Conservative Volumetric Visibility with Occluder Fusion

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Definitions

- **Viewcell**: Axis-aligned box containing viewpoints.
- **Blocker**: Axis-Aligned box causing occlusion (occluder).
- **Shaft**: Volume identical to umbra of the blocker.
- **Leaf voxels**:
  - **Opaque**: Completely inside an object.
  - **Empty**: Completely outside an object.
  - **Boundary**: Contains a portion of surface.
Algorithm

- Scene discretization:
  - Rasterize the boundary of scene objects.
  - Determine opaque and empty voxels.
- Blocker extension:
  - Find a blocker that is not already hidden.
  - Group with neighboring opaque voxels.
- Shaft construction
- Occlusion tracking
  - Use the shaft to classify voxels.
  - Fully inside voxels → Occluded.
2D Case: Scene Discretization

- Space subdivision: Quadtree.
- Voxels containing surface → Boundary.
- Identify empty and opaque voxels:
  - Odd parity rule.
  - Depth-first seed-filling.
2D Case: Blocker extension

- Find an opaque voxel.
- Extend the blocker (keeping box-shape):
  - Along the axis that maximizes angle subtended.
2D Case: Blocker extension

- Block can be extended into an L-shape.
- Optimizations:
  - Blockers used from the viewcell outwards.
  - Large blockers used first.
2D Case: Blocker extension

Extend blocker into hidden space regardless of whether the added space is empty or opaque → Occluder fusion.
2D Case: Blocker extension

This mechanism (and the resulting occluder fusion) is essential.
2D Case: Shaft construction
Occlusion of scene objects

Querying an object for occlusion:

- Insert its bounding box into the quadtree.
- Check that all intersected voxels are hidden.

If BVH exists queries can be accelerated:

- Interleave traversal of BVH and quadtree.

Occlusion queries can be made for objects not in the original scene:

- Ignore bad occluders.
- Queries for dynamic objects.
3D Case

• Space subdivision: Octree.

• Differences:
  • Shafts in 3D.
  • Blocker extension in 3D.
3D Case: Shafts

Treated as the intersection of three 2D shafts (the shaft's projections onto the three coordinate planes).
3D Case: Blocker extension

- Extend the blocker in one dimension.
- Half its length.
- Extend it orthogonally.
- Extend again along the first axis.

The blocker is also extended along additionally visible faces (like the L-shaped blocker).
2D \( \frac{1}{2} \) Case

- Space subdivision: Quadtree.
- Scene discretization: Record the height of the highest and lowest points of every primitive.
  - Voxels are occluded if they are inside the shaft up to their maximum height.
  - Voxels are occluders up to their minimum height.
- Blocker extension: Same as 2D.
- Shafts: Same as 3D.
- Difference: Children may be hidden, but not necessarily their parent $\rightarrow$ Store the height up to which a voxel is hidden.
Results