
3D GEOMETRIC MODELING & PROCESSING

Paolo Cignoni

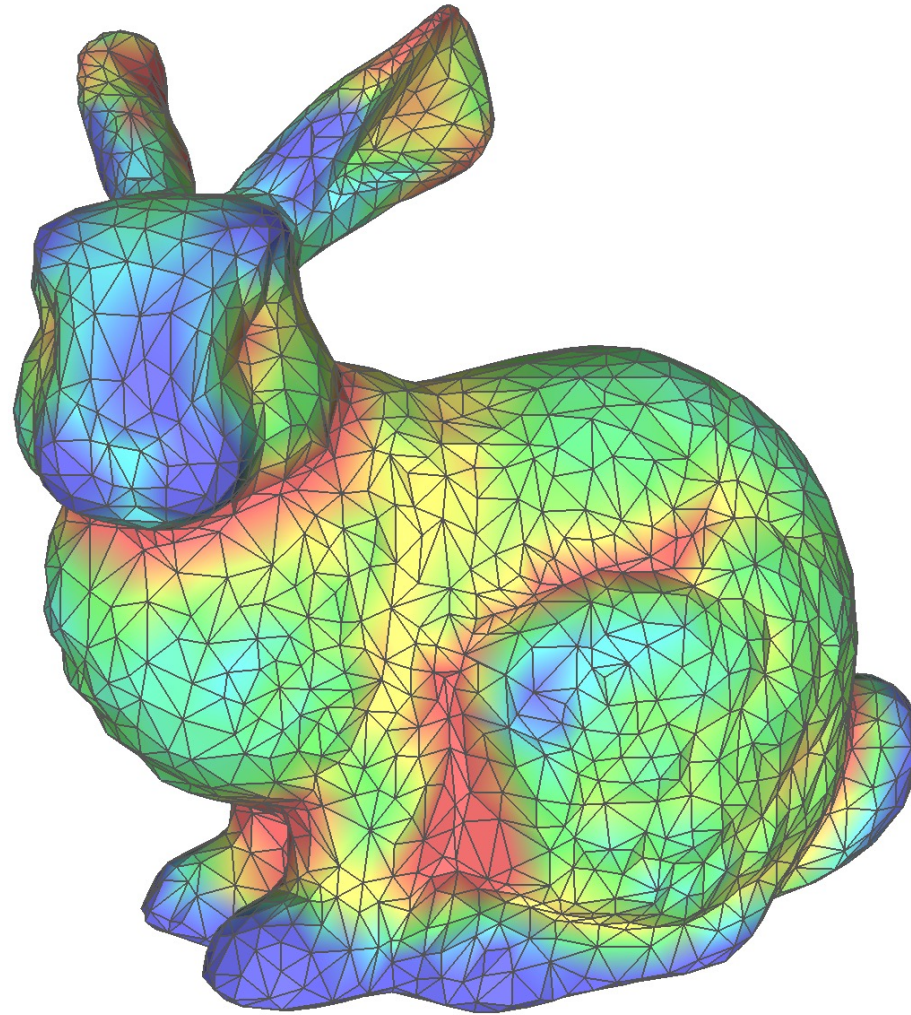
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Obiettivi

- ❖ Foundations for treating 3D surfaces and shapes in mathematics and computer science
 - ❖ Discrete Representations for Surfaces
 - ❖ Data Structures for Simplicial Complexes and spatial Indexing
 - ❖ Differential Geometry and Topology for Comp. Graphics
 - ❖ Mesh Processing Algorithms
 - ❖ Remeshing, Refinement & Simplification
 - ❖ Parametrization and Texturing
 - ❖ Fairing and Smoothing
 - ❖ Surface reconstruction and Sampling
 - ❖ Shape Analysis and Representations for Machine Learning

Dove servono queste cose?



Dove servono queste cose?

Dovunque serva una rappresentazione 3D

- Computer Graphics (ovvio)
- Data Visualization
- Machine Learning and AI
 - Come rappresento l'informazione su un manifold?
 - Come rappresento le caratteristiche di forma di una superficie in termini numerici?

Requisiti

- ❖ Conoscenza minima delle basi della grafica
 - ❖ Rendering?
 - ❖ RayTracing vs Rasterization?
 - ❖ Texture Mapping?
 - ❖ Lighting Models?

Requisiti

- ❖ Geometria, algebra lineare e un minimo di analisi
- ❖ Conoscenza del C++
 - ❖ Buona. Se non la avete iniziate subito.
- ❖ Conoscenza python
 - ❖ Media. Basta che sia migliore della mia :)
- ❖ Git as usual

Esame

- ❖ Costituito da una parte teorica ed una progettuale.
- ❖ La parte teorica riguarda gli argomenti teorici non coperti dal progetto e' sostenuta con un orale al momento della consegna della parte progettuale.
- ❖ La parte progettuale vale 20/30, mentre la parte teorica vale 10/30.

Voto finale = progetto +orale

MeshLab

- ❖ Generic mesh processing tool
- ❖ Open source GPL available for win and linux
 - ❖ The system relies on a vcglib large GPL library for mesh processing
- ❖ Aimed to the (almost) automatic processing of large unstructured 3d models
 - ❖ acquired 3D models are different from human built models
 - ❖ No structure, no particular need of a scene graph
 - ❖ Large datasets : millions of primitives

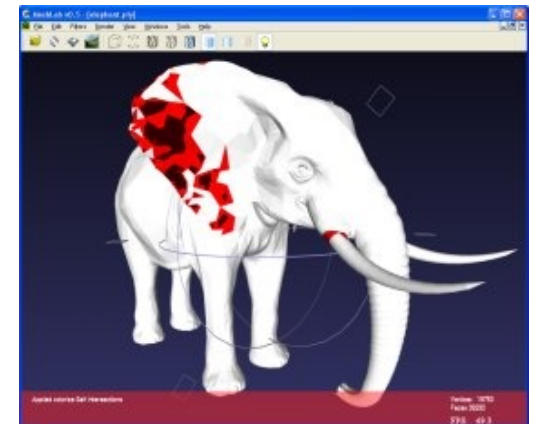
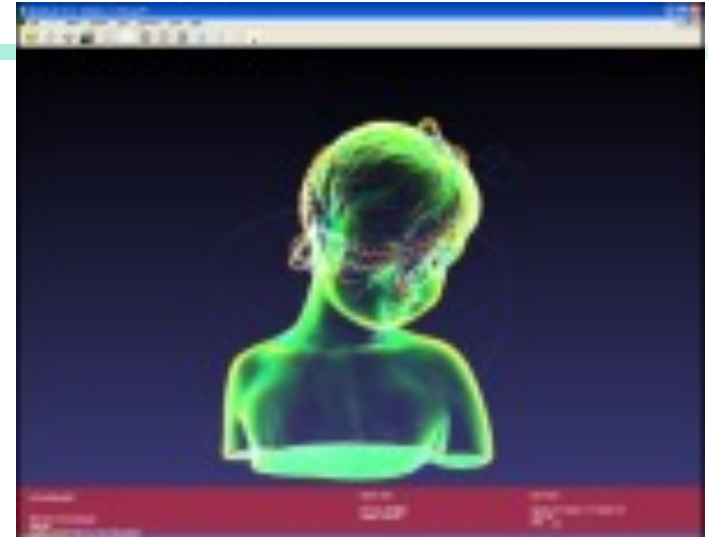
MeshLab

❖ Audience

- ❖ 3D scanning (mesh cleaning, etc)
- ❖ Entertainment industry (mesh reduction, checking, conversion)
- ❖ Simulation (checking, visualization)
- ❖ 3D printing
- ❖ Research Labs (it is a swiss knife)

Checking

- ❖ Visual inspection
 - ❖ See through filters (shaders)
- ❖ Quality evaluation
 - ❖ Curvatures, distances
- ❖ Automatic marking of mesh inconsistencies
 - ❖ topological: non manifoldness)
 - ❖ Geometric: self intersection
 - ❖ Small connected components removal



MeshLab tasks

❖ Filtering

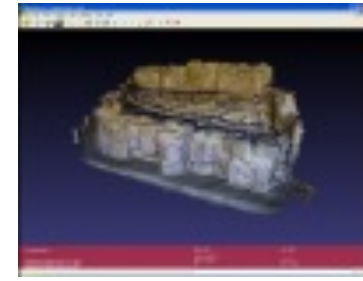
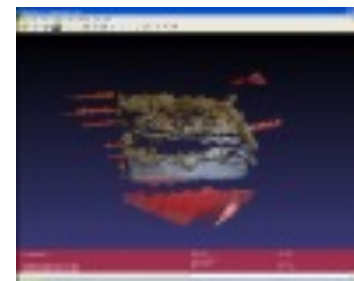
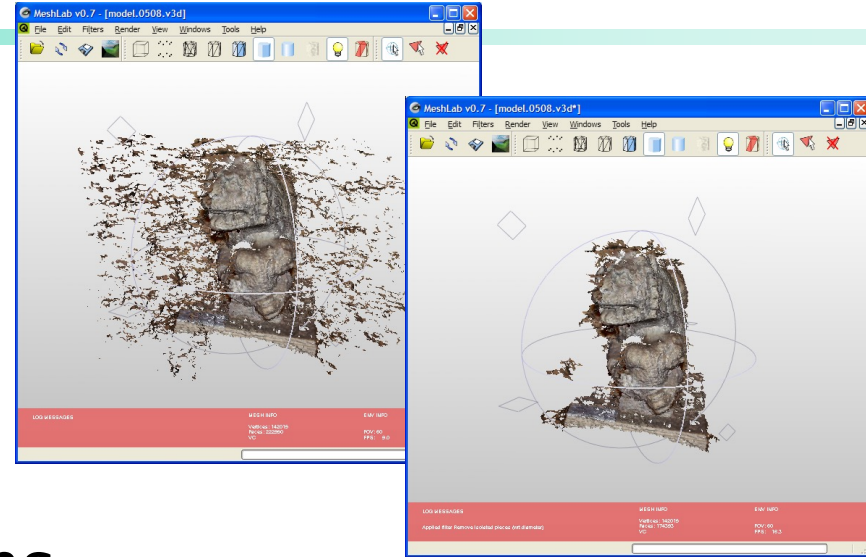
- ❖ Removal of outliers according to various heuristics

❖ Smoothing out noise

- ❖ Various fairing algorithms

❖ Editing

- ❖ Selection of parts and removal of non interesting portions of the acquired data



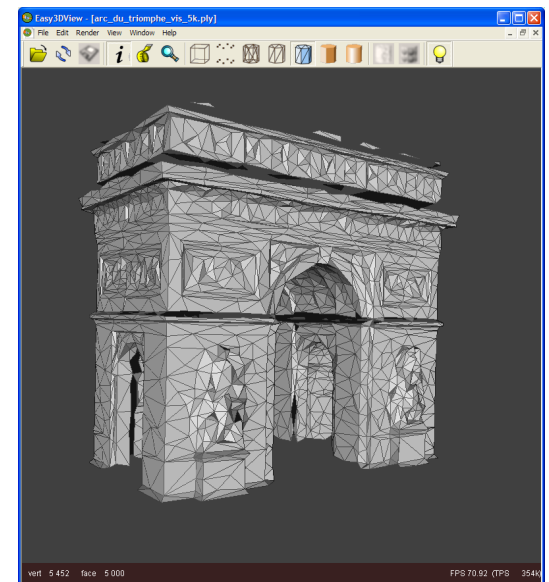
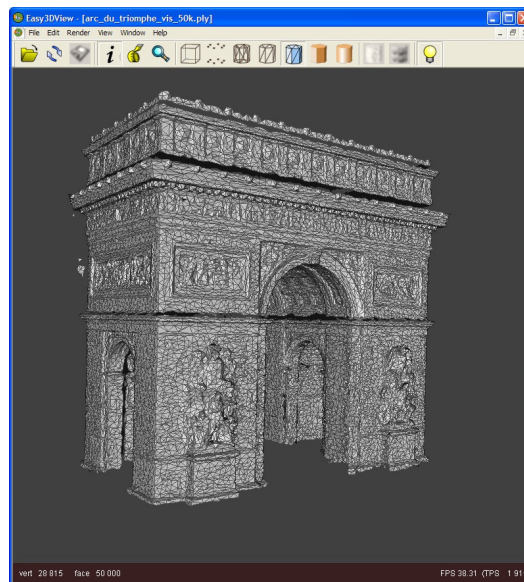
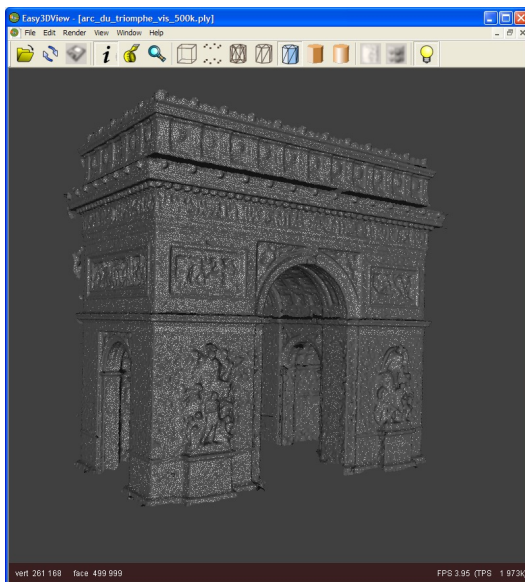
Remeshing

- ❖ Subdivision Surface (loop and butterfly)
- ❖ Reducing complexity through simplification
 - ❖ Both fast approximate and slower high quality algorithms

❖ 500k

50k

5k



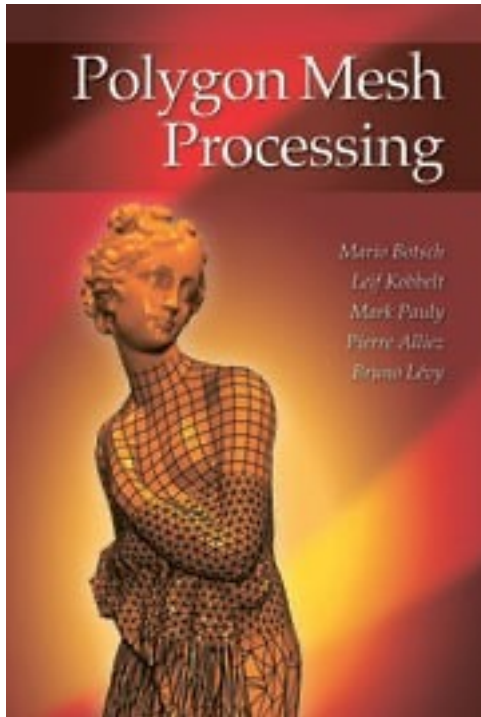
MeshLab Architecture

- ❖ Basic plugins are the filters
 - ❖ Algorithms that take some meshes in input, some user parameters and create/modify meshes.
 - ❖ Automatic dialog creation
 - ❖ Developer of filters simply declare the parameters and the gui for asking them is automatically created.
- ❖ More than two hundred filters
- ❖ pymeshlab
 - ❖ python version of meshlab that exploits the same filtering plugins for exposing scriptable functions

MeshLab numbers

- ❖ 2M download in the last 3y
- ❖ 30k monthly downloads
- ❖ Used in hundred of university all over the world
- ❖ Many companies using it
 - ❖ Game, simulation, aerospace, 3d scanning, FX industries, military, medical,

Riferimenti Biblio



❖ Polygon Mesh Processing

*Mario Botsch, Leif Kobbelt,
Mark Pauly, Pierre Alliez,
Bruno Lévy*

A K Peters/CRC Press