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USE OF NEW TECHNIQUE OF IMAGE BASED MODELING AIMED TO PERSPECTIVE RETURN

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Abstract
The diffusion of Image-based 3D modeling techniques, through image-based free, low cost and open source software, have increased drastically in the past few years, especially in Cultural Heritage domain (Architecture, Archeology, Urban planning) [2, 3]. Computer vision techniques use photographs from dataset collection to rapidly build detailed 3D models. The simultaneous applications of different algorithms (MVS), the different techniques of image matching, feature extracting and mesh optimization are inside an active field of research in computer vision. Computer vision techniques - Structure from Motion (SfM)- allow to fulfill detailed 3D models from photos dataset collections. The results are promising: the obtained models are beginning to challenge the precision of laser-based reconstructions. This research investigates the limits and potentialities of 3D models obtained by using image based techniques in Architectural Heritage field, in order to verify the applicability of the method for the perspective return of the solid perspective of the artistic repertoire in my territory. My approach to this challenging problem is to verify the reliability of the 3Dmodels by Autodesk 123D Catch (web-based package). This paper aimed to demonstrate the efficiency of 123D Catch to obtain an accurate 3D model to operate the perspective return of artistic models.

Keywords: Image-based modeling, 3D reconstruction, Photogrammetry, Computer Vision, Architectural/Artistic Heritage

1. Introduction
Image-based modeling method can be employed to extract original texture and illumination directly from images for visual 3D modeling [21], without the need for complicated processes, such as geometry modeling, shading and ray tracing. These techniques – named Structure from Motion (SfM)- are usually less accurate, but offer very intuitive and low cost methods for reconstructing 3D scenes and models [1, 9, 10, 11]. There are now a number of software packages that offer the ability to acquire 3D models from a set of images without any a priori information about the scene to be reconstructed. 3D reconstruction from images has undergone a revolution in the last few years [12, 13, 14]. Thus, there is a growing attention among academics and practitioners due to the great potentialities of these systems [24]. Among all available web based software (ARC3D, 123D Catch, Hyp3D, my3Dscanner) I have chosen 123D Catch for the easiness of use, the visual quality of the reconstructed scene and the possibility to interact with and develop the results. Furthermore, Catch 3D mesh is suitable for all 3D modeling software. This web-based package exploits the power of cloud computing, allowing to carry out other tasks but it works like a black box and the user does not have the possibility to interact with the software in order to improve the outcomes [25, 26].
I will use 123DCatch on the bronze tile in S. Caterina urn in Dome of Palermo.

2. 123D Catch Model

123D Catch is a web-based, at present time free, package of Autodesk. It overcomes Autodesk's Photofly project launched in 2010 summer, using technology developed by Realviz [8, 22]. The used approach underlying 123D Catch technology is well described in [20].

Exploiting the photogrammetric approach and the algorithms of Computer Vision, 123D Catch is able to reconstruct internal parameters of the digital camera and the position in space of the homologous points from a number of correspondences between sequences of photographic images, suitably taken [17].

The 3D coordinates of all points of the scene have been found and the polygonal model has been reconstructed through the correspondence pixel-pixel.

To use 123D Catch you have to:

1) Capture a photographic sequence of convergent photos of the object with an overlapping of about 70%;
2) Upload the photos to Autodesk cloud (user can decide whether to wait the 3D reconstruction or to be advised by email);
3) Improve the results by manual stitching of homologous points on triplets of images and submit again the scene to the cloud;
4) Create a video;
5) Export the 3D polygonal model thus obtained in OBJ format and use it in other 3D packages. In professional field, 123D Catch has carried out good results both under metric and visualization output and both on large and small architectural scale.

To use 123D Catch you need:

1) A pc with a low Ram profile also, for example 3 giga and a fast internet connection (the mesh elaboration takes place on cloud);
2) A camera with resolution range of 6/12 Mpix.

123D Catch mesh processing is excellent if data set is composed of a range of 30/200 photos. The number of the dataset photo collection depends on the scale of the object [23].

There are two strong conditions to carry out a useful mesh: 1) use the same camera and the same focal length; 2) have a structured photos data set collection where each image captures the entire object. These latter two conditions are mandatory to have a regular geometric and metric mesh without any distortions. The second condition is an unfavorable limit in architectural buildings application but in archeological, architectural element, museum collection or small scale objects the output mesh is in almost cases excellent [18].

Below there is a pipeline to use image-based modeling techniques for architectural heritage digitalization.

Data set:

· 123D Catch photos dataset is structured and its development is easy to get. The number of images goes from 30 to 200 and depends from the object scale;

Running time and hardware resources:

· 123D Catch calculation take place on cloud and so you do not need of particular hardware resources;

Output:

· 123D Catch output is a mesh file and this is an advantage; nevertheless, Catch tends to automatically close all the holes and does not declare where this operation happens, one should be very carefully into covering the whole object and into inspection the output mesh;

Metric accuracy of architectural element:

· 123D Catch 2.71 mm

Metric accuracy of architectural building:

· 123D Catch 0.03 m

2.2 Bronze tile 123D Catch Model of S. Cristina urn in Palermo Dome

The data set, to carry out the 123D Catch model, is composed of 21 photos made on two different paths around the object with two different gradients.

The number of photos has been designed according to the real dimension of the object. The output carried out, as you can observe in the figures reported below, shows a good visual accuracy.

Furthermore, its metric accuracy has been verified through a comparison with a direct survey: the horizontal and vertical sections, between 123D Catch model and the drawing obtained from direct survey, result perfectly overlapped.

The 123D Catch OBJ model has been exported in standard resolution: I did not used the maximum one because the goal of the research was to analyze the geometrical aspects of the urn in its perspective construction and not to have the best resolution. The imperfections that you can see in the 123D Catch model are in the real object and that is because it has been created in bronze material [4, 15, 16,27, 28, 29].

Fig. 1: S. Cristina urn in Palermo Dome.

Fig. 2: 123D Catch data set and wireframe visualization of OBJ model of a part of S. Cristina urn in Dome of Palermo

Bronze tile of S. Cristina urn	
Dimension of the object	0,51x0,63 m
Number of images	21
Resolution	8.5Mpixel
Camera	Nikon 3200
Focal distance (mm)	24
123 D Catch processing time (min)	23
123D Catch mesh	793,736 triangles 468,357 vertices

Tab 1: parameters values

Once I exported the 123D Catch OBJ model, I can use it in other 3D packages to make the perspective return. I have chosen Rhinoceros5.

3. Rhino elaboration for perspective return

In order to perform the perspective return in the geometric space, it is necessary to reconstruct the trunk prismatic box that contains the tile. Therefore, it is necessary to find the planes that form the walls of the tile. To do this, I had to dissect the 123D model with horizontal and vertical planes with the same step away in Rhinoceros 5 (Figg. 3, 4).

The intersection between the level curves, obtained by bundles of horizontal and vertical planes, intercept the exact points on which to pass the four planes that make up the tile (Figg. 5, 6, 7). In this way, I obtained profiles that generate the geometric shape in the space.

Extending the carried out planes, we obtain the pyramidal solid through their intersection (Fig. 8). Within the solid, is identified the trunk prism and the straight line where there is $F'_{n\pi}$, the vanishing point of the straight lines perpendicular to the framework.
As you can see in Fig. 9, the extended straight lines of the lateral walls are not aligned. This happens because in the figure the object is not read from the perspective point of view.

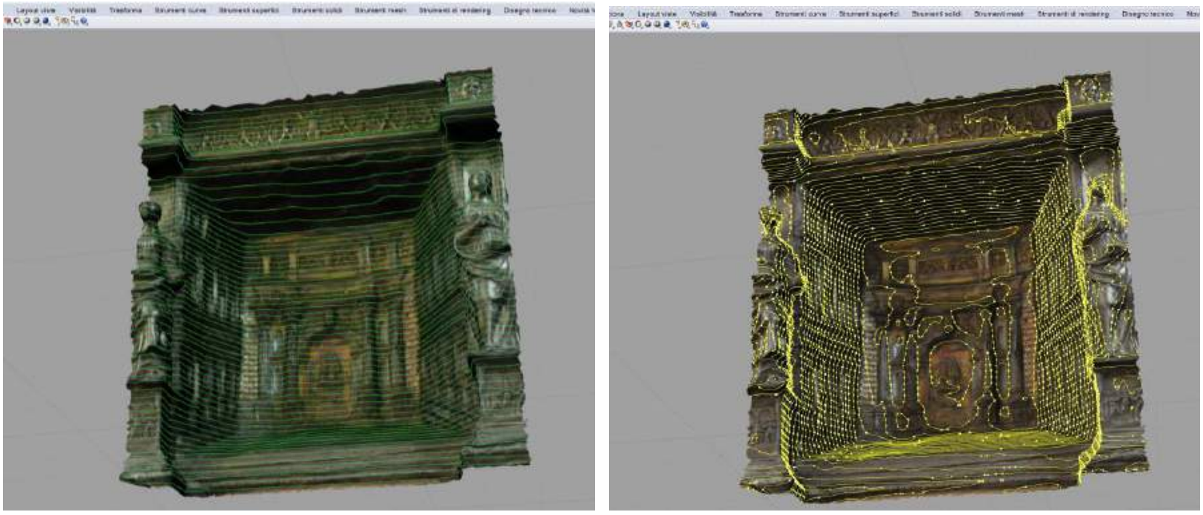

Fig. 3: 123D Catch OBJ model in Rhino5: horizontal and vertical sections.

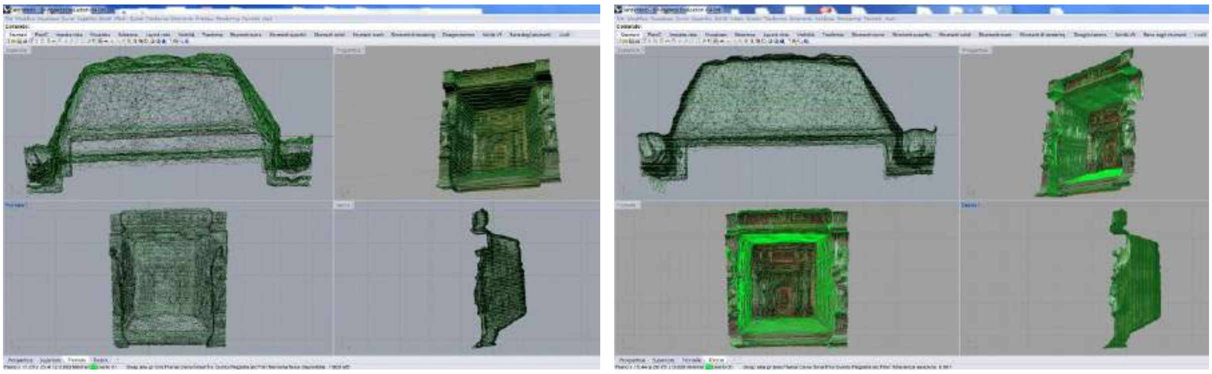

Fig. 4: 123D Catch OBJ model in Rhino5: horizontal and vertical sections.

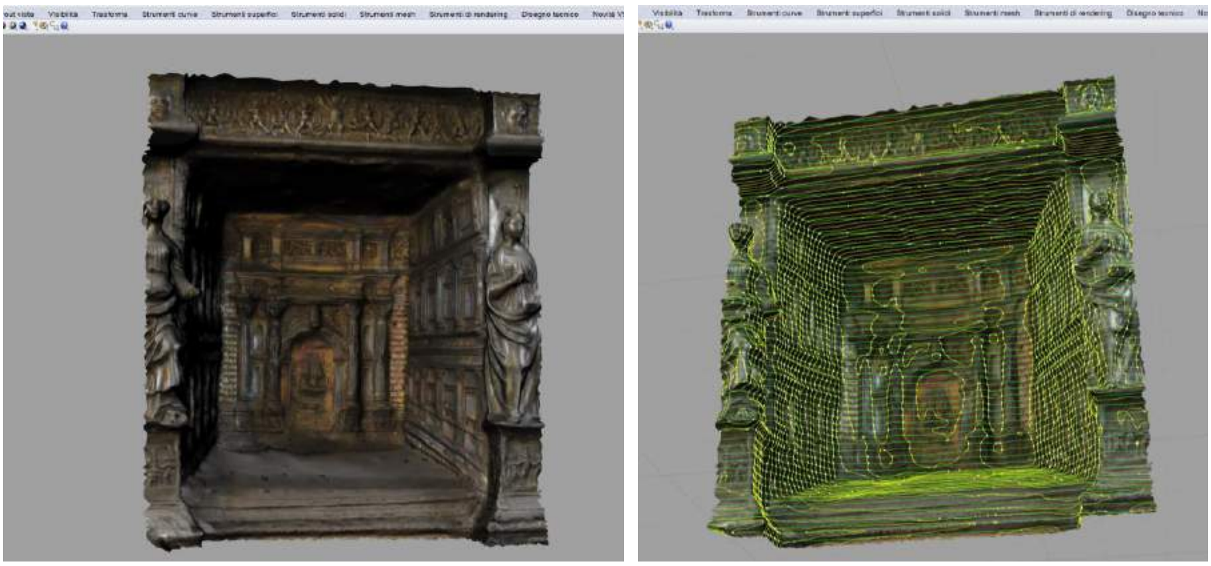

Fig. 5: 123D Catch OBJ model in Rhino5: rendered model and intersection between horizontal and vertical sections.

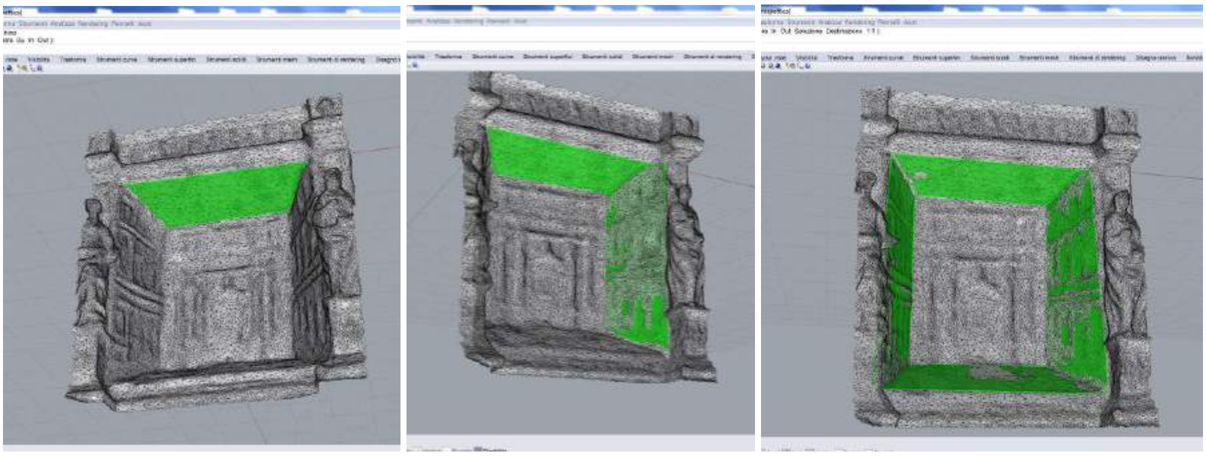

Fig. 6: 123D Catch OBJ model in Rhino5: planes that make the prismatic object.

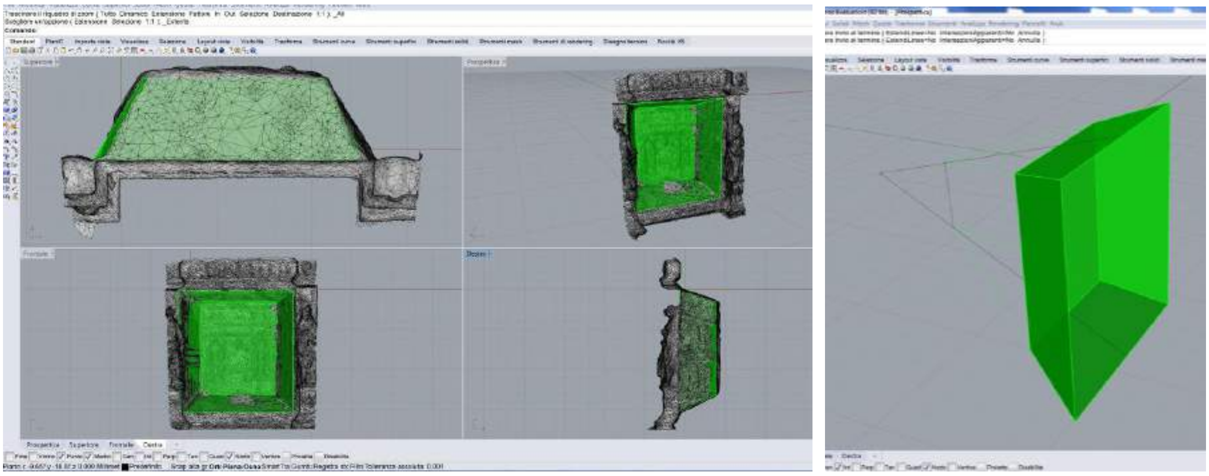

Fig. 7: 123D Catch OBJ model in Rhino5: planes that make the prismatic object in the four views and pyramidal solid.

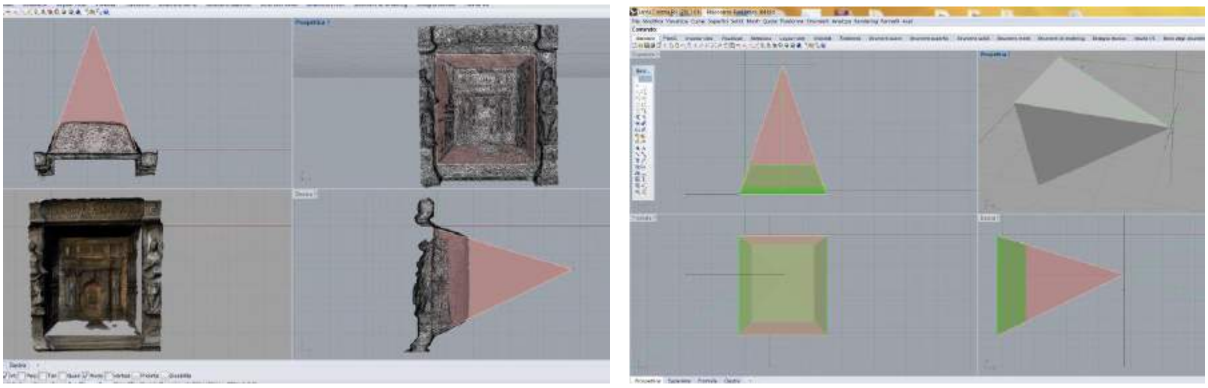

Fig. 8 123D Catch OBJ model in Rhino5: geometric analysis for perspective return.

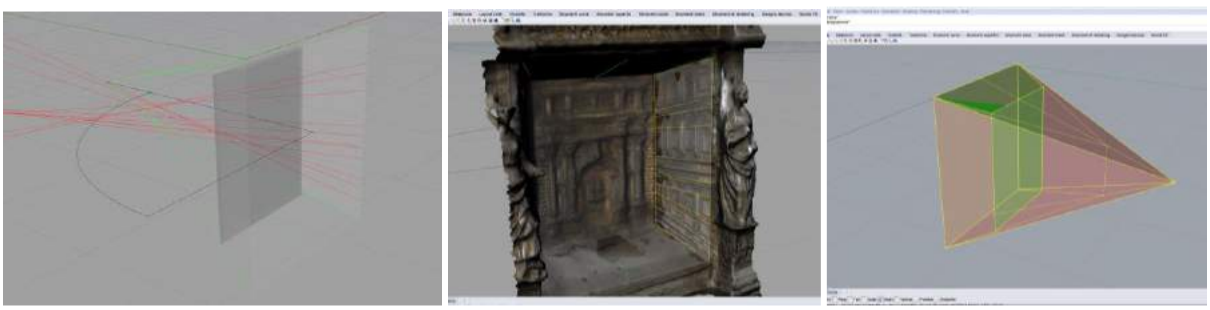

Fig. 9: 123D Catch OBJ model in Rhino5: geometric analysis for perspective return.

The 3D model elaborated in Rhino is the first step for the descriptive geometric analysis, aimed to carry out the perspective return of the object.

4. Perspective return

Thanks to the geometric 3D model carried out in Rhino, I was able to individuate the $F'n\pi$ (vanishing point of all the straight lines perpendicular to the framework) position on f'_{α}. The framework is on the front of the scene and the trace $t\alpha$ of the plane α (the perpendicular plane to framework) is on the bottom of the framework and its vanishing straight line $f'\alpha$ contains $F'n\pi$ (Fig.10).
We obtain other two planes: β and γ with tβ, tγ, f'β, f'γ. The plane β is the one that contains the floor of the box and the γ one is the right vertical wall. The plane β has been found applying the line of maximum inclination of β, mp*β carried out from the real section made on Rhino and imported to have the perspective return [5, 6, 7, 19].
Through the rotation of the point of view once from F'pb and once from F'pg we have all the elements to have the perspective return.
Therefore, we can read the real depth and the perceived depth.

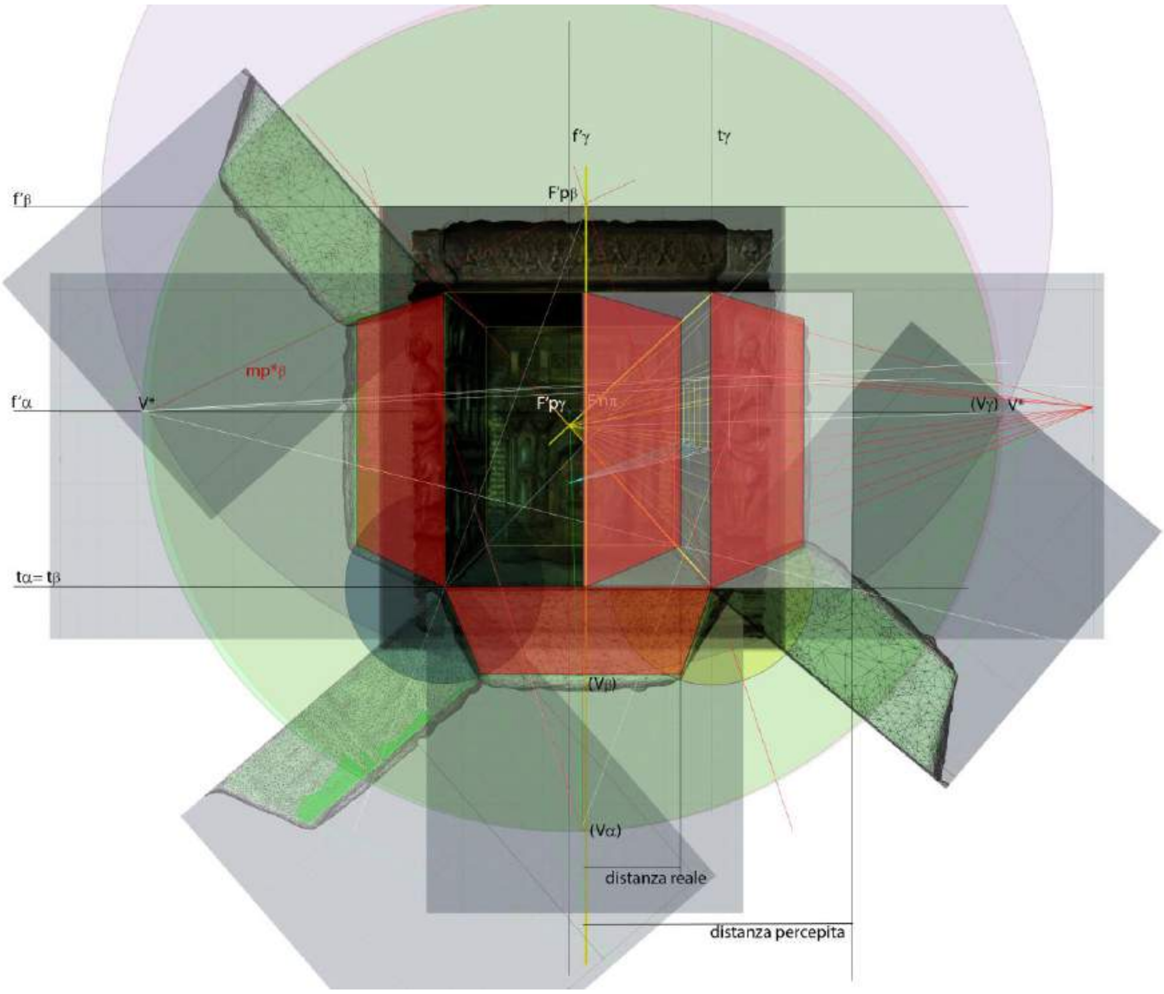

Fig. 10: Perspective return of the bronze tile of S. Cristina urn.

However, if on one hand we have returned the real size of the box, to the other side we should verify if the builder had considered the geometrical rules to obtain, on that box, that one perceived image. Therefore, it would be appropriate to draw the real box and study which aberration must be used to have that view from that point of view. Nevertheless, this study has not been addressed yet. Moreover, this is not the appropriate contest to do so.
At last, we have to consider that work with the bronze is not as easy as with marble and some little imprecision could be made for this reason.

5. Conclusion

This paper was aimed to verify the reliability of the image-based modeling techniques applied to architectural elements in order to make a return perspective.
The result obtained showed that these techniques were entirely satisfactory, at zero cost and with a very low processing time. The metric and visual accuracy allowed me to follow all steps from data acquiring to 3Dmodeling, to geometric analysis, to return perspective, with a result (Fig. 10) quite satisfactory.
Using of 123D Catch is a suitable choice when you have to elaborate architectural elements or museum items.

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