

Back to basics:

3D is just a bunch of measures



MARCO CALLIERI

*DME WORKSHOP
BRUSSELS – 12/3/15*

Who am I?

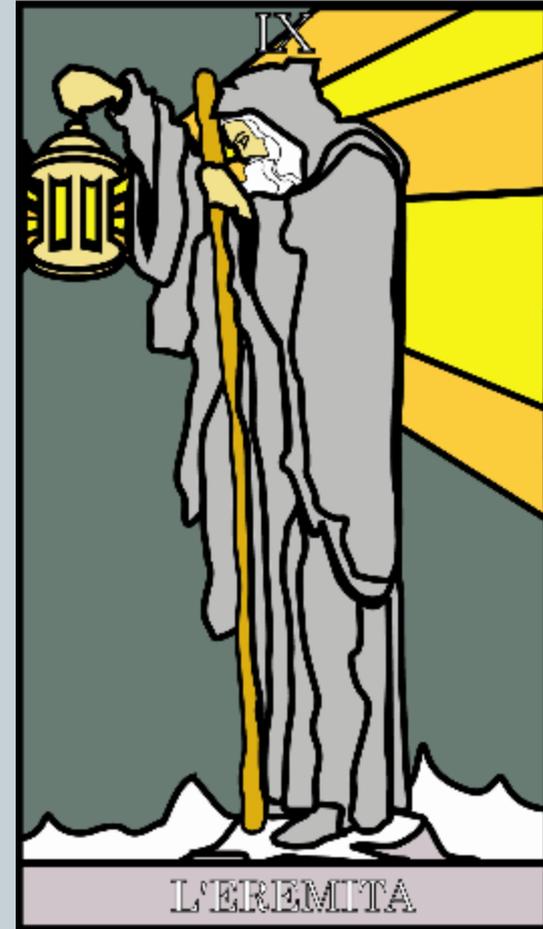


Marco Callieri

- 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



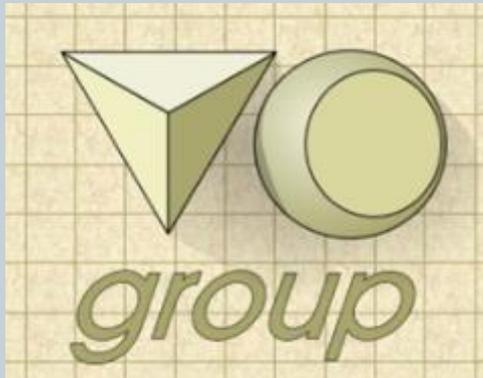
Research group working on **3D computer graphics**

part of:

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

part of:

National Research Council (**CNR**)



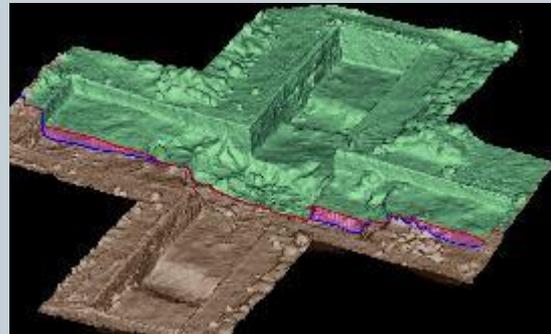
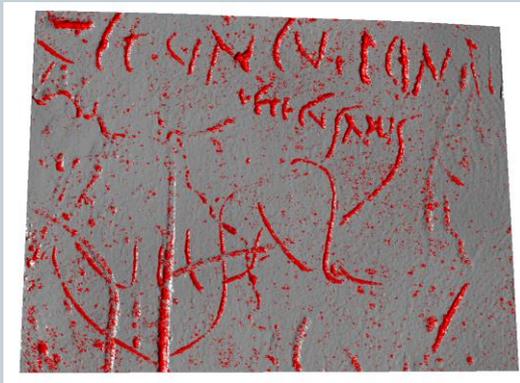
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Visual Computing Lab

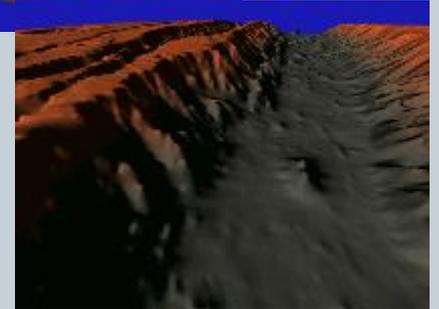
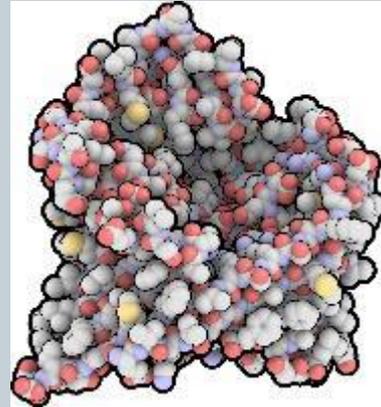
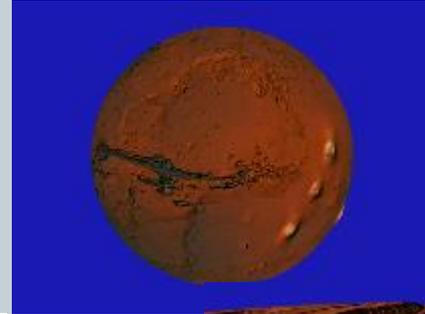
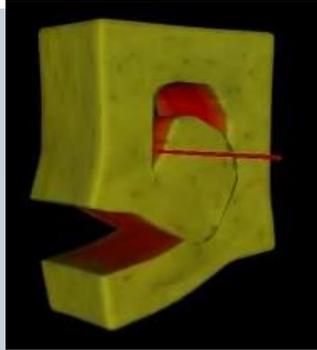


Cultural Heritage

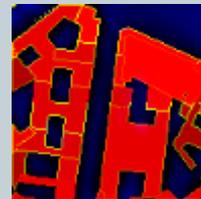
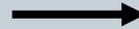


Visual Computing Lab

Realtime



3D

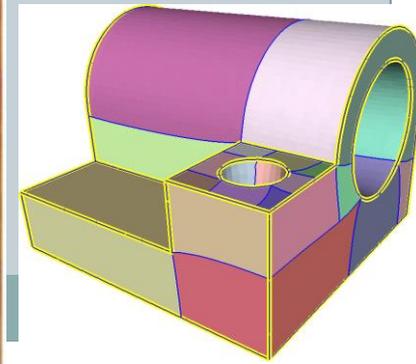
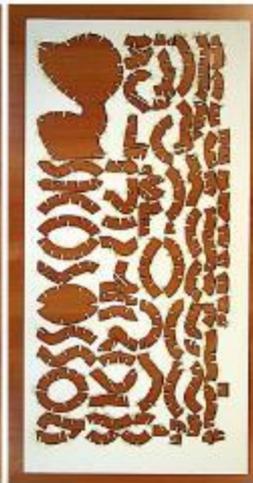
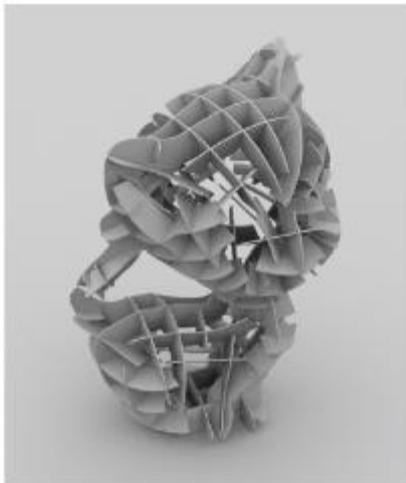
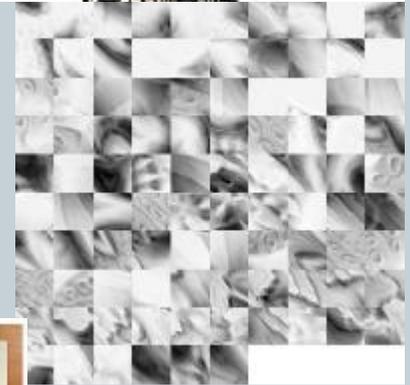
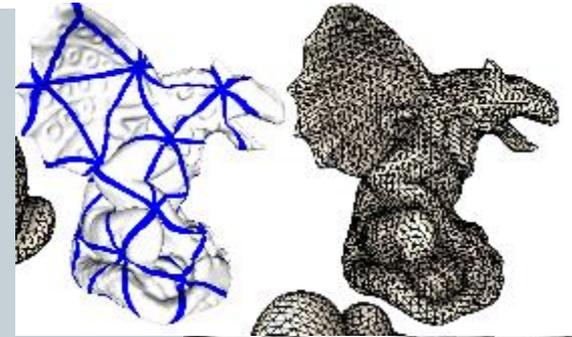
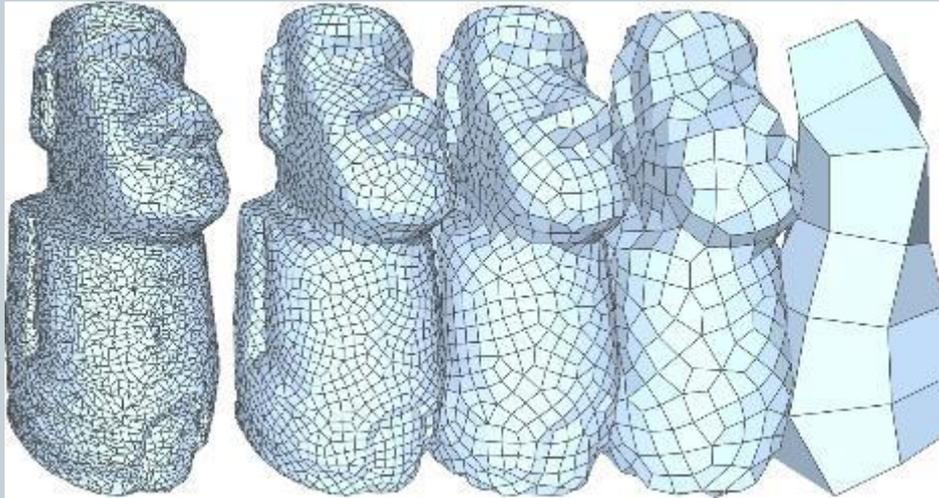


Texture encoding

Visual Computing Lab



Geometry Processing



The *double nature* of 3D



3D is a peculiar kind of data, because it has two sides:

- **PURE DATA:** 3D is made of measures, it is pure geometric information, a numerical representation of something... you may use this number-based representation do calculation, simulation, measurements on it.
- **VISUAL DATA:** can be displayed, presented and perceived visually using the part of the brain we use for everyday perception... you may explore, analyze and understand it in the same way you look at the physical world

Too bad...



This double nature is one of the key points of 3D !

The problem is, too often 3D is used **only** for its visual side...

Since 3D models coming from sampling ARE a scientifically-valid data with metric capabilities, it's really a terrible waste of resources

Difficulties



What is the main problem in using the metric capabilities of 3D?

The density of the sampling is now a limit... After all the work done to have *denser, more detailed* 3D data, we have now **too much data** in our hands...

Our work is to design tools and define methodologies and algorithms for the use of such high-res 3D data.

MeshLab is one of these tools...



The David's skin (and belly)



One of the first time we used the “pure measure” side of 3D was many years ago, working on the Michelangelo's David...

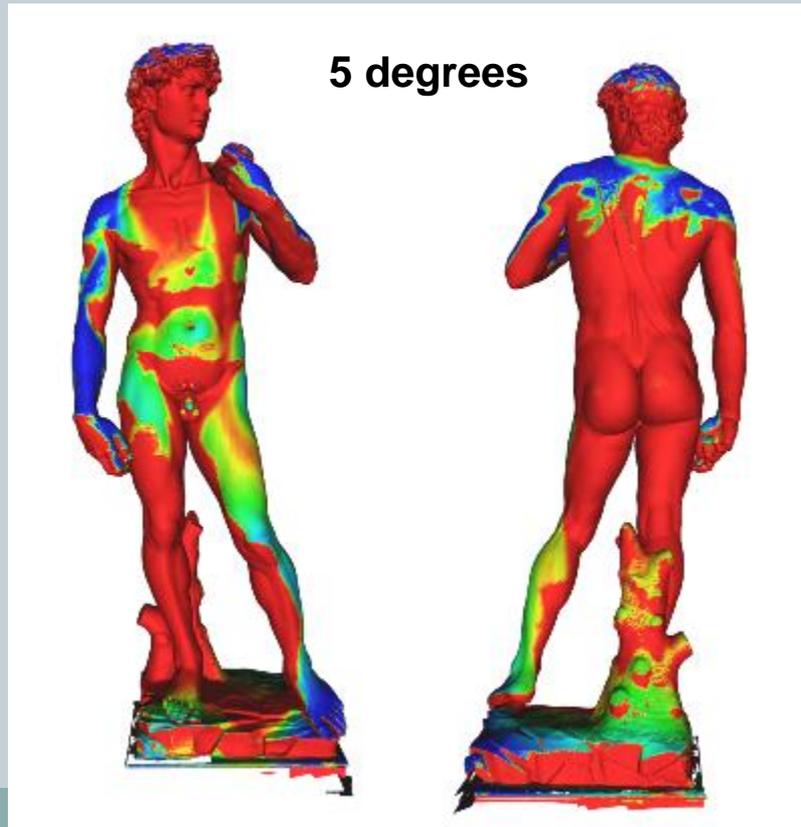
- How much is the surface of the David?
- Where does its barycenter falls?

Restorers/curators were actually surprised that we were able to give these answers...

The David's skin (and belly)



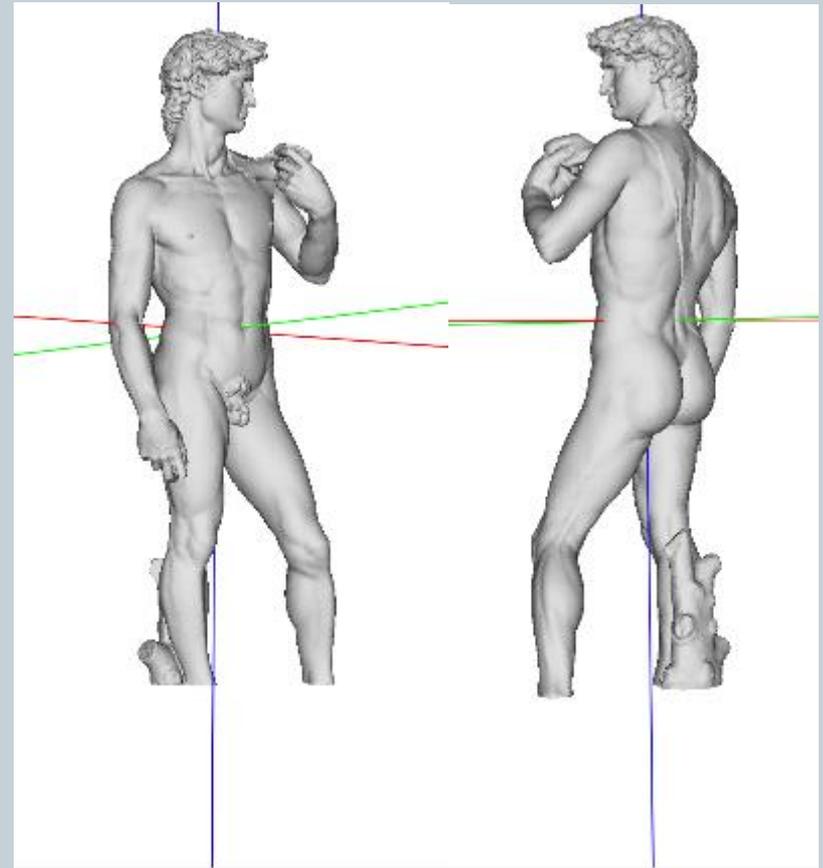
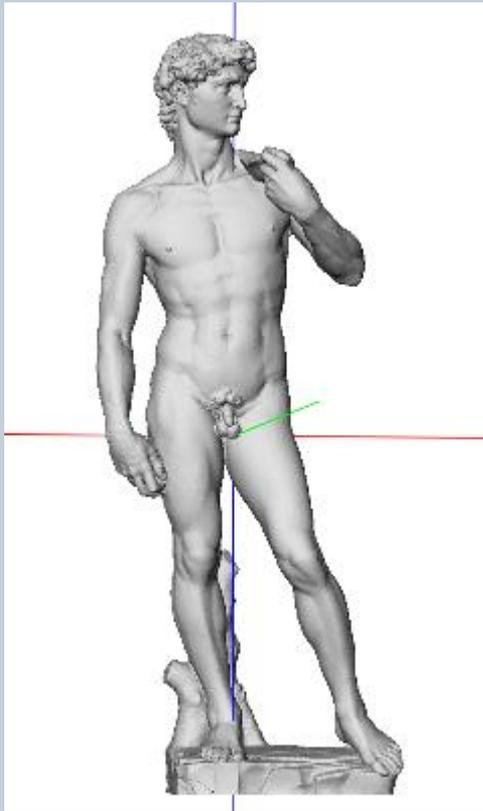
We calculated total surface area, and area of the parts where, geometrically, dust is accumulating more.



The David's skin (and belly)



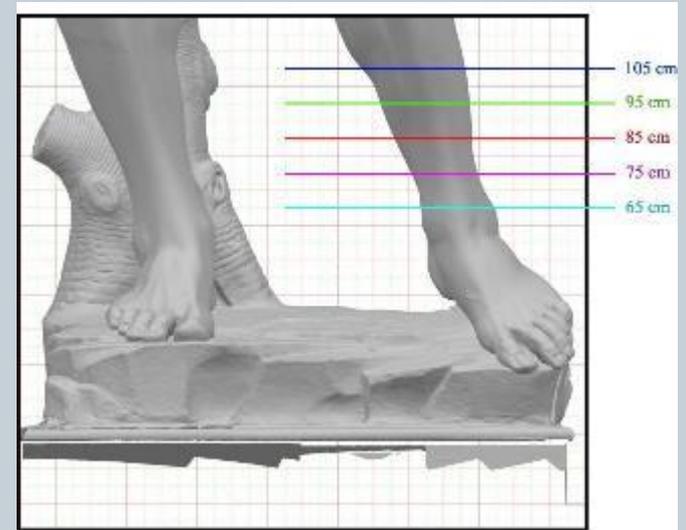
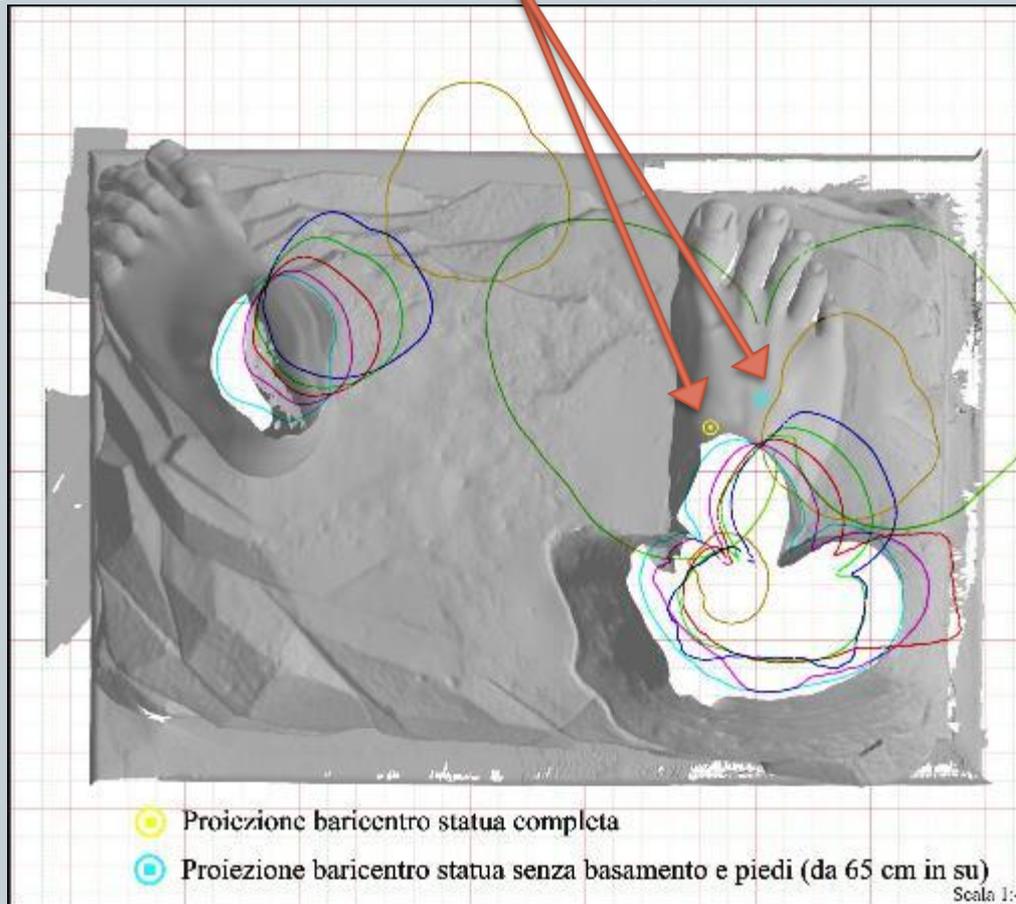
We were asked to find barycenter *with* and *without* the base...



The David's skin (and belly)



They wanted to see these points...



The David's skin (and belly)



And then, stability analysis using the *whole* 3D model (although heavily simplified).

Evaluation of the static condition of the statue via **FEM** processing...
(by prof. A. Borri, Univ. Perugia)

Stress regions correspond to real cracks locations!



The Tower's equilibrium



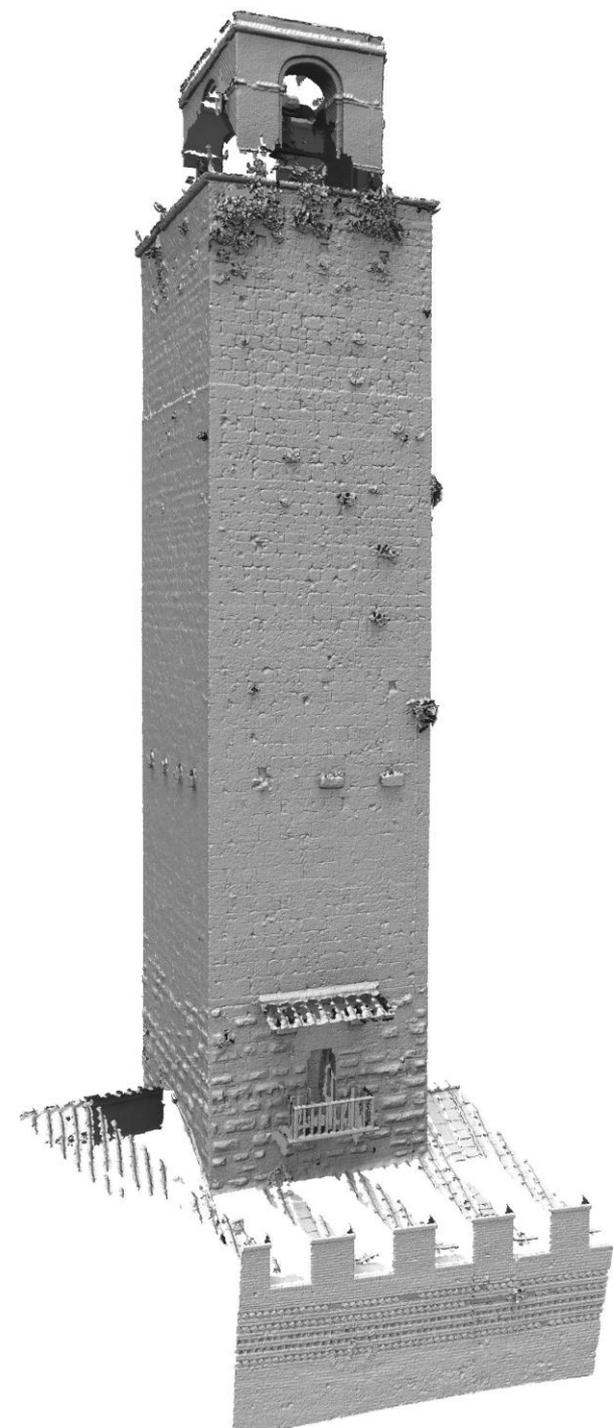
Torre Rognosa, San Gimignano, Italy

3D model created for

- Stability check
- Structural documentation
- Mapping of sensor network data

Difficult to scan & process (especially aligning the scans) with standard tools → we used our tool to solve the issue.

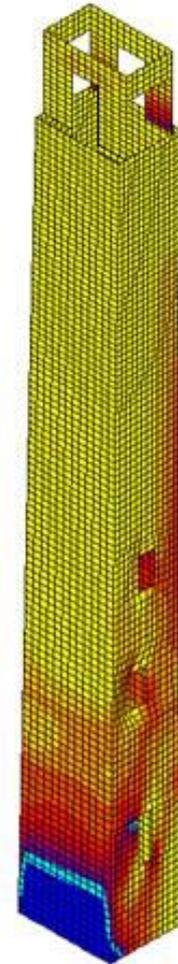
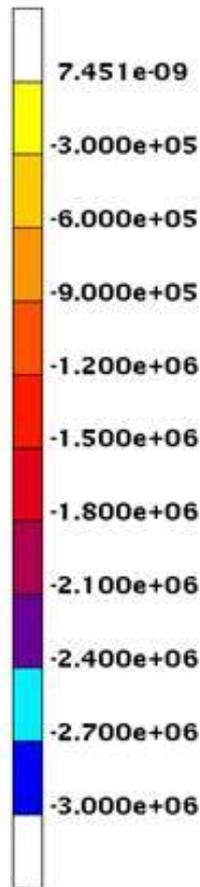
Difficult to work directly on a pointcloud → we created a 3D surface model.



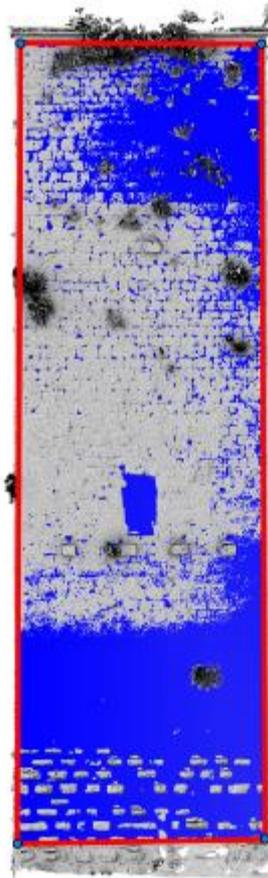
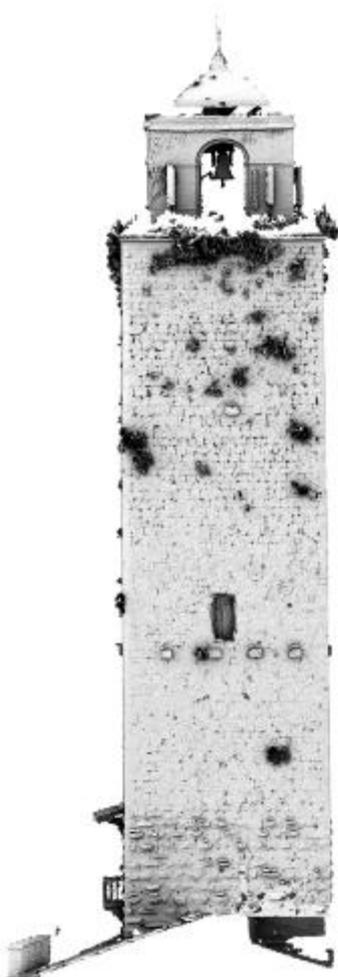
The Tower's equilibrium

FEM model created combining standard survey for the inner part + cut-through sections and measured points on the 3D model surface

Inc: 343
Time: 3.410e+00

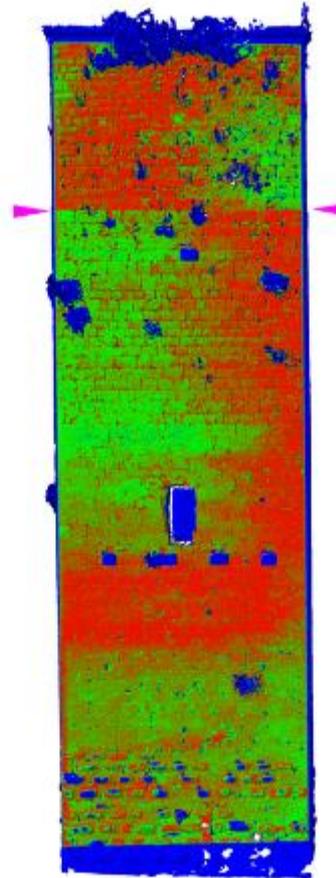


The Tower's equilibrium



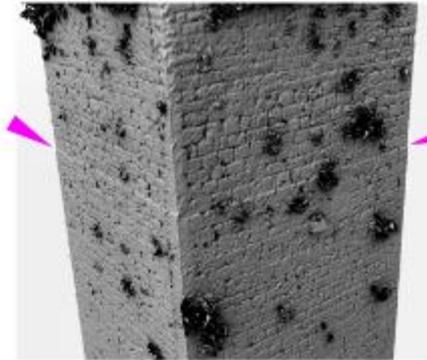
Piano di riferimento generato selezionando quattro punti agli estremi della facciata SUD.

- i cerchi rappresentano i punti
- in rosso, i confini del piano
- in blu, il piano di riferimento

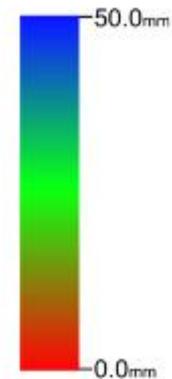


Visualizzazione in falsi colori della distanza in valore assoluto della geometria della facciata dal piano di riferimento.

Le aree blu scuro sono a distanza > 50.0mm



Nella parte alta della torre è possibile notare un repentino salto di distanze, in corrispondenza di una fila di conci (indicato dalle frecce viola). Il salto è abbastanza evidente anche visivamente sul modello tridimensionale, utilizzando la luce radente.



The lost church



Church of the Camaldolese Abbey in Volterra (Tuscany, Italy). Abandoned in 1890 and caved in shortly after, now partially recovered and used for public events.

We were involved in a project for the study, documentation and possible re-use of historical buildings.

The lost church



The lost church

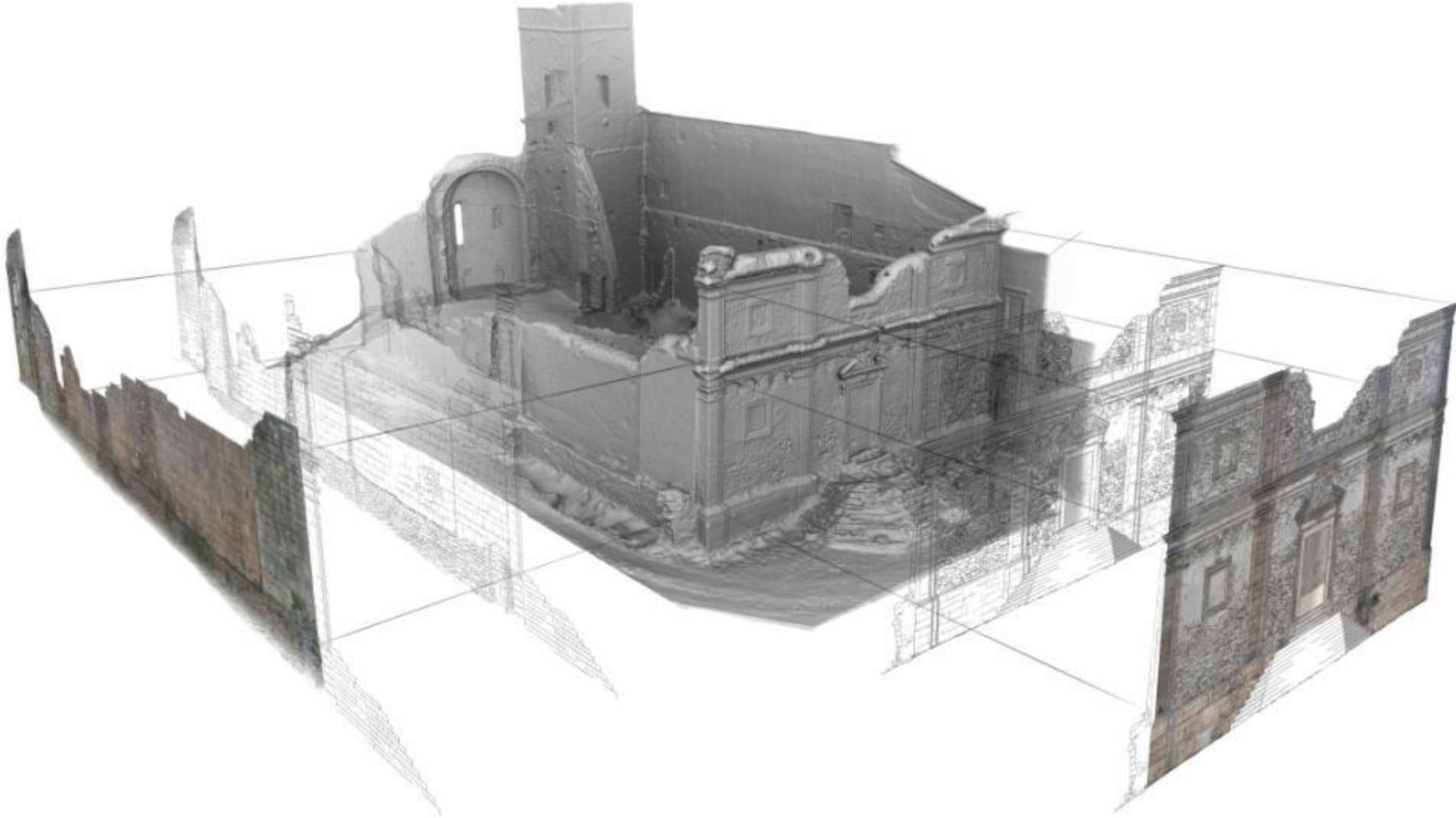


Technical documentation...

I have not mentioned it at the begin, but this is the most straightforward use of METRIC properties of a 3D model...

But, still, extracting sections/views/plans out of a high-resolution 3D dataset is not a trivial task...

The lost church



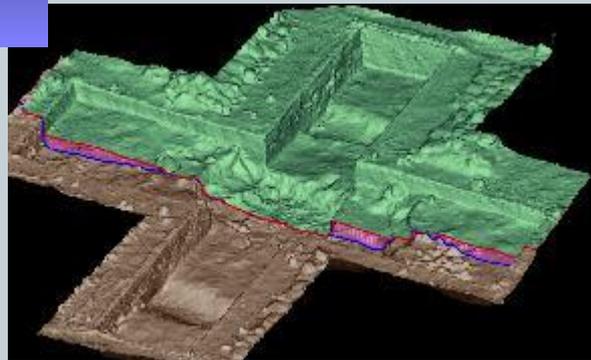
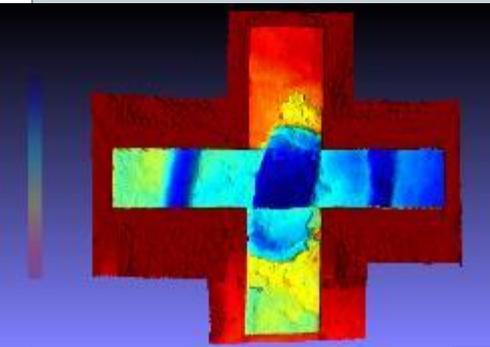
The lost church



From documentation to GIS



3D → 2D documentation is useful... 3D documentation would be even better... It is easy to calculate & map info on 3D, or to use geometry processing to manipulate 3D to bring out numerical-visual information



People would love to go full way... in a 3D GIS interface. Things are getting there, but sloooowly, especially for DENSE datasets.

The lost church



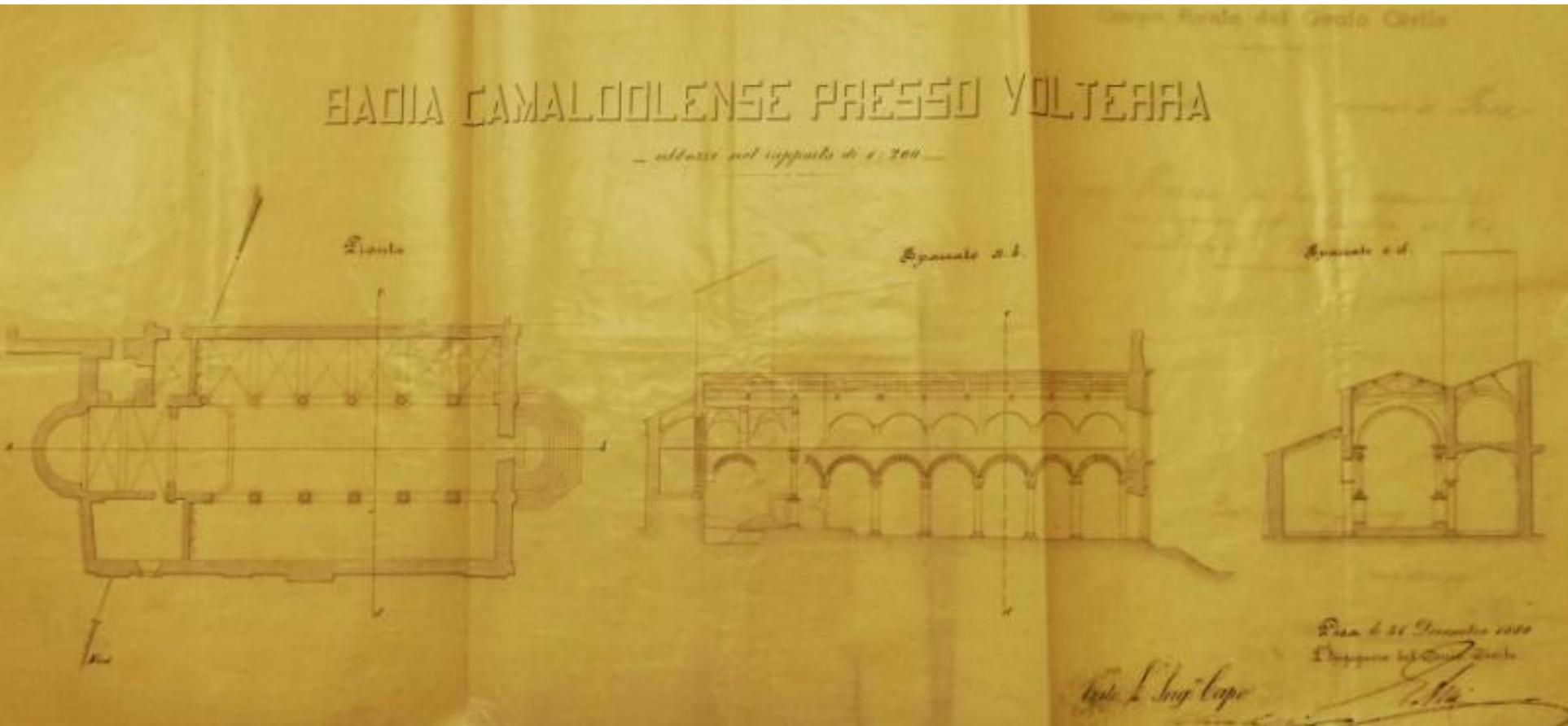
The art historians of the project wanted to recreate the state of the church before its collapse.

The available data, however, was insufficient.

So, we used the survey as a source of measures to integrate the available data...

Again, having a dense, visual model helped a lot in deciding where and what to measure, and specific tools to extract metric data from the high-res model

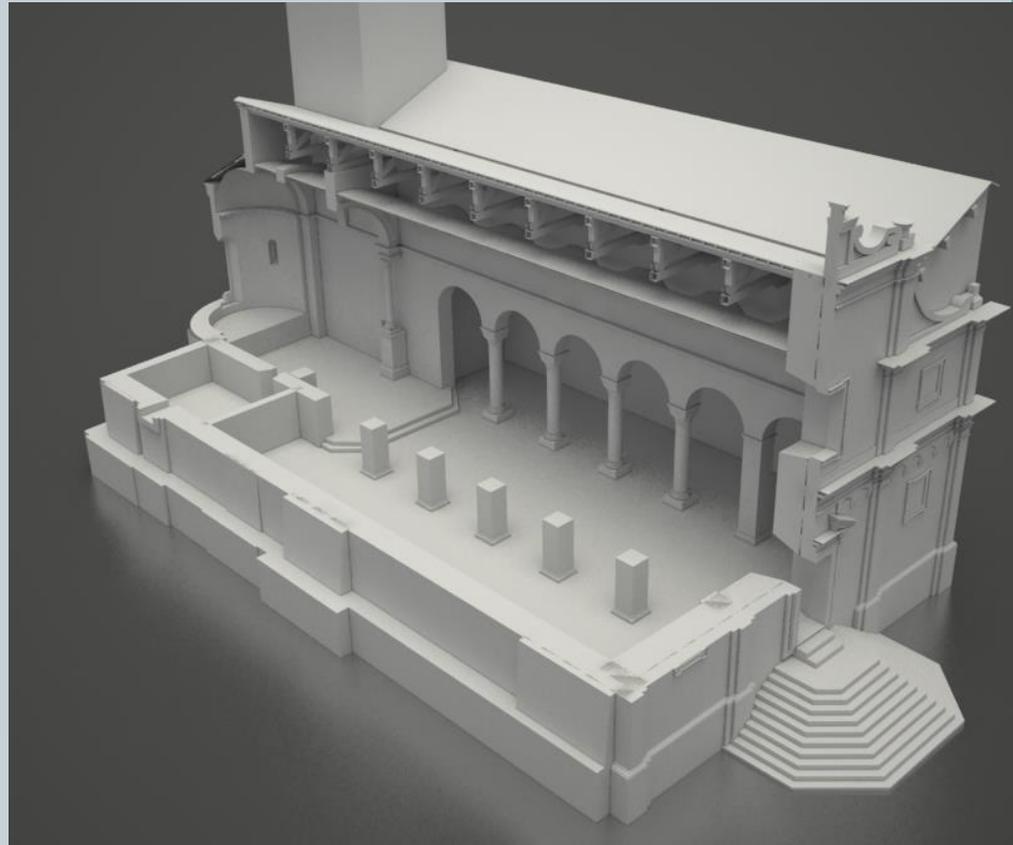
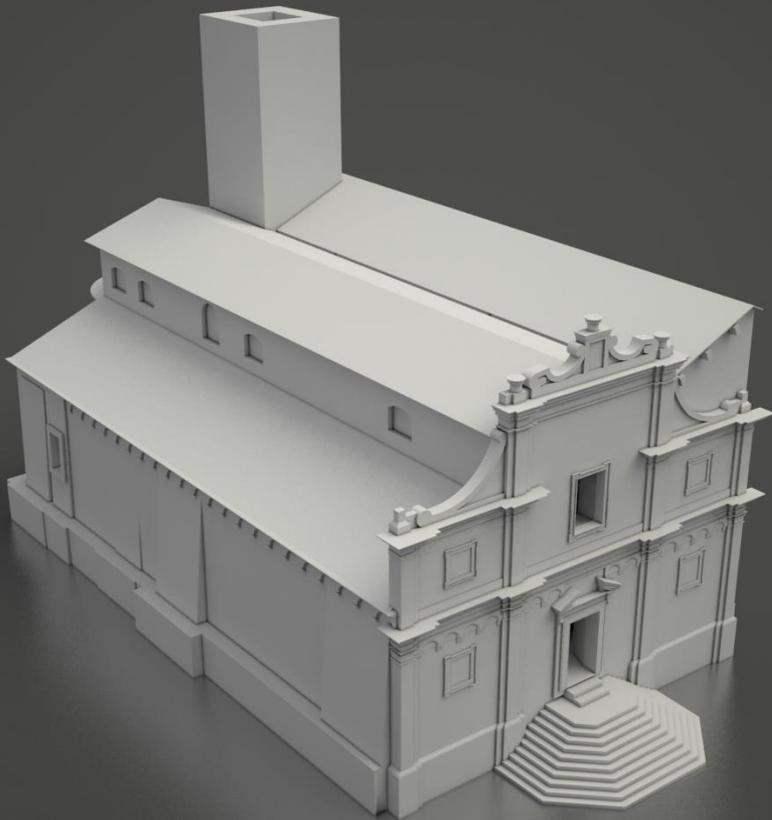
The lost church



The lost church



The lost church



Pietranico's Madonna



Terracotta statue, destroyed in the Abruzzo earthquake.
We used digital 3D technologies to create documentation
and **support the restoration.**



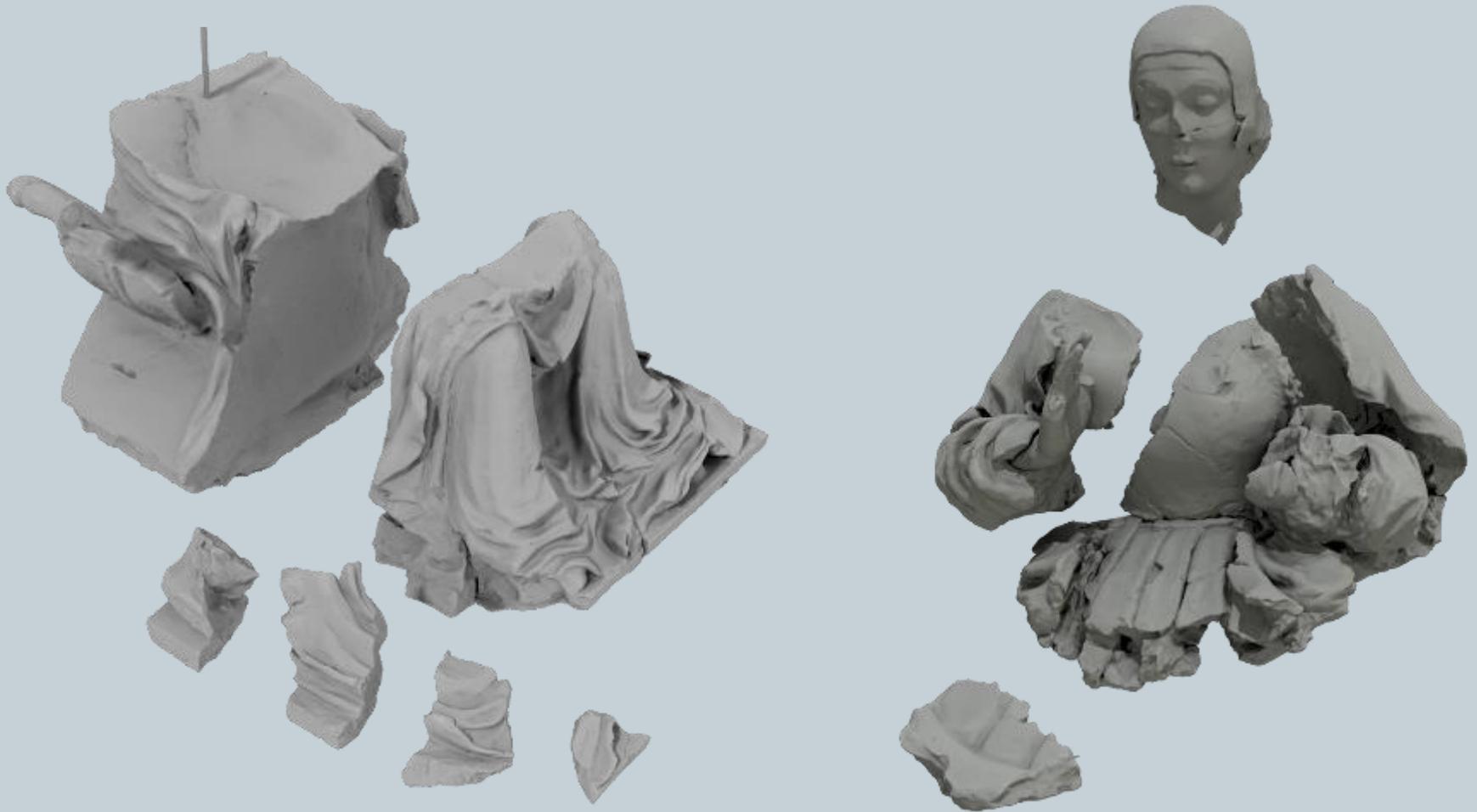
Pietranico's Madonna



Two different actions:

- **Helping the reassembly**
 - Use the geometric properties to compute the position of the fragments
 - Measure distances, missing areas,
 - Help finding the correct position of the two main sub-blocks
- **Helping the physical reconstruction**
 - Well... I'll explain this later

Pietranico's Madonna



Pietranico's Madonna

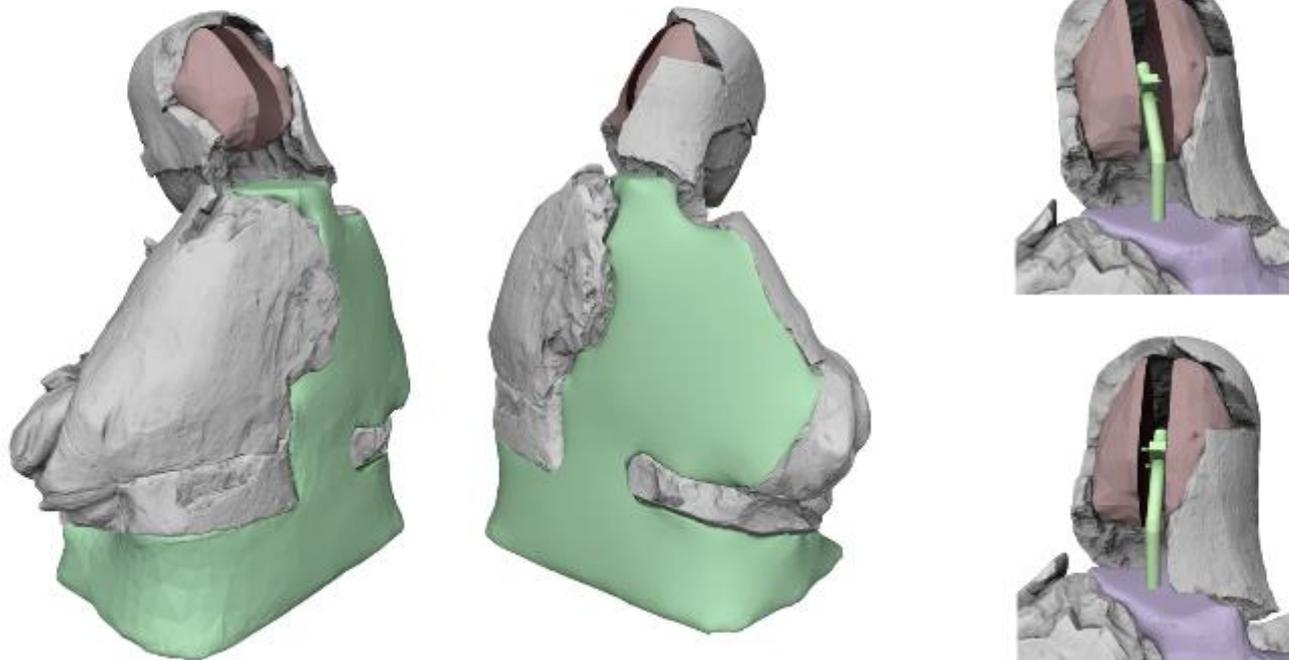
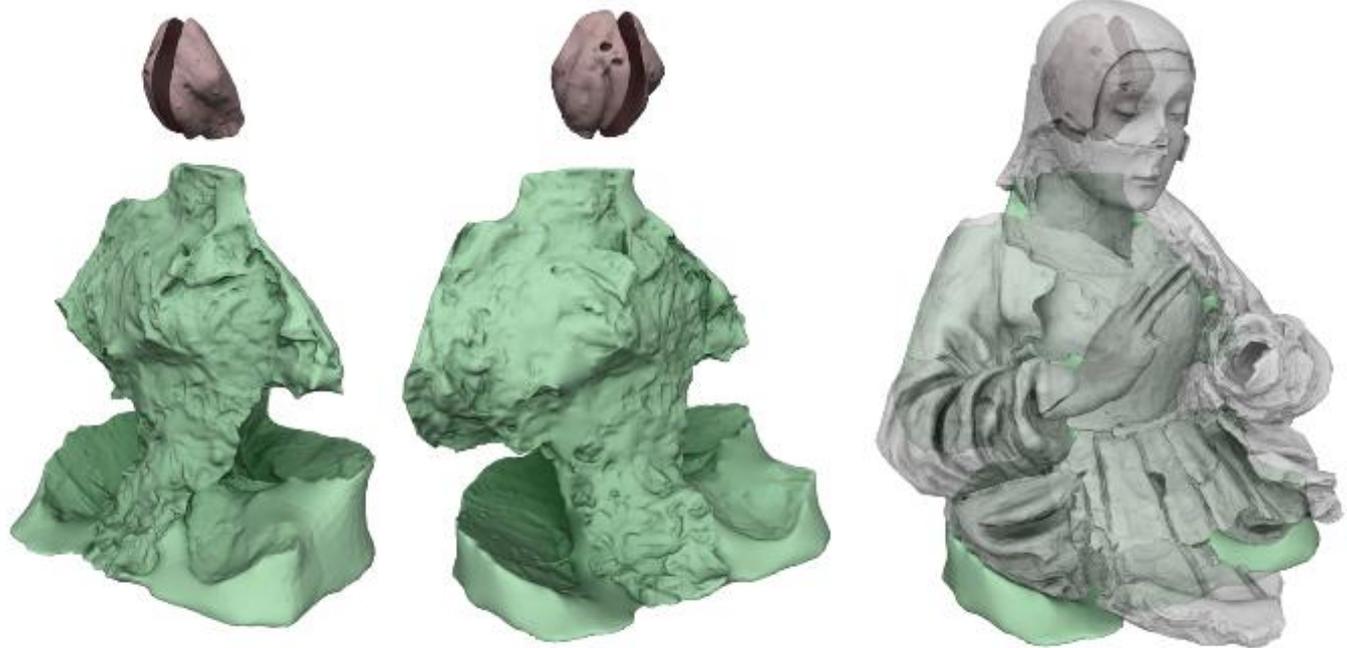


Pietranico's Madonna



Helping the physical reconstruction

- *Problem:* the statue cannot stand without support
- *But* we have a metric 3D description of the empty space
- *Then* we can design a “filler” object that can support the pieces...



Pietranico's Madonna



Question Time



THANKS FOR YOUR ATTENTION...

callieri@isti.cnr.it

?

A light blue speech bubble with a black outline containing a red question mark.

!

A light blue speech bubble with a black outline containing a blue exclamation mark.

???

A light blue speech bubble with a black outline containing three orange question marks.

!

A light blue speech bubble with a black outline containing a blue exclamation mark.

??

A light blue speech bubble with a black outline containing two pink question marks.

!

A light blue speech bubble with a black outline containing a blue exclamation mark.