IMGD 3000 - Technical Game Development I: Scene Management

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Overview

- Graphics cards can render a lot, very fast
  - But never as much, or as fast as we'd like!
- Intelligent scene management allows us to squeeze more out of our limited resources
  - Scene graphs
  - Scene partitioning
  - Visibility calculations
  - Level of detail control

Scene Graphs

- A specification of object and attribute relationships
  - Spatial
  - Hierarchical
  - Material properties
- Transformations
- Geometry
- Easy to attach objects together
  - Riding a vehicle

Scene Graphs (cont.)

- Can use instances to save resources
  - Geometry handles instead of geometry
  - Texture handles
- To take advantage of GPUs, reducing the amount of shader (cg) and texture switching is preferred

Geometry Sorting and Culling

- Keys to scene management
  - Render only what can be seen
  - Render at a satisfactory, perceivable fidelity
  - Pre-process what you can
  - Use GPU as efficiently as you can
- First-level
  - View-frustum culling
  - Back-face culling
  - Bounding sphere
- One or more ***acceleration structures*** can be used

Acceleration Structures

- Hierarchical bounding structures
  - Test if parent is visible
    - If not, then none of its children are
    - If so, then recursively check the children
- Could use information about your application to optimize approach
  - Many interior levels have cells and portals
  - No need to solve the general problem, just the specific one

Acceleration Structures

- Many structures exist
  - Appropriateness depends on the scene, and the game (e.g., dynamic objects)
- Space partitioning
  - Uniform Grid
  - Quad/Oct Tree
  - Binary-Space Partitioning (BSP) trees
  - k-d trees
- Geometry partitioning
  - Bounding boxes/spheres/capsules

Acceleration Structures - Space Partitioning

- Uniform Grids
  - Split space up into equal sized (or an equal number of) cells
- Quad (Oct) Trees
  - Recursively split space into 4 (8) equal-sized regions
- Binary-Space Partitioning (BSP) trees
  - Recursively divide space along a single, arbitrary plane
- *k*-dimensional trees (k-d trees)
  - Recursively

Acceleration Structures - Object Partitioning

- Bounding boxes/spheres/capsules
- Axis-Aligned Bounding Boxes (AABB)
- Oriented Bounding Boxes (OBB)
- Discrete Oriented Polytope (DOP)
  - Polytope: 2D = polygon, 3D = polyhedron
  - *k*-DOP: *k* planes in a DOP
  - Common: 6-DOP (AABB), 10-DOP, 18-DOP, 24-DOP
- Bounding-Volume Hierarchies (BVHs)

Cell-Portal Visibility

- Keep track of which cell the viewer is in
- Somehow enumerate all the visible regions
- Cell-based
  - Preprocess to identify the potentially visible set (PVS) for each cell
- Point-based
  - Compute at runtime
- Trend is toward point-based, but cell-based is still very common
  - Why choose one over the other?

Visibility of Cells

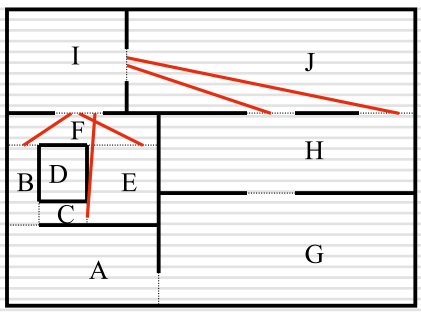
- Point-based algorithms compute visibility from a specific point
  - Which point?
  - How often must you compute visibility?
- Cell-based algorithms compute visibility from an entire cell
  - Union of the stuff visible from each point in the cell
  - How often must you compute visibility?
- Which method has a smaller potentially visible set?
- Which method is suitable for pre-computation?

Potentially Visible Set (PVS)

- PVS: The set of cells/regions/objects/polygons that can be seen from a particular cell
  - Generally, choose to identify objects that can be seen
  - Trade-off is memory consumption vs. accurate visibility
- Computed as a pre-process
  - Have to have a strategy to manage dynamic objects
- Used in various ways:
  - As the only visibility computation - render everything in the PVS for the viewer's current cell
  - As a first step - identify regions that are of interest for more accurate run-time algorithms

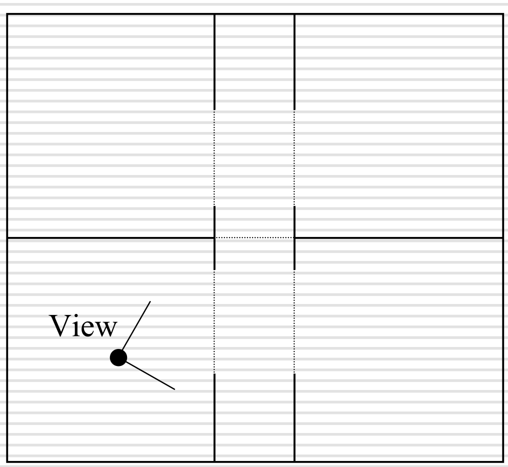
Cell-to-Cell PVS

- Cell A is in cell B's PVS if there exists a *stabbing line* from a portal of B to a portal of A
  - *Stabbing line:* a line segment intersecting only portals
  - Neighbor cells are trivially in the PVS

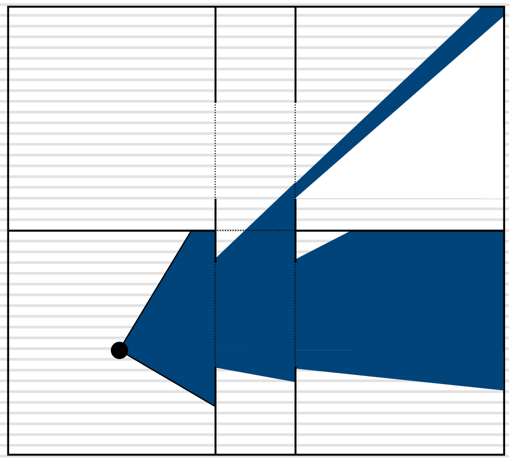


PVS for I contains:
B, C, E, F, H, J

Eye-to-Region Example (1)



Eye-to-Region Example (2)



Putting it all Together

- The "best" solution will be a combination
  - Static things
    - Oct-tree for terrain
    - Cells and portals for interior structures
  - Dynamic things
    - Quick reject using bounding spheres
    - BVHs for objects
- Balance between pre-computation and run-time computation

References

- http://www.cs.wisc.edu/graphics/Courses/679-f2003/