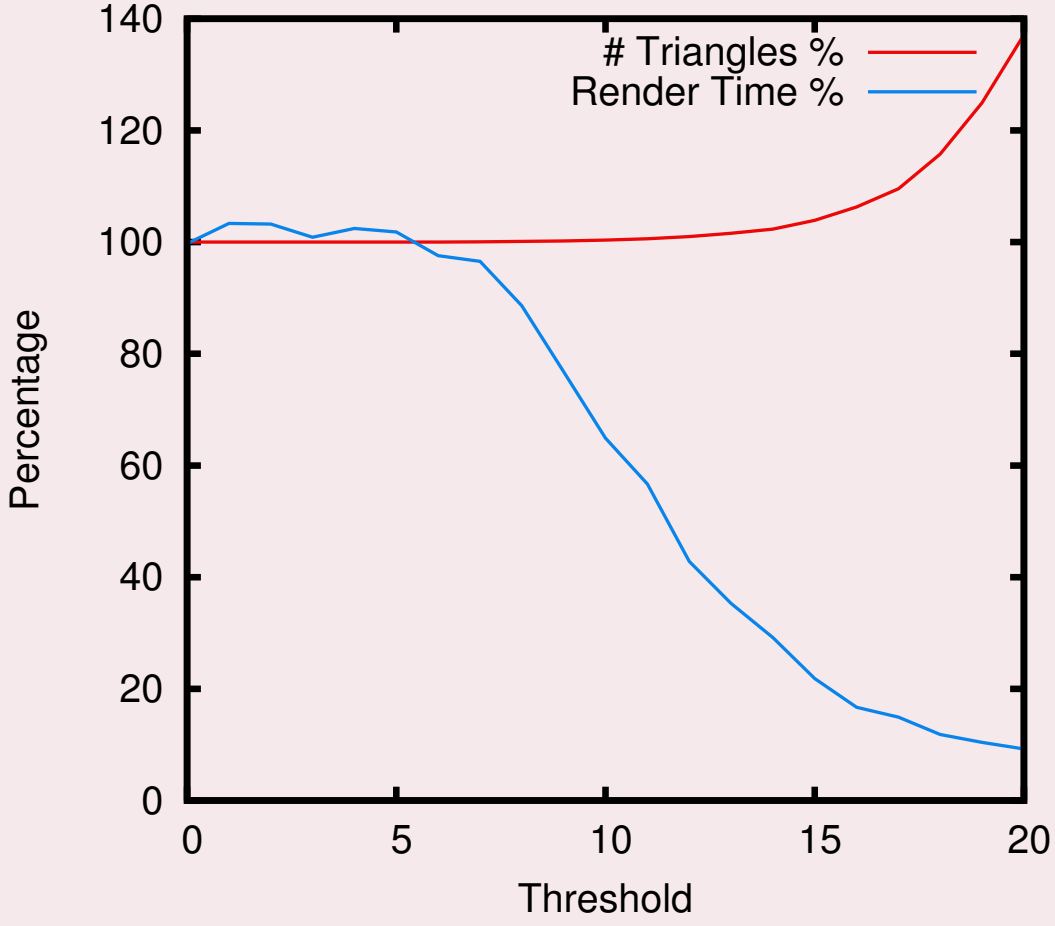


No triangles are split

Results - Static Scenes

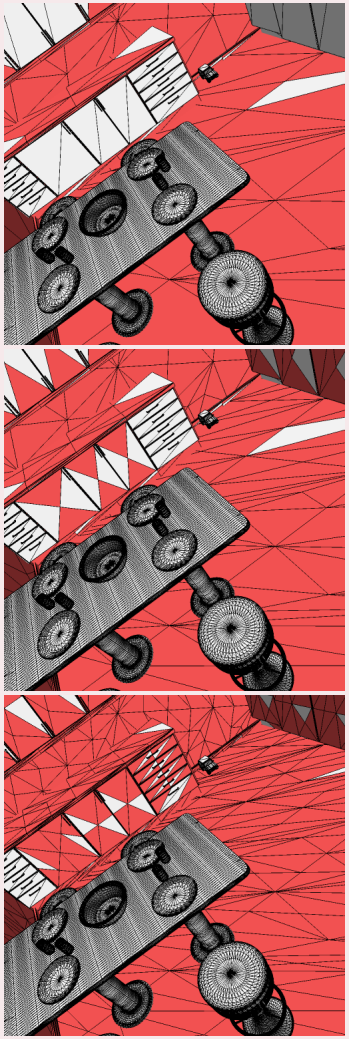
Space Ship

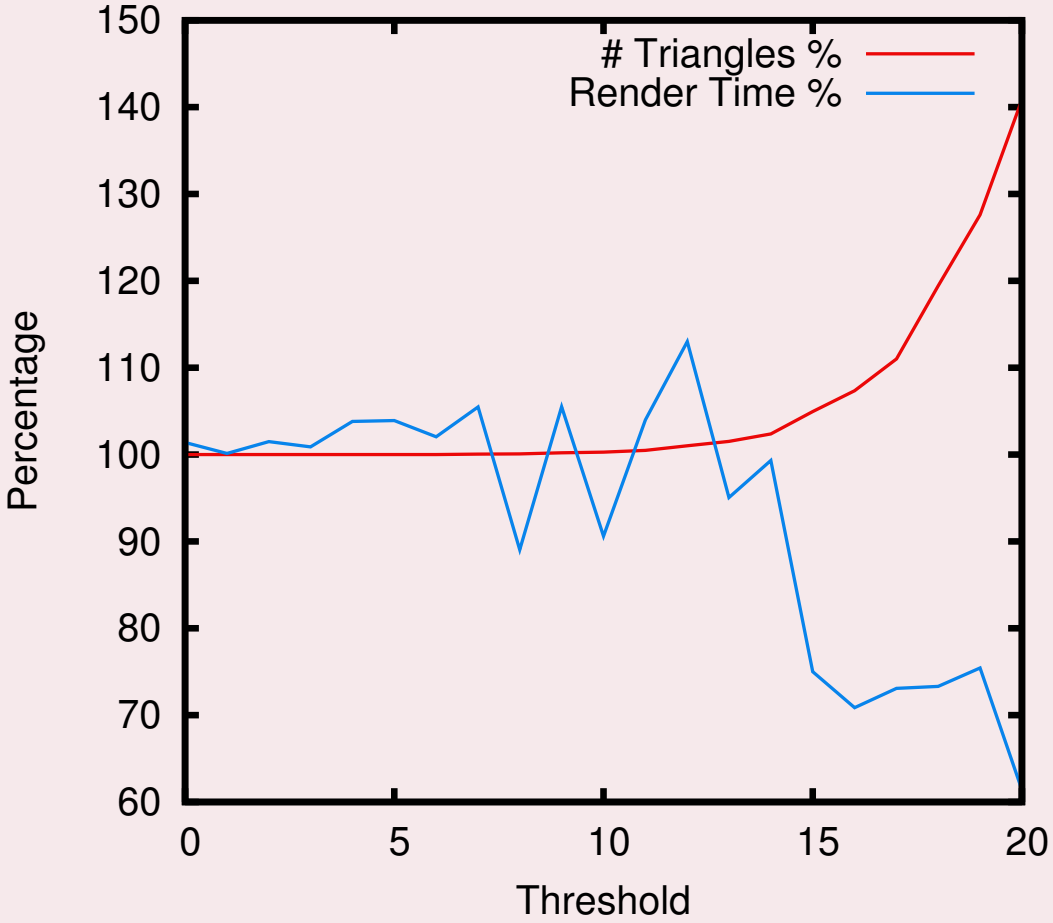




Results - Static Scenes

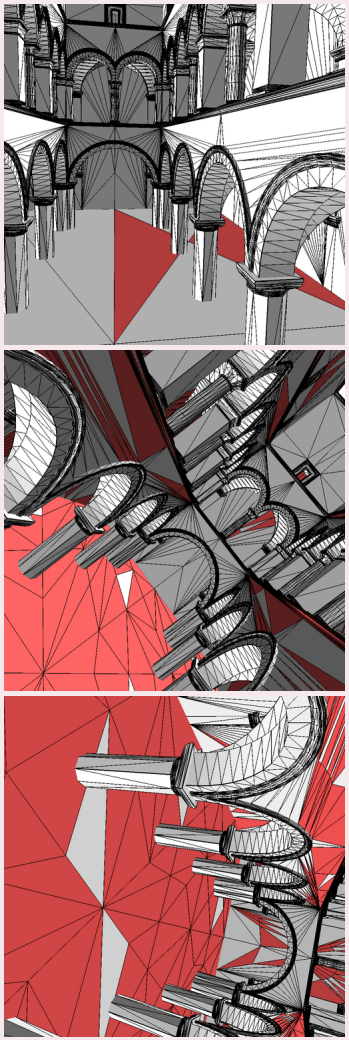
Rotated Kitchen

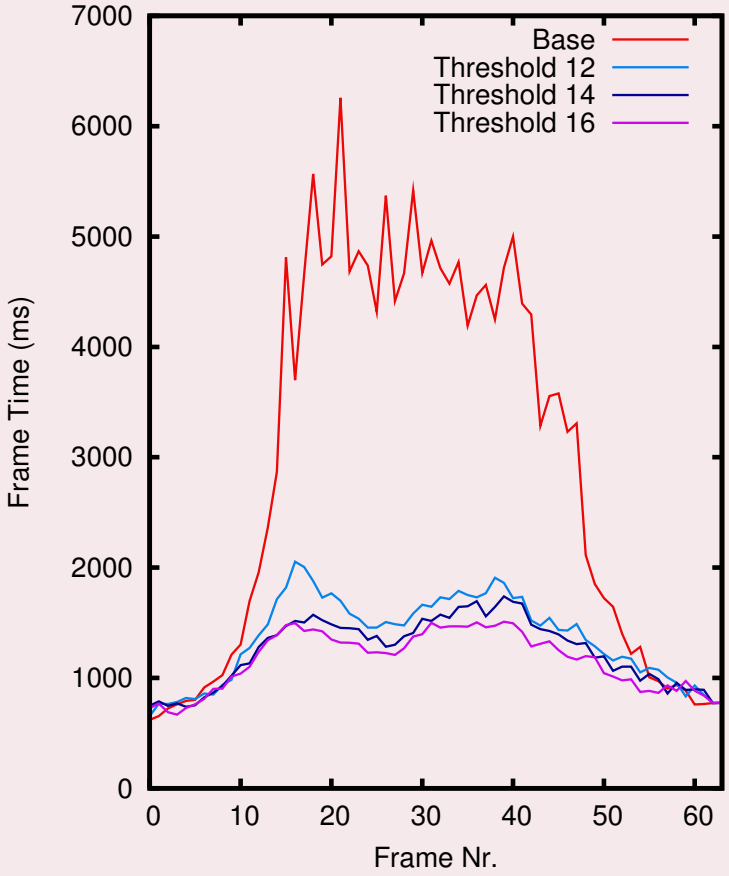




Results - Simple Animation

Rotated Sponza - Performance Statistics





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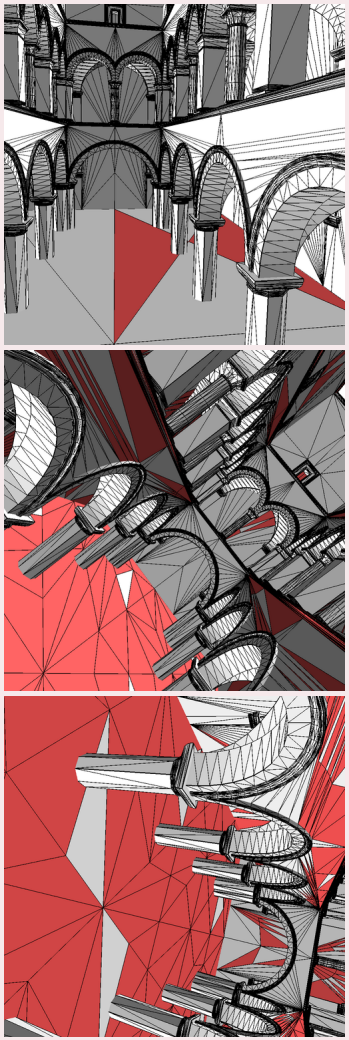

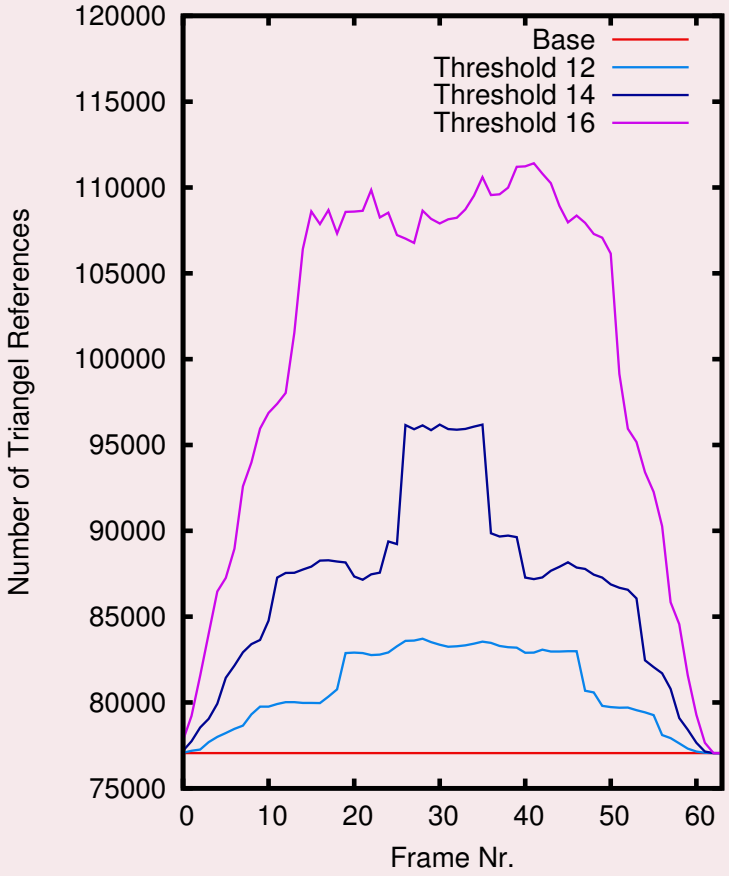

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- Efficiently reduces the overlap of triangles
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Questions?