FROM WOODEN MAQUETTES TO DIGITAL MODEL: VIRTUAL RECONSTRUCTION OF A DESIGN PATH

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Keywords: laser scanner, digital photogrammetry, 3d modelling, virtual reconstruction, digital documentation.

Abstract*: the events determining the construction of a building often occur over a prolonged period of time, during which different projects for its actualization are presented. What we see today is often the result of a number of ideas, second thoughts and interventions that have not always come into being. Architectural models have always represented the project "in nuce" in the most effective and direct way. Through a "simulation" on scale, they anticipate how a final product is going to be. Nowadays, different terms such as scale models, maquettes, point clouds, and 3D computerized models, all allude to a particular cognitive path that leads us to the knowledge of an object or a building through a mimetic process. Each one of them represents a specific form of re-creating reality, subjected to a translating process allowing it to express itself in a specific context or to engage in dialogue with a specific public. Today, we do not use wooden models anymore, but digital and numeric ones. This allows us to cover in a single representation system the whole possible "vision" mechanisms, even for the old projects. Through modern 3D representations and surveying technologies (digital photogrammetry and laser scanning), we reached our goal: we insert in the current context some projects never built or not visible anymore that survived in the shape of wooden models, in their different variations. In particular, this study concerns Frank Lloyd Wright's project for the Masieri Memorial in Venice, on a site facing the Grand Canal.This study also gave us the opportunity to determine the efficiency of triangulation laser scanning in surveying, and digital low cost photogrammetry suites for surfaces modeling. This surfaces are characterized by a high formal complexity for the presence of a lot of shady areas that might generate many gaps in the acquisition. The integration of the two methodologies ensures the achievement of a good result in shapes definition.*

1. The Masieri Memorial of Frank Lloyd Wright

1.1 Introduction

The design history of a building is often complex and made of adjustments bringing to many results. Among all the possibilities only one can be the definitive choice, the one considered the best from the designer. The Masieri Memorial in Venice represents a peculiar case; the choice takes part in the eternal cultural discussion between modernists and traditionalists and it's not only up to the architect. In this context the wooden model can be used as an instrument to understand and to represent the architectural design.

1.2 The history of the project

In 1951, Angelo e Savina Masieri gave the commission for their home in Venice to Frank Lloyd Wright. Angelo, young architect from Udine, loved Wright's works and wanted him to be the one to design his new house, for him and his wife. The place was that of the old palace of which the two were owner, located in "volta del canal" the intersection between the Canal Grande and Rio Novo: a focal place, the arrival point of the historical and annual Gondola race in Venice. When Angelo Masieri died of a car accident, Savina decided to continue with the project but to transform it in a hostel for 20 students of the Architecture University in Venice, IUAV.

The first presentation of the work took place in the Public Library of New York. Rumors coming from United States about Wright's sketches created alarm in Venice. The intervention of the architect Bruno Morassutti as a supporter of Wright's work and Wrigh's willingness to change many project's features as the common wanted, weren't enough to make the Commissione Igienico Edilizia approve the project, more because of the fear of the public opinion than because of real technical problems. Even if in the end the Masieri Memorial haven't been built as Wright designed it, and the old palace was restored by Carlo Scarpa, Wright's project make us understand something important about his evolution.

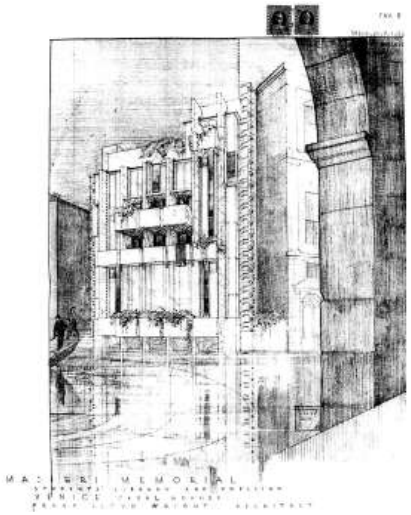

Figure 1: Wright's design, perspective view on Canal Grande

Figure 2: present day view of "volta del canal"

There are three different versions of the project. The American architect brought the triangular shape of the site to a rectangular triangle, because in his opinion, this form represented the structural unit.

Then Wright, that used a grid for his projects, as a consequence of his Foroebeliane influences, made a even more regular shape, dividing the triangle in a regular grid of 1,9m x 1,9m. We can find this grid in the projects of January 1953 and of February 1953(figure 3). Both projects are made by two volumes, the only difference between the two is the position of the "tower". In the first placed near the entrance calle and in the second placed nearby Palazzo Balbi.

Analyzing the sketches of the American architect we can notice that in the project of March 1954 he used a grid of 1,2m x 1,2 and maintained a triangular shape but the design was bigger than the available space. Probably it was due to a mistake in reading the survey of the place, in particular the distances between the neighboring buildings. However we can see that the layout is similar to the previous projects: two volumes and a "tower" nearby Palazzo Balbi.


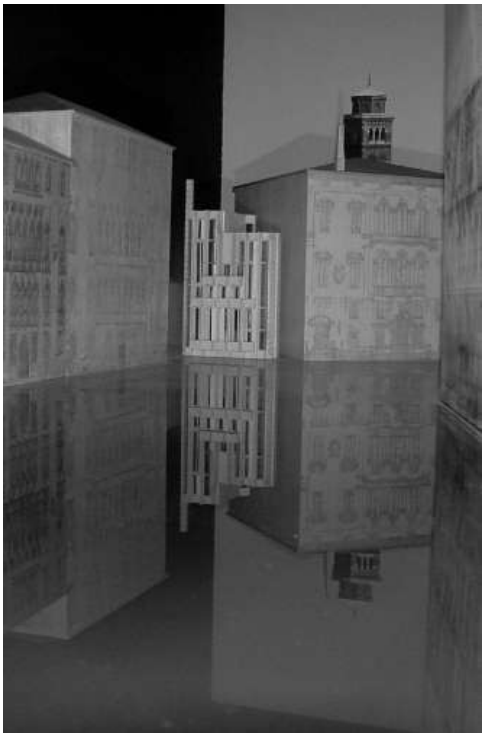

Figure 3: the wooden models of Masieri Memoria: (left) the model referred to the II version of the project, property of Archivio Progetti, Iuav; (right) model referred to another version. The differences between the two versions are evident in tha facade and in the position of the tower.

2. THE MODEL

The wooden model, in architecture, has always been important for the project as decisional instrument but also as a synthesis of the choices that were made. It is a balance between abstraction and similitude. Abstraction makes it possible to see the project naked from aspects of interpretation and comprehension. Similarity is the feature that makes the model a specific description, clear and evident expression. The wooden model is also characterized by its constructive technology, by the reached level of detail and by its genesis. The wooden models, perfect in their construction and details, tend to crystallize the thought and anticipate the reality. They absolve the need to communicate the project and satisfy the client wish to "see before".

The wooden model of the Masieri Foundation, owned by the Project Archive of the IUAV Architecture University in Venice, is the one of the 1953 project. It's a clear representation of the Architecture thought by Wright. The model scale is at scale 1:25, built in wood and Plexiglas. It was made for a better comprehension of the project and to verify the facades on the Canal Grande.

Thanks to the latest technologies, models can be used in many other ways, not only to represent one of the steps of the project, but also the changing during its genesis. The digital model makes it possible to visualize all the features of a project from the single object until reality simulation by virtually putting the model in the designated context. So today the wooden model becomes a digital model with features of geometry, topology and photometry. Geometry describes points, coordinates, topology for the relations between geometric components and photometry is used for what regards object's colors and textures. Another important difference between the two models is that the wooden one is realized starting from 2D drawings (plans, drawings and sections), while the virtual model is a result of the digitization of a pre-existing model. The digital model of the Masieri Memorial comes directly from that of wood, thanks to digital 3D acquisition methods. New technologies (photogrammetry and above all laser scanner) are useful for the survey of cultural heritages and allow to digitalize a big amount of data from which it is possible to obtain useful models.

2.1 Digital survey

This case study is interesting also because the digitization of a wooden model is not yet common in geomatics: normally the applications concern a whole building or small objects, and not medium-sized things. Different sizes and different accuracy bring to utilize different instruments and methods. As regards laserscanners, for example, TOF (time of flight) and phase-shift instruments can be used for big objects, while triangulation sensors (point, line or pattern) for those small. The wooden model of 1m x 1m x 1m can be considered neither big nor small, that's why it was needed to find new ways of acting.

So we decided to follow two methods, photogrammetry and 3D scanner, to obtain models as precise as possible.

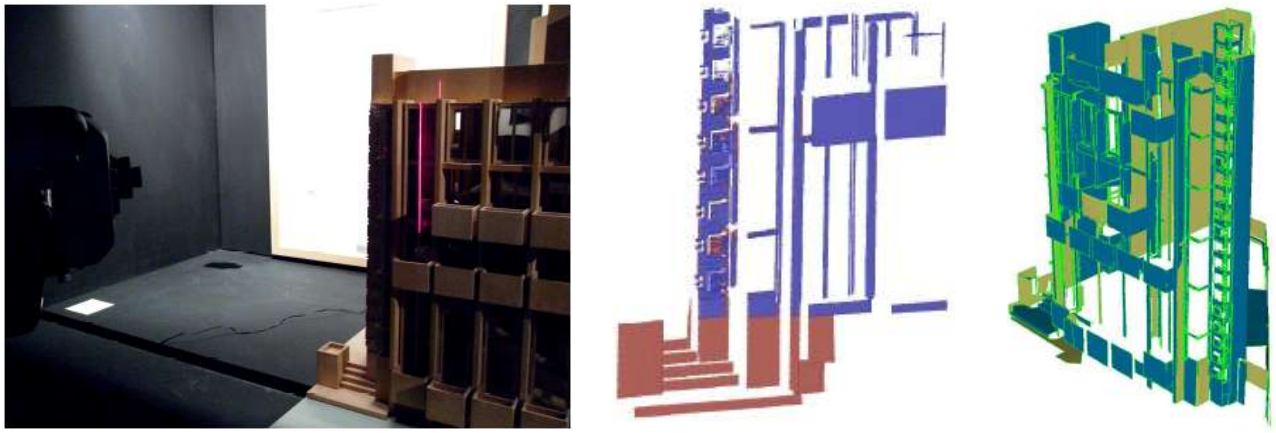

Figura 4: triangulation scanner: scan of the model (left), registration of two single scans (center), result of all scans registration (right)

For 3d scanner we used the triangulation sensor Minolta Range 7 (figure 4), based on light sectioning method, characterized by a high accuracy degree.

Depending on the used lens (tele, lens or wide-angle) the scanner gives the chance to obtain at maximum scans of A4 size-sheets with an accuracy inferior to the tenth part of millimeter. Even if the instrument has a limited range, it gives the chance to work even in bad weather conditions or with low light conditions as it can be for a university exhibition hall. The scanner have been preventively calibrated. Then a lot of scans were made to be sure to have the needed overlap to orientate each point cloud by the ICP algorithm (Iterative Closest Point). But the model had a quasi-planar side, without any features, so we couldn't apply the ICP registration for all its sides. So we used the acquiring software of Minolta, Range Viewer, that gives the chance to orient automatically clouds thanks to known targets placed on the model. In the acquiring step we had good results on wooden parts but not on plexiglas parts, obviously because of the reflective features of the material.

The orientation of each point cloud in a unique reference system was made, as already said, through ICP algorithm with Geomagic Studio 11 software. Clouds have been divided in groups; every group refers to a façade, each group matched with the others. Results were highly correct for each single façade but showed some errors in the common parts due to the little overlapping between the facades and in some cases to their quasi planarity

The second method is photogrammetry (figure 5). As for the first case it is possible to make the survey without a direct contact with the object so this technique is particularly useful while talking about cultural heritages.

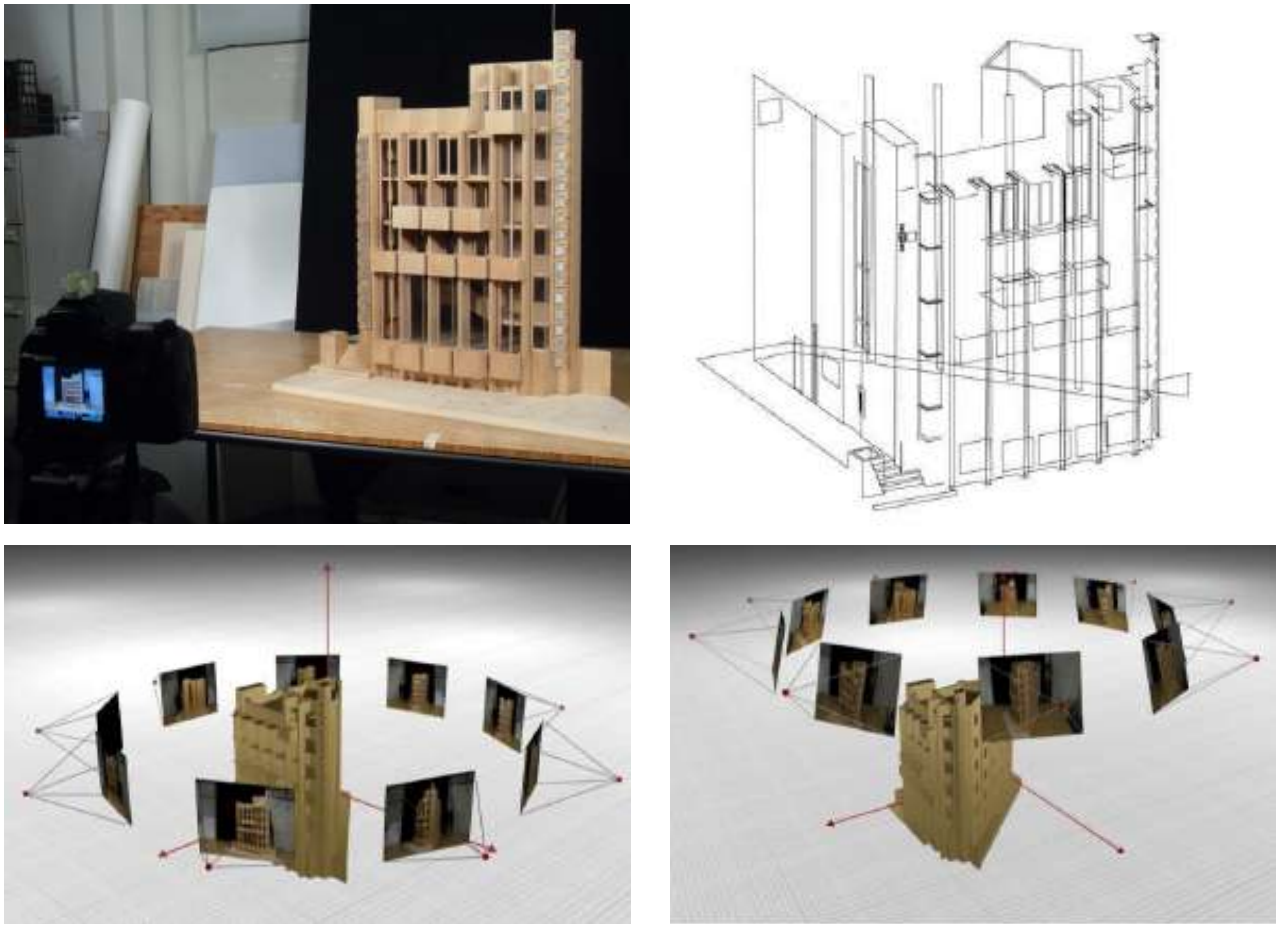

Figure 5: photogrammetric survey: image acquisition (upper left), acquiring configuration (bottom), wireframe model (upper right)

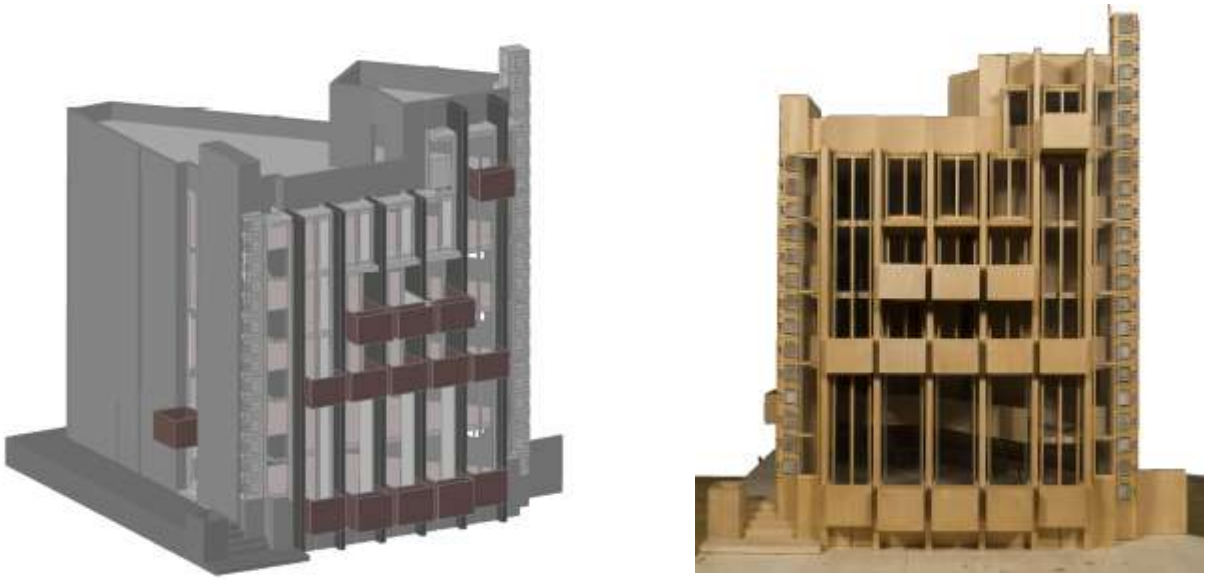

Figura 6: Digital model and wooden model

Acquisition was made with a D700 Nikon camera and 35mm lens. The scheme is that of converging shoots taken all around the model at two different heights. The pictures were acquired in order to avoid deep shadows, which could generate difficulties in collimation, orientation and design phases. The camera was calibrated by Photomodeler software, and then each photo was oriented to obtain the three-dimensional digital model made of tiepoints. The 3D model was scaled by using some measurements from the wooden model and with other measurements we made a validation of the scale-transformation. The last steps to get a wireframe model were manuals.

3.1 Two models

The two models, obtained by laser scanner and photogrammetry, were compared as concerning the acquisition and even in the result (mesh and solid). The two different procedures are nearly overlapping. Each method needs the calibration of the camera, a 3D acquisition and orientation (or recording) of each point cloud or picture.

Laser scanning method provides a better result for precise measurements, but it's slower in the acquisition (the speed is determined by the measurement range of the instrument) and it shows difficulties in recording because of the size of the object. Some problems are also evident in the digitization of some elements: the plexiglas of the windows. 3D scanner gives many data, that's why specific software and manual work are needed after acquisition. The photogrammetric method applied requires more manual intervention, but the acquisition instrument, the digital camera, is more easy to handle. On the other hand modelling is different between the two methods. More automatic the one that comes from the 3D scanner that results in a mesh. More manual the one of the photogrammetric method in which the operator decides what to ask, what to design and what to model, going from the wireframe model of the design draft to the definitive model.

From the analytic comparison of the two digital models (oriented with ICP in the same reference system and compared according to the distance between single elements) (figure 7) we can notice a good correspondence between the two, with a maximum difference of ± 3mm, except for the areas where the operator interfered to simplify or to edit. So we can say that differences are in the manual modelling phase and not in first digital results.

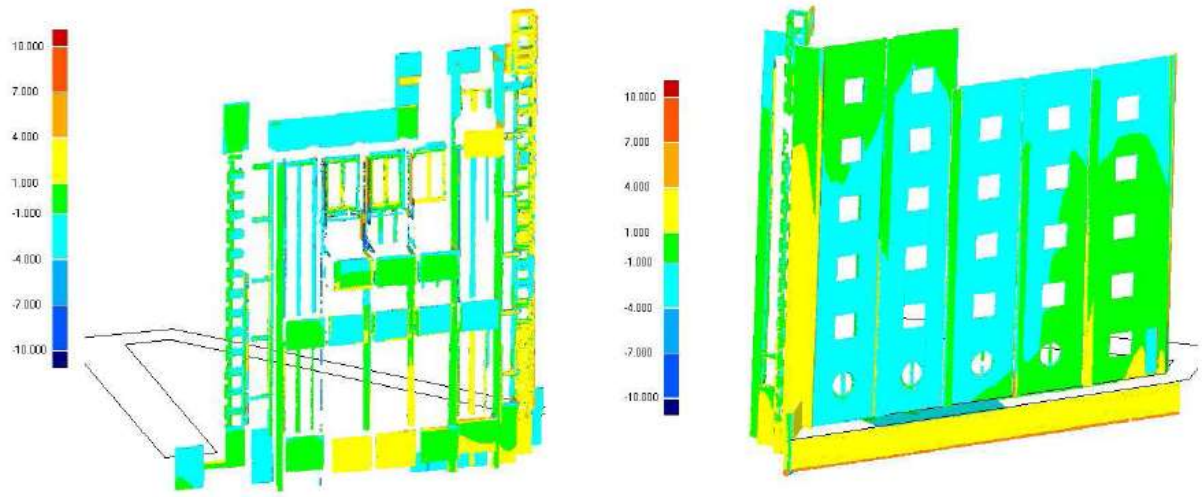

Figure 7: Comparison of the two models about two facades: the more complex (left) and the most simplified and homogeneous (right).

3. VIRTUAL RECONSTRUCTION

By these two methods we came to a digital model of Masieri Memorial that makes it possible to analyze many aspects of the building. It also gives the chance to show Venetians how it could appear having

Wright's building realized. The historical urban structure of Venice haven't changed since 1950, so the mock-up is particularly significant. Also in this simulation we worked in two different ways.

A city model has been realized using municipal cartography and some scans acquired by the laserscanner Riegl LMS 390 (TOF). It was built in the well known way by extracting the planimetric shape of the buildings from cartography and the height from the scans. It is made of volumes on which façade's orthorectified images were applied. Then we inserted the model in the right position, simulating real materials of the project (the Istria stone). In this way we obtain a correct simulation of the place but in the result images we notes some errors. In fact we see a big difference concerning the façade of the Masieri Memorial, which is very detailed and it has a 3D description, and the other facades which are constituted only by a plane with a orthorectification and so they don't appear really 3D.

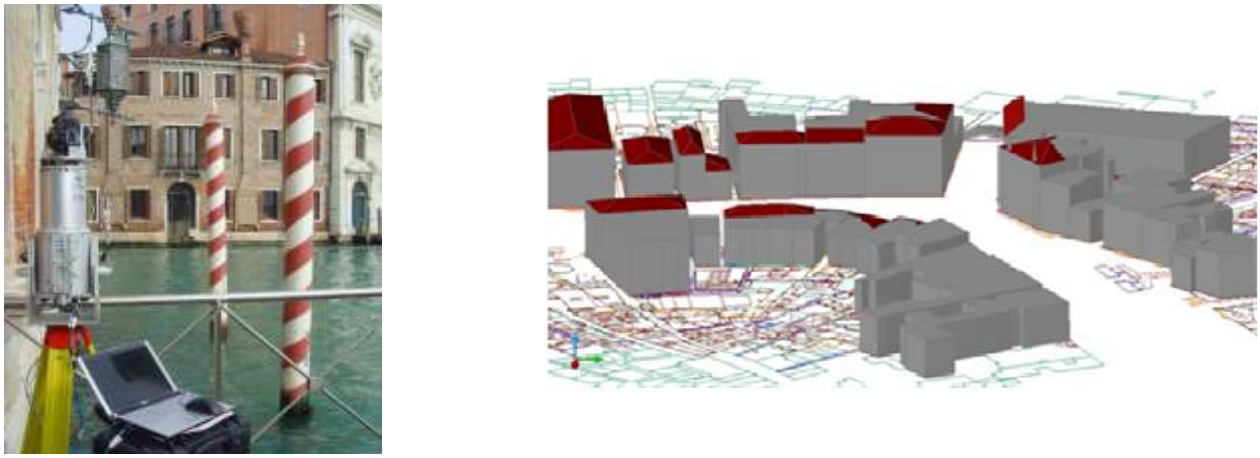

Figure 8: time of flight laserscanner (left) for the construction of 3d city model.

Figure 9: mock-up of the model in the 3d city model at the present day. Some mistakes are due to the use of simple volumes texturized by the orthorectified images of the facades.

Figure 10: mock-up of the model in a photo by using the camera match procedure

In the second case we worked with a paste-up of a image of the 3d model and an image of the context. In order to do this we used a photogrammetric methods which allows to find the true point in space of the camera. Using the camera-match of 3D Max Studio, we had to apply a procedure which is similar to a backward resection using the city model of the context. We realized a render where the context image is used as a background and the 3d model is oriented as if it was taken from the same point and the same – virtual-camera. In this way, figure 10, the result is much more realistic because the other facades on the Canal Grande are real.

4. CONCLUSION

The model confirms its important role in the architectural process both for the spatial simulation as a design tool and for representation as an overview on reality. As well known, digital technologies are useful to simulate reality with renderings. But they allow also to use existing wooden models as real design tool. The possibility to digitize a wooden model, to put it in the real context e to compare with other designs are new digital tools which allow a new approach in the history of architecture but also in the process of improvement of cultural Heritage. We can assign an important and objective-metric role to wooden model as a part of the design process.

We could apply this method also with other important wooden models such as the Ca' Vernier dei Leoni basement in Venice or San Pietro's Antonio da Sangallo il Giovane's project, to better understand how these designed buildings would relate with reality.

In addition to all these features, with the use digital technologies applied to Cultural Heritage, we obtain digital copies of wooden models which can be published in virtual museum but also can be used by scholars to have a free access to a object which is difficult to handle and to move.

4.1 Acknowledgements

Thanks to Chiara Gortani who contributed to this study and created, as part of her dissertation, the schemes that enrich this article.

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