Carlos L. Marcos *Editor*

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The Influence of Representation and Ideation Tools in Architecture

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Carlos L. Marcos
University of Alicante
San Vicente del Raspeig, Alicante
Spain

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The Cultural, Geometric, Virtual Models for the Representation of a Survey

Emma Mandelli and Alessandro Merlo(✉)

DIDA-Department of Architecture, University of Florence, Florence, Italy
{emma.mandelli,alessandro.merlo}@unifi.it

Abstract. In the field of documentation of cultural heritage, the employment of surveying instruments and methods and graphic representation that use digital technology has become a consolidated praxis in the past decades. The literature of such issues tends to show, with few exceptions, the potential (often not fully expressed) of the latest hardware and software, throughout surveying experiences, some more intriguing than others (from a figurative point of view), without really indulging on the true problems behind their overall usage: from the very first data-acquisition to the final graphic panels. In truth, the procedures for digital survey are relatively new and not unanimously shared by the scientific community, and the central role taken by 3D digital models in such a processes is often mystified. Maquettes with apparent-colour textures, achieved throughout the integrated use of image-based techniques (digital photogrammetry) and range-based tools (laser scanner), do not always lead to a correct understanding and interpretation of the architectural artefacts, hence impedes to proficiently describe them throughout the codes of representation. The contribution aims to provide, with the chosen examples, some indications in this apparent paradox, with special emphasis on the limitations of nowadays technologies and the complications that could arise due to a-critical construction of digital models.

Keywords: Architectural survey · 3D model · Integrated representation
Cultural model · Digital survey

1 The Model and the Representation in Surveying

The scientific value of a surveying campaign can be fully conveyed only via a rigorous and verified representation, which primarily consists in determining a valid ‘geometric model’ as a record of all the measured reference elements. By narrowing the context to just the figurative field of surveying design, the meaning is complex and differs according to the operator’s ability, and does not depend on the used systems, so to display his interpretation of the standing reality in a both comprehensible and visible form.

Over time, the model/representation has gone through a formal and conceptual evolution: from a set of scientific and geometric references, to a physical object (*maquette*) and lately to current virtual reality on computers. In these steps, inevitably, the adopted tool has highlighted, from time to time, the geometrical, structural or simply formal features of the analysed artefacts. The link between the real object and its

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representation has so far been the complex scheme of measures, expressed by linear lengths associated to a given understanding and constructing architecture according to the historical period (model from the Latin *modulus*, diminutive of *modus* i.e. measure).

In a general sense, a complex system of information exchange strictly depends on the level of culture and achieved specific knowledge. Theories about communication have recently clarified that the mechanism of the transmission of practical and academic knowledge as a part of the 'cultural models' defined by the specific society.

When surveying, the code of a "system of illustration" has for centuries narrowed the field of expression in an exquisitely technical ground of communication, controlled by the surveyor in a rigorous application of geometric knowledge and formalized symbols. The current situation is definitely oriented towards a 'digital cultural model' with many aspects and possibilities. In this model, each measuring operation leads to representations revealing different methodologies. By doing so it is often hard to overlap all different methods of representation, which are the result of an evolution following the development of indirect methods, from photography to topographic/digital elaborations or even *laser scanners*. The results, however, need to be compared, corrected and fit together in order to develop into the scientific "representation" of a particular architecture, its context, its environment or its landscape; only by these means can we speak of a fully integrated communication.

2 Reality Based Models

The introduction of digital technologies has for the first time in human history allowed to transfer some physical features of the real environment into a virtual one, in which the user, in a more or less interactive form, in a 3-dimensional space (Guidi 2007). Excluding any sort of physical contact with the real artefact, these technologies are able to create a virtual "copy" of it. This innovation is not the real revolution; to an architectonic scale (for small-sized objects this discourse cannot be applied *tout court*) the real innovation is given by new automated methods, in which such process takes place, questioning the principle of '*discretization*', which has for centuries set the base for both the theory and *praxis* of surveying disciplines. Determining the shape of an artefact is no longer achieved by assigning it to a Cartesian space of 'identified points', picked a priori by the surveyor on the basis of geometric characteristics of the piece of heritage, but by a far greater number of points belonging to the surface of the 'object on which the surveyor has no control except for the definition, once again a priori, of a number of limited parameters including the average distance between one point and another. And if in the first case the description of the architecture is entrusted essentially to the cross-section (known points defined by measurement belong to secant planes), whose trend is also defined a priori, in the second case, such description it is associated with a three-dimensional model (initially discontinuous) so to acquire information, in a second stage, regarding the object's morphometric characteristics. It is therefore appropriate to question whether a 3D model, which is the result of an automatic acquisition of the position in a space of millions of points, can to be considered a survey (result of a metric and geometric analysis of the object) or rather a mere operation of 'transposition' from reality to virtual (as above defined) leading the operator, to reach conclusions basing his analysis on the digital model and no longer on the real object, thus considering only the data he needs.

The question may very well seem like a futile argument, but in reality its consequences on a academic level have already been noticed for quite some time (Bianchini 2014), referring, for example, to the training in Architecture and Engineering Schools. In fact, in the last decades, the increasing interest towards the technical aspects relating to the acquisition of morphometric and chromatic data of an artefact has relegated those concerning the decoding of data to the background.

There is no doubt that the matters issued by ICT have long entered the sphere of interests of the surveyor (Gaiani et al. 2011, p. 36); however, sometimes there is a risk of misunderstanding the true scope of a survey, by classifying as primary the accurate management of a 3D model's databases (the points that contribute to defining a 3D model are just one of the many databases associated with it), while in reality, this should only be one of the needed means for a correct survey.

3 The Role of Computer Graphics

The shift from the analogical to digital era has brought many daily operations to be mediated by computers; the latter uses a language that, rare exceptions made, belongs to trained programmers, whereas the average operator needs the mediation of predefined filters (commands). In the field of computer graphics, the creating *reality-based* 3D digital models (acquisition of data relating to the morphology and colour of an object, surface modelling and Marquette management) implies even more specialized computer knowledge (or at least the main problem-solving techniques related to this branch of computer science) that goes well beyond the practice, even virtuous, that neither a graduate in Architecture or Building Engineering-Architecture today posses (Scateni et al. 2005). The absence, moreover, of *software* platforms dedicated to surveying architecture (never forget that the possible operations are always and however bound to the ability of the programs to execute them), of tested and working *procedures* and, finally, of shared protocols of result's verification, sometimes makes it difficult to guarantee optimal results (Ippolito 2007).

How many times the results of a digital survey are not in fact useful? In some cases it depends on the inability of the client to manage the data, in others, the inadequacy of the graphic materials, often unable to communicate the artefact's geometric and dimensional features, often due to the misuse codified graphic rules. It has long been believed that the 3D model alone could fulfil the final purpose of a survey. Although faithful to the starting data based on predetermined parameters, thus assigning erroneously other subjects the task to interpret the data and then to produce the two-dimensional graphic drawings that still today constitute an essential work base in this professional field.

4 Exemplifications

The three images that completing this contribution, each followed by an extensive description, aim to explain by examples the assertions in the previous paragraphs. Each paper highlights one of the composite issues that those who deal with digital survey must face daily and, for this reason, will probably be known to most.

Regarding the process of reducing the amount of data to create 3D polygonal models, reference was taken from the work done at the *iglesia de la Compania de Jesus in Antigua Guatemala*: the drawing shows how, when the polygons describing the surface of the building are different, elements' shape that make up the architecture change drastically (Fig. 1). An adequate historical-architectonic knowledge of the

Fig. 1. Il The process of data decimation (*iglesia de la Compañia de Jesus*, Antigua Guatemala). 3D models are *'simulacra'* of reality and as such a version that always gives back partial information; this statement is also valid for morphometric data. According to the purpose for which a 3D model is realised, the amount of initial data is decimated, both because it is in fact unmanageable with today's *hardware*, and second because it is generally not necessary to describe with such attention an architectural artefact (depending on the exported scale—see Senatore 2011, pp. 47). The more the operator acts on the initial data, the more the final 3D model will shift from the real object's geometry; the data related to the morphometric deviation between the 3D 'point cloud' model (the raw starting data) and the models that can be deduced from this, make it possible to verify the reliability of the latter

morphological and structural elements was essential, and lead to a correct semantic analysis of the numerous components of the structure. Without that knowledge one could have risked building an incorrect model, whose geometry would not match the truth.

Mixing different techniques must however imply an intelligent use of IT tools in order to avoid errors, such as those nesting in the alignment of models and their different geometric definition (Russo et al. 2011).

Being able to choose between different methods to create a 3D reality-based model enables to work with the most suitable tools, based both on the purpose of the survey and the quality and quantity of data available; the outcomes however are not generally the same and the choice of one procedure rather than another could nullify the end result. The proposed example refers to the creation of an integrated model of the Capuchin garden in Pistoia (Fig. 2), in which the trees were modeled using software *Geomagic* from dense point clouds.

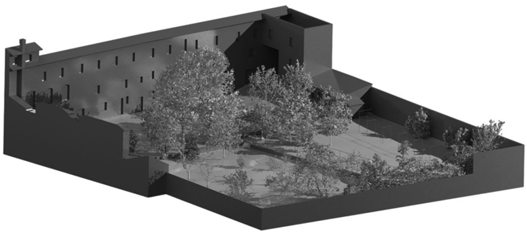

Fig. 2. *Mesh* modelling and NURBS modelling (Capuchin garden, Pistoia). The surfaces of reality-based 3D models can be defined by a network of flat surfaces (mesh surfaces) or by parametric equations determining their trend (NURBS surfaces). The choice to operate with one system or the other substantially depends on the geometric complexity of the artefact and on the degree of detail required: a mesh surface follows the point's progression from the 3D model being generated itself from those same points (three non-aligned points generate one surface), while a NURBS surface, having to describe the course of those same points from the mathematical point of view, and not being able in practice to pass through every point of the cloud, tends to 'approximate'. Furthermore, in order to model a complex surface using NURBS surfaces, *n* surfaces must be connected to each other (Furiani et al. 2013)

The role played by two-dimensional documents produced through the Mongian system of orthogonal projections, is evident in the church of San Giovanni Battista (Fig. 3) in Campi Bisenzio. The complex articulations of surfaces and volumes that characterize the monument have made it necessary to work for 'sections' in order to understand the real conformation of its space.

Finally, the possibility of freeing the chromatic data from the geometric one, delegating to a surface the definition of the morphometric and textural aspects those relating to the apparent color can lead to a partial and therefore incomplete interpretation of an artefact.

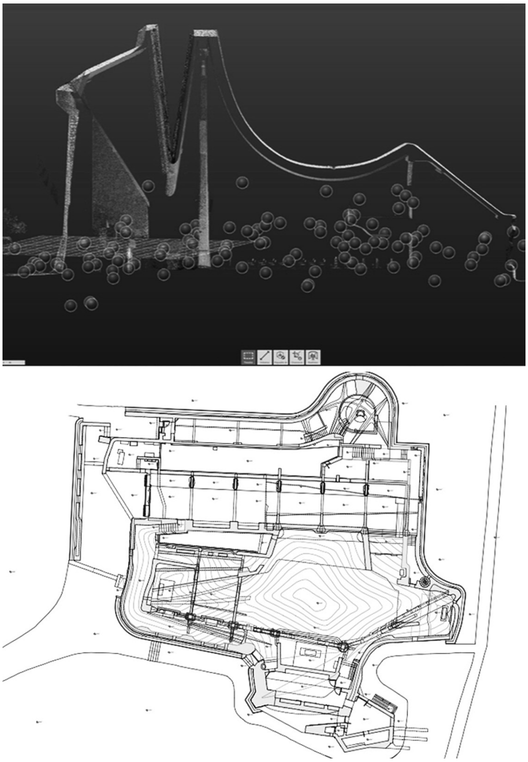

Fig. 3. The importance of the two-dimensional data (church of *San Giovanni Battista*, Campi Bisenzio—Florence). The 3D model realised from the point clouds enabled the extraction of horizontal and vertical sections required to describe the artefact with due detail. Since this is a well articulated artefact from a formal point of view, the section proved (as it often happens in this kind of operations) that the most congenial representation to understand the geometric characteristics of architecture is the possibility of obtaining a sequence of secant planes at a regular distance allowed to determine the progress of each element, thus evaluating the generating shape present in each section and its director vector (the software can generate polylines directly from the points belonging to the secant plane chosen). The operator on the basis of the sections, interpreting all the data available, can then developed the CAD drawings (Vernizzi 2006)

5 For a Cultural Model

The numerous data, the different technical languages, the difficulties of integrated representation are sometimes, even in when technological correct, a source of final ambiguity when trying to understand qualities of an object. In order to translate it into 2D and 3D images providing a correct and meaningful information, it is therefore necessary to operate in a critical way, examining the different cases and intervening with specific methods that respect the architectural characteristics.

In order to achieve the desired cultural goal it is necessary to clearly distinguish the two phases in the development of the virtual model: taking and returning data. In both, performed according to integrated criteria, even sophisticated, the IT operations are followed by a technician-surveyor. This ‘order’ in the survey process is now only possible with the direct participation of a culturally and disciplined expert surveyor.

Data and surveying process, duly documented, verified and adherent to the scientific protocols, can thus accomplish a final representation identifying with an appropriate ‘cultural model’.

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Emma Mandelli is Full Professor of Architectural and Landscape Survey at University of Florence; since 2006 to 2012 she heads the Ph.D. National School in “Drawing and Representation of Architecture and Environment”.

She specialises in integrated systems of survey for the analysis of the Old Heritage, working on many research projects, often as principal investigator of large interdisciplinary research groups (e.g. fortified walls of Massa Marittima). Professor Mandelli has published widely and participated in international congresses mostly on survey and documentation of monuments and sites. She is member of UID (Unione Italiana Disegno), A.E.D. (Associazione Europea del Disegno) and she is an expert of ICOMOS.

Alessandro Merlo Ph.D. in “Drawing and Representation of Architecture and Environment” and associate Professor for the scientific field 08/E1-Disegno. He held the course of “Architecture Drawing” and the course of “Architectural Survey”; he coordinates the UNIFI Master’s Degree in “Documentation and Management of Cultural Heritage” at the School of Architecture of the University of Florence. He heads the research unity DM-SHS (Documentation and Management of Small Historical Settlements) and the CHMLab (Cultural Heritage Management Laboratory). He practices the following activities at the international level: integrated

systems of survey for the analysis of the processes of formation and transformation of the buildings, the city and the territory; reverse modeling for architecture and the city; 3D information systems for the use of digital data from campaigns integrated survey; digital mapping and 3D modeling in archeology; documentation, protection, enhancement and management of cultural heritage. He is member of the UID and ISUF; he is a member of the board of Ph.D. teachers of the School of Architecture of University of Florence. He is on the editorial board of the series "Studi e Documenti di Architettura" and in that of "Firenze Architettura". He is on the scientific committee of the magazine "U + D" and "Restauro Archeologico".

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