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Survey, Data Analysis and Modeling Raphael's Stables in Villa Farnesina, Rome

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Abstract: This work contributes to the knowledge of historical contexts that have radically mutated over centuries and have lost their original characteristics. In these cases, information techniques and technologies can support the reconstruction of peculiarities in the digital domain and reveal their distinctive traits. This process applies to the architectural complex of Villa Farnesina in Rome, the realization of which involved the collaboration of influential artists from the 16th century; in particular, we focus on the Stables building, which no longer exists and can only be visualized by joining survey data, historiographic data, and metric measurements in digital and virtual assets. Starting from an integrated digital survey project, the paper highlights the potential of the graphic analysis of iconographic-archival and cartographic components for reconstructing a 3D model of the original appearance of the building. Furthermore, the correlation of geometric data and information parameters allows for the construction of a digital model to fulfill the demand for the transmission of interdisciplinary information to portray this jewel of Renaissance Rome to real and virtual tourism consumers.

Keywords: cultural heritage; survey; documentation; digital reconstruction; 3D model

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1. Introduction

The study and representation of ruined and largely disappeared architecture constitute a very active field of research into the knowledge of our history. In the complex field of activity to recover the memory of architectural heritage, digital tools today offer potent means for acquiring and documenting, through digital surveying, fundamental and precise data about the actual state of places, which are useful for scientific analysis and digital reconstruction of architectural artifacts [1].

The question is even more sensitive for those architectures of significant importance, for which it is necessary to define a rigorous methodological approach between surveys and models (Figure 1). An example of this need is the building designed by Raphael for the Villa Farnesina complex in Rome, the ancient Chigi Stables, which today is in a state of precariousness with only a few walls remaining, so digital analysis processes can help to interpret and simulate the reconstructive hypotheses of the original *facies* to disseminate knowledge of an otherwise forgotten asset.

In 1506, the first stone was laid to construct wealthy banker Agostino Chigi's new residence near the Vatican called Villa Farnesina alla Lungara [2], and the land plot destined for the Stables was also acquired. Indeed, in 1511, the purchase of other adjacent land plots in the North, which widened the Villa's gardens—basically doubling their surface—led Chigi to designate Raphael, who was already known as a gifted painter and an emergent architect, for the construction of stables overlooking the new Via della Lungara. The artist was already busy with several other commitments to the banker; among them were the interventions on the decorative apparatuses of the new residence. They would have the most elegant stables ever, Chigi promised the Pope, who instead glorified the beauty of the new Riario Palace (Palazzo Corsini) just before it. Undoubtedly, Agostino Chigi kept his word.

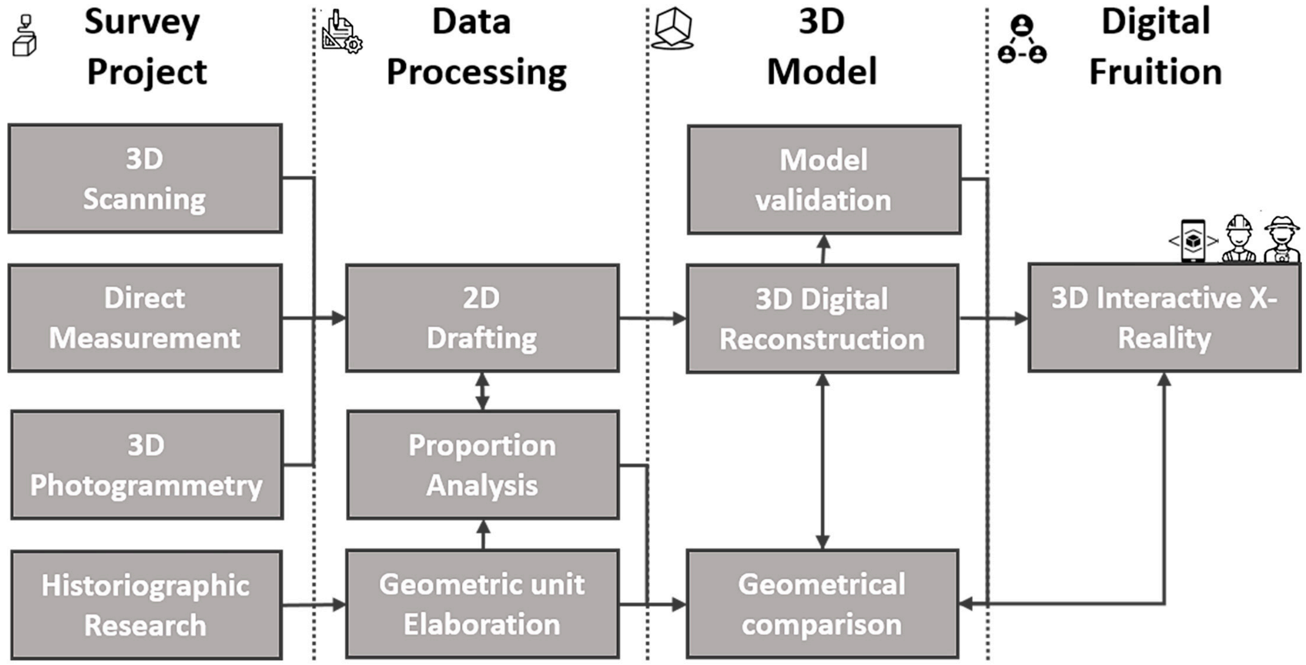

Figure 1. Outline of the method used to optimize the process for the reconstruction and digital fruition of the model.

The construction started in 1514 and was completed by February 1510, when the Stables hosted a sumptuous banquet, centered on the new Pope Leo X [3] (p. 64) [3] (p. 5); work continued for a couple of years more and then definitively ended in 1520 after the artist's, Chigi's, and his widow Francesca Ordeaschi's deaths [3] (p. 26). Today, there are few remains of the Stables' building, which was demolished in 1808 due to serious instability [3] (p. 70) (Figure 2).

Scientific studies of the building are few and have mainly concerned the historical and documentary context. Part of the original configuration of the artifact was described in some rediscovered sixteenth-century drawings. However, in-depth investigation is required to turn these annotations into survey output through a three-dimensional digital model for analyzing and validating construction hypotheses.

Moreover, the historiographical documentation represents the only evidence to reveal the original configuration of the building; therefore, its acquisition and analysis represented a crucial phase of the survey project, performed between 2018 and 2020, including an integrated, range-based, and image-based survey campaign to document the current layout of the architectural asset. Hence, the conspicuous number of materials produced during the acquisition process of the artifact, collected in operational datasets and expanded through further in-depth analyses and acquisitions, have supported the investigation of the geometric-proportional ratios between the various parts of the artifact.

This process made it possible to generate a reconstructive hypothesis of the artifact through the elaboration of a reliable digital model respecting the essential architectural characteristics of the time, based on the principles of *firmitas* (stability), *venustas* (beauty), and *utilitas* (functionality) [4]. The virtual model, therefore, served as a tool for interpretation and simulation of the initial layout of the building [5,6], with the forthcoming horizon of a scientific dissemination project of the results produced in the halls of the Farnesina

Complex. This process could help, through an experience of augmented reality in progress, to recover of the original spatial and visual sensations that today can manifest themselves in expanding knowledge and sharing the residual cultural asset.

Figure 2. Framing of the Villa Farnesina complex: at the top, location of the buildings in the case study area with the planimetric project of the range-based survey acquisitions and internal and external views (in plant, (**1**–**8**)) of the remaining elements of the Stables designed by Raphael.

Background Methodology

There are numerous archaeological contexts, monumental ruins, unrealized or partially completed works, and devastated spaces with visible traces of a past built heritage, examined—using the tools of surveying and digital reconstruction—by the large community of scholars of cultural heritage with various purposes, including: historical documentation [7–9]; digital preservation [10]; recording and analyzing of formal/ideal metric and geometric models [11,12]; and the evaluation of diachronic reconstructive hypotheses to recover the memory of the place [13–17].

In particular, philological digital reconstruction starting from existing remains is a reasonably frequent operation in the field of studies of cultural heritage, supported today using digital technologies [18] for the survey, analysis, and modeling of multidisciplinary components of architectural systems [19].

The investigation and rereading of the works, gradually transformed from a coherently built architecture into a sort of architectural *memento mori*, can contribute to the understanding of an author, of an architectural period, and of a historical era; in particular, it can increase knowledge of the events of a past context, leading to a wealth of transferable and coherent information capable of reconstructing the reasons for its creation, the lack thereof, or even the events of its destruction or transformation [20].

In this research process, the tools of digital representation offer potent means of documentation and presentation, creating the conditions both for collecting fundamental and precise data on the state of the place investigated through digital surveys and for structuring three-dimensional models for the analysis and presentation of the specific qualities of a place, even to a non-specialist audience [21]. Therefore, in defining the most appropriate documentary and investigation strategies, specific updated digital methodologies have been developed to collect significant data, subsequently attempting to outline a form and structure for the data themselves in response to the assessment of the knowledge needs of cultural heritage.

Whatever the complexity of the object of study and the purpose for which the reconstruction is intended, the phase of data collection and knowledge acquisition regarding the object of analysis is absolutely crucial. The starting point is comprehension of the state of the places, integrated by any representations of its past appearance, such as drawings and illustrations, photographs, archival documentation, and written descriptions. Some complementary operations are integrated geomatic investigation techniques, which provide a suitable means for representing the shape and geometry of the existing elements [22,23]. Surveying and mapping of architectural heritage constitute a significant basis and prerequisite for architectural heritage conservation and architectural history research. This process refers to the application of image- and range-based survey methods and tools to acquire the spatial geometric information about architectural heritage [24] and to guarantee the maximum reliability of the subsequent reconstruction operations regarding the model collected. These first stages of acquisition facilitate the production of the first two-dimensional technical drawings, reconducting the real spatial model in a two-dimensional schematic form useful for the interpretation of both the data drawn from comparable historical elements and the aspects related to the geometric-proportional criteria and the units of measurement typical of the time [25]. These elements represent valid support for retro-design processes, that is, a workflow to rediscover the choices of past architects, builders, and clients. It is a backward path in the search for compositional grids and modular schemes aimed at favoring the recognition of choices and phases, strongly contributing to understanding the reasons for what has appeared in our time [26] (pp. 41–42).

In addition, three-dimensional modeling tools help to verify the reconstruction hypotheses according to a process that declares the levels of approximation obtained [27] per the "scientific transparency" and "historical rigor" of the Charter of London and Seville [28,29]. From this point of view, constructing interpretative models [30] encompassing the interpretation of the survey and historical documents is a remarkably complex process. Nevertheless, the result is not only a representative model but also a model that includes the geometric and dimensional data and the formal, figurative, architectural, and spatial values of the object of study [31]. The model becomes an information-aggregating nucleus [32], favoring a continuous multidimensional and multilevel interpretation in synthetic visualizations and simulations. From this point of view, the approach used to reconstruct the original *facies* of Raphael's stables is not far from what is methodologically required to "review" what can be deduced today only through written descriptions or approximate drawings [33].

2. Materials and Methods

2.1. The Stables throughout Historiographic Research

The contemporary fame of the complex of Farnesina alla Lungara is mainly related to the importance of the pictorial features of the Villa—produced by exceptionally ingenious, skillful, and famed artists, among whom it is worth mentioning Baldassarre Peruzzi, who also handled the design and construction; Raphael; and Sebastiano del Piombo. However, the other ancillary buildings of the main body, located in the vast garden between Via della Lungara and the Tiber, are no less important (Figure 2).

Among them is the building designed by Raphael around 1510, destined for the Stables, the only current remains of which are a part of the perimetral wall on Via della Lungara. However, it was demolished starting from the half of the lower order, where it is possible to see the subdivision of the whole wall into seven bays, with an alternation between paired pilasters and masonry veneer buffer walls. On the corner, the wall is connected to the remains of the northern prospect, originally located on the property's border and currently overlooking the more recent Salita del Buon Pastore. On both sides, different wall typologies testify to the artifact's transformation phases, with openings, covered with brickworks over time, such as the windows on the socle of the pedestal, presumably closed initially by bars, as shown in 16th-century drawings.

Hence, historiographic research is essential, and it is only one of the key phases of survey operations for understanding the critical interpretation of the residual elements. Some surveys from the 16th century—one by an anonymous French-Flemish surveyor, currently kept in the Metropolitan Museum of New York (Figure 3) and one by an anonymous French surveyor, kept in the Kunstbibliothek of Berlin (Figure 4)—provide a fairly reliable image of the building, which is currently only portrayed using this graphic evidence since it was demolished in 1808 due to its dilapidated state [34] (pp. 123–124).

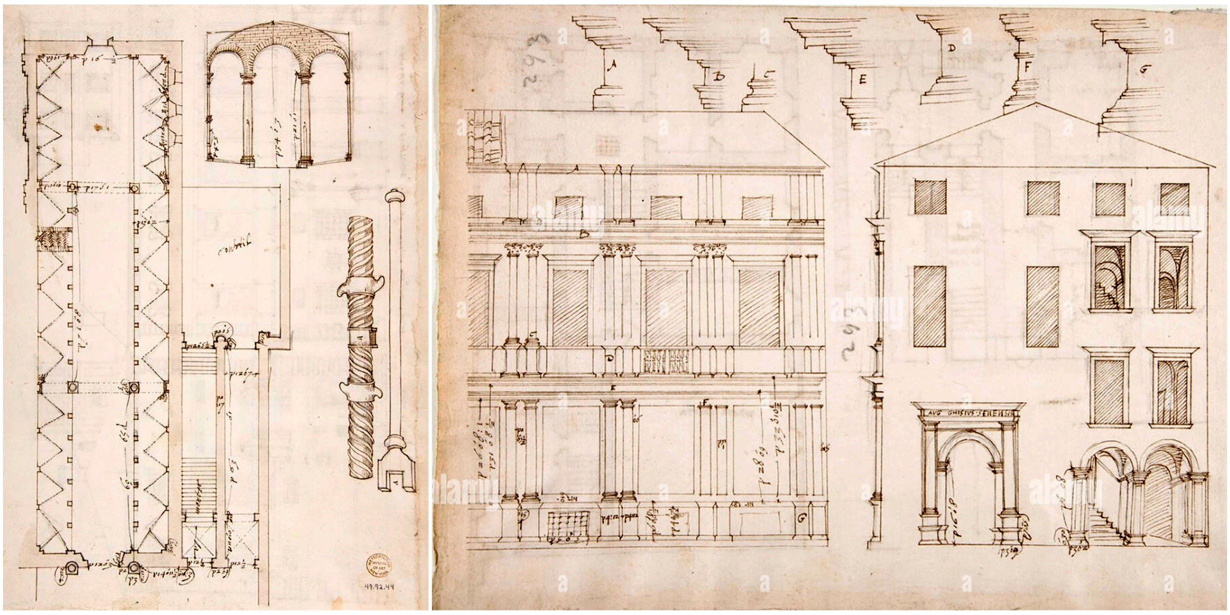

Figure 3. (**Left**), plan and cross-section of the Stables by an anonymous Franco-Flemish surveyor, second half of the 16th century, New York, Metropolitan Museum, Inv. 49, 92, 44v; (**Right**), a rise from the Stables by an anonymous Franco-Flemish surveyor, second half of the 16th century, New York, Metropolitan Museum, Inv. 49, 92, 50r.

Sixteenth-century surveys unanimously reported three aboveground levels: the Doric-order ground floor, the internal height of which was close to the level below; and a mansard, set at different heights by the two draftsmen.

Greater attention has been paid to detailed drawings, reproduced—albeit in a general sketch—in *Membri della stalla di augustino Chigi in Trastevere di preta biga di Baldasari opera architectura* by Cherubino Alberti (Figure 4) [33] (p. 124), which portrays the upper Corinthian order and the Doric order of the ground floor with analytical dimensions.

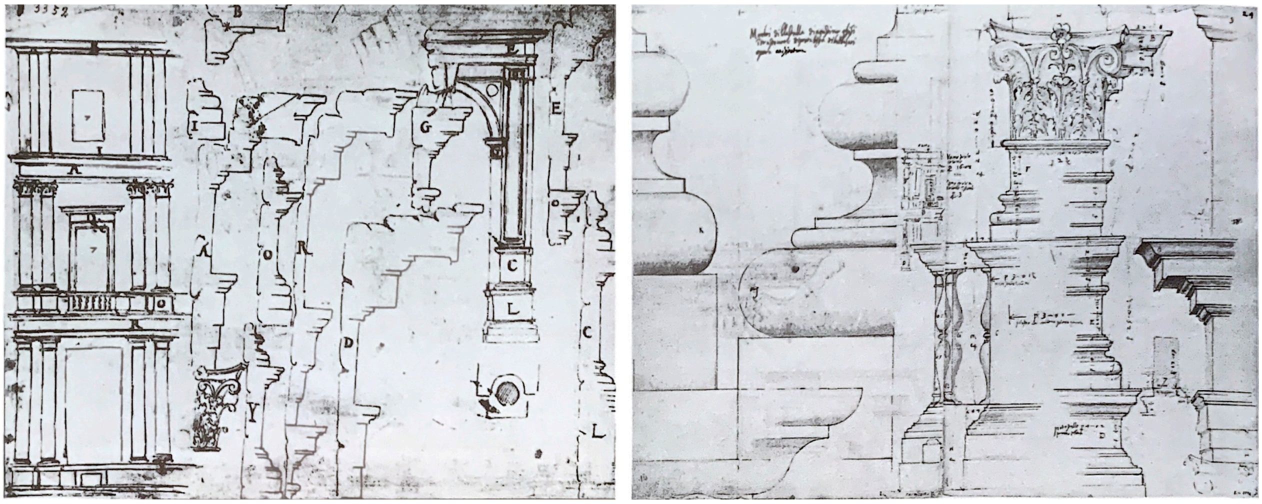

Figure 4. (**Left**), elevation of the façade and portal of the Stables and details, Anonymous French surveyor, second half of the 16th century, Berlin, Kunstbibliothek, Hdz. 3267/83 = OZ 109, fol. 70r; (**Right**), members of Augustino Chigi's stable in Trastevere di preta biga by Baldasari opera architectura, Cherubino Alberti, second half of the 16th century, National Prints Cabinet, FN no. 7988.

Instead, the anonymous French-Flemish drawings provide us with a rigorous representation of the layout, recognizably showing the spaces for horses' stalls [35] and the section of the ground level highlighting the vaulted ceiling of that level.

Among the representations, we also highlight the principal and lateral prospects, with the detail of the access portal to the Stables and the distribution of openings, following the indoor layout and also showing the articulation of roofing vaults and the vaults of the loggias and the staircase.

The drawing of the stairs to the upper levels is more ambiguous, both in the floor plan and in the elevation, as it seemingly indicates the existence of a basement, but we have little information about it. However, some elements were found during an excavation in 1970: these elements include the foundation walls and the remains of the foundations of the Southern access portal, documented by drawings and photographs [3] (pp. 52–54). Indeed, the late 20th-century excavations also discovered fragments of the base of the main access portal and traces of foundation walls, the layout of which is coherent with the 16th-century anonymous survey. The excavation also highlighted the currently increased height of the internal floor, also documented by the successive excavations from 1999 by the Central Institute of Restoration [3] (pp. 54–55) and a substantial confirmation of which was reported by the 16th-century draftsmen, documenting the presence of a basement accessible through the staircase from the backyard, proven by the discovery of basement window well fragments.

Due to the limited and fragmentary nature of the documental corpus, the reconstruction of the long history of the buildings is a markedly complex task. For example, there is scarce documentation of the organization of the upper floors of the artifact, as well as the possible configuration of the prospects overlooking the Tiber. The vast repertoire of views and cartographies of the city of Rome [36] (Figure 5), spanning more than five centuries, has helped us to hypothesize the configurations that cannot be directly inferred from the acquired graphic documentation.

If the rubbersheeting of historical maps in the dedicated information system—through the identification of Ground Control Points (GCPs) for adapting the oldest maps to the most recent ones—has made it possible to understand the evolution of architectural emergencies, the views—although in pseudo-perspective forms and not always exhaustive and documenting the actual relationships between the different architectural elements—nonetheless offer interesting suggestions for reconstructing the consistency of the place [37]. Moreover, the vast digital survey campaign allows us to recognize the layout and entities of the existing elements. In particular, integrating image- and range-based data [38] has favored punctual reflections on Raphael's design themes and original solutions to this delicate commitment.

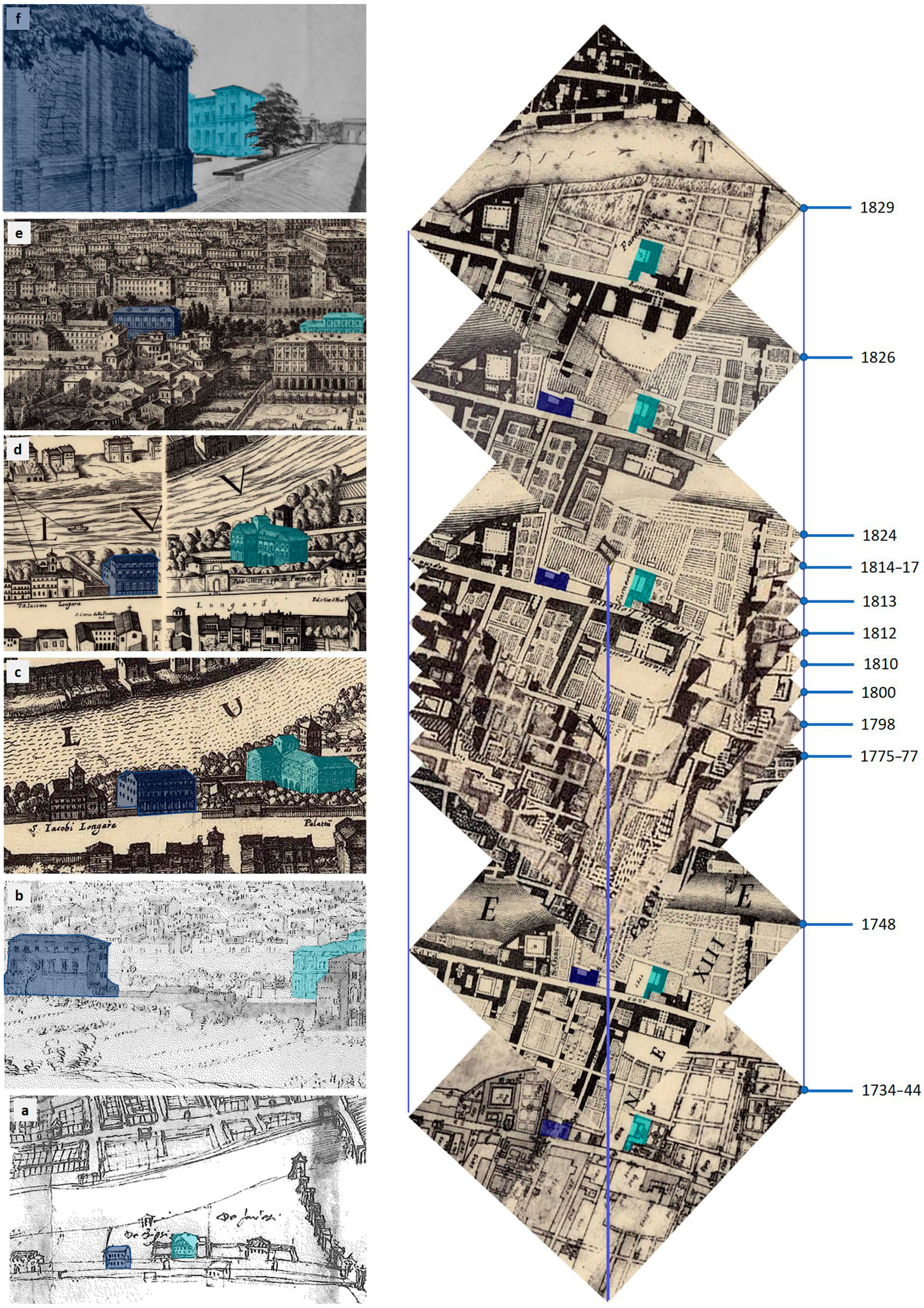

Figure 5. The evolution of the building through the views and the adaptive georeferencing of the historical maps of Rome. On the left, the views of: (**a**) 1563-64 by Sallustio Peruzzi; (**b**) the second half of the 16th century by Antonis Van Den Wijngaerde; (**c**) 1593 by Antonio Tempesta; (**d**) 1667 by Giovanni Battista Falda; (**e**) 1765 by Giuseppe Vasi; (**f**) the first half of the 20th century by an anonymous surveyor. On the right, from bottom to top, the maps of the study area from 1734-44 and 1748 by Giovanni Battista Nolli to those from 1826 by Angelo Uggeri and from 1829 by the Directorate General of the Census [7].

2.2. Digital Survey: Toward a Knowledge Integration Model

The construction history of the building was understood through an analytic, scientific, and critical survey of the remaining elements of the building system, which was also performed using advanced digital technologies aimed at the reinterpretation and documentation of its history and transformations [39,40].

Indeed, the iterated inspections of the building study area have highlighted the peculiarity of particular sectors, such as the remains of some brick stone models of pilasters and the corbels of the vaults along the walls of indoor environments or some pieces of the frames: in the past, they decorated the external elevations, and now they are abandoned on the ground of the area immediately next to the Stables. Hence, there is a need for rigorous documentation of the morphological aspects that would have been interesting for the comprehension of the history of the building [9]. Following the preliminary inspection, the acquisition process for the digital morphometric survey was developed with an integrated approach between range-based (Terrestrial Laser Scanning-TLS) and image-based (camera photogrammetry) applications [41]. The former collected reference morpho-metric databases according to the highest and certified measurement accuracy. The latter also developed Structure-from-Motion (StM) acquisition sequences for localized mapping of detail elements [42]. At the same time, direct or similar processes (laser distance, double laser meter, etc.) were used to scale photogrammetric models for punctual checks and for rapid comparisons between digital survey results. Furthermore, some architectural elements were detected with progressive direct measurements, avoiding the accumulation of errors and excessive approximations, that were useful in comparing the data obtained with detection performed with a triangulating laser scanner.

A fundamental operation was the laser scanning survey, which contributed to structuring the digital datasets of the study, which also included the output of the photogrammetric survey of detail elements. Considering the relationship of the Stables with the surrounding urban context and the nearby main body of the Villa Farnesina—a TLS survey-performed with a laser Leica Station C10 time-of-flight laser scanner—was essential for the documentation and acquisition of the data required for the reconstruction of its original layout (Figure 6). The design and planning of the laser scanner survey were performed on the preparatory plan sketch of the state of the places drawn up during the preliminary inspection.

In particular, in this first phase, the scanner station points were evaluated with respect to the accessibility and size of the area surrounding the ruined building. The assessment considered both the degree of visibility of the building surfaces from each station point and the degree of accuracy and uniformity of the resolution of the scans to facilitate the alignment and registration of the acquired point clouds. At the same time, numbered 2D targets were used to facilitate the alignment phase of the point clouds of a ruined artifact characterized by few recognizable elements.

In particular, square targets 15 $\times$ 15 cm in size and spherical targets 15 cm in diameter were used and later recognized as vertices for the automatic alignment of the point clouds. Therefore, for the complete documentation of the external surfaces of the building, the digital scans were also performed from observation points at different heights. This process was mainly due to the plani-volumetric configuration of the building, which resulted from the remaining visible architectural elements and the aforementioned historical surveys, as well as the importance of obtaining a model to verify its historical appearance. Hence, additional scanning was performed from Via della Lungara, Salita del Buon Pastore, Lungotevere Farnesina, and Palazzo Corsini, adjusting the acquisition density of the instrument each time. These modalities characterized the entire documentation process, with acquisitions of high-density point clouds obtaining a resolution of 0.5 cm at an average distance of about 10 m for the survey of even the most minor details.

The 45 scans necessary to cover the entire study area allowed for the creation of an out-and-out "closed loop" of scans, both outside and inside the area of Villa Farnesina, to achieve the correct ratio between the outside and inside data and to facilitate point cloud union in the post-processing phase.

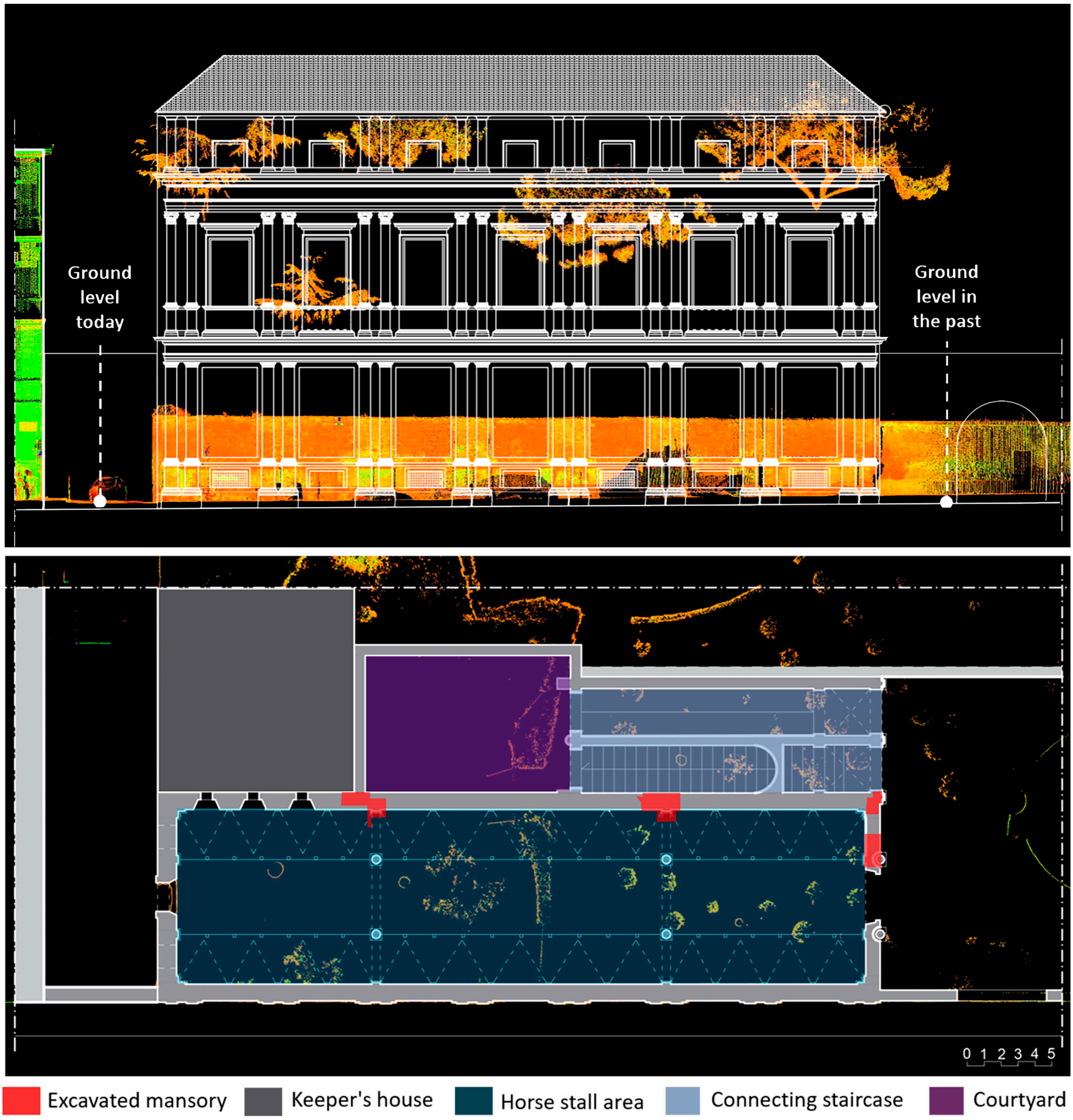

Figure 6. Elevation from via della Lungara and the floor plan, of Raphael's Stables based on laser scanner data, with the thematization of the foundation walls, which came to light in 1970, and a description of the intended use of the various building parts.

All the obtained scans allowed for realizing an overall point cloud, in which the remains of the ancient Stables are also localized in the urban context.

The digital integration of the data, developed in Cyclone software, generated a high-resolution textured 3D mesh model, characterized by high precision and millimeter-level accuracy. This process was helpful for documenting the building in its complexity but not for describing the geometric composition of the detailed architectural elements preserved at the site (stone models of frames or friezes placed in the area). Therefore, the data acquisition activity was integrated with the subsequent two levels of in-depth analysis, expecting to create the overall reconstructed digital model.

A particularly relevant survey was conducted using a 3D Systems-Sense triangulating laser scanner (Figure 7). The latter was equipped with two cameras, one for image acquisition and the other for evaluating depth, to reconstruct an unstructured point cloud model in real time. Thanks to the image calibration procedure, the result was a detailed model of the textures of the surviving architectural elements, described by a surface of polygons textured through the mapping of photogrammetric images.

Figure 7. Range-based data integration environment of the remaining elements of the main elevation along via della Lungara, acquired with a triangulating laser scanner and integrated with TLS data through homologous control points.

It was then necessary to verify the accuracy of the survey of small-sized finds and to improve the chromatic level of the laser scanner acquisitions. Hence, the different research phases involved a close-range digital terrestrial photogrammetry acquisition with a Nikon D3100 SLR camera equipped with a fixed 24-mm lens. For better data output, the photographic acquisition phase (with sets of images referring to the same internal or external portion of the building) considered both the distance from the survey object and the lighting conditions [43]. Like the architectural elements, the elevations were digitally reconstructed using SfM (Structure from Motion) techniques in Agisoft Metashape software, with markers, i.e., the same target control points, acquired previously. The common control points also favored the integration of range-based and image-based acquisitions [44], exploiting the strengths of both systems, performing the 3D measurements, and subsequently producing graphic output [45].

In this way, the critical integration of the data has allowed for obtaining a measurable point cloud model [46] of the state-of-the-art architectural elements, the remains of the Stables' building, and their context. Furthermore, the subsequent slicing operations of the point cloud produced the first drawings (plans, elevations, sections) of the site's current state.

These operations are indispensable for evaluating the original configuration of the building in a direct comparison with the geometric-proportional studies conducted and the measurements obtained from the reinterpretation of the historiographical documentation [19,47,48]. Finally, the two-dimensional restitutions were validated by the three-dimensional reconstruction of the model of the Stables through a volume-based Constructive Solid Geometry (CSG) representation, verifying the hypotheses drawn from the analysis of the historiographical and survey data.

3. Discussion and Results

Analysis, Interpretation, and Modeling of the Original Facies

The organization of digital survey activities and the levels of historiographic documentation of the building have become the starting point for its geometric-proportional analysis and the morphological-virtual reconstruction of its original configuration [49].

The operational methodology is subdivided into the following phases:

1. Preliminary analysis of the archival documents to determine measurement units, representation scales, positions of section planes, reference surfaces, and architectural elements;
2. Comparison between archival drawings and range-based surveys to evaluate the congruence of the conversion between metric linear units and the original linear units adopted in the representation;
3. Analysis of drawings to search for geometric-proportional rules to reconstruct the floor plans and the elevations of the Stables;
4. Three-dimensional reconstruction of the Stables, in the formal and functional articulation of spaces, completed in their ideal reconstruction according to the reference models.

Just like other foremost Renaissance architects, Raphael was very attentive to building proportions; he used reference models as starting points to seek innovative solutions from an aesthetical and functional perspective.

Based on that assumption, examining historiographic sources allows us to reconstruct the proportional and spatial values of the building and understand it from different perspectives, revealing its original *facies*, the set of aspects concurring with the Vitruvian triad, as well as in the relationship between form and structure. In particular, the graphical sources and the partially dimensioned drawings, combined with historical iconography, allow us to reconstruct volumes, spaces, and forms in the complex relationships of the various aspects of the building, evaluating the geometric-proportional rules and the reference model adopted to define its layout (Figure 8).

Not all graphical-historical representations originate from a rigorous scientific process that uses canonical representation methods to deliver information; instead, they illustrate a synthetic architectural reality. Such was the case of Cherubino Alberti, who altered the morphological interpretation of some elements [50] (Table 11).

While these representations thoroughly describe the geometry of the corbels of the Stables' vaults, the internal organization was better documented by the anonymous French-Flemish surveyor, who favored the interpretation of the Stables' layout, which appears to consist of a primary volume along Via della Lungara on four levels, with the stalls on the raised floor, a small courtyard, and a second volume on the Northern front, internally connected by a large staircase. It was noted that the measurement unit of the survey drawings is clearly related to the "Roman palm" (c. 0.2234 m).

Hence, an overall analysis was conducted with the support of a preliminary representation of the digital survey and the information obtained from archival and iconographic materials. The purpose was an overall analysis to individuate the elements of the initial 16th-century building body in the current configuration and determine their measurements on the floor plan and the elevation [51] (p. 130). The drawings show that the floor plan of the Stables measured around 56 × 191 palms, with a c. 2:7 ratio, while the total width of the floor plan between the staircase and the backyard measured c. 87 palms. Moreover, the whole layout of the main prospect on Via della Lungara can be inferred: eight pairs of pilasters on pedestals punctuated a Doric-order ground floor and then a Corinthian-order upper floor and a mansard [52] (p. 202).

In particular, these dimensions emphasize that the width of the first-order bays was c. 26 palms, while the pilasters were three palms (c. 0.67 m) each, and the blind walls were c. 15 palms. Moreover, thanks to the letters added by Alberti to his drawings, which are also repeated in the details, it is possible to infer the proportions and the dimensions of the single elements of each order [4] (p. 5).

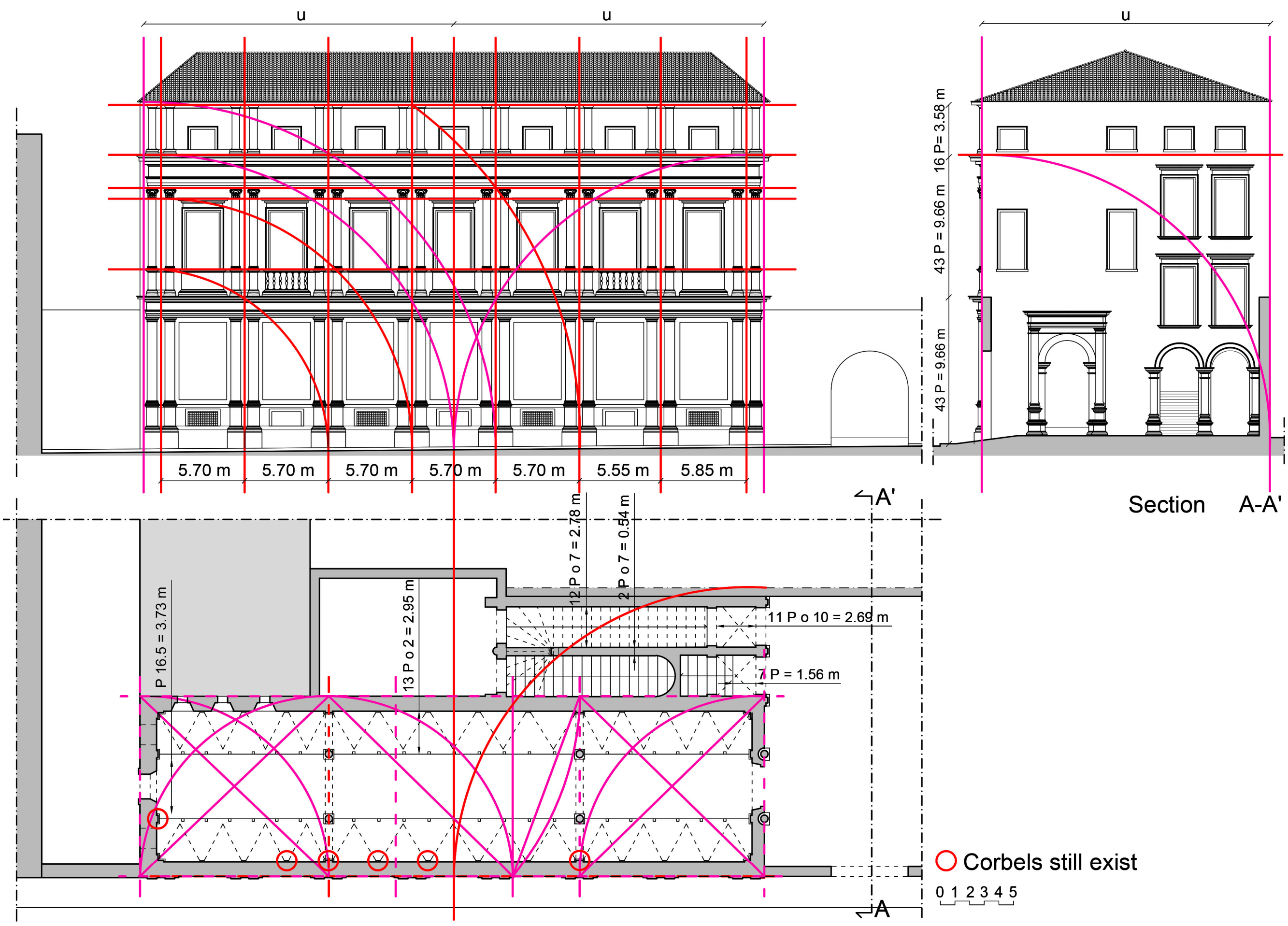

Figure 8. Two-dimensional results of Raphael's Stables with the geometric-proportional analysis of the elevation towards via della Lungara and Villa Farnesina (in red the relationship between the axes of the openings and the composition of the elevations by arcs of circumference), and of the plan space intended for the horse stall (in purple the arcs of circumference that make up the quadrilateral figures of the plan). Note in the plan the projection of the steps of the double-ramp staircase with the radial connection.

Concerning the Doric order, it is found that the capital, pilaster, and base were 25 palms (c. 5.60 m) tall in total and 2.5 ounces, while the pilaster alone was 21 palms (c. 4.69 m) tall. For the Corinthian order, Alberti indicated every single part and specified the moldings and balustrades of balconies [53] (pp. 35–36), for which no other details can be found; the capital, the pilaster, and the base were 22 palms (c. 4.95 m) tall and 2.5 ounces in total; the pilaster was 2.5 palms (c. 0.56 m) wide; the cymatium of the pedestal was 7.5 ounces (c. 0.13 m) tall; and the dado's height, which was the same as the balustrade's, was three palms (c. 0.67 m. The base was two palms (c. 0.45 m) tall. Moreover, the distance between the pairs of pilasters was three palms (c. 0.67 m), while the distance between the pilasters delimiting the window compartment was 16 palms (c. 3.58 m). The comparison with the data from the digital survey and the verification of the remaining external wall reveals that Raphael, in the construction phase, deviated from using round numbers in dimensions: the total length was c. 42.65 m, (c. 190.1 palms), each bay was c. 5.75 m (c. 25.7 palms), the blind walls were c. 3.83 m (c. 17.1 palms), and the distance between the pilasters was c. 0.55 m (c. 2.45 palms), widening the margins by c. 0.28 m (c. 1.25 palms). Including the mansard, the height of which was c. 3.58 m (c. 16 palms), the building reached c. 22.89 m (c. 102 palms), with the height of the first two orders being c. 9.66 m (c. 43 palms).

Considering also the height and the width of the prospect along via della Lungara, a proportional ratio close to 1:2 emerges (Figure 8). The geometric proportions of the composition were presumably constructed based on the circumference determined by the edge of the prospector based on the distance between each pair of columns. After all, the height of the mansard is the most controversial parameter, as this level was drawn with two different heights in the two 16th-century surveys. However, by integrating the metric data of the historical drawings, the reconstruction of the original height is compatible with the geometric-proportional analysis. Nonetheless, this proportion remains theoretical and can only be referred to as the design idea since the instrumental survey has shown a reduction in the last two spans. Nevertheless, this different length compensates for and does not affect the proportional description of the elevation or the horizontal layout of the Stables. The latter is described by the accurate composition of the architectural elements, for example, in the three different spans of the space intended for horses. Moreover, when comparing survey data, there is uncertainty about the external ground level (risen over time) with the prospect along Via della Lungara, showing a constant interval only for the first five bays from the East (Figure 5). This fact raises a question: what could be the reason for the metric inhomogeneity adopted by Raphael in the prospect? Due to the unavailability of metric and documental data, it is impossible to know the reason for the irregular modular composition. Nevertheless, it is likely that the polyhedric artist had to adapt the project to the pre-existent organization of part of the basement, which strongly conditioned the layout of the openings of the prospect [3] (p. 43). Indeed, the excavations performed by the Central Institute of Restoration in Rome found that some parts of the underground level were occupied by the foundations of the houses demolished to construct the Stables. Due to the detected discordances, it cannot be excluded that Raphael, despite starting from round numbers and proportions, made some changes during the construction phases. The reason was presumably the need to adapt to the pre-existing elements while maintaining the proportion within the first two orders through the geometric relationship between the width and the height of the architectural compositions. The result is a system that matched the various functions of the Stables, with a tall base and low windows near the basement wall windows, the blind walls between the Doric-order pilasters of the stalls, tall windows between the Corinthian-order columns of the *piano nobile*, and the lesenes on the lower cornice of the mansard.

The virtual relocation of the constitutive elements of the prospect and the southeastern volume completed the analysis. The prospect overlooking the Villa, documented in the French-Flemish anonymous drawing, allows us to complete the volume of the Stables with an opening delimited by Doric columns leading to the hall on the raised floor; two large windows on the upper floor; and two smaller windows on the mansard. Concerning the staircase volume, two adjacent openings led to the entrance hallway and the corridor connected to the backyard; on the upper floor, there were three rows of windows, some of which were blind.

Continuing with the virtual reconstruction of the external fronts, the prospect along Salita del Buon Pastore required the formulation of some hypotheses (Figure 9) based on the few surveys elements available and the reading and interpretation of historical views and iconography. For example, Tempesta's 1593 view (Figure 4) clearly showed the layout of the openings along Salita del Buon Pastore, the prospect's architectural orders on Via della Lungara, and the connections between the various functional areas of the construction. The Stables' building seems to be leaning against a minor one along Salita del Buon Pastore on the corner next to the backyard, which was probably added during the expansion works in 1520 [54] (pp. 90–94). The Stables' volume is characterized by an opening on the raised floor and two rows of windows on the upper floors, with the same composition as the prospect overlooking Villa Farnesina.

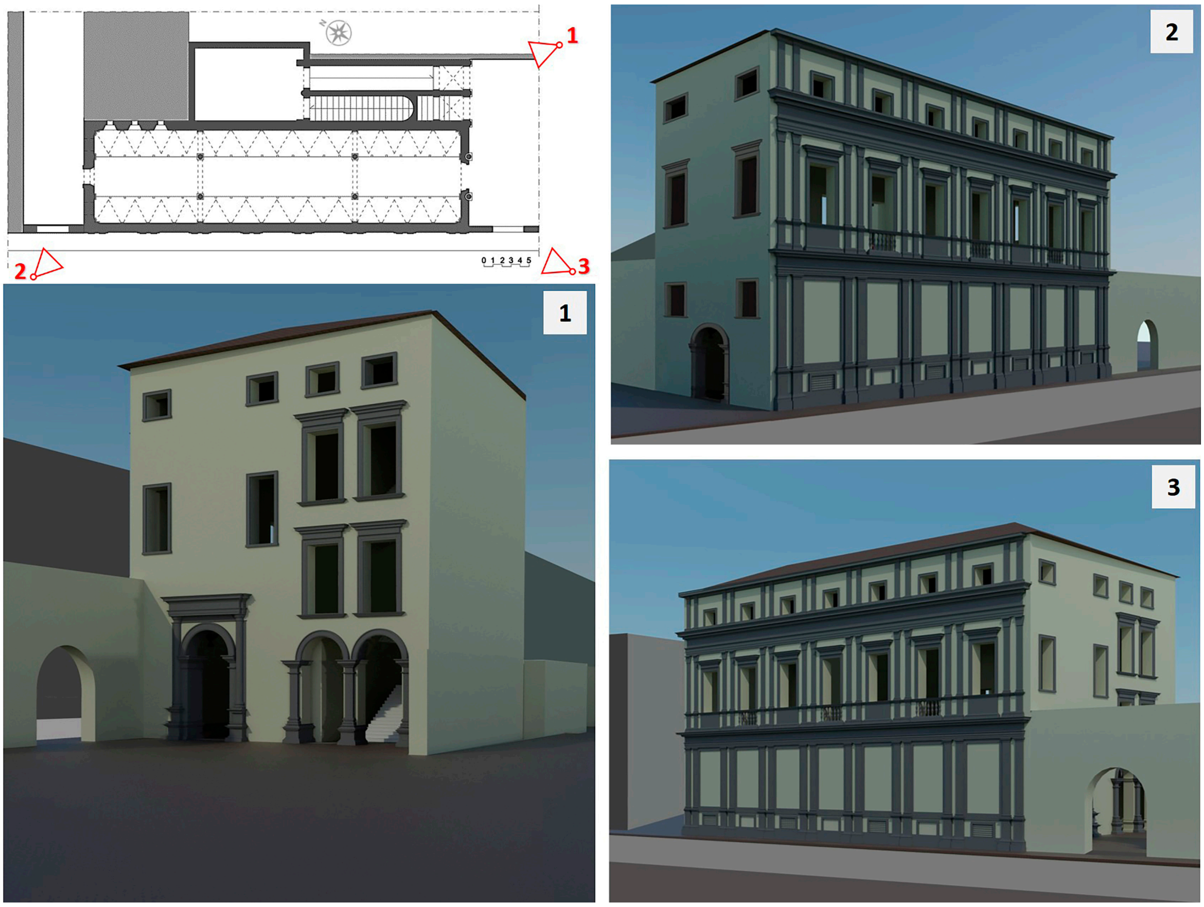

Figure 9. External views of the virtual model of Raphael's Stables in the original configuration: (**1**) view from the northeast with the majestic access portal to the Stables and the access gates to the staircase connecting the upper floors and the rear courtyard; (**2**) northwest view of the prospects along Salita Buon Pastore and via della Lungara; (**3**) southeast view of the prospect along via della Lungara with the access portal to the Stables area.

The description of the external fronts was accompanied by the reconstruction of the spatial organization and the architectural layout of the building, revealing a highly artistic and technically skillful solution compatible with the stable models described in Leonardo's codes (Figure 10). The genius also paid attention to the ventilation, exhaust and removal, wastewater drainage, and hay supply systems, which were probably integrated into Raphael's building.

The comparison with historiographic sources highlights the following: a basement, with openings for ventilation and lighting overlooking the main street; a raised floor (Figure 5) destined for horses' stalls, divided into three modules with the adjacent vertical connecting staircase; the first floor, presumably used as a warehouse, with large windows with balconies and balustrades; and a mansard, probably serving as a guesthouse. The basement perhaps had a barrel vault just like the Villa, with perimetral window walls [3] (pp. 52–54) at least in the southern part, which was accessible through the large staircase reported in the 16th-century drawings. Concerning the geometric organization of the Stables (Figure 11), the analysis allows us to reconstruct the internal space in coherence with the findings of the 1970 excavations.

In particular, the raised floor, the internal height of which was c. 9 m., was divided into three sections by arches on Tuscan columns, which divided the space into three bays along the longitudinal axis; the wider central section, with a depth of c. 17 m, included 10 stalls for the horses on all sides, each c. 3 m deep; instead, the side sections had seven boxes on each side. Then, the analysis of the height of the various levels revealed compatibility with the articulation of the external prospects. This compatibility facilitated understanding of the profiles for the immediate interpretation of the various soffit layouts of the composite and complex surfaces of the lunette barrel vault of the hall. It also allowed for verifying the curve of each lunette in its direction of extrusion, which was compatible with the present position of the corbels and the width of the openings overlooking Via della Lungara.

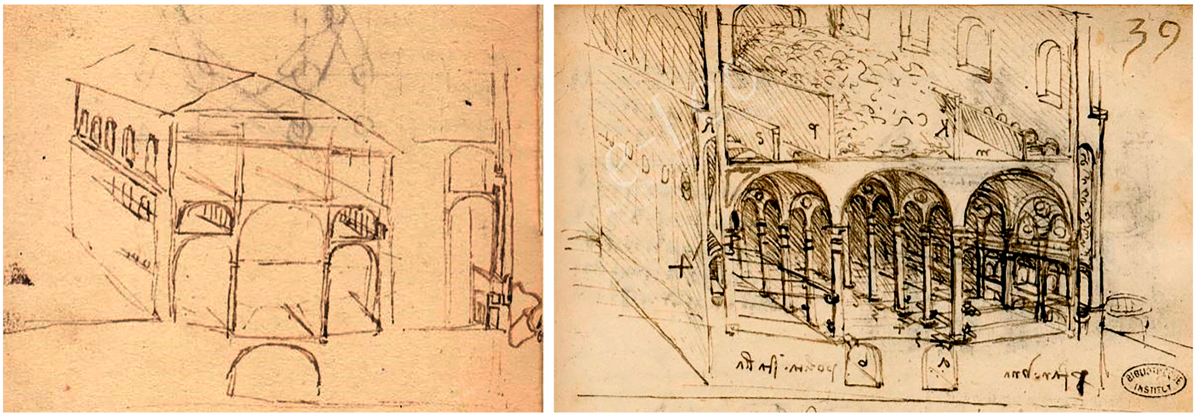

Figure 10. Examples of architectural models intended for the Stables, described by Leonardo da Vinci in his treatises: on the (**left**), Codex Trivulziano del 1490 (f. 21v); (**right**), Manuscript B from the Institut de France del 1490 (f. 39r) [55] (pp. 68–70). The models described in the architectural illustrations also included the ventilation systems, the wastewater drainage systems, and the hay supply systems, which were probably integrated into Raphael's construction.

Moreover, we recall that, for the Stables floor, the digital reconstruction was also favored by the discovery and acquisition of some remains of the fenestrations and some peperino elements that were kept on the site, along with the remains of the lesenes and corbels of the ceiling vaults of the Stables (Figure 5).

The remaining elements, which number far fewer than the disappeared ones, do not allow for a reliable reconstruction of the internal organization of the upper floors. It is only possible to offer an interpretation of the correspondences between the ground floor walls and the documentary sources to detect functions and intended uses. It is difficult to determine the spatial organization of the staircase accurately; on this topic, it is customary to hypothesize its most likely articulation beyond the first floor up to the mansard, also in conformity with the representations of the roofing vaults indicated in the French-Flemish drawing. Indeed, the description of the external openings has raised some doubts about the overall design of the vertical connections. The realization of a digital model of the building has also allowed us to formulate a hypothesis on the organization and the plani-altimetric layout of the staircase. Then, the comparison with the available historiographic material and stairs of the same typology in some coeval buildings confirmed the hypothesis providing the basis of the digital reconstruction. The interpretation of this final drawing has allowed us to reconstruct the typological hypothesis of a double-flight staircase, leading to the various levels of the Stables' building from the basement with a slope to access the internal courtyard from the entrance hallway. On one side, the entrance hallway led to the flights for the upper floors; on the other side, below the upper flight, it allowed for access to the internal courtyard, which was enclosed by walls, allowing people to reach the stairs of the underground floor. Compared with coeval solutions, the articulation of the staircase is coherent with the position of the first landing, located at the height of c. 3.65 m, and the second landing, at the height of c. 6.55 m. This distribution allowed for a limited slope for the flights for the first and second floors (respectively, at the heights of c. 9.66 m and c. 19.32 m), the values of rise and tread of which were aimed at a "comfortable" ascent for the horses, to unload materials on the first floor. This was the configuration of the staircase at the various levels, as described in the virtual reconstruction of the original layout of an artifact where Agostino Chigi wanted to "far più ricca la stalla, che non faranno i Riarj la Sala Maggiore" ("make the Stables richer than the Riars would make their Great Hall") [56] (p. 181), through a modeling and communication approach [6] that allowed for a punctual reflection on the design problems overcome by Raphael in providing this delicate commitment and the original solutions that he adopted.

Figure 11. Internal view of the virtual model of Raphael's Stables in the original configuration: view on the ground floor toward the entrance from Salita del Buon Pastore. Note the room's high openings for ventilation and lighting as shown in the plan and cross-section of the Stables in Figure 3 by the anonymous Franco-Flemish artist from the second half of the 16th century.

Thanks to the construction hypothesis embodied in the 3D model, progress has been made in the knowledge of this artifact, using the virtual model as a tool of interpretation and simulation. Moreover, the data (historiographical and relevant) of the digital reconstruction are recorded in the model to give a visual indication of the degree of reliability of each part. Different colors were used to represent each of the following categories: current manifestation; those derived from iconographic sources and historical photos; interpretations; and suppositions (Figure 12).

However, the importance of disseminating the results of scientific research should be underscored. Therefore, the effort here has been to translate the model for digital fruition [57] to support the sectors of arts, tourism, and culture, as well as the fields of recovery and conservative restoration.

The creation of explorable virtual models is an indispensable step in strengthening interest in these goods and in recreating a bond to enhance the general public's interest through emotional connection. Reviving the spatial and visual sensations of the building, with the possibility of moving inside it, allows users of virtual tourism to access and appreciate places that are now partly lost. In this sense, steps are being undertaken to respond to the last phase of the workflow, i.e., placing the digital contents of the Stables at the service of the museum areas of Villa Farnesina. Through an augmented reality experience, knowledge of a precious asset will spread (Figure 13) in hopes of increasing users' sensitivity to the enhancement and protection of our cultural heritage.

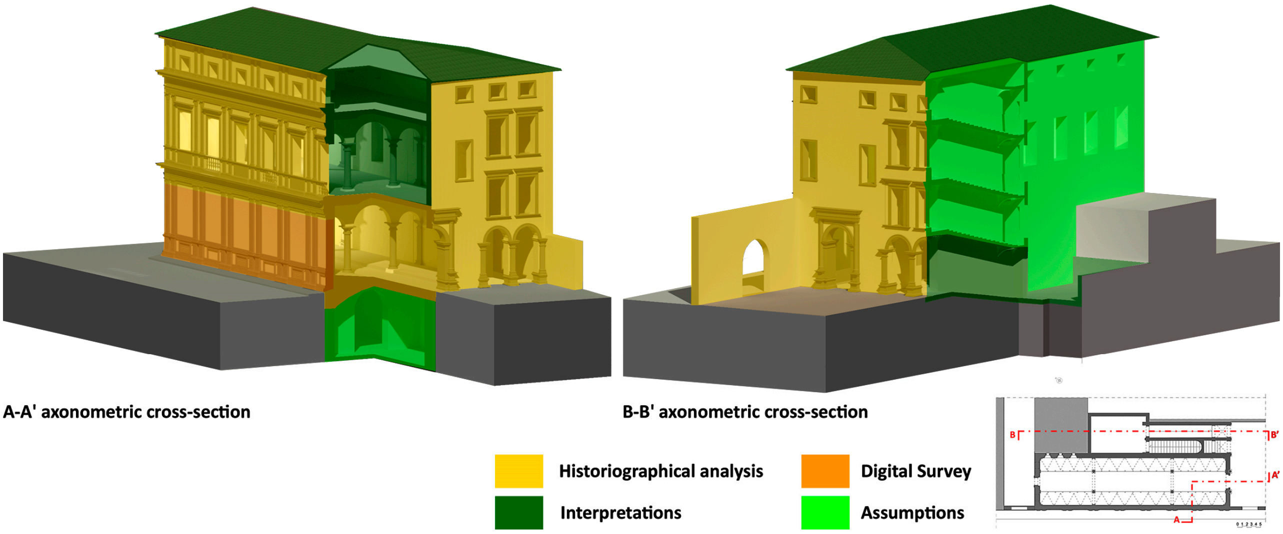

Figure 12. Axonometric cross-sections of the virtual model with the thematization of the sources used to support the hypotheses and interpretations.

Figure 13. App simulation of the augmented fruition of Raphael's Stables; view from via della Lungara with the digital reconstruction of the building on the survey of the state of the place.

4. Conclusions and Future Developments

For a disappeared building, the construction of a virtual model represents an advancement in the knowledge of the monument. It therefore contributes to its historical recovery and appreciation of its role in cultural heritage. This goal is possible as long as it is characterized by scientific rigor and based on an integrated survey campaign, including the analysis of historiographic sources to describe its original appearance. Moreover, the application of information technology and the production of scientific virtual models contribute to improving the documentation of architectural assets, facilitating the undertaking of precise studies on the constructive and typological models and facilitating implementations with respect to new research or discoveries on the disappeared historical heritage, which can be validated or integrated with previous studies.

In this field, the research conducted on Raphael's Stables in Villa Farnesina in Rome represents an applied example of a methodology to reveal, as much as possible, the original face of the artifact, thus increasing the interest of all audiences, i.e., helping to raise awareness of the historical importance of a piece of heritage that has almost completely disappeared. In the specific case, the analysis of the historiographical documentation and the evidence of the digital survey made it possible to digitally reconstruct the original plani-altimetric system at the end of the first construction phase.

The digital detection of the remaining elements of the elevations corresponding to the raised floor along via della Lungara and Salita Buon Pastore and the evidence of the excavations carried out in the last century made it possible to reconstruct the planimetric layout. The analysis of the few important historical drawings made it possible to reconstruct the compositional grammar of the external elevations, the architectural conformation of the volume for the horse stall, the organization of the connecting staircase, and the lexicon of the architectural details. Thus, the research, which developed the first three phases of the methodological workflow in Figure 1, has highlighted the excellent quality of this building and its artist—Raphael—who artistically organized the architectural composition of the artifact with design solutions that integrated the geometric-proportional aspects in an interdependent relationship with the nearby Villa Farnesina.

The opportunity to digitally translate the original project, as well as validate the hypotheses, enables technical and tourist use of the model, which is capable of constituting a helpful dataset both for restoration and valorization projects and for cultural dissemination strategies to deliver a significant piece of Renaissance history to the broad public via virtual tourism. Therefore, future research aims to develop this last point of the methodological workflow, i.e., to create a virtual context that can be visited, enhancing the perception of the current state of places through visions and multidisciplinary information content [13] in a multimedia presentation that will convey the evolution historical-artistic usefulness to "preserve the aesthetic and historical value of the monument" [58].

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References

1. Pietroni, E.; Ferdani, D. Virtual Restoration and Virtual Reconstruction in Cultural Heritage: Terminology, Methodologies, Visual Representation Techniques and Cognitive Models. *Information* **2021**, *12*, 167. [CrossRef]
2. Cundari, C.; Bagordo, G.M.; Cundari, G.C.; Cundari, M.R. *La Villa Farnesina a Roma. L'invenzione di Baldassarre Peruzzi*; DGA Documenti Grafici di Architettura e di Ambiente; Edizioni Kappa: Roma, Italy, 2017.

3. Frommel, C.L. *La Villa Farnesina in Roma*; Edizioni Cosimo Panini: Modena, Italy, 2003.
4. Schiavo, A. Le architetture della Farnesina. *Capitolium* **1960**, *35*, 3–14.
5. Fiorillo, F.; Remondino, F.; Barba, S.; Santoriello, A.; De Vita, C.B.; Casellato, A. 3D digitization and mapping of heritage monuments and comparison with historical drawings. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.* **2013**, *2*, 133–138. [CrossRef]
6. Gaiani, M.; Benedetti, B.; Apollonio, F.I. Teorie per rappresentare e comunicare i siti archeologici attraverso modelli critici. *SCIRES-IT SCIentific REsearch Inf. Technol.* **2011**, *2*, 33–70.
7. Doneus, M.; Neubauer, W. 3D Laser Scanners on Archaeological Excavations. In Proceedings of the CIPA 2005 XX International Symposium, Torino, Italy, 26 September–1 October 2005; Volume 34, pp. 226–231.
8. El-Hakim, S.; Gonzo, L.; Voltolini, F.; Girardi, S.; Rizzi, A.; Remondino, F.; Whiting, E. Detailed 3D modelling of castles. *Int. J. Archit. Comput.* **2007**, *5*, 199–220. [CrossRef]
9. Bertocci, S.; Parrinello, S. (Eds.) *Digital Survey and Documentation of the Archaeological and Architectural Sities: UNESCO World Heritage List*; Edifir. Edizioni Firenze: Firenze, Italy, 2015.
10. Akca, D.; Remondino, F.; Novak, D.; Hanusch, T.; Schrotter, G.; Gruen, A. Recording and Modelling of Cultural Heritage Objects with Coded Structured Light Projection Systems. In Proceedings of the 2nd International Conference on "Remote Sensing in Archaeology", Rome, Italy, 4–7 December 2006; pp. 375–382.
11. Li, Z.; Chen, J.; Baltsavias, E. Advances in Photogrammetry, Remote Sensing and Spatial Information Sciences. In *ISPRS Congress Book*; Taylor & Francis Group: London, UK, 2008.
12. Spallone, R.; López González, M.C.; Vitali, M. Integration of new survey and modeling technologies aimed at the analysis of banded vaulted systems. In *Connecting. Drawing for Weaving Relationships. Proceedings of the 42nd International Conference of Representation Disciplines Teachers*; Arena, A., Arena, M., Brandolino, R.G., Colistra, D., Ginex, G., Mediati, D., Nucifora, S., Raffa, P., Eds.; FrancoAngeli: Milano, Italy, 2020; pp. 2716–2735.
13. Guidi, G.; Russo, M.; Angheleddu, D. 3D survey and virtual reconstruction of archeological sites. *Digit. Appl. Archaeol. Cult. Herit.* **2014**, *1*, 55–69. [CrossRef]
14. Balzani, M.; Maietti, F. Urban Space and Places of Memory: The Survey as a Tool for Investigating the Process of Transformation. In *Graphic Imprints: The Influence of Representation and Ideation Tools in Architecture*; Marcos, C.L., Ed.; Springer: Cham, Switzerland, 2018; pp. 541–556.
15. Campofiorito, N.; Santagati, C. Reconnecting present and past: The virtual reconstruction of the kitchens of the Benedictine Monastery in Catania. In *Connecting. Drawing for Weaving Relationships. Proceedings of the 42nd International Conference of Representation Disciplines Teachers*; Arena, A., Arena, M., Brandolino, R.G., Colistra, D., Ginex, G., Mediati, D., Nucifora, S., Raffa, P., Eds.; FrancoAngeli: Milano, Italy, 2020; pp. 1800–1819.
16. Frommel, S.; Apollonio, F.I.; Gaiani, M.; Bertacchi, G. Some reconstruction hypotheses of Leonardo's project for the tiburio of the Milan cathedral by using 3D digital models. *SCIRES-IT SCIentific REsearch Inf. Technol.* **2020**, *10*, 53–66.
17. Bolognesi, C.M.; Fiorillo, F. Virtual Representations of Cultural Heritage: Sharable and Implementable Case Study to Be Enjoyed and Maintained by the Community. *Buildings* **2023**, *13*, 410. [CrossRef]
18. Poulopoulos, V.; Wallace, M. Digital Technologies and the Role of Data in Cultural Heritage: The Past, the Present, and the Future. *Big Data Cogn. Comput.* **2022**, *6*, 73. [CrossRef]
19. Bianchini, C. Survey, modeling, interpretation as multidisciplinary components of a Knowledge System. *SCIRES-IT SCIentific REsearch Inf. Technol.* **2014**, *4*, 15–24.
20. Borghini, S.; Carlani, R. La restituzione virtuale dell'architettura antica come strumento di ricerca e comunicazione dei beni culturali: Ricerca estetica e gestione delle fonti. *Disegnarecon* **2011**, *4*, 72–79.
21. Russo, M.; Guidi, G. Reality-based and reconstructive models: Digital media for cultural heritage valorization. *SCIRES-IT SCIentific REsearch Inf. Technol.* **2011**, *2*, 71–86.
22. Croce, V.; Caroti, G.; Piemonte, A.; Bevilacqua, M.G. Geomatics for Cultural Heritage conservation: Integrated survey and 3D modelling. In Proceedings of the 2019 IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage, Florence, Italy, 4–6 December 2019.
23. Ebolese, D.; Lo Brutto, M.; Dardanelli, G. The integrated 3D survey for underground archaeological environment. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2019**, *XLII-2/W9*, 311–317. [CrossRef]
24. Bini, M.; Bertocci, S. *Manuale di Rilievo Architettonico e Urbano*; CittàStudi: Torino, Italy, 2012.
25. Fasolo, V. *Analisi Grafica dei Valori Architettonici*; Istituto di Storia dell'Architettura, Facoltà di Architettura, Università di Roma: Roma, Italy, 1960.
26. Verdiani, G. *Retroprogettazione Metodologie ed Esperienze di Ricostruzione 3D Digitale per il Patrimonio Costruito*; Dida Press: Firenze, Italy, 2017.
27. Apollonio, F.I. Classification schemes and model validation of 3D digital reconstruction process. In Proceedings of the 20th Cultural Heritage and New Technologies, Vienna, Austria, 2–4 November 2015; Börner, W., Uhlirz, S., Eds.; Museen der Stadt Wien-Stadtarchäologie: Vienna, Austria, 2016.
28. Bentkowska-Kafel, A.; Hugh, D.; Drew, B. (Eds.) *Paradata and Transparency in Virtual Heritage*; Ashgate: Farnham, UK, 2012.

29. Brusaporci, S. The Importance of Being Honest: Issues of Transparency in Digital Visualization of Architectural Heritage. In *Handbook of Research on Emerging Technologies for Architectural and Archaeological Heritage*; Ippolito, A., Ed.; IGI Global GI Global: Hershey, PA, USA, 2017; pp. 66–93.
30. Viscogliosi, A. Lo studio della Storia dell'Architettura fra tradizione e high-tech. *Disegnare Idee Immagin.* **2015**, *7*, 51.
31. Centofanti, M.; Brusaporci, S. Architectural 3D modeling in historical buildings knowledge and restoration processes. In *Less More*; Gambardella, C., Ed.; La Scuola di Pitagora: Napoli, Italy, 2012.
32. Brusaporci, S. (Ed.) *Sistemi Informativi Integrati per la Tutela la Conservazione e la Valorizzazione del Patrimonio Architettonico e Urbano*; Gangemi Editore: Roma, Italy, 2010.
33. El-Hakim, S.; Lapointe, J.; Whiting, E. Digital reconstruction and 4D presentation through time. In *SIGGRAPH '08: ACM SIGGRAPH 2008 Talks, Proceedings of the International Conference on Computer Graphics and Interactive Techniques (SIGGRAPH), Los Angeles, CA, USA, 11–15 August 2008*; Association for Computing Machinery: New York, NY, USA, 2008.
34. Frommel, C.L.; Ray, S.; Tafuri, M. *Raffaello Architetto*; Electa: Roma, Italy, 1984.
35. Fratarcangeli, M. (Ed.) Dal cavallo alle scuderie. Visioni iconografiche e architettoniche. In *Atti del Convegno Internazionale di Studi*; 12 Aprile 2013, Frascati, Museo Tuscolano, Scuderie Aldobrandini; Campisano Editore: Roma, Italy, 2014.
36. Frutaz, A.P. *Le piante di Roma*; Istituto Nazionale di Studi Romani: Roma, Italy, 1962.
37. Berti, C.; Gabellieri, N.; Gallia, A.; Grava, M. *Historical GIS. Strumenti Digitali per la Geografia Storica in Italia*; Edizioni Università di Trieste EUT: Trieste, Italy, 2020.
38. Grassi, C.; Ronchi, D.; Ferdani, D.; Franco Pocobelli, G.; Manganelli del Fà, R. A 3D survey in archaeology. Comparison among software for image and range-based data integration. In *D-SITE Drones—Systems of Information on Cultural Heritage for a Spatial and Social Investigation*; Pavia University Press: Pavia, Italy, 2022; pp. 138–145.
39. Fiorillo, F.; Rossi, C.; Galli, S. Interpretazione dei dati archeologici basata sul reperimento diretto e remoto delle informazioni. In *Serie di Conferenze IOP: Scienza e Ingegneria dei Materiali*; IOP Publishing: Bristol, UK, 2020; Volume 949, pp. 1–8.
40. Demetrescu, E.; Ferdani, D. From Field Archaeology to Virtual Reconstruction: A Five Steps Method Using the Extended Matrix. *Appl. Sci.* **2021**, *11*, 5206. [CrossRef]
41. Hassan, A.T.; Fritsch, D. Integration of Laser Scanning and Photogrammetry in 3D/4D Cultural Heritage Preservation—A Review. *Int. J. Appl. Sci. Technol.* **2019**, *9*, 76–91.
42. Adamopoulos, E. Multi-sensor documentation of metric and qualitative information of historic stone structures. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2019**, *4*, 1–8. [CrossRef]
43. Barsanti, S.G.; Remondino, F.; Visintini, D. 3D Surveying and Modeling of Archeological Sites—Some Critical Issues. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.* **2013**, *2*, 145–150. [CrossRef]
44. Beraldin, J.A. Integration of laser scanning and close-range photogrammetry—The last decade and beyond. In Proceedings of the XXth ISPRS Congress, Isttabul, Turkey, 12–23 July 2004; Volume 35, pp. 12–23.
45. Remondino, F. Heritage Recording and 3D Modeling with Photogrammetry and 3D Scanning. *Remote Sens.* **2011**, *3*, 1104–1138. [CrossRef]
46. Fassi, F. 3D modeling of complex architecture integrating different techniques—A critical overview. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2007**, *36*, 1–11.
47. Chiavoni, M.; Filippa, M.; Docci, M. (Eds.) *Metodologie Integrate per Il Rilievo, il Disegno, la Modellazione dell'Architettura e della Città*; Gangemi Editore: Roma, Italy, 2011.
48. Cundari, C. *Il Rilievo Architettonico: Ragioni, Fondamenti, Applicazioni*; Kappa-Aracne: Roma, Italy, 2018.
49. Ferdani, D.; Demetrescu, E.; Cavalieri, M.; Pace, G.; Lenzi, S. 3D Modelling and Visualization in Field Archaeology. From Survey to Interpretation of the Past Using Digital Technologies. *Groma* **2019**, *4*, 1–21. [CrossRef]
50. Hermanin, F. *La Farnesina*; Istituto Italiano d' Arti Grafiche: Bergamo, Italy, 1927.
51. Bartoli, L. L'unità di misura e il modulo proporzionale nell'architettura del Rinascimento. In *Quaderno dell'Istituto di Elementi di Architettura e Rilievo dei Monumenti dell'Università di Genova*; Edizioni Studium: Roma, Italy, 1970; Volume 6, pp. 129–137.
52. Milizia, F. *Memorie Degli Architetti Antichi e Moderni*; Dalla Stamperia Reale: Parma, Italy, 1781.
53. Geymuller, E. *Raffaello Sanzio Studiato Come Architetto*; Hoepli: Milano, Italy, 1884.
54. Cugnoni, G. *Agostino Chigi il Magnifico. Note al Commentario di Alessandro VII Sulla Vita di Agostino Chigi*; Bardi Edizioni: Roma, Italy, 2021.
55. Firpo, L. *Leonardo Architetto e Urbanista*; Casa Editrice UTET: Torino, Italy, 1971.
56. Buonafede, G. *I Chigi Augusti*; Editore F. Valvavense: Venetia, Italy, 1660.
57. Máñez Pitarch, M.J.; Garfella Rubio, J.T. The diffusion of architectural heritage, through social networks, as a digital heritage. *DisegnareCon* **2019**, *12*, 41–417.
58. ICOMOS. European Charter of Architectural Heritage. 1975. Available online: http://www.icomos.org/en/charters-and-texts/179-articles-en-francais/ressources/charters-and-standards/170-european-charter-of-the-architectural-heritage (accessed on 1 April 2023).