Progressive Mesh Decimation

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Main Topics

Introduction to surface representation

Mesh simplification

Mesh compression

Procedural Representation

Procedural Representation

- mathematic functions
- small data
- slow solving of complex functions
- NURBS, etc.
- usually represented by polygonal representation at the end of visualization pipeline

Polygonal Representation

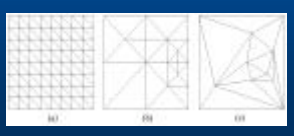
Polygonal Representation

- mesh of polygons (usually triangles - faces)
- types of mesh
  - semi regular (a)
  - semi regular, hierarchicaly divided (b)
  - irregular (c.)
- usually hw accelerated

Polygonal Representation 2

Polygonal model definiton

- topology - object at all
- geometry - vertices positions
- connectivity - edges between vertices



Mesh simplification

Must be preserved

- shape
  - planar area
  - sharp edges
  - pointed edges
- topology
- aproximation error
- manifoldability

Goals of simplification

Continual LOD

Progressive loading of shape

Lowering amount of data

Faster work

Polygonal simplification - operators

Normalization
Vertex simplification
Edge simplification
Angle-based simplification
Face size simplification
Face normal simplification

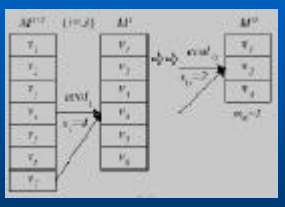
Polygonal simplification - categories

Geometry Removal

Adaptive Subdivision

Sampling

Progressive Meshes



$$\left(\hat{M} = M^{n}\right) \xrightarrow{ecol_{n-1}} \cdots \xrightarrow{ecol_{1}} M^{1} \xrightarrow{ecol_{0}} M^{0}$$

Mesh simplification - algorithms

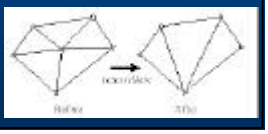
Mesh Decimation
Progressive Meshes
Full-Range Approximation of Triangulated Polyhedra

Mesh Decimation

Schroeder at al 92

Local characteristics
Multiple passes
For each pass:
- ***select all vertices matches criteria & remove***
- ***retriangulate***

Criterium: distance to plane/edge
Fast & Simple
Big memory allocation



Progressive Meshes

Hoppe 96

Energy function

- *closeness to original mesh*
- *proportions of triangles*
- *color and texture*
- *topology & normals*

Progressive Meshes 2

Steps:

- *Sort the edges using the least cost of simplification.*
- *Apply the edge collapse operator for the edge at the head of the list and record the corresponding vertex split in the progressive mesh structure (including color, texture and normal information).*
- *The position of the new vertex is chosen among the two initial vertices and the center of the edge, depending on which one is the closest to the original mesh.*
- *Recompute the cost for the edges that have been affected by the operator and reorder the list.*
- *If the list is empty or the cost of the next simplification exceeds a certain bound, the algorithm terminates and returns the final progressive mesh. Otherwise, return to step 2.*

Full-Range Approximation of Triangulated Polyhedra

Ronfard at al 96

Energy function

- *local tesselation error - normals must not overlap*
- *local geometric error - closeness to original mesh*

Steps:

- *Sort all edges by increasing cost.*
- *Apply the region merging operator to the first edge in the list.*
- *Modify the position of the resulting vertex to get it closer to the original mesh.*
- *Recompute the cost for modified edges and sort the list. The cost is accumulated at each iteration so that the simplification is more evenly distributed across the mesh.*
- *If the list is empty or if the cost for the next edge is higher than a threshold, the algorithm terminates. Else return to step 2.*

Mesh compression

Mesh simplification - simplify geometry

But: big data must be transmitted

each vertex:

- **[x,y,z]**
- **connectivity - list of vertex id or edge id**
- **normal [x,y,z]**
- **texture coordinates and/or color information**

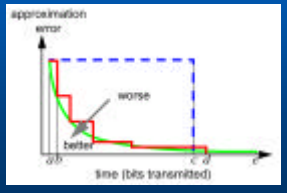
⇨Mesh compression

Progressive mesh transmission

Balance between accurancy and data amount

No multiple refining vertices

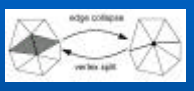
Estimation of vertices position

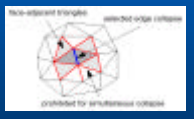


Mesh compression - steps

Steps:

- **create progressive mesh**
- **code diferences between levels of mesh only**
- **compress diferences**





Mesh compression - algorithms

Compressed Progressive Meshes
Progressive Geometry Compression

Compressed Progressive Meshes

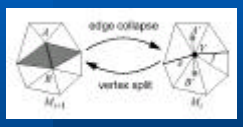
Pajarola at.al 99

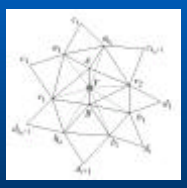
Batched simplification

Greedy selection
About 50% faces in one step

CPM prediction

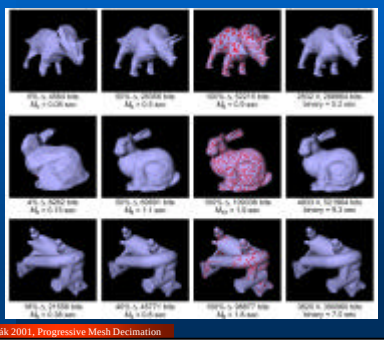
Geometry prediction





Only correction vector is sent

CPM results



Progressive Geometry Compression

Khodakovsky at.al 2000

Wavelet-based compression

Steps:

- resample model to semi-regular mesh
- apply Loop wavelet tranformation
- zerotree coding

PGC wavelet compression

$$\mathbf{p}^{j+1} = \begin{bmatrix} \mathbf{P} & \mathbf{Q} \end{bmatrix} \begin{bmatrix} \mathbf{p}^{j} \\ \mathbf{d}^{j} \end{bmatrix}$$

P & Q is low pass resp high pass recontruction filter
p is control point
d is wavelet coefficient

Vertex position magnitudes
Wavelet coefficient magnitudes

PGC zerotree coding

- **Send highest order bits of largest magnitude first**
- **If canonical traverse order is set**
  - **send significance test**
  - **send sign bit**
- **Create canonical sets which are below threshold**
- **Edge based quadtree**

PGC results

PGC x CPM

PGC

CPM

References

Progressive Geometry Compression, Andrei Khodakovsky, Peter Schröder, Wim Sweldens;
http://cm.bell-labs.com/who/wim/papers/compression/

A Topology Modifying Progressive Decimation Algorithm, William J. Schroeder;
http://citeseer.nj.nec.com/240504.html

Compressed Progressive Meshes, Renato Pajarola, Jarek Rossignac;
http://citeseer.nj.nec.com/pajarola00compressed.html

Progressive Simplicial Complexes, Jovan Popovic, Hugues Hoppe;
http://citeseer.nj.nec.com/popovic97progressive.html

Decimation of Triangle Meshes, William J. Schroeder, Jonathan A. Zarge, William E. Lorensen;
http://citeseer.nj.nec.com/schroeder92decimation.html

Face Fixer: Compressing Polygon Meshes with Properties, Martin Isenburg, Jack Snoeyink;
http://citeseer.nj.nec.com/isenburg00face.html

Mesh Reduction with Error Control, Reinhard Klein, Gunther Liebich, W. Straßer;
http://citeseer.nj.nec.com/klein96mesh.html

Out-of-Core Simplification of Large Polygonal Models, Peter Lindstrom;
http://citeseer.nj.nec.com/lindstrom00outcore.html

Software

JADE v2.1 : http://vcg.iei.pi.cnr.it/swOnTheWeb.html
Progressive Geometry Compression:
http://cm.bell-labs.com/who/wim/papers/compression/

That's all

Thank you for your time and attention

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