THE ABBAS MIRZA MOSQUE OF IREVAN: A MULTI-SOURCE DIGITAL RECONSTRUCTION FRAMEWORK FOR LOST ARCHITECTURAL HERITAGE

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1. Introduction

The destruction of cultural heritage is one of the most topical issues of global preservation communities in the 21st century. Architectural monuments across the globe are under threat as never before, whether due to intentional iconoclastic assaults on archaeological sites or simple deterioration through neglect and environmental factors. Digital reconstruction technologies have also become important resources in the heritage preservation field and have allowed the documentation, analysis and virtual restoration of threatened or lost cultural sites [1]. The technologies are not only used in academic and educational contexts but also in maintaining the cultural memory and heritage recovery of cultures that have had their architectural heritage disrupted. One example of the global heritage crisis is the Abbas Mirza Mosque, also referred to as the Sardar Mosque, as shown in Figure 1 [2].

This monument was built in the Qajar period in the historical Irevan Fortress (modern Yerevan) and was the main mosque of the administrative center of the Irevan Khanate. The mosque represented an architectural fusion of Persian and Caucasian building styles, typical of the region, reflected in its rich glazed tile decoration, ornate dome, and exquisite courtyard design [3]. With the conquest of the Russians in 1827, the mosque was converted into military stores and was slowly neglected for over a century. Only fragmented walls were left by the beginning of the 20th century. The last traces were cleared in 2014, and the physical disappearance of the monument from the urban landscape was complete [4]. It is a fundamental issue to cultural heritage conservation that the entire physical loss of the Abbas Mirza Mosque poses: how do we decide to correctly rebuild an existing monument when only partial historical records have been preserved? Such a lack of architectural plans, photographic evidence and destruction of all material remains, requires new methodological tools that bring together various historical sources of data, such as archival documentation, artistic renderings, photographs and architectural analogues into a consistent digital reconstruction framework.

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Figure 1. Nineteenth Century painting of the Abbas Mirza (Sardar) Mosque, by August Wilhelm Kiesewetter (1848-49) [2].

This study will deal with the challenges by accomplishing the following four main objectives: (1) Prepare an overall digital 3D representation of Abbas Mirza Mosque with the help of multisource historical materials; (2) Develop a methodological framework of rebuilding for wholly demolished heritage that is applicable to other analogous instances worldwide; (3) Evaluate the reliability and fidelity of the reconstruction techniques in cases where primary architectural sources are inadequate and missing; (4) Add to the heritage restitution and academic visualization of Irevan Khanate architecture, to restore the collective memory and scholarly visibility of this monument.

Research Hypothesis: The hypothesis of the research is that multisource historical records such as archival plans, artistic representations, photographic evidence, and architectural analogies, when used together with computational 3D modeling may provide the academically stable digital rehabilitation of entirely deteriorated architectural heritage with dimensional margins in the range of 0.510% tolerance limits. It is, moreover, also supposed that these reconstructions, appropriately validated by cross-referencing and expertise consultation, can be used as valid scholarly resources toward the recovery of heritage and architectural research.

The paper is organized in the following way: Section 2, gives a historical background of the Irevan Khanate and the construction of mosques in the country; Section 3, discusses the digital restoration methodology which analyses the architectural parts with regards to surviving documentation and synthesizes the historical context and visual records; Section 4, provides details of the digital restoration process; the results and discussion; and the conclusion is given in Section 5.

2. Literature Review

The Abbas Mirza Mosque became a major monument of the Abbasid Persian kingdom of Irevan as a result of the synthesis of Turkic and Persian architectural ideas in the Qajar patronage. This part outlines the political and cultural history of the Khanate, beginning with the building of the mosque in the fortress, and its original meaning before its seizure by the Russians.

2.1. Irevan Fortress and the Khanate Context

The Abbas Mirza Mosque was constructed inside the Irevan Fortress (Irevan Gala or "Irəvan Qalası" the fortress which controlled the city of Irevan), a citadel located in the middle of the city of Irevan (Yerevan) when the city was the capital of the Irevan Khanate. It was a Turkic Azerbaijan province which was ruled by the Safavid and then by the Qajar, and was periodically disputed by the Ottoman Empire, then finally annexed by the Russian Empire in 1828. The fortress itself was built on a rocky hill along the Zangi river and had existed since the 16th century but was rebuilt many times. Early travel descriptions explain the strategic and symbolic significance of the fortress. Indicatively, in 1655, JeanBaptiste Tavernier paid a visit and even printed a depictive city plan of Irrevan illustrating the structure of the fortress and major buildings. According to the plan the fortress is located in the southwestern area of the city, surrounded by two walls and a moat and the palace buildings with the mosque within it. According to the author, who wrote about Irevan city in the 1670s, the fortress was a small town (calling it a little town) occupied by a Persian governor (Sardar) and his garrison of 2,000, with the Armenians merely having stores there during the day. This comment highlights the fact that the citadel was a Muslim enclave of influence, where the khan, his harem, his barracks, baths, and mosques were located, whereas the Armenians lived beyond the walls of the fortress [5-6].

Nonetheless, in 1679, an earthquake destroyed most parts of old Irevan including its mosques. The Safavid authorities later reconstructed the fortress, although on a different architectural plan. The author notes that the fortress built before 1679 was aesthetically more impressive than the version which was rebuilt afterwards. It is particularly noteworthy that the author refers to a tower within the fortress – described as *curieux* – which was likely a minaret or watchtower and was still standing at that time. This structure would disappear in subsequent decades during the wars between the Safavids and the Ottomans. Indeed, when the Ottoman forces seized Irevan in 1635, they razed all mosques built by the Persians. Conversely, when the Persians under Nadir Shah retook the city in 1735, they likely removed Ottoman additions. This cycle of destruction and rebuilding under successive regimes meant that by the late 18th century, Irevan's Islamic architecture was relatively new [6-7]. The main Friday Mosque in the city (the Gök Jami or Blue Mosque, built in 1765) is dated to Khan Huseyn Ali's era (1759 – 1783), while several smaller neighborhood mosques were founded in the late 1700s. Within the fortress, travelers of the early 19th century reported two prominent mosques: one Sunni Ottoman Mosque and one Shia Qajarera Mosque.

2.2. Construction of the Abbas Mirza (Sardar) Mosque

The Shia Mosque which came to be known as the Abbas Mirza Mosque was constructed in the first decade of the 19th century, during the reign of Sardar Ḥusayn Quli Khan – the last khan (governor) of Irevan. It was built to serve as the palace mosque within the fortress, adjacent to the Sardar's residence, and it was named in honor of Abbas Mirza (1789–1833),

the crown prince of Qajar Persia. Contemporary sources indicate that Abbas Mirza himself supported or sponsored the mosque's reconstruction around 1807–1810. In fact, Russian imperial documents from after the Russo-Persian War refer to it explicitly as the "Abbas Mirza Mosque", implying that the name was in use by 1827. The German traveler, Baron August von Haxthausen, visiting Irevan in the 1840s, noted that the mosque was dedicated to Abbas Mirza, who had led Persian efforts to fortify the region [8-9].

Crucially, the Abbas Mirza Mosque was one of two major mosques inside the fortress – the other being an older Sunni Mosque built during an earlier Ottoman occupation. The Sunni Mosque, known as the Rajab Pasha Mosque (built 1725), had a large arched prayer hall supported by four pillars. When the Persian forces regained Irevan from the Ottomans, they repurposed the Ottoman Mosque as an armory, reflecting their sectarian rivalry (it was no longer used for worship). After the Russian conquest in 1827, the Rajab Pasha Mosque was converted into an Orthodox church (St. Pokrov) commemorating the Russian victory. By contrast, the newer Abbas Mirza (Sardar) Mosque – being a Shiite Qajarian foundation – was respected by the local Turkic population but later neglected under Russian rule. Figure 2 illustrates the relative positions of these structures: the Abbas Mirza Mosque stood near the Sardar's palace complex toward the fortress's southern side, while the Rajab Pasha Mosque (later St. Pokrov Church) was at the northern end of the fortress. Together, they represented the layered political and religious history of Irevan's fortress in the 18th–19th centuries [10-11].

Figure 2. Map of the Erivan Fortress (17th century) – excerpt from JeanBaptiste Tavernier's published plan (c.1660s) [11].

It is worth noting that while the mosque is often called "Persian" in a variety of sources, that generic label is avoided in favor of a more precise cultural historical context. The Irevan Khanate's elite and the majority of the local population were of Azerbaijani Turkic origin (in some sources mentioned as "Tatars"), and though they served the Persian Qajar state, they patronized local art and architecture that reflected a blend of Persian Islamic

forms with Turkic and Caucasus influences. Therefore, the Abbas Mirza Mosque can be seen as a product of Qajar period Azerbaijani architecture. Contemporary Armenian historians also acknowledge that in late medieval Irevan, “a luxurious palace, mosques, a bathhouse, a gunpowder armory and other important buildings” in the fortress were built by the Turkic Muslim khans and described by travelers like Chardin. The mosque was thus an integral part of Irevan’s urban development during Qajar rule [12].

Russian archival records affirm the significance of the Sardar’s Mosque at the time of conquest. In April 1828, just months after Russia captured Irevan (Russian sources use “Erivan” for the city’s name), an imperial decree ordered that “the estate of Hussein Khan, former Sardar of Irevan, consisting of his palace complex, mosque, and garden” be protected from looting or alteration. The same decree explicitly forbade the local Armenian administration from converting or tampering with Muslim religious sites (the mosque) without authorization. This is one of the clearest official confirmations of the mosque’s existence and importance right after the Russian annexation. Despite this initial injunction to preserve the mosque, its fate in the ensuing decades was grim (as later sections will detail). Nonetheless, circa 1827, the Abbas Mirza Mosque was intact and, according to accounts, one of the finest architectural monuments in the fortress [13]. The precise location of the Sardar Mosque, constructed during the Qajar period within the Irevan Fortress, is confirmed through the topographical surveys conducted by a municipal engineer between 1906 and 1911. His detailed urban mapping of Irevan, which formed the basis of the official municipal cadastre, records both the Sardar Khan Palace complex and the mosque, each distinguished by their respective courtyard centered layouts. Such structures can easily be traced in Figure 3 [14] and Figure 4 [15], which are illustrations of parts of the initial survey drawings. The architectural footprint of these lost monuments is given an extremely rare and accurate spatial reference in this documentation.

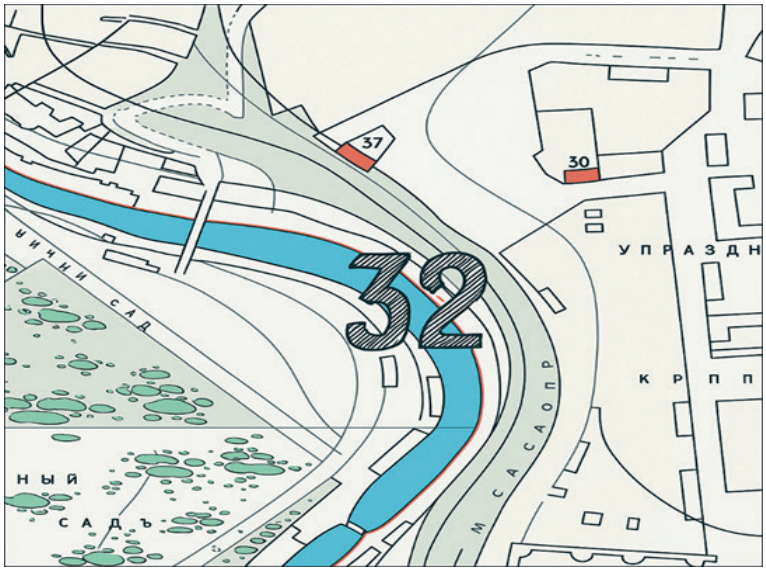

Figure 3. Section 32 depicts a digitally restored portion of the historical urban fabric surrounding the Erivan Fortress (Yerevan Fortress) in modern-day Armenia [14].

Figure 4. Fragment of the Plan of Irevan, surveyed by municipal technician B. Ya. Megrabyan between 1906-1911 [15].

2.3. Architectural description of the mosque

Eyewitness descriptions and visual records allow us to partially reconstruct the architecture of the Abbas Mirza (Sardar) Mosque. Like many mosque complexes of the Caucasus in the 18th–19th centuries, it featured a courtyard with a pool, a decorated entrance facade with arches, and a large domed prayer hall. Its construction materials were primarily brick and glazed tile, and stylistically it likely followed a late Safavid/Qajar period mosque design adapted to local traditions. In general, the stylistic features of the Irevan Khanate period architecture exhibit notable affinities with the Nakhchivan (Ajami) School and the Arran School of Azerbaijani architecture, particularly in their use of baked brick construction and glazed tile decoration [16].

2.3.1. The courtyard

The mosque was approached through an enclosed *sahn* (courtyard) which provided a transitional space for worshippers and served for ritual ablutions. Historical photographs and paintings strongly suggest the presence of a fountain or water basin at the center of the courtyard [17]. Baron von Haxthausen's travel notes in 1843 mention a "spacious courtyard with a fountain" when referring to the Sardar's mosque. More strikingly, paintings from 1839 and 1848 show a fountain in front of the mosque, with a number of people gathered around it, as seen in Figure 5 [18]. This fountain was likely used for *wuzu* (ablution) before prayers, as was customary. By analogy with Irevan's Blue Mosque (which survives and also has a large courtyard pool), we can infer that the Abbas Mirza Mosque's courtyard was a serene, gardenlike space.

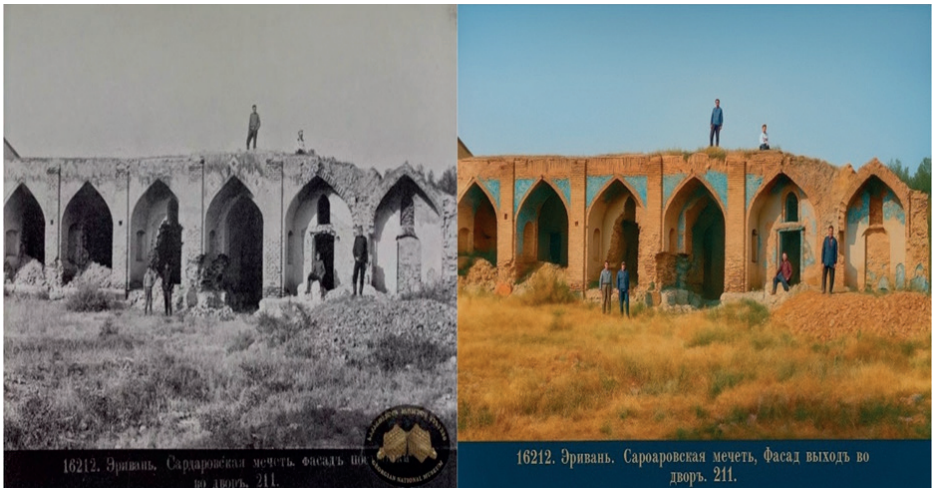

Figure 5. Irevan, Sardar Mosque, façade of the structure in the courtyard. View No. 211. Original on the left; restored version using historical analog color modeling method on the right [18].

2.3.2. The façade

The mosque's most striking feature was its facade, richly decorated with glazed tile ornamentation. Archival research and artistic depictions concur that the exterior surfaces were embellished in the vibrant ceramic colors typical of Qajarera architecture. An Armenian scholarly study notes: “The mosque was constructed using fired bricks, while the dome and exterior walls were clad in blue and green glazed tiles.” This is corroborated by Kiesewetter's painting, which clearly shows the facade of the prayer house covered in decorative motifs, predominantly in blue and turquoise hues under direct sunlight [19]. The use of blue-green tiles likely gave the mosque a visual affinity to the so-called Blue Mosque in the city as shown in Figures 6 and 7, though the latter's tiles are more azure [20-21].

Figure 6. Facade elevation of the Abbas Mirza (Sardar) Mosque drawn by Frédéric Dubois de Montpéreux during his travels in the South Caucasus (circa 1839) [20].

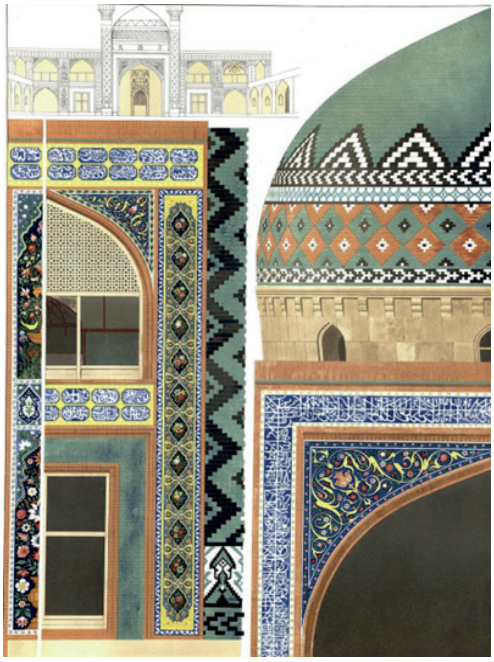

Figure 7. A highly detailed chromolithograph of the façade and dome of the Abbas Mirza (Sardar) Mosque in Irevan [21].

2.3.3 The dome

Crowning the mosque was a singular dome (Azerbaijani "günbəz" / Persian "gunbad") which covered the main prayer hall [22]. This central dome was a prominent component of the mosque's silhouette and is frequently noted in historical descriptions. As with the façade, the dome was embellished: surveys confirm the dome was surfaced with the same blue and green glazed tiles as the walls. In bright sunlight, this dome would have glinted turquoise – an eye-catching sight against the skyline of the fortress [23].

2.4. Historical accounts and visual documentation

As Abbas Mirza (Sardar) Mosque no longer exists, knowledge of it relies on historical documentation. Fortunately, a variety of primary sources from the 17th century through to the early 20th century provide evidence, from travelogues by Europeans, to official Russian surveys, to photographs and paintings. The first detailed descriptions of Irevan for Western audiences came from travelers, Tavernier (1660s) and Chardin (1670s). Tavernier's city plan marks a generic "mosque" in the pre-1679 fortress, but that would have been an earlier structure that did not survive the earthquake in 1679. The author talks about the fact that there are several mosques in the city and castle. He also talks about the citadel having a tiny Friday Mosque for the garrison [24].

During the first decades of the 1800s, several Europeans visited Irevan – often as part of diplomatic or military missions – providing eyewitness data at the time the Abbas Mirza Mosque was new. A British artist and diplomat visited in 1817 while the city was still under Qajar rule [25]. He recounted that the fortress contained "a newly built mosque of elegant appearance" and made a sketch of Irevan from a distance where the outline of a domed mosque is visible. Another British traveler provides one of the last European eyewitness accounts of the site. In his 1901 book, Armenia: Travels and Studies, he describes Yerevan shortly after the Russian Empire had reshaped it into a provincial city. By the 1890s the fortress had been largely demolished or repurposed, but the author writes: "With the exception of the mosque in the fortress, the Mohammedan edifices [in Yerevan] are extremely well maintained". This single remark tells us that the fortress mosque was in a derelict state, unlike the city's Blue Mosque which Lynch admired and photographed [26].

The late 19th and early 20th centuries fortunately coincide with the advent of photography in the Caucasus. While no known photograph shows the Abbas Mirza Mosque in its intact glory, there are several images of the fortress where one can identify the mosque's remains. Famed photographer Dmitri Ivanovich Yermakov visited Irevan in the 1870s–1880s and took a series of images of the fortress ruins [27].

The consistent cross-referencing of textual descriptions with visual records allows for a more authoritative reconstruction of the mosque's appearance and significance. Despite the fragmentary nature of sources, the convergence of evidence from multiple independent observers provides a solid foundation for digital reconstruction efforts [28].

3. Digital restoration methodology: A comprehensive framework

This section presents the systematic methodology developed for the digital reconstruction of the Abbas Mirza Mosque. Given the complete absence of physical remains and the fragmentary nature of historical documentation, it was necessary to develop a multi-stage, cross-validated framework that integrated diverse source types into a coherent 3D computational model, as shown in Figure 8.

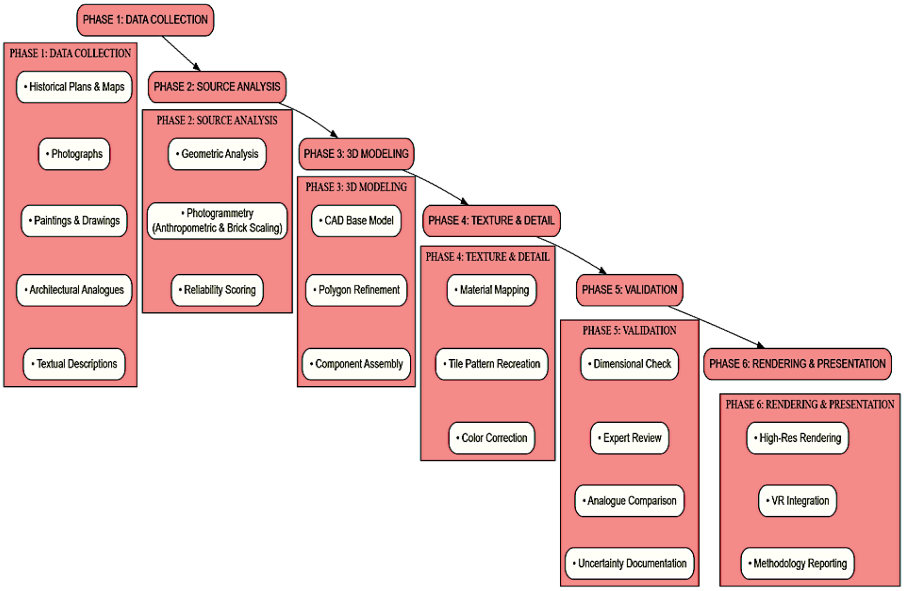

Figure 8. Proposed workflow for digital restoration.

3.1. Data collection and source categorization

The reconstruction relied on five primary categories of historical documentation, each contributing distinct information types to the digital model as shown in table 1 regarding source type, specific source data reliability score, and relevant information and limitations.

Reliability Scoring System:
- 5 = Primary source, high precision, verifiable
- 4 = Contemporary documentation, some interpretation
- 3 = Secondary or artistic interpretation
- 2 = Indirect reference
- 1 = Speculative or unverified

The above reliability scoring system follows our hierarchical weighting system: a score of 5 indicates a primary, high-precision visual or planimetric source. Gagarin's chromolithographs are rated 5 because they provide unusually fine detail and consistent color/ornament information for the façade (see Figure 7) and thus serve as a principal basis for tile pattern and color reconstruction. By contrast, while Dubois de Montpéreux's 1839 elevation remains valuable for proportions and elevational composition, closer inspection reveals a degree of artistic romanticization and a single static viewpoint; therefore, its score has been adjusted to 4 to reflect slightly lower independence and higher interpretative risk compared to Gagarin.

Table 1. Source matrix for Abbas Mirza Mosque reconstruction

Source Type	Specific Source	Date	Reliability Score (1-5)	Information Provided	Limitations
Historical Plans	Tavernier city plan	c. 1660s	3	Fortress layout, spatial relationships	Predates Abbas Mirza Mosque; shows earlier structure
	Megrabyan cadastral survey	1906-1911	5	Precise location, footprint dimensions, courtyard layout	Post-deterioration; limited elevation data
	Russian military plans	1827-1828	4	Fortress context, mosque position	Limited architectural detail
Photographs	Yermakov archival photos	1870s-1880s	4	Facade details, structural condition, scale reference	Partial views, degraded state, B&W
	Baron de Bay photographs	1898	4	Iwan arch, dome condition, ornamental details	Limited angles, deteriorated condition
	Russian Defense Ministry archives	1882	3	Courtyard arcades, structural typology	Severe degradation visible
Paintings/Drawings	Gagarin chromolithographs	1840s	5	Color scheme, facade ornamentation, minarets, dome patterns	Artistic interpretation; some romanticization
	Kiesewetter painting	1848-49	3	Overall composition, courtyard fountain, architectural massing	Romanticized; perspective distortion
	Dubois de Montpéreux elevation	1839	5	Accurate facade elevation, proportions, architectural details	Limited to single viewpoint

3.2. Photogrammetric analysis and dimensional calibration

Accurate dimensional reconstruction from historical photographs required the development of photogrammetric scaling techniques adapted to the limited available imagery.

3.2.1. Scale determination methodology

1. Anthropometric Analysis: Human figures visible in Yermakov's photographs (c. 1880s-1900s) provided baseline measurements. Using average adult male height in 19th century Caucasus (165-170 cm), we calibrated image scale.
2. Brick Module Calculation: Visible brickwork in close-up photographs enabled brick counting. Regional Qajar-era bricks standardly measured 22-25 cm length × 11-13 cm width × 5-6 cm height. By counting brick courses in columns and arches, vertical dimensions were calculated.
3. Comparative Proportional Analysis: Measurements from Blue Mosque (extant) provided proportional ratios for similar architectural elements [29-30].

Mathematical Formula for Height Estimation:
Total Height = (N_bricks × h_brick × (1 + m_factor)) + H_adjustment

Error Margin Assessment:
- Dimensional measurements: ±5-8% uncertainty
- Color reconstruction: ±15-20% uncertainty (due to B&W photo colorization)
- Ornamental pattern details: ±10-15% uncertainty (artistic interpretation variance)

3.2.2. 3D modeling pipeline

The digital reconstruction employed a sequential modeling approach using industry-standard CAD and 3D graphics software. Software tools utilized:
- AutoCAD 2021: Base 2D floor plans and elevation drawings
- Rhinoceros 3D 7.0: Parametric modeling of dome and complex geometries
- Blender 3.6: Polygon mesh refinement and texturing
- Adobe Photoshop/Illustrator CC: Tile pattern recreation and texture mapping

Step-by-Step Modeling Process:
- Step 1: Base Geometry (AutoCAD) – Import Megrabyan 1906-1911 cadastral plan as underlay georeferenced and trace mosque footprint (i.e. some 28m x 35m with courtyard).
- Step 2: Elevation painting (rhinoceros 3D) Import facade higher elevation drawings and bench measure them to photo grammatic-Scaled dimensions.
- Step 3: Dome Construction – based on the historical pictures depicting dome shape/profile, and comparison with Blue Mosque.

The digital reconstruction process began with the establishment of the mosque's base geometry in AutoCAD. The Megrabyan cadastral survey (1906–1911) was imported as a georeferenced underlay, allowing the precise tracing of the mosque's footprint and courtyard boundaries, which measure approximately 28 × 35 meters. This spatial foundation provided the primary planimetric framework for all subsequent modeling stages. Building upon the base plan, the second stage involved generating accurate elevation geometry inside Rhinoceros 3D. Here, higher-elevation façade drawings,

particularly the 1839 elevation by Dubois de Montpéreux, were aligned with photogrammetrically derived scale measurements to ensure correct vertical proportions [30-31]. These elevations served as the structural basis for wall heights, iwan dimensions, and façade articulation.

The third stage focused on reconstructing the dome, a defining element of the mosque's architectural silhouette. While early historical photographs and sketches provided general information about the dome's massing, Gagarin's chromolithograph offered the most detailed and accurate reference for its curvature, proportional relationship to the drum, and decorative tile banding. This source was crucial because it depicts the dome's surface segmentation, color fields, and ornamental pattern distribution with exceptional clarity. These details were integrated into the geometric model and then cross-validated using proportional analogues from the extant Blue Mosque of Irevan, whose Qajar-era dome shares similar construction principles and glazed-tile techniques [32]. Together, these datasets allowed for a historically grounded reconstruction of the dome's form, height, and decorative structure, ensuring both geometric accuracy and stylistic authenticity.

3.2.3. Texture reconstruction and material authenticity

To obtain visual realism, the glazed tilework and surface treatment of the Qajar period had to be recreated very carefully. The chromolithographs of Gagarin were the most detailed in color information; each tile design was traced as a vector graphic including geometric border designs, epigraphic bands, and floral arabesque spandrel designs.

3.2.4. Validation and accuracy assessment

A systematic validation protocol was applied to the entire scope of the reconstruction procedure, so as to provide academic rigor. The validity of every reconstructed element was checked in relation to at least three independent sources, and the model was repeatedly viewed by the architectural historians of the Qajar period, specialists of Islamic art, and regional heritage specialists.

4. Results and Discussion

Testing the proposed multi-source framework provided a digital 3D image of the Abbas Mirza Mosque: the most complete and provable visualization of the lost monument so far. This section explains how the final reconstructed model was obtained, including its architectural elements, and measures the accuracy of the results.

4.1. The integrated 3D model

The last constructed model is the one that combines all of the spatial, dimensional, and textual information in a complete whole. The model reconstructs the mosque complex in its historical setting, illustrating the enclosed courtyard bounded by surrounding walls, alongside the principal prayer hall and the distinctive dome. The footprint which is accurately georeferenced to the Megrabyan cadastre is about 28 meters by 35 meters. As shown in Figure 9, the model is displayed in two configurations: a complete reconstruction with theorized chromatic and material finishes, and a wireframe model emphasizing geometric precision derived from size-based analytical measurements.

4.2. Architectural element reconstruction

Reconstructing the individual architectural elements was done by synthesizing information of the highest-weighted sources of each component.

1. Prayer Hall and Dome: The interactive plan of the central prayer hall took the form of a square which shifted to an octagonal drum, topped by one hemispherical dome. The profile of the dome, as well as its height (estimated as 18.5 meters between the base of the drum and the apex) was based on the silhouette in the painting of Kiesewetter and cross-tested on the proportional ratios of the remaining Blue Mosque. Rhinoceros architecture was such that the geometry of this transition was guaranteed.
2. Facade and Ornament through iwan: The principal façade was reconstructed with high accuracy using Gagarin's chromolithographs, which offer the most detailed and reliable visual evidence for the mosque's ornamental program, including tile colors, girih patterns, spandrel decoration, and the proportional relationship of the iwan arch to the flanking wall surfaces. Unlike Kiesewetter's romanticized painting and the more stylized elevation by Dubois de Montpéreux, Gagarin's drawings exhibit a high degree of architectural fidelity, making them the primary source for façade reconstruction. Gagarin himself had managed to capture and document the fine glazed tile work in chromolithographs, and this work was reproduced as high resolution texture maps in Blender. The colors mostly used were cobalt blue, turquoise green, and white, and the geometric girih patterns and floral arabesques were used to decorate the spandrels and to frame the arch.
3. Courtyard and Minarets: The courtyard was filled with a central fountain, which is in line with numerous pictorial references. The arcades surrounding the central fountain, observed in a ruined state in the photographs of Baron de Bay, were reconstructed according to calculated proportions derived from brick-module measurements. The model included two slim minarets, which were depicted in a few paintings but omitted in the subsequent photographs, and therefore flagged with the lower confidence rating.

4.3. Accuracy assessment and confidence levels

Table 2 summarizes the quantitative measure of the accuracy of the reconstruction. The level of fidelity of the model is a function of the component, the quality and nature of the underlying sources. The positive outcomes of this project make it clear the source heterogeneity is of paramount importance. There was no single category of sources that could be employed to reconstruct the situation entirely. The Megrabyan cadastre had a definite spatial underpinning that was beyond dispute but could not give elevation information. Photographs were taken of the structure in a poor condition, which provided the real-life scale of photogrammetry. Paintings were indispensable in color and massing, in general, and were liable to artistic license. The combination of these sources through their synergistic integration under the guise of a transparent weighting scheme is what was able to achieve a viable and justifiable reconstruction. The structure demonstrated considerable robustness in handling discontinuous and contradictory evidence, exemplified by the depiction of minarets in early paintings that were no longer visible in later photographic records. This level of categorization of confidence gives transparency and users of the model can appreciate the well supported geometric data and less interpretative aspects, such as color and finer ornamentation.

The paper contributes to digital heritage in a number of ways:

- Artistic Evidence Integration: The fact that a systematic integration of paintings and drawings as sources of quantitative data was realized attests to the extent to which artistic media can be made more than an illustration, that it can in fact be quantified as an architectural record.
- Adapted Photogrammetric Methods: The anthropometric scaling and counting of brick modules of non-survey, historical photography is an anthropometric approach to extracting dimensional information of archives not initially planned to be analyzed metrically.
- Clear Uncertainty Management: The written record of ranges of accuracy and levels of confidence of various elements of the model establishes a standard of intellectual integrity in the digital reconstructions, where the boundary between evidence-based modeling and speculation can frequently be hard to recognize.

The virtual reconstruction of the Abbas Mirza Mosque confirms the main hypothesis of the study, which was that a multi-source approach would be able to deliver a scholarly sound model of completely demolished architectural heritage. The approach is discussed in terms of its methodology implications, the contributions of scholars and the limitations associated with the approach.

Table 2. Quantitative accuracy and confidence assessment of the Abbas Mirza Mosque digital reconstruction

Architectural Component	Accuracy	Confidence Level	Primary Basis for Reconstruction
Structural Dimensions	±5–8%	High	Based on Megrabyan's cadastral survey and photogrammetric scaling analysis
Dome Profile & Height	±7–10%	Medium-High	Derived from painting silhouettes and proportional analogues from comparable monuments
Facade Proportions	±3–5%	Very High	Reconstructed from Dubois de Montpéreux's architectural elevation drawing
Ornamental Patterns	±10–15%	Medium	Inferred from Gagarin's chromolithographs through digital vector tracing
Color Reconstruction	±15–20%	Medium	Modeled using artistic color evidence and comparative regional material analogies

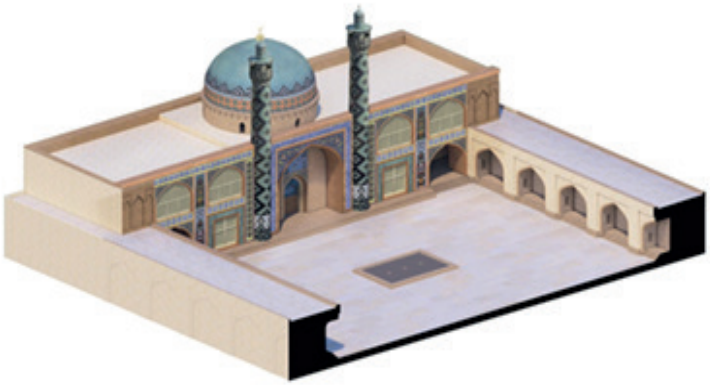

Figure 9. The 3D reconstruction of the Abbas Mirza Mosque which is a digitally restored model. a) View of the courtyard and the dome building.

b) Perspective of the main entrance and facade iwan.

c) Structural wireframe model with emphasis on its geometric accuracy based on photogrammetric and planimetric data.

5. Conclusion

The study managed to create, implement, and test a sophisticated methodological framework for the digital reconstruction of the lost Abbas Mirza Mosque of Irevan. The project validates the main research assumption: that a critically engaged, multi-source approach can generate an academically valid and dimensionally sound (± 5 8% structural elements) digital representation of architectural heritage that has been entirely destroyed. The main outcome of this project is now the most comprehensive and evidence-based visualization of the mosque so far, which serves the purpose of restoring an important heritage monument, displaying the architectural artwork of 18th-century Azerbaijan, to historical records and becoming part of the scholarly and popular discourse on this subject. The principal contribution of this study is the development of a transferable six-stage reconstruction and visualization pipeline. This framework demonstrates how heterogeneous, fragmentary, and often ambiguous historical sources can be rigorously and coherently integrated, cross-validated with historical records, and translated into both academic and public discourse. Its most significant components include a formalized hierarchical source-weighting system; the adaptation of photogrammetric techniques, such as anthropometric scaling and brick-module counting to non-survey historical imagery; and the transparent representation of interpretative uncertainty through clearly defined confidence levels. This framework can be adopted as a practical model for addressing evidentiary gaps in the reconstruction of lost heritage. Beyond its technical and methodological contributions, the study demonstrates that digital reconstruction functions as a powerful form of historical inquiry and heritage management. It offers a meaningful response to physical destruction by preserving and revitalizing the cultural memory of structures whose architectural legacy has been disrupted or erased. Several future developments of the model can be envisaged. The integration of hyperspectral analysis of archival photographs may enable the recovery of previously obscured or lost visual information. More extensive comparative research on interior layouts could further refine the reconstruction process. In addition, the development of an interactive web platform through which both the model and its provenance can be explored by scholars and the wider public would enhance its value as a tool for critical engagement and scholarly discourse The model created here would be easily applied to other victims of cultural destruction and provide a powerful instrument to the digital heritage community across its continued effort to keep our collective architectural memory.

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Biographical notes

Fazil Humbatli is an architect and researcher specialising in the digital restoration of architectural heritage from the Iravan Khanate period. He is currently pursuing doctoral studies in Architectural Theory, History, and the Restoration of Monuments at Azerbaijan University of Architecture and Construction, focusing on the reconstruction of historical structures and the wider urban fabric of Yerevan city. His work integrates archival sources, analogical architectural analysis, and advanced visualisation technologies to develop methodologically rigorous approaches to digital restitution. His research centres on the intersection of architectural historiography, cultural memory, and digital humanities, with particular emphasis on monuments and fortification complexes that have been destroyed, lost, or substantially transformed. Fazil aims to advance scholarly understanding of architectural heritage through precise, source-based reconstruction methods

intended for academic, educational, and heritage-preservation contexts. His broader interests include Qajar-era architecture, nineteenth-century urban morphology in the South Caucasus, and visual techniques for representing architectural heritage in digital environments.

Summary

The systematic destruction of cultural heritage, as exemplified by the complete demolition of the Abbas Mirza Mosque by 2014, represents an irreversible loss to global architectural memory. This research addresses this challenge by developing a comprehensive digital 3D reconstruction of the lost mosque, establishing a transferable methodological framework for monuments destroyed with only fragmentary evidence. Our six-phase reconstruction pipeline integrates heterogeneous sources including cadastral plans, archival photographs, artistic renderings, architectural analogues, and textual descriptions. Dimensional data was extracted via photogrammetric analysis using anthropometric scaling and brick module counting, supported by cross-validation protocols and expert consultation. The resulting model achieves a dimensional accuracy of ±5–8% for structural elements, ±10–15% for decorative components, and ±15–20% for color reconstruction. A hierarchical source weighting system and confidence-level categorization ensure transparent uncertainty documentation. This study validates that multi-source digital reconstruction is a potent tool for heritage preservation, contributing to digital heritage scholarship through its innovative integration of artistic evidence, adaptation of photogrammetry for non-survey imagery, and transparent management of interpretative uncertainty.

Riassunto

La distruzione sistematica del patrimonio culturale, come dimostrato dalla demolizione totale della moschea di Abbas Mirza nel 2014, rappresenta una perdita irreversibile per la memoria architettonica mondiale. La presente indagine affronta tale sfida sviluppando una ricostruzione digitale tridimensionale completa della moschea perduta, delineando un approccio metodologico applicabile ai monumenti distrutti di cui rimangono solo testimonianze frammentarie. Il processo di ricostruzione, suddiviso in sei fasi, integra una molteplicità di fonti eterogenee, tra cui piani catastali, fotografie d'archivio, rendering artistici, analoghi architettonici e descrizioni testuali. I dati dimensionali sono stati estratti mediante un'analisi fotogrammetrica che ha incluso il ridimensionamento antropometrico e il conteggio dei moduli in mattoni, con il supporto di protocolli di validazione incrociata e la consulenza di esperti nel settore. Il modello risultante raggiunge una precisione dimensionale del ±5-8% per gli elementi strutturali, del ±10-15% per i componenti decorativi e del ±15-20% per la ricostruzione dei colori. Un sistema gerarchico di ponderazione delle fonti e una categorizzazione del livello di confidenza garantiscono una documentazione trasparente delle incertezze. Lo studio in questione dimostra che la tecnologia di ricostruzione digitale multisorgente rappresenta uno strumento efficace per la conservazione del patrimonio culturale. Tale tecnologia contribuisce alla ricerca nel settore del patrimonio digitale attraverso l'integrazione innovativa delle prove artistiche, l'adattamento della fotogrammetria alle immagini non topografiche e la gestione trasparente dell'incertezza interpretativa.