GRAPHIC STUDIES ON THE BUILT HERITAGE, A CRITICAL REVIEW

TECHNICAL ADVANCES VS TRADITIONAL STUDIES

Pilar Chìas Navarro
Universidad de Alcalá
Department of Architecture
pilar.chias@uah.es

ARCHITECTURAL SURVEY
CARTOGRAPHY
SPANISH ROYAL SITES
BUILT HERITAGE
TEACHING STRATEGIES

Research on the built heritage should periodically review the good practices to be used in surveying theories and practices. Written and graphic precedents provide a valuable knowledge of historical buildings built over centuries. Previous surveys must be checked through an exhaustive fieldwork because of their lack of accuracy and reliability, that results from the fact that ancient methodologies are based on direct measuring. Therefore, old datasets must be compared with later outcomes obtained with modern photogrammetric or scanning techniques. Accordingly, our teaching strategies must promote a critical and responsible use of technologies. Moreover, graphic information sources such as perspectives, photographs, and ancient cartography can be used to supplement the information of the building provided by other methodologies. The Monastery of El Escorial is a paradigmatic case study because of the large amount of written and graphic information that is preserved, that includes the original 16th century traces and drawings, together with surveys dating back to the 18th, 19th, and 20th centuries.

INTRODUCTION

Since the Renaissance period, survey methods and techniques have been refined. Recent advances have made it possible to digitally model heritage, use virtual reality –VR– and link metadata to drawn elements through the infinite possibilities of augmented reality –AR– to provide a holistic simulated experience of architecture (Spallone et al., 2022); but at the same time, the incorporation of artificial intelligence –AI– is opening fields of research in architecture that were inconceivable just a few years ago.

Such an increase in possibilities requires a change of mindset, having clear criteria, and approaching any work from the priority established by the objectives, from a critical position that is fully aware of the possibilities, but also of the limitations. Nowadays, more than ever, an image can be spectacular and fake at the same time.

This paper is a critical reflection on the documentation, study, and dissemination of built heritage in today's context, from the experience and perspective of the six centuries that have elapsed between the drafting of the Charter and the complex and multifaceted context of today. Consequently, the objective of this study is essentially didactical and can be summarised as 'to know before acting' and stresses the importance of knowledge and critical think.

It is not the aim of this article to detail each method or technique deeply, as this has been dealt with in the classic manuals (Marino, 1990; Di Grazia, 1991; Docci & Maestri, 1993; Cundari, 1997), as well as in the more recent and updated compendium by Antonio Almagro (2004), who provides an interesting critical perspective from his long practical and theoretical experience with surveys. Examples also abound in compilations such as Chías and Cardone (2016) and in prestigious specialized journals as *EGA Revista de Expresión Gráfica Arquitectónica*, *EGE Revista de Expresión Gráfica en la Edificación*, *Arqueología de la Arquitectura*, *Disegnare. Idee immagini*, *diségno*, *DISEGNARECON*, in

which, with an increasingly analytical approach, they already constitute most contributions. In addition to the circumstances associated with the specific purpose of each work, it must be pointed out that science today is embedded in the European context and consequently must consider its objectives and strategies, especially regarding the public information of processes and results –Open Data, Open Science– citizen participation and transfer to society (Chías, 2023).

Case study is the Monastery of San Lorenzo el Real de El Escorial in Madrid, a Spanish Royal Site that was built in the 16th century (Figure 1). It is an outstanding example because of the numerous historic documents kept both on site and in the Spanish archives. This collection encompasses most of the original work contracts and traces, and other related to later refurbishments and partial reconstructions. Surveys dating back the past three centuries are available too. Such an outstanding 'graphical corpus' allows for comparisons and analysis of documents in many ways, not only formal or aesthetical but structural and constructive.

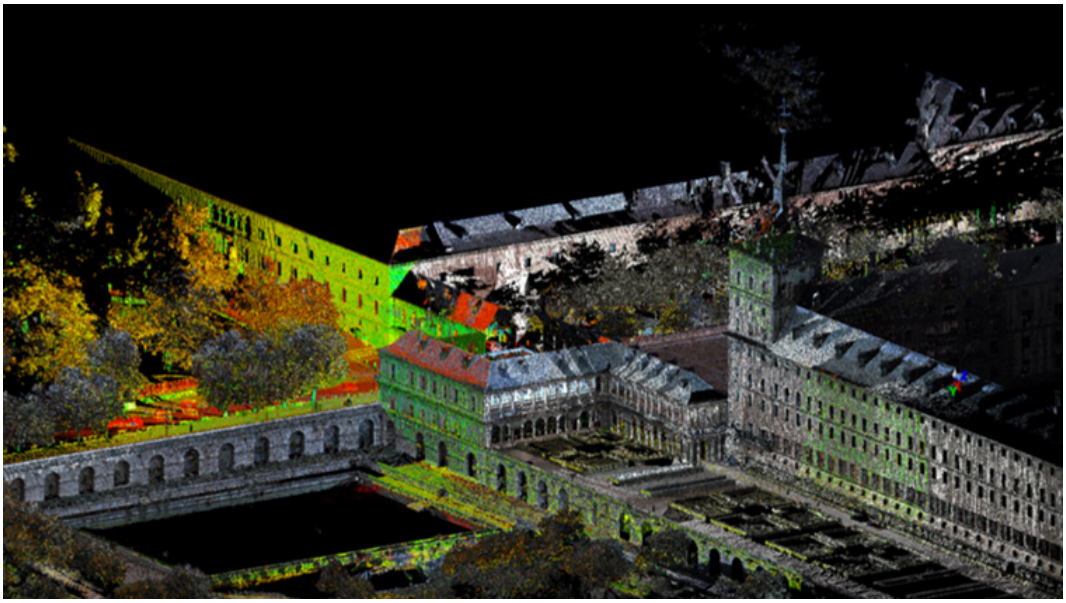

Fig. 1 Monastery of El Escorial, point cloud obtained with a laser scanner with a range of 60 metres. Author's image, 2017.

METHODOLOGY

Methodology is grounded on two main questions: firstly 'Why?' should be related to the targets of each survey, while 'How?' must meet the demands of a critical use of methodologies and techniques.

Why: The Purpose of the Survey

The role of the architect and the archaeologist in the tasks involved in the survey is to collect, select, order, and process the data obtained in the fieldwork, exercising rigorous metric and geometric control (Zerlenga, 2016), and with clear objectives. As Bertocci resumes:

> We can therefore have thematic surveys for historical knowledge, surveys for restoration, surveys for archaeological documentation, surveys for cataloging, surveys for formal and dimensional knowledge, or something else; we can also have an experimental survey, which is also developed in a didactic manner, aimed at understanding the tools and working methods. (2016, p. 30)[1]

Implicit in this list of possibilities should be the fact that a comprehensive knowledge of historic architecture and the historic city should not be limited to what is visible, but should investigate other aspects such as the internal order and its construction mechanisms (Fatta, 2016), structures, construction methods and techniques, deformations and pathologies, even if this requires the application of other strategies and instruments –such as infrared thermal cameras or X-rays, to mention only non-invasive techniques– that reveal the interior of the walls. In this regard, it is also essential to investigate what is hidden in hidden or difficult to access spaces such as vaults, attics, and crypt and dome infills that can be visited, etc. (Figure 2). Moreover, historic buildings have barely been built in a single phase[2], and even in these rare cases later interventions have affected the original masonry variably; therefore, this approach to the interior of the walls and residual spaces allows us to understand the

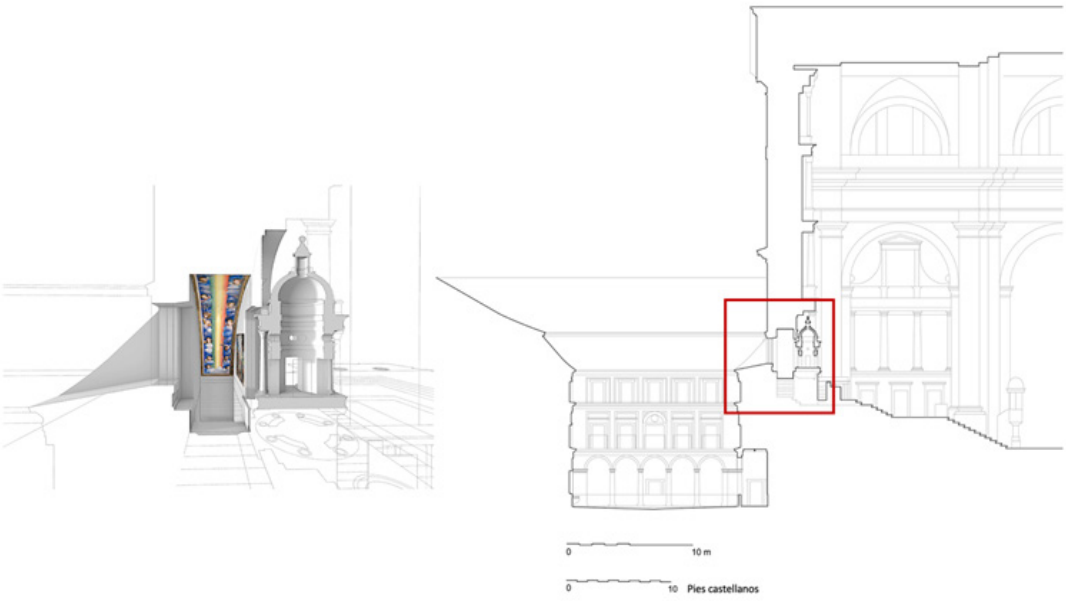

Fig. 2 Royal Monastery of San Lorenzo de El Escorial, transaltar, longitudinal section and detail of the fugated section (Chías, Abad, De Miguel, & Llorente, 2020).

construction phases, to know the historical processes through which they have passed, and to approach their analysis. As a result, the study of architecture cannot be restricted to its public or most representative spaces and the elements that define and shape them, forgetting those that have allowed it to fulfill its fundamental function of habitation over the centuries, such as the galleries and service spaces, the cisterns and basements, etc., as this knowledge is essential and must be before any intervention. It is these spaces that often require the adaptation of established techniques to the challenges they pose –lack of geometry, lack of visual and physical connection between spaces, lack of light, loss of connectivity, etc.– and to make up for the shortcomings with imaginative solutions (Figure 3).

On the other hand, surveys obtained through digital techniques can provide graphic results that have opened a wide range of possibilities in the documentation of historical architecture. Among them, the possibility of making very thin sections of the point clouds from the laser scans and exporting them to CAD programs to make plans and dihedral

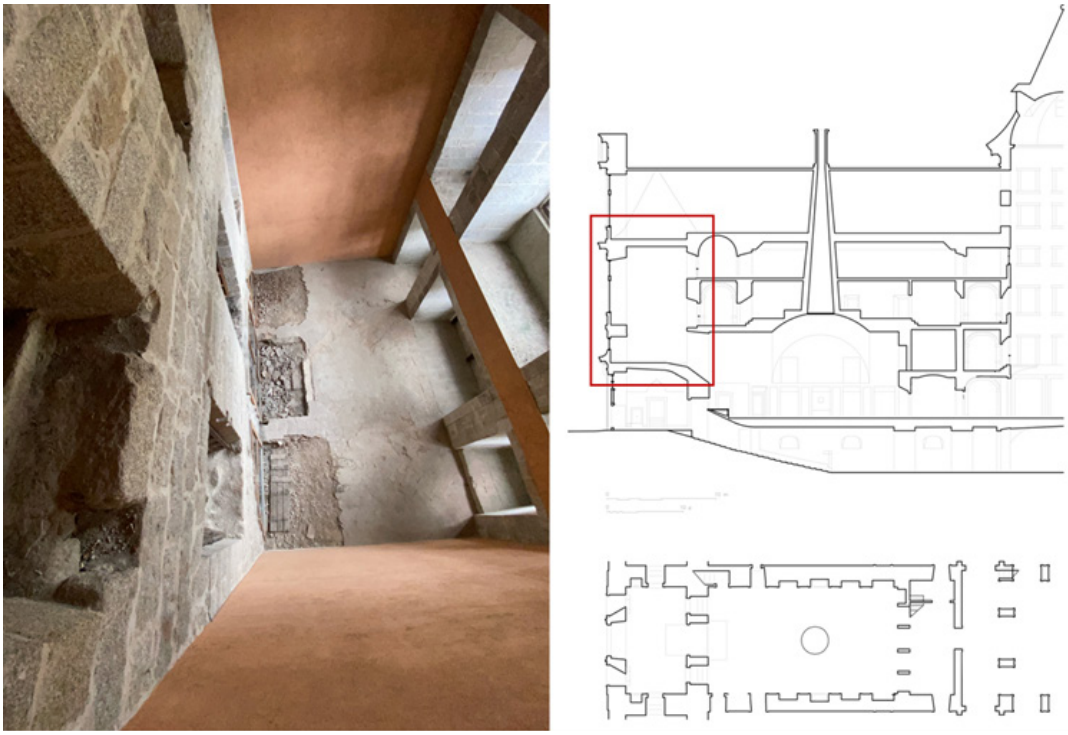

Fig. 3 Left, Monastery of San Lorenzo de El Escorial, photograph of the interior of the double façade space of the old kitchen of the Convent, inaccessible, obtained with a selfie stick from the 45-foot level. Right, longitudinal section along the axis of the wing of the original kitchen of the Convent and ground floor plan. Author's images, 2023.

sections at the desired scale, is as well-known as it is used by professionals and researchers. In recent times, using cameras mounted on drones –UAVs-Unmanned Aerial Vehicles– and specific computer programs are facilitating the formation of these three-dimensional models, improved in appearance and visualization with the superimposition of mappings on the point clouds (Sánchez, Fernández, & San José, 2016), while avoiding the costly assembly of scaffolding. Another set of possibilities opens with the construction of digital models from photogrammetric or point cloud methods obtained from laser scans[3] (Centofanti, 2012), which allow in later phases to link architectural and archaeological elements to each other and to different multi-format databases to create three-dimensional information systems – BIM-Built Information Modelling. These systems can facilitate both construction management (Brusaporci & Maiezza, 2016) and the interventions to be carried out[4].

Besides the documenting and disseminating, these systems facilitate the drafting of master plans, as the linked databases make it possible to give context to heritage in different historical and cultural moments, showing that a historic building "is the result of the concatenation of multiple architectures that succeed one another and constructively superimpose themselves on the same space over time" (Latorre, 2012, p. 52) while highlighting its dual diachronic and historical condition. However, the application of methodologies based on information systems in heritage buildings –HBIM-Built Heritage Information Modelling– must be very critical and even questionable, as it comes to assume oversimplifications such as the homogeneous composition of the different sections of the walls, which is rare in historic buildings. Within this field of 3D simulation, the possibility of generating 360º visualizations and 'fly-through' virtual tours makes it possible to design tailor-made virtual visits and introduce augmented reality (Herráez et al., 2000).

But digital models also have other applications that allow the study of other qualities of architecture such as acoustics, energy efficiency, and even the symbolic and functional aspects that are frequently linked to the treatment of light (Chías et al., 2020), as well as studies on the relationships established between different spaces, in which the simultaneous use of several representation systems is essential (Chías et al., 2023a). Changes of scale open new options that transcend the architectural realm and are applied to environment regeneration, the city and its historic infrastructures, while facilitating the creation of Digital Twins through the use of moving laser scanner captures, which are systems that allow data to be obtained quickly and cheaply without compromising quality (Stendardo et al., 2022). Another application –no less interesting and very didactic– is comparing the information obtained by modern methods to check the reliability and accuracy of surveys considered 'historical' in which direct methods were essentially applied

(Chías et al., 2023b), and even to compare the applicability of contemporary techniques, as we shall see below (Figure 4).

How: Critical Use of Methods and Techniques

Once the objectives of the survey have been established, it is time to consider how to carry it out; but the successive choices must be made from a critical stance that compares the methods and optimizes the available means according to the objectives. Ortega (2000) commented on the difficulties he had encountered in carrying out some partial direct and

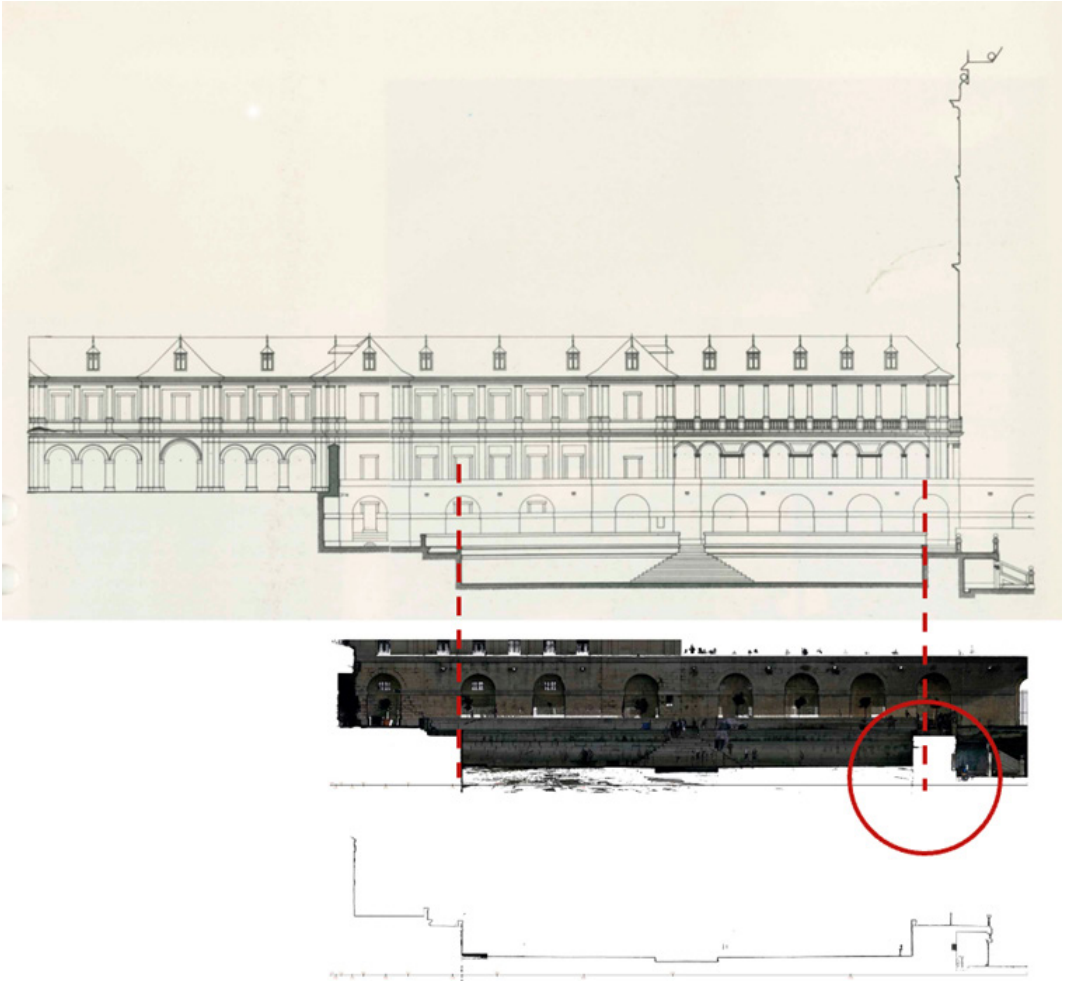

Fig. 4 Monastery of San Lorenzo de El Escorial, east-west section. From the top, comparison of the survey by Cervera Vera, 1985, with direct methods, the one by the author, 2022, with laser scanner, and the section obtained by choosing a very thin section of the point cloud. Circumference shows the metric mismatch in the width of the pond.

'artisanal' surveys of the Escorial, to which he attributed the great advantage of direct contact with the factory.

This direct experience of architecture and the knowledge it provides is, from my point of view, indispensable and unavoidable regardless of the method to be followed later to carry out the survey. Prior visits to the building before undertaking the fieldwork serve to obtain complete knowledge, choose the means and techniques to be used, and to be able to plan the work. During this phase, accessibility difficulties are anticipated, a contingency plan can be drawn up and solutions, sometimes as imaginative and inexpensive as using a selfie stick, can be proposed. Another benefit of direct surveying is its low cost and immediate availability if there is no need to incorporate personal or auxiliary means that would make it more expensive. Disadvantages include slower processes, greater inaccuracy, and occasional difficulties in accessing certain architectural elements, especially at heights. However, direct measurements must be part, even if only on an ad hoc basis, of other indirect survey techniques because they serve as a check on the data obtained with instruments based on digital techniques. The topographic supports provide consistency to the data obtained and allow to detection of possible errors of scale when entering or exporting the data to other computer programs. Another aspect to bear in mind is that most historic buildings were constructed before the widespread introduction of the decimal metric system[5], so the units of measurement used in their construction responded to anthropometric patterns and diverse traditions, often local or regional in scope[6].

Knowing these patterns or moduli is essential if conclusions about dimensions and proportions are to be drawn, as the metric system would provide decimal fractions. Hence the interest of drawing a double graphic scale that reflects both units in the required projections. In the various indirect methods, digital instruments play a major role, such as techniques based on digital photogrammetry and laser

Fig. 5 *La Cachicanía* –house for the orchard's keeper– at the Monastery of El Escorial. Top, elevation (Cervera Vera, 1949); bottom, point cloud obtained with a laser scanner, author's image, 2023.

scanning. In both cases, it is advisable to plan the station points and draw the necessary sketches to locate them, even if they are recorded by the instrument itself. The former is cheaper and more accessible but requires certain rules to be followed in the capture of the photographs, such as obtaining overlapping pairs and not forcing the camera to tilt the camera concerning the walls, as well as composing high-resolution photomosaics and rectifying the images, and using georeferencing systems. It should also be borne in mind that there are serious limitations when erecting towers and high vertical elements if scaffolding is not used, due to the lack of parallelism between the camera plane and the photographed plane and the convergence problems that this implies; with distance, loss of detail can also occur (Molina et al., 2021). Laser scanners pose other problems such as their high price, which may not be justifiable or cost-effective in cases such as surveying small areas or facades, even if they are highly ornamented. It is obviously necessary to consider operational aspects such as the need for intervisibility between consecutive or nearby station points, leveling –even if automatic– georeferencing or the duration of the batteries –sensitive to low temperatures– when long campaigns are to be undertaken. On the other hand, its major advantages include its range –which can avoid the use of drones– and accuracy, as well as the possibility of densifying the point cloud in areas where more information is required. There is little discussion of the importance of point cloud management software, as depending on its functions and ease of use –even with a tablet to check during fieldwork– it can facilitate automatic alignments or require lengthy model assembly processes. Other techniques such as georadar are interesting in specific survey cases like buried features (Franco et al., 2004).

Finally, I believe that it is necessary to reflect on the aspects related to graphic design, since the cultural context in which the surveys are produced not only reflects technical limitations, but also graphic fashions.

The Mudejar façade of the Palace of King Don Pedro in the Royal Convent of Santa Clara in Tordesillas serves as an example, since although both drawings coincide in the aim of documenting the morphology and ornamentation, the one on the left –a praiseworthy survey carried out with direct methods by Torres Balbás– tends to complete the information that is not visible or that has disappeared, incorporating graphic assumptions that do not necessarily correspond to reality. Almagro's photogrammetric survey, on the other hand, includes exclusively what he sees, in an exercise of graphic honesty that leads him to leave blank everything that is not verifiable.

The comparison is also relevant if we consider the different use of graphic codes shown in the two images, the former reflecting the historicist academic tradition, while the latter is essentially synthetic (Figure 5).

CONCLUSIONS

After six centuries, surveys have broadened their expectations, objectives, and scope thanks to new techniques that allow the recording and processing of data of diverse nature and origin, the digitalization of methods of analysis and information management, and new and powerful means of dissemination and communication. But this has been possible because this advance in methods and techniques has been accompanied by the necessary conceptual development, while progress has been made in holistic experience and towards new ways of enjoying architecture. From these theoretical approaches, the focus is no longer on methods and techniques, but on the knowledge they provide of architecture, and on the analyses that can be made that transcend the mere visual appearance of its surface elements.

Finally, the European Union has set itself two priorities in relation to heritage research: firstly, it calls for a science

that is open to society, not only in terms of the possibility of accessing data, processes, and results without limitations – Open Science, Open Data– and in terms of requiring citizens to become involved through transfer activities; and in this regard, the multiple applications of virtual and augmented reality and artificial intelligence are as varied as they are promising. And secondly, the dissemination of Europe's heritage will effectively contribute to strengthening the sense of identity of the different communities that comprise it.

NOTES

1 Translation by the author.
2 Even the seemingly monolithic Monastery of El Escorial, built in a record time of barely twenty-three years, has different phases and features in its construction due to various causes such as changes in the management of the work or even quarries; to these must be added the changes suffered after the fires and the interventions carried out in the second half of the 20th century, which have introduced modifications to the original masonry.
3 From the point clouds, specialised programs construct triangular meshes – TIN-Triangulated Irregular Network. Another option is to construct simplified solid models of the building elements with primitives adapted to the three-dimensional mesh.
4 Particularly useful when applied to new buildings or relatively modern constructions for which reliable and accurate information is available.
5 Universal implementation officially began in 1875 at the Metre Convention, with the signing of the relevant treaty in Paris on 20 May.
6 For example, the Monastery of El Escorial was built using the Castilian foot, equivalent to 0.2786 metres, and the Castilian rod, equivalent to three feet.

REFERENCES

Almagro Gorbea, A. (2004). *Levantamiento arquitectónico.* Granada, ES: Universidad de Granada.

Bertocci, S. (2016). Beni archeologici e tecnologie digitale per la documentazione. In P. Chias & V. Cardone (Eds.), *Dibujo y arquitectura 1986-2016, 30 años de investigación / Drawing and Architecture, 1986-2016. Thirty Years of Research* (pp. 16-31). Alcalá de Henares, ES: Editorial de la Universidad de Alcalá.

Brusaporci, S., & Maiezza, P. (2016). Re-loading BIM: Between spatial and database information modelling for architectural heritage documen-

tation. *Dibujar, construir, soñar. Investigaciones en torno a la expresión gráfica aplicada a la edificación* (pp. 835-847). Valencia, ES: Tirant lo Blanch.

Centofanti, M. (2012). Interpretative 3D digital models in architectural surveying of historical buildings. In P. Gambardella & al. (Eds.) *Computational Modelling of Objects Represented in Images* (pp. 433-438). London, UK: CRC Press

Cervera Vera, L. (1949). La Cachicanía del Monasterio de San Lorenzo el Real. *Archivo Español de Arte*, *87*, 215-231.

Chías, P., & Cardone, V. (Eds.). (2016). *Dibujo y arquitectura 1986-2016, 30 años de investigación / Drawing and Architecture, 1986-2016. Thirty Years of Research*. Alcalá de Henares, ES: Editorial de la Universidad de Alcalá.

Chías, P. (2023). Research, Diffusion and Transfer in Architecture. The European Context. In P. Lizancos, D. Leite, F. Morais & J. Vieira (Eds.), *Formal Methods in Architecture* (pp. 27-33). Singapore, SG: Springer Nature. doi:10.1007/978-981-99-2217-8_3

Chías, P., Abad, T., & Fernández Trapa, L. (2023a). From Design to Construction: Digital Reconstruction of the Convent's Kitchen Area in the Monastery of El Escorial. In I. Trizio & al. (Eds.), *Virtual Restoration and Digital Reconstructions, Digital Innovations in Architecture, Engineering and Construction*. Cham, CH: Springer Nature. doi:10.1007/978-3-031-15321-1_4

Chías, P., Abad, T., & Fernández-Trapa, L. (2023b). Los paisajes del agua en el Real Sitio de El Escorial. Presas, fuentes y estanques / Landscapes of Water in the Royal Site of El Escorial. Dams, Fountains, and Ponds. *Informes de la Construcción*, *76*(569): e298. doi:10.3989/ic.6167

Chías, P., Abad, T., De Miguel, M., & Llorente, P. (2020). The Transparente in the Basilica of the Monastery of El Escorial. *Nexus Network Journal*, *22*, 1133-1154. doi:10.1007/s00004-020-00495-z

Cundari, C. (1997). *L'immagine nel rilievo. Il rilievo architettonico come conoscenza e documentazione*. Rome, IT: Gangemi.

Di Grazia, V. (1991). *Rilievo e disegno nell'archeologia e nell'architettura. Tecniche, Opinioni e Teorie*. Rome, IT: Kappa.

Docci, M., & Maestri, D. (1993). *Storia del rilevamento architettonico e urbano*. Bari, IT: Laterza.

Fatta, F. (2016). Il disegno del mediterraneo: il racconto dei luoghi in trent'anni di ricerche (1986-2015). In P. Chias & V. Cardone (Eds.), *Dibujo y arquitectura 1986-2016, 30 años de investigación / Drawing and Architecture, 1986-2016. Thirty Years of Research* (pp. 130-143). Alcalá de Henares, ES: Editorial de la Universidad de Alcalá.

Franco, J. A., Arias, P., Lorenzo, H. y Tarrío, S. (2004). Dibujar lo que no vemos mediante el radar de rango cercano. Una metodología aplicada al patrimonio arquitectónico. In J. Casado & A. Gómez-Blanco (Eds.), *Dibujar lo que no vemos. Actas del X Congreso Internacional de EGA* (pp. 457- 464). Granada, ES: Publicaciones de la Universidad de Granada.

Herráez, J., Martínez-Llario, J.C., & Navarro, P. (2000). Visualizador métrico 3D de la Comunidad Valenciana. *Las nuevas tecnologías de la representación gráfica arquitectónica en el siglo XXI. Actas del VIII Congreso Internacional de EGA* (pp. 373-376). Barcelona, ES: Universitat Politècnica de Catalunya.

Latorre, P. (2012). El monumento como un todo. El plan director de restauración. *Informes de la Construcción*, *64*, 45-46. doi:10.3989/ic.11.079

Marino, L. (1990). *Il rilievo per il restauro*. Milan, IT: Hoepli.

Molina, S., Juan, F., Cirpiani, L., & Denia, J.L. (2021). Limitaciones en el levantamiento digital de bienes patrimoniales con tipología de torre. *Revista EGA*, *42*, 76-89. doi:10.4995/ega2021.14749

Ortega, J. (2000). *El Escorial: dibujo y lenguaje clásico*. Madrid, ES: Sociedad Estatal para la Conmemoración de los Centenarios de Felipe II y Carlos V.

Sánchez, J.I., Fernández, J.J., & San José, J. (2016). Decisión, croquis, láser y dron. Sistema de documentación de torres campanario en la provincia de Burgos. *El Arquitecto, de la tradición al siglo XXI. Actas del Congreso EGA 2016* (pp. 1111-1118). Alcalá de Henares, ES: Fundación de la Universidad de Alcalá.

Spallone, R., Lamberti, F., Olivieri, L. M., Ronco, F., & Castagna, L. (2022). AR and VR for enhancing museums' heritage through 3D reconstruction of fragmented statue and architectural context. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *46*. doi:10.5194/isprs-archives-XLVI- 2-W1-2022-473-2022

Stendardo, L., Spera, R., Campi, M., Cera, V., & Di Luggo, A. (2022). Urban design strategies for the upcycling of urban infrastructure residual pockets: 3D city modelling from Open Data and low-cost rapid mapping tools. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *48*. doi:10.5194/ isprs-archives-XLVIII-3-W2-2022-59-2022

Zerlenga, O. (2016). Temi di ricerca attorno alla geometria. In P. Chias & V. Cardone (Eds.), *Dibujo y arquitectura 1986-2016, 30 años de investigación / Drawing and Architecture, 1986-2016. Thirty Years of Research* (pp. 360-371). Alcalá de Henares, ES: Editorial de la Universidad de Alcalá.

Article available at

DOI: 10.6092/issn.2724-2463/18869

How to cite

as article

Chías Navarro, P. (2024). Graphic studies on the built heritage, a critical review: technical advances vs. traditional studies. *img journal*, *10*, 24-39.

as contribution in book

Chías Navarro, P. (2024). Graphic studies on the built heritage, a critical review: technical advances vs. traditional studies. In S. Brusaporci (Ed.), img journal 10/2024 Imagin(g) Heritage (pp. 24-39). Alghero, IT: Publica. ISBN 9788899586461