


Multiresolution Meshes II

COS 526
Lecture by Tom Funkhouser
Slides by Igor Guskov,
Emil Praul, Wim Sweldens, etc.




Multiresolution Meshes

Huge meshes are difficult to

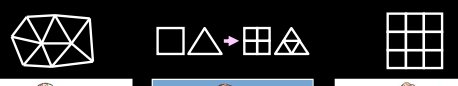
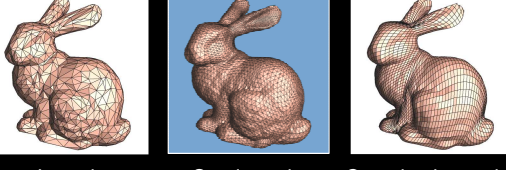
- render
- store
- transmit
- edit

Multiresolution is crucial



[Guskov et al.]

Multiresolution Meshes

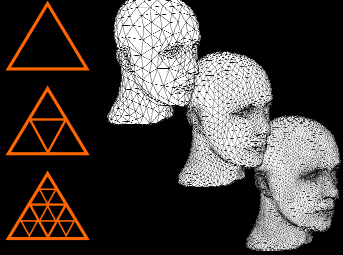



Irregular Semi-regular Completely regular

[Hoppe]

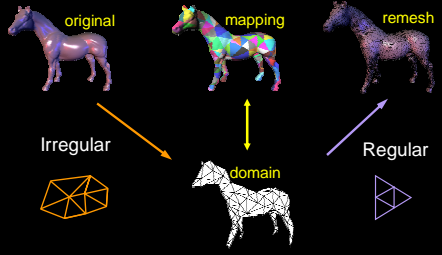
Semi-Regular Mesh

Arbitrary base mesh + refinement via subdivision



[Hoppe]

Multiresolution Analysis



original mapping remesh

Irregular domain Regular

[Guskov et al.]

Multiresolution Analysis

step 1: construct a simple domain mesh K
step 2: construct a parametrization r of M over K
step 3: remesh

Multiresolution Analysis

Step 1: construct simple base domain

- topological type of K = topological type of M
- small number of triangular regions
- smooth and straight boundaries

mesh M partition domain mesh K

[Lounsberry et al.]

Multiresolution Analysis

Step 2: construct parameterization

- Map each face of domain mesh to corresponding triangular region

local map

[Lounsberry et al.]

Multiresolution Analysis

Step 2: construct parameterization

- Map each face of domain mesh to corresponding triangular region
- Local maps must agree on boundaries and introduce small distortions \rightarrow harmonic maps

planar triangle triangular region

[Lounsberry et al.]

Multiresolution Analysis

Step 3: remesh

- Regular subdivision

[Hoppe]

Multiresolution Representation

Wavelet representation

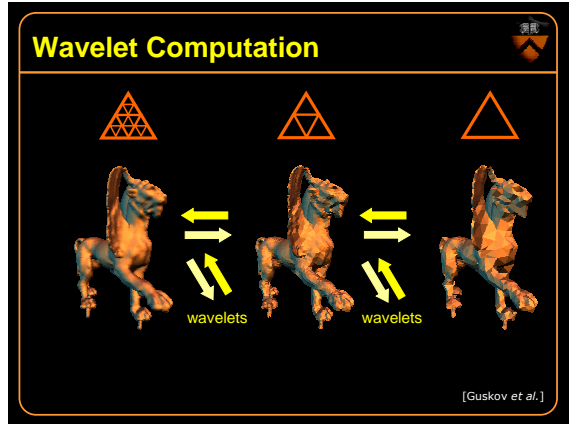
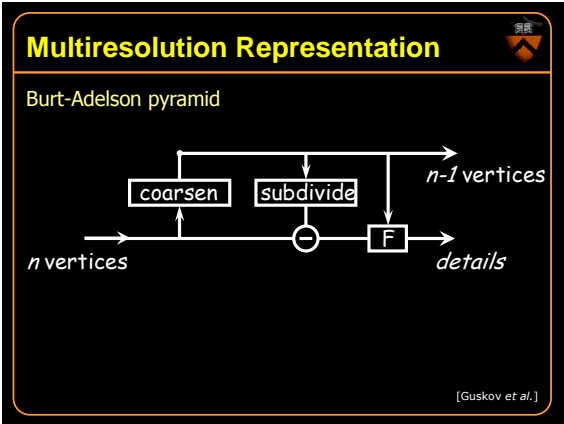
base shape M^0
+
sum of local correction terms
(wavelet terms)

[Lounsberry et al.]

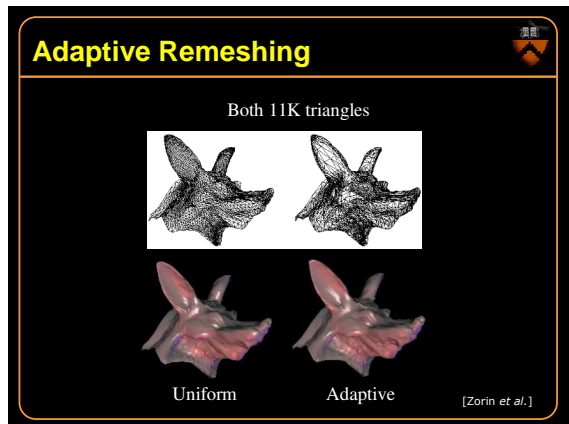
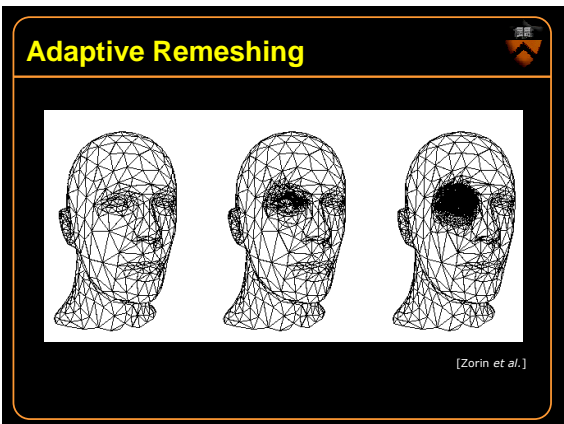
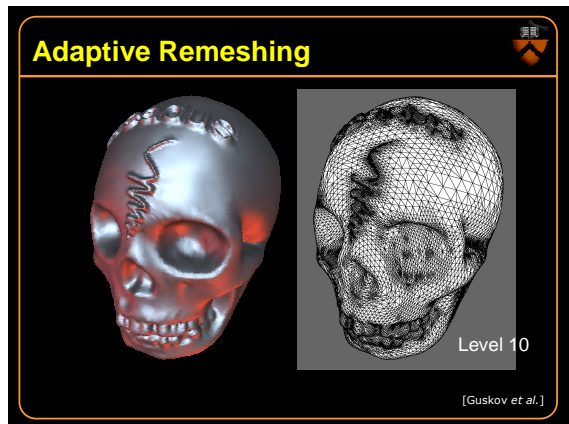
Multiresolution Representation

u downsample predict/subdivide u details/wavelets

[Guskov et al.]



- ### Multiresolution Meshes
- Applications:
- Adaptive remeshing
 - Compression
 - Filtering
 - Editing
 - Morphing
 - Principle component analysis
- [Guskov et al.]



Multiresolution Meshes

Applications:

- Adaptive remeshing
- Compression
- Filtering
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- Morphing
- Principle component analysis

Mesh Compression

Effect of wavelet transform

- changes distribution of coefficients
 - almost all coefficients close to zero

[Guskov et al.]

Mesh Compression

Two scalar displacement (t,n) One scalar (normal mesh)

[Guskov et al.]

Mesh Compression

Normal mesh

[Guskov et al.]

Mesh Compression

Progressive compression:

- encode largest coefficients first
 - encode only significance bit
 - subsequent bits in later iterations

0	2	5	7	11	14	Send: new coeffs.	refining bits
0	0	0	0	0	0	2	
0	0	0	0	0	0	2	0 1
0	0	0	0	0	0	1	0 1 1 1
0	0	0	0	0	0	0	0 1 1 1 0

[Guskov et al.]

Mesh Compression

Fixed file size

Normal Meshes:

CPM:

[Guskov et al.]

Mesh Compression

956B 2004B 4806B 26191B

20K 4 bits/v

1253B 2804B 6482B 14844B

15K 2.5 bits/v

[Guskov et al.]

Multiresolution Meshes

Applications:

- Adaptive remeshing
- Compression
- Filtering
- Editing
- Morphing
- Principle component analysis

Multiresolution Mesh Processing

Smoothing

[Guskov et al.]

Multiresolution Mesh Processing

Enhancing

$\text{smoothed} + 2 * (\text{original} - \text{smoothed}) = \text{enhanced}$

[Guskov et al.]

Multiresolution Mesh Processing

Filtering

[Guskov et al.]


Multiresolution Meshes

Applications:

- Adaptive remeshing
- Compression
- Filtering
- Editing
- Morphing
- Principle component analysis

Multiresolution Mesh Editing

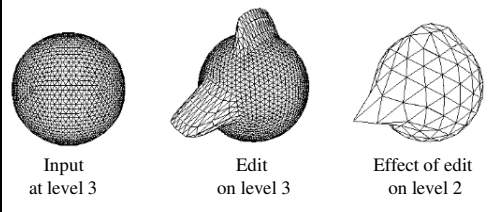
Goal: edit surface with operations at various resolutions



[Guskov et al.]

Multiresolution Mesh Editing

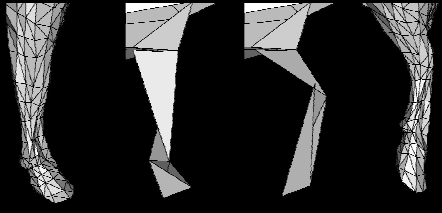
When edit at fine resolution, update higher levels of multiresolution hierarchy



Input at level 3 Edit on level 3 Effect of edit on level 2

[Zorin et al.]

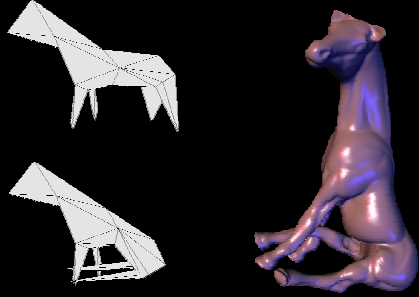
Multiresolution Mesh Editing



original coarse edit coarse edit fine

[Guskov et al.]

Multiresolution Mesh Editing



[Guskov et al.]

Multiresolution Mesh Editing



[Zorin et al.]

Multiresolution Mesh Editing



[Zorin et al.]

Multiresolution Mesh Editing



[Zorin et al.]

Multiresolution Mesh Editing



[Zorin et al.]

Multiresolution Mesh Editing

Edit & Enhance



[Guskov et al.]

Multiresolution Meshes

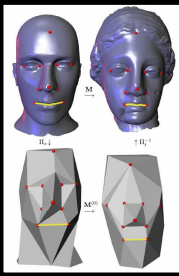
Applications:

- Adaptive remeshing
- Compression
- Filtering
- Editing
- Morphing
- Principle component analysis

Multiresolution Mesh Morphing

Goal: generate intermediate models

- Requires common parameterization

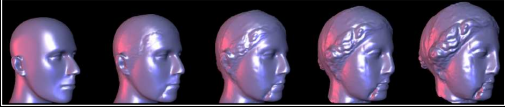


[Lee et al.]

Multiresolution Mesh Morphing

Goal: generate intermediate models

- Requires common parameterization



[Lee et al.]



Multiresolution Meshes

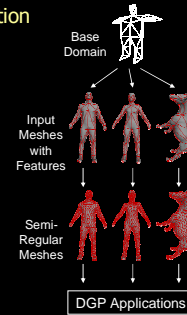
Applications:

- Adaptive remeshing
- Compression
- Filtering
- Editing
- Morphing
- Principle component analysis

Consistent Mesh Parameterization

Goal = consistent parameterization

- same base domain
- correspondences
 - § vertices, edges
- smooth & fair

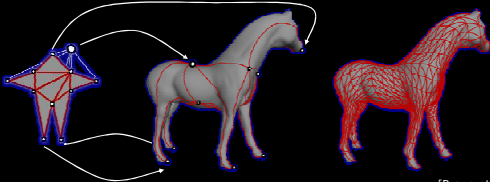


[Praun et al.]

Consistent Mesh Parameterization

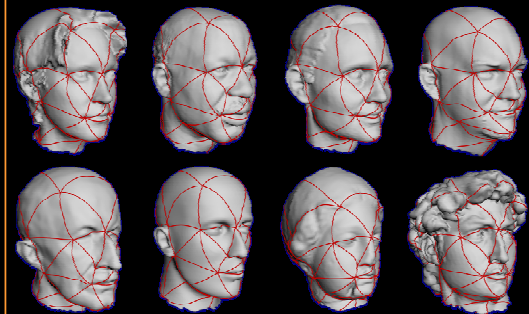
Approach

- Identify feature points (user)
- Trace curves for base domain edges
- Parameterize interior of patches



[Praun et al.]

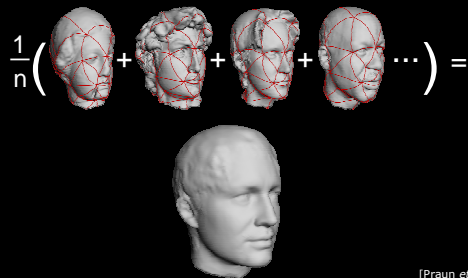
Consistent Mesh Parameterization



[Praun et al.]

Consistent Mesh Parameterization

Computing the mean surface



[Praun et al.]

Consistent Mesh Parameterization

Principal component analysis



[Praun et al.]

Consistent Mesh Parameterization

Principal component analysis

[Praun et al.]

Consistent Mesh Parameterization

Morphing

[Guskov et al.]

Consistent Mesh Parameterization

Morphing

[Praun et al.]

Consistent Mesh Parameterization

Morphing

Horse .33		Horse .5
Man .33		Man .25
Cow .33		Cow .25

Horse .25		Horse .25
Man .25		Man .5
Cow .5		Cow .25

[Praun et al.]

Consistent Mesh Parameterization

Texture transfer

[Praun et al.]

Consistent Mesh Parameterization

Texture transfer

[Praun et al.]

Consistent Mesh Parameterization

Texture transfer

Labeled Brain Multires Mesh used for Registration Patient's Brain

[Juame et al.]

Consistent Mesh Parameterization

Texture transfer

Brain features (e.g., sulci) labeled at multiple resolutions

[Juame et al.]

Consistent Mesh Parameterization

Detail transfer

[Praun et al.]

Multiresolution Meshes

Key ideas

- Multiresolution analysis provides parameterization
- Can map operations in parameter domain to operations on mesh (e.g., smoothing, morphing, etc.)

Acknowledgements

Slides by

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