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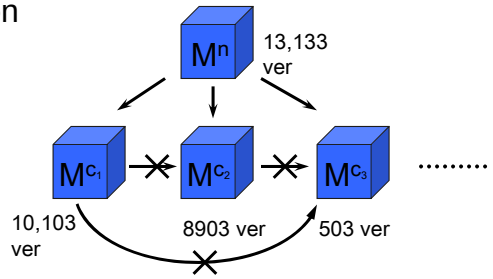
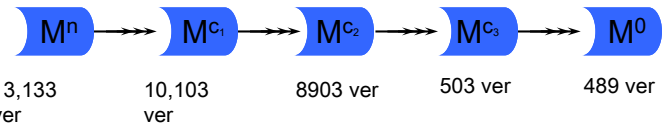
Simplification II: Progressive meshes

Progressive Meshes

- Basic simplification



- Progressive mesh



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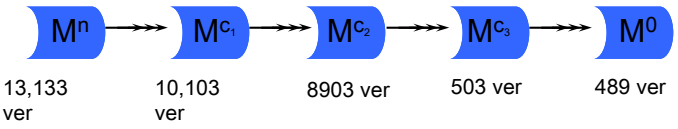
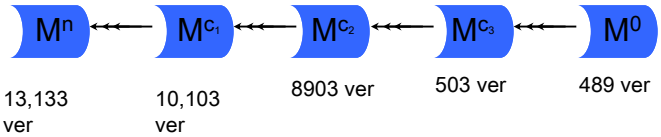
Progressive Meshes

- Simplification



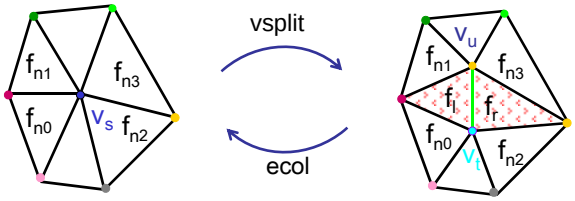
13,133 ver | 10,103 ver | 8903 ver | 503 ver | 489 ver

- Refinement



13,133 ver | 10,103 ver | 8903 ver | 503 ver | 489 ver

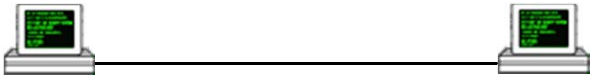
Definition of vsplit and ecol

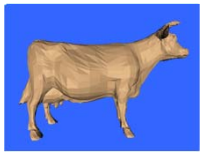


- ecol changes
  - Connectivity - $\{v_u, v_t\}$ is removed
  - Geometry - v_t and v_u disappear & v_s is created (somewhere)
- V_s is *parent* of V_u & V_t
- V_u and V_t are *children* of V_s

Progressive Transmission

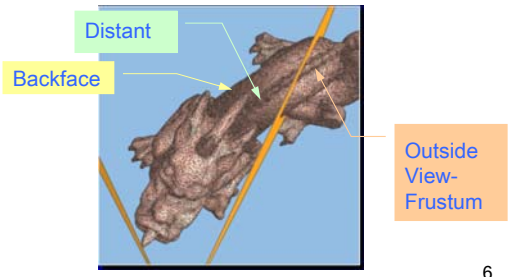
- Base mesh (M^0) transmitted first
- Refinement records transmitted later & mesh reconstructed progressively





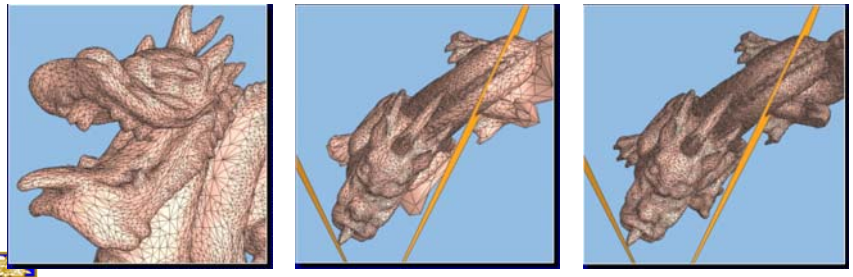
View-Dependent Refinement

- Problem:
  - Large parts of rendered models are hidden
    - Hidden faces are view dependent
  - Basic simplification: all faces rendered at same LOD
    - Waste effort rendering hidden faces



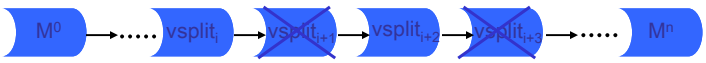
View-Dependent Refinement

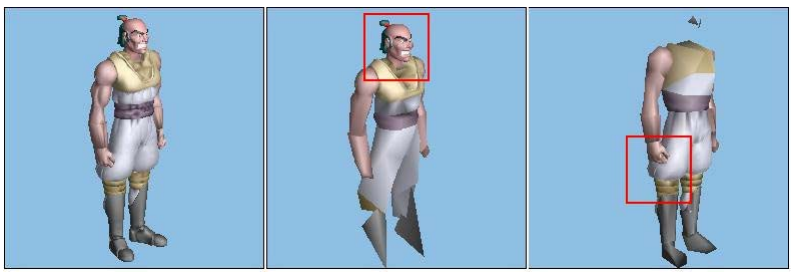
- Goal:
  - Generate progressive representation of mesh s.t. *only some* faces are simplified & others are fully detailed



Selective Refinement

- Refine only in desired area

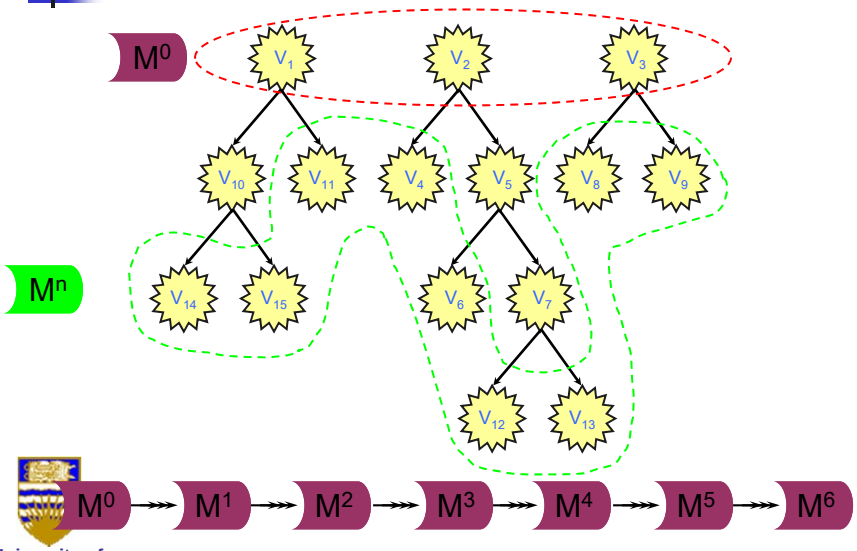




Vertex Hierarchy

- Generate Parent-Child forest by combining Progressive Mesh representation with Parent-Child relationship
- M^0: Set of root vertices (most simplified mesh)
- M^n: Set of leaves of the forest (original mesh)

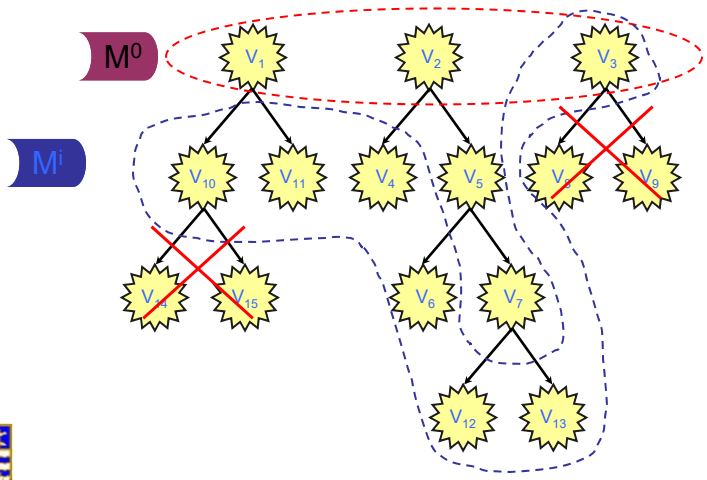
Vertex Hierarchy



Selective Refinement

- Given vertex hierarchy forest - selective refinement mesh generated by using selective, out-of-order vsplits and ecols operations
- Current refined/simplified mesh is vertex front in the forest

Selective Refinement

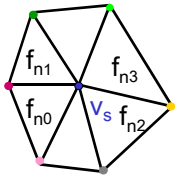


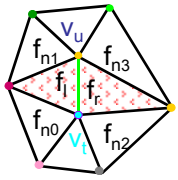
Is This Enough ?

- Is Selective-Refinement data-structure enough for View-Dependent operations ?

Legal Operations

- Face/vertex is *active* if it exists in current front
- **Legal vsplit:**
  - V_s is active vertex
  - Faces $\{f_{n0},f_{n1},f_{n2},f_{n3}\}$ are all active
- **Legal ecol:**
  - V_t & V_u are both active
  - Faces $\{f_{n0},f_{n1},f_{n2},f_{n3}\}$ are adjacent to f_l & f_r





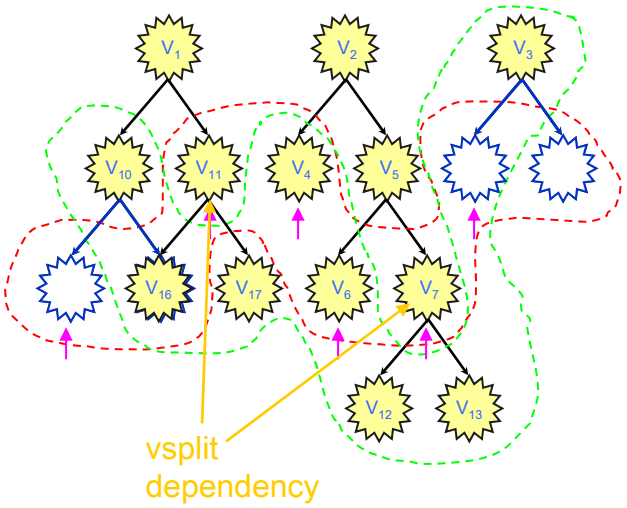
Data-Structure Implementation

- To achieve a real-time View-Dependent algorithm need efficient data-structure to maintain vertices & faces information
  - Vertex list array - holds vertices that participate in View-Dependent model
  - Active vertices list - holds current mesh front
  - Faces & active faces lists

View-Dependent Algorithm

- Traverse active-vertex-front before each rendering operation
- For each vertex test if vertex should be
  - Refined
  - Simplified
  - Left as it is
- Perform simplification operations (ecol) **only if legal**
- Perform **all** refine operations (vsplit)
  - to make it legal (sometimes) perform additional vsplit operations

View-Dependent Alg



Refinement Criteria

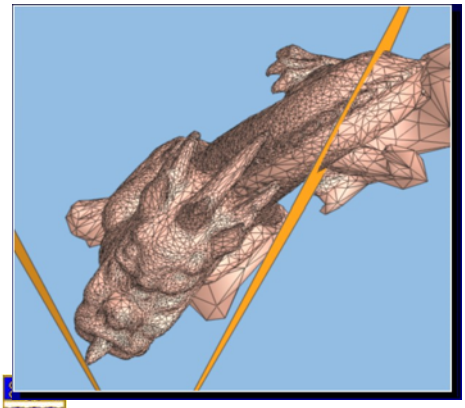
- View-Frustum Criterion:
  - Each original mesh vertex is center of sphere containing all its neighbors
  - Vertex considered **outside** view-frustum if its associated sphere is outside

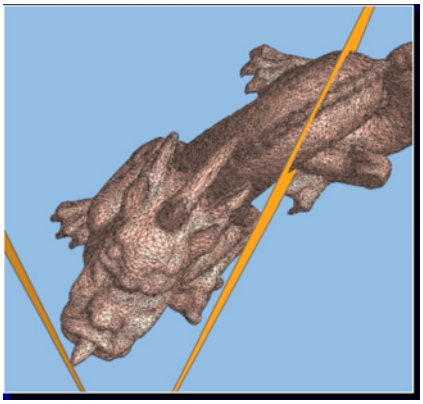
$$a_i v_x + b_i v_y + c_i v_z + d_i < -r_v$$
$$\| (a_i, b_i, c_i) \| = 1$$

  - (v_x, v_y, v_z) - vertex v position
  - (a_i, b_i, c_i, d_i) for $i=1\ldots4$ - frustum faces
  - r_v – radius of sphere associated with v

Refinement Criteria

- View-Frustum Criterion:



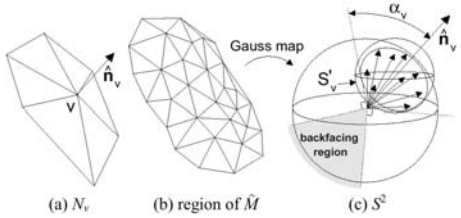


Refinement Criteria

- Surface Orientation:
  - Each mesh vertex associated with cone in direction of its normal with angle α_v
  - Given viewpoint e - it is unnecessary to split v if:

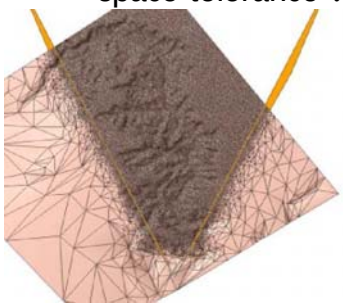
$$(v-e)\cdot\hat{n}_v > 0 \quad \&$$

$$((v-e)\cdot\hat{n}_v)^2 > \|v-e\|^2 \sin^2\alpha_v$$

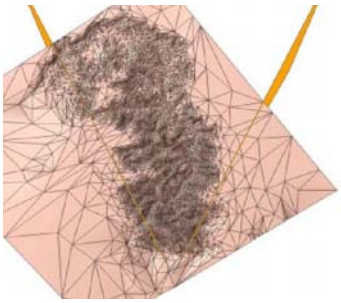


Refinement Criteria

- Screen-Space Geometric error:
  - Refine mesh only if distance between approximated & original surfaces **when projected on the screen** is larger than screen-space tolerance τ

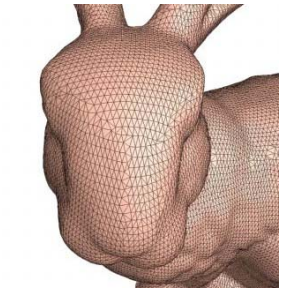


τ = 0%

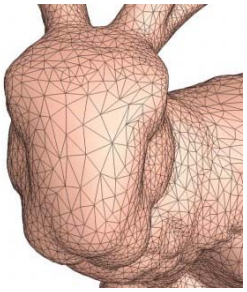


τ = 0.33%

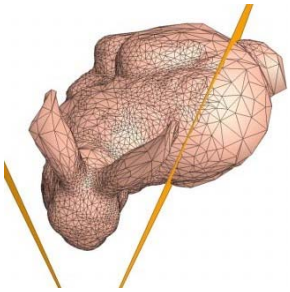
Examples



Original

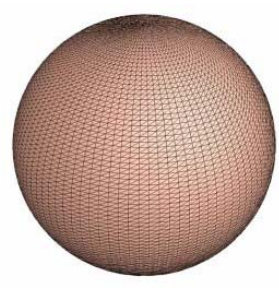


Simplified

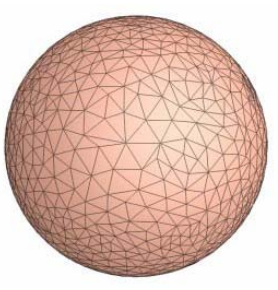


Top-View

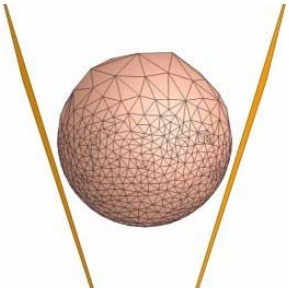
Examples (cont')



Original



Simplified



Top-View