3D GEOMETRIC MODELING & PROCESSING

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Objectives

❖ **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

Why geometry is important?
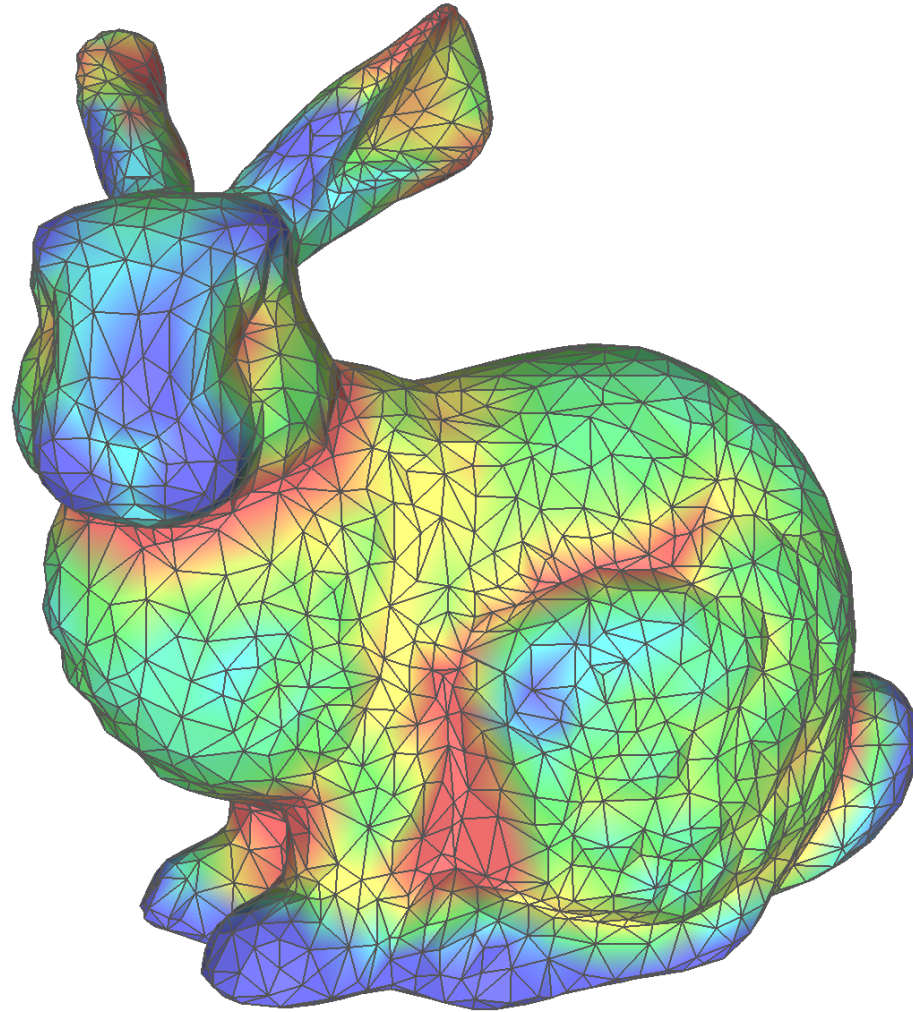
Dove servono queste cose?

Dovunque serva una rappresentazione 3D

- Computer Graphics (ovvio)
- Data Visualization
- Machine Learning and AI
  - Come rappresento l'informazione su un manifold?
  - Come rappresento le caratterische 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)
  - ❖ Entertainement 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
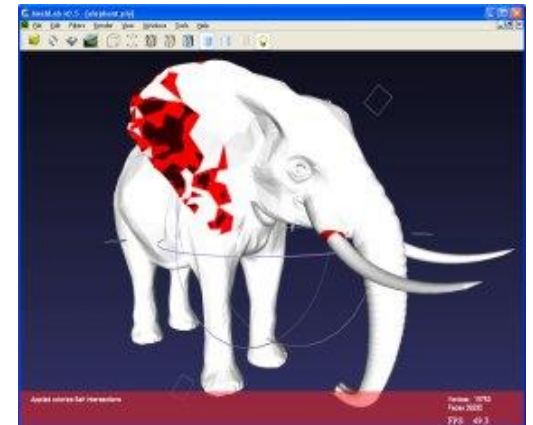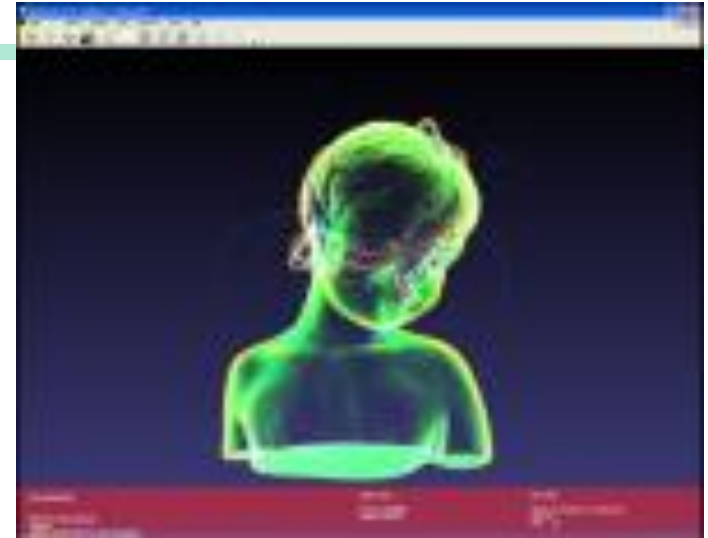
MeshLab tasks

❖ 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
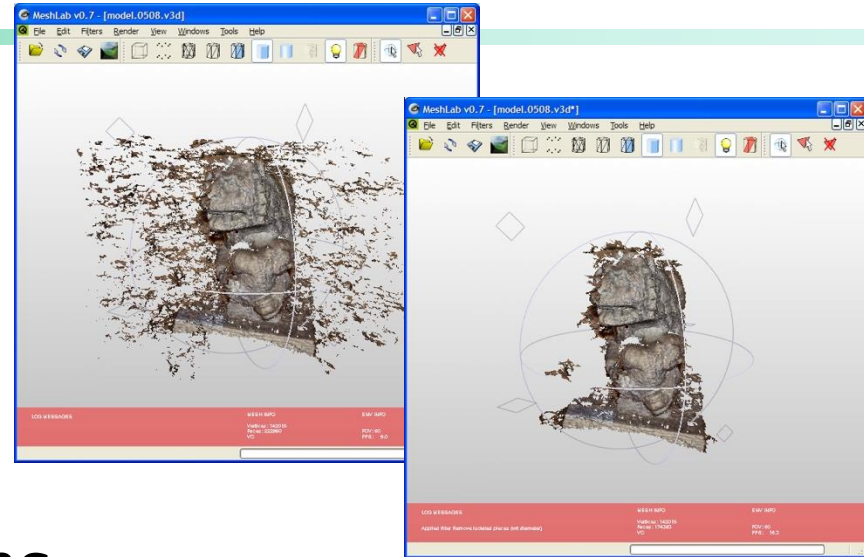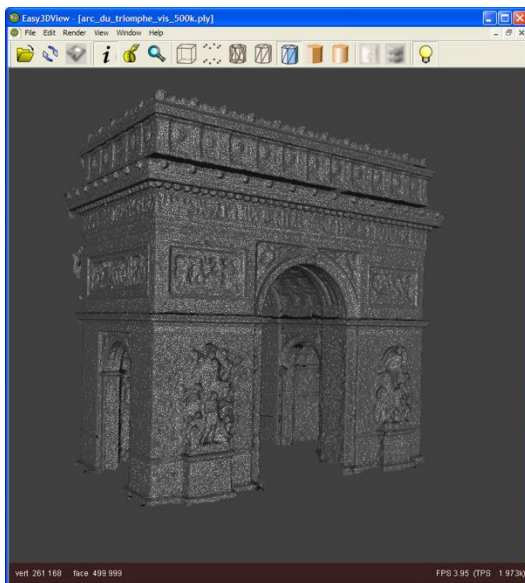
Remeshing

❖ Subdivision Surface (loop and butterfly)
❖ Reducing complexity through simplification
  ❖ Both fast approximate and slower high quality algorithms
 ❖ 500k   50k   5k
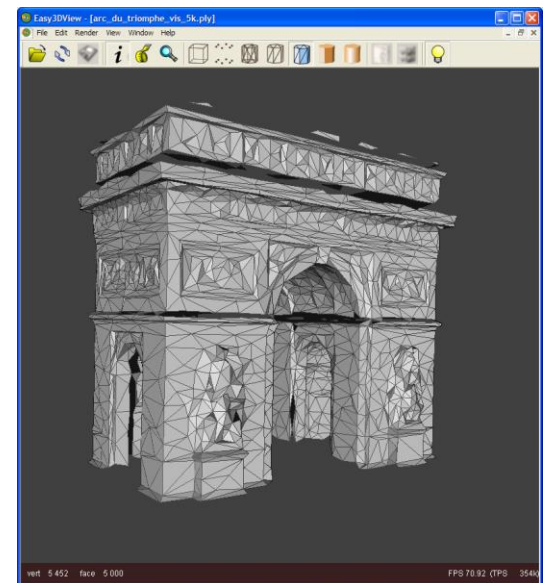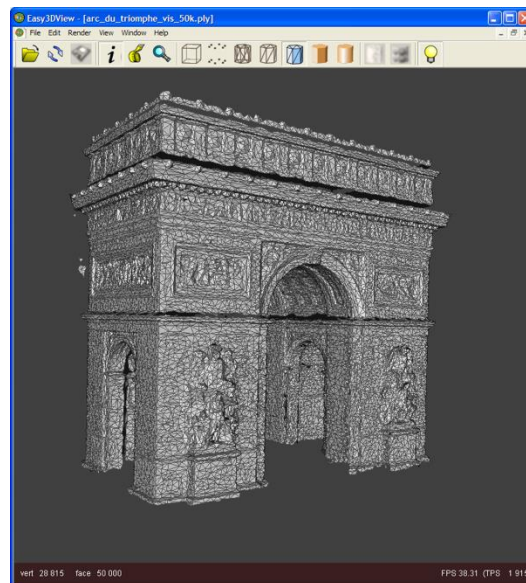
MeshLab Architecture

❖ 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

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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, aerospatial, 3d scanning, FX industries, military, medical,
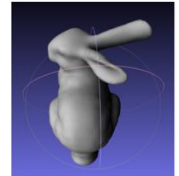
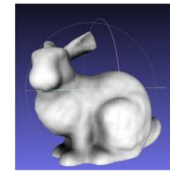# Successful Projects

- Discrete Developability
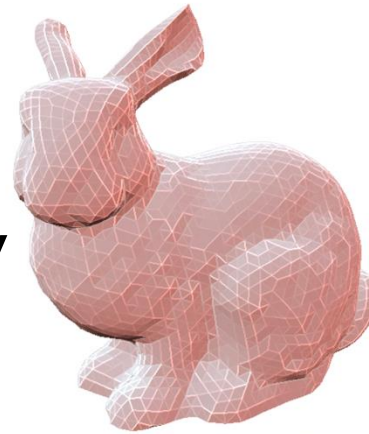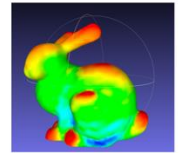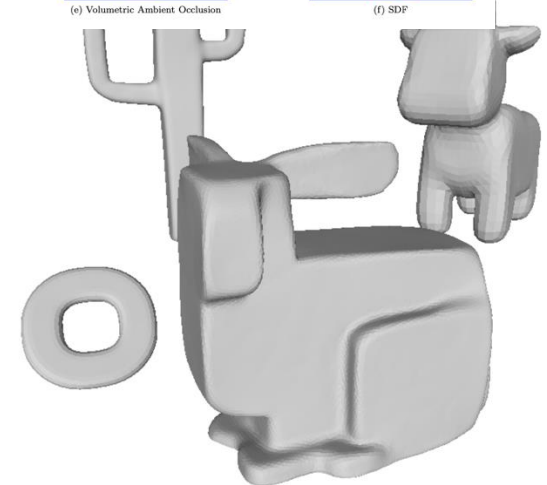
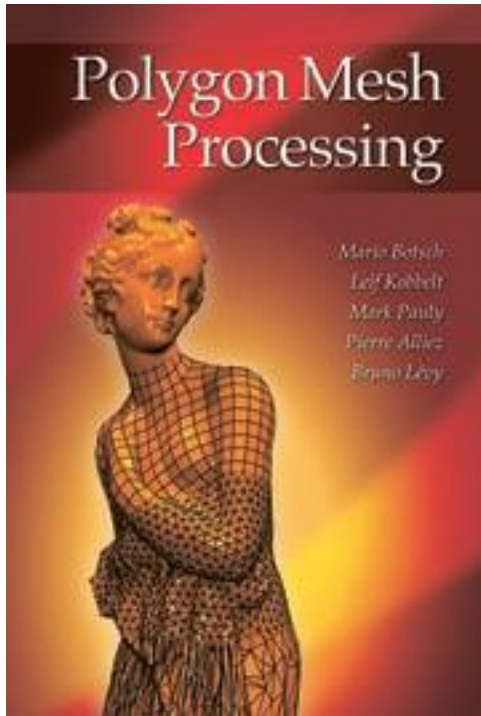- Embree adaptors
  (efficient Intel library for raytracing)
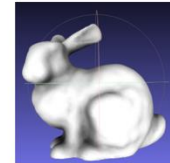
- Cubization filter

Riferimenti Biblio

❖Polygon Mesh Processing

Mario Botsch, Leif Kobbelt, Mark Pauly, Pierre Alliez, Bruno Levy

A K Peters/CRC Press