Acceleration Structures
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(Spatial) acceleration structures are data structures used to efficiently answer various queries:

- Which two geometric models intersect
- What’s in front or behind something
- What’s close to something else
Acceleration Structures

- Probably most associated with ray-tracing
- Also used for collision detection
- Useful for implementing things like the painter’s algorithm
What Do We Split

Generally acceleration structures can work by dividing either space, or objects.
Some Examples

- The following slides present a (very) partial list of acceleration structures used.

- There is no “best” structure, only ones that work better for a particular application.
Grid

- Uniformly splits space
- Objects may appear in more than one cell
- Simple to implement
Grid

- Not necessarily Cartesian

- May require a lot of memory
BSP

- Binary Space Partitioning
- Splits the space in a hierarchical manner
- Each level splits space in two using a splitting line/plane
BSP
BSP
BSP

[Diagram of a binary space partitioning tree with nodes A, B1, C1, D1, C2, D2, B2, D3, and C1, C2, D1, B2, A, and D3.]
BSP
BSP
BSP
The spaces created by the splits are all convex

Requires objects to be split in two (or appear twice)

It is np-hard to decide whether a given set of segments admits an auto-partition that does not make any cuts
BVH

- Splits the objects
- More flexible than other structures
BVH

- BVH is constructed recursively, by splitting objects into two groups

- There are many ways to split the objects
  - Compare to the mean of the x/y/z position of all objects
  - Compare to the center of the bounding box
  - Use surface area heuristic (SAH)

- Optimal BVH construction can have a great impact on query performance
BVH
BVH
OcTree

- Splits the space hierarchically as needed
- Eight nodes are created for each split
KD Tree

- Recursive split of space
- Split along one axis at a time
- Split space to two halves
KD Tree
KD Tree

- Splitting at the median will create a balanced tree
- Other splits are possible however (SAH)
- The best way is the one that works best
- k-d trees are a special case of BSP trees
Acknowledgments/References

- Additional information that relates to ray tracing at https://www.scratchapixel.com/lessons/advanced-rendering/introduction-acceleration-structure


- Images from Wikipedia