Using Trees:
Spatial Trees and Searches

(slides based on those of Han-Wei Shen and also of MIT CS Lab)
Motivation

- Sorting objects front to back to rendering
- Nearest-Neighbor Searches
- Correspondence Searching in Range
- Image Registration
- What’s Wrong with Brute Force?
Sorting Objects

Fundamental operation for rendering synthetic scenes

What should be rendered at each pixel: the cube or the plane?

Answer: whichever is in front
Correspondence Searching in Range Image Registration: 
Range Image Registration
Correspondence Searching in Range Image Registration:

Range Image Registration (cont.)
Correspondence Searching in Range Image Registration:

Correspondence Search
Nearest-Neighbor Searches in Matching

Images from http://avalon.viewpoint.com/
Why Bother?

- $O(N)$ vs. $O(\log N)$
- Nearest-neighbor searches
  - Range Image Registration
  - High-dimensional feature-based object/image matching
- Ray-object intersections
  - Range Image Registration
  - Ray tracing
- Volumetric object representations
Options

**Bottom-up approach:**
- Bounding Volume Hierarchy
  - “put objects into groups”

**Top-down approach:**
- Spatial Subdivision
  - “partition space into chunks”
Bounding Volume Hierarchies

Starting with each individual object (e.g., polygon, point, object, etc.), build a tree bottom-up:
- Note: top-down approaches also possible
- Each node in the tree has a bounding box ("volume") that encloses the geometry in the entire subtree
- The actual data is contained in the leaf node
Spatial Subdivision

What point/object is closest to A?
Spatial Subdivision

How can I organize the data to efficiently find points/objects near any A?
Spatial Subdivision Techniques:

Uniform Subdivision
Spatial Subdivision Techniques:

Octrees in 3D/Quadtrees in 2D
Spatial Subdivision Techniques:

Octrees in 3D/Quadtreesc in 2D
Spatial Subdivision Techniques:

**k-D Trees**
Spatial Subdivision Techniques:

**Binary Space Partitioning (BSP) Trees**

A generalization:

- Can we just split space recursively and arbitrarily?
  - Yes – the smarts are in knowing what the recursive split is but that is application dependent
Spatial Subdivision Techniques:

Binary Space Partitioning (BSP) Trees
For Further Information...

  - Uniform Subdivision
  - Octrees
  - BSP Trees
  - Intersection tests

  - k-D Trees

  - BSP Trees