



Article

The Mosque-Cathedral of Cordoba: Graphic Analysis of Interior Perspectives by Girault de Prangey around 1839

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Abstract: The work of Philibert Girault de Prangey, who was a draughtsman, pioneering photographer and an Islamic architecture scholar, has been the subject of recent exhibitions in his hometown (Langres, 2019), at the Metropolitan Museum (New York, 2019) and at the Musée d’Orsay (Paris, 2020). After visiting Andalusia between 1832 and 1833, Prangey completed the publication “Monuments arabes et moresques de Cordoue, Seville et Grenada” in 1839, based on his own drawings and measurements. For the first time, this research analyses his interior perspectives of the Mosque-Cathedral of Cordoba (Spain). The novel methodology is based on its comparison with a digital model derived from the point cloud captured by a 3D laser scanner. After locating the different viewpoints, the geometric precision and the elaboration process are analysed, taking into account historic images by various authors, other details published by Prangey and the architectural transformations of the building. In this way, the veracity and documentary interest of some beautiful perspectives of a monument inscribed on the World Heritage List by UNESCO is valued.

Keywords: Mosque-Cathedral; Cordoba; Girault de Prangey; view; perspective; 3D laser scanner



Citation: Gámiz-Gordo, A.; Cantizani-Oliva, J.; Reinoso-Gordo, J.F. The Mosque-Cathedral of Cordoba: Graphic Analysis of Interior Perspectives by Girault de Prangey around 1839. *ISPRS Int. J. Geo-Inf.* **2021**, *10*, 181. <https://doi.org/10.3390/ijgi10030181>

Academic Editors: Wolfgang Kainz and Andreas Georgopoulos

Received: 12 February 2021

Accepted: 14 March 2021

Published: 19 March 2021

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1. Introduction

1.1. Brief Historical Overview of the Mosque-Cathedral of Cordoba

Over the centuries, the Mosque-Cathedral of Cordoba has been transformed and adapted to the needs of each period, without losing the essential features of its architectural identity [1]. In its long history, three major stages can be considered, which are outlined below.

The first Umayyad mosque was built in the middle of the 8th century by Abd al-Rahman I, with arches and parallel naves that facilitated the southern expansion by Abd al-Rahman II and later by Al-Hakam II. The last eastern extension was completed by Almanzor in the 10th century, filling a space with surprising interior perspectives between columns and double horseshoe arches [2–4]. The skylight of the first mihrab, today the Villaviciosa chapel, and three other ones next to the Al-Hakam II mihrab were especially important for its natural lighting [5].

The second stage began with the town conquest by King Ferdinand III in 1236. While other mosques in the Iberian Peninsula were demolished and replaced by churches or cathedrals, the Mosque of Cordoba was used as a Christian temple and survived with important transformations. Around 1313, the Capilla Real (Royal Chapel) was built inside the cathedral for the burial of Ferdinand IV of Castile, together with the Villaviciosa Chapel [6]. Between 1523 and 1607, a large volume was erected in the building centre that heavily altered it [7] and, progressively, the inner perimeter was occupied by chapels. In the first quarter of the 18th century, many naves were covered with plaster vaults, new

skylights were opened and the interiors were covered with lime to achieve greater clarity and visual unity.

A third stage began around 1815, after restoring the entrance arch to the mihrab. In the second half of the 19th century, the altarpiece in the Villaviciosa Chapel was removed and its original skylight was revealed. Between 1864 and 1884, the lime coating was removed. In 1887, the architect Ricardo Velázquez Bosco took over the building conservation, and since then, architectural pieces from different periods have been recovered [8]. This monument was inscribed on the World Heritage List in 1984 and the property was extended to include part of the Historic Centre in 1994 [9] (Figures 1–3).

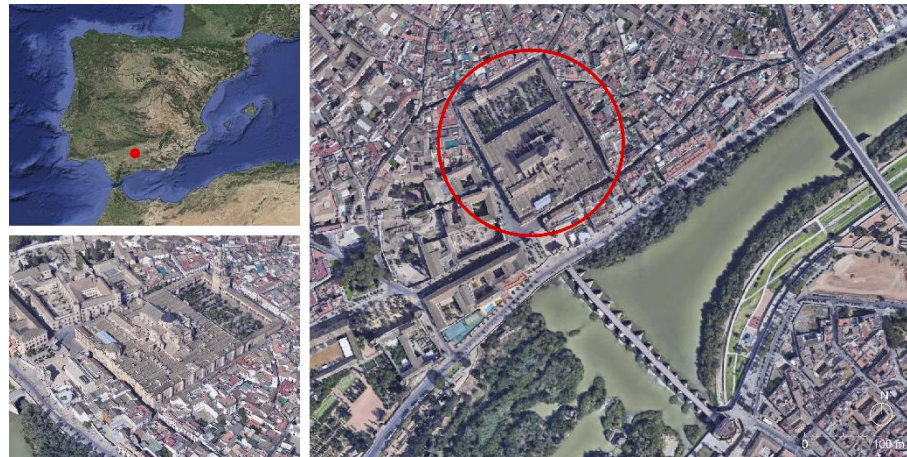


Figure 1. The geographical location of Cordoba in southern Europe and the Mosque-Cathedral placement downtown near the Guadalquivir river and Roman bridge.

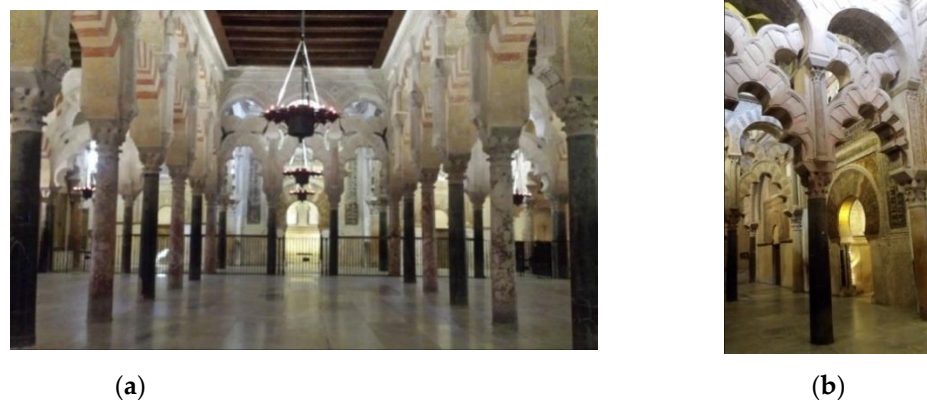


Figure 2. Inner view: (a) Mihrab front and (b) Mihrab side. Source: Own photographs.



Figure 3. Inner view: (a) columns forest and (b) Royal Chapel. Source: Own photographs.

1.2. Interior Views of the Mosque-Cathedral in the First Half of the 19th Century

The Mosque-Cathedral of Cordoba has been illustrated in many images before the spread of photography around 1850. This graphic legacy is very important in heritage research and is complemented by other historical or archaeological documentary sources, both Muslim [10] and Christian [11], and with the analysis of the architectural reality itself.

The first scaled plans of the monument were published by the Real Academia de Bellas Artes de San Fernando in Madrid in “Las Antigüedades Árabes de España” (1787–1804) [12]. The first interior perspective appeared in Henry Swinburne’s book, “Travels through Spain, in the Years 1775 and 1776” (1779) [13]. The first collection of views was published in Alexandre Laborde’s book, “Voyage pittoresque et historique de l’Espagne” (1812, t. II) [14]. In the first third of the 19th century, the views of James C. Murphy were remarkable in “The Arabian Antiquities of Spain” (1813) [15], as were the ones by Isidore Taylor in “Voyage pittoresque en Espagne, et Portugal, et sur la cote d’Afrique” (1826–1832–1860) [16].

Particularly noteworthy views from the 1830s include those by David Roberts in “Picturesque sketches in Spain taken during the years 1832–1833” (1837) [17] and “The tourist in Spain. Andalusia” (1838, t. II) [18], by John Frederick Lewis in “Sketches of Spain & Spanish Character made during his Tour in that Country in the Years 1833–1834” (1837) [19], as well as the work of Girault de Prangey (the focus of this study), “Monuments Arabes et Moresques de Cordoue, Séville et Grenade, dessinés et mesurés en 1832 et 1833 . . . ” (1839) [20].

Later, other views of Francisco Javier Parcerisa were published in “Recuerdos y bellezas de España” (1855, t. 8) [21] and the plates of the Real Academia de Bellas Artes de San Fernando in Madrid entitled “Los Monumentos Arquitectónicos de España” (1852–1881) [22].

Studies on these images have been scarce, though many have been re-produced repeatedly. A book by Nieto-Cumplido and Luca-de-Tena (1992) [23] compiled the main plans and drawings of the Mosque-Cathedral, but did not include urban or interior views. Another book by Cosano-Moyano (1999) [24] included all kinds of images from Cordoba. In three articles by Gámiz-Gordo and García-Ortega (2012, 2015 and 2018), the views of Alexandre Laborde in 1812 [25], David Roberts in 1833 [26] and others [27] have been analysed.

The surveys on the monument preserved in the Real Academia de Bellas Artes de San Fernando have been part of an exhibition and catalogue curated by Almagro-Gorbea (2015) [28]. The first photographs and photographers of the Mosque-Cathedral, between 1844 and 1875, have been presented in a book by González (2018) [29]. Another book with current plans by Ruíz-Cabrero (2009) [30] and Herrero-Romero’s thesis on restoration in the 20th century (2015) should also be highlighted [31]. Furthermore, an article by Gámiz-Gordo (2019) [32] reviews graphic sources up to 1850.

1.3. Girault de Prangey: Draughtsman, Traveller, Islamic Architecture Scholar and Photographer

Joseph Philibert Girault de Prangey (1804–1892) was a draughtsman, pioneering photographer and scholar of Islamic architecture (Figure 4a). The museum in his hometown, Langres (France), devoted a small book to him in 1998 [33] and, in 2020, the museum held an exhibition with a catalogue that provides abundant information and illustrates the artist's solid education [34]. Prangey studied at the École des Beaux-Arts in Paris. He inherited a great fortune that allowed him to travel and indulge his interest in Islamic architecture. He took a trip to Italy in 1831 and others to Tunisia, Algeria, Spain and Sicily between 1832 and 1833.

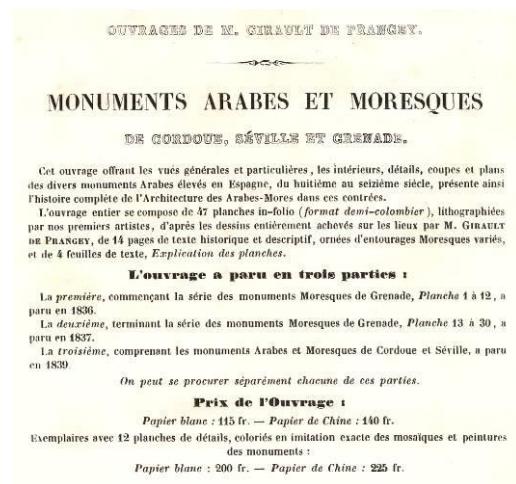
According to the date of one of his original drawings, on 4 October 1832, he embarked on his journey to Spain. Girault de Prangey appears in the visitor's signature book kept at the Alhambra on 12 November and 4 December 1832 [35]. According to the abovementioned catalogue, several original drawings from Granada are signed in June and July 1833, and others from Tarragona and Barcelona in October 1833. Thus, he spent several months in Andalusia, but no information is known about his visits to Seville and Cordoba, except for his published views.

After this stay, Girault de Prangey published "Monuments Arabes et Moresques de Cordoue, Séville et Grenade, dessinés et mesurés en 1832 et 1833 . . . Mosquée de Cordoue, Giralda et Alcazar de Séville: vues générales, intérieurs, détails, coupes et plans de ces monuments" [20] printed at the prestigious Lemercier et Cie. from Paris and edited by Veith et Hauser. According to ads at the time, the pictures of Granada appeared in 1836 and 1837, and those of Seville and Cordoba in 1839 (Figure 4b).

On the cover, the Cordoba views are said to have been drawn in 1833 by Girault de Prangey, although a general view is signed by Leon Auguste Asselineau as a draughtsman. Engravers whose names appear on each plate collaborated on the figures. Such engravers include Leon Auguste Asselineau, Louis Philippe Alphonse Bichebois, Charles Villemin, William Wyld, Jean Charles Danjoy, Paul Dumouza and Adolphe Jean Baptiste Bayot.



(a)



(b)

Figure 4. (a) Girault de Prangey's self-portrait (1840). Source: gallica.bnf.fr, Bibliothèque Nationale de France; (b) Plate ads from Granada (1836 and 1837), Cordoba and Seville (1839). Source: Private collection.

In 1841, Girault de Prangey published the book entitled "Essai sur l'architecture des Arabes et des Mores, en Espagne, en Sicile et en Barbarie" [36] that includes plates of the Mosque of Cordoba, which will be mentioned later. Furthermore, in 1842, he published another book entitled "Choix d'ornements moresques de l'Alhambra" [37] including some views from the Andalusian monument.

Between 1839 and 1849, the French historian Jules Gailhabaud published various editions of the work entitled “Monuments anciens et modernes . . . ” including plates about the architecture history of different peoples ranging through all their periods [38]. Many authors collaborated on that publication, and some plates from the Mosque of Cordoba, that will be commented on later, were included. The invention of the daguerrotype in 1839 was a great interest to Prangey, who was using it to take images of monuments in Paris by 1841 [39]. He then decided to study other Mediterranean landmarks and, in 1842, began a three-year journey. He produced more than 800 daguerreotypes in Greece, Egypt, Syria, Lebanon, Turkey, and Jerusalem. In 1846, he published “Monuments arabes d’Égypte, de Syrie et d’Asie-Mineure dessinés et mesurés de 1842 à 1845” [40].

These publications can be considered as complementary and offer a remarkable graphic synthesis on the characteristics and periods of Islamic art in the Mediterranean. Although Prangey’s theories have been nuanced by historiography, they contributed an incredibly unique value to his graphic work compared to other works of that time.

His entire work and his interest in graphically documenting architecture has raised great interest since Christie’s London Auction auctioned the artist’s daguerreotypes in 2003 and 2004 [41–43]. The exhibition *Monumental Journey: The Daguerreotypes of Girault de Prangey*, held in 2019 at the Metropolitan Museum in New York, included 120 daguerreotypes taken during his Mediterranean journey, as well as paintings, watercolours and lithographs [44]. Between 2020 and 2021, the Musée d’Orsay in Paris devoted another exhibition to his activity as a photographer [45].

1.4. General Objectives

Prangey made his own drawings and measurements in the Mosque-Cathedral, when photography did not yet exist, as the basis for his later published images. It is not known if in Cordoba he was able to use advanced instruments, such as the camera lucida, which he apparently had previously used [46,47].

In any case, the veracity of the data reflected in any drawing should not be taken for granted, as they are always more or less accurate personal views, with a graded simplification of reality. Assessing the precision or certainty from each drawing requires analysing the real model that contrasts the faithful description of the photograph. The interests or abilities of the draughtsman and even the possible manipulations of the original drawings for their stamping should also be considered.

Studies on the images of Girault de Prangey in Andalusia are scarce. Some comments about his views of Granada in a book by Galera-Andreu on the romantic image of the Alhambra in the 19th century should be highlighted [48], as well as those in a book by Orihuela-Uzal and Tito-Rojo on the Casas del Chapiz [49]; in an article by Orihuela-Uzal about a hammam [50]; and in another recent one by Sánchez-Gómez and Piñar-Samos [51]. Prangey’s views of Cordoba have not been studied until now.

There is also no research on the documentary reliability of the Mosque-Cathedral drawings prior to the appearance of photographs around 1850. It is only worth mentioning a study by Almagro-Gorbea on the precision of plans preserved in the Real Academia de Bellas Artes de San Fernando in Madrid [52], which does not include anything on perspectives.

The aim of this research is to analyse Girault de Prangey’s interior perspectives of the Mosque-Cathedral of Cordoba and to assess their veracity, geometric reliability and documentary interest, considering at that time Prangey had not yet begun to use daguerrotype as a technique for the documentary record of architectural heritage. To do this, a digital model with the geometry of the monument has been created using 3D laser scanner data, and then compared to Prangey’s perspectives, taking into account the transformations that the monument has undergone and the drawings by other authors.

The digitisation of architectural heritage has undergone a great development in recent decades thanks to data collection technologies that allow accurate and efficient modelling [53]. There is an abundant literature on the use of the 3D laser scanner and the

subsequent processing to obtain some meshes. Many articles refer to survey methods of historical buildings, civil structures, archaeological objects, etc. Others refer to processes for generating heritage information models (as-built models) based on 3D digitisation [54–56]. Comparisons between historical drawings and 3D digitisation is a field where research can unveil important findings and they have got remarkable results [57]. In any case, it seems important to obtain suitable accuracy, considering the model size and whether it is a complete building [58,59], certain parts [60,61], structural elements [62], decorative details [63] or even isolated sculptures [64]. The proceedings of the latest Graphical Heritage International Congress, held in 2020, have also been reviewed [65].

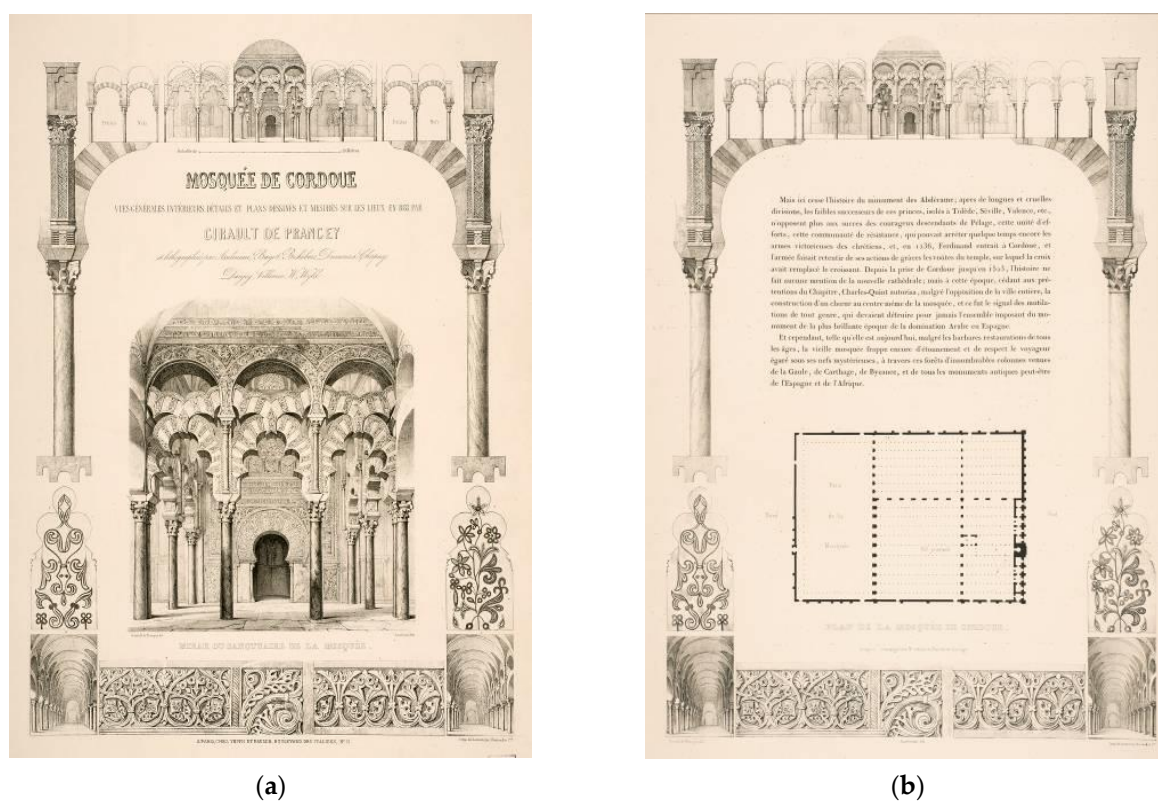
It should not be forgotten that the graphic documentation in architectural heritage always depends on the interests or objectives proposed in each case [66]. Due to the large size of the Mosque-Cathedral, it has been necessary to sketch its details according to scale and accuracy in order to streamline work. A careful simplification of reality has been carried out to build a simple geometric model and obtain linear perspectives from the point cloud. The novelty of this research is to use said digital model to assess the perspectives of a great draughtsman of the 19th century, taking into account the history and transformations of the monument.

2. Materials and Methods

2.1. Prangey's Images of the Mosque-Cathedral of Cordoba

The Langres exhibition catalogue [34] contains original drawings by Prangey that give an idea of his solid education as a draughtsman. However, his original views of Cordoba are not known, and, for this reason, this work focuses on the published plates, which were reworked by different engravers for their stamping.

In “Monuments arabes et moresques de Cordoue . . . ” (1839) [20], a view of the mihrab lithographed by Asselineau (Figure 5a) appears on the cover. The plates' edges are composed of details and ornaments of the building.



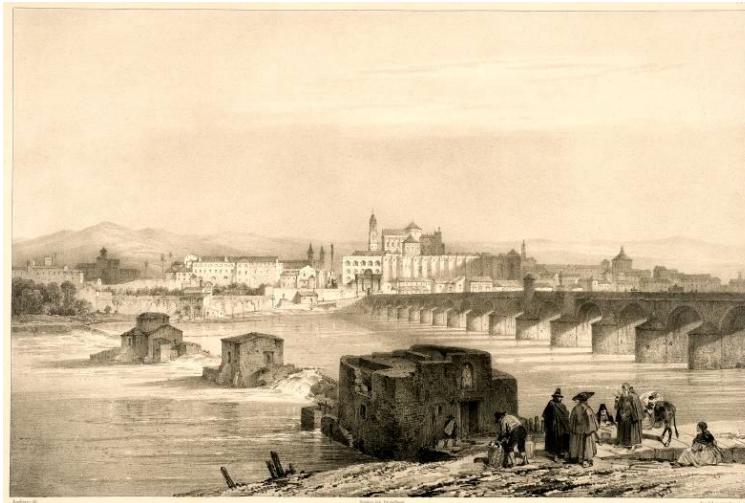
(a)

(b)

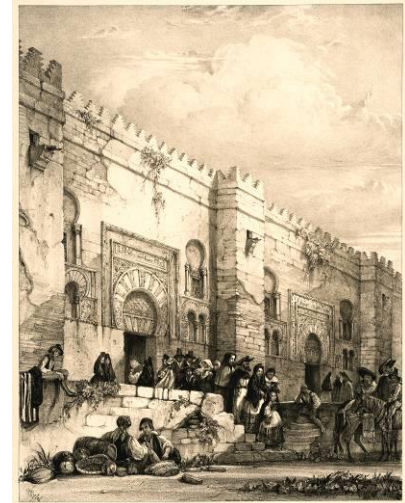
Figure 5. Girault de Prangey: (a) Publication cover including mihrab view (Asselineau, lit.) (b) Building plant hypothesis in the Islamic period. Source: Monuments arabes et moresques de Cordoue, Seville et Grenada, 1839.

The details mentioned above were used in another plate including a schematic plan of the building in Islamic times (Figure 5b). It marks the perspective viewpoints that appear in other plates, all of which were produced in the Al-Hakam II extension, one of the most architecturally interesting parts of the monument.

The first plate (plate 1; Figure 6a) includes a general view of the Mosque-Cathedral and the Roman bridge in their urban context. It was drawn from the other bank of the Guadalquivir river by Asselineau, a collaborator of Prangey. Another exterior view (plate 4; Figure 6b) shows the access doorways to the Mosque.



(a)



(b)

Figure 6. Mosque-Cathedral of Cordoba views: (a) The Guadalquivir river, the Roman bridge and the town (Bichebois, lit.; Bayot, fig.) (b) Lateral entrance facade (Wyld, lit.). Source: *Monuments arabes et moresques de Cordoue*, 1839.

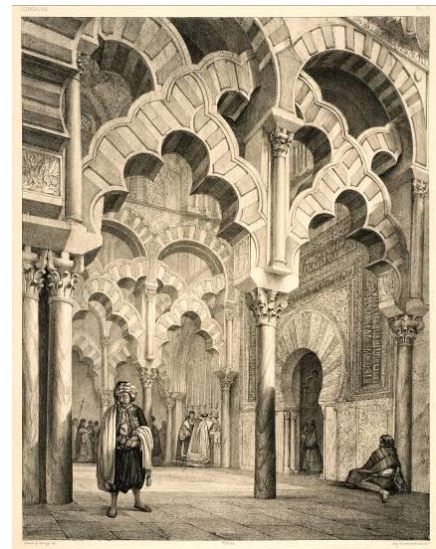
Prangey's two most significant interior perspectives focused on the surroundings of the Mosque mihrab. One of them, more general (plate 5; Figure 7a), comprises the forest of columns and the double horseshoe arches. The other one (plate 7; Figure 7b) is closest to the mihrab and frames its intertwined arches.

A perspective of the Royal Chapel was erroneously entitled *Capilla de Villaviciosa* (plate 2; Figure 8a), which is located right next to it, where Abd al-Rahman II's mihrab was. The archeries with double arches can be seen at the bottom of the drawing. Another plate including a mihrab sectional elevation is framed by decorative details (plate 8; Figure 8b).

In addition, Prangey composed two plates with capitals, muqarnas and ornaments from the Royal Chapel and the mihrab, represented by elevations or perspectives (plate 3; Figure 9a, plate 6; Figure 9b).



(a)



(b)

Figure 7. Girault de Prangey: (a) Front view from the forest of columns and mihrab (Villemin, lit.); (b) Mihrab side view (Wyld, lit.). Source: *Monuments arabes et moresques de Cordoue*, 1839.



(a)



(b)

Figure 8. Girault de Prangey: (a) Royal Chapel side view (Villemin, lit.); (b) Section-elevation and details from mihrab (Dumouxa, lit.). Source: *Monuments arabes et moresques de Cordoue*, 1839.

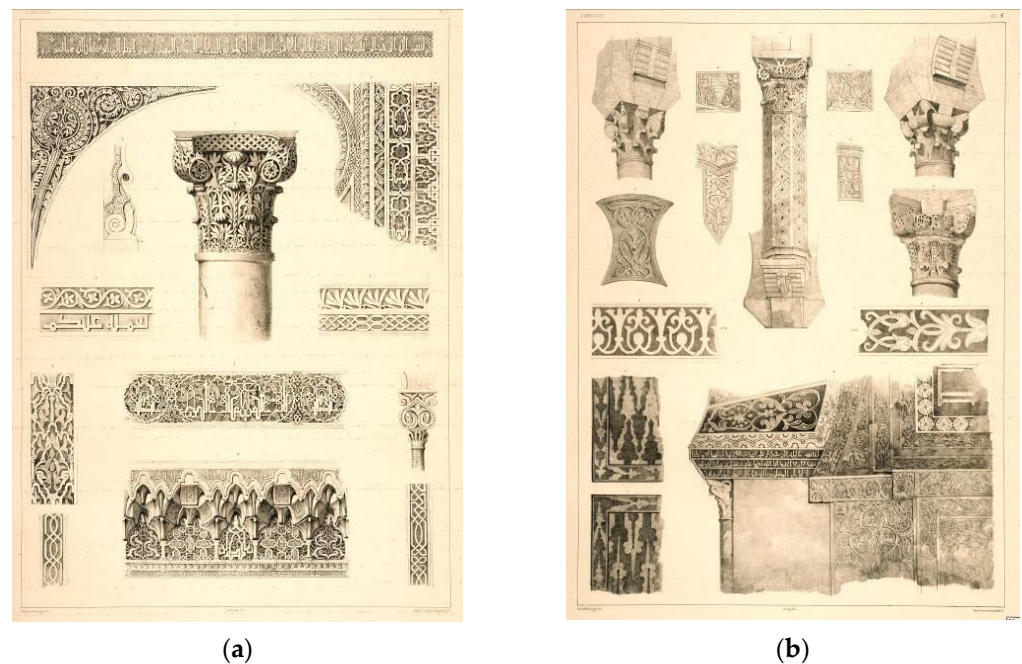


Figure 9. Girault de Prangey. (a) Details (Asselineau, lit.); (b) Details (Danjoy, lit.). Source: *Monuments arabes et moresques de Cordoue*, 1839.

Prangey published four plates on the Mosque-Cathedral of Cordoba in his work “*Essai sur l’architecture des Arabes et des Mores, en Espagne, en Sicile et en Barbarie*” (1841) [36]. One includes an elevation and details from the Villaviciosa Chapel (plate 3; Figure 10a). Another plate is a perspective section from the space next to the mihrab (plate 6; Figure 10b), which was drawn by Nicolás Chapuy, and it included in the same plate a similar image from a mosque in Toledo. It also includes a plate with coloured details (plate 4; Figure 11a) and another with Arabic inscriptions (plate 5; Figure 11b).

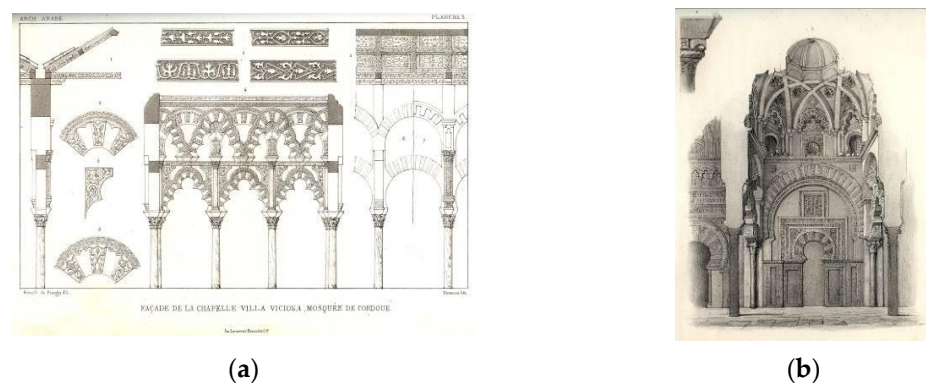


Figure 10. Girault de Prangey: (a) Villaviciosa Chapel facade (Bouillon, lit.); (b) Section-perspective from the surrounding mihrab (Chapuy, dib.; Asselineau, lit.). Source: *Essai sur l’architecture des Arabes et des Mores, en Espagne . . .* 1841.



Figure 11. Girault de Prangey: (a) Details and mosaics (Dumouza, lit.); (b) Arabic inscriptions (Asselineau, lit.). Source: *Essai sur l'architecture des Arabes et des Mores, en Espagne . . .* 1841.

Furthermore, in Jules Gailhabaud's work, "Monuments anciens et modernes . . ." (c. 1845) [38], there are five plates of the Mosque-Cathedral: three views copied from other authors; one with a general plan and section including details, drawn by J. Jourdan and based on Prangey (Figure 12a); and another with details drawn by Prangey and Niel (Figure 12b).

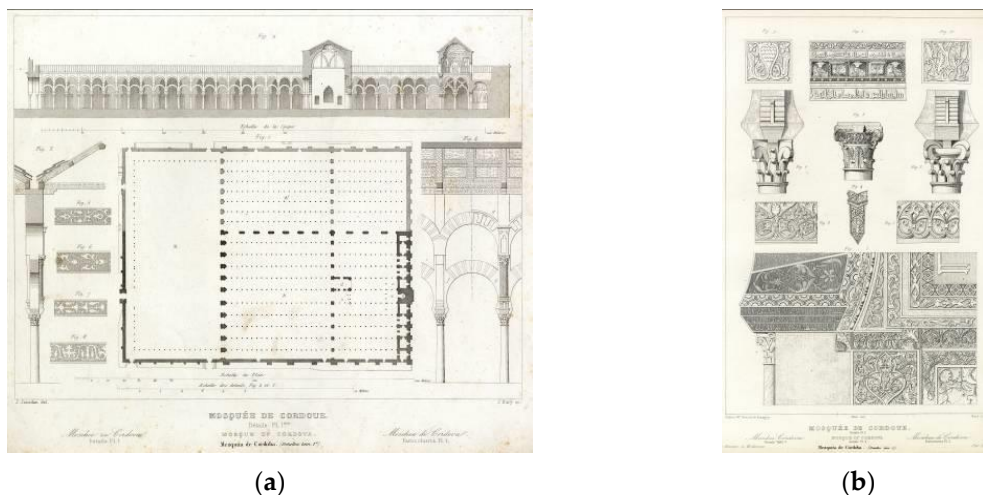


Figure 12. Girault de Prangey: (a) General plan and section and details from the Mosque (Jourdan, dib.; Bury, eng.); (b) Mosque details (Prangey, dib.; Niel, dib.; Bury, eng.). Source: *Monuments anciens et modernes . . .* c. 1845.

2.2. Obtaining the Point Cloud

A point cloud has been obtained from the area of the Mosque-Cathedral enlarged by Al-Hakam II, in which Girault de Prangey drew his views. Two laser scanners from the Department of Graphic Expression in Architecture and Engineering of the University of Granada, Leica C10 and Leica BLK360, have been used, with the following specifications:

Leica C10 (Figure 13a): It has a double axis compensator for levelling with an accuracy of 1", while the 3D positioning of a point is performed with an accuracy of 6 mm. It has a laser plummet that allows stationing on a predetermined point on the ground. It can scan a 360° horizontal field of view and a 270° vertical one. Its spatial resolution is variable: medium resolution implies capturing points every 10 cm, assuming a plane is 100 m away, while the high resolution would imply 5 cm at 100 m.

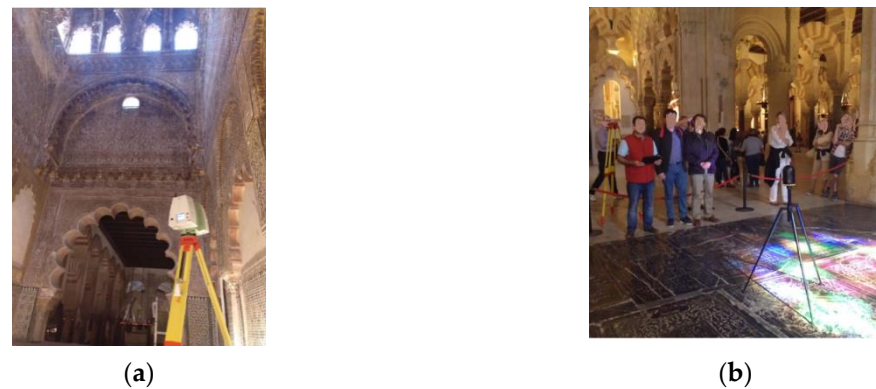


Figure 13. Scanners used to obtain the point cloud: (a) Leica C10; (b) Leica BLK360. Source: Own photographs.

Leica BLK360 (Figure 13b): This scanner is not able to be levelled or stationed, but it has a 360° scanning field of view similar to the C10. The spatial resolutions for positioning points in 3D are 20 mm, 10 mm and 5 mm at 10 m, which are referred to as low, medium and high resolution, respectively.

The C10 scanner was used to establish the reference system and level the entire point cloud model. To do this, it was stationed at point mq1 and the mihrab nave was oriented as the X axis. With this orientation, a target was placed (Figure 14a) on the mq7 point, the coordinates of which were obtained by radiation with the C10 from its station in mq1—simultaneously, a scan was obtained with the C10 at mq1.

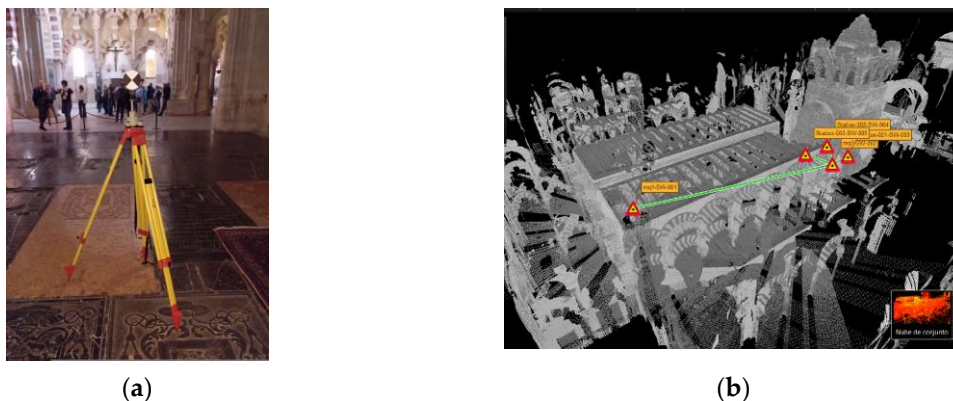


Figure 14. (a) Target used to give coordinates and get orientation (b) links between scan stations. Source: Own images.

To link the Royal Chapel, located on a higher level, in the same coordinate system, the C10 was stationed at mq7 and oriented at mq1 with an error of 4 mm, after which it performed a scan. Three additional free scans were carried out in the Royal Chapel, which were recorded automatically with the Cyclone Register 360 software, resulting in an error of 4 mm in all the links. The distribution of the stations is shown in Figure 14b.

The remaining scans were performed with the BLK360, carrying out four itineraries. They all started their registration using the C10 scan stationed at the mq1 reference. Figure 15a shows the baseline and the scans recorded by the C10 (colour yellow) and the four traverses by the BLK360 (colour white). These traverses refer to the surroundings of Villaviciosa Chapel and the mihrab central nave (traverse 1), two lateral naves (traverses 2 and 3) and the mihrab (traverse 4).



Figure 15. Scan trajectories. (a) General plan; (b) interior view (the spheres mark the scanner positions). Source: Own images.

Figure 15b shows a view where the locations of the scans are represented by spheres; the whole point cloud was built from those scans.

All the scans were performed with medium resolution, which means a separation between captured points of 1 cm at a distance of 10 m.

The records made with the BLK360 scanner have been processed with Recap, and their quality measurements have been obtained using the following parameters: overlap (common volume percentage between the reference scan and the registered one), balance (amount of data captured in the three orthogonal directions of space and how much these directions have influenced the constriction of the registered scan) and percentage points with an error below 6 mm (between the reference scan and the registered scan). Table 1 shows a quality summary obtained for each of the traverses carried out with the BLK.

Table 1. Summary of the quality obtained in the four itineraries carried out with the BLK360 scanner.

Traverse	Overlap	Balance	% <6 mm
1	62.5855	53.9155	99.3852
2	58.1112	54.1019	99.9587
3	56.9395	55.7934	99.9459
4	62.9627	49.9022	99.2762

2.3. The 3D Model Geometric Construction

The 3D digital model of the building's current state has been made by importing the point cloud to CAD as a reference. To define the geometry, orders have been used to obtain lines or edges, as well as planes and intersections from said cloud.

To draw it, the geometric characteristics of the architectural elements that make up the monument have been analysed. Having a deep understanding of these elements is very important to undertake the simplification or graphic synthesis of a large building, considering the relevant scales or details.

First, recurring elements (arches, capitals, etc.) were drawn as the basis for the graphic construction of the whole building. For this, the representation criteria used in important drawings of the 19th century were reviewed: Academics (1787; 1804) [12], Laborde (1812) [14], Murphy (1813) [15], Parcerisa (1855) [21] and "Los Monumentos Arquitectónicos de España" (1852–1881) [22]. The graphic conventions in drawings of the 20th century [23] and others made with a computer in the 21st century [30] have also been reviewed, considering the interests of the authors and the scale of each drawing.

In addition, the proportion theories of Rafael de la Hoz have been considered (1924–2000). After studying the Mosque-Cathedral and other Arabic designs in Cordoba, Rafael de la Hoz detected the repeated appearance of the number 1.306562964876 . . . , which he called the "Cordovan proportion" [67,68].

All this has facilitated the construction of simple modules as the digital model basis. Overlapping the grouping of modules on the point cloud revealed that there are small deformations due to restorations or repairs over centuries (Figure 16a). The workflow was simplified, equalising all the modules with dimensional differences of less than 2% (Figure 16b). This accuracy degree is far superior to that required in the schematic perspectives that are to be overlaid with Prangey's perspectives.

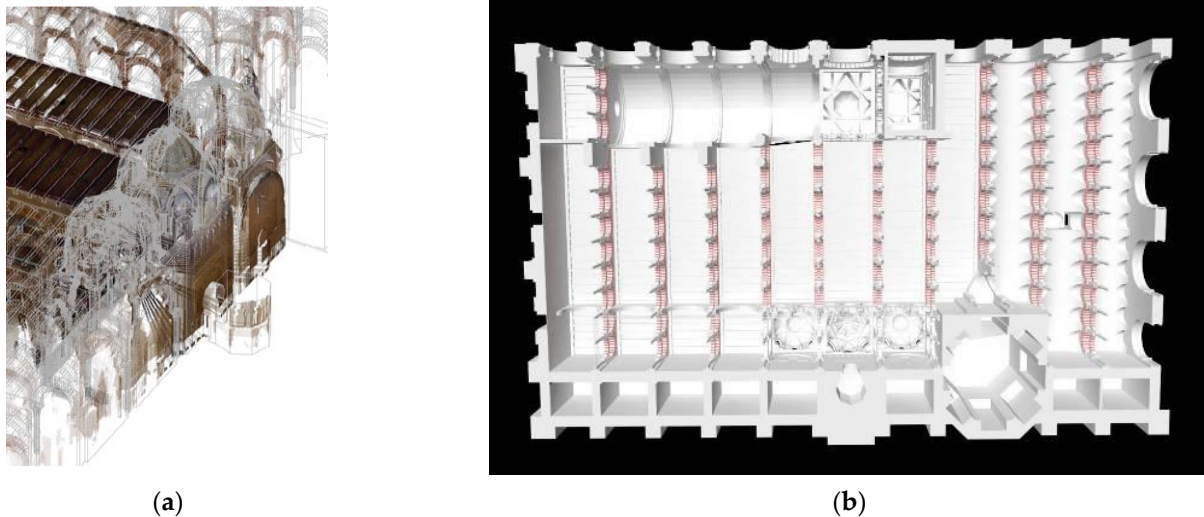


Figure 16. Detail from the Al-Hakam II expansion in the Mosque of Cordoba: (a) Overlapping between the geometric model and the point cloud; (b) 3D geometric model derived from the point cloud (view from bottom). Source: Own images.

2.4. Location of Viewpoints and Horizon Lines; Prangey's Viewpoints and 3D Model Overlapping

The viewpoints were identified in an earlier visit to the monument and from them each perspective were located in the digital geometric model (Figure 17), which Girault de Prangey indicated in a schematic plan of the building in Islamic times, as mentioned above (Figure 5b).

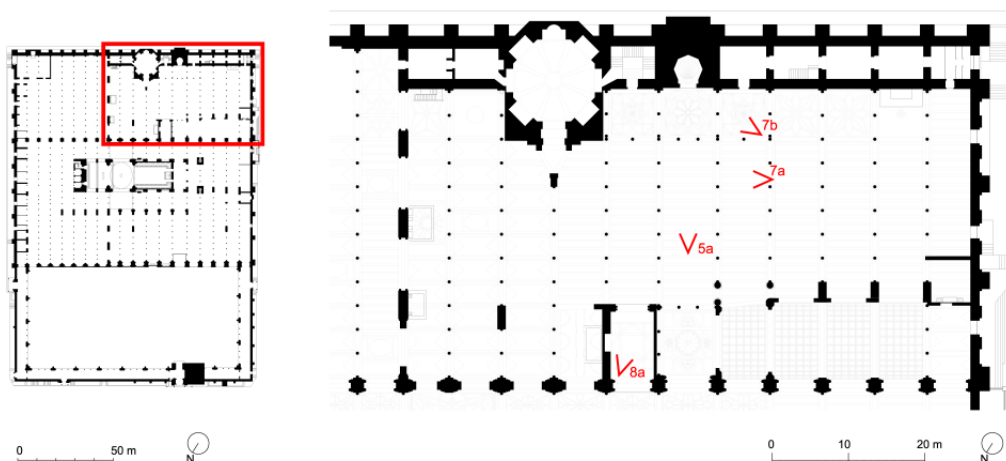


Figure 17. Location of Prangey's viewpoints marked on the current plan. Source: Own image.

In the mihrab front view (Figure 18a), the viewpoint is centred on the nave with a position close to the ground. The local coordinates are 3505.545 m and 3824.231 m and the viewpoint height is 1.20 m.



Figure 18. Horizon and vanishing lines on the Girault de Prangey perspectives: (a) Mihrab front view; (b) Forest of columns and mihrab view. Source: Own production.

In the mihrab's side view with the forest of columns, the local coordinates are 3500.544 m and 3811.877 m; the height of the viewpoint is similar to the previous case (Figure 18b).

In the detailed side view of the mihrab (Figure 19a), the vanishing points are outside the image. The local coordinates are 3504.006 m and 3806.937 m and the viewpoint height is 1.00 m.



Figure 19. Location of horizon and vanishing lines in the Girault de Prangey's perspectives: (a) Side view of the mihrab; (b) Royal Chapel view. Source: Own production.

The elevated view from the Royal Chapel has two vanishing points, and the local coordinates are 3504.088 m and 3845.140 m and the viewpoint height is 2.65 m (Figure 19b).

After locating the viewpoints in the 3D geometric model derived from the point cloud, the interior elevations that appear in the inner elevations of Prangey's viewpoints were visualised. It should be taken into account that a common method of drawing conic architectural perspectives manually is to use these inner elevations as the basis for graphic production. Prangey sometimes placed the elevations both frontally in true size, and in other cases, he used a vanishing point for foregrounds. In addition, the horizon line height has been taken into account, which, according to the rules of the conical perspective, is always located at the draftsman or observer's eye level. The vanishing points are placed on the horizon line, also considering the angle of view covered in each case. This methodology facilitated overlapping the 3D model on Prangey's viewpoints, to assess its accuracy and its level of agreement, as explained below.

3. Results and Discussion

3.1. Front Perspective of the Mihrab

The Prangey mihrab front view fits quite well when overlapped with the digital geometric model in the interlaced portico arches represented in the foreground (Figure 20) and also in the background.

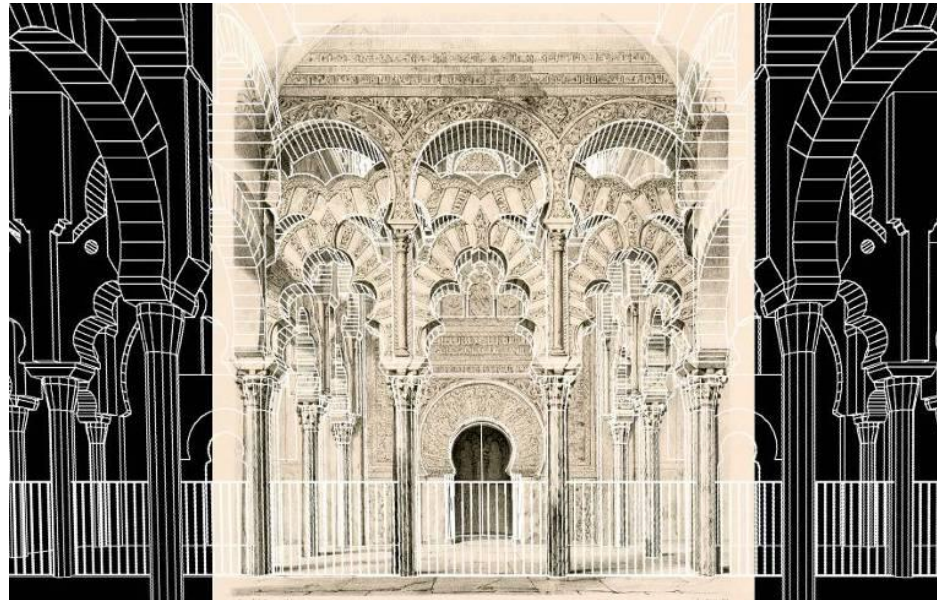


Figure 20. Girault de Prangey (1839): Digital model overlapping the mihrab perspective. Source: Own production.

However, the absence of the current grille is surprising, as it was placed there after 1741 and drawn by Swinburne in 1775-75 [13] and Lewis in 1833 [19]. Today, it is lower in height because it was lowered in the restorations by architect Velázquez Bosco [31].

Among the details located on the edges of the plate, there is a similar view above, more schematic and with a wider field of view. It is obvious that it is not a photographic view, because when such a wide field of view is covered, reality would be distorted. When compared with the geometric model, it is observed that the foreground arches are fairly consistent, as is the mihrab arch (Figure 21). There is a surprising coincidence in the height of the columns, capitals and the layout of the arches. However, the side arches of the Treasury and Sabbath are poorly located, as they are on both sides of the mihrab but far apart. It seems clear that this perspective was drawn from the arcade elevation in the foreground, which was accurately measured.

This is of great interest because it reveals that the original level of the ground has changed throughout the history of the monument. [11]. The superimposition of the drawings confirms that the mihrab environment has maintained its level from 1833 to the present, after the pavement was replaced by the architect Velázquez Bosco at the beginning of the 20th century.

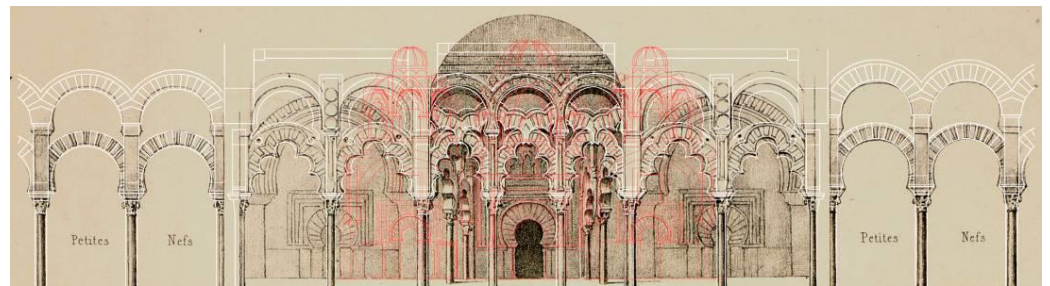


Figure 21. Girault de Prangey (1839): Digital model (white foreground and red background) overlapping the surroundings of the mihrab. Source: Own production.

3.2. Mihrab Side Perspective Along with the Forest of Columns

This interior view of the monument would only be possible if the arcade closest to the draughtsman were removed, so as not to obscure the next arch work. The geometric overlap between the model and Prangey's drawing is quite similar. Despite the complexity of the frame, there is a certain agreement even in the layout of the most distant planes (Figure 22).



Figure 22. Girault de Prangey (1839). Digital model overlapping the mihrab side and the forest of columns. Source: Own production.

The grille that delimited the mihrab area were also not drawn in this case. The lighting that comes from the skylight that was dismantled by Velázquez Bosco along with the Baroque vaults to recover the Islamic ceiling is also surprising [31]. Other drawings and photographs from the 19th century locate this skylight in the fourth intercolumniation (from the grille) [29], but in Prangey's image, the light seems to penetrate through the second one, with dubious veracity.

The text Prangey included in the plate stated that the width of the 19 parallel naves of the Mosque ranges between 6.35 and 7 meters in the main nave of the mihrab; and between 6.35 and 5.80 metres for the intercolumniation. In other words, the draughtsman took careful measurements to create his drawings.

These measured drawings would serve as the basis for this perspective, using a graphical method similar to the previous view. The elevation of the arcade, which is now placed obliquely, was used as a starting point. The digital model and the vanished elevation, which Prangey placed in the foreground, show good correspondence. The careful drawing of the brick pavement, which was replaced by the current marble pavement at the beginning of the 20th century, is also of interest.

However, the characters represented "on their knees" have an exaggerated size in relation to the columns. This error is frequently seen in many contemporary engravings,

which invented scenes that did not appear in the original drawings in order to command greater visual attention for purely commercial interest.

3.3. Side Perspective with Mihrab Detail

When superimposing Prangey's view with the digital model, there is also good correspondence, with small mismatches in the interlaced arches and in the mihrab access arch (Figure 23). The draughtsman would start his drawing from an elevation placed obliquely, in a similar way to the previous case.



Figure 23. Girault de Prangey (1839). Digital model overlapping the mihrab side. Source: Own production.

The then-existing high grille was not drawn either, and in the background, neither the chapel of Santa Teresa nor the altarpiece of the Holy Supper appear, which were represented in a plan from 1741 [22] and were there until 1912. Once again, the draughtsman removed elements that he would have thought were not suitable for the place, as did other contemporary draughtsmen.

Some inaccuracies and errors in details have been detected, such as decorative circles drawn in the upper part, where there are rhombuses, or columns between the interlaced arches, where there are pilasters. These columns can be found on the back face of the same portico, which is slightly different. In other words, Prangey used the back elevation of the portico that is not visible from his viewpoint. Furthermore, the size of the characters added by the lithographer does not correspond to the height of the columns.

3.4. Royal Chapel Perspective

The perspective from this elevated place was also produced from an oblique elevation. The polylobulated arch and the upper frieze approximately match, but there are small mismatches on the right side. The nave and the porticoes composed by double arches in the background show quite good correspondence (Figure 24).

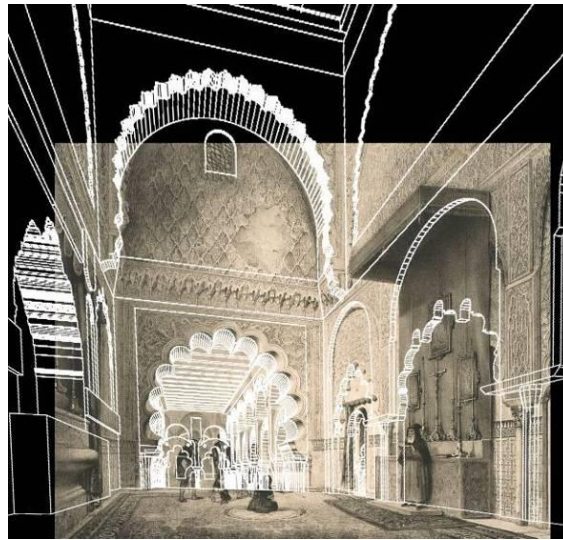


Figure 24. Girault de Prangey (1839). Digital model overlapping the Royal Chapel. Source: Own production.

3.5. Perspective from the Space Near the Mihrab

This perspective from the space near the mihrab was published by Prangey in 1841. Again, the section would be used as the basis for the graphic construction. When overlapping the perspective and the digital model, some mismatches can be found, especially in the upper part, which was represented with little height (Figure 25a).

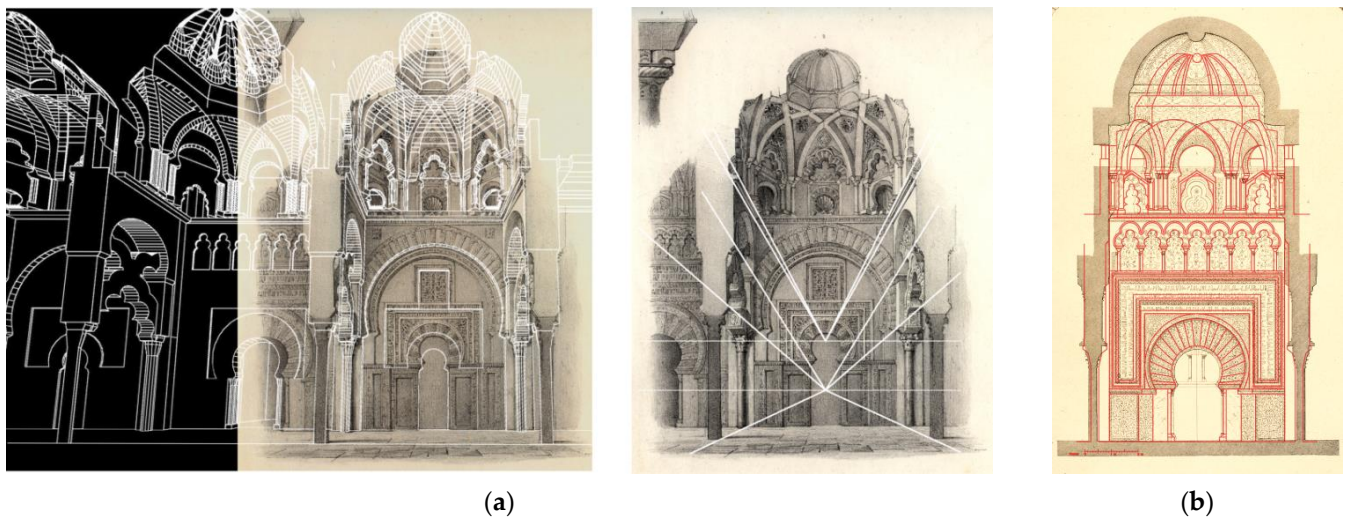


Figure 25. Girault de Prangey (1841 and 1839): (a) Digital model overlapping the mihrab annexed to the mihrab. Duplicity in horizon and vanishing. (b) Mihrab section overlapping the current section. Source: Own production.

When drawing the vanishing lines, it is surprising to see that the height of the horizon line is different at the top and bottom (Figure 25a). In other words, there are two different vanishing points for parallel lines, but according to the rules of conic perspective, they should converge in one. It is hard to believe that this was a simple mistake. It was perhaps a device, sometimes used by experts in perspective, to get a better view of the space by skilfully manipulating the proportions.

Although it is not a perspective, the digital model has also been compared with the mihrab elevation (Figure 25b). There is enough correspondence in the arch and its voussoirs. The height of the columns and the start of interlaced arches in the dome also coincide. However, there are significant differences in the seven small arches located in the

middle frieze, and there is no correspondence in the upper part. This confirms that data collected in elevated areas were carried out with some difficulty and little rigour.

3.6. Details and Decoration

Although this work focuses on perspectives, various architectural and decorative details published by Prangey have also been verified for accuracy. This gives a general idea about the accuracy, since they surely served as a basis for the graphical construction of the perspectives.

Let us take into account that the details were published by the artist in 1839, 1841 and around 1845, sometimes as elevations and sometimes as perspectives. In this section, some details of 1839 are presented. They have been grouped according to their location, most corresponding to the mihrab (Figure 26) and the Royal Chapel (Figure 27). First, they have been identified on photographs, and then, they have been compared with the orthogonal projection of the point cloud, which is provided here as a reference for their location.

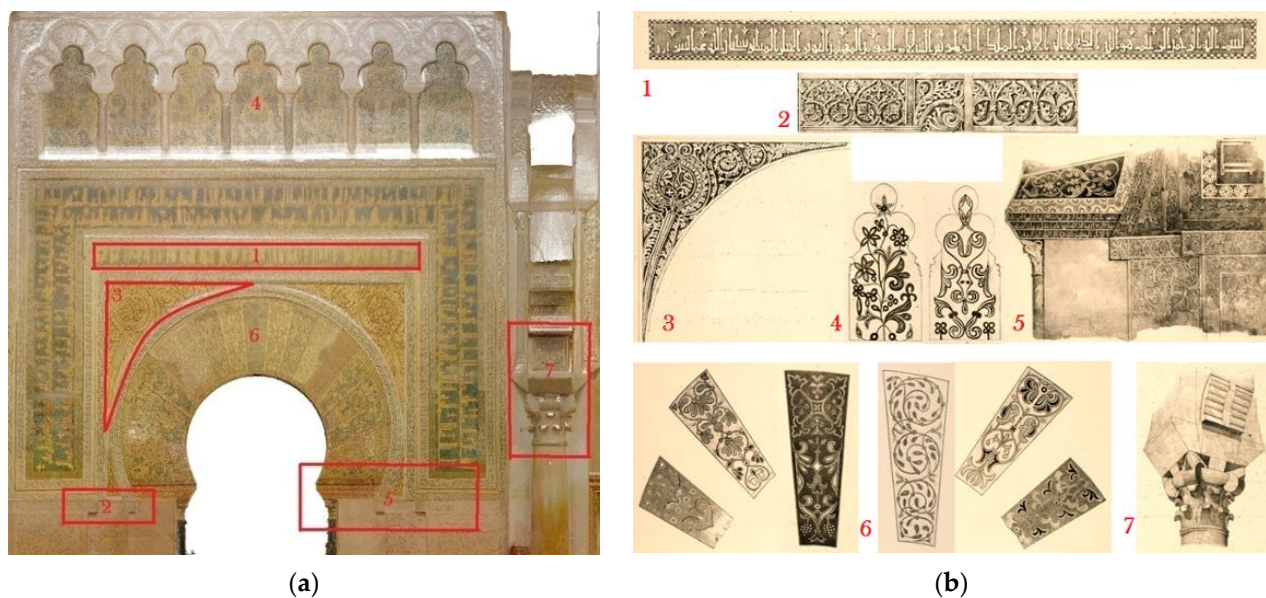


Figure 26. Details in the mihrab: (a) Point cloud from laser scanner; (b) Lithographs published by Girault de Prangey (1839). Source: Own production.

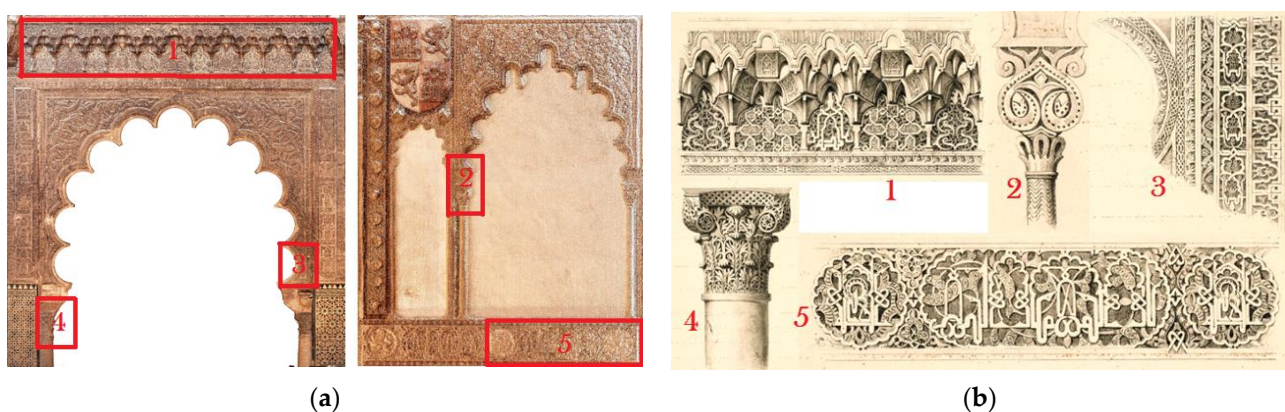


Figure 27. Details in the mihrab in the Royal Chapel: (a) Point cloud from laser scanner; (b) Lithographs published by Girault de Prangey (1839). Source: Own production.

The accurate representation of the perspectives is surprising. This suggests that they could have been drawn on a true scale. That is what Owen Jones and other architects who drew ornaments of the Alhambra in those years would have done, using tracing papers,

many of them preserved in the Patronato de la Alhambra archives [69]. A camera lucida could also be used to draw capitals, pilasters and other details, although this is a mere hypothesis. In any case, the great effort made and the accuracy of these details as a basis for developing perspectives, when photography did not exist, should be highlighted.

4. Conclusions

It should be remembered that architectural drawing is a discipline situated between art and science, and that perspective is the most widespread representation system in our culture, due to its affinity with natural vision [70]. Since the appearance of perspective in the Renaissance period [71], various instruments that can be considered as antecedents of the daguerreotype were devised to facilitate its complex graphic construction (camera obscura, camera lucida, etc.). The proliferation of photography in the mid-19th century was a revolution similar to the recent arrival of computing and digital imaging.

Girault de Prangey has been recognised in recent international exhibitions as a pioneer in the use of photographic techniques to document architecture. His pre-photography perspectives have also been found to be invaluable in researching architectural heritage in this work.

There is no known background on the use of digital techniques to assess perspectives from the 19th century and, for this reason, a novel methodology has been proposed here to analyse interior perspectives of the Mosque-Cathedral of Cordoba. These images have hardly been studied, despite their relevance to the understanding of a monument that has undergone many transformations throughout its long history. To assess the views veracity, we must consider the architectural model drawn, the basic rules of perspective, the education and interests of the draughtsman that drew them and the drawings produced by other contemporary authors.

A digital geometric model has been created from the point cloud obtained with a laser scanner. It has been necessary to simplify its representation after a careful architectural analysis and after reviewing the graphic conventions in monument drawings from the 19th century to the present day.

The overlapping between the Prangey perspectives and the digital model has allowed us to check the accuracy of their framed views. It seems unlikely that the interior perspectives were produced with a camera lucida, an instrument Prangey had used before [46,47]. They also do not seem to be copied from other drawings, such as those published in 1812 by Alexandre Laborde, who did use a camera lucida [25].

It should be remembered that the title of the 1839 publication includes the words “dessinés et mesurés en 1832 et 1833”. Therefore, Prangey would first make plans, sectional elevations and scale details drawn from his own measurements. He would use the metric system, which began to be used in France just a few years before, in a novel way. He would then obtain the perspectives from these initial plans and drawings.

The frontal view of the mihrab was derived from the elevations in true magnitude used as the basis of the graphic construction. The other cases are more complex, since, in each one, an elevation was placed in the foreground obliquely, using its own vanishing point. The perspective that Prangey published in 1841 is especially interesting, drawn by Nicolas Chapuy and cleverly manipulated, with two horizon lines, to improve the view of the space represented.

Although they are not the central focus of this work, the architectural and ornamental details that would serve as a basis for the perspectives have also been reviewed. The meticulousness and great effort required by the artists to produce the perspectives are remarkable.

No remarkable errors have been detected from the comparisons between the perspectives and the digital model. Only in elevated areas around the mihrab do some highlighted discrepancies, which would be difficult to measure by hand, appear.

Furthermore, the Prangey drawings confirm that the pavement level of the Mosque-Cathedral did not change after the replacement of the brick pieces by the current marble ones, placed at the beginning of the 20th century. The artist drew building elements that

have now disappeared, such as the plaster vaults, which correspond to consulted drawings and photographs from the 19th century.

Some reality manipulations should be highlighted; among them, in all the drawings the removal of the grille along with the mihrab is remarkable. The artist, along with other draughtsmen, would probably have regarded it as an unpleasant visual obstacle, and therefore, did not draw it. Prangey drew the skylight illumination located near the mihrab in such a close way that it seems unreal, perhaps to give a more pleasant luminous environment. In addition, the engravers included human characters with a disproportionate and unrealistic size.

Prangey's perspectives are among the most beautiful and accurate representations of the interior of the monument throughout its history, along with those produced by noteworthy 19th century artists, such as David Roberts or John Frederick Lewis.

Finally, it should be noted that Girault de Prangey promoted—as a draughtsman and photographer—modern ideas on architectural graphic expression; the visual memories of architecture can be rigorously understood, stored, retrieved, grouped and displayed. He used sound and advanced graphic techniques to discover and spread knowledge on architectural heritage in a methodical and scientific way.

Author Contributions: Antonio Gámiz-Gordo, Juan Cantizani-Oliva and Juan Francisco Reinoso-Gordo all took part in the entire research process. All authors have read and agreed to the published version of the manuscript

Funding: This research has been funded by internationalisation grants awarded to the Instituto Universitario de Arquitectura y Ciencias de la Construcción (IUACC) of the VI Plan Propio de Investigación y Transferencia of the University of Seville.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: This research has been made possible thanks to the collaboration of the Cabildo de la Catedral de Córdoba. The authors are also grateful for the support from the research group Expregrafica, Lugar Arquitectura y Dibujo (PAIDI-HUM-976); Programa de Doctorado en Arquitectura, Instituto Universitario de Arquitectura y Ciencias de la Construcción from the University of Seville; the research group Ingeniería Cartográfica (PAIDI-TEP-164) from the University of Jaén; and the Survey and Modelling Laboratory (SMLab) from the University of Granada.

Conflicts of Interest: The authors declare no conflict of interest.

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