VU Rendering SS 2014
186.101

Thomas Auzinger

Károly Zsolnai

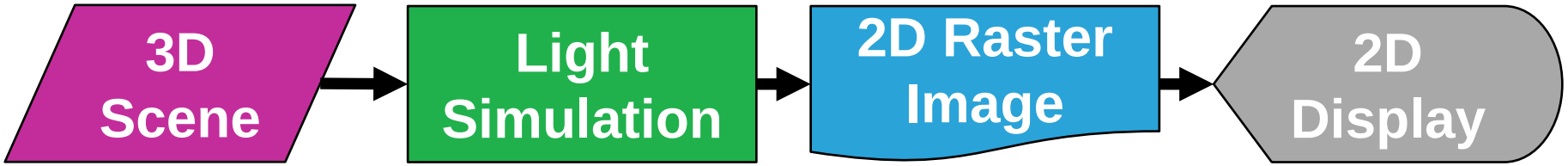
Institute of Computer Graphics and Algorithms (E186)
Vienna University of Technology
http://www.cg.tuwien.ac.at/staff/ThomasAuzinger.html
http://www.cg.tuwien.ac.at/staff/KarolyZsolnai.html

VU Rendering SS 2014

Unit 06 – Spatial Acceleration Structures

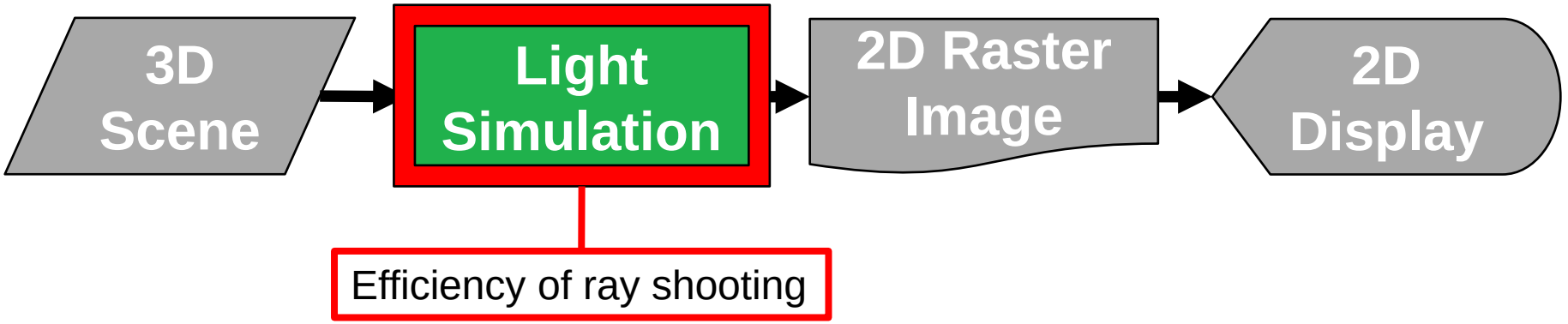
Scope

Rendering pipeline



Scope

Rendering pipeline



Problem

Generally, Monte-Carlo methods use ray shooting to sample the integrand of the rendering equation.

Computing the closest intersection with the scene is equivalent to computing the local visibility.

This is very expensive for a large amount of scene objects.

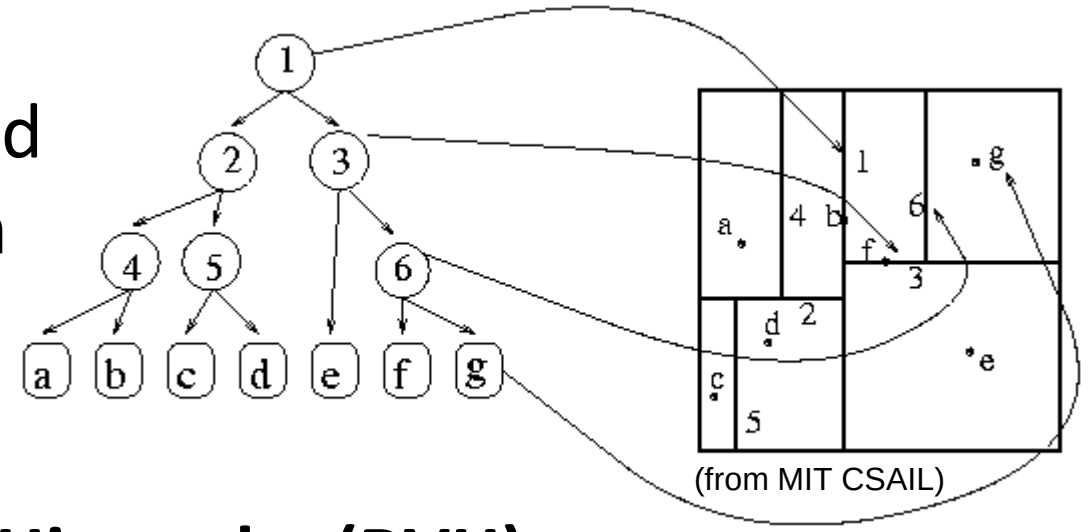
Solution

- **Naive approach:**
  Intersect ray with all objects to determine the closest intersection ($O(n)$ for n objects)

- **Better approach:**
  Reorganize the objects into a spatial hierarchy to skip large parts of the scene ($o(n)$ for n objects)

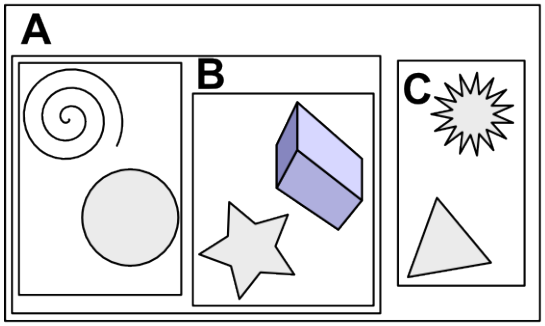
Spatial hierarchies

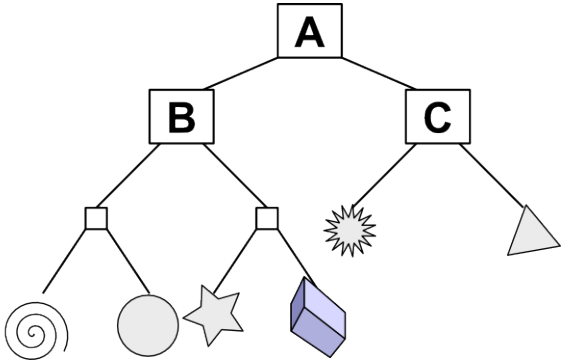
- **k-d tree**
  Subdivide space and store the objects in overlapping nodes



(from MIT CSAIL)

- **Bounding Volume Hierarchy (BVH)**
  Group objects recursively into a tree structure





(from wikipedia)

Spatial hierarchies

- **k-d tree**
  + Faster traversal on the CPU
  - Larger amount of nodes (and duplicate references)

- **Bounding Volume Hierarchy (BVH)**
  + Faster traversal on the GPU
  + Easier to update (for dynamic scenes)
  + Every object only in one tree leaf
  - Spatial overlap of nodes

Bounding Volume Hierarchies

Object grouping can be done in many ways – optimality is usually scene dependent but heuristics exist.

Surface area heuristic (SAH)

$$SAH = C_{\text{inner}} \sum_{I} \frac{A_n}{A_{\text{root}}} + C_{\text{leaf}} \sum_{L} T_n \frac{A_n}{A_{\text{root}}}$$

$I \ldots \text{inner nodes}, L \ldots \text{leaf nodes}$

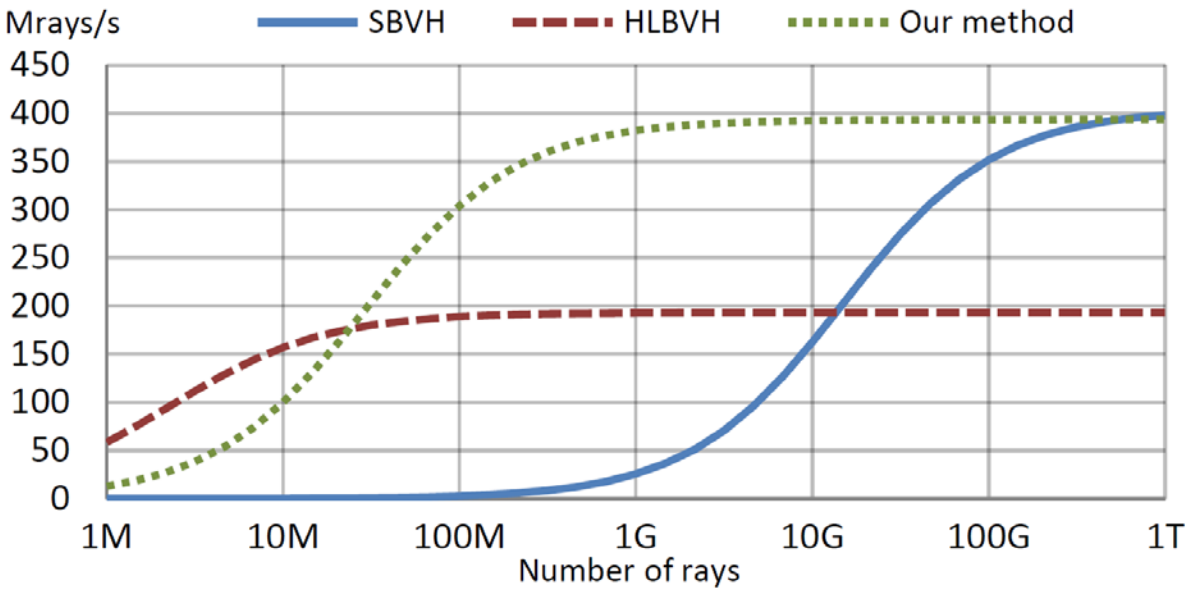
$A_n \ldots \text{surface area node n}$

$A_{\text{root}} \ldots \text{surface area of its root}$

Bounding Volume Hierarchies

Constructing the tree with the minimal SAH cost is expensive → usually approximations are used.

This leads to a quality/speed trade-off:



Comparison of different BVH construction methods. From [1].

Literature

Textbooks

- PBRT chapter 4
- C. Ericson, *Real-Time Collision Detection*, 2005

Papers

- I. Wald, *On fast Construction of SAH-based BVHs*, IRT 2007
- Z. Wu et al., SAH KD-Tree construction on GPU, HPG 2011
- T. Karras, *Maximizing Parallelism in the Construction of BVHs, Octrees and k-d Trees*, HPG 2012
- T. Karras, T. Aila, *Fast Parallel Construction of High-Quality Bounding Volume Hierarchies*, HPG 2013
- M. Doyle et al., *A Hardware Unit for Fast SAH-optimised BVH Construction*, Siggraph 2013

End

Questions?