Progressive Compression for Lossless Transmission of Triangle Meshes

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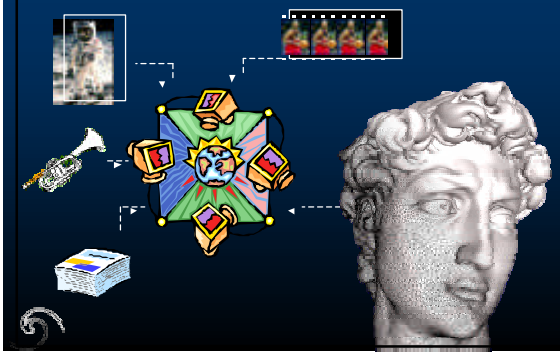
SIGGRAPH 2001

Context: Transmission of 3D



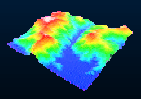
3D Data Compression

Games

Virtual malls

Medical

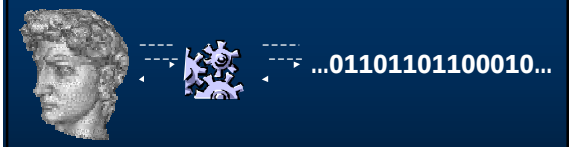
Engineering

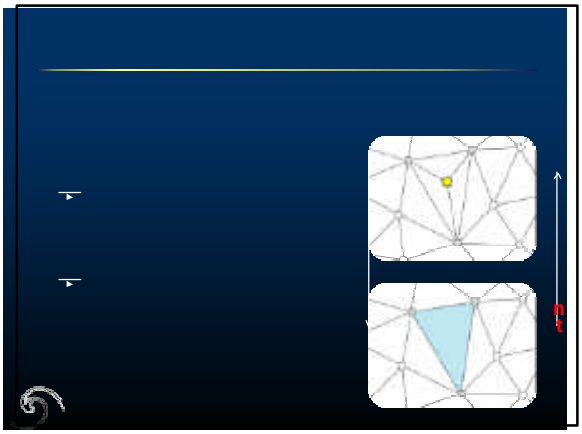


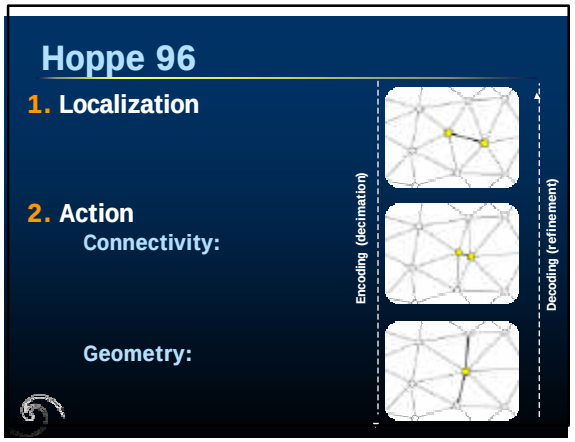
Topography

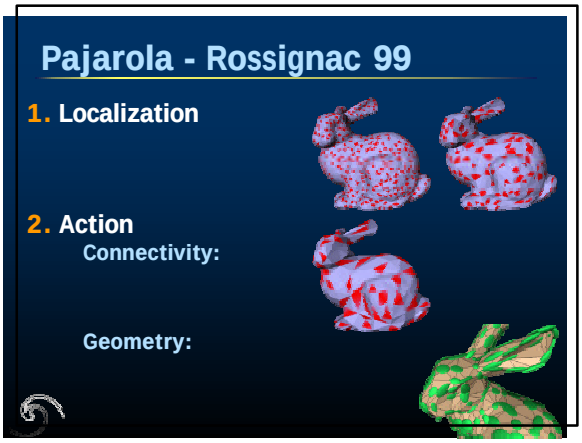
3D Data Compression

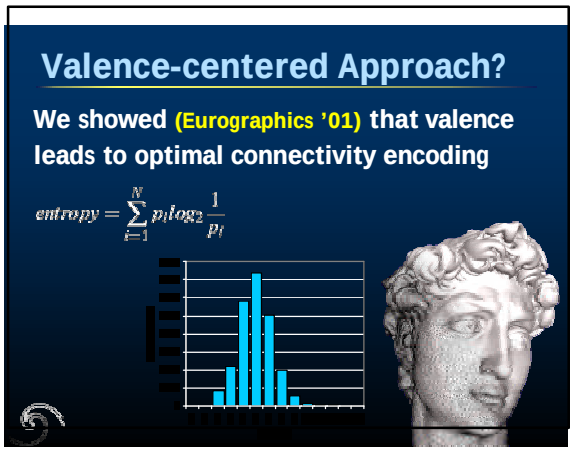
Our Goal

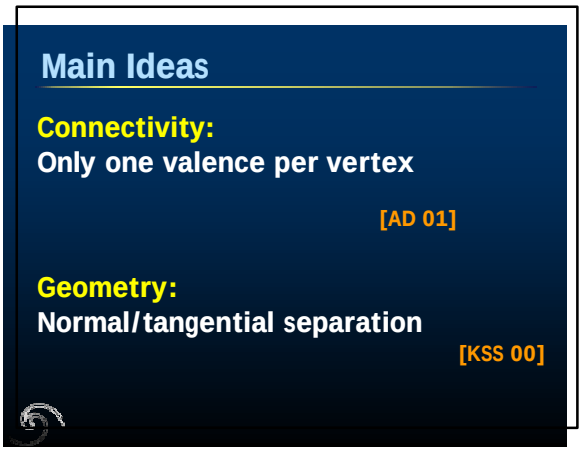





Hoppe 96
1. Localization
2. Action
Connectivity:
Geometry:
Encoding (decimation)
Decoding (refinement)


Pajarola - Rossignac 99
1. Localization
2. Action
Connectivity:
Geometry:


Valence-centered Approach?
We showed (Eurographics '01) that valence leads to optimal connectivity encoding
$entropy = \sum_{i=1}^{N} p_i \log_2 \frac{1}{p_i}$


Main Ideas
Connectivity:
Only one valence per vertex
[AD 01]
Geometry:
Normal/tangential separation
[KSS 00]

Our Method at a Glance

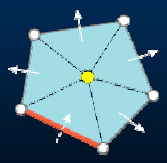
Decimation Strategy

Entropy Encoding

Basic Primitives

Gate
(oriented edge)

Ordinary patch



1 input gate
N-1 output gates
1 vertex removal

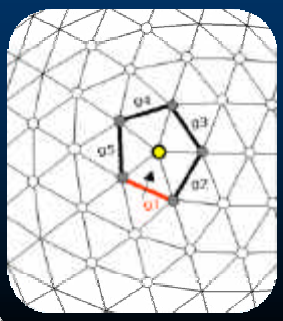
Null patch

1 input gate
2 output gates
0 vertex removal

Decimation Strategy

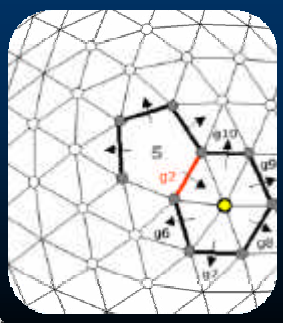
Denny - Sohler 97

Example of Conquest



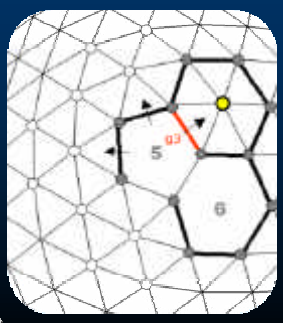
Codes	Fifo
5	g1
	g2
	g3
	g4
	g5

Conquest - Step 2



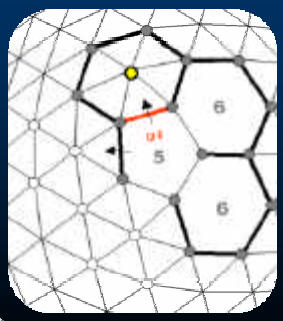
Codes	Fifo
6	g2
5	g3
	g4
	g5
	g6
	...

Conquest - Step 3



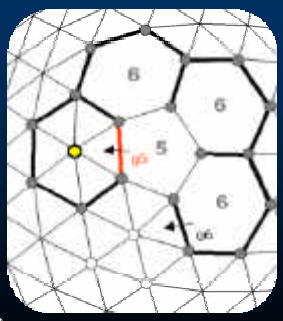
Codes	Fifo
6	g3
6	g4
5	g5
	g6
	g7
	...

Conquest - Step 4



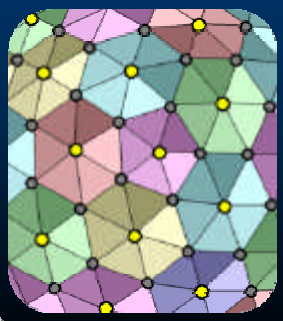
Codes	Fifo
6	g4
6	g5
6	g6
5	g7
	g8
	...

Conquest - Step 5



Codes	Fifo
6	g5
6	g6
6	g7
6	g8
5	g9
	...

Conquest - End

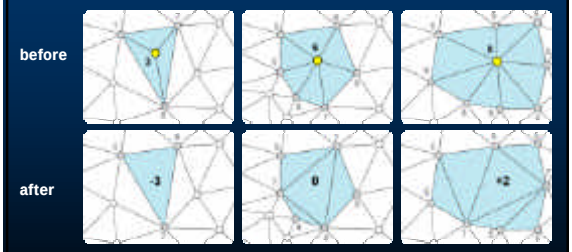


Codes	Fifo
6	
5	
6	
4	
5	
...	

Decimation Strategy

- Gate-based deterministic conquest
  - Vertex removal
  - Fifo of gates
  - Eliminate localization cost
- Targeting special vertices
  - Low valences to respect balance [Denny - Sohler 97]
  - Cosmetic decisions
- Automatic re-triangulation
  - Favor regular remeshing
  - Look-up table

Valence Dispersion



Before : V = (valences, central vertex s excluded)

After : V' = (valences)

V' = V + (valence(s)-6)

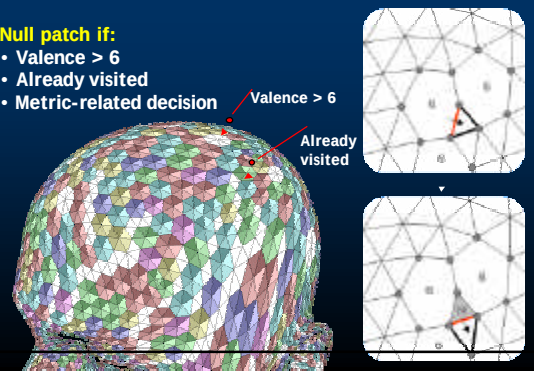
remove only valences [3-6]

[3-4] on boundaries

Vertex Selection

Null patch if:

- Valence > 6
- Already visited
- Metric-related decision



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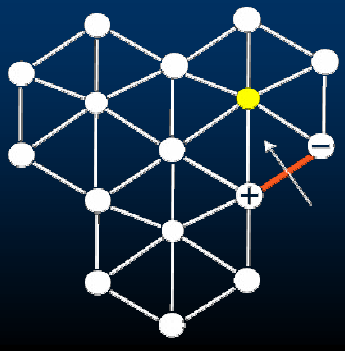
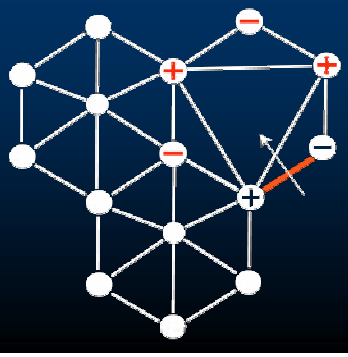
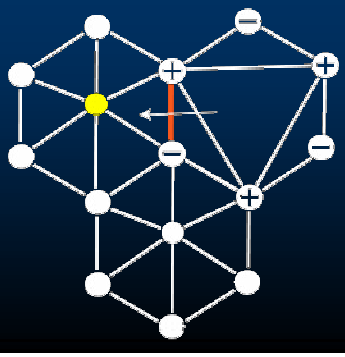
Remeshing strategy



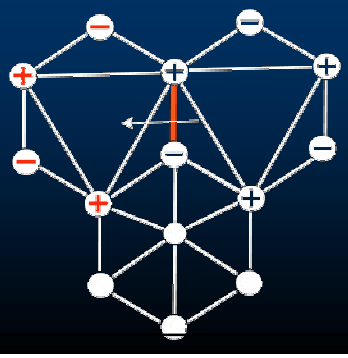
Remeshing strategy



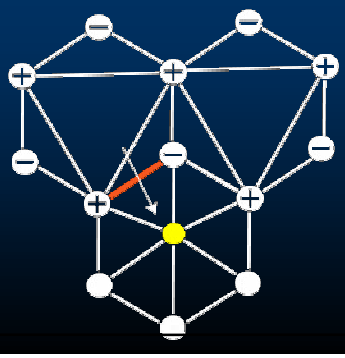
Remeshing strategy



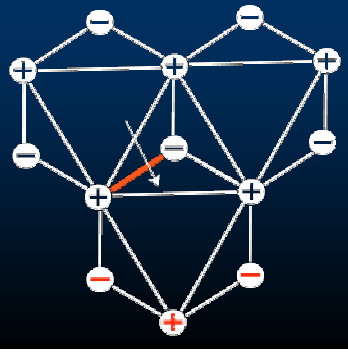
Remeshing strategy



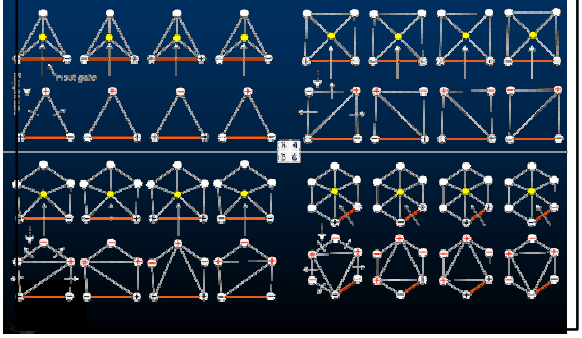
Remeshing strategy



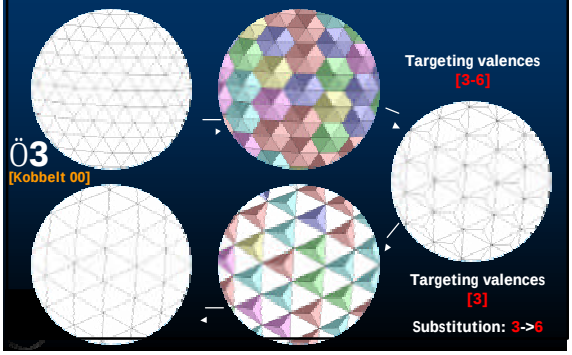
Remeshing strategy



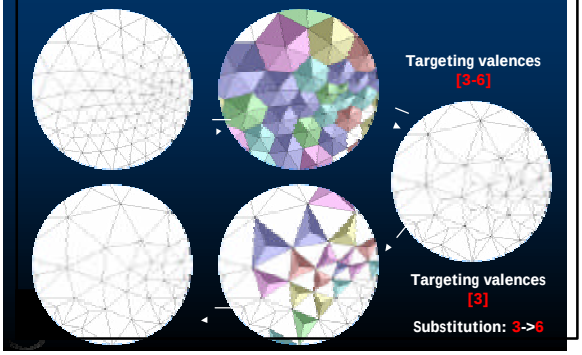
Retriangulation Look-up Table



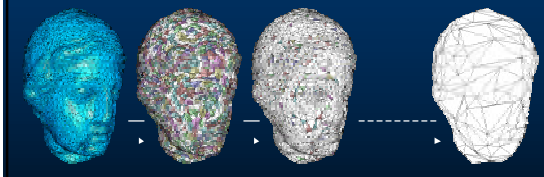
Regular Decimation



Irregular Decimation

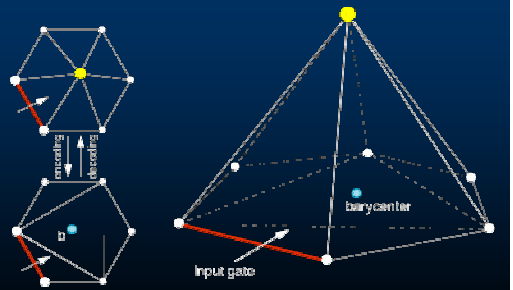


Entropy Encoding



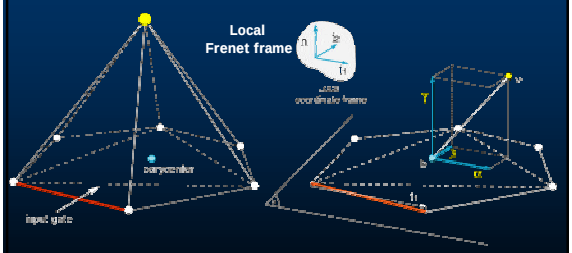
Adaptive arithmetic encoding [Schindler 99]

Geometry encoding



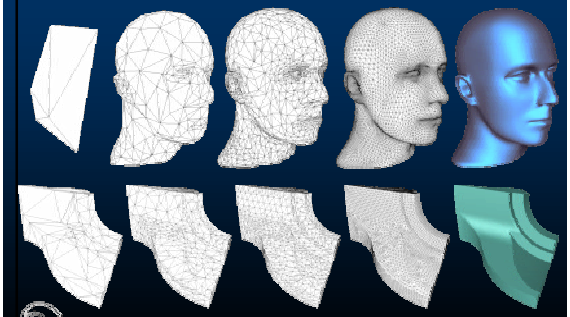
Barycentric prediction

Normal / tangential separation

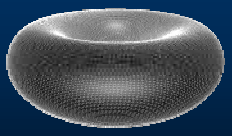


~ [Khodakovsky et al. 00]

Results

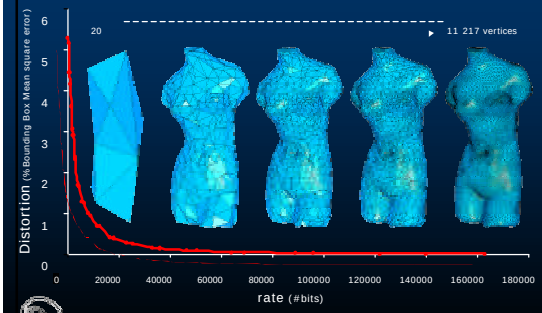


Results



Decimation	19851 -> 4 vertices	Decimation	36450 -> 24 vertices
Quantization	12 bits	Quantization	10 bits
Connectivity	4.61 b/v	Connectivity	0.39 b/v
Geometry	16.24 b/v	Geometry	3.58 b/v
	20.87 b/v		**3.97 b/v**

Rate / Distortion



Recap

Lossless methods	Connectivity (b/v)	Geometry (b/v)
~~Hoppe 96 (PM)~~	~~16~~	~~15-25~~
~~Taubin et al. 98 (PFS)~~	~~10~~	~~20~~
~~Pajarola - Rossignac 99 (CPM)~~	~~7.2~~	~~~17~~
~~Cohen-Or et al. 99~~	~~6~~	~~~17~~
~~Alliez - Desbrun 01~~	~~3.7~~	~~12.2~~

Conclusions

- No change of genus
- Requires 2-manifold meshes
+ Handle full range of triangle meshes
  irregular to regular
+ Valence & connectivity encoding
  per-vertex progressivity
  natural adaptation to regularity
+ Set of VRML meshes = 18 Mb
  zip 4 Mb
  ours 400 Kb

Future work

Geometry and attributes encoding:
colors, materials, texture coord.

Entropy-driven remeshing engine?

Progressive encoding
- Polygon meshes
- Topology
- Polygon soups
- Resiliency