Lecture 20: LODs

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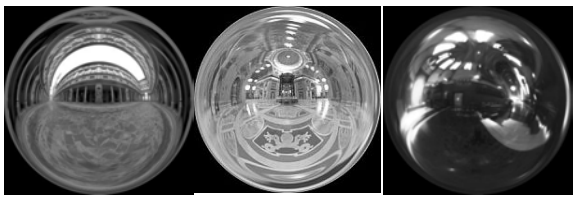
Research on many lights

- Ward '91
- Shirley, Wang, Zimmerman '94
- Fernandez, Bala, Greenberg '02
- Wald and Slusallek '03
- Environment Map Sampling…

Rendering w/ Environment Maps

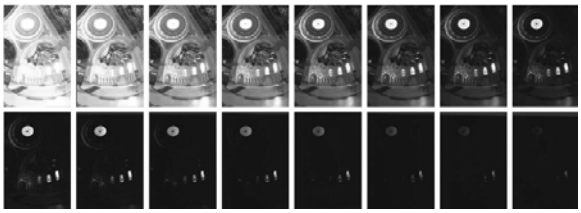
- High lighting complexity



- Rich: captures real world

High-Dynamic Range Imagery

- Multiple Exposures

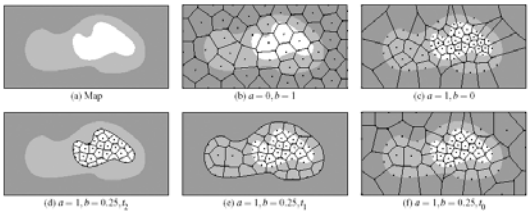


Sampling Environment Maps

- Say we have a fixed budget of samples
  - Say 300 or 3000
- Goal: sample environment maps $L^a \Delta\omega^b$
- Basic idea: sample according to …
  - Illumination importance sampling: over-samples small bright lights
  - Area-based stratified sampling: distribute samples over area (under-samples bright lights)

New Metric

- Instead $L\Delta\omega^{\frac{1}{4}}$

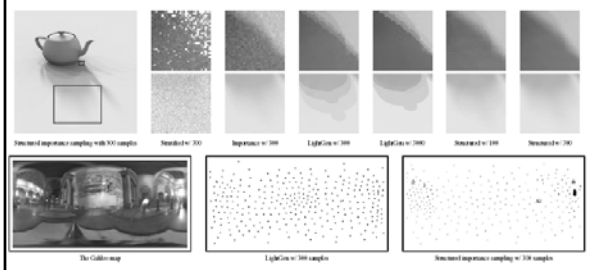


Hierarchical Threshold

- Create regions from $i\sigma$ to $(i+1)\sigma$
- Distribute samples in region according to metric

$$N_j = N\frac{Metric_j}{Metric_{map}}$$

- Distribute samples in each region according to Hochbaum-Shmoys
  - Minimize maximum distance



Summary

- Rendering with many lights remains an open problem
  - Techniques are linear in number of lights
  - Hard to handle visibility
- Some interesting new approaches needed for interactive rendering with many lights

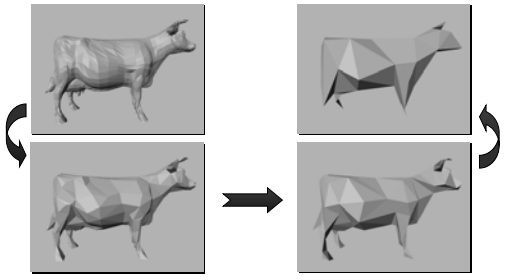
Complexity

- Lighting: many lights, environment maps
  - Global illumination, shadows
- Materials: BRDFs, textures
- Geometry: Level-of-detail, point-based representations
- All: impostors, image-based rendering

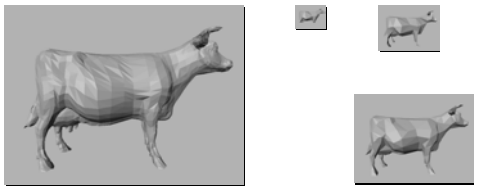
LOD

- What is Level of detail used for?
- When close, want detail
- When far, want approximation
- *Level of Detail* (LOD) techniques draw models at different resolutions depending on their relevance to the viewer

LOD Models (I)

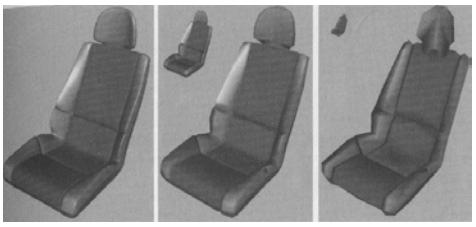


LOD Models (II)



LOD Models (3)

- Effect of LOD less obvious if smooth shaded
- Note also that shading changes with LOD



Standard LOD

- Used in games
  - Finite set of models
  - Hand generated
  - Or using automatic decimation/simplification
- Use of LODs: based on distance from eye or projected screen size

Issues with LODs

- LOD Creation
- LOD Selection: Choosing which model to display
- LOD Switching: Artifact-free switching between LODs

Selecting LOD Models

- For any given frame, decide what resolution to display
- Option 1: Choose each object's resolution independently
  - For example, use projected area or distance
  - The current standard practice: fast, simple
  - Potential problem: total # polygons may be large
- Option 2: Fix number of polygons and choose models to fit in budget
  - Ensures near constant frame rate, but harder to implement

LOD Switching

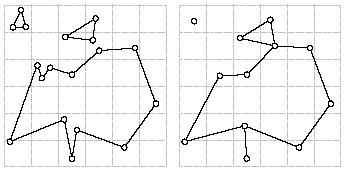
- Popping when models switched
- Popping is visually disturbing
  - Why?
  - Flickering when at threshold
- Solutions:
  - Have more resolutions in hierarchy
  - Blend two resolutions
    - Image blend: draw both resolutions
    - Geometry blend: morph between resolutions

Creating the LOD

- Convert high resolution *base mesh* to hierarchy of lower resolution meshes
- Desirable properties:
  - Fast (although not real-time)
  - Generates "good" approximations in some sense
  - Handles a wide variety of input meshes
  - Allows for geometric blending

Vertex Clustering

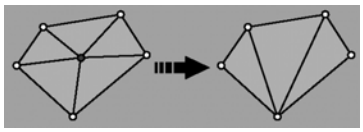
- Spatial partition
- Merge all vertices in a cell
- Fast but not good quality



Before After

Vertex Decimation

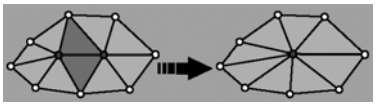
- Starting with original model, iteratively
  - rank vertices according to importance
  - Remove unimportant vertex, retriangulate
  - a fairly common technique



Slide courtesy Michael Garland, http://graphics.cs.uiuc.edu/~garland

Iterative Edge Contraction

- Contraction can operate on any set of vertices
  - edges (or vertex pairs) are most common
- Starting with the original model, iteratively
  - rank all edges with some cost metric
  - contract minimum cost edge
  - update edge costs



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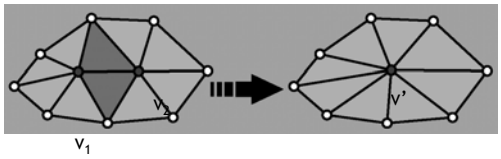
Edge Contraction

- Single edge contraction $(v_1, v_2) \rightarrow v'$ is performed by
  - moving v_1 and v_2 to position v'
  - replacing all occurrences of v_2 with v_1
  - removing v_2 and all degenerate triangles



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Operations to Algorithms

- One operation doesn't reduce a mesh!
- Use greedy algorithm: *iterative edge contractions*
  - Rank each possible edge contraction
  - Contract edge that introduces the least error
  - Repeat until done
- Does NOT produce optimal meshes
  - An optimal mesh has lowest error
  - But optimal mesh computation is intractable (NP-hard)

Summary

- LODs used extensively in interactive applications
- Other work
  - Progressive meshes
- But, can handle only single objects
- What about trees?