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Simplification and LOD Applications

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Contents

- Static LOD
  - Support for LOD-based visualization
    - VRML, Metastrea, Java3d
  - Support for simplification and construction of LOD models
    - Jade, SGI Cosmo, SGI Optimizer, HP Direct Model Tk, IMCompress
- Dynamic LOD
  - constant resolution
  - view-dependent resolution
- Use of MultiRes: ***data trasmission, GIS, FlightSimulators***
- Resolution Modelling
  - user-driven variable resolution
- Multiresolution for Volume dataset management

Level of detail (LOD)

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- LOD repr. [Clark76,Funkhouser93]
  - multiple instances/representations of the same object at different resolutions
  - decide which to render depending on current object position
    - near
    - ....
    - far
  - reduces download time (smaller first)
  - improves frame rate


38,000 faces


4,000 faces


1,200 faces

LOD -- OpenInventor

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LOD support under SGI **OpenInventor**

- scene represented by a tree of ***shape***, ***property*** and ***group*** nodes
- *SoLevelOfDetail* node:
  - group node
  - specifies the shape of a single object at multiple level of details (children ***shape*** nodes specified in order of decreasing details)
  - at rendering time, object's **projected size** detemines which child is choosen to be displayed
    - uses 3D bounding box to compute the projected area

LOD -- VRML (Virtual Reality Modeling Language)

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LOD support under **VRML 2.0**

- *LOD* grouping node (one child displayed at a time):

```
LOD {
      MFNode  level[]
      SFVec3f center  0. 0. 0.          (-∞,∞)
      MFFloat range[]                   (0,∞)
    }
```

  - main difference with OpenInventor: object's ***distance from the viewer*** detemines which child is choosen
  - level field: list of shape nodes at different level of detail (specified in order of decreasing details)
  - center field: object's baricenter used to compute viewing distance
  - range field: defines distances to switch between shape nodes

LOD -- VRML (Virtual Reality Modeling Language)

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LOD support under **Java3d**

- *LOD* Abstract Class

```
java.lang.Object
+--javax.media.j3d.SceneGraphObject
   +--javax.media.j3d.Node
      +--javax.media.j3d.Leaf
         +--javax.media.j3d.Behavior
            +--javax.media.j3d.LOD
               +--javax.media.j3d.DistanceLOD
```

One abstract class (`javax.media.j3d.LOD`) for any possible lod choosing strategy

One implementation (`javax.media.j3d.DistanceLOD`):
object's ***distance from the viewer*** detemines which child is choosen

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Problems with LOD approach:

1. level transition may generate a *popping* effect
   - disparity between different LOD instances must be very smooth
   - sudden changes in shaded color or texture are very easily detected by humans!!
2. selection of the optimal ranges for LOD transition

(Partial) Solutions

① generate high quality approximations

② use *dynamic LOD* (selection done at run time, adaptively)

LOD Construction

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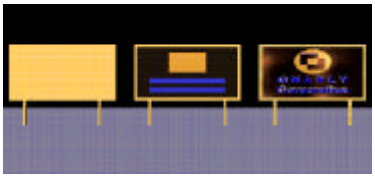
- Standard approach to construct an LOD model
  1. eliminate **details**
     - textures
     - text
  2. **simplify** geometry



- But preservation of detail is crucial for good perception

  ==>

  use an ***attribute-preserving*** simplifier!!

LOD Construction -- Systems for mesh simplification

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Commercial

- SGI
  - [Cosmo Worlds]
  - OpenGL Optimizer
- HP DirectModel
- IBM Interaction Accelerator
- Innovmetrics IMCompress
- ...

Public domain

- VTK (Visualization Toolkit)
- Quadric Error Metrics
- Jade 2
- Mesh Optimization
- Simpl. Envelopes

Systems for mesh simplification -- Jade v2.0

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Jade 2.0 (Multiresolution Global Error Decim.)

[Ciampalini et al.'97]

- decimation-based simplifier
  - global error evaluation
  - multiresolution output
  - I/O: SGI OpenInventor
- available on the web (**http://miles.cnuce.cnr.it/cg/enhadecimation.html**)
- executable for SGI ws only

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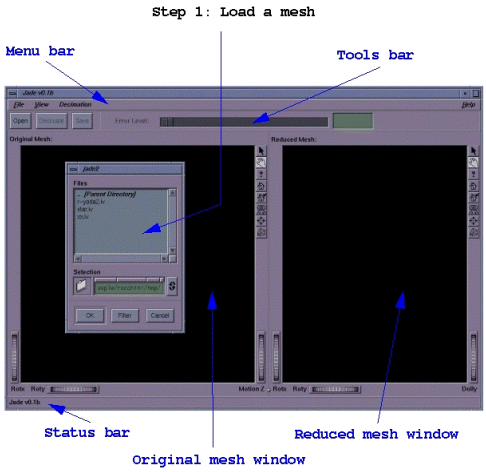
- Jade's GUI



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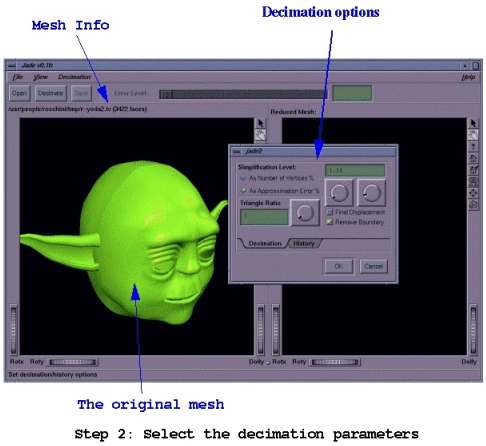
- Jade's GUI



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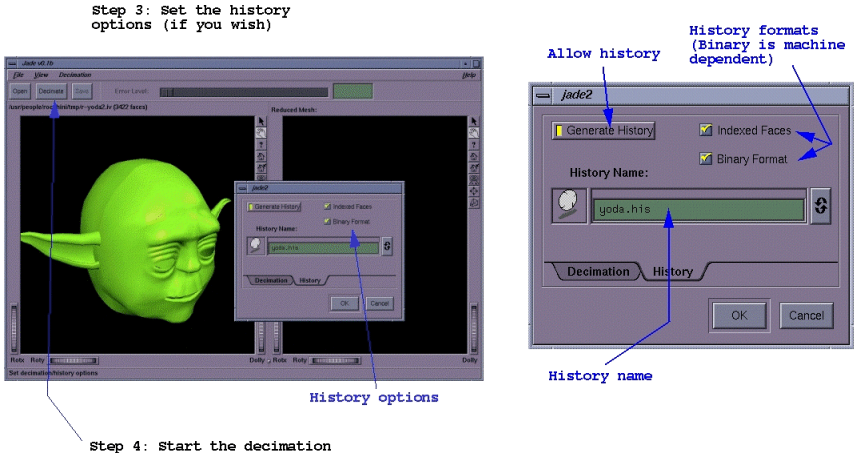
- Jade's GUI



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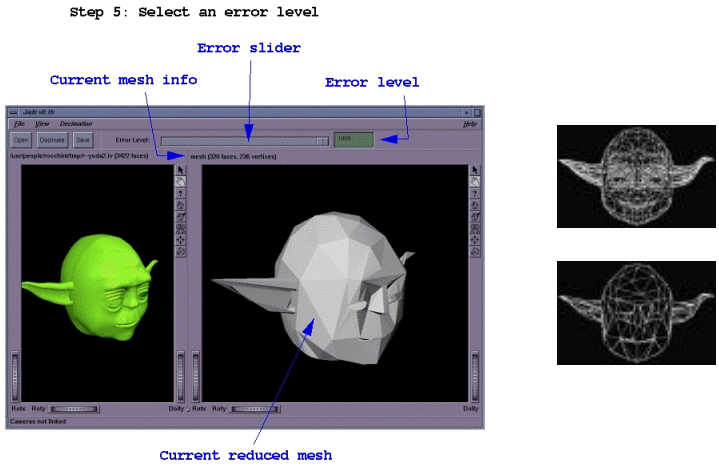
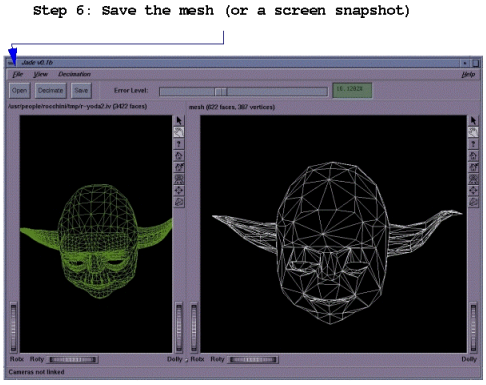
- Jade's GUI



S I M P L I F. | A P P L I C A T I O N S

- Jade's GUI



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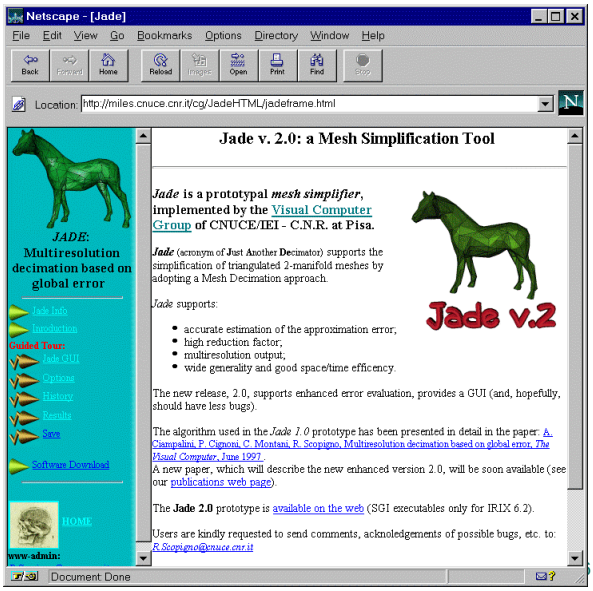
Jade's on line HTML User Guide



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Cosmo Worlds

- supports creation and editing of virtual 3D worlds (VRML);
- **Optimization Tools** suite:
  - **Polygon Reduction Editor**
  - **Inline Editor**
  - **LOD Editor**
- **Polygon Reduction Editor** reduces polygon # :
  - deletes points by **curvature**
  - discards triangles by **area**
  - discards edges by **lenght**
  - **merge** initial coordinates (clustering)

but SGI has dismissed the Cosmo division...

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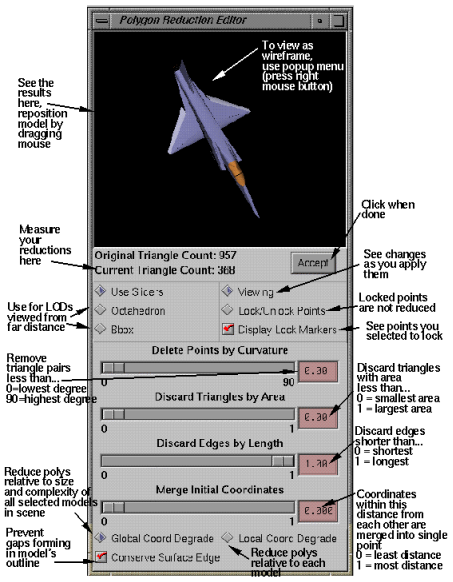
Polygon Reduction Editor GUI



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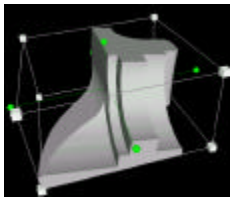
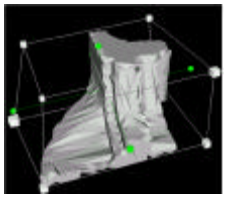
Polygon Reduction Editor

- clustering--based simplification
  - fast
  - low quality approximation
  - any measure or bound on simplified mesh approximation
  - user goes through a number of attempts ==> process cannot be easily reproduced



Fandisk, 6300 vertices



Cosmo, 1278 vertices

Jade, 129 vertices

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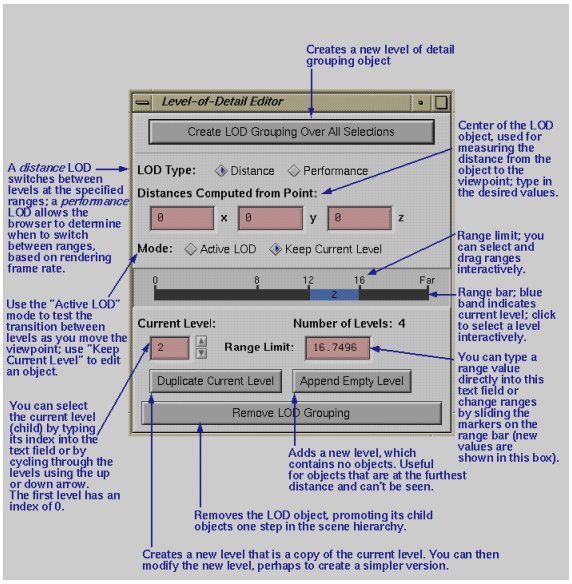
LOD Editor GUI



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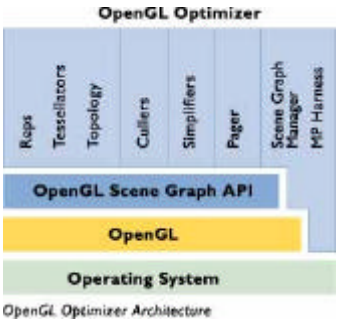
OpenGL Optimizer

- specifically developed to meet the demands of high performances visualization applications (e.g. CAD/CAM/CAE games, medical, scientific).
- OpenGL API built on top of OpenGL.
- Optimizer v.1.3 will become the core component to SGI/ Microsoft "**Fahrenheit**" project



OpenGL Optimizer Architecture

web:
http://www.sgi.com/Technology/OpenGL/optimizer/

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OpenGL Optimizer Technical Specifications (v.1.1 released June '98)

- Simplification
  - Successive Relaxation Simplifier
    - Target polygon count or percentage
    - Target surface deviation
    - Automatic surface normal recalculation
    - Maintains surface topology
  - Detail removal as percentage of entire model volume space
  - Spatial grid simplifier
    - Non-topological spatial simplification
    - Target model percentage
- Geometry Operators
    - Spatialization - breaks scene graph into optimal spatial sizes
    - Unified triangle stripper and triangle fanner optimizer
    - Spatial and graphics state combiner reduces needless scene graph and rendering overhead

Systems for mesh simplification -- HP Direct Model

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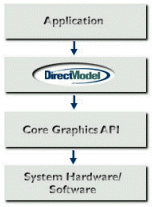
- *goal* : enable real-time visualization of very large and highly complex models
- object oriented toolkit, scene described with a graph
- includes different simplification methods (C++ Simplifier classes):
  - bounding box
  - drop component (discard some nodes from the input graph)
  - convex hull
  - vertex clustering (octree-based), with/without feature edge preservation
  - edge-based decimation
  - tri-stripper



web:http://www.hp.com/unixwork/products/grfx/dmodel

Systems for mesh simplification -- IBM Interaction Accelerator

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IBM 3D Interaction Accelerator

- workstation-based interactive software
- enables real-time visualization of very large and highly complex mechanical and architectural CAD models
- includes a simplification module, based on the **Vertex Clustering** algorithm [Rossignac 93]

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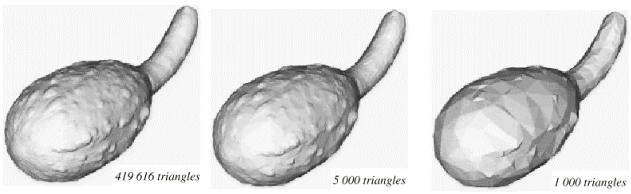
IMCompress by Innovmetrix

(specialized on range scanner data management; sw by Soucy et al.)

- automatic polygon reduction tool, included in the PolyWorks integrated line of software tools for building 3-D polygonal models from 3-D range scanner data
- adopts a *global error decimation* approach
- guarantees bounded 3-D tolerances between compressed and original models
- preserves local topology, surface edges and **color/ textures**



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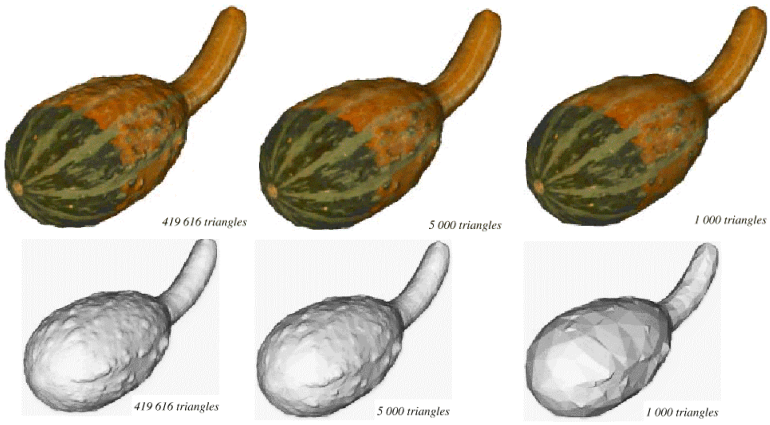
IMCompress

- preserves **color / textures**



Other systems for Surface Simplification

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- ***Geomagic Decimator Surface simplifier***, by Geomagic, **http://www.geomagic.com/products/decimator.html**
- ***Rational Reducer Surface simplifier***, by System in Motion **http://www.sim.no/polyred.html**
- ***Decimate***, by Cyberware **http://www.cyberware.com/products/Decimate.html**
- ***Multiresolution Geometry SDK***, by Sven Technologies, **http://www.sven-tech.com/products/mrg/**

"The future (?)"

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- What ***near future*** will take us?
  - ***MPEG 4*** -- a new International Standard
  - ***Fahrenheit*** *architecture* -- an industrial project (MS + SGI)

3D graphics in **MPEG-4**

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MPEG-4

- ISO standard from the MPEG (Moving Picture Experts Group)
- Version 1 I.S. in Dec.'98
  - still images and video
  - audio
  - 3D graphics:
    - **VRML-like data definition features (with binary format)**
    - **improved control of 3D data animation and behavior**
    - **texture compression**
  - … and more...

… 3D graphics in **MPEG-4**…

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MPEG-4

- Version 2 planned for Dec.'99
  - 3D graphics:
    - **improved animation (body animation)**
    - **3D mesh compression**
      - **topology : *topologic surgery***
      - **geometry : quantization, predictive coding, entropy coding**
    - **LOD representation**
    - **progressive representation (and trasmission)**
  - … and more...
  - See web at: **http://cselt.it/mpeg**

Fahrenheit Architecture

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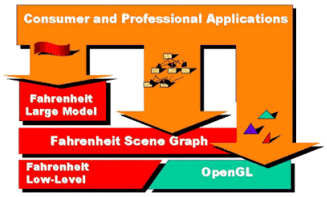
Collaborative SGI - Microsoft project :

- design of a complete high-performance graphics architecture, for both ***WinNT*** and ***Unix***
- three components (API):
  - **Fahrenheit Low Level**
    - expected Y2000, replaces Direct3D
  - **Fahrenheit Scene Graph**
    - tree-like data structure for scene representation
    - expected 2Q'99, ~replaces Open Inventor
  - **Fahrenheit Large Module Visualization**
    - tools for the visualization of large models, based on SGI Performer and HP DirectModel
    - expected 2Q'99, replaces SGI Performer and MS plans to deliver HP DirectModel



Multiresolution Management

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Exploit multiresolution representation:

- **to speed-up visualization**
  improve visualization *frame rate* and *quality* in environments with constrains on data transmission/rendering
  - dynamic LOD
  - view-driven variable resolution
- **to enhance geometric data content**
  link geometric detail to a user-driven interpretation of the data
  - resolution modelling

Dynamic LOD

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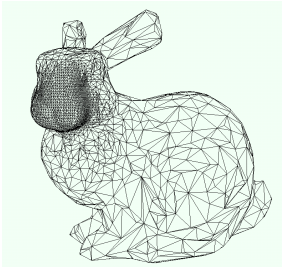
- Reasons for the construction of **Dynamic LOD**:
  - Produce the ***best-fit model*** for a given graphics throughput (constant resolution)
    Can be done:
    - interactive simplification (very low quality)
    - post-processing (hystory or progressive mesh)
  - Produce the ***best-looking model*** for a given view point ,
    also known as ***adaptive LOD***
    (or variable resolution)



... Dynamic LOD ...

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MetaStream™ **(http://www.metastream.com)**

- new open PC file format announced jointly by Intel and MetaCreations
- plug-in technology to create, delivery and display 3D objects :
  - **progressive transmission** over Internet of 3D data
  - **dynamic selection of best-fit model** (given the graphics performances of the local host): Metastream plug-in (or user) may adjust the resolution of any object, so that it will rotate and react in real time
  - developed to manage 3D meshes with **texture-coded detail** (e.g. color)
  - data creation: MetaStream 3D **file format conversion plug-in** available for Ray Dream Studio™ 5 and Ray Dream 3D™ modelling applications

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Metastream plug-in example:

- **best-fit** model (Pentium 166MHz)
  4,667 faces
- **user-selected** resolution
  23,161 faces

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Multi-Resolution Geometry SDK™

(http://www.sven-tech.com/products/mrg/)

MRG SDK

- software development kit
- to build interactive application based on dynamic lod technology
- available for Web, PC, Playstation, N64
- Integrates with 3DS MAX, Softimage, Maya, Lightwave, and proprietary pipelines/run-time formats.

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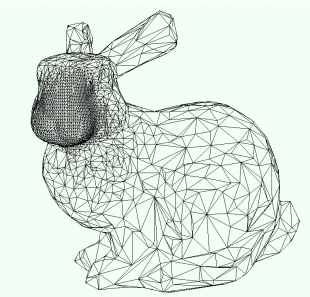
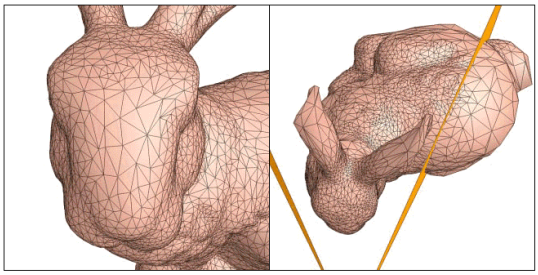
- View-dependent best-looking model:
  - distance from the observer
  - region of interest





(b) Front view and (c) Top view (τ=0.1%; 10,528 faces)

[Image by H. Hoppe]

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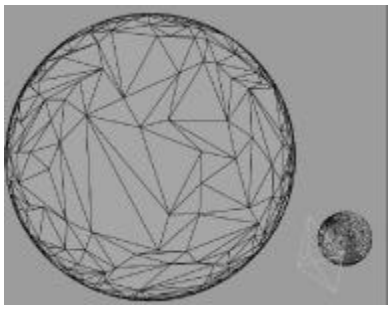
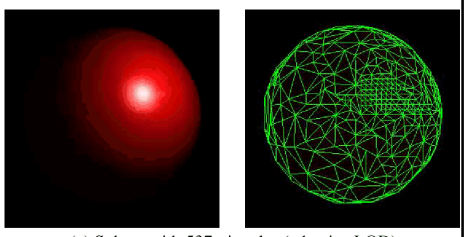
... View-dependent **best-looking model**:

- object's silhouette
- lighting model



Variable resolution: 1% silhouette error, 20% interior error (1,950 faces).

[Image by Luebke et al.]



(c) Sphere with 537 triangles (adaptive LOD)

[Image by Xia et al.]

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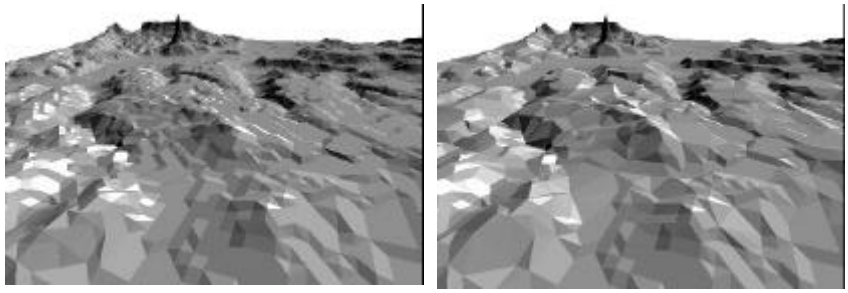
- Applications: ***terrain visualization***
  - **full** resolution
  - 54K triangles
  - **variable** resolution (view-depend.)
  - 12K triangles



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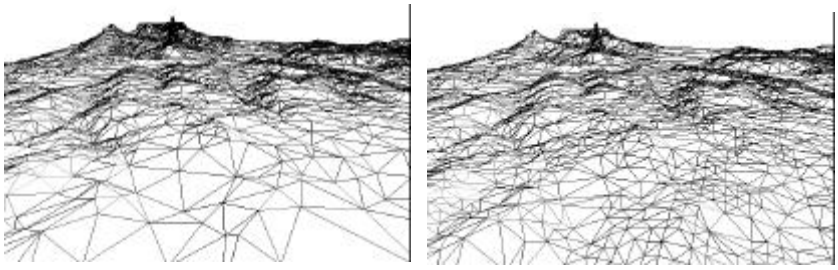
- Applications: ***terrain visualization***
  - **constant** resolution
  - 12K triangles
  - **variable** resolution (view-depend.)
  - 12K triangles



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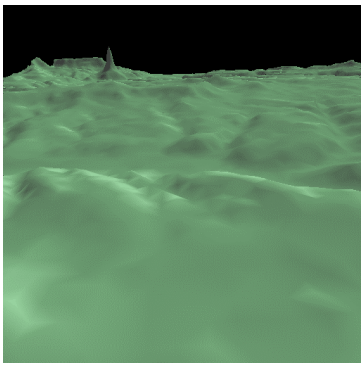
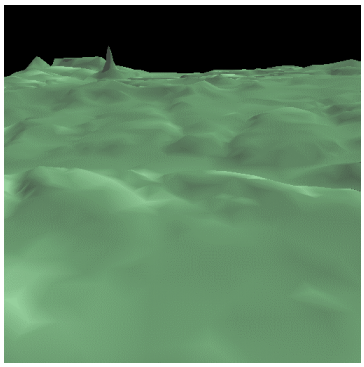
- once we add shading (and texture-based color) the difference becomes negligible



Original terrain, 54K faces



Variable resolution, 5K faces

MultiRes - Data Transmission

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- Moving large meshes over the net is critical
- LOD models:
  - send different levels of detail in a sequence
  - each level gives a full mesh, replacing the previous level
  - levels stored independently ==> redundant information transmitted
- Linear sequences (e.g., PM):
  - send data in given sequence and perform incremental reconstruction
  - reconstruction based on progressive refinement: *no data wasted*
  - Delaunay meshes can be reconstructed in linear time

    [Snoeyink Van Kreveld '96 , De Floriani, Magillo and Puppo '97]

MultiRes - G.I.S.

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Multiresolution applied to terrain data

- Operations:
  - display
  - windowing
  - estimation of local properties
  - contour lines
  - overlay with thematic maps
  - visibility computation and line-of-sight problems
- Each operation can be performed at a level of detail specified by the user/application.
- Hierarchical organization can support structured processing, and speedup data access.

MultiRes - GIS...

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- All queries on a multiresolution model can be seen as specialization of a general query
  - *threshold function* t : R^2 --> R
  - *focus set* F in R^2
  - **General query**:

    return a representation of the surface satisfying t , and relevant with respect to ***F*** (e.g., either restricted to ***F*** , or made of elements that intersect ***F***).
- Examples of focus set:
  - a ***point***: point location query (to estimate local properties)
  - a ***polyline***: configuration of terrain along a street, a river, etc.
  - a ***rectangle***: windowing
  - a ***sector***: view frustum for perspective display

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Multiresolution query processing -- two alternative approaches:

- two-steps: extract a mesh, then resolve query on it
  - exploit standard algorithms for single-resolution representations
  - can be less efficient
- direct: resolve query directly on the multiresoluton model
  - exploit the inherent hierarchical structure of a multiresolution model
  - can be more difficult to implement

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VARIANT (VAriable Resolution Interactive ANalysis of Terrain)

- Multiresolution GIS based on the MT
- MT-manager module implements basic operations on the MT:
  - I/O operations
  - update operations
  - general query
- MT-client modules implement applications through primitives provided by the MT-manager:
  - MT-builder: construction
  - MT-viewer: perspective display
  - .....

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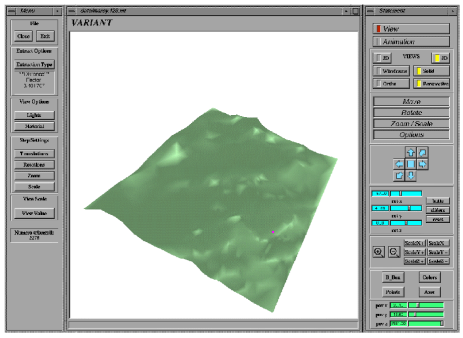
VARIANT (VAriable Resolution Interactive ANalysis of Terrain)



- see web:

  http://www.disi.unige.it/research/Geometric_modeling/

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- Based on adaptive LOD. Resolution of extracted mesh is varying with:
  - distance from viewpoint
  - size of triangles projected onto the screen
- Extraction algorithms based on dynamic update of extracted mesh are better suited to navigation
- Existing interactive systems:
  - **Georgia Tech** display algorithm (based on implicit hierarchy of right triangles)
  - **TopoVista** from CS Arizona (based on explicit hierarchy of right triangles)
  - **VARIANT** animation mode (based on explicit MT)
  - .....

Resolution Modeling

SIMPLIF. | APPLICATIONS

A three-phases global ***modelling conceptual framework*** may be conceived as follows:

- **shape modeling**, canonical 3D shape design (CAD design / automatic acquisition / surface fitting) → ***user-assisted***
- **multiresolution model construction** (supported by surface simplification tools) → ***semi-automatic***
- **resolution modeling,** construction of variable resolution representations (depends on user interpretation/use of data content) → ***user-assisted***

… Resolution Modeling …

SIMPLIF. | APPLICATIONS

- Two different approaches in literature:
  - Interactive multiresolution mesh editing based on patch-based surface representations and mesh subdivision

    D. Zorin,P. Schroeder, W. Sweldens
    "Interactive Multiresolution Mesh Editing"
    Siggraph '97

  - Zeta, resolution modeling based on multiresolution triangle-based representation

    P. Cignoni, C. Montani, C. Rocchini, R. Scopigno
    "Zeta: a Resolution Modeling system"
    GMIP: Graphical Models and Image Processing, 1998.

Zeta [Cignoni et al.'98]

SIMPLIF. | APPLICATIONS

- construction of ***variable resolution models*** from a multiresolution mesh represented with the *hypertriangulation* scheme.

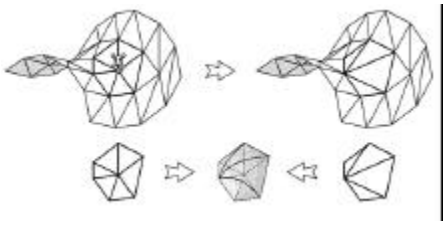
Zeta supports:

- efficient extraction of ***fixed resolution meshes***;
- unified and interactive management of ***selective refinements*** and ***selective simplification***;
- easy ***composition*** of selective ref./simpl. actions;
- ***no cracks*** in the variable resolution mesh produced;
- ***shape editing*** capabilities;
- ***interactive*** response times.

- **available on the web - http://miles.cnuce.cnr.it/cg/zeta.html (SGI only)**

SIMPLIF. | APPLICATIONS

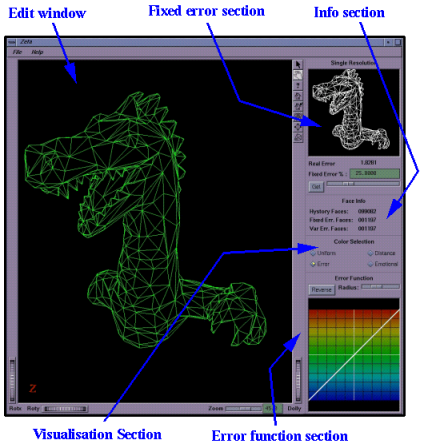
- Zeta input:
  - a simple multiresolution representation
    (**history** of incremental updates of a *global_error*--based simplificator)
- Zeta run time representation: ***hypertriangulation scheme***
  - holds in a compact way **geometry**, **error intervals** and **topology**
  - each single local update is not replaced, but glued to the current multiresolution mesh



Zeta -- GUI

SIMPLIF. | APPLICATIONS

- Zeta's GUI



Zeta -- Variable resolution modeling

SIMPLIF. | APPLICATIONS

Proposed approach:

- interactive selection of resolution on a ***base mesh***,

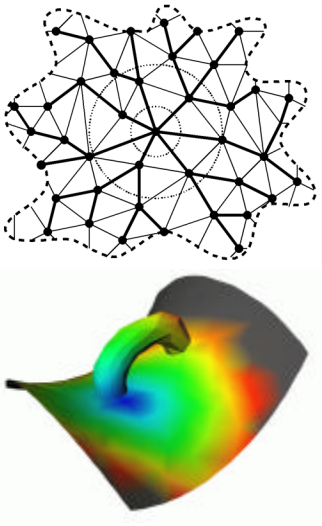
  through the composition of ***multiple selective refinements / simplification*** actions

  each of them affecting a ***focus region***

Zeta -- Region of interest selection

SIMPLIF. | APPLICATIONS

- interactive selection of a **radius** and a **focus point**, which define the region of interest (***roi***) affected by the following ***selective refinement / simplification*** **actions**
- resolution in the updated area will depend on the approximated geodetic distance from the **focus point**
- distances computed solving a shortest path tree problem on the surface graph
  (graph arcs = mesh edges)



Zeta -- Selection of the *roi* **radius**

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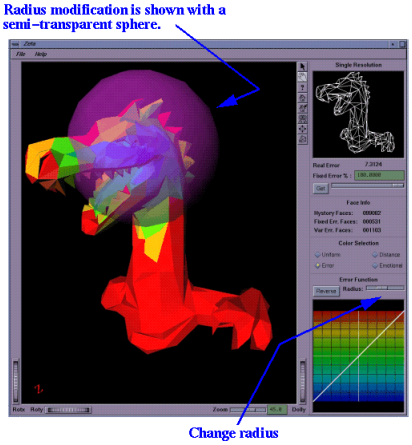
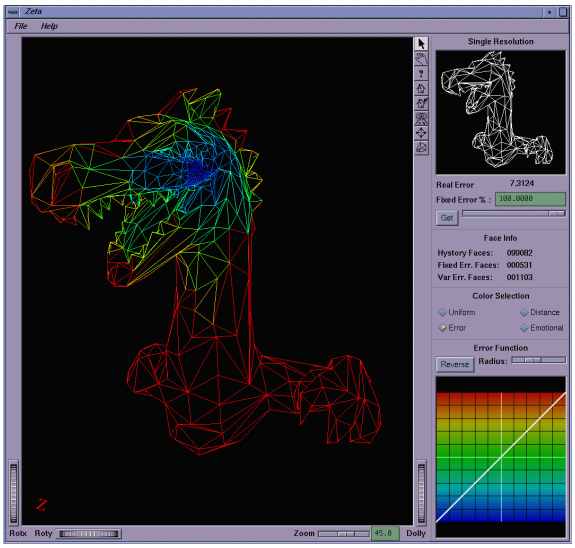


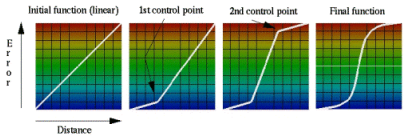
the sphere represents *visually* the approximate magnitude of the selective refinement region of interest (***roi***)

Zeta: selective refinement



Error management in selective refinement

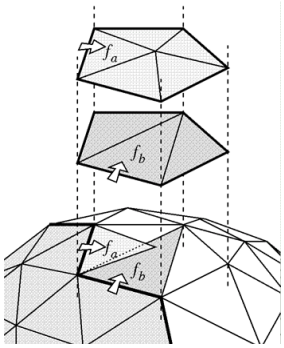
- error in the updated area varies following a user-defined function



- during the topologic expansion the border of the updated area should not self-intersect or fold-over

  (a double heap is adopted to maintain the facet-edges to be further expanded)

- ordering the facet-edge expansion is critical to:
  - minimize size of the current *expansion front*
  - get a smoother approximation refinement on the updated area



Zeta: **composition** of multiple selective refinements

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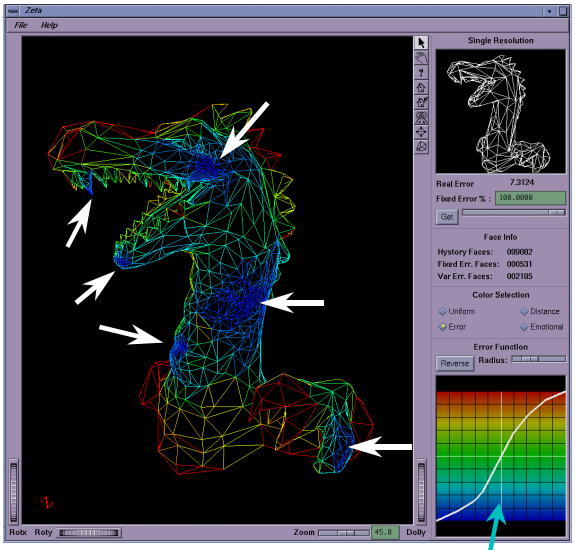
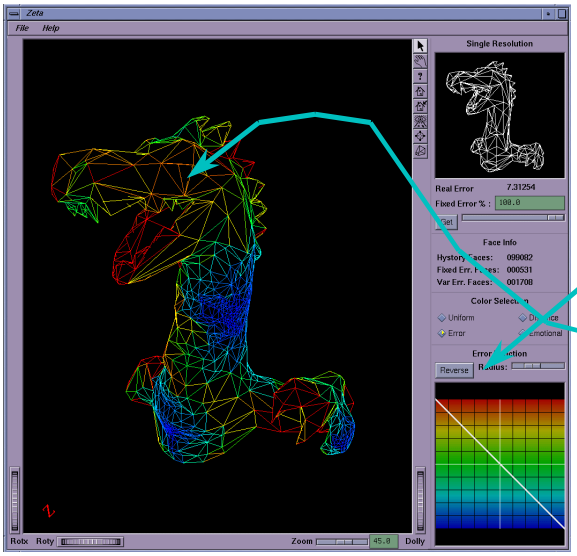


user changed the current Error function

Zeta: selective **simplification**

SIMPLIF. | APPLICATIONS



step1) revert the Error function

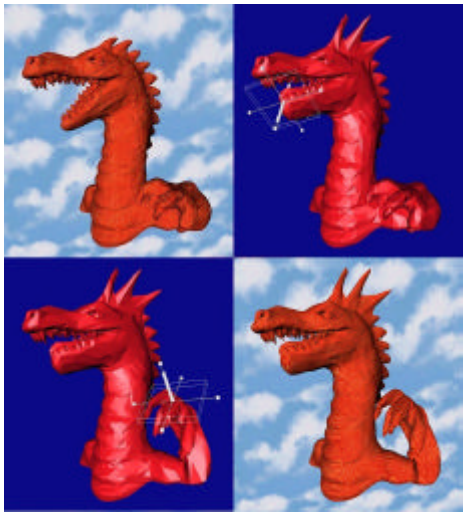
step2) select the focus point

Zeta: interactive shape editing actions

SIMPLIF. | APPLICATIONS

original mesh

shape editing on the low res. mesh (2)



shape editing on the low res. mesh (1)

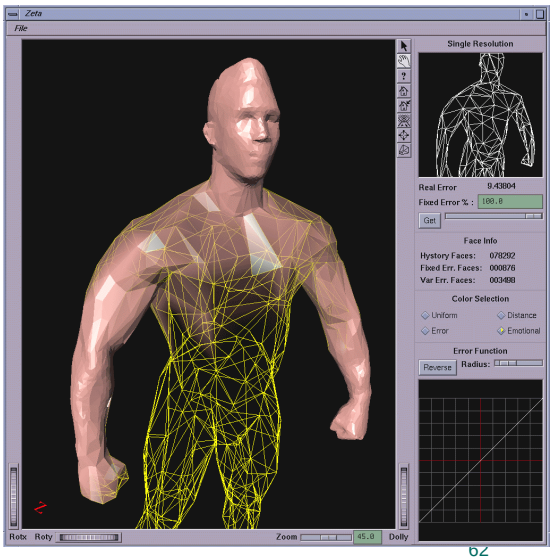
results of shape editing in high resolution

Zeta -- Applications

Use Zeta to produce illustrations:

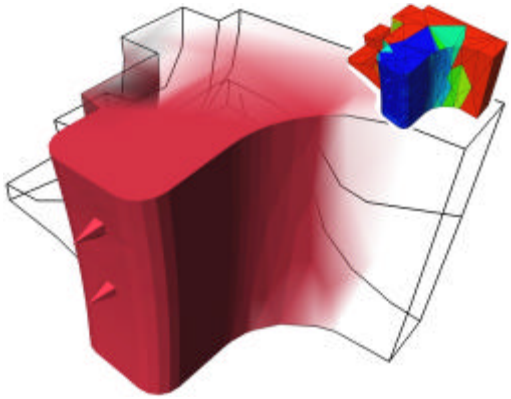
SIMPLIF. | APPLICATIONS

- Use multiple rendering modes which depend on mesh resolution:
  - **normalize error in (0., 1.)**
  - ① **render shaded with opacity = *(1-error)***
  - ② **render wireframe with opacity = *error***



Use of multiple rendering modalities

- ❍ normalize error in (0., 1.)
- ① render shaded with opacity = *(1-error)*
- ② render feature edges only with opacity = *error*



Multiresolution in Volume Visualization

- ❑ Why ?
  - ❍ to reduce ***data size*** (run time)
  - ❍ to improve ***interactivity***
    - ✧ simplified models, LOD representation
    - ✧ progressive rendering
  - ❍ to ***focus*** on region of interest
    - ✧ use full resolution only on limited areas

Simplification of Volume Data

SIMPLIF. | APPLICATIONS

- Extension of techniques developed for surfaces:
  - subsampling
  - octree-based decomposition scheme [Wilhelms van Gelder 94]
  - refinement of Delaunay mesh [Cignoni et al.94, HamannChen, 1994]
  - decimation [RenzeOliver '96, Cignoni et al. 97, StaadtGross98]

Multiresolution in VolVis

SIMPLIF. | APPLICATIONS

Approaches based on:

- ***hierarchical structures***
  - octrees, k-d trees [WilVGel'94]
  - hierarchical Delaunay tetrahedrization [Bertolotto et al., 1994]
  - hierarchy of regular tetrahedra [Zhou et al' 97]
  - adaptive hierarchy of non regular tetrahedra [Grosso et al '97] [Rumpf et al '97]
- ***linear sequence of tetrahedra*** [Cignoni et al '94, '97]
- ***MT 3D*** *[under implementation]*
- ***wavelets*** [Muraki92-93,Guo95]

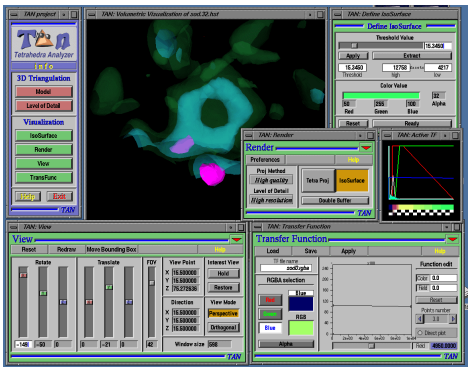
SIMPLIF. | APPLICATIONS

TAn (Tetrahedra Analyzer) [Cignoni et al.94/97]

- Volume visualization system based on linear sequences of tetrahedra

Features:

- both **structured** and **unstructured** data
- simplification based on either **refinement** or **decimation**
- extraction of a mesh at uniform resolution
- efficient extraction and rendering of multiple **isosurfaces**
- **direct volume rendering** through tetrahedra projection
- **hybrid rendering**
- **progressive rendering**

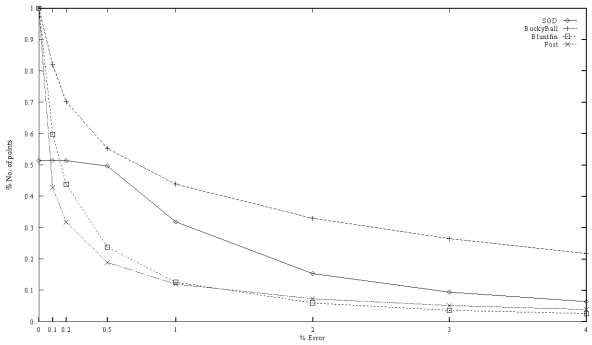


SIMPLIF. | APPLICATIONS

TAn - dataset simplification

some results:

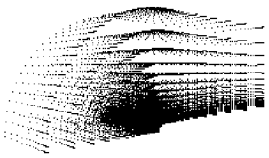
- SOD
  32x32x32, 32K sites
- BuckyBall
  32x32x32, 32K sites
- Bluntfin
  40x32x32, 40K sites
- Post
  38x76x38, 109K sites



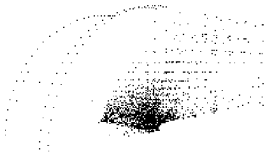
SIMPLIF. | APPLICATIONS

- bluntfin dataset 40x32x32

full precision (40K sites)



2% precision (2K sites)



SIMPLIF. | APPLICATIONS

A *multiresolution* organization of the data may support

- **isosurface fitting**: simplified surfaces comes free
  - simplification is operated on the dataset (pre-proc. time);
  - efficient isosurf fitting, no simplification added costs;
- **hierarchical** or **progressive** rendering
- **multiresolution** data rendering

SIMPLIF. | APPLICATIONS

Progressive rendering

the availability of a multiresolution representation allows to:

- visualize a ***low resolution model*** when user--system interaction is high (e.g during interactive view settings);
- visualize a ***high resolution model*** when user--system interaction is low

the choice of the resolution level may depend on:

- complexity of the dataset at full precision
- graphics performances of the current system
- required rendering quality and/or frame rate

SIMPLIF. | APPLICATIONS

Multi-dimensional Trees [Wilhelms et al 94]

- an example of ***hierarchical*** Coherent Projection

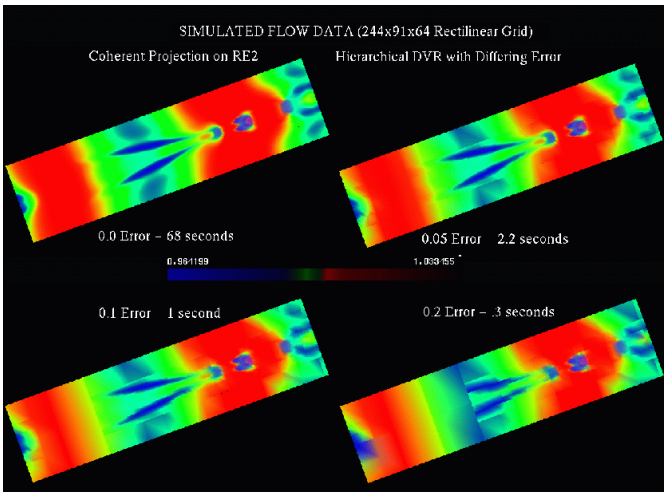
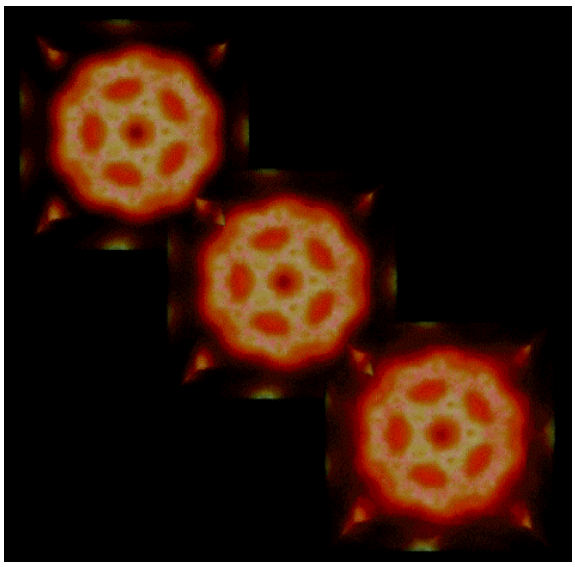


image by J. Wilhelms and A. van Gelder, UCSC

TAn

SIMPLIF. | APPLICATIONS

- Buckyball (chemical dataset, 32x32x32)
- projected tetrahedra algorithm, different data resolutions:
  - 100% of the data
  - ~50% of the data
  - ~10% of the data



SIMPLIF. | APPLICATIONS

Multiresolution rendering

how multiple levels of detail (LOD) may contribute to a single image?

if the goal is to *produce images* of reality:

for each object, use an LOD proportional to its *visible magnitude* or *distance to the observer* (in the current view)

(e.g. virtual environment rendering, VRML applications)

if the goal is to *get insight* into reality:

adopt ***viewing filters***, e.g. process the data to give synthetic, enhanced and/or interpreted visual presentation

(e.g. multiple resolution models and MagicSphere)

SIMPLIF. | APPLICATIONS

Multiresolution rendering via ***MagicSphere*** [Cignoni et al EG'94]

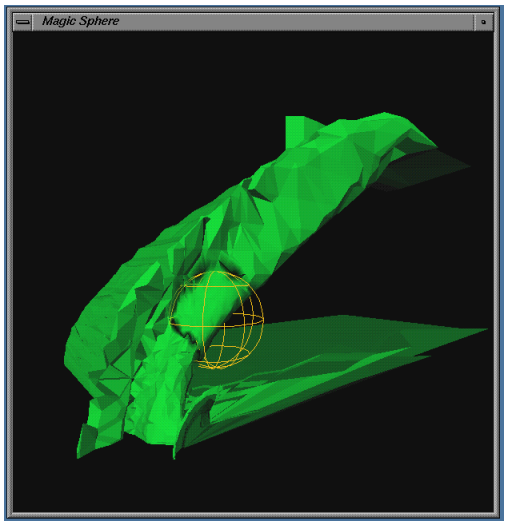
based on the metaphor of a 3D glass lens

- user defines a ***spherical focus volume*** in the data space;
- two different levels of detail are linked to the interior / exterior of MagicSphere
- user can define ***different rendering modalities*** for the data visualized in the interior/exterior of MagicSphere

SIMPLIF. | APPLICATIONS

Multiresolution rendering via ***MagicSphere***

MagicSphere
with a MultiRes filter



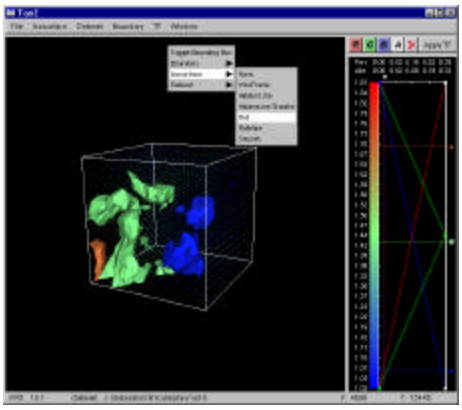
TAn 2 (Tetrahedra Analyzer Second Release) [Cignoni et al.94/97]

SIMPLIF. | APPLICATIONS

- Volume visualization system based on ***MT*** multires data structure

Features:

- Portable (win, sgi, linux)
- **unstructured** data
- simplification system based on either **refinement** or **decimation**
- extraction of a mesh at uniform resolution
- efficient extraction and rendering of multiple **isosurfaces**
- **Fixed and variable** resolution dataset management



TAn 2 (Tetrahedra Analyzer Second Release) [Cignoni et al.94/97]

SIMPLIF. | APPLICATIONS

- Volume visualization system based on ***MT*** multires data structure

Variable resolution features:

Refinement depending on

- field value
- space based
- dataset clipping through MT