

# 3D Digitization for Cultural Heritage



**NOT ALL 3D HAS BEEN CREATED EQUAL**

# Who am I?

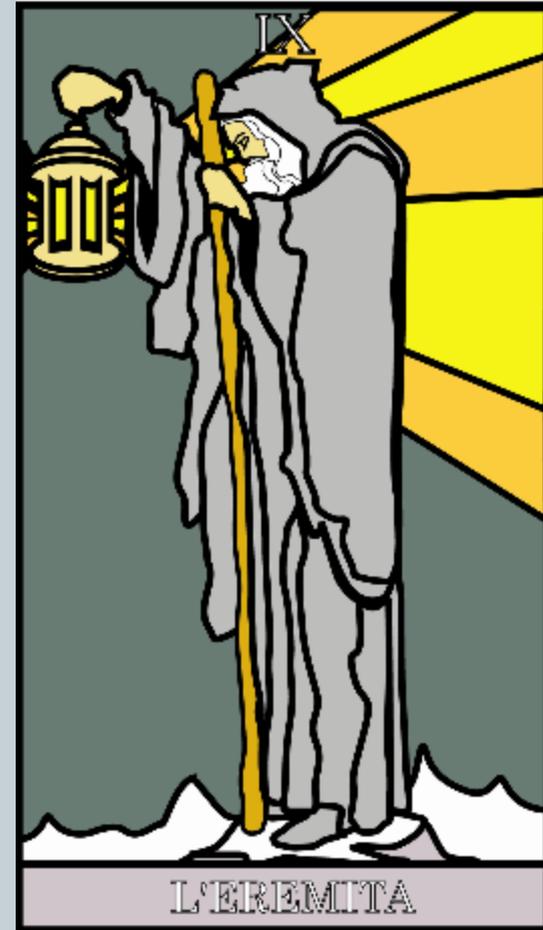


## Marco Callieri

- 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

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Beside this:

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

# Visual Computing Lab



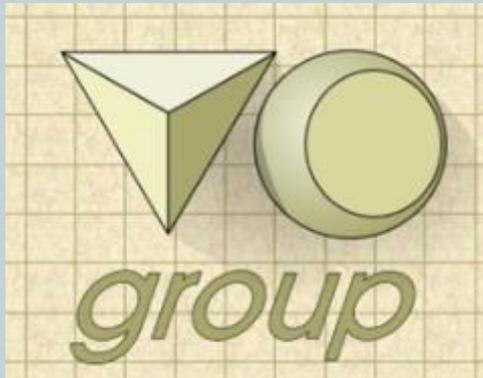
Research group working on **3D computer graphics**

part of:

Institute 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:

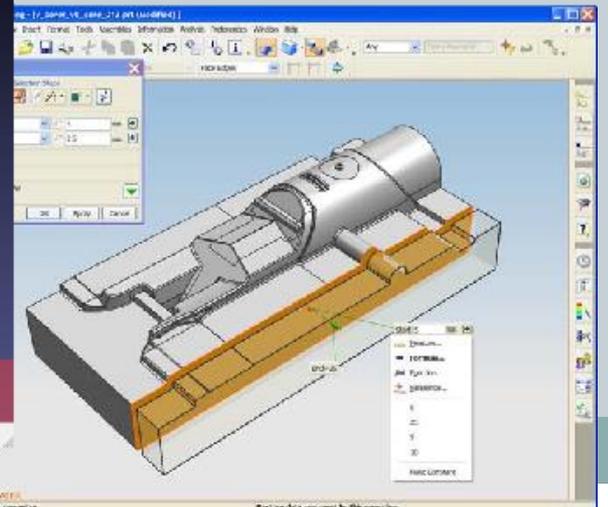
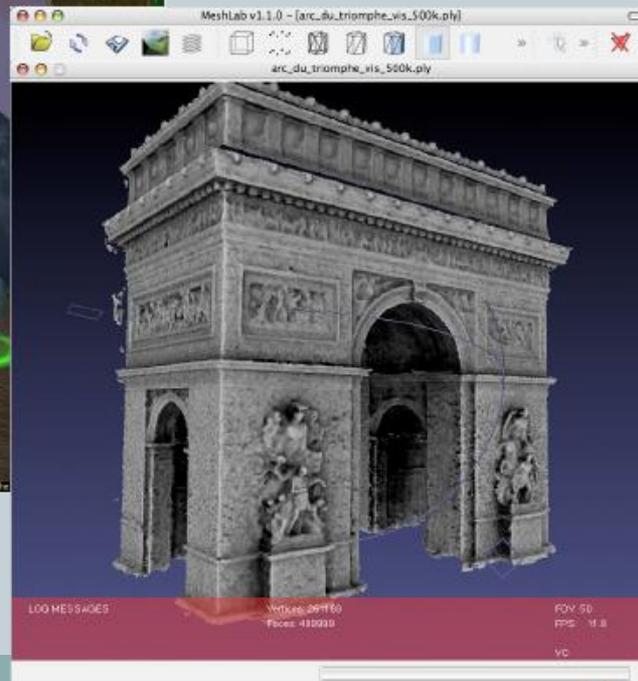
- **PURE DATA:** 3D is metric, geometrical information.... In a word: numbers. It is possible to do calculation over it, and work on it from a mathematical point of view.
- **VISUAL:** 3D data can be visualized such that is perceived in the same way we perceive reality. In this way we can access the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



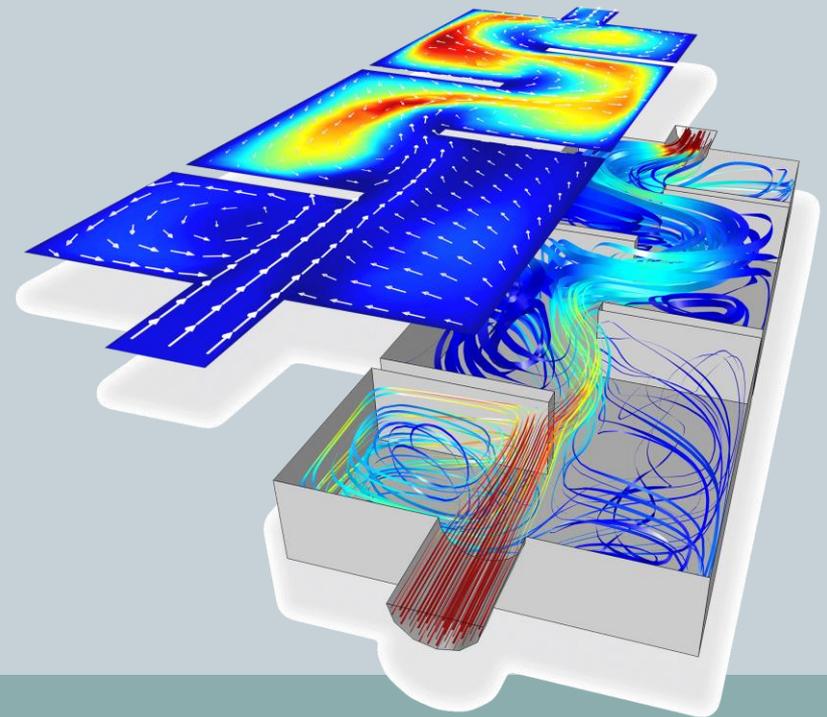
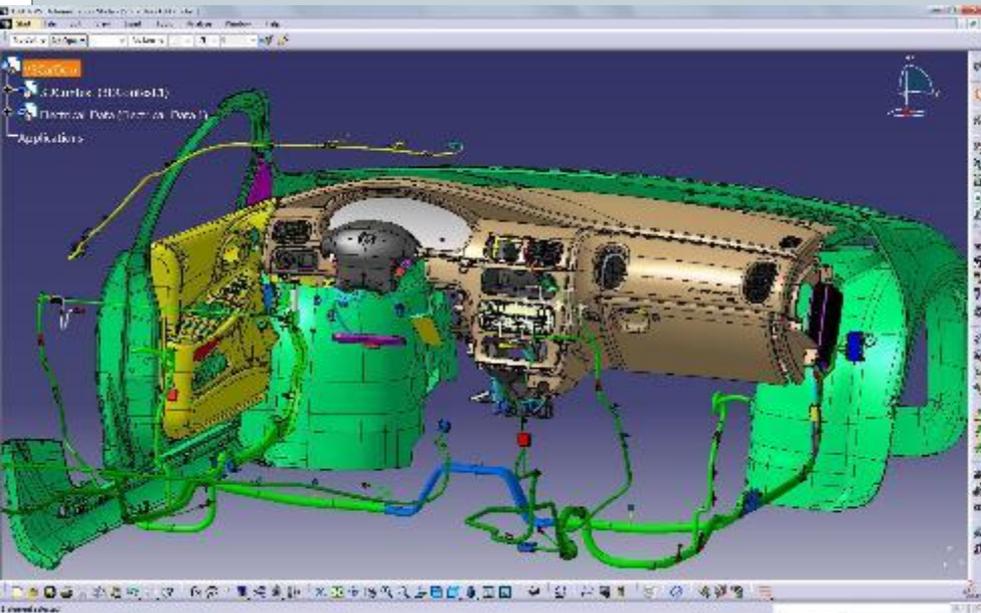
But you may have also seen images and videos generated from 3D...



# 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 3D<sub>s</sub>**

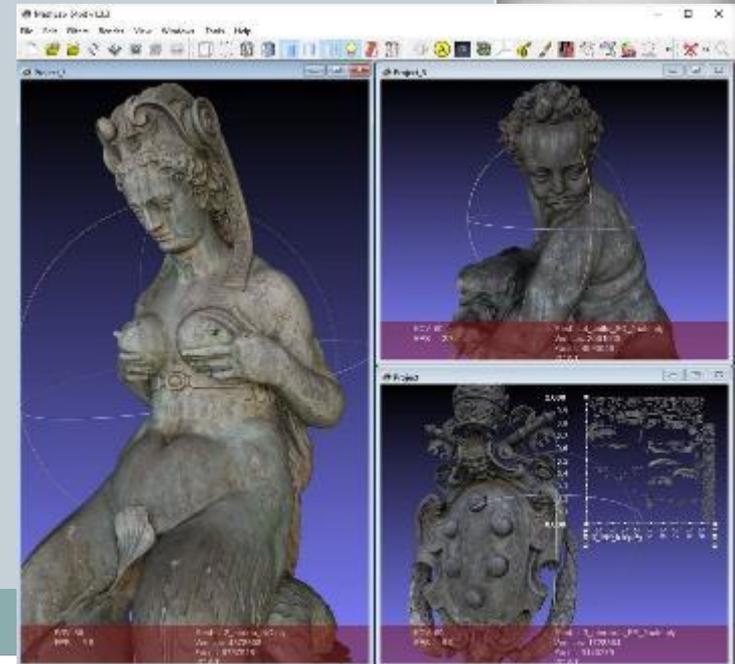
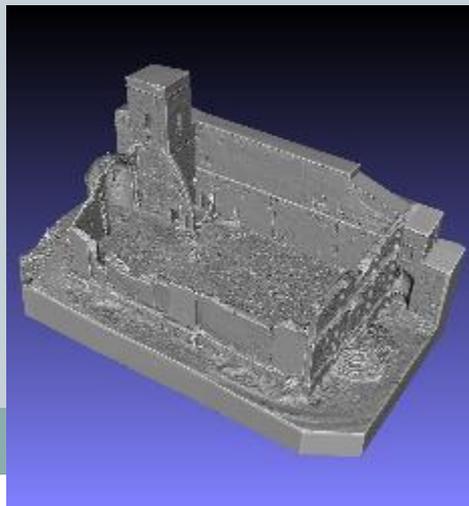
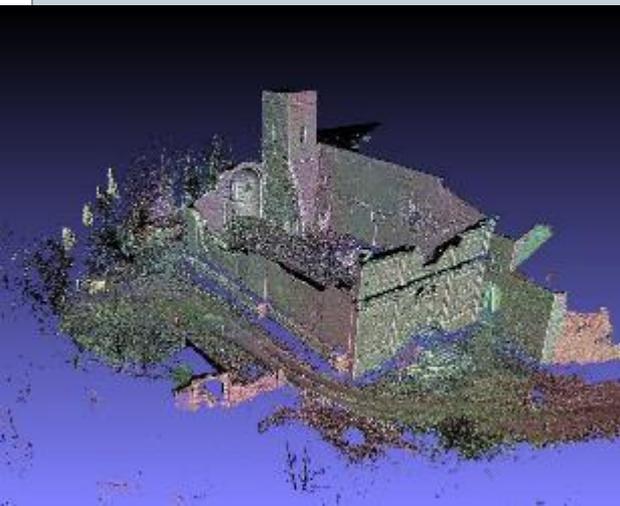
# 3D as we know it



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



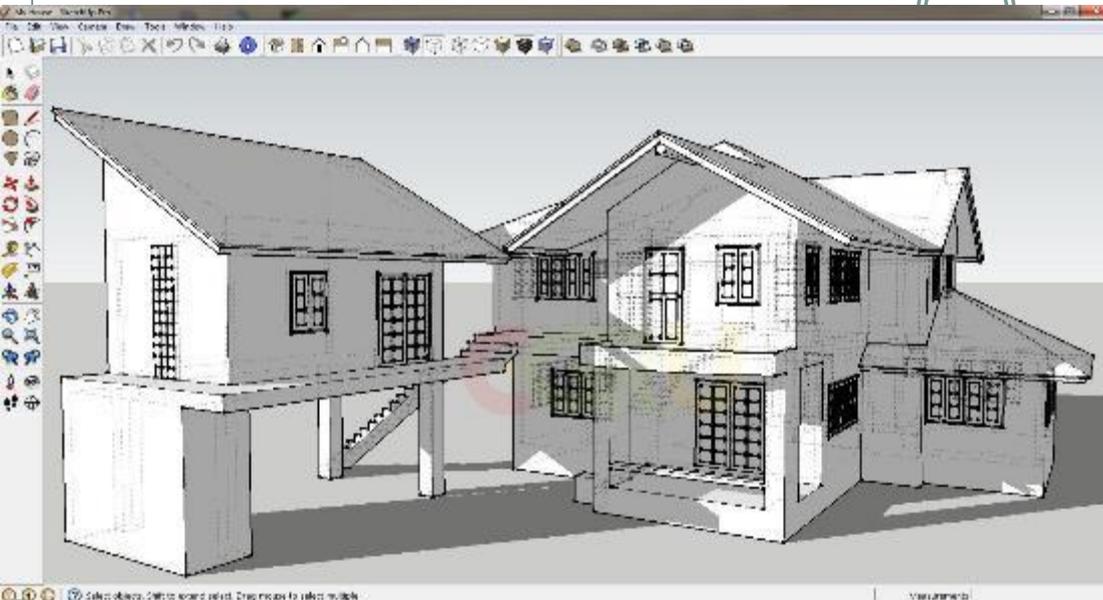
# 3D for design, CAD-CAM, architecture



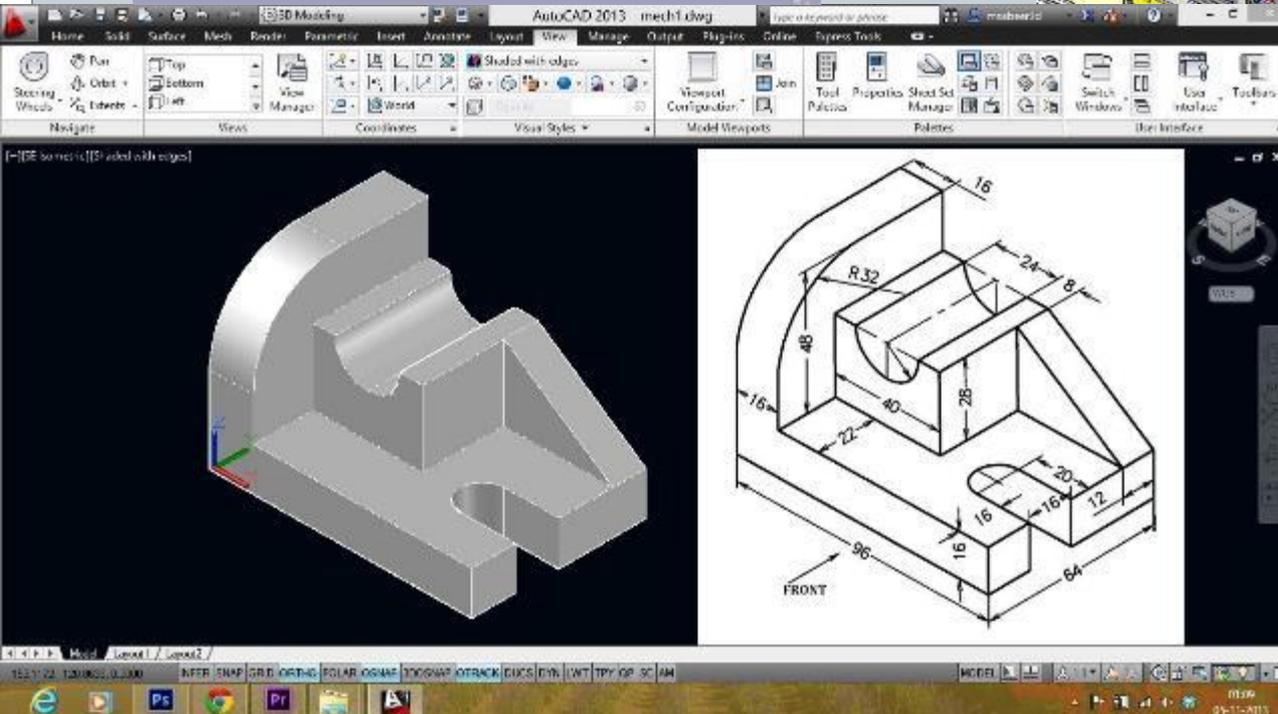
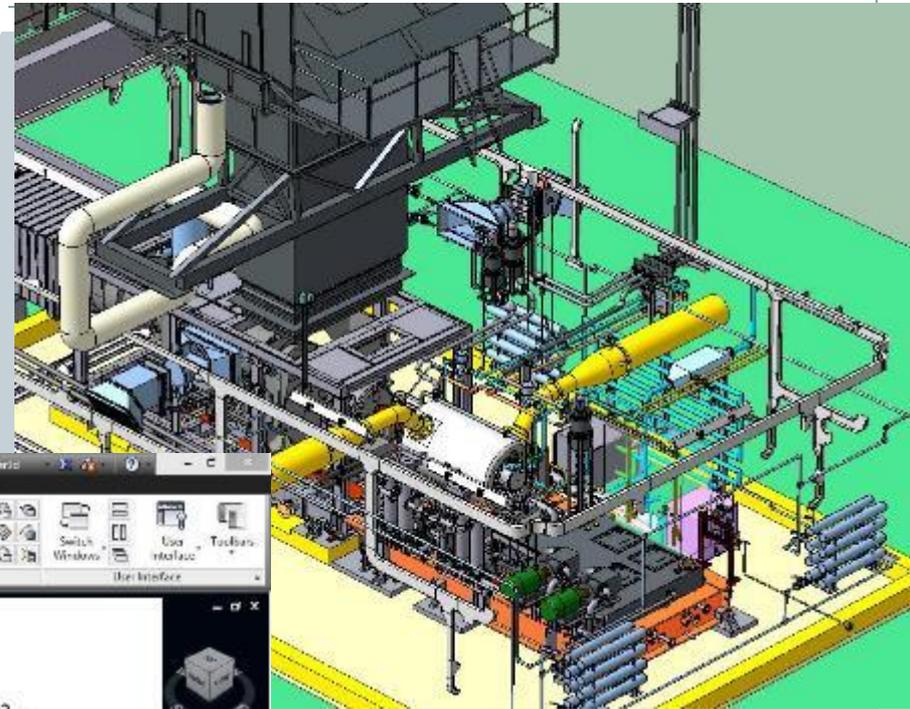
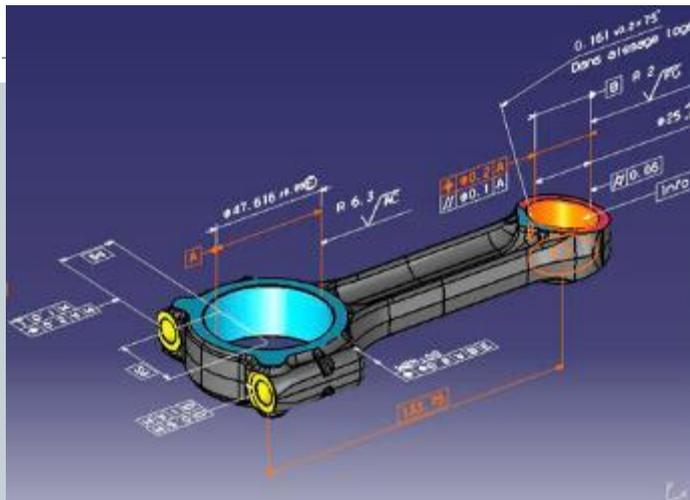
Created by human, or, more precisely: "modeled" by experts using specific programs.

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

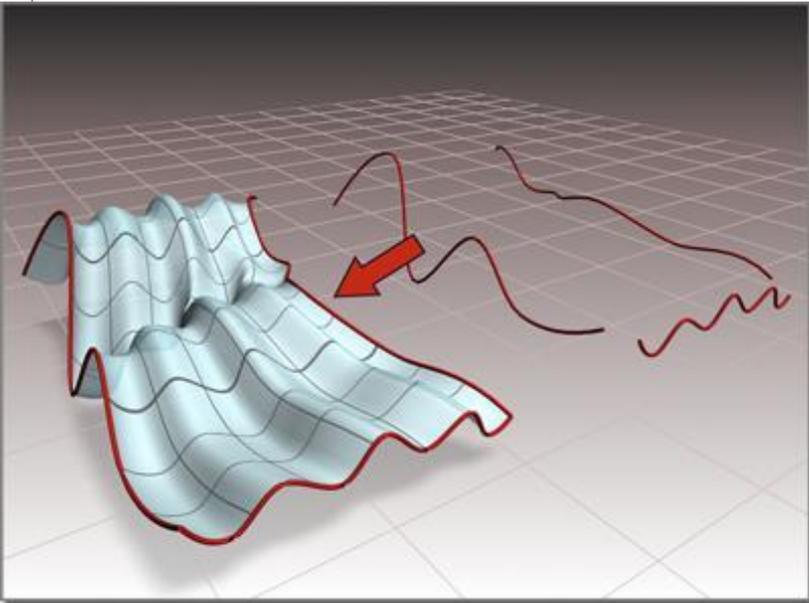
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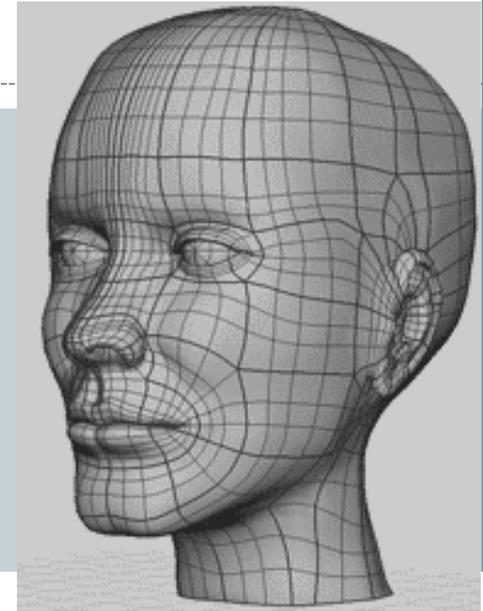
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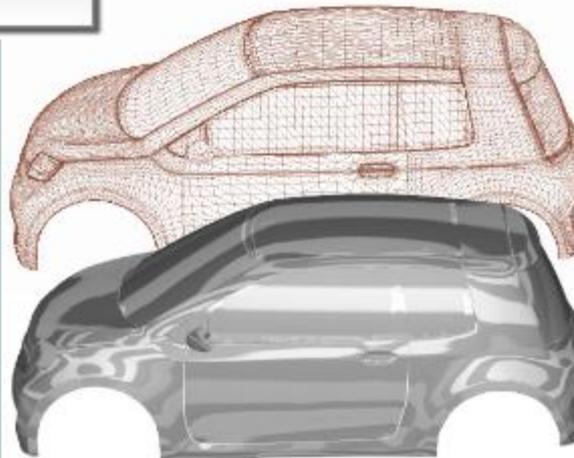
# Not just triangles



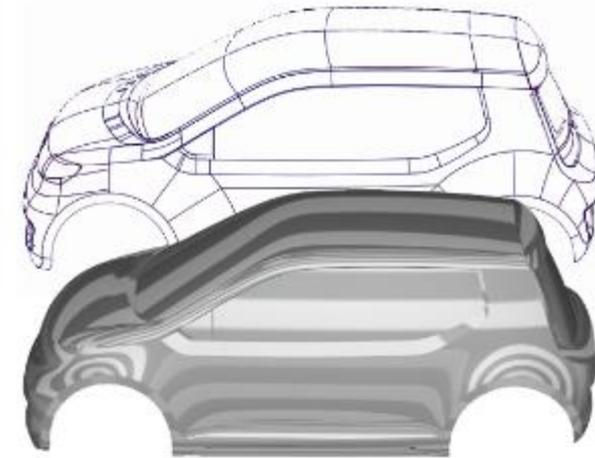
*Polygon model*



*NURBS model*



*Poor surface quality*



*Pure, smooth highlights*

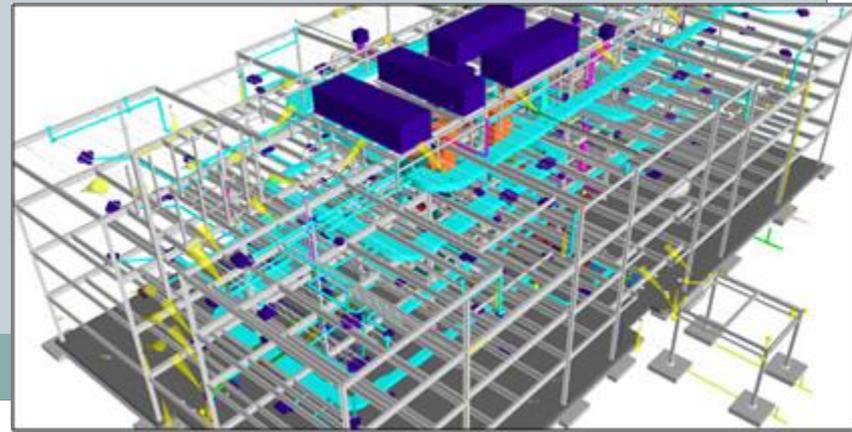
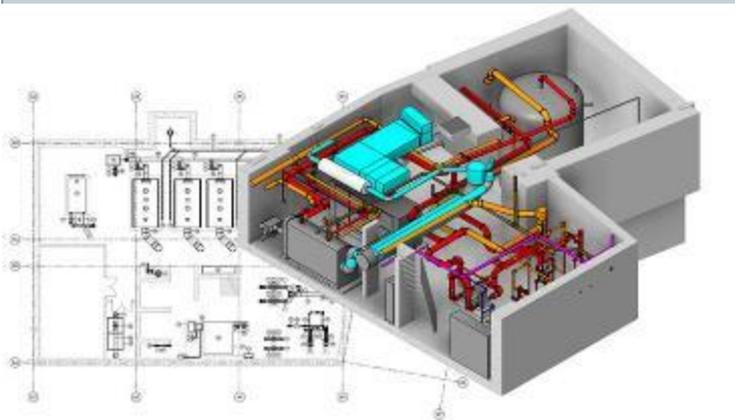
# BIM



**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, construction cost, organizing the construction, reference for future maintenance...



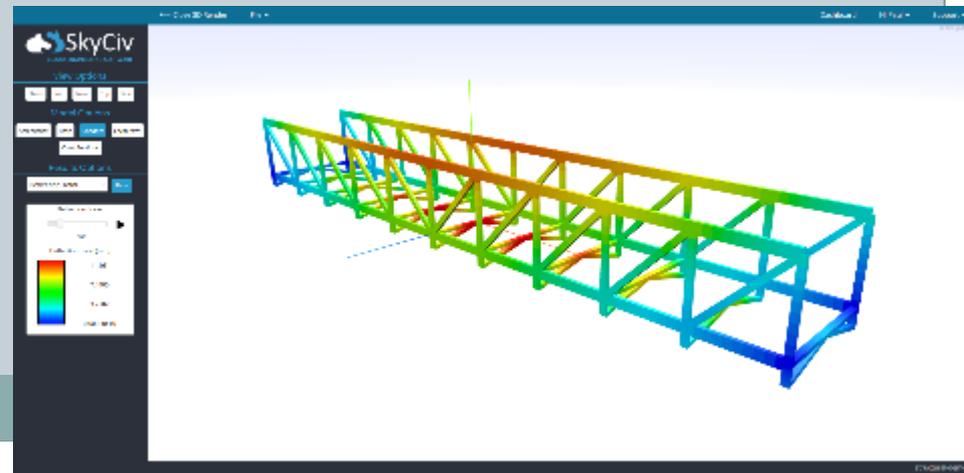
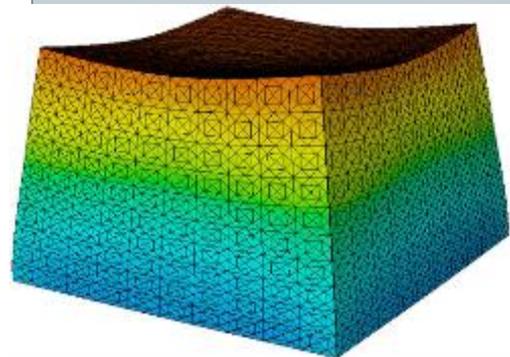
# 3D for structural engineering



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 is associated to these elements (weight, temperature, mechanical resistance, joint properties,...).

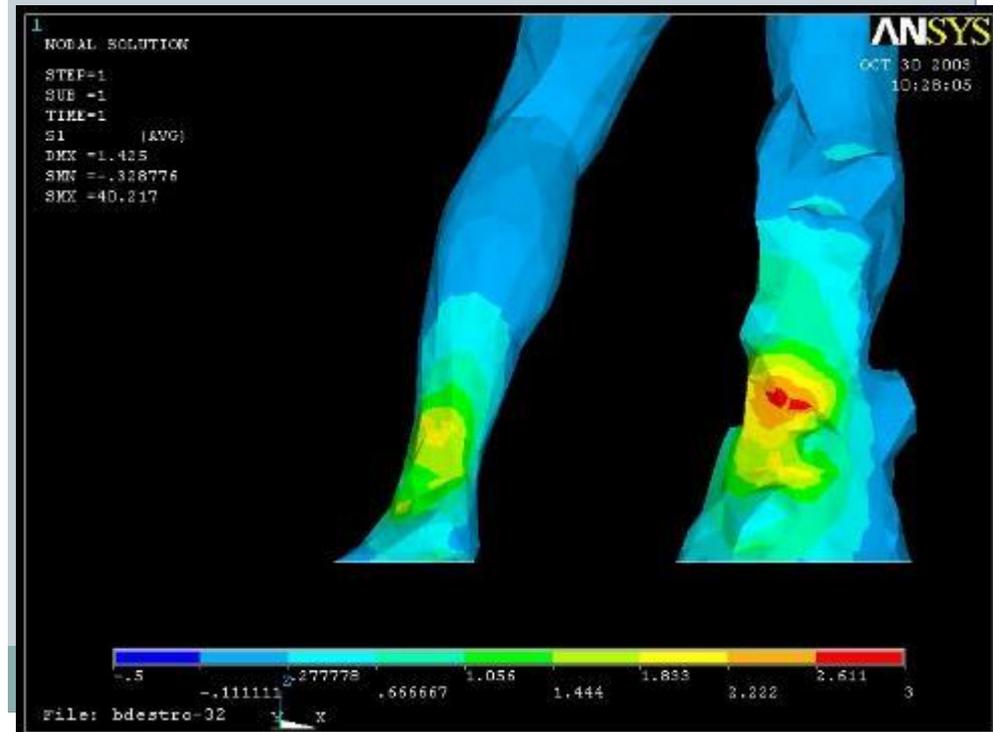
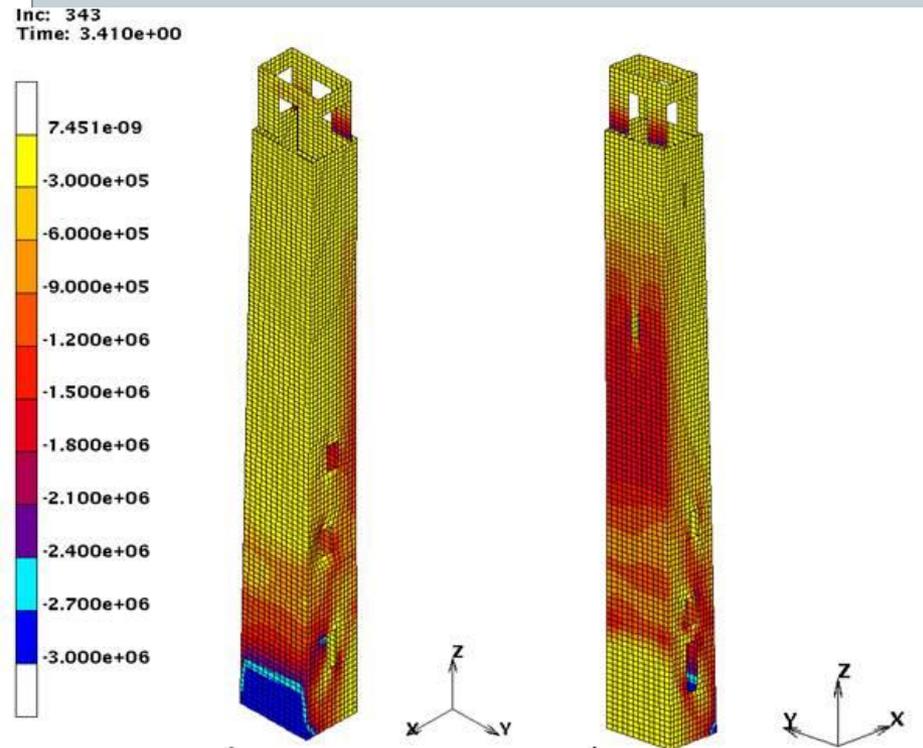
A numerical simulation of physical behaviour is then run (FINITE ELEMENTS)



# 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...

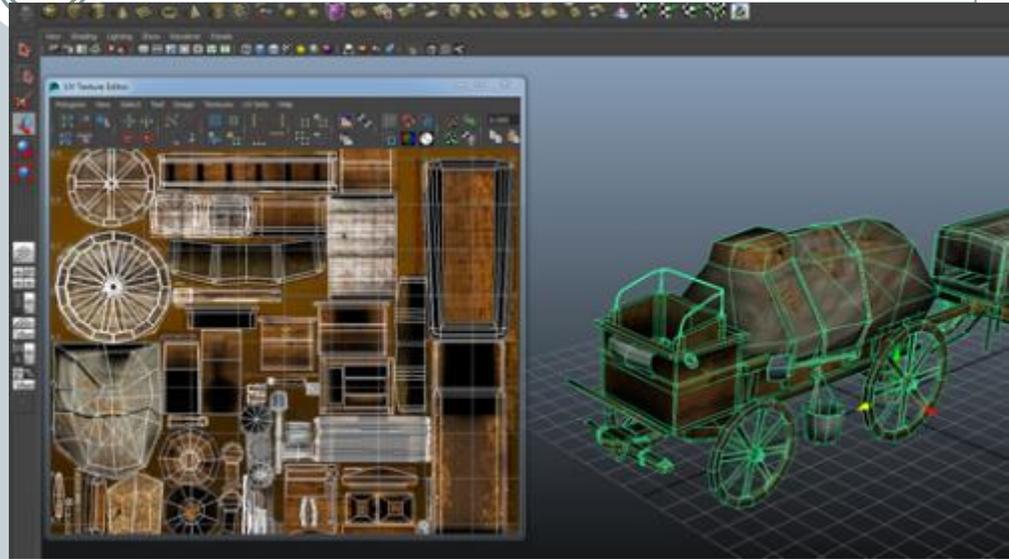
And also VR, in the end, is just a different sort of interactive game ;).



# 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).

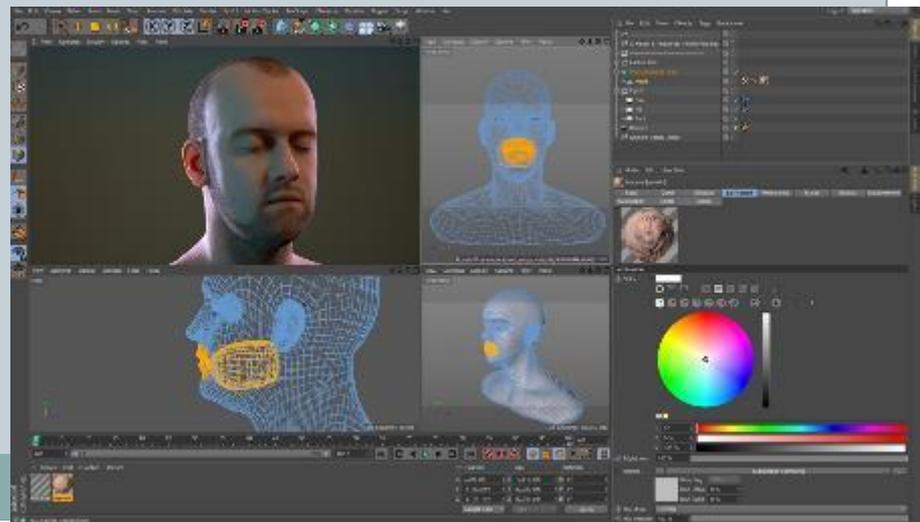
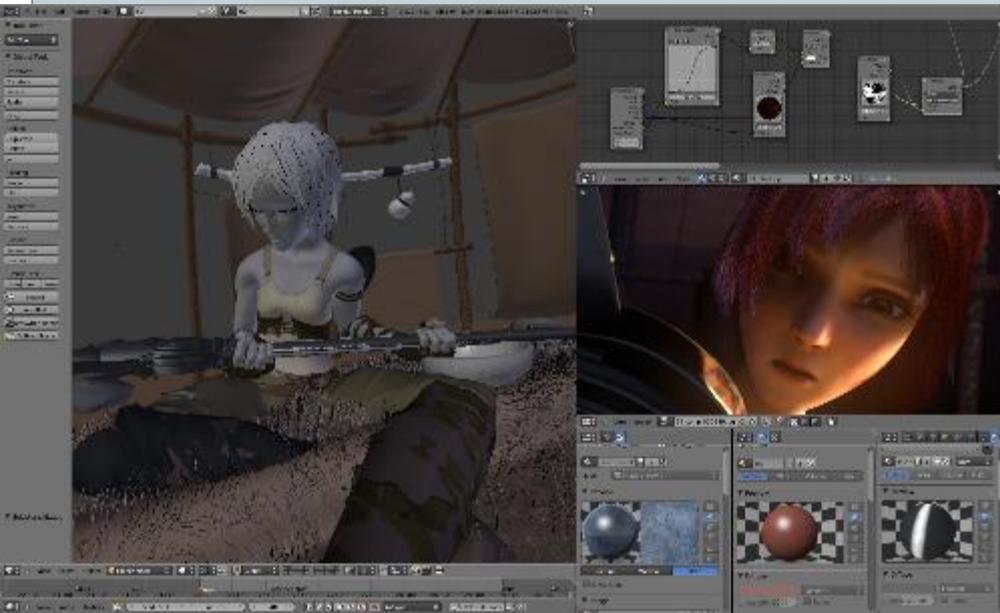
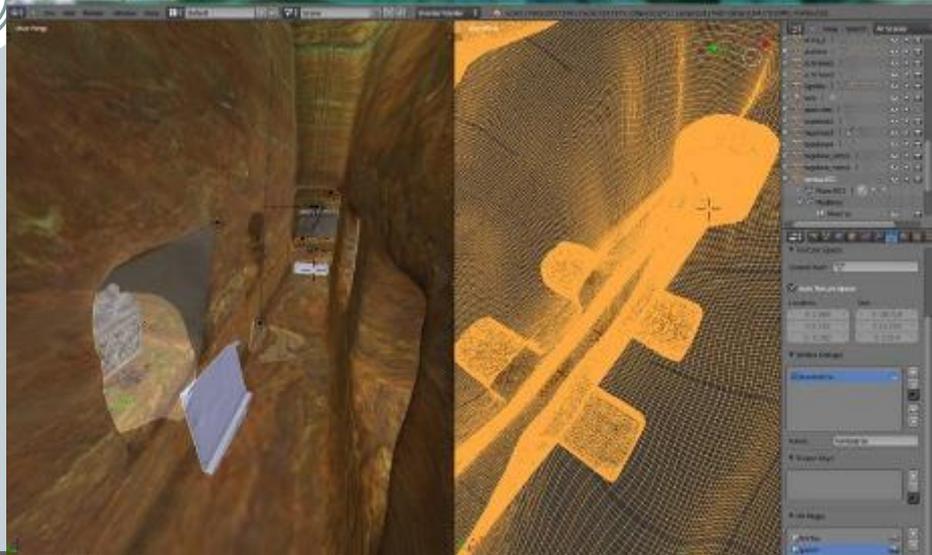
Hand-modeled, not as precise/metric as the CAD, but more geometrically complex than realtime game assets.

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 kind of light simulation.

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

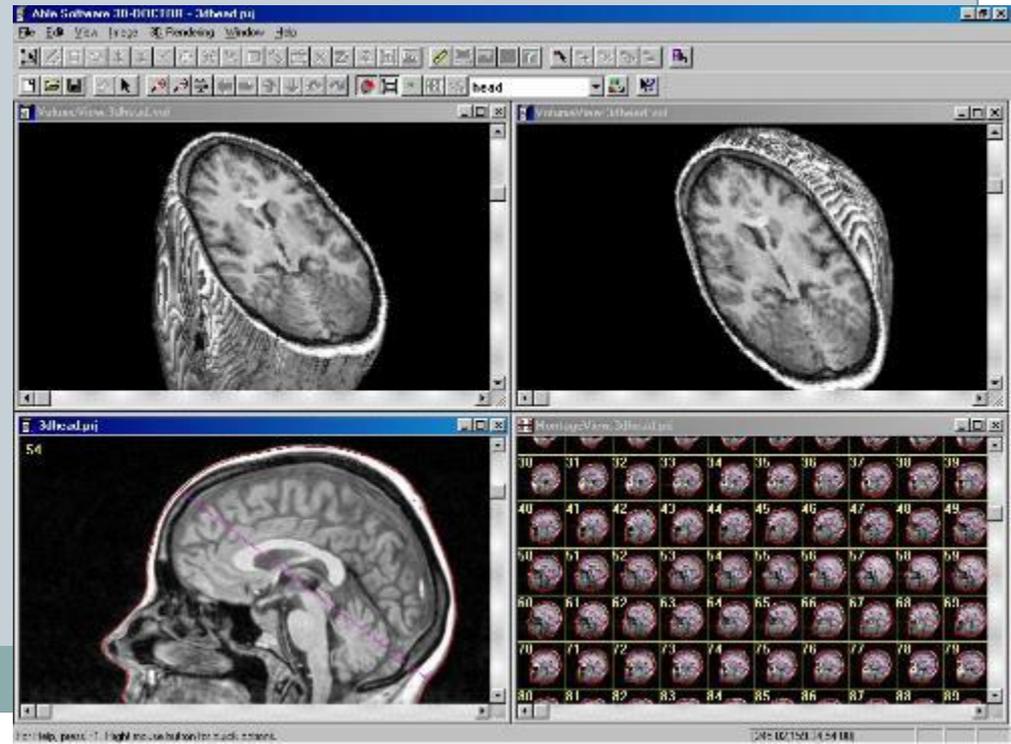
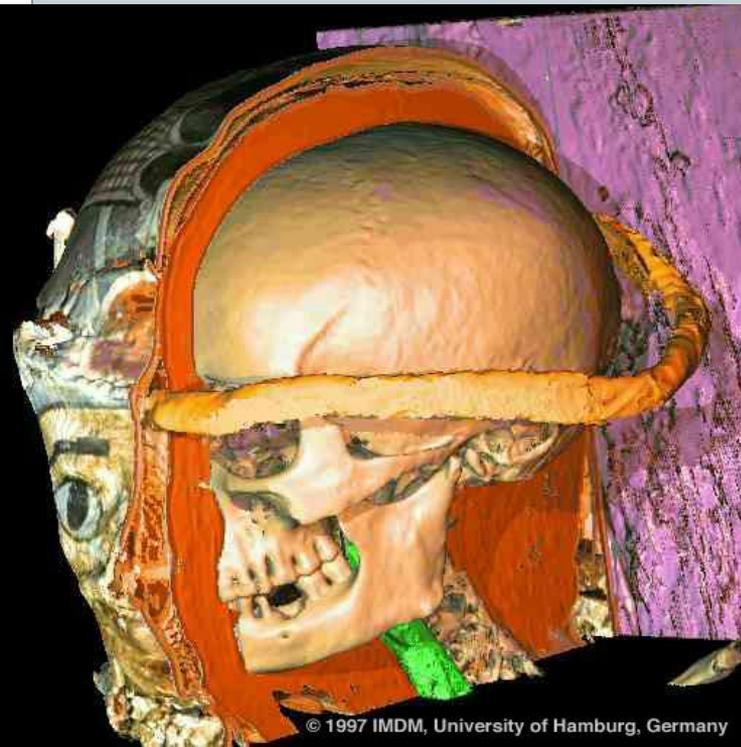
# 3D for rendering



# 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.

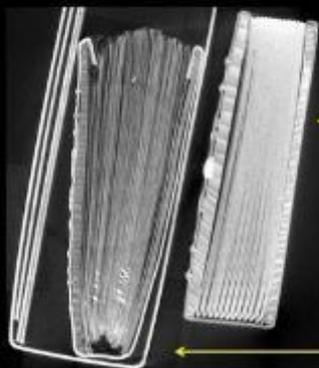
Mummies, parchment/manuscript unroll and study, fully enclosed objects, multi-part objects...



# 3D in medical field



Facsimile comparison



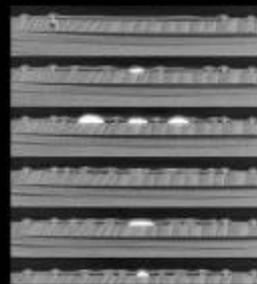
← Facsimile

← Original in phase box

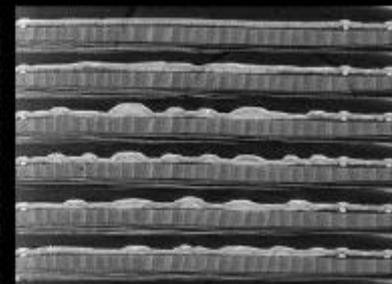


Folio size 138 x 92 millimetres

Central motif filling



Facsimile



St Cuthbert Gospel



Left board

Goatskin cover

Gesso used as filler in the facsimile

# 3D for physical reproduction

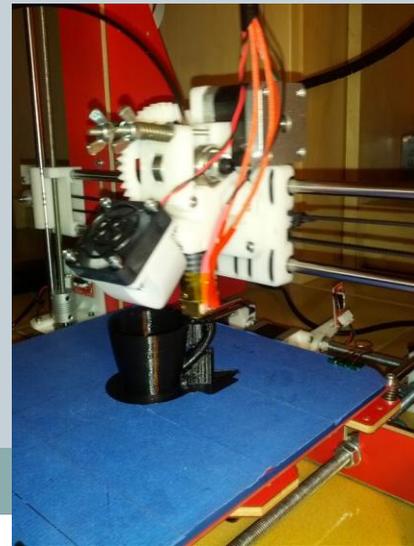
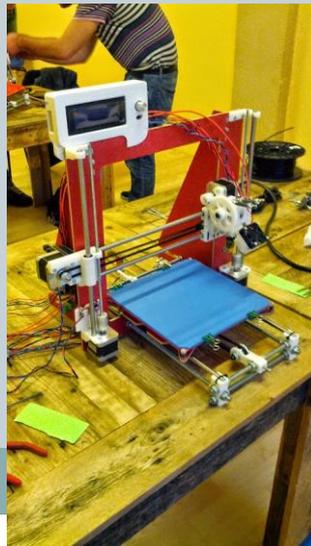


3D Printing is the new hype...

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...



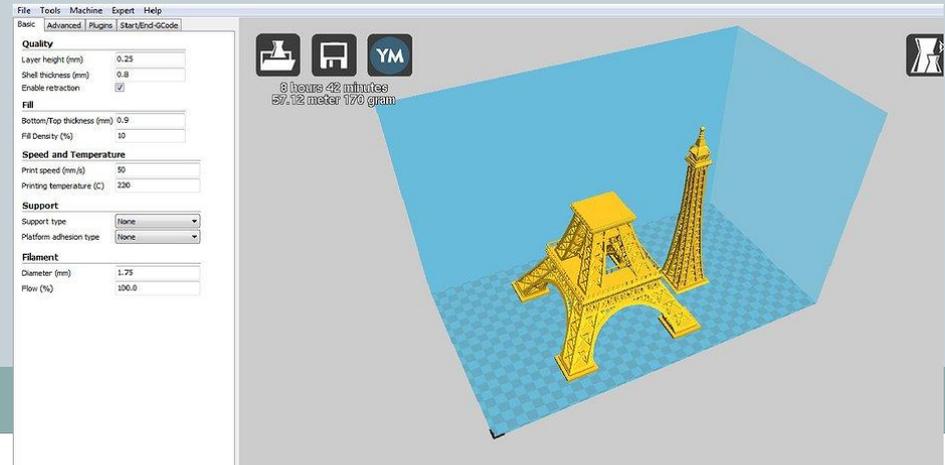
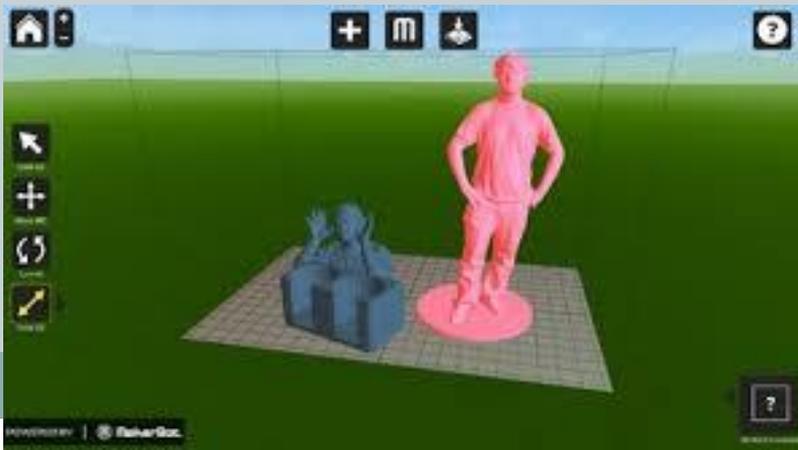
# 3D for physical reproduction



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

- Closed and not too complex
- "Topologically Clean"
- "Printable"

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



# 3D, but not 3D



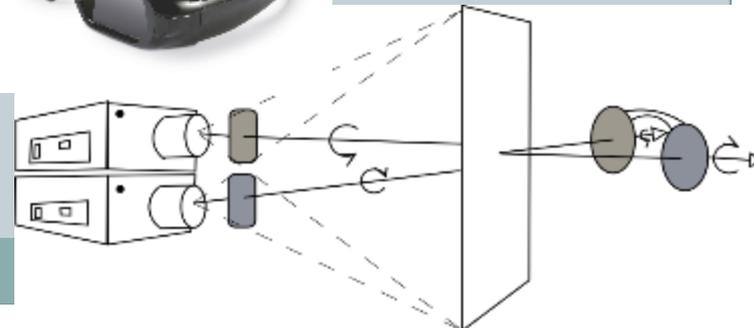
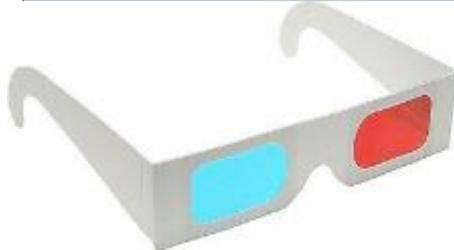
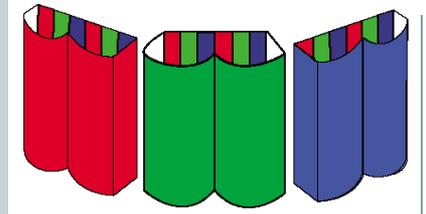
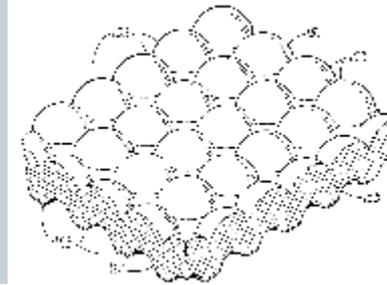
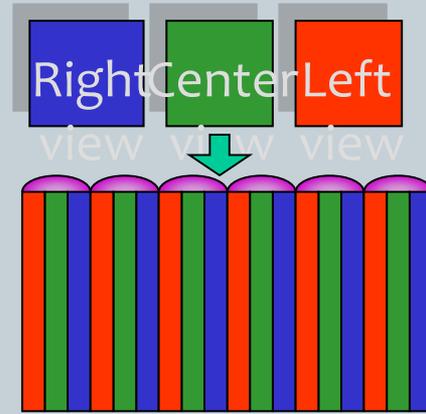
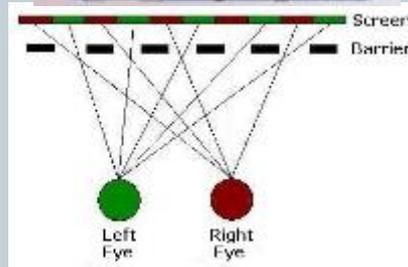
3D TV, 3D cinema, 3d cameras, 3D cards/posters  
Is, actually, not 3D but just STEREOSCOPIC 2D.

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`

?

A light blue speech bubble with a black outline and a tail pointing down and to the left, containing a red question mark.

!

A light blue speech bubble with a black outline and a tail pointing down and to the left, containing a blue exclamation mark.

???

A light blue speech bubble with a black outline and a tail pointing down and to the left, containing three orange question marks.

!

A light blue speech bubble with a black outline and a tail pointing down and to the left, containing a blue exclamation mark.

??

A light blue speech bubble with a black outline and a tail pointing down and to the left, containing two pink question marks.

!

A light blue speech bubble with a black outline and a tail pointing down and to the left, containing a blue exclamation mark.