LOW COST HANDHELD 3D SCANNING FOR ARCHITECTURAL ELEMENTS ACQUISITION

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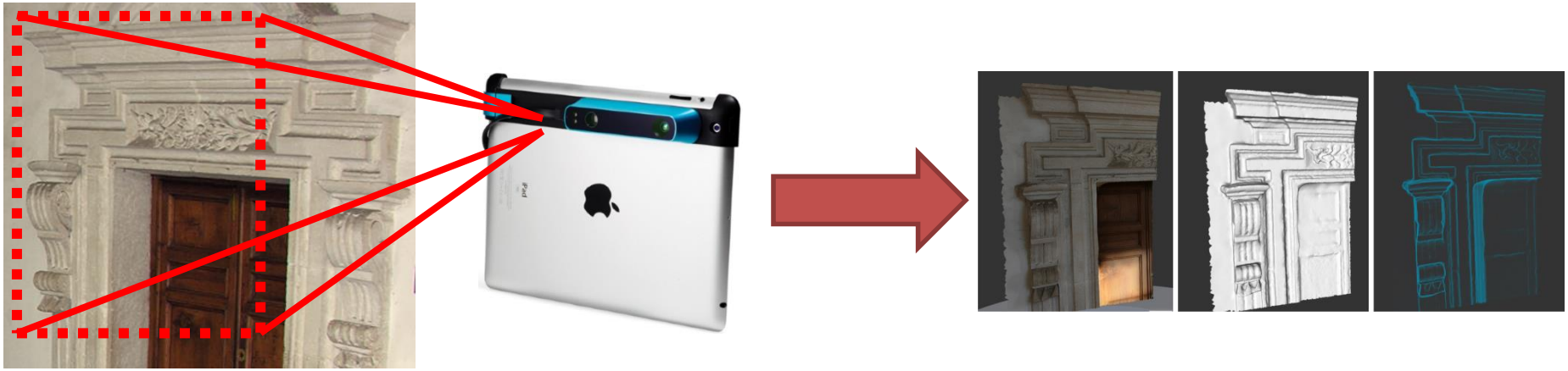
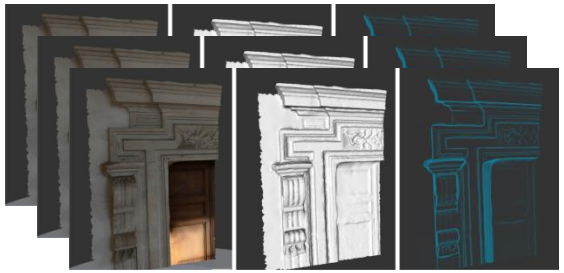
Outline

- Motivation
- Handheld 3D Scanning
- Case study
  - Setting
  - Method description
  - Comparison with Time of Flight 3D scanning
- Conclusions

Motivation:
Cultural Heritage Preservation



Multiple Digital Copies



Digital Restoration

Catalogue and Archive
(monitoring purposes, …)

Handheld 3D Scanning

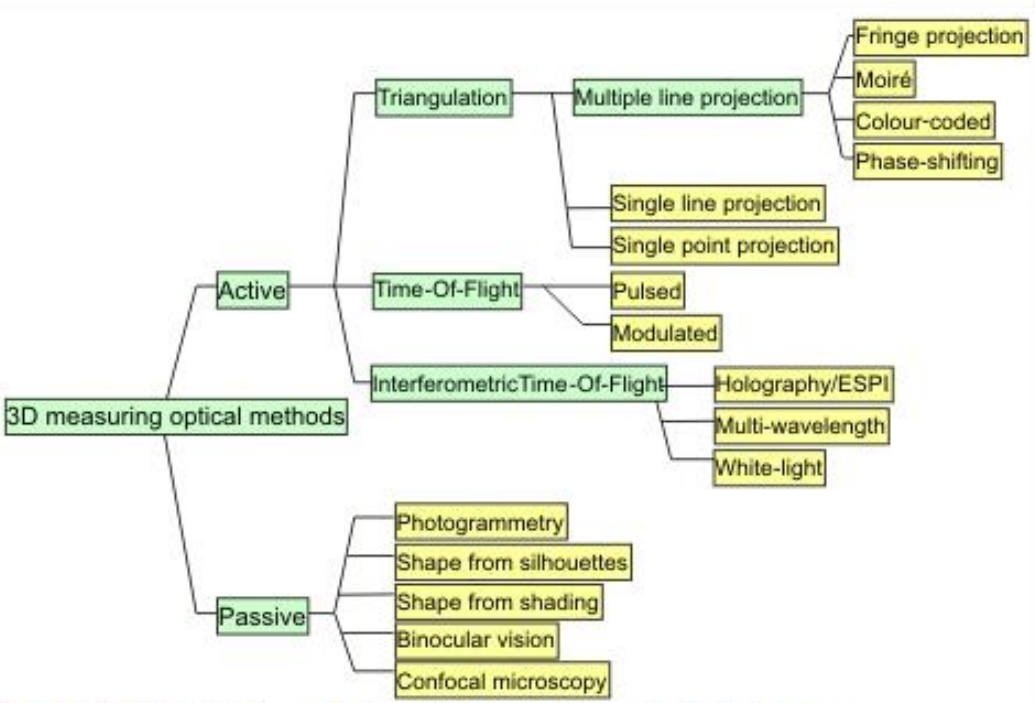


Fig. 3.2.1: Classification of optical 3D measuring main techniques.

© Pezzati et al., in: "Handbook on the Use of Lasers in Conservation and Conservation Science", 2008.

Kinect (v1 & v2)

Xtion Pro

Fuel 3D

Artec Eva

Artec Spider

Tango

Structure

Case study

- 18th century doorway in the complex of the Benedectine Monastery of Catania
- It provided access to one of the cells of the friars, nowadays used as offices
- Is made by plane and complex surfaces, different materials and sculpted decorations

Case study: setting

- We employed Structure sensor, clipped on an iPad to enable RGB+Depth data acquistion
- We selected an Indoor environment in order to avoid sunlight issues
- We monitored the behaviour of the sensor with relation to scanned materials and geometries:
  - Opaque vs Transparent surfaces
  - Rich vs Poor geometry surfaces

- Scanning volume has been set to $1m^3$ in order to limit the scanning volume and mantain a good resolution

Case study: method description

- We acquired a total of 23 parts
  - Starting from the bottom left corner until the top right one
  - At least 30% of overlapping between adjacent parts
  - Meshes have an average number of 600K vertices and 1M faces

- We process and align meshes with MeshLab
  - Noise reduction: Quadric Edge Collapse Decimation
    - 80% of the points have been decimated without any visual-perceptible loss of details
  - Point Glue Alignment

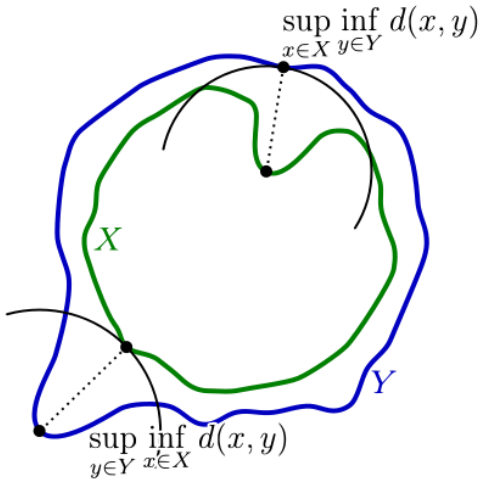
- Final model has been saved in the common OBJ format

Case study: comparison with ToF

- We used a ToF model of the case study as ground truth
  - The ToF model has been acquired using a HDS 3000 Leica device
- We computed the Hausdorff distance between the models acquired by the low cost handheld Structure scanner and the ToF model
  - Hausdorff distance has been computed onto 2 details and on the whole case study
- Quality histograms have been computed and analyzed

Definition of Hausdorff distance

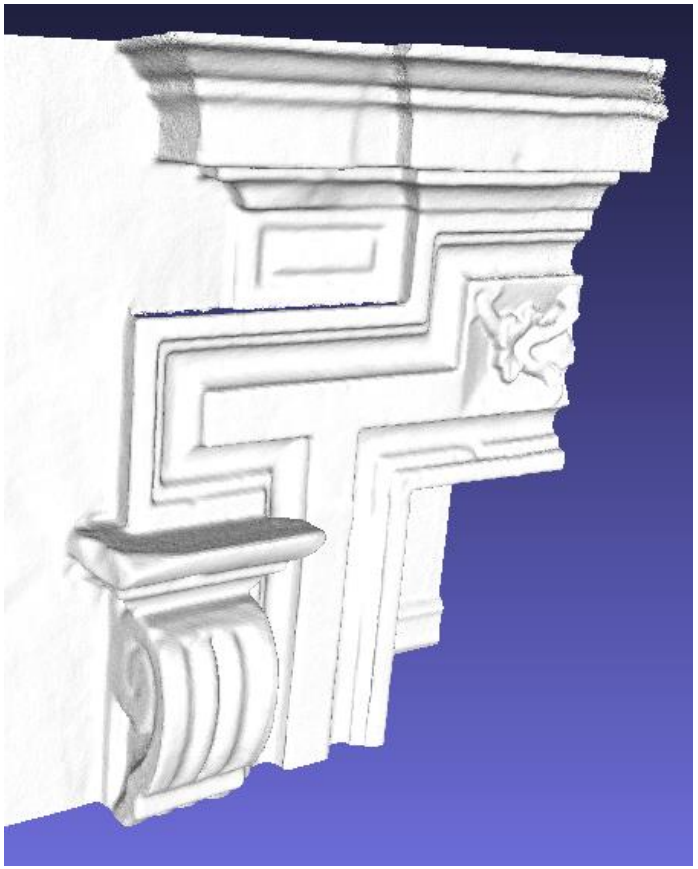
- In mathematics, the Hausdorff distance, or Hausdorff metric, measures how far two subsets of a metric space are from each other.
- Informally, two sets are close in the Hausdorff distance if every point of either set is close to some point of the other set. In other words, it is the greatest of all the distances from a point in one set to the closest point in the other set.

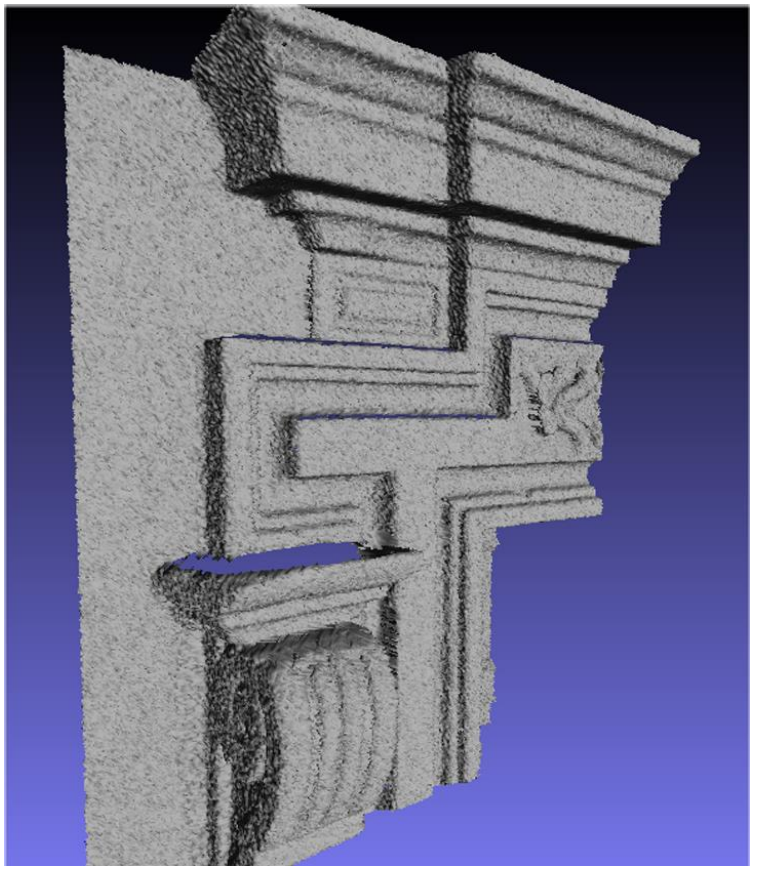


Case study: comparison with ToF

- In terms of visual accuracy of the 3D reconstructions
  - Structure sensor single parts are more detailed and less noisy

Structure





ToF

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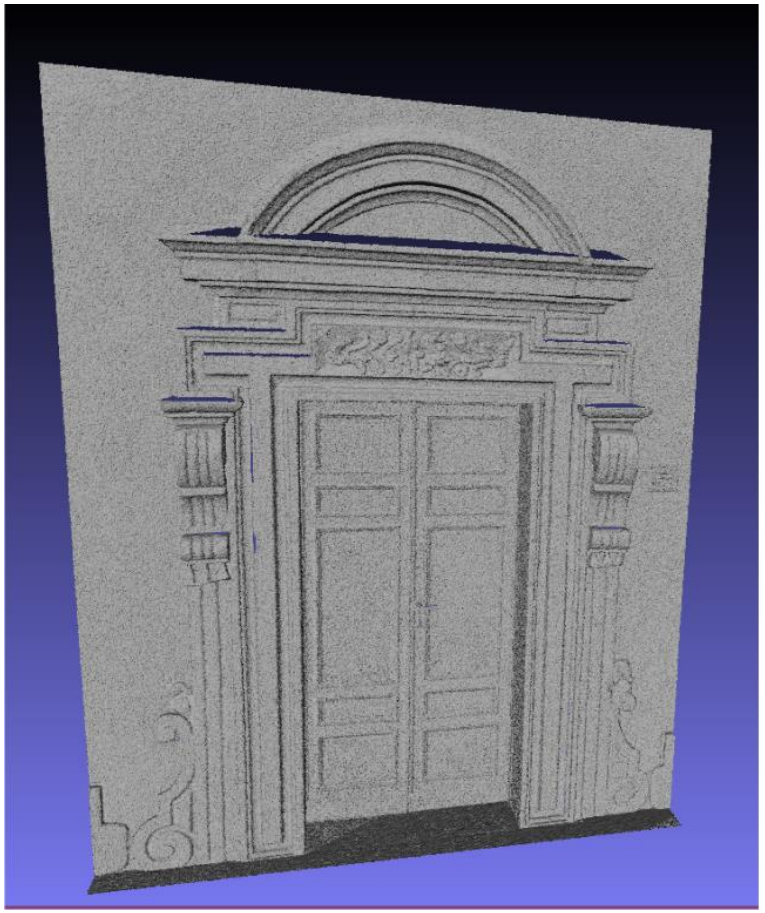
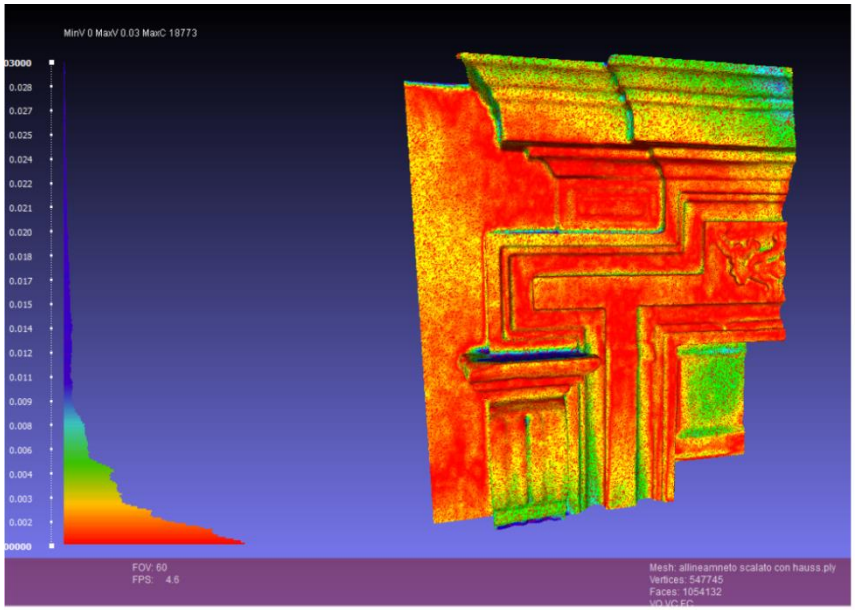
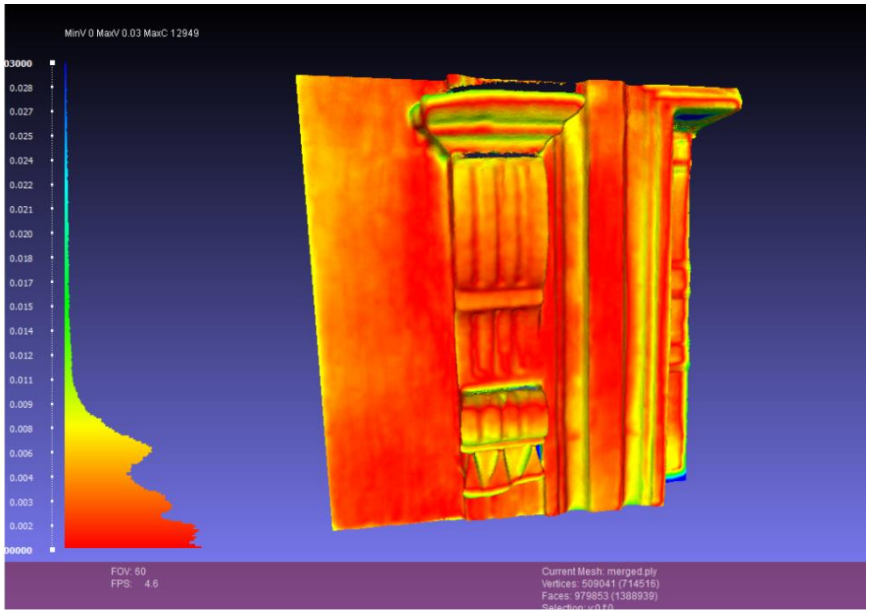


ToF

Case study: comparison with ToF

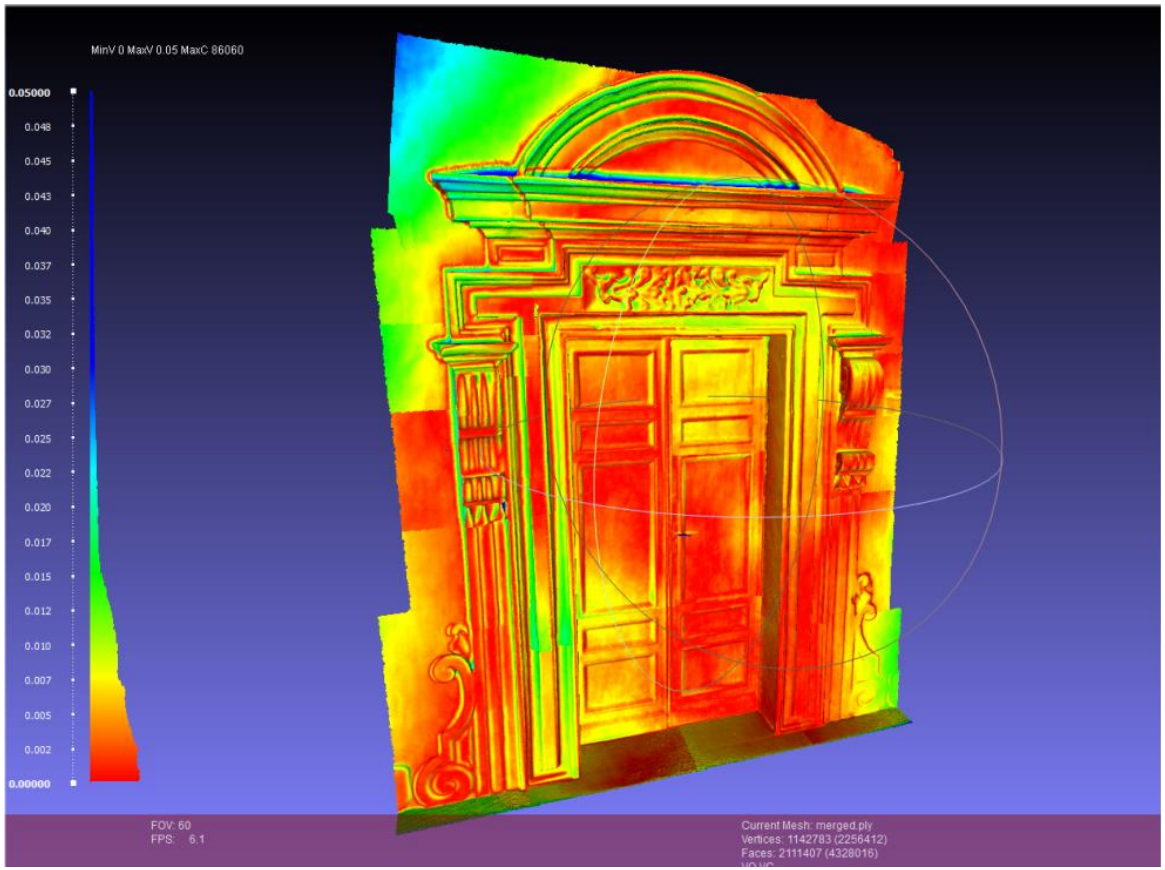
- Hausdorff distance and subsequent quality histogram between TOF model and Structure Sensor model of two chosen details.





Case study: comparison with ToF

- Hausdorff distance and subsequent quality histogram between TOF and Structure Sensor models



Case study: comparison with ToF

- A detailed visual analysis of the Structure Sensor model reveals some mismatches in the overlapping areas.
  - These alignment errors could be interpreted as fallacies of the alignment step probably due to boundary geometric inconsistencies of the single scans

- The experimental results are shown in Table (values are in mm):

Model	Hausdorff Range	Mean	RMS
Capital	0 – 30	4.344	6.879
Entablature	0 – 30	4.775	6.797
Overall Model	0 – 50	9.619	14.104

- Mean distance computed on details is lower than 5mm, comparable with the usual ToF accuracy
- The Mean distance computed on the whole model is 9.6mm, due to the severe amount of noise introduced by alignment process

Conclusions

- In this paper we defined a low cost indoor procedure facing the criticalities of the handheld 3D scanner Structure sensor for architectural elements acquisition.
- Furthermore, the metric accuracy test highlighted the reliability of this sensor for the details acquisition.

- The results demonstrate that Structure sensor can obtain high quality 3D models of architectural details
  - useful to integrate ToF scannings and make the digitization of the cultural heritage
  - easier and faster
  - with affordable economical efforts

THANKS!

Any question?