

Level of Detail: View-Dependent Simplification



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(slides based on those of David Luebke @ NVIDIA)



View-Dependent LOD: Algorithms

- Many good published algorithms:
 - *Progressive Meshes*
 - *Hierarchical Dynamic Simplification*
 - *Multitriangulation*
 - Others...



Overview: The VDS Algorithm

- Overview of the VDS algorithm:
 - A preprocess builds the *vertex hierarchy*, a hierarchical clustering of vertices
 - At run time, clusters appear to grow and shrink as the viewpoint moves
 - Clusters that become too small are collapsed, filtering out some triangles



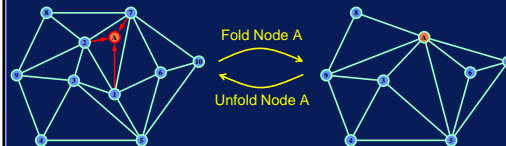
Data Structures

- The *vertex tree*
 - Represents the entire model
 - Hierarchy of *all* vertices in model
 - Queried each frame for updated scene
- The *active triangle list*
 - Represents the current simplification
 - List of triangles to be displayed
 - Triangles added and deleted by operations on vertex tree

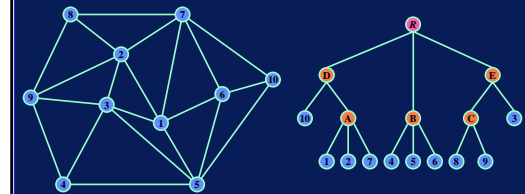


The Vertex Tree: Folding And Unfolding

- *Folding* a node collapses its vertices to the proxy
- *Unfolding* the node splits the proxy back into vertices

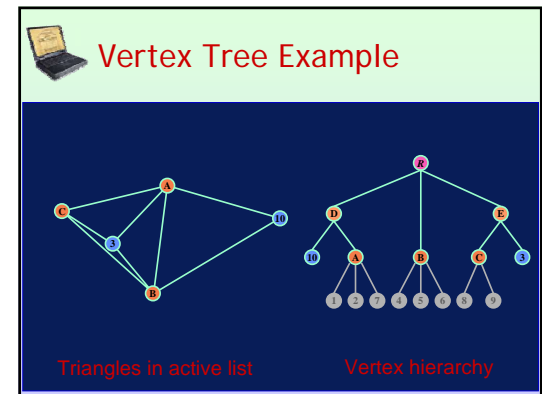
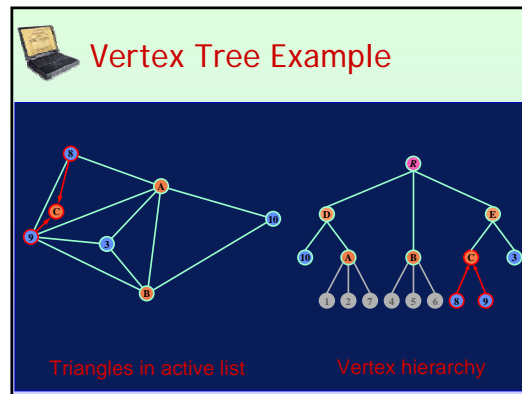
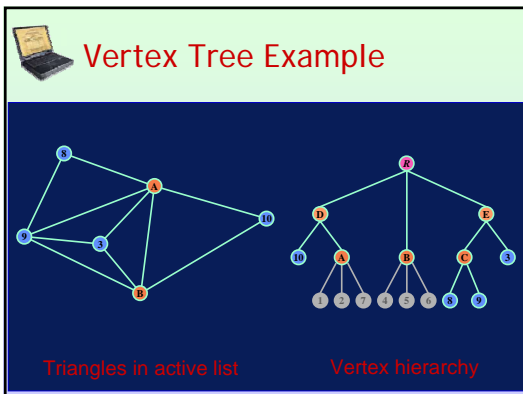
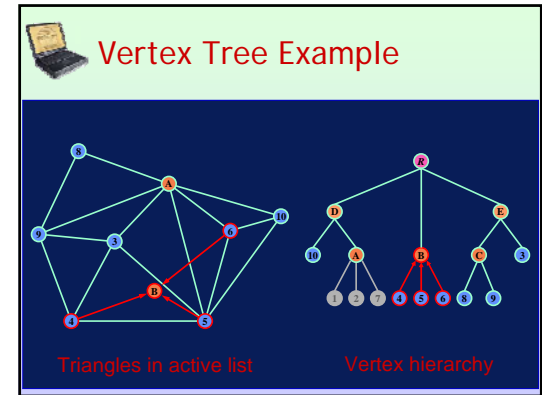
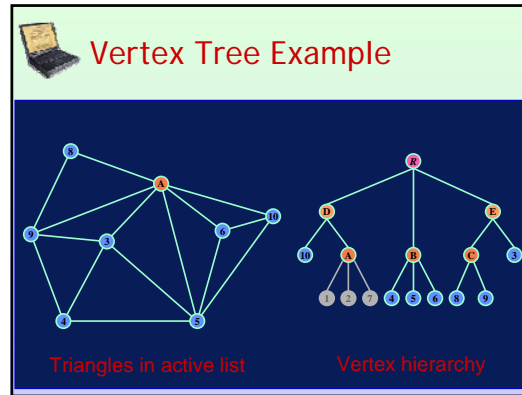
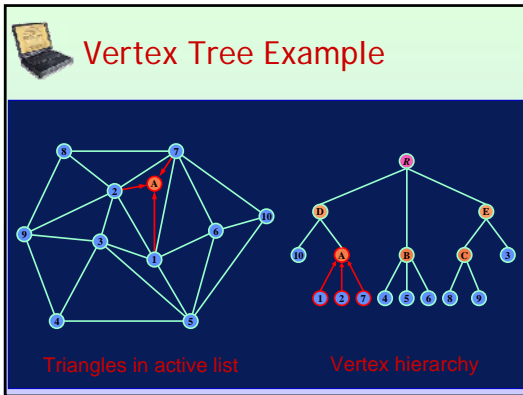


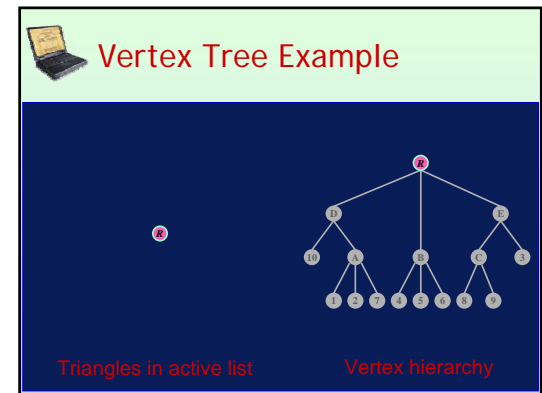
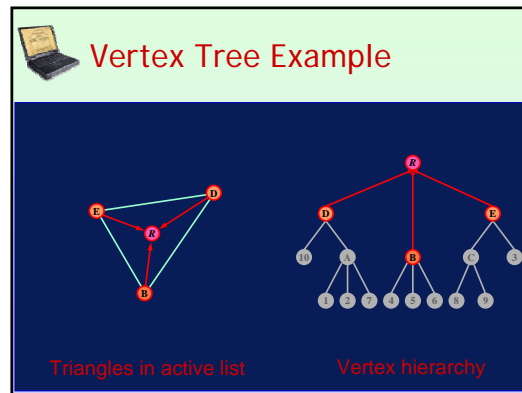
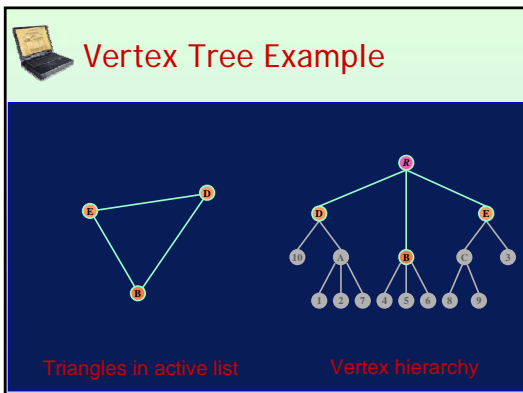
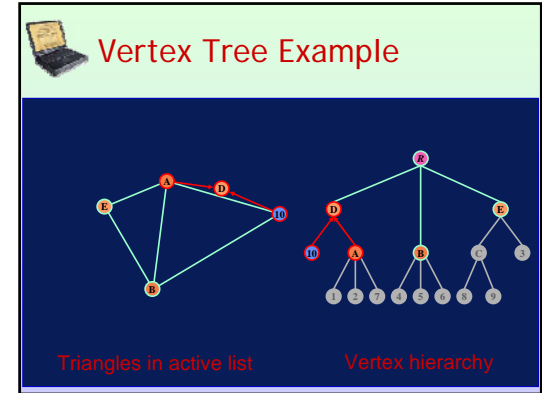
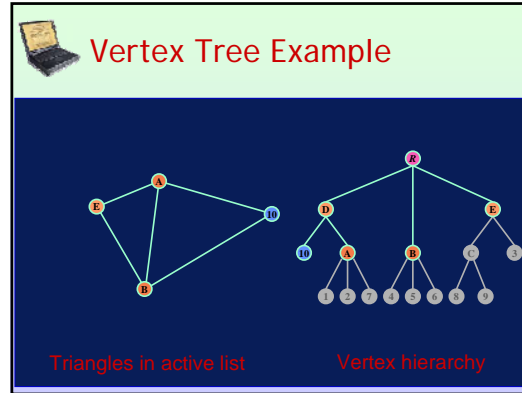
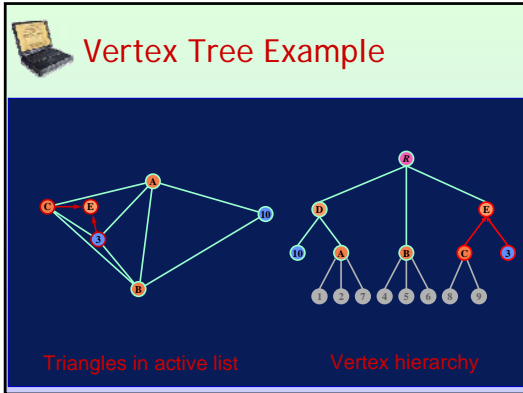
Vertex Tree Example



Triangles in active list

Vertex hierarchy





The Vertex Tree

- At runtime, folds and unfolds create a cut or *boundary* across the vertex tree:

This part of the model is represented at high detail

This part in low detail

View-Dependent Simplification

- Any run-time criterion for folding and unfolding nodes may be used
- Examples of view-dependent simplification criteria:
 - Screenspace error threshold
 - Silhouette preservation
 - Triangle budget simplification
 - Gaze-directed perceptual simplification

Screenspace Error Threshold

- Nodes chosen by projected area
 - User sets screenspace size threshold
 - Nodes which grow larger than threshold are unfolded

Silhouette Preservation

- Retain more detail near silhouettes
 - A *silhouette node* supports triangles on the visual contour
 - Use tighter screenspace thresholds when examining silhouette nodes

Triangle Budget Simplification

- Minimize error within specified number of triangles
 - Sort nodes by screenspace error
 - Unfold node with greatest error, putting children into sorted list
 - Repeat until budget is reached

Asynchronous Simplification

- Algorithm partitions into two tasks:
 - Run them in parallel



Asynchronous Simplification

- If S = time to simplify, R = time to render:
 - Single process = $(S + R)$
 - Pipelined = $\max(S, R)$
 - Asynchronous = R
- The goal: efficient utilization of GPU/CPU



Temporal Coherence

- Exploit the fact that frame-to-frame changes are small
- Three examples:
 - Active triangle list
 - Vertex tree



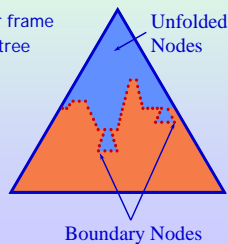
Exploiting Temporal Coherence

- Active triangle list
 - Could calculate active triangles every frame
 - But...few triangles are added or deleted each frame
 - Idea: make only incremental changes to an *active triangle list*
 - Simple approach: doubly-linked list of triangles
 - Better: maintain coherent arrays with swapping



Exploiting Temporal Coherence

- Vertex Tree
 - Few nodes change per frame
 - Don't traverse whole tree
 - Do local updates only at *boundary nodes*



VDSLlib

- Implementation: *VDSLlib*
 - A public-domain view-dependent simplification and rendering package
 - Flexible C++ interface lets users:
 - Construct vertex trees for objects or scenes
 - Specify with callbacks how to simplify, cull, and render them
 - Available at <http://vdslib.virginia.edu>



GLOD

- An easy-to-use library for level of detail in OpenGL
 - LOD generation
 - LOD run-time management
 - View-dependent LOD (using VDSLlib)

<http://www.cs.jhu.edu/~graphics/GLOD>