3D Digitization for Cultural Heritage

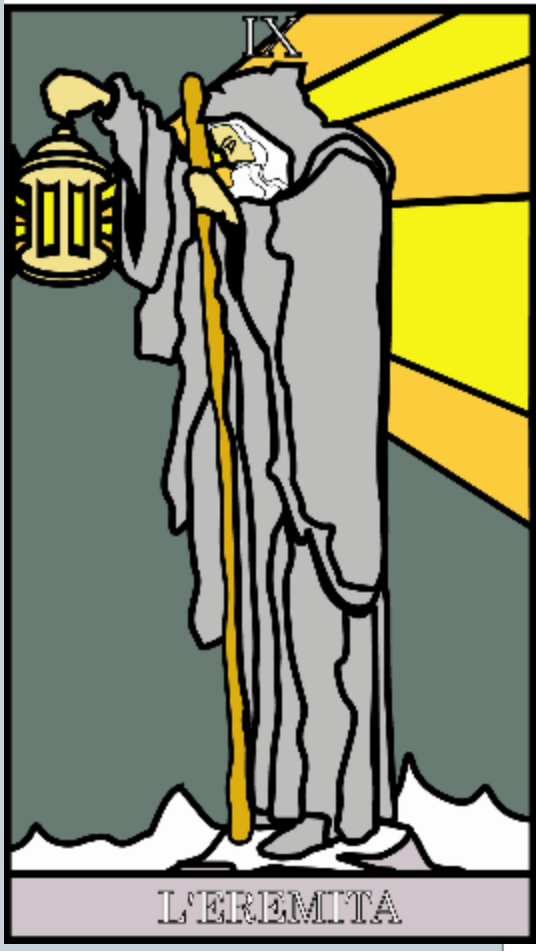
NOT ALL 3D HAS BEEN CREATED EQUAL

Who am I?

Marco Callieri

- Master degree & PhD in computer science

- Researcher at the Visual Computing Lab, ISTI-CNR, in Pisa
- I work on 3D data manipulation and rendering... lot of experience in 3D scanning and data processing
- Most of my activities are in the field of cultural heritage



http://vcg.isti.cnr.it/~callieri

callieri@isti.cnr.it

Beside this:

an eclectic artisan, an avid gamer, a former biker, a good cook, an incorrigible geek... and much more

Visual Computing Lab

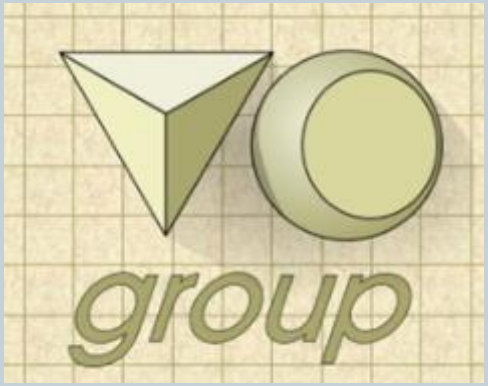
Research group working on **3D computer graphics**

part of:

Istitute of Science and Technologies of Information (**ISTI**)

part of:

National Research Council (**CNR**)



http://vcg.isti.cnr.it

Dual nature

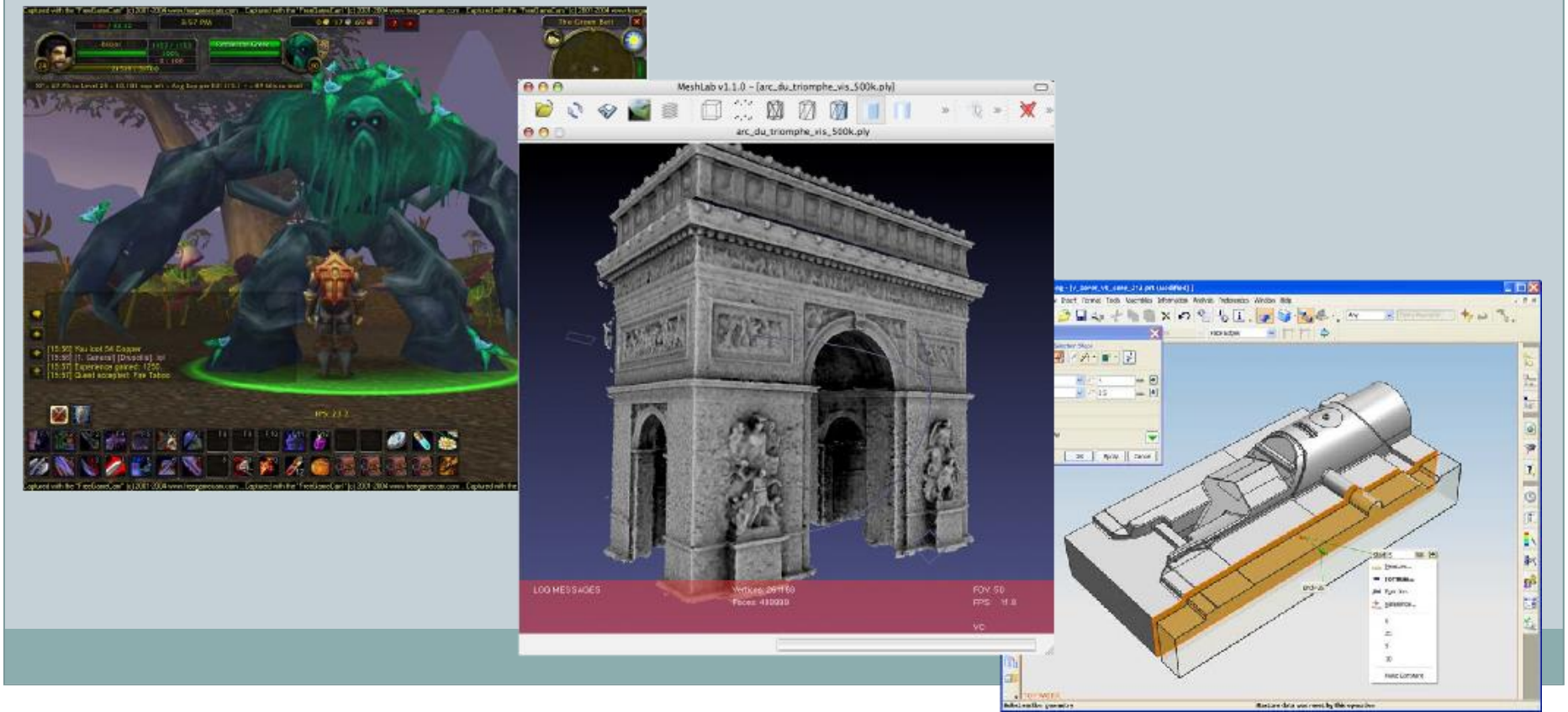
3D is used a lot because it has two natures:

- **PURE DATA:** 3D is metric, geometrical information…. In a word: numbers. It is possible to do calculation over it, and work on it from a mathematical point of view.
- **VISUAL:** 3D data can be visualized such that is perceived in the same way we perceive reality. In this way we can access the data in a more natural way.

The combination of these two properties is what makes 3D valuable…

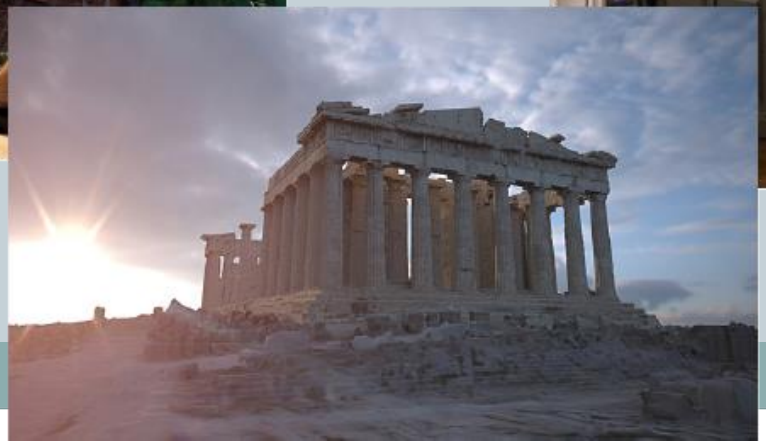
Interactive 3D

You may have encountered applications where a digital 3D world is *somehow* displayed and, *somehow* the user may change the view over this world or the world content...



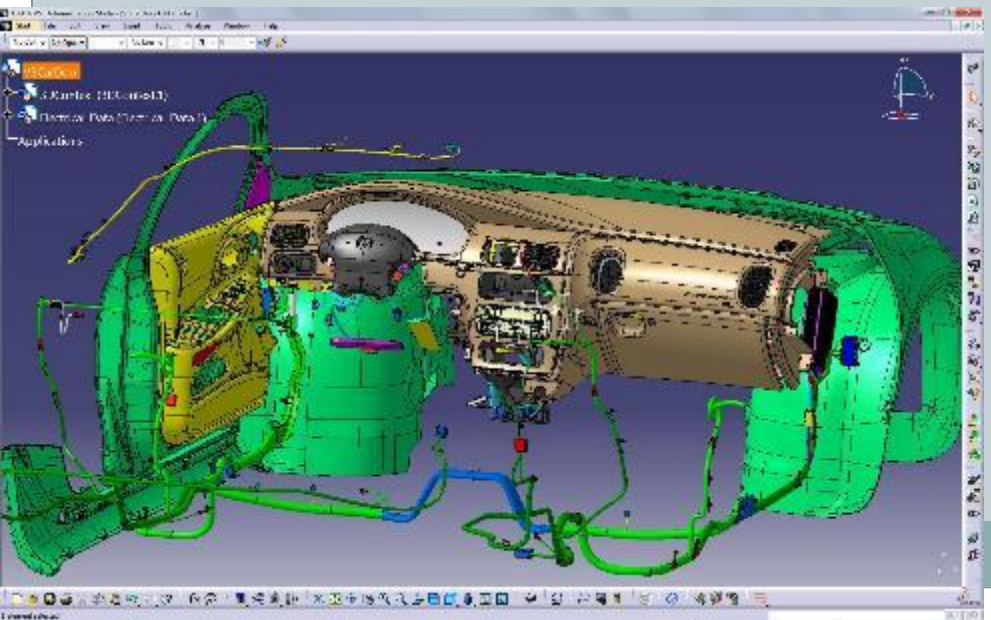
Non-Interactive 3D

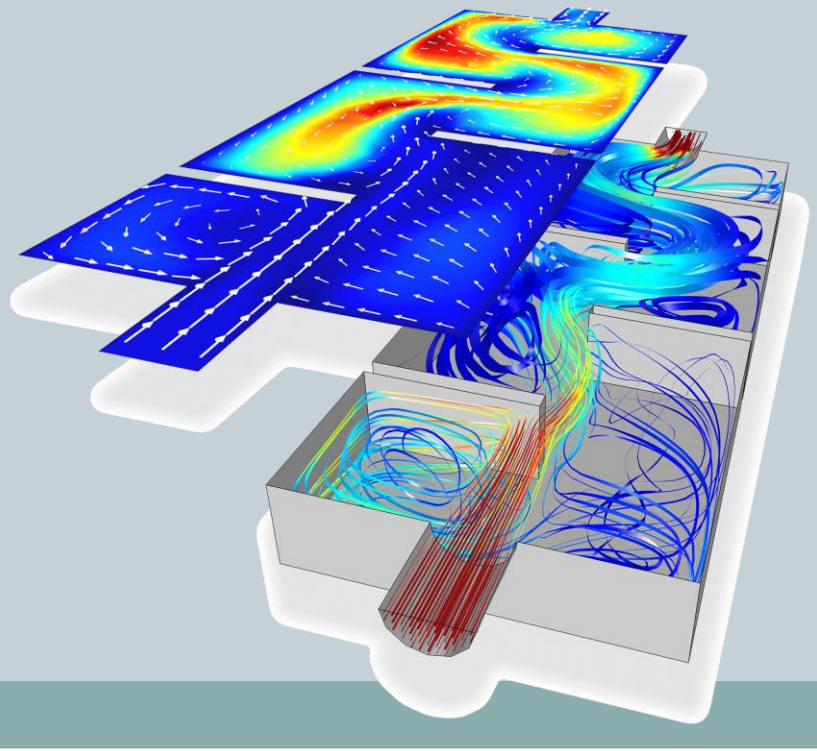
But you may have also seen images and videos generated from 3D...



Technical 3D

3D, sometimes, is a purely technical entity, that is created **and** consumed without being the final product, like in industrial design, CAD-CAM, simulation.





Different Worlds

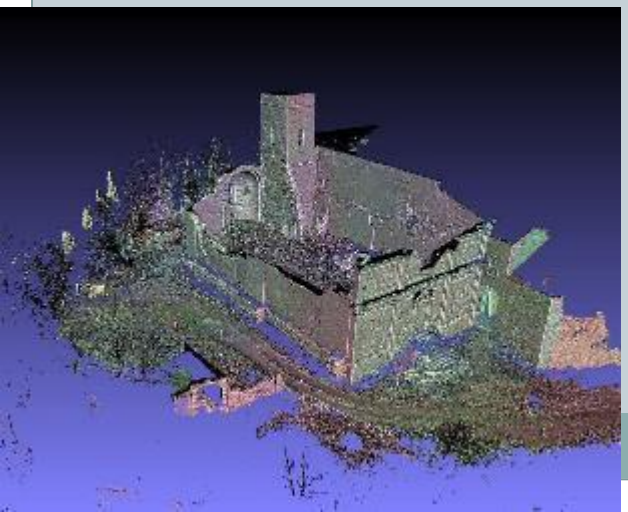
REQUIRE DIFFERENT 3Ds

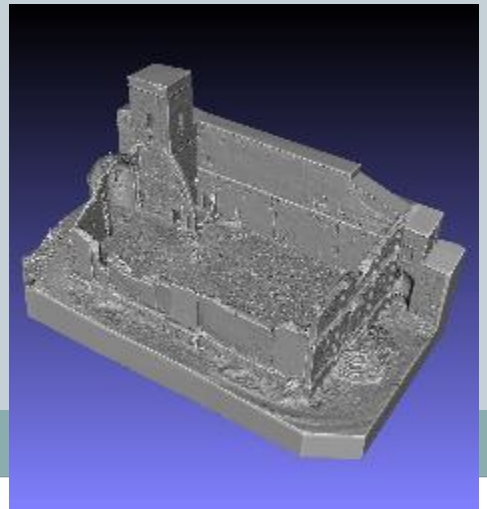
3D as *we* know it

And, by "we" I mean our lab…

We work with a very specific kind of 3D.

- Digitized from reality
- Unstructured Triangulated Mesh / Pointcloud
- High-density (but generally uniform)
- Colored/textured from photos



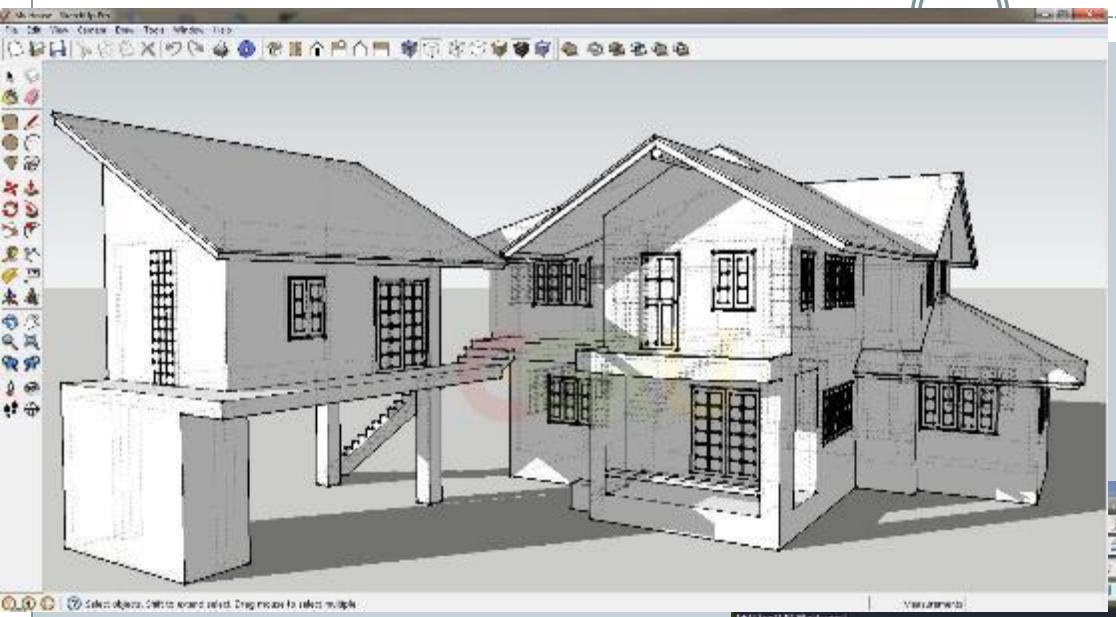


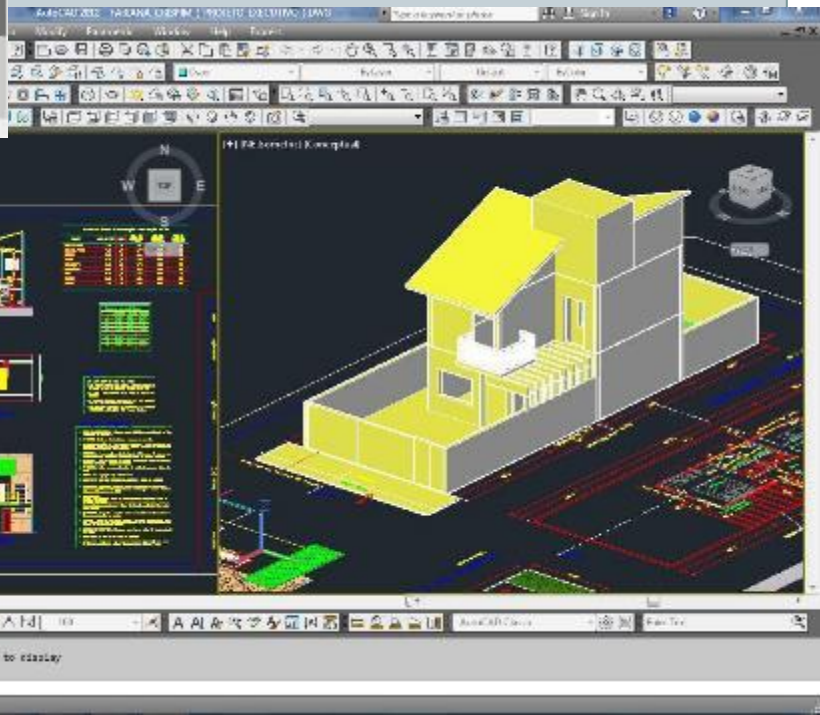
3D for design & CAD-CAM

Created by human, or, more precisely: "modeled" by experts using specifc programs.

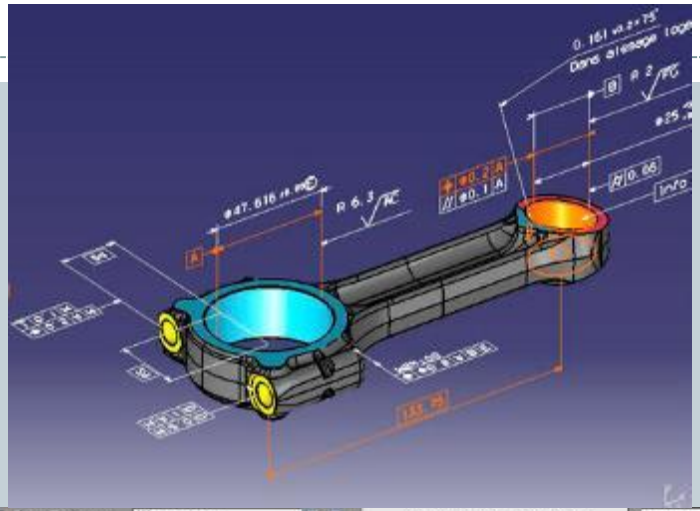
- Higly structured
- Low geometric complexity (with respect to digitized 3D), and non-uniform
- 3D model made of triangles, polygons, mathematical surfaces, …

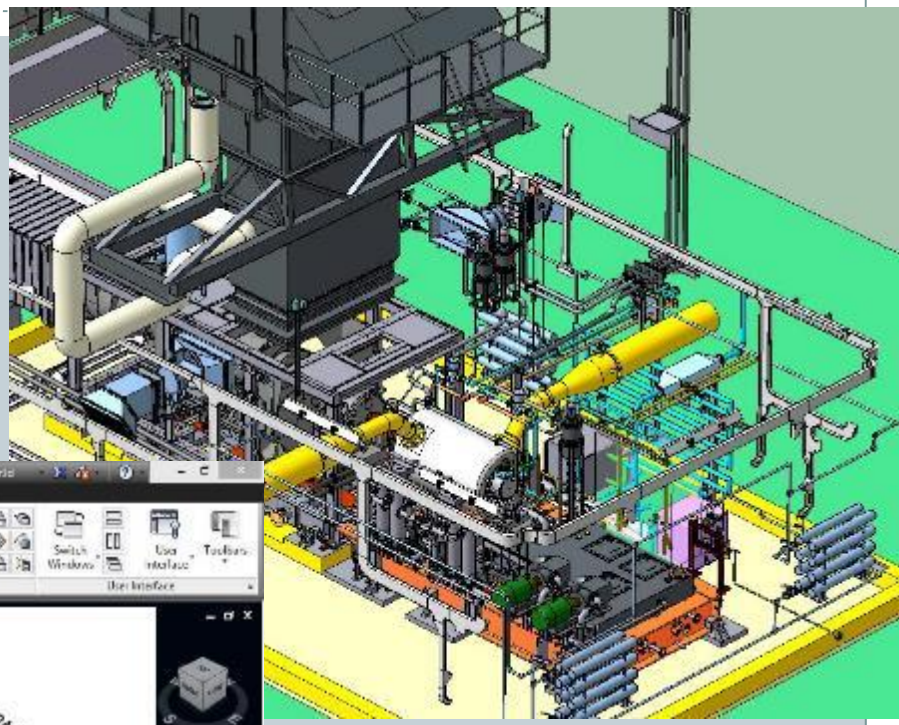
3D for design & CAD-CAM

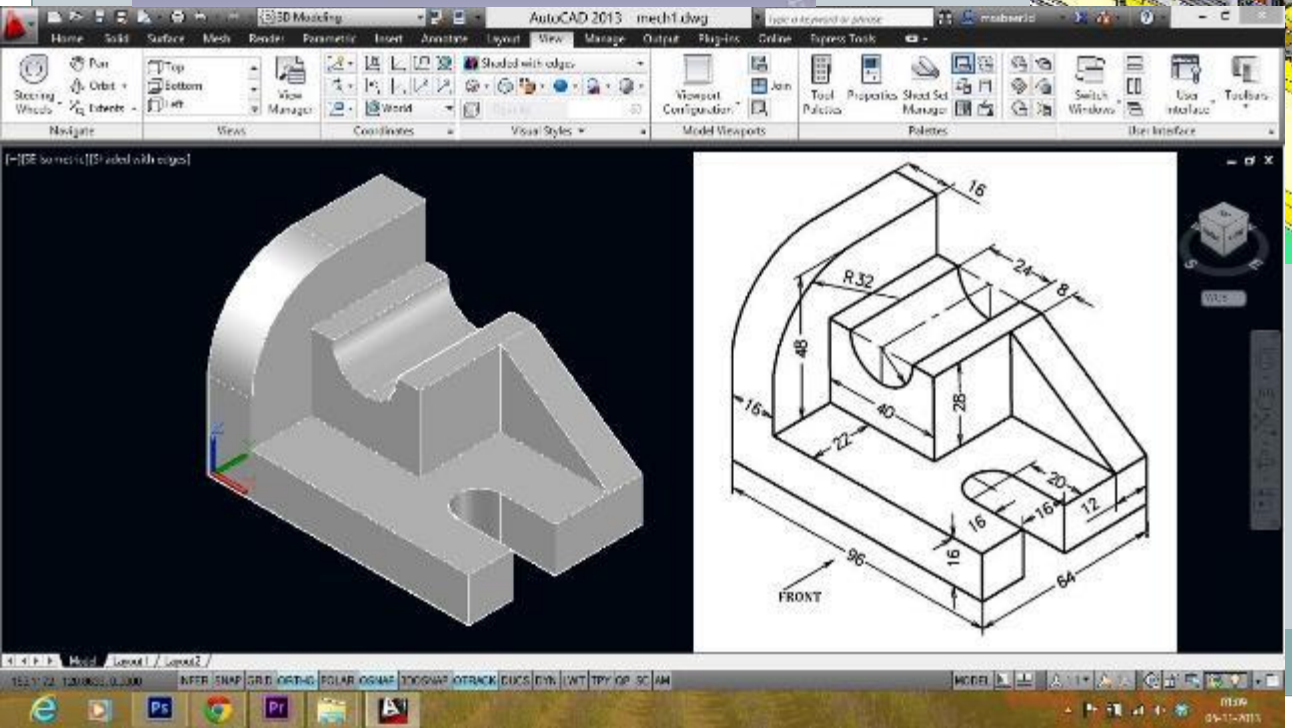




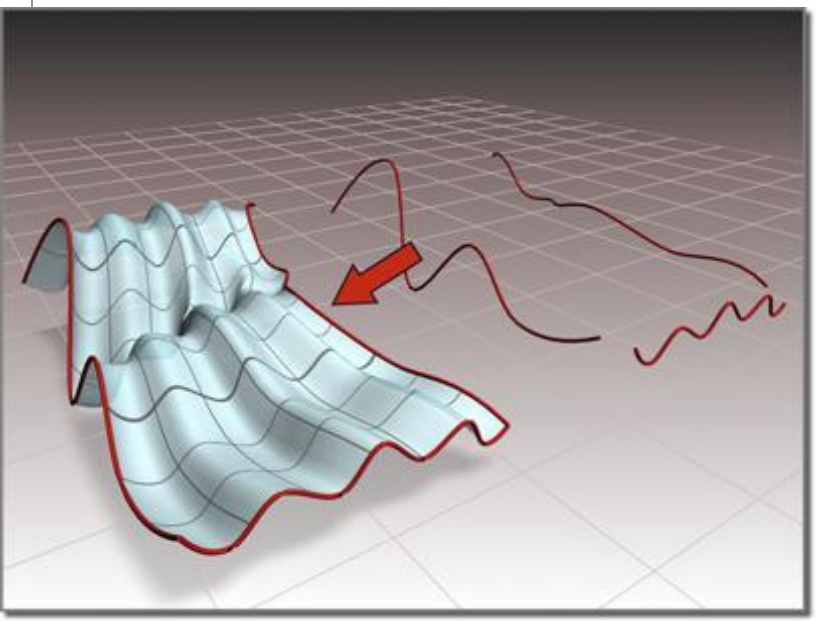
3D for design & CAD-CAM

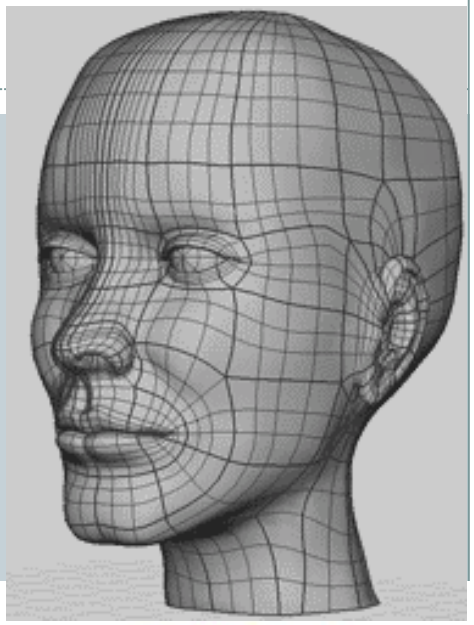






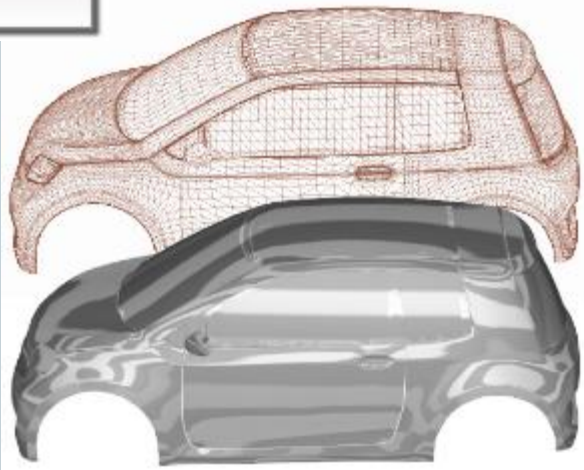
3D for design & CAD-CAM

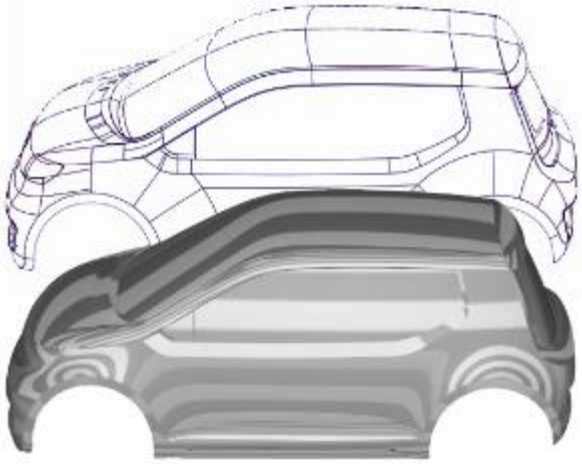




Polygon model

NURBS model





Poor surface quality

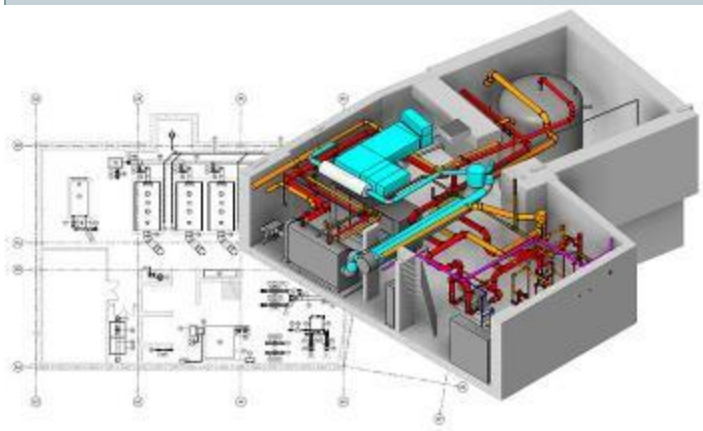
Pure, smooth highlights

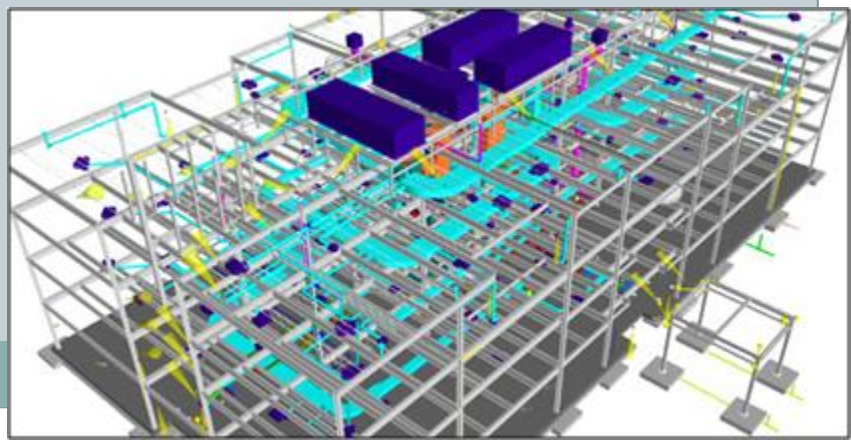
BIM

BIM is becoming more and more popular, nowadays.

A design 3D model of a building, where each part is also ANNOTATED, describing the function and specification of each component. Basically, all the information that transform the 3D model from a geometry into a usable blueprint.

These information may be used to compute building efficiency, contruction cost, organizing the contruction, reference for future maintenence…



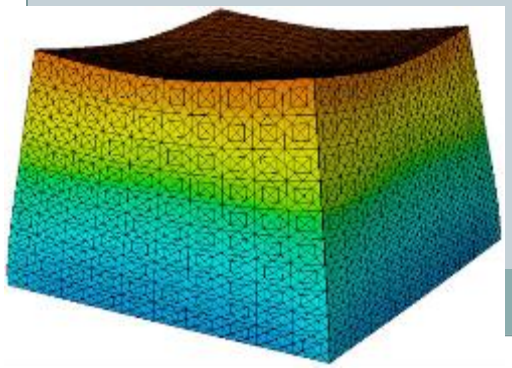


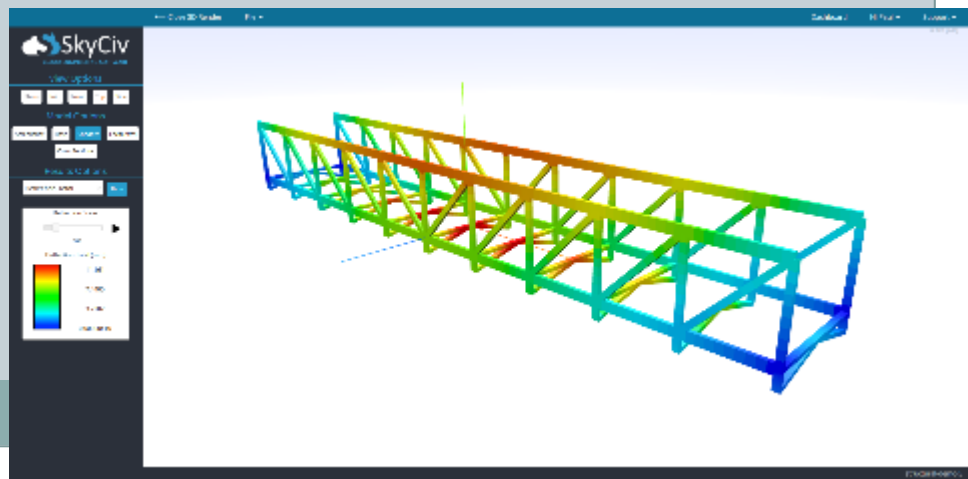
3D for structural engineering

3D is used, in engineering, to assess structural integrity of buildings and objects.

In most cases, objects are subdivided in small components, with uniform properties, and a lot of additional data in associated to these elements (weight, temperature, mechanical resistance, joint properties,…).

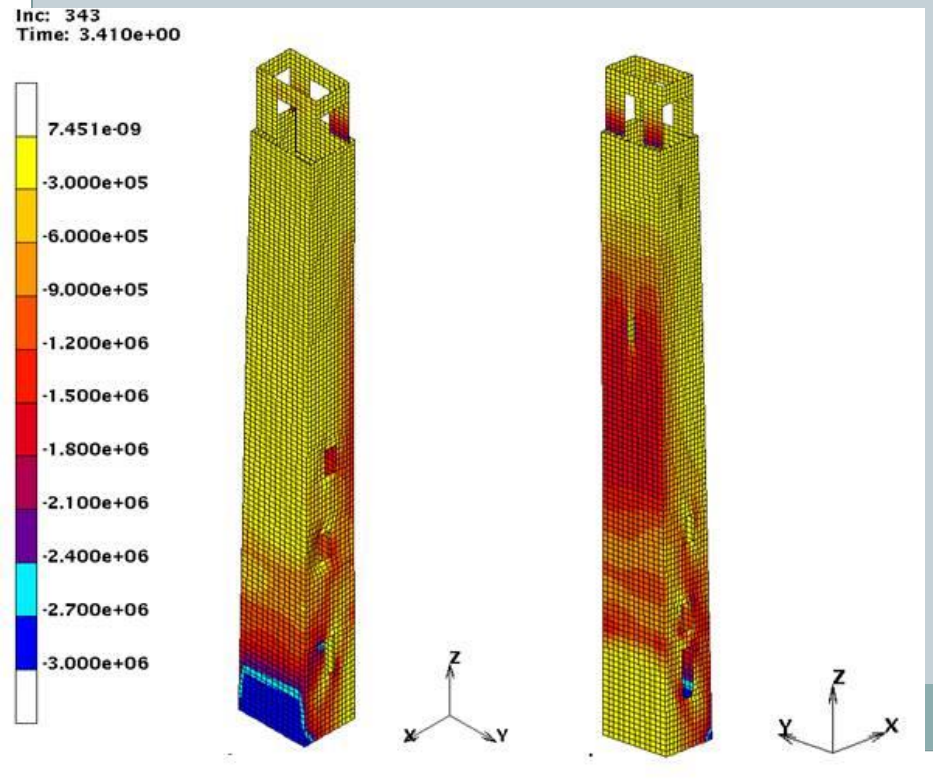
A numerical simulation of physical behaviour is then run (FINITE ELEMENTS)





3D for structural engineering

It may be manually created (e.g. designed objects/buildings);
It may be generated from scanned (measured) data, with lot of effort…



3D for structural engineering

Also used for other kind of simulations:

- Temperature (e.g. metal casting)
- Air/water flow
- Medical
- Mechanical stress

Specific software is used for these tasks, lot of work is required in setting up the 3D data for the simulation

3D for Games & VR

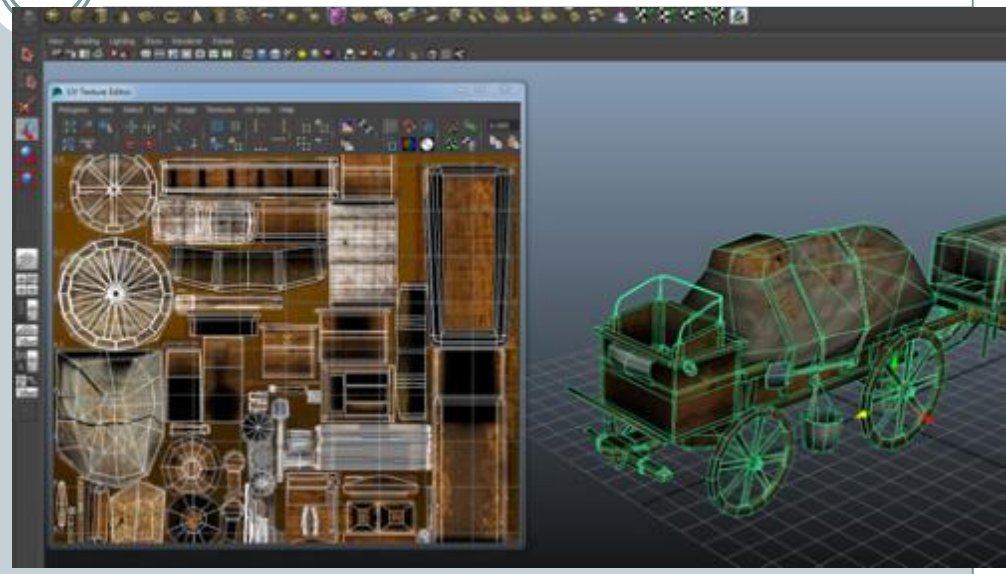
Games are relevant because… reasons.

Between games and «serious» interactive CH apps (e.g. virtual reconstructions) there is not much difference…

And also VR, in the end, is just a different sort of interactive game ;).

3D for Games & VR

The 3D models used in games are different from other fields



- Generally, hand-made
- Low-poly geometry
- A scene is made of many, many low-complexity objects
- Lot of data is associated to the surface (color, optical properties, material information)
- 3D models may be “animated”

3D for rendering

Basically, an in-between two of the previous types (CAD – games).

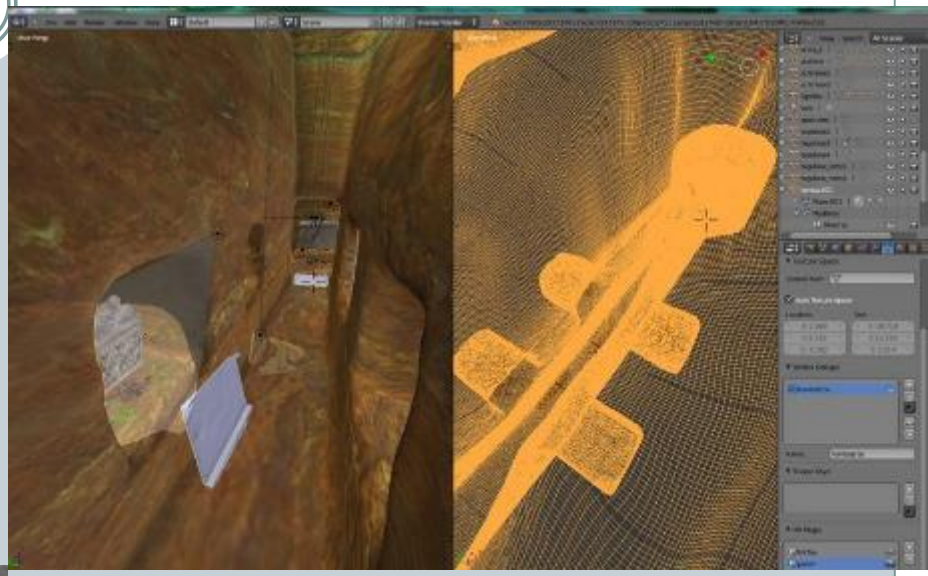
Hand-modeled, not as precise/metric as the CAD, but more geometrically complex than realtime game assets.

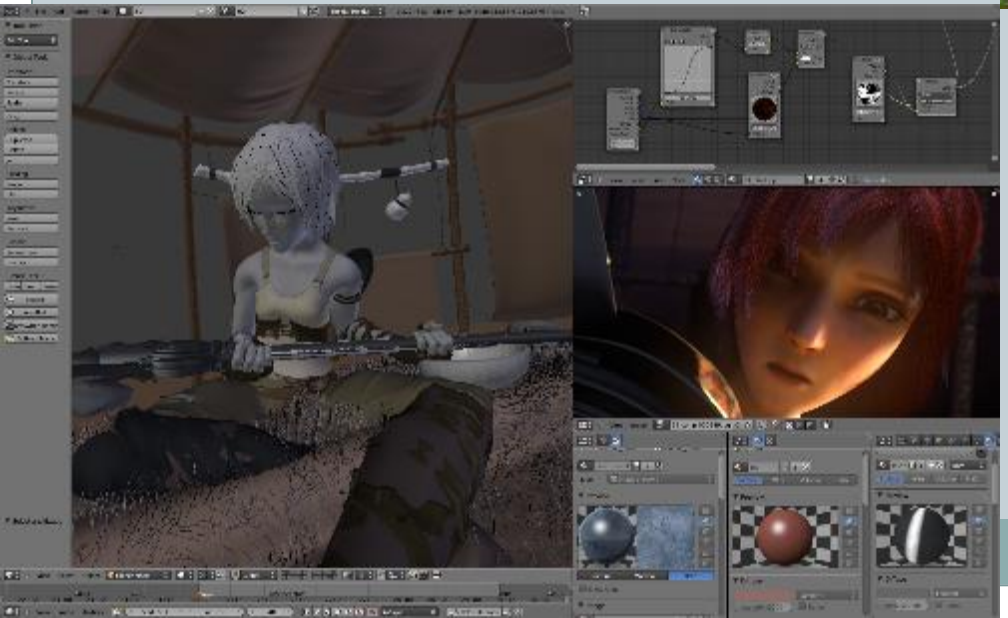
Additional non-geometric geometry for specific kind of objects/phenomena: water, fire, grass, hair, fog. Normally, particle systems.

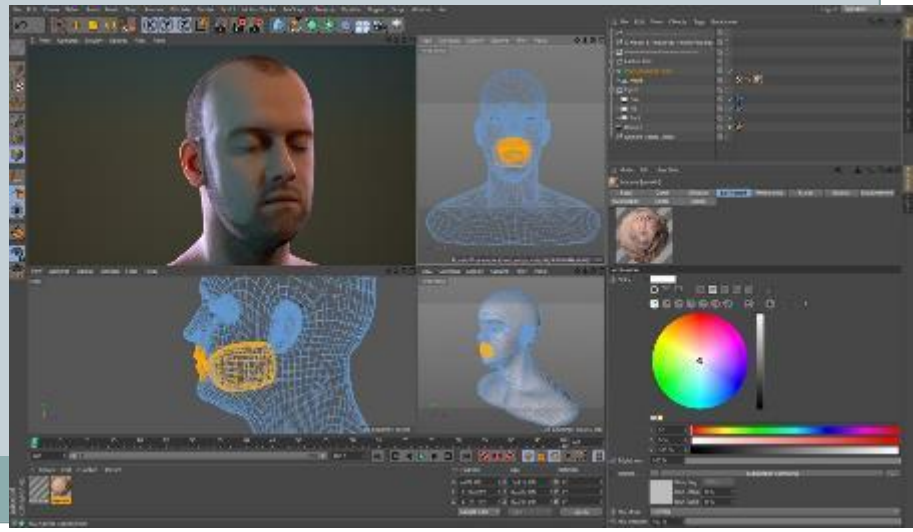
Plus, A LOT of additional data to create photorealistic images, using various kid of light simulation.

Rendering asset may be created from real-world data, in various ways.

3D for rendering

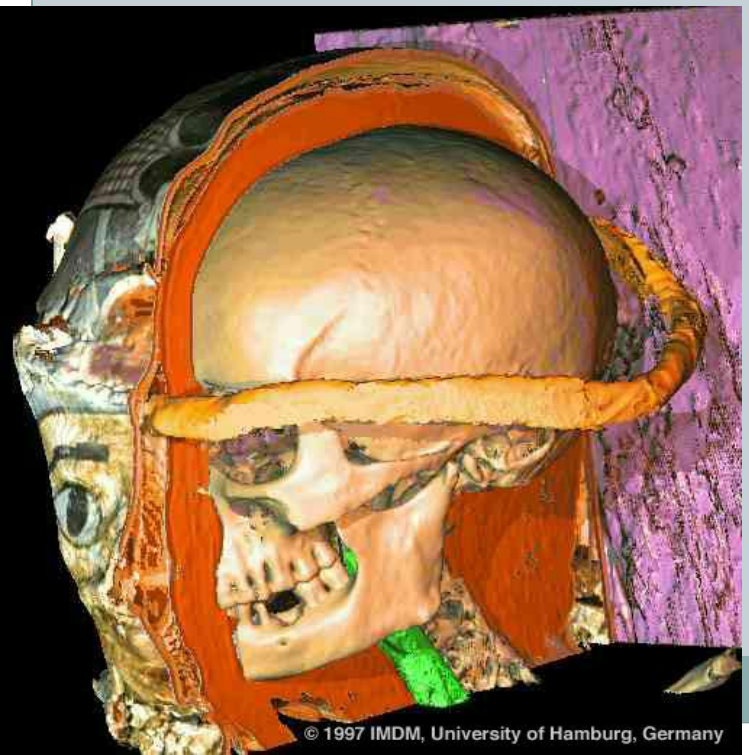


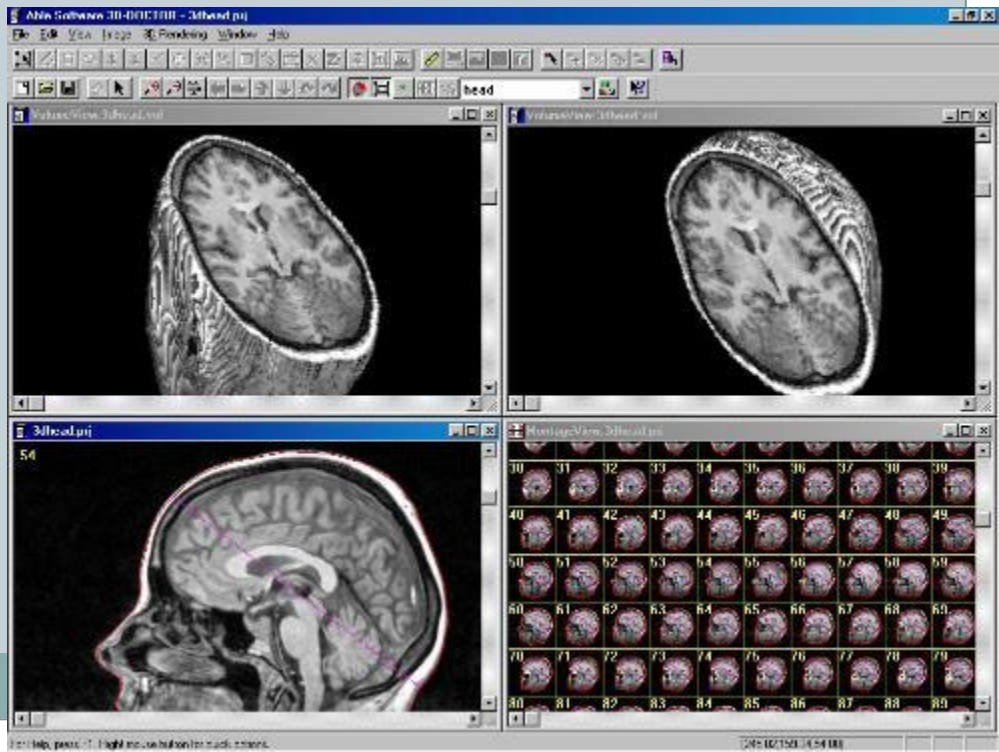




3D in medical field

3D is used a lot in medicine, mostly using things like CAT, PET, MR. These generate VOLUMETRIC 3D: for every point of the object, a density value is measured.

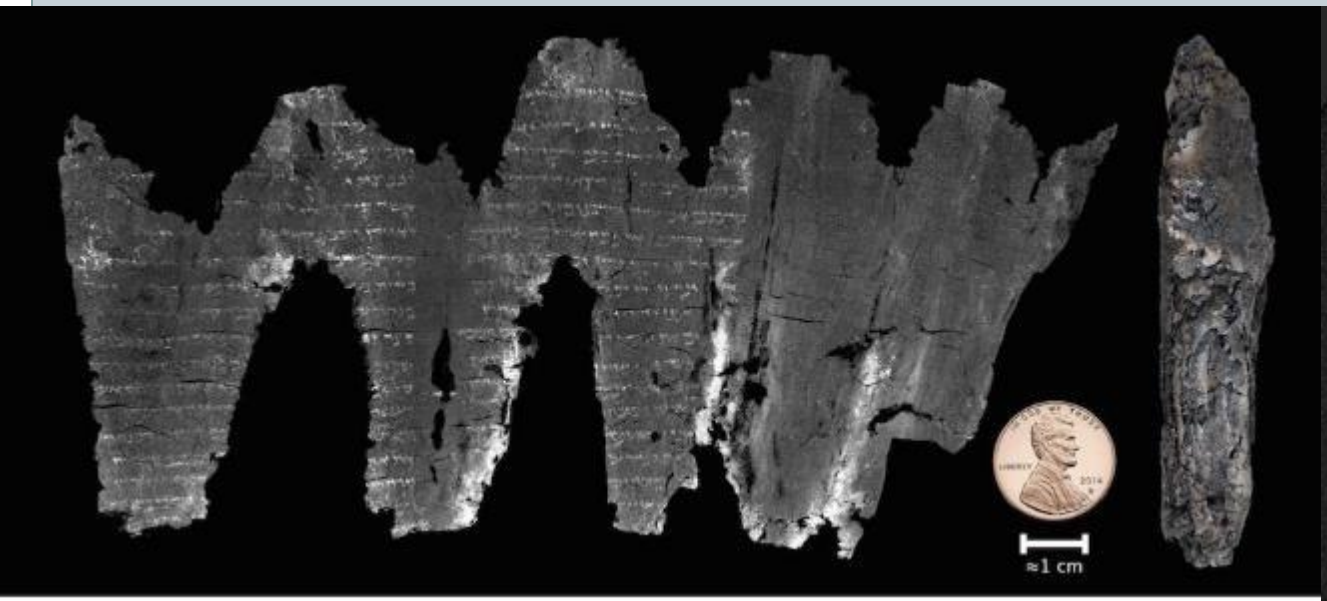


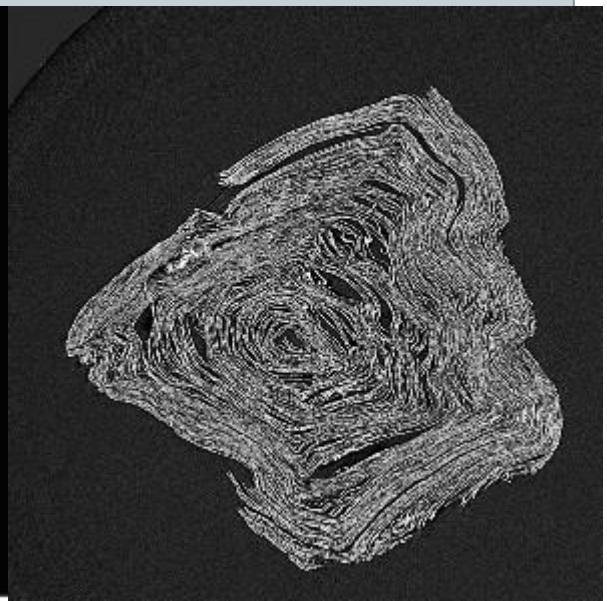


3D in medical field

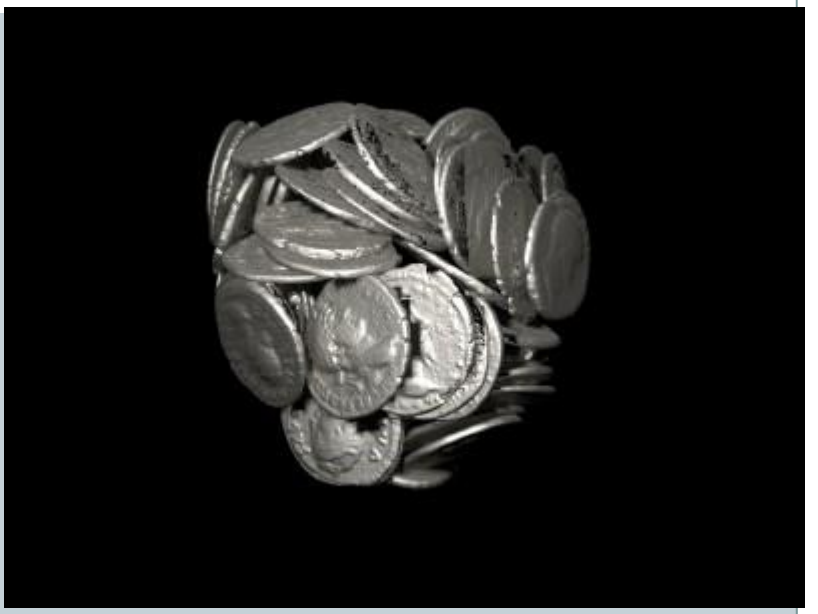
Also used in the CH field, but not easy to obtain and manage.

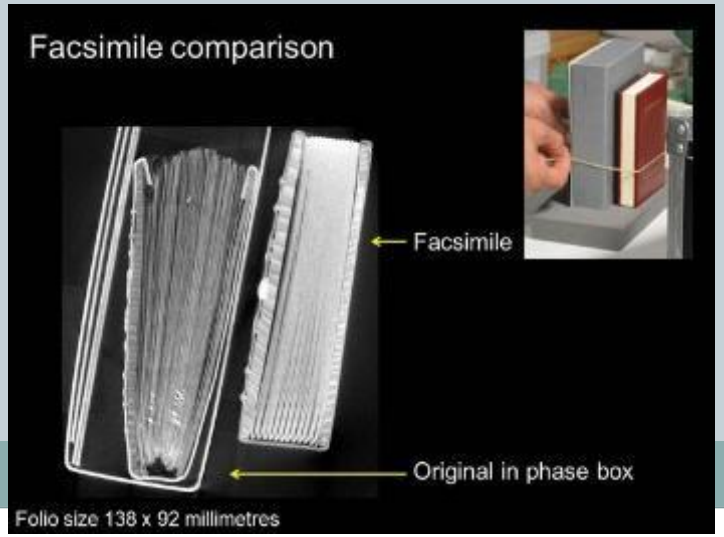
Mummies, parchment/manuscript unroll and study, fully enclosed objects, multi-part objects…

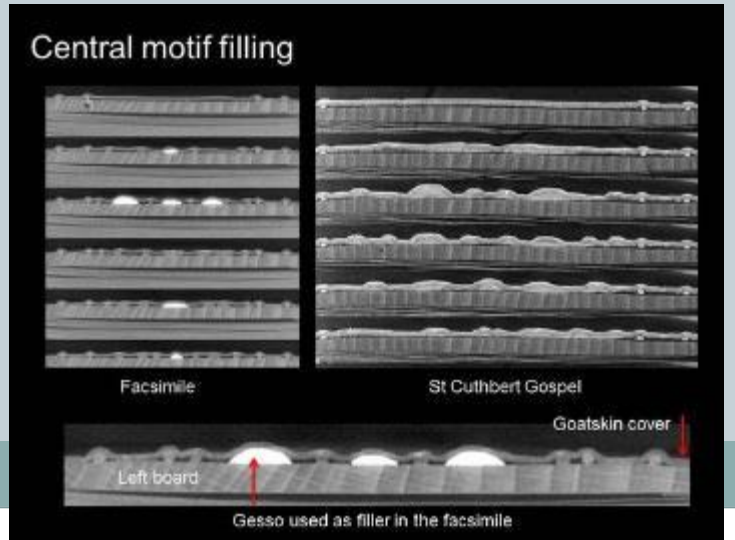




3D in medical field







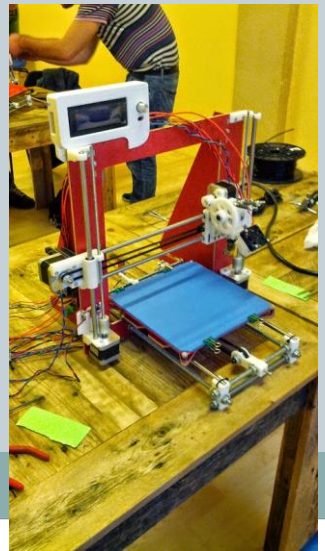
3D for physical reproduction

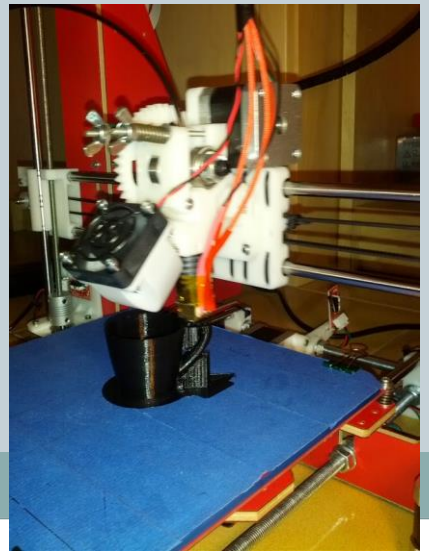
3D Printing is the new hype…

Building a physical copy of a 3D model is now a technology accessible from anyone.

Lot of use in the CH field (as we will see).

We are lucky, 3D printing uses triangulated meshes: both hand modeled (CAD –like) and digitized (the kind we work with)… but…



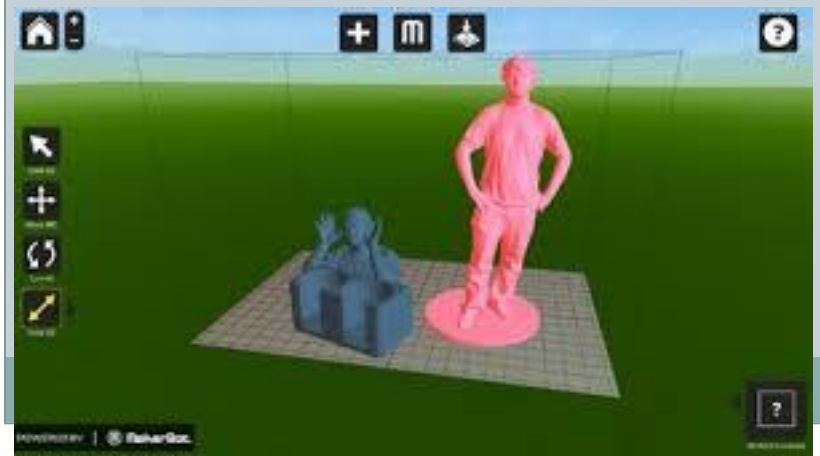


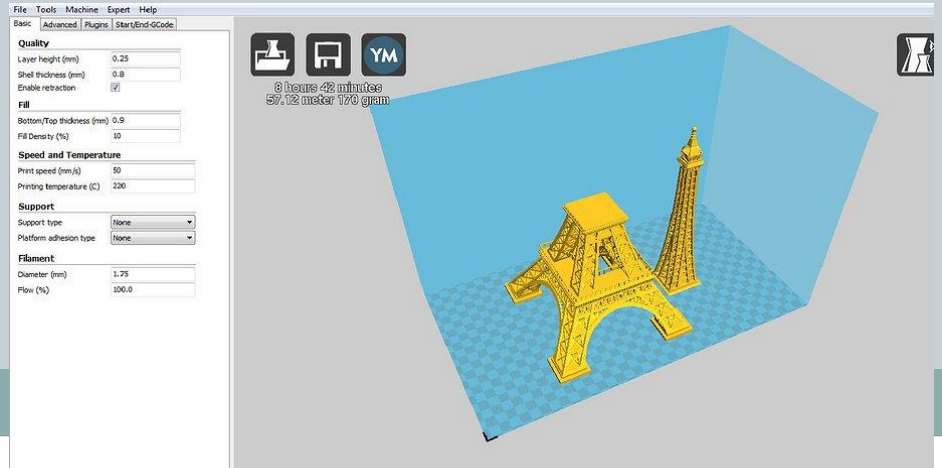
3D for physical reproduction

Problem: not all 3D models can be printed… They should be

- Closed and not too complex
- "Topologcally Clean" (more later)
- "Printable" (we will be more precise later)

And, unfortunately, choosing *how* to print is an art…





3D, but not 3D

3D TV, 3D cinema, 3d cameras, 3D cards/posters

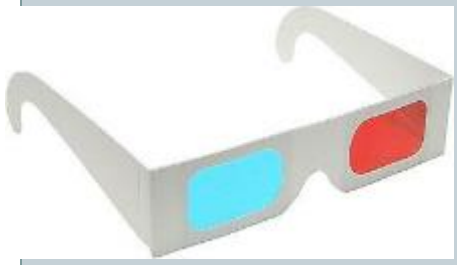
Is, actually, not 3D but just STEREOSCOPHIC 2D.

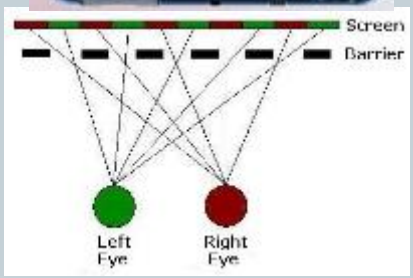
3D environment (or reality) is reduced to two perspective images, generated by two side-by-side cameras, and each image is fed to the corresponding eye.

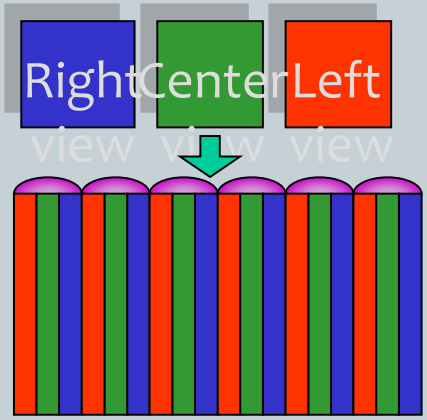
Our brain do the rest, and we perceive the depth of the scene…

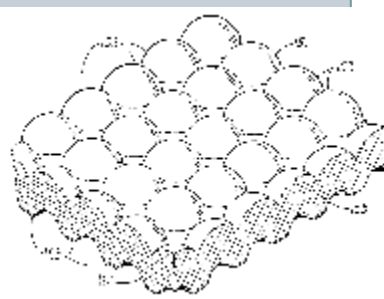
3D, but not 3D

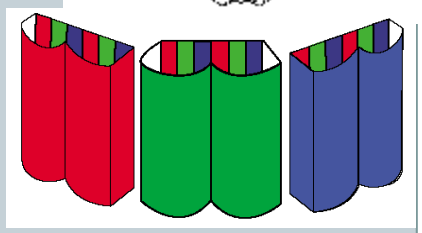
2+ images, and a way to direct the correct image to the correct eye…

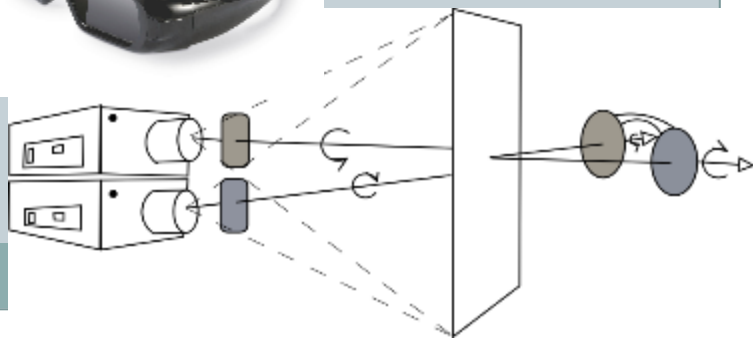










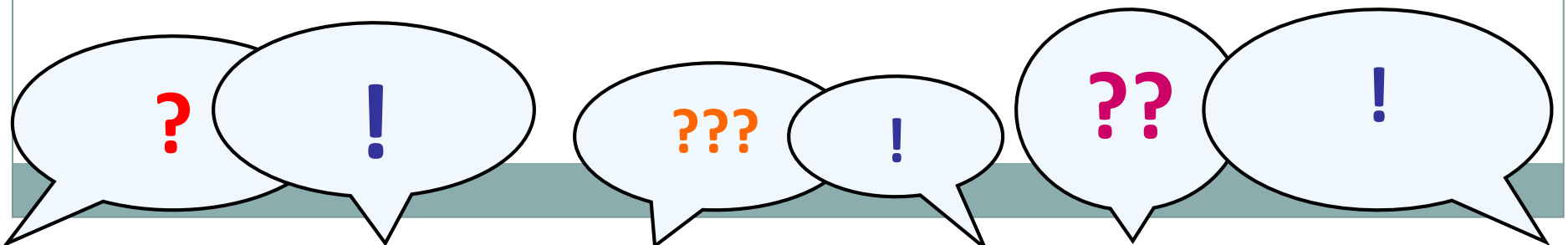


Other stuff

Holograms…

“3D” displays…

Question Time

INTERRUPT ME ANYTIME FOR QUESTIONS

callieri@isti.cnr.it