Point Reprojection and Dynamic Scenes

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Overview

- Point reprojection
- Animation

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Point Reprojection

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Brute Force Ray Tracing:

- Enables interactive ray tracing
- Does not allow large image sizes
- Does not scale to scenes with high depth complexity

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Solution:

- Exploit temporal coherence
- Re-use results from previous frames

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Practical Solutions:

- Tapestry (Simmons et. al. 2000)
  - Focuses on complex lighting simulation
- Render cache (Walter et. al. 1999)
  - Addresses scene complexity issues
  - Explained next
- Parallel render cache (Reinhard et. al. 2000)
  - Builds on Walter's render cache
  - Explained next

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Render Cache Algorithm

Basic setup

- One front-end for:
  - Displaying pixels
  - Managing previous results
- Parallel back-end for:
  - Producing new pixels

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Render Cache Front-end

Frame based rendering

For each frame do:

- Project existing points
- Smooth image and display
- Select new rays using heuristics
- Request samples from back-end
- Insert new points into point cloud

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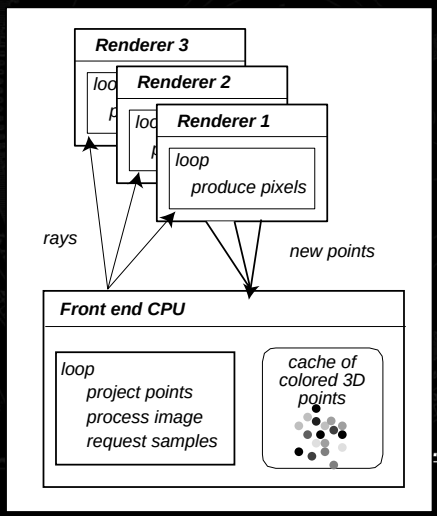
Render Cache



Render Cache (2)

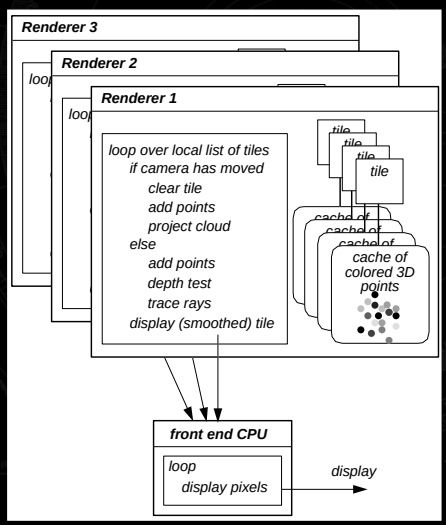
- Point reprojection is relatively cheap
- Smooth camera movement for small images
- Does not scale to large images or large numbers of renderers → front-end becomes bottleneck

Parallel Render Cache

Aim: remove front-end bottleneck

- Distribute point reprojection functionality
- Integrate point reprojection with renderers
- Front-end only displays results

Parallel Render Cache (2)



Parallel Render Cache (3)

Features:

- Scalable behavior for scene complexity
- Scalable in number of processors
- Allows larger images to be rendered

- Retains artifacts from render cache
- Introduces new artifacts

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Artifacts

- Render cache artifacts at tile boundaries
- Image deteriorates during camera movement

These artifacts are deemed more acceptable than loss of smooth camera movement!

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Test Scenes

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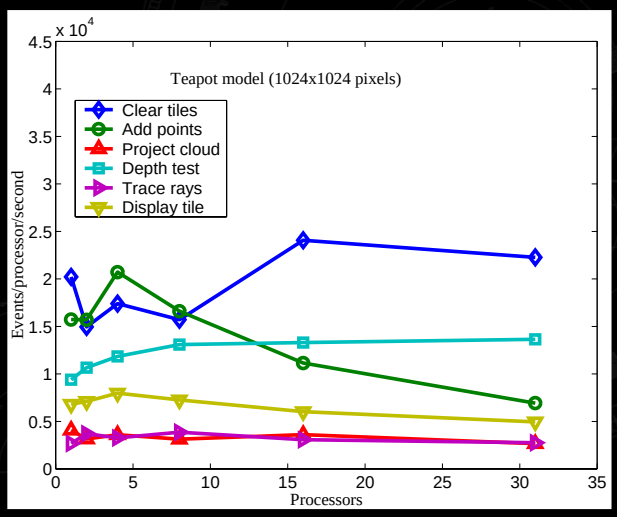
Results

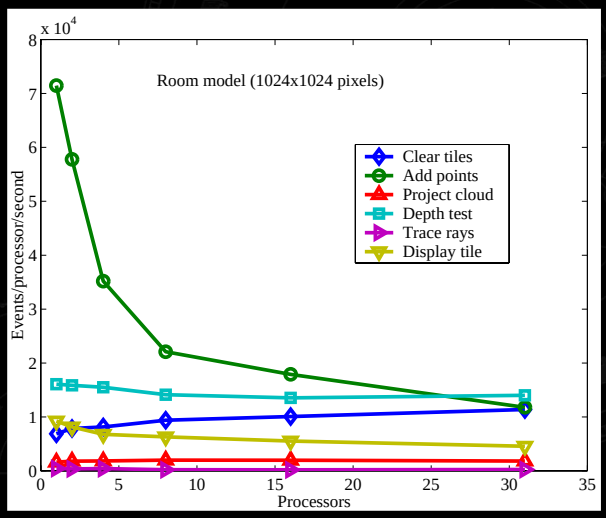
Sub-parts of algorithm measured individually

- Measure time per call to subroutine
- Sum over all processors and all invocations
- Afterwards divide by number of processors and number of invocations
- Results are measured in events per second per processor

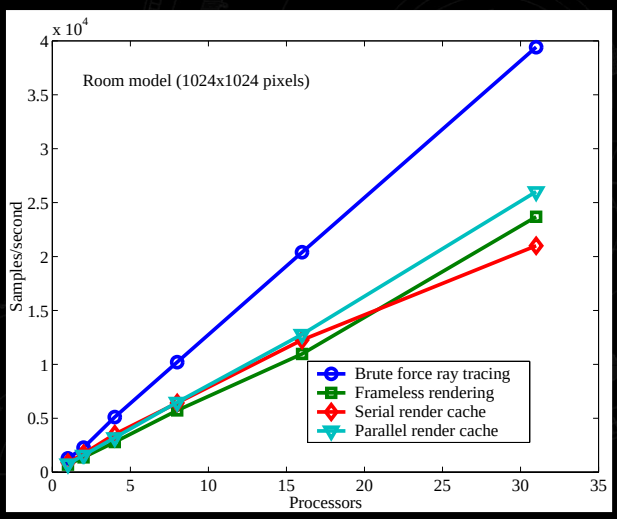
Scalability (Teapot Model)



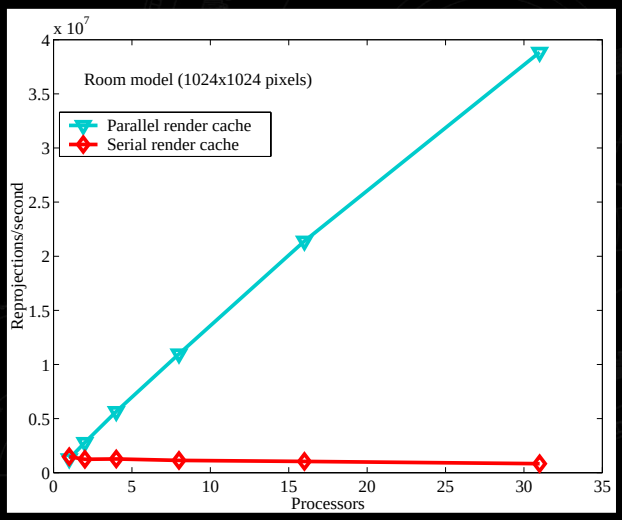
Scalability (Room Model)



Samples Per Second



Reprojections Per Second



Conclusions

- Exploitation of temporal coherence gives significantly smoother results than available with brute force ray tracing alone
- This is at the cost of some artifacts which require further investigation
- (More results available in course notes)

Overview

- Point reprojection
- Animation

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Animation

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Why Animation

- Once interactive rendering is feasible, walk-through is not enough
- Desire to manipulate the scene interactively
- Render preprogrammed animation paths

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Issues to Be Addressed:

What stops us from animating objects?

- Answer: spatial subdivisions
- Acceleration structures normally built during pre-processing
- They assume objects are stationary

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Possible Solutions:

Target applications that require a small number of objects to be manipulated/animated

- Render these objects separately
  - Traversal cost will be linear in the number of animated objects
  - Only feasible for extremely small number of objects

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Possible Solutions (2)

Target small number of manipulated or animated objects

- Modify existing spatial subdivisions
  - For each frame delete object from data structure
  - Update object's coordinates
  - Re-insert object into data structure
- This is our preferred approach

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Spatial Subdivision Should Be Able to Deal With the Following:

- Basic operations such as insertion and deletion of objects should be rapid
- User manipulation can cause the extent of the scene to grow

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Subdivisions Investigated:

- Regular grid
- Hierarchical grid
  - Borrows from octree spatial subdivision
  - In our case this is a full tree: all leaf nodes are at the same depth

Both acceleration structures are investigated in the next few slides

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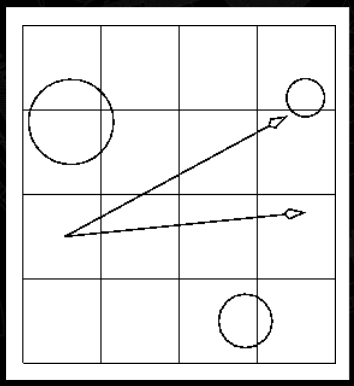
Regular Grid Data Structure

We assume familiarity with spatial subdivisions!



Object Insertion Into Grid

- Compute bounding box of object
- Compute overlap of bounding box with grid voxels
- Object is inserted into overlapping voxels

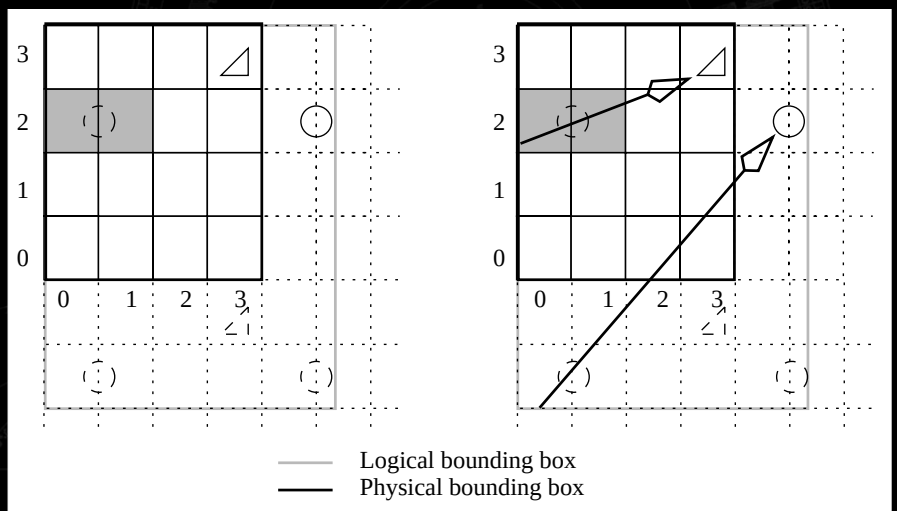
- Object deletion works similarly

Extensions to Regular Grid

Dealing with expanding scenes requires

- Modifications to object insertion/deletion
- Ray traversal

Extensions to Regular Grid (2)



Features of New Grid Data Structure

We call this an 'Interactive Grid'

- Straightforward object insertion/deletion
- Deals with expanding scenes

- Insertion cost depends on relative object size
- Traversal cost somewhat higher than for regular grid

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Hierarchical Grid

Objectives

- Reduce insertion/deletion cost for larger objects
- Retain advantages of interactive grid

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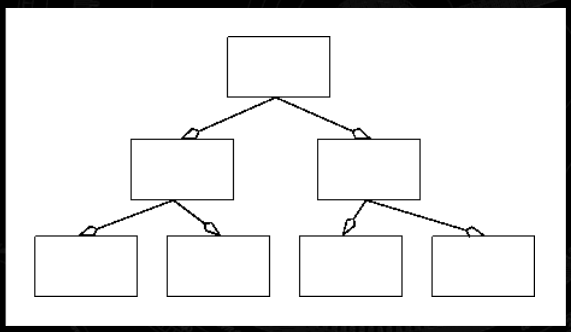
Hierarchical Grid (2)



Hierarchical Grid (3)

Build full octree with all leaf nodes at the same level

- Allow objects to reside in leaf nodes as well as in nodes higher up in the hierarchy
- Each object can be inserted into one or more voxels of at most one level in the hierarchy
- Small object reside in leaf nodes, large objects reside elsewhere in the hierarchy

Hierarchical Grid (4)

Features:

- Deals with expanding scenes similar to interactive grid
- Reduced insertion/deletion cost
- Traversal cost somewhat higher than interactive grid

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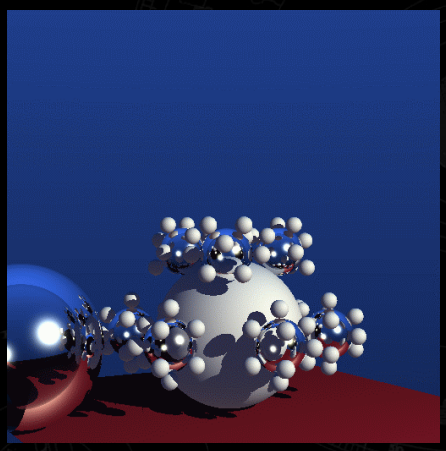
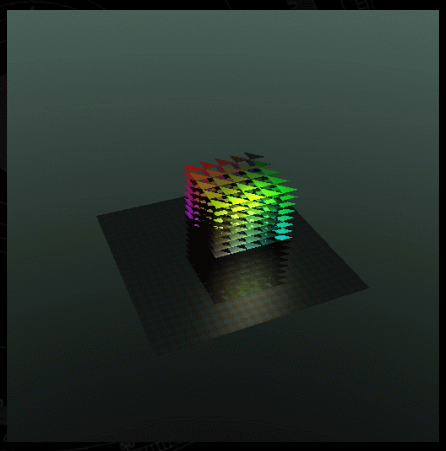
Test Scenes





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Video

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Measurements

We measure:

- Traversal cost of
  - Interactive grid
  - Hierarchical grid
  - Regular grid
- Object update rates of
  - Interactive grid
  - Hierarchical grid

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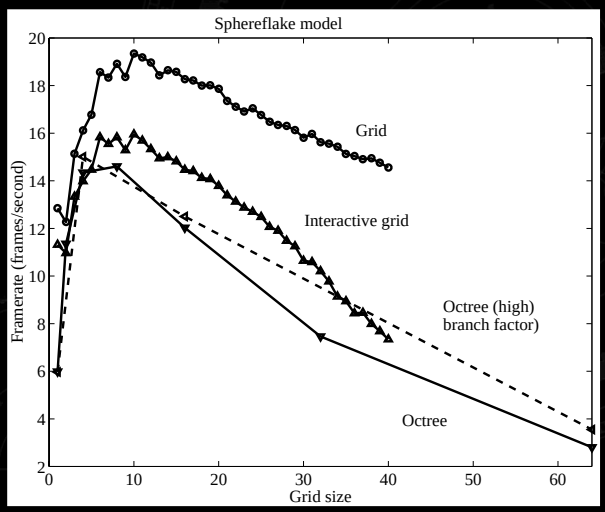
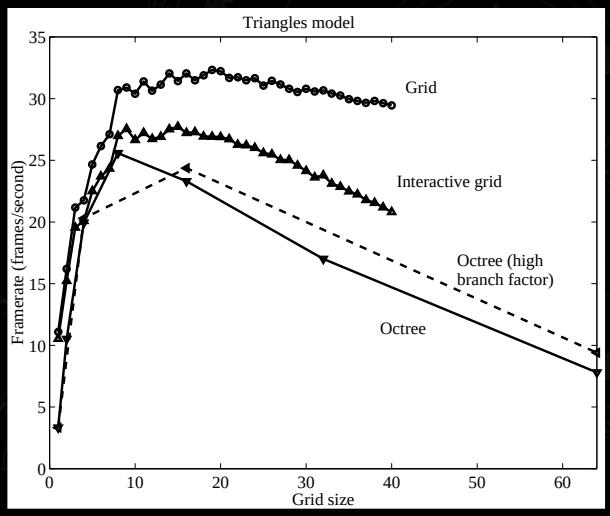
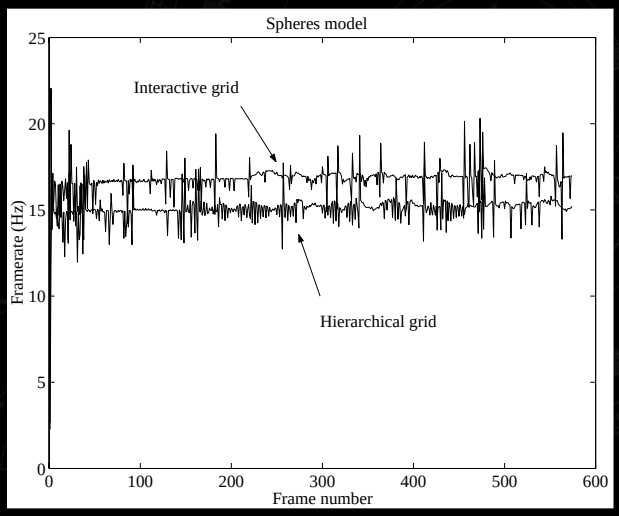
Framerate vs. Grid Size (Sphereflake)



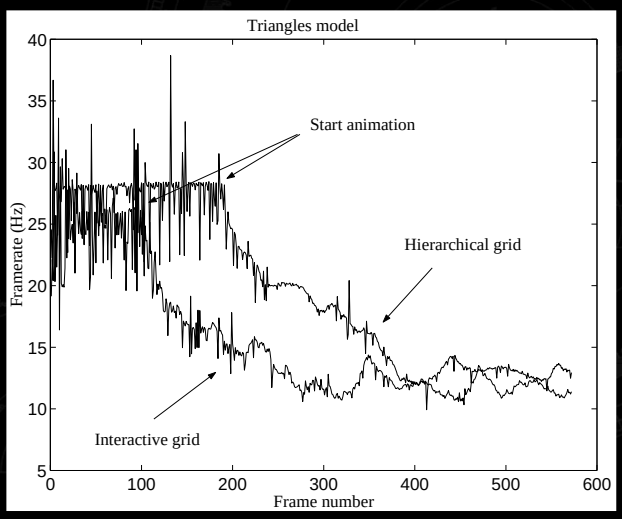
Framerate vs. Grid Size (Triangles model)



Framerate Over Time (Sphereflake Model)



Framerate Over Time (Triangles Model)



Conclusions

- Interactive manipulation of ray traced scenes is both desirable and feasible using these modifications to grid and hierarchical grids
- Slight impact on traversal cost
- (More results available in course notes)

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Acknowledgements

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